EFFECT OF PLANTING MATERIAL ON GROWTH, YIELD AND QUALITY OF TURMERIC VARIETIES

THESIS

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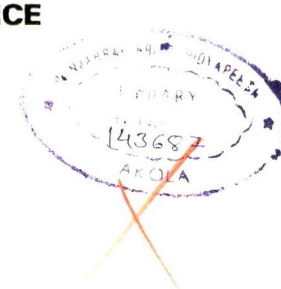

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DECLARATION OF STUDENT

I, hereby declare that the experimental work and it's interpretation of the thesis entitled, **"EFFECT OF PLANTING MATERIAL ON GROWTH, YIELD AND QUALITY OF TURMERIC VARIETIES"** or the part thereof has not been submitted for any other Degree or Diploma of any University or Scientific Organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF PLANTING MATERIAL ON GROWTH, YIELD AND QUALITY OF TURMERIC VARIETIES"** submitted in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture (Horticulture)** of the Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafied research work carried out by **Mr. Nishant Anandrao Deshmukh** under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee.

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ABBREVIATIONS USED

%	:	per cent
/	:	per
@	:	at the rate of
Abbr.	:	abbreviations
C.D.	:	critical difference
cm	:	centimeter(s)
Cv.	:	cultivar
DAP	:	days after planting
e.g.	:	*exmpli gratia* (for example)
et al.	:	*et alii* (and associates)
Fig.	:	figure
g	:	gram
ha^{-1}	:	per hectare
i.e.	:	*id est* (that is)
K	:	Potash
kg	:	kilogram
m	:	meter
mg	:	milligram
ml	:	milliliter
°C	:	degree celsius
N	:	Nitrogen
N.S.	:	non significant
P	:	phosphorous
q	:	quintals
S.E. (m) ±	:	standard error of mean
Sig.	:	significant
t	:	tonne
Var.	:	variety
Viz.,	:	*videlicet* (namely)

CHAPTER - I

INTRODUCTION

Turmeric (*Curcuma longa L.*) is an important cash crop and has a good demand in India and other countries. It is a herbaceous perennial crop with thick underground rhizomes giving rise to primary and secondary rhizomes called fingers. It belongs to family *Zingiberaceae*, which comprises of 40 genera and 400 tropical species. Member of genus *Curcuma* are strong, erect herbs with rhizomes bearing habit. Leaves are broadly lanceolate with long stalks. (Rao and Ram, 1994).

India is the leading producer and exporter of turmeric in the world. Turmeric occupies about 6.02 per cent of the total area under spices and condiments in India with about 1.69 lakh hectares area under cultivation, production about 6.98 lakh tonnes and productivity 4,130 kg was recorded in 2000-01 (Anon., 2000). 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.

In Maharashtra turmeric is grown under 6,191 ha having production 38,202 tonnes during 2000 - 2001. Vidarbha contributed 11,147 metric tonnes. In Maharashtra turmeric is mainly grown in Satara, Sangli, Kolhapur, Pune, Parbhani, Nanded, Wardha, Chandrapur, Nagpur, Amravati, Yawatmal and Akola districts. In Nagpur district, turmeric is grown on 168 hectares of land and production ranges to 1986.30 tonnes fresh rhizomes. Bhivapur Tehsil alone occupied 140 hectare of lands producing 1680 tonnes of turmeric during 2001-2002. In Nagpur region it is taken as minor crop. (Anon., 2003).

Spiced are low volume, high value and export oriented crops. Spices constitute and important group of horticultural crop and are

defined as vegetable product or mixture free from extraneous matter, used for flavouring, seasoning and imparting aroma in food. It is no wonder that Indian spices are a preferred choice by the consumer world over due to their price economy, high quality and grade specification.

India is known as the home of spices. 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 capita per annum consumption of spices in India was estimated to be nearly 2.639 kg during 1999-2000 and it was found double as compared to per capital consumption of 1.448 kg in U.S.A. (Chadha, 2001).

The major quantity of turmeric produced in India is used as a condiment and only a small quantity is used in medicines and cosmetics. Turmeric is best known a seasoning, food preservation and is extensively use in India in Ayurveda and Unani system of medicine. It is known for its versatile role as "recipe' of several common ailments". It is used as dye, drugs, stuff, cosmetics and medicine both externally and internally.

It is a cure for blood; urinary tract, skin diseases, eye infections, poisoning against biliary and antivascular complication, cough, diabetic, wound hepatitis disorders and for healing small pox and chicken pox lesion, used against jaundice and leprosy "complexion promoter of body", brain tonic etc. Besides, turmeric is widely used among Hindus in religious ceremonies. The antioxidant properties of curcumin from turmeric that prevent the entry of cancer virus is well documented (Anon. 2002).

Turmeric largely utilized in most of the Asiatic countries as a food adjunct in vegetable, meat and fish preparations. It is used to flavour and at the same time to colour butter, cheese, margarine, pickles and other food stuffs. It contains 5 to 6 per cent essential oil (volatile oil termerol), which gives the aromatic taste, flavour and also

the preservative quality. Essential oil of turmeric has antimicrobial properties against a set of representative, saprophytic plant and human pathogenic bacteria and fungi (Menon 1975, Banerjee and Nigam 1978).

The type of planting materials used has a direct bearing in yield of the crop. The turmeric is mainly propagated by vegetative means has a high degree of limitation owing to use of corms. Turmeric is mainly propagated vegetatively using corm, halves of corm, primary rhizomes and secondary rhizomes. Desai (1939), and Aiyadurai (1966) reported higher yields in case of mother rhizomes than that of the finger rhizomes. Philip (1983) reported that the halves of mother rhizomes was found to be the best planting material in turmeric in view of yield of cured produce and curcumin/ha. Patil and Besse (1980), Balashanmugam and Vanagamudi (1988) and Singh and Kar (1991) also observed that the growth and yield of turmeric was significantly superior with bigger sized mother rhizomes over other treatment like half mother rhizomes, fingers and small rhizomes. But the reports of Rao (1979), Anjaneyulu and Krishnamurthy (1979) indicated higher yield from finger rhizomes.

Thus, not much work seem to have been done on turmeric to find out the best planting material as well as superior improved variety for increasing the productivity. The scientific information on package of practices and Improved production technology of turmeric under this region is meager. Therefore, keeping in view, the inadequate information available in literature regarding various genotypes of turmeric, the present investigation in respect of "Effect of planting material on growth, yield and quality of turmeric varieties" have been planned under the following objectives.

1. To identify the best planting material.
2. To screen the variety for high yield and better quality of turmeric.

CHAPTER - II

REVIEW OF LITERATURE

The studies regarding the "Effect of planting material on growth, yield and quality of turmeric varieties" were carried out during 2003-2004. Attempts, therefore, have been made to put forth the review on the following aspects.

2.1 GROWTH PARAMETERS FOR VARIETAL PERFORMANCE AND PLANTING MATERIALS :

2.1.1 Height of plant :

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

2.1.1.1 Varietal performance:

The performance of 19 turmeric cultivars was tested by Philip and Nair (1983) and found that the plant height was highest in Chayapasupa (41.1 cm) closely followed by Nandyal (40.2), Kuchipudi (39.8 cm) and Armoor (39.7 cm). Philip (1983) tested 32 promising types of turmeric germplasm. Plant height was highest in Chayapasupa (41.0 cm) closely followed by Amrutapani Kothapeta (40.05 cm) and lowest in NBPGR/T-17 (21 cm). Jalgaokar *et al.*, (1988) tested 10 cultures and indicated that Alleppey, Sugandham, Tekurpet and Salem were the taller plants (100-107 cm).

Radhakrishnan *et al.*, (1995) compared 6 turmeric cultivars out of which BSR-1 was the tallest (48.25cm) while, Sudarshana recorded the lowest height (24.82 cm). The performance of 12 *Curcuma longa* cultivars were investigated in Southern dry region of Karnataka resulted that Bangalore Local can grow upto 45 cm height (Hegde *et al.*, 1997). Thankamani *et al.*, (1998) evaluated four

turmeric cultivars in laterite soil at Calicut, Kerala and revealed that plant height increases in all cultivars up to 180 DAP. Alleppey produced the tallest plant followed by Suvarna, Suguna and Sudarshan. In 20 years old coconut plantation, Hegde *et al.*, (1998) tested 12 turmeric cultivars in which Cuddapahw as the tallest plant (57.27 cm).

The evaluation of 11 turmeric germplasm in West Bengal by Datta *et al.*, (2001) indicated highest plant height of Kasturi. Jana and Bhattacharya (2001) studied 22 turmeric cultivars in Terai, West Bengal and concluded that plant height was maximum in PTS-19 (160.13 cm), followed by Suroma (156.11 cm) and Duggirala (155.96 cm).

Meshram (2002) screened eight genotypes of turmeric and observed that the plants of Krishna were taller and it was followed by Alleppey, Waigaon and Pratibha. Suvarna classified as medium stature. However, Sudarshan was dwarf followed by Pratibha. Kadu (2003) studied the effect of planting material on eight genotypes of turmeric and found that cultivars Krishna, Waigaon and Alleppey identified as tall whereas, Sudarshan and Sugana had dwarf stature.

2.1.1.2 Planting materials :

Philip (1983_a) carried experiment on different plating materials in Kerala and observed no significant influence in plant height. The height of turmeric plant produced by whole mother rhizomes (25-34 g) was 37.51 cm, halves of mother rhizomes (13-17 g) was 33.11 cm and that of finger rhizomes (15-20 g) was 35.55 cm. Barholia *et al.*, (1992) planted daughter rhizomes and mother rhizomes of local cultivars of *Curcuma longa* on 16 April, 16 May or 16 June and obtained the greatest plant height (100 cm) from mother rhizomes planted on 16 May than that of daughter rhizomes.

Investigation on growth and yield of turmeric as affected by various types and weights of seed rhizomes at the spacing 75 x 30 sq. cm was conducted at Thailand by Ong art Hanchanlert *et al.,* (1996) and found the maximum (141.17 cm) plant height in whole rhizomes followed by the primary rhizomes. Yothasiri *et al.,* (1997) conducted experiment on effects of types and size of seed rhizomes on growth and yield of *C. longa* at Thailand and produced the most rapid growth and development of plants when whole mother rhizomes was used. The primary, secondary and tertiary rhizomes with 3-4 internodes did not differ from one another in terms of growth.

Studies conducted in Karnataka, on the best planting material indicated that the mother rhizomes recorded highest plant height than the fingers (Meenakshi *et al.,* 2001). Kadu (2003) measured the maximum vegetative growth from mother rhizomes than finger rhizomes in turmeric.

2.1.2 Number of leaves :

Leaves play an important role of photosynthesis and take part in the growth of plant. The leaves can be viewed in photosynthetic terms as autonomous organs, which are themselves physically robust but still offer a well buffered aqueous medium for the delicate operation of chloroplast. These organells are provided with energy and raw materials within the limits set by environmental conditions and subject to regulation by internal feedback. Adaptations in leaf morphology, plus physiological specialization within their photosynthetic tissue, favour light interception and CO_2 at absorption with close control over evaporative losses. The leaves at 180 DAP emerged as an important component of rhizomes yield in turmeric.

2.1.2.1 Varietal performance :

Testing 19 cultivars of turmeric in Kerala by Philip and Nair (1983) and obtained maximum number of leaves (20.7) in Mannuty Local whereas, 'Aromatica' type produced less number of leaves per plant. In other experiment Philip (1983) assessed 32 types of *curcurma longa* and revealed that 'NBPGR/T6' recorded maximum number of leaves per plant (21.0) and Dingrigam minimum number of leaves (13.4). Ramakrishna *et al.,* (1995) reported the significant variation among the cultivars for number of leaves per plant and PCT had more leaves (10.33).

Banglore Local had the highest number of leaves (28.33) as reported by Hegde *et al.,* (1997) in Southern dry region of Karnataka. Hazra *et al.,* (2000) observed that only the leaves per clump at 180 DAP emerged as an important rhizomes yield component of turmeric.

Datta *et al.,* (2001) recorded in Roma variety of turmeric the highest leaves per plant. Kadu (2003) observed more number of leaves in Krishna followed by Waigaon and Alleppey while, Suguna produced minimum number of leaves per plant.

2.1.2.2 Planting materials :

Philip (1983_a) concluded that mother rhizomes (25-34 g) produced 16.94 leaves/plant, halves of mother rhizomes (13-17 g) 17.01 and finger rhizomes (15.20 g) 16.96 leaves per plant. The experiment on daughter rhizomes and mother rhizomes of local cultivars of turmeric at different planting dates was conducted by Barholia *et al.,* (1992) and found to get more number of leaves per plant (13.12/plant) by mother rhizomes than daughter rhizomes (10.95/plant) with later planting date. The number of leaves for mother rhizomes was greater than the fingers had also noticed by Meenakshi *et al.,* (2001).

2.1.3 Leaf length and breadth:

In turmeric the leaves are long and borne in a turf. They are thin and light fresh in color, lanceolate, acuminate, with a long leaf stalk. The length and breath of leaf varies with the cultivars. The petiole length, leaf length, leaf breadth and leaf area index (L x b) were found to be positively correlated with the yield. Higher petiole length will definitely be helpful for better exposure of the leaf to the sun. The other factors directly increase the photosynthetic area and thereby increase the rate of photosynthesis, which account for higher yield.

2.1.3.1 Varietal performance:

Spectacular length of leaf was noticed in cultivar Chayapasupa (68.5 cm) and Armoor C11-324 had the smallest leaves with minimum length (50-2 cm) and breadth (13.9 cm). However Amruthapani Kothapeta C11-317 produced largest leaves with maximum breadth at centre (17.2 cm) (Philip and Nair, 1983). In another experiment Philip (1983) noted maximum leaf length (61.90 cm) in cv. Chayapasupa.

Cultivar BSR-1 was significantly superior with length and breadth of leaf (Radhakrishnan *et al.*, 1995). Chandra *et al.*, (1999) studied 25 genotypes of *Curcuma longa* and concluded that length and breadth of leaf were significantly and positively associated with fresh rhizomes yield per clump. 11 turmeric germplasm evaluated by Datta *et al.*, (2001) showed that PTS -8 produced highest leaf length and PTS-14 for leaf breadth. Meshram (2002) recorded maximum leaf length and breadth in Waigaon followed by Krishna and Pratibha. The genotypes, Suvarna, Prabha and Suguna had comparatively smaller size of leaf.

2.1.3.2 Planting materials :

The turmeric is extensively cultivated by the use of corms and rhizomes. Planting materials as such has found no significant variations with regards to the growth characters. Although plants resulting from mother rhizomes are vigorous in the take off stage and the growing season with more availability of food material.

Philip (1983_a) measured more length and breath of leaf in accordance to whole mother rhizomes (25-34 g) 49.39 cm and 16.45 cm respectively, as against halves of mother rhizomes (13-17 g) 46.66 cm and 15.50 cm respectively. For finger rhizomes (15-20 g) length and breadth was 48.44 cm and 16.02 cm respectively.

2.1.4 Leaf area :

2.1.4.1 Varietal performance:

The rhizomes yield was significantly and positively correlated with leaf area. Philip and Nair (1983) obtained the greater leaf area (1214.3 cm^2) in Amruthapani Kothapeta whereas, Tekurpeta produced smaller leaf area (860.7cm^2). Similarly in another field experiment Philip (1983) concluded that the Amruthopani Kothopeta had maximum leaf area (973.4 cm^2) whereas, smallest in NBPGR / T17 (547.9 cm^2). 12 cultivars of *Curcuma longa* were investigated by Hegde *et al.*, (1997) and stated that Banglore Local had the highest leaf area Index (LAI) (6.91).

Thankamani *et al.*, (1998) found highest leaf area in Suvarna followed by Alleppey and lowest in Sudarshan. Leaf Area Index (LAI) increases until 5 months after planting and decreased thereafter. In another experiment Hegde *et al.*, (1998) proved that ACCN-10/8 had the highest LAI (6.15). Meshram (2002) computed the maximum leaf area in Waigaon followed by Krishna and lowest in Pratibha.

2.1.4.2 Planting materials :

Philip (1983) found no significant variation among the planting materials with regard to the growth character; nevertheless maximum leaf area (568.5 cm^2) was produced by mother rhizomes (25-34 g) followed by halves of mother rhizomes (13-17 g) 544.5 cm^2 and than finger rhizomes (542.0 cm^2).

2.1.5 Number of tillers:

Consistent variation in morphological trials was not observed among the turmeric germplasm. Planting material also did not have much effect on growth and vigour of plant. The variation among the turmeric types with regard to tillers per plant and rhizomes yield was positively or negatively correlated with number of tillers per plant.

2.1.5.1 Varietal Performances:

Philip and Nair (1983) observed more number of tillers per plant varied from 3.7 in Mannuty Local to 2.0 in Dindrigam. Patil *et al.,* (1995) reported in Suvarna (PCT-8) the greatest number of tillers per plant, but it was inferior to other varieties for other growth traits. Where as, Radhakrishnan *et al.,* (1995) counted in CO-1 and BSR-1 the highest number of tillers. Hegde *et al.,* (1997) produced the highest number of tillers (7/clump) in BSR-1. Similar result were also recorded in another experiment by Hegde *et al.* (1998) where in BSR-1 possessed the greatest number of tillers (4.47/clump) in Karnataka under coconut cropping system. Datta *et al.,* (2001) reported the highest values for number of tillers in Roma. Meshram (2002) found that variety Krishna and Waigaon had more tillers per plant. Whereas, less tillers were noted in Suguna and Sudarshan.

2.1.5.2 Planting materials :

Philip (1983_a) obtained changed variation, the maximum

number of tillers in mother rhizomes and halves of mother rhizomes (3.29/plant) and minimum in fingers rhizomes (3.24/plant). Barholia *et al.,* (1992) concluded that mother rhizomes gave significantly more number of tillers (2.62/plant) as compared to daughter rhizomes. Meenakshi *et al.,* (2001) reported that mother rhizomes produced higher number of tillers compared to finger. Kadu (2003) recorded maximum number of tiller in mother rhizomes while, finger rhizomes showed minimum number of tiller per plant.

2.1.6 Number of leaves per tiller:

2.1.6.1 Varietal Performances :

Philip and Nair (1983) produced 6.9 and 4.3 leaves per tillers in G. L. Puram-II, Armoor and C11-324 respectively. The highest leaves/tillers in 'NBPGR/T6' (7.60) and lowest number leaves/tillers in Mannuthy Local (5.60) was recorded by Philip (1983). The genotypes Krishna and Waigaon had more number of tillers and leaves per tiller reported by Kadu (2003).

2.1.6.2 Planting materials :

Number of leaves/tillers was greater in case of fingers and halves of mother rhizomes as compared to the mother rhizomes, which showed non-significant variations (Philip, 1983_a).

2.1.7 Maturity/Duration of crop:

Maturity means gradual transition of morphology, growth rate and flowering capacity. There are variations with respect to crop duration among the different cultivars some varieties took relatively less number of days for maturity (7 months) and they are grouped as early types. The medium, duration types matured within 8 months. Whereas, cultivars required 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). Performance of 12 cultivars in Southern dry region of Karnataka tested by Hegde *et al.,* (1997) revealed that PCT-13, PCT-5, PCT-14, and PCT-8 found to be early duration types (193-208 days). Whereas, Amalapuran, BSR-1, Cuddapah, Rajapuri, Sangli, Bidar-1 Bidra-4, PCT-8 PCT-14 and ACCN 10/8 had a medium cycle duration (230-244 days) and PCT 13, PCT-5 had a short duration (203-207 days) showed by Hegde *et al.,* (1998) under coconut cropping system in Karnataka. Meshram (2002) classified variety Suguna and Sudarshan as early types. Waigaon and Pratibha was found medium. Whereas cultivars like Krishna and Alleppey were grouped under late duration types.

2.2 YIELD CHARACTERS FOR VARIETAL PERFORMANCE AND PLANTING MATERIALS:

2.2.1 Harvesting of crop :

Philip *et al.,* (1982) harvested turmeric 270 DAP and obtained the maximum yield of rhizomes, oleoresin and curcumin per unit area.

2.2.2 Yield of mother rhizomes and fingers :

The finger per mother rhizomes ratio showed highly variation among the turmeric types. The source and sink relationship in plant is an important in increasing finger/mother rhizome ratio. Translocation and mobilization of assimilates and nutrients from source are more in mother rhizomes from where they are further translocated and accumulated in fingers thereby helping in increasing finger/mother rhizome ratio. A higher finger/mother rhizomes ratio indicates higher percentage recovery of finger rhizomes, which constitutes the marketable produce in turmeric.

2.2.2.1 Varietal Performance:

Philip and Nair (1983) obtained more number of secondary fingers per plant in Mannuthy Local (20.9), Chayapasupa and Armoor (19.8 each) whereas, cultivar Armoor C LL-324 (7.9) and G. L. Puram-1 (8.3) produced less number of secondary fingers per plant. Philip (1983) recorded the maximum finger/mother ratio i.e. 4.88 and 3.97 cultivar ST-17 and Dindrigam respectively. Jana and Bhattacharya (2001) noted the maximum length and width of rhizomes clump from Sugandham (21.16 cm) and PCT-14 (13.92 cm), respectively. Datta *et al.,* (2001) produced the highest number of mother rhizomes primary and secondary fingers in Roma, whereas, Kasturi and PTS-62 recorded the highest number of mother rhizomes, primary and secondary fingers respectively.

2.2.2.2 Planting materials :

Philip (1983_a) computed the maximum finger/mother rhizome ratio (1.82) from whole mother rhizomes and it was significantly superior to halves of mother rhizomes but fingers rhizomes were on par with halves of mother rhizomes

2.2.2.3 Yield of fresh turmeric :

The yield of fresh turmeric varies highly with cultivars. Yield variations among the cultivars could be attributed to genetic characters of the cultivars beside their response to particular agro climatic conditions. Planting materials have also found significant effect on fresh yield of turmeric. Mother rhizomes helps in early establishment, root development and better utilization of stored food materials and have stronger source and sink relationship which ultimately help increasing fresh yield of turmeric.

2.2.3.1 Varietal Performance :

Philip (1983) in a trial on 32 promising types of turmeric, 'Armoor' types had maximum fresh yield (29.34 t/ha) and lowest in NBPGR T-17 (14.27 t/ha). Pushkaran *et al.,* (1985) produced in cultivar Amruthapani Kothapetta (A) 72 gave the highest total yield (17.36 t/ha) and the cultivar Ventimetta the lowest (4.78t/ha). Krishna gave the highest fresh rhizomes yield (427.27 q/ha) followed by the cultivar Duggierals with 329.22 q/ha of fresh yield as reported by Pujari *et al.* (1987). The yield of fresh rhizomes was highest with Krishna (53.86 t/ha) followed by Duhgi (43.65 t/ha), (Jalgaokar *et al.,* 1988).

Evaluation of fourteen genotypes in Orissa by Nandi (1990) indicated that the varieties PTS 25 gave the highest yield of fresh rhizomes (27.5 tonnes/ha and 480 g yield/plant) followed by CLS.9 24.6 t and 430 g, respectively. Indiresh *et al.,* (1990) evaluated fifteen cultivars of turmeric and recorded the highest fresh rhizome yield for PCT 8 followed by Waigaon (32.3 and 31.6 t/ha, respectively). Maurya (1990) during a trial with 10 lines, RH-10 was found superior with regard to fresh rhizomes yield (41.98 t/ha) of turmeric. Sheshagiri and Uthaiah (1994) produced the greatest fresh turmeric yield with BSR-1 (16.57 t/ha) followed by Waigaon (15.45 t/ha). Shahi *et al.,* (1994) collected forty genotypes of turmeric from different parts of India and identified the CLL – 326 cultivar as high yielding genotypes with wide adaptability and stability.

Six turmeric cultivars were compared by Radhakrishnan *et al.,* (1995) and showed that cultivar C0-1 produced the highest yield of fresh turmeric (16-54 t/ha), followed by BSR-1 (14.74 t/ha). Patil *et al.,* (1995) obtained the greatest yield (20.88 t/ha fresh rhizomes) in BSR-1 followed by Suvarna (19.32 t/ha) and Suroma (19.04 t/ha). Ramakrishna *et al.,* (1995) obtained in PCT 13 the greatest yield of (19.15 t/ha). Hegde *et al.,* (1997) reported the highest fresh yield

(44.88 t/ha) with the Banglore Local followed by PCT8 (12.76 t/ha) and Sangli (15.2 t/ha).

BSR-1 recorded the highest fresh rhizomes yield (31.43 t/ha) followed by CO-1 (30.44 t/ha) and Cuddapah (25.90 t/ha) and lowest yield was recorded in Suvarna (14.49 t/ha) (Gangadharappa *et al.,* 1997). Eighteen new genotypes of turmeric and two standard varieties were evaluated by Nirmal and Yamgar (1998) and identified CLS-19, CLI-320 and CLI-324 as promising varieties. Sadanandan *et al.,* (1998) obtained the rhizome yield highest in cultivar Alleppey followed by cultivars Sudarshan, Suguna and Suvarna. Hegde *et al.,* (1998) in ACCN 1018, produced the greatest fresh rhizomes yield (34.16 t/ha), followed by Rajapuri (31.76 t/ha) and Cuddapah (29.87 t/ha). Naidu *et al.,* (2000) evaluated seven turmeric cultivars in three crop season in A.P and concluded that BSR-1 exhibited maximum productivity of fresh rhizomes respectively followed by PTS-62.

Jana and Bhattacharya (2001) recorded highest fresh rhizomes yield from Sugandham (28.83 t/ha), followed by Kasturi (27.64 t/ha) and PCT -13 (25.98 t/ha). Datta *et al.,* (2001) produced in Kasturi the highest yield (54.68 t/ha) followed by PTS-62 (49.58 t/ha), Armoor (46.47 t/ha) and PTS-8 (44.48 t/ha). Meshram (2002) obtained more fresh yield of turmeric per plant in Krishna followed by Waigaon while Sudarshan recorded lower yield of fresh turmeric.

2.2.3.2 Planting materials:

Philip (1983_a) planted whole mother rhizomes and recorded maximum yield/plot (14.92 kg) and it was significantly superior to that of finger and halves, which were on par with each other. Tayde and Deshmukh (1986) produced the highest yield of turmeric (30.67 t/ha) from the mother rhizomes than that of secondary rhizomes and

fingers. Chattopadhyay *et al.,* (1990) recorded the highest total yield (17.16 t/ha) with the heaviest fingers compared with (24.16t/ha) the heaviest rhizomes. The full mother rhizomes produced the highest yield/ha (29.93 t) followed by half mother rhizomes and fingers in their descending order of weight evaluated by Singh and Kar (1991). Barholia *et al.,* (1992) obtained the highest yield by planting on 16 May (151.58 and 204.07 q/ha) for daughter and mother rhizomes respectively. Turmeric cultivars Sindhuri and Dimla grown from corms or primary or secondary corms and concluded that fresh yield were highest 28.67 t/ha from corms and lowest 19.43 t/ha from secondary cormels (Rashid *et al.,* 1996).

The use of the whole mother rhizomes 15 to 30 g as planting material gave highest yield, per clump of total rhizomes 652.49 g and the yield was reduced with the decreased weight of seed rhizomes as evaluated by Ong art Hanchanlert (1996). Yothasiri *et al.,* (1997) harvested the yield per unit area highest from the whole mother rhizomes (566.4 kg/ha) followed by the primary rhizomes with 5-6 internodes (454.56 kg/ha) and half-cut mother rhizomes (454.4 Kg/ha). Singh *et al.,* (1988) obtained higher mean yields from mother rhizomes (41.01q/ha) than from daughter rhizomes (30.07 q/ha). Meenakshi *et al.,* (2001) produced the highest yield (13.64 t/ha) in mother rhizomes than that of fingers. Kadu (2003) obtained higher fresh turmeric yield from mother rhizomes than from finger rhizomes.

2.2.4 Yield of cured turmeric and curing percentage:

The commercial product is the cured turmeric. The out turn of cured produce is of vital importance. The turmeric types should be judged for their production capacities more on the net out turn of the cured produce rather than on the gross yield of raw material. 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.

2.2.4.1 Varietal Performance:

The driage percentage ranged from the lowest 14.85 (Amrutapani Kotahapeta) to the highest of 31.55 (Dindrigam) (Philip, 1983). Pujari *et al.,* (1987) reported in trials with eight *curcuma longa* cultivars, that Krishna gave the highest yield of cured produce (70.11 q/ha) followed by the cultivar Duggierals with 60.25 q/ha cured produce.

Reddy *et al.,* (1989) assessed twelve and thirteen 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). Maurya (1990) in a trial with 10 line, variety Dholi Local and RH-10 found to produce superior with regard to dry rhizomes yield (7.53 t/ha). Indiresh *et al.,* (1990) evaluated fifteen cultivars at Brahmavar and reported that PCT-8, Waigaon and Kasturi gave the highest cured turmeric yields (6.48, 6.21 and 4.81 t/ha respectively).

Nine local types of turmeric were compared with popular Indian cultivar Sugandham in Kerala. All the local types gave the higher raw and cured rhizomes yields than Sugandham (Kurian and Valsala, 1995). Hoque (1995) compared two newly released turmeric cultivars Dimla and Sindhuri with local cultivars and found in Dimla the highest yield of dry turmeric but Sinduri gave the highest net returns. Ramakrishna *et al.,* (1995) screened eighteen turmeric lines and reported high curing percentage in Ca 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 produced the highest yield of cured rhizomes (9.72 t/ha), followed by Sangli and PCT-8 (8.32 t/ha

and 8.3 t/ha respectively) PCT-5 had highest curing percentage (26.4%).

Thankamani *et al.,* (1998) evaluated four turmeric cultivars and reported that rhizomes dry weight per hectare were highest with Suguna and Sudarshan. Hegde *et al.,* (1998) produced in ACCN 10/8 the greatest cured rhizomes yield (7.32 t/ha) followed by Rajapuri (5.36 t/ha) and Cuddapah (5.0 t/ha). Meshram (2002) reported the highest cured turmeric per hectare from Krishna (68.10 q) and it was closely followed by Waigaon (65.07 q). Varieties Suguna and Sudarshan produced considerably less quantity of cured turmeric.

2.2.4.2 Planting materials :

Philip (1983_a) concluded that the yield of cured produced (5517 kg/ha) was highest with whole mother rhizomes weighing 25-34 g than the halves and primary fingers. The full mother rhizomes produced the highest cured weight/plant (116.0 g), followed by half mother rhizomes and fingers in their descending order of weight as concluded by Singh and Kar (1991). Meenakshi *et al.,* (2001) reported that planting of mother rhizomes produce the highest curing percentage (21.14%) and cured rhizome yield (2.19 t/ha) as compared with finger rhizomes. Kadu (2003) had produced highest yield per hectare of cured turmeric from mother rhizomes as compared to finger rhizomes.

2.2.5 Curcumin percentage :

The principal colouring constituent imparting characteristic yellow colour to turmeric is curcumin. This is an active ingredient having numerous important pharmacological properties, viz. anti-inflammatory, anti-allergic, wound healing, anti-spasmodic, hepatoprotective, anti-bacterial, anti-fungal, anti-tumour and anti-thrombotic. Quality, demand and premium price of turmeric in the

market can be determined on the basis of curcumin content. The variation in curcumin content among the cultivars can be attributed the genetic character of the cultivars.

2.2.5.1 Varietal Performance :

Krishnamurthy *et al.*(1975), screened 22 cultivars of turmeric and reported that the values of curcumin varied from 1.2% to 4.97% according to locality, season and cultivars. Philip (1983) assessed 32 types of *curcuma longa* for quality component and Mannuthy Local synthesized the maximum curcumin content (7.58%) followed by Duggirala C11-325, (7.30%). In a trial with 10 lines and Dholi Local, RH-10 was found to be superior with regard to curcumin content (8.4%) as reported by Maurya (1990). Kurian and Valsala (1995) evaluated nine types of cultivars and concluded that Sugandhan had higher curcumin than local types. Radhakrishnan *et al.*, (1995) compared six turmeric cultivars and found that BSR-1 has highest curcumin content (4.1%) after drying. The highest curcumin content (8.08%) in PCT-8 rhizomes was observed by Hedge *et al.*, (1997). Sadanandan *et al.*, (1998) reported that curcumin yields was highest in cultivar Alleppey followed by cultivars Sudarshan, Suguna and Suvarna. Cultivar PCT-8 had the highest curcumin content (8.13%) (Hegde *et al.*, 1998). Chandra *et al.*, (1999) studied 25 genotypes in which Lakadong gave poor yields but had the highest curcumin (7.33%). Poduval *et al.*, (2001) recorded from two cultivars of *Curcuma domestica*, Mohitnagar and G. L. Puram had highest percentage of curcumin 9.36 and 9.31 respectively.

2.2.5.2 Planting materials :

Philip (1983_a) exhibited no significant variations in planting materials. Maximum yield of curcumin per ha (362.5 kg) was obtained in whole mother rhizomes. The average curcumin contents

from mother and finger rhizomes were 5.50 and 6.43% at Chumphon 8.32 and 7.06% at Buri Ram, 7.18 and 7.28% Prachin buri, respectively concluded by Somsook *et al.,* (1990) at Thailand.

Kumar *et al.,* (1992) estimated the highest curcumin content (3.70%) when mother rhizomes of cultivar Duggirala was used for planting, grown in Anantharajupet. The size of propagating material had no effect on the curcumin content of the rhizomes was concluded by Main *et al.,* (1995). The highest curcumin content of 3.13 per cent was observed in mother rhizomes compared to finger rhizomes evaluated by Meenakshi *et al.,* (2001).

CHAPTER - III

MATERIALS AND METHODS

An investigation on "Effect of planting material on growth, yield and quality of turmeric varieties" was carried out at College Garden, College of Agriculture, Nagpur during the year 2003-2004. The trial was laid out in Factorial Randomized Block Design (FRBD) with twenty four treatments replicated thrice. The details of materials used and methods adopted during the course of investigation are given below under different titles and subtitle.

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°10' N latitude and 79° 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 9.8°C and 44.6°C in the month of June 2003 to January 2004 during the growth and development of turmeric in the field. The rainfall received during the year 2003 to 2004 was 1248.9 mm in about 53 rainy days mostly from 1st June 2003 to 31st January 2004. The relative humidity ranges from 87 to 19 per cent.

The weekly meteorological data on various weather parameters recorded at meteorological observatory of College of Agriculture, Nagpur during the year 2002 to 2003 are presented in Appendix -A.

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 No.1 : Chemical composition of soil.

Particulars	Value	Analytical Methods used
pH	8.8	Black man's gas electrode pH meter (Jackson, 1967)
EC	0.35 dSm^{-1}	Electric conductivity meter
Organic carbon	0.56%	Walkely and Black's rapid titration method (Piper, 1966)
Total nitrogen	0.146%	Modified Kjeldahl method (Piper, 1966)
Available phosphorus	4.48 kg ha^{-1}	Olsen's method (Jackson, 1967)
Available potash	269 kg ha^{-1}	Flame photometer (Jackson, 1967)

3.2 EXPERIMENTAL DETAILS :

The trial was laid out in Factorial Randomized Block Design with twenty four 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 : Zingiberaceae

3.2.5 Cultivars : Alleppey
Krishna
Prabha
Pratibha
Sudarshan
Suguna
Suvarna
Waigaon

3.2.6 Year of experiment : 2003-2004

3.2.7 Experimental design : Factorial Randomized Block Design

3.2.8 Number of treatment : 24

3.2.9 Number of replications: 3

3.2.10 Treatment details :

I. Factor A :	
Planting materials	Abbreviations used
a. Halves of mother rhizomes	M_1
b. Primary rhizomes	M_2
c. Secondary rhizomes	M_3
II. Factor B :	
Varieties	Abbreviations used
1. Alleppey	V_1
2. Krishna	V_2
3. Prabha	V_3
4. Pratibha	V_4
5. Sudarshan	V_5
6. Suguna	V_6
7. Suvarna	V_7
8. Waigaon	V_8

3.2.11 Total number of plots : 72

3.2.12 Gross plot size : 1.8 x 1.8 m

3.2.13 Net plot size : 1.2 x 1.2 m

3.2.14 Spacing : 30 x 30 cm

3.2.15 Spacing between two plots : 50 cm

3.2.16 Spacing between two replications: 1.0 m

3.2.17 Date of planting : 29th May 2003

3.2.18 Season : Kharif

3.2.19 Total number of rows per plot : 6

3.2.20 Total number of plants per plot: 36

3.2.21 Type of layout : Ridges and furrows.

3.3 DETAILS OF CULTIVATIONS :

3.3.1 Preparation of field :

The experimental field was prepared by two ploughing and two cross harrowing. 25 tonnes farmyard manure per hectare was incorporated while ploughing. The field was brought to fine tilth and beds were prepared as per plan of layout. Seventy two plots were demarcated on field leaving 50 cm between two plots and 1 m between two replications. The demarcated plots at size 1.8 x 1.8 m was prepared as per plan of layout.

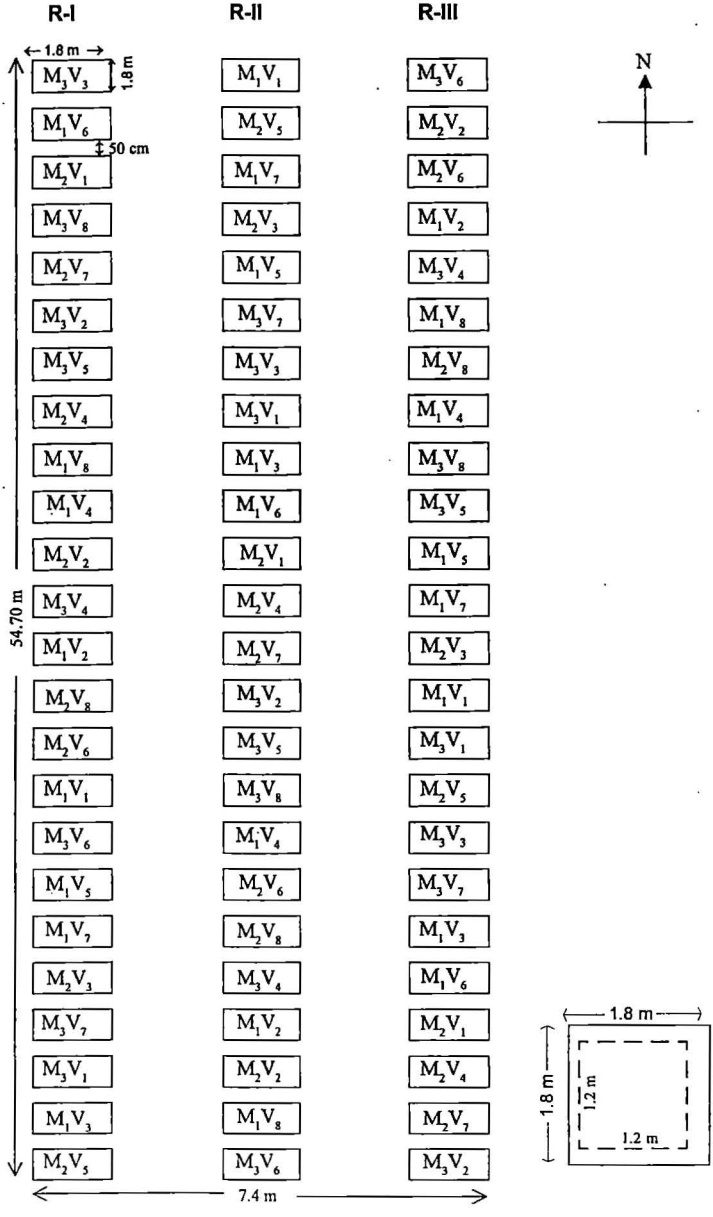
1) Source and preparation of planting material :

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 (NRCS), Calicut in the year 2000. The eight varieties obtained from NRCS, Calicut were multiplied in this college and stored in under ground pits. At the time of planting, the sprouted healthy and disease free mother rhizomes with primary and secondary rhizomes were taken out from the pits. Then mother rhizomes were cut from the middle section to made halves of mother rhizomes. The halves of mother rhizomes, primary rhizomes and secondary rhizomes weighing about 18-22 g respectively were selected and treated with bavistin @ 0.15% for 15 minutes. These rhizomes were planted on 29th May 2003 at 30 cm spacing between rows and 30 cm plant to plant and 7.5 cm deep on the ridges.

2) Cultural operation :

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

Fig. 1 : Plan of Layout



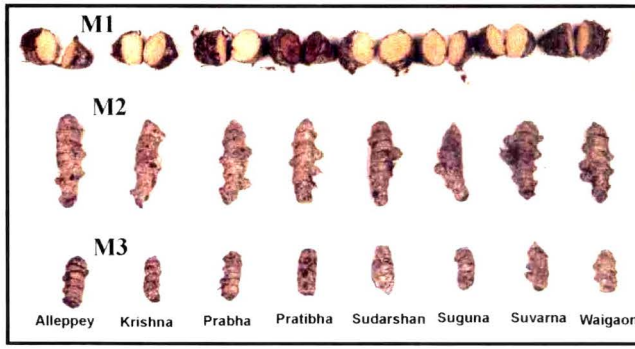


Plate 1 : Planting Materials Used : M1 - Halves of Mother rhizomes M2 - Primary rhizomes, M3 - Secondary rhizomes

Plate 2 : Turmeric Experimental Plot

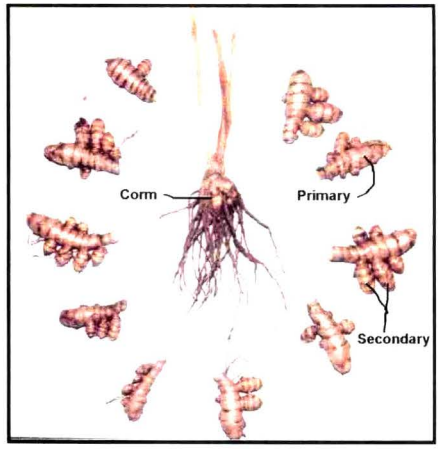


Plate 3 : Mother rhizomes with fingers

i) Fertilizer application :

Chemical fertilizers were applied as per recommendation i.e. 200:100:100 NPK kg per hectare. Half dose of nitrogen and full dose of P_2O_5 and K_2O was applied to the plots after sprouting of rhizomes i.e. 1 month after planting. Remaining half dose of nitrogen was top dressed at 45 days after first application of the fertilizers.

ii) Irrigation :

To keep the plot moist, irrigation was given at an interval of 7 to 8 days during the period of experimentation. First irrigation was given immediately after planting. Frequency of irrigation depends upon the weather condition. Light irrigation 3 to 4 days before harvesting was given to facilitate easy harvesting.

iii) Interculture :

a) **Weeding :** *Cynadon dactylon* and *Cyperus rotundas* weeds were removed in order to keep the plot clean and to have good aeration. In all, five weedings were done.

b) **Earthing up :** After weeding and fertilization earthing up was done to cover the rhizomes and save from exposure to sun and also for better development of rhizomes.

c) **Loosening of soil :** This operation was done with sickle very carefully without damage to rhizomes to maintain proper aeration.

3) 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. Four spray of Dithane M-45 @ 2.5g in one liters of water at

an interval of 15 days during the period of incidence of disease were under taken to control the disease.

4) Harvesting :

Depending upon the cultivars, the crop was ready for harvest in 7-9 months. The maturity was judged when all the leaves were dried and hanging down. Harvesting was done as and when the variety showed the signs of maturity. The rhizomes were dug with digging fork and cleaned out of sand and other extraneous matter adhering to them.

3.4 OBSERVATIONS :

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

3.4.1 Pre-harvest observation :

3.4.1.1 Height of plant (cm) :

The plant at the base of pseudostem 3.00 cm above the ground level was demarcated with paint. The height of the plant was measured with meterscale from the point of demarcation of the pseudostem to the growing tip of leaf on randomly selected five plants of turmeric at an interval of 30 days after planting (DAP) till 180 DAP. In each individual observation, every time 3.00 cm was added and average worked out.

3.4.1.2 Girth of Pseudostem (cm) :

The pseudostem at 3 cm above ground level was demarced on five observation plants with white paint was also used to record the diameter of plant with the help of Vernier Callipers. The diameter

was measured at an interval of 30 DAP. The observations so recorded were averaged at each of the intervals.

3.4.1.3 Number of leaves per plant :

The leaves on five observational plants were counted at an interval of 30 days till 180 DAP and mean values were calculated.

3.4.1.4 Length of leaf (cm) :

Leaf length was measured with scale in cm along the midrib initiated from the petiole to the leaf tip under each treatment at an interval of 30 days till 180 DAP 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, at an internal of 30 days till 180 DAP under each treatment and averages were worked out.

3.4.1.6 Leaf area (cm^2) :

The leaf area was measured by leaf area meter. Leaves selected for length and breadth were subjected for this observation. Since the leaves were larger than the size of mask plate of calculating machine, they were cut into small pieces and arranged on mask plate of 200 cm^2 opening area. Depending upon the size, the individual cut pieces of the plant was arranged twice or thrice. The digital reading of each observations of the leaf was summed up resulted into total area of leaf. Thus, the reading of five leaf samples were taken and averages worked out.

3.4.1.7 Number of tillers per plant :

Tillers were emerged after 80 to 90 days onwards from planting

were counted from the observational plants with an interval of 30 days.

3.4.1.8 Number of leaves per tiller :

The leaves borne on each tiller of the plant were counted at an interval of 30 days and averages worked out.

3.4.1.9 Number of days required for maturity :

Turmeric crop is said to be matured and ready to harvest when the leaves turned yellow and started drying. All the leaves dried and hanging down and at last the plants completely collapse on the ground. Days from planting till maturity were counted under each treatment.

3.4.2 Post-harvest observation :

Turmeric crop became ready for harvesting from 7 to 9 months after planting depending upon the variety. During harvesting the rhizomes were lifted carefully with a digging fork and clean out mud and extraneous matter adhering to them. The rhizomes form observation plants were selected from each treatment for recording the 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 cleaned and their numbers counted after harvest of crop. Average numbers of fingers per plant were worked out.

3.4.2.2 Length of fingers (cm) :

From the clump of observational plants five fingers were selected and length of fingers were measured in centimeter and

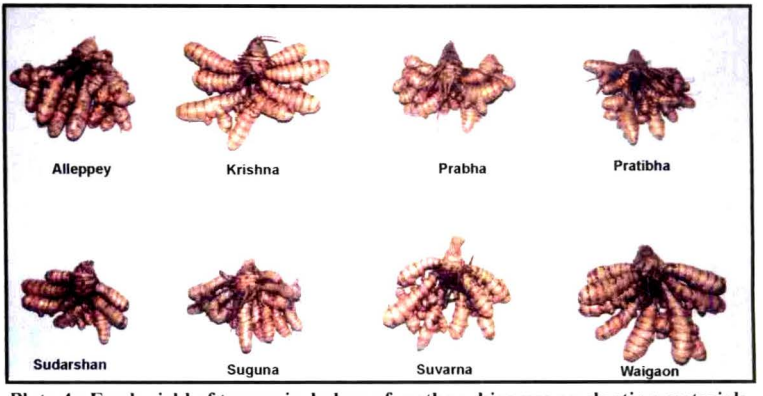


Plate 4 : Fresh yield of turmeric, halves of mother rhizomes as planting materials

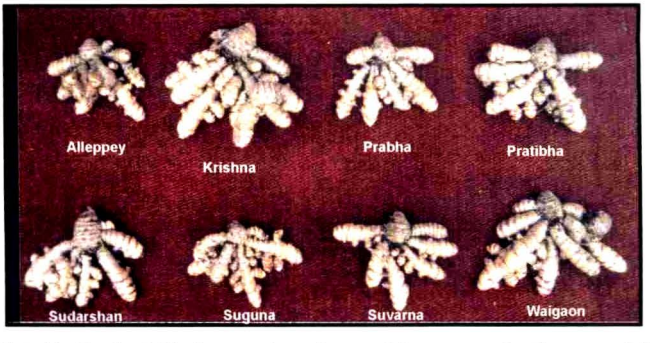


Plate 5 : Fresh yield of turmeric, primary rhizomes as planting materials

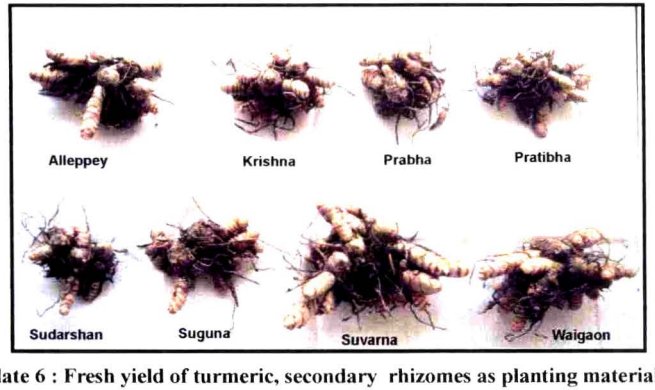


Plate 6 : Fresh yield of turmeric, secondary rhizomes as planting materials

average of five fingers was recorded.

3.4.2.3 Diameter of fingers (cm) :

The fingers selected for measurement of length were also used to record the diameter of finger. At the center portion of the finger the diameter was measured with the help of Vernier Callipers and the averages were worked out.

3.4.2.4 Yield of fresh turmeric per plant (g) :

The turmeric crop after full maturity was harvested following the standard method. After the crop was harvested, the fresh weight of rhizome was recorded on spring balance from observational five plants under each treatment and averages were worked out per plant.

3.4.2.5 Yield of fresh turmeric per hectare (q) :

After harvest of crop, the fresh rhizomes were separated and weighed from the plot under each treatment and mean yield per plot was calculated. The average yield of fresh turmeric per hectare in quintal under each treatment was computed for the plot yield.

3.4.2.6 Weight of cured turmeric/curing per cent :

Fresh rhizomes from each treatment were randomly selected for post harvest curing of 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 kept in sun for 10-15 days until they become dry and hard. The composite sample of 200 g fresh turmeric per treatment was subject for weight of cured turmeric.

3.4.2.7 Yield of cured turmeric per hectare (q) :

On the basis of average cured weight of rhizomes obtained per 200 g fresh turmeric under each treatment the yield of cured

turmeric per hectare in quintals was calculated.

3.4.2.8 Curcumin percentage :

After curing and polishing of 200 g turmeric samples of each treatment powder is prepared. The estimation of curcumin percentage of cured turmeric powder was carried out by solvent extraction and spectrophotometer measurement method (Anon., 1984).

Calculations :

Absorbance of standard curcumin solutions. 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 design adopted for the experiment was Factorial Randomized Block Design (FRBD) and standard Method of analysis known as "Analysis of variance" was applied for statistical analysis (Panse and Sukhatme 1985). The data was analysed by computer software at College of Agriculture, Nagpur.

CHAPTER - IV

FINDINGS AND DISCUSSION

The results pertaining to present investigation entitled "Effect of planting material on growth, yield and quality of turmeric varieties" was undertaken at College garden, College of Agriculture, Nagpur during 2003-2004 are presented in this chapter, under suitable headings.

4.1 Pre-harvest observations :

4.1.1 Effect of Planting materials and varieties on height of plant :

The data related to mean height of the plant affected by different treatments and recorded at 30, 60, 90, 120, 150 and 180 DAP of turmeric by each treatment are presented in table-1.

A perusal of the table-1 indicated that the height of the plant was increased with successive stages of growth. The rate of increment in plant height was extremely slow between 30 and 60 days, whereas,, it was accelerated between 90 and 120 days as grand growth and again slowed during advance stages. i.e. 150 and 180 days (Fig.2).

Regarding the effect of planting materials, the differences in plant height of turmeric, planting materials, viz. halves of mother rhizomes (M_1), primary rhizomes (M_2) and secondary rhizomes (M_3) recorded during 30, 60, 90, 120 and 150 days were found significant. However, the height of turmeric plant at 180 DAP was found non-significant.

The height of the plant produced by the halves of mother rhizomes (M_1) was significantly more (13.41, 26.59, 46.97, 72.92, 85.56 cm respectively) than that of primary rhizomes (M_2) and secondary rhizomes (M_3). Secondary rhizomes (M_3) recorded significantly less height (12.20, 22.95, 41.68, 65.51, 79.62 cm respectively) except at 180 days.

Table 1 : Average height of plant (cm).

Treatments	Abbr.	Mean height of plant (cm)					
		30 days	60 days	90 days	120 days	150 days	180 days
Planting Materials							
Halves of mother rhizomes	M_1	13.41	26.59	46.97	72.92	85.56	93.05
Primary rhizomes	M_2	12.61	23.51	42.18	67.13	80.49	91.14
Secondary rhizomes	M_3	12.20	22.95	41.68	65.51	79.62	90.58
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	N.S.
SE m (±)		0.26	0.73	1.09	1.72	1.67	1.87
CD at 5%		0.76	2.09	3.14	5.07	4.91	-
Varieties							
Alleppey	V_1	10.27	24.90	44.81	71.00	85.80	97.94
Krishna	V_2	13.63	24.48	48.92	75.24	90.51	99.63
Prabha	V_3	11.54	20.76	44.48	68.98	77.69	87.65
Pratibha	V_4	13.09	28.87	43.17	66.47	80.17	89.39
Sudarshan	V_5	15.44	22.51	39.34	64.13	76.88	85.07
Suguna	V_6	14.10	26.68	42.12	66.79	78.00	87.96
Suvarna	V_7	12.82	24.20	42.70	65.34	81.18	89.31
Waigaon	V_8	11.07	22.40	43.40	70.25	84.91	95.77
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m (±)		0.46	1.19	1.87	3.12	3.06	3.41
CD at 5%		1.33	3.42	5.49	9.14	8.93	10.14
Interaction							
'F' test		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SE m (±)		0.80	2.07	3.10	4.97	4.81	5.31
CD at 5%		-	-	-	-	-	-
GM		12.74	24.35	43.61	68.52	81.89	91.59

Analysis of data in table-1 at 180 DAP showed the non-significant differences and the turmeric plant from the halves of mother rhizomes possessed the maximum height (93.05 cm) followed by primary rhizomes (91.14 cm) and secondary rhizomes (90.58 cm).

Comparative study on the relative performance of corm either full or half with fingers of constant weight would clearly suggest that the merit of corm undoubtedly excelled the performance of fingers of both types. It is also discernible that weight of planting materials has profound effect on the productivity. Such a difference in the performance of planting materials i.e. Halves of mother rhizomes, primary rhizomes and secondary rhizomes can be sought from source and sink relationship in plant. Halves of mother rhizome constitutes a stronger sink than primary and secondary rhizomes.

The sigmoid growth curve typifies the pattern of whole plant growth and its constituent parts, including volume, leaf area, height etc. The pattern of growth over a generation is typically characterised by a growth function referred to as the sigmoid curve. The linear phase of the curve is representative of crop growth in turmeric plant and is of greatest interest, which expresses crop yield.

Thus, maximum height of turmeric plant was produced by halves of mother rhizomes than that of primary and secondary rhizomes. The growth rate of stem in height of plant quickly increased after sprouting and reached its peak at 5 months after planting and decreased afterwards. The results are comparatively similar with that of Philip (1983_a), observed no significant influence in plant height, whereas,, the height of plant produce by whole mother rhizomes (25-34 g) was 37.51 cm, halves of mother rhizomes (13-17 g) was 35.11 cm and that of finger rhizomes (15-20 g) was 35.55 cm. Ong art Hanchanlert *et al.* (1996) found maximum plant height (141.17 cm) in whole mother rhizomes followed by primary rhizomes. Yothasiry *et al.* (1997) and Meenakshi *et al.* (2001).

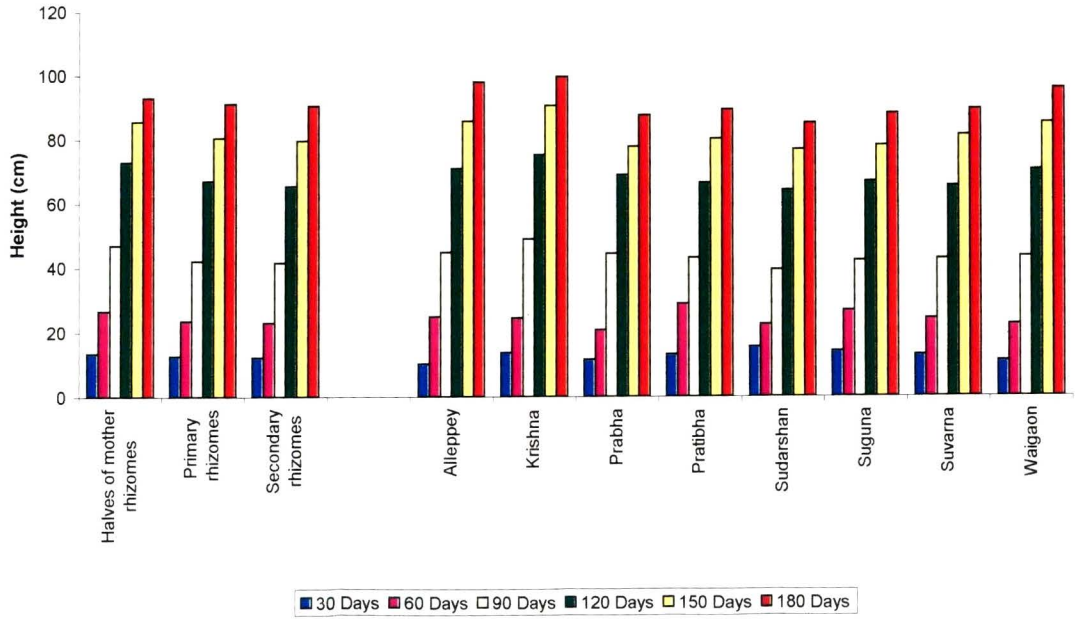


Fig.2. Height of Plant (cm)

As regards, the influence of varieties, the analysis of variance in respect of height of plant exhibited (Table-1) significant differences in all the stages i.e. 30, 60, 90, 120, 150 and 180 days of observation. Variety Krishna possessed significantly more height in all the intervals except at 30 and 60 days, whereas, Pratibha had more height at 60 days, which was significantly more than rest of the varieties. The variety Sudarshan was found significantly inferior in almost all the intervals except at 30 and 60 DAP.

Analysis of data in table-1 at 180 DAP revealed that significantly maximum height was achieved by the Krishna followed by Alleppey and Waigaon. These treatments were superior over rest of the other five varieties. Varieties Pratibha, Suvarna, Suguna, Prabha and Sudarshan were found at par.

Three varieties viz., Krishna, Alleppey and Waigaon attained the height 99.63 cm, 97.94 cm and 95.77 cm respectively. These values were higher than the general mean (91.59 cm) at 180 days. Whereas, varieties Pratibha, Suvarna, Suguna, Prabha and Sudarshan possessed 89.39 cm. 89.31 cm, 87.96 cm, 87.65 cm and 85.07 cm respectively which was lower than general mean (91.59 cm) at 180 days.

No regular sequence in average height of varieties was noticed during the various intervals of observation. The estimates ranged from 99.63 cm to 85.07 cm for Krishna and Sudarshan varieties respectively at 180 DAP.

Thus, in this investigation, variety Krishna followed by Alleppey produced the tallest plant (99.63 cm). The increase in height of the aerial shoot may be helpful for better exposure of the leaves to the sun thereby increasing the photosynthetic efficiency of the plant. Variations in plant height in turmeric among the cultivars due to genetic make up of individual cultivars and their response to

particular agro-climatic conditions was reported by Philip (1983), Philip and Nair (1983).

Similar results were also noticed by Thankamani *et al.* (1998) as 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 up to 180 DAP, whereas, Meshram (2002) suggested that the plants of Krishna was taller and it was followed by Alleppey, Waigaon and Pratibha under Nagpur conditions. Variations in the height among the cultivars under different agro-climatic conditions were also reported by Jalgaokar *et al.* (1988), Radhakrishnan *et al.* (1995) and Hegde *et al.* (1997).

Treatment combination exhibited no significant effect in respect of plant height, indicated thereby that the planting materials had no influence on the turmeric varieties. As such, the height of turmeric plant varieties under studies did not differ significantly by the use of planting materials.

4.1.2 Effect of plant materials and varieties on girth of pseudostem of plant (cm) :

Girth of pseudostem as influenced by different treatments were recorded periodically starting from 30 DAP till 180 DAP and data are presented in table -2.

For planting materials the analysis of data (Table-1) indicated significant differences in all the interval except on 180 days. It was indicated that the girth of pseudostem of turmeric produced by halves of mother rhizomes was significantly superior over the primary and secondary rhizomes till 150 DAP. The girth of pseudostem of turmeric plant, though, recorded maximum (2.78 cm) in halves of mother rhizomes indicated thereby that use of any planting materials whether halves of mother, primary and secondary rhizomes had no great influence on size of pseudostem.

Table 2 : Average girth of pseudostem (cm).

Treatments	Abbr.	Mean girth of pseudostem of plant (cm)					
		30 days	60 days	90 days	120 days	150 days	180 days
Planting Materials							
Halves of Mother rhizomes	M_1	0.91	1.13	1.68	2.16	2.59	2.78
Primary rhizomes	M_2	0.81	1.05	1.55	2.05	2.47	2.71
Secondary rhizomes	M_3	0.77	1.00	1.48	2.00	2.42	2.64
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	N.S.
SE m (±)		0.02	0.02	0.03	0.04	0.04	0.07
CD at 5%		0.06	0.07	0.09	0.11	0.11	-
Varieties							
Alleppey	V_1	0.88	1.02	1.52	2.14	2.66	2.94
Krishna	V_2	0.89	1.36	1.97	2.35	2.87	2.98
Prabha	V_3	0.83	1.01	1.50	2.02	2.35	2.58
Pratibha	V_4	0.86	0.91	1.41	1.90	2.40	2.69
Sudarshan	V_5	0.64	0.96	1.26	1.79	2.18	2.51
Suguna	V_6	0.60	0.82	1.40	1.84	2.13	2.34
Suvarna	V_7	0.87	0.99	1.48	2.08	2.42	2.62
Waigaon	V_8	1.09	1.43	2.03	2.45	2.92	3.09
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m (±)		0.03	0.05	0.06	0.07	0.11	0.12
CD at 5%		0.09	0.14	0.18	0.21	0.29	0.31
Interaction							
'F' test		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SE m (±)		0.06	0.07	0.10	1.13	0.17	0.19
CD at 5%		-	-	-	-	-	-
GM		0.83	1.06	1.57	2.07	2.49	2.71

At 30 days of planting, variety Waigaon produced maximum girth of pseudostem and it was at par with Krishna for 60 to 120 DAP of observations. Subsequently, in next two months i.e. 150 and 180 DAP, Waigaon, Krishna and Alleppey were found at par. Thus, all results indicated that genotypes Waigaon and Krishna were significantly superior to rest of the varieties. However, Suguna was significantly inferior over all other varieties at all intervals except 90 DAP and 120 DAP where variety Sudarshan was found significantly inferior.

In Table-1 variety Waigaon achieved maximum girth of pseudostem (3.09cm) at 180 DAP. It was significantly higher than all other treatments and at par with Krishna (2.98 cm) and Alleppey (2.94 cm). While, variety Suguna had poor girth (2.34 cm) and at par with Sudarshan (2.51cm), Suvarna (2.62 cm) and Prabha (2.58 cm).

Thus, varieties Waigaon, Krishna and Alleppey recorded the radial girth of pseudostem to the extent of 3.09 cm, 2.98 cm and 2.94 cm respectively, which was more than general mean (2.71 cm) at 180 DAP. However, rest of the five varieties, i.e., Pratibha, Prabha, Suvarna, Sudarshan and Suguna attained the girth of pseudostem 2.69 cm, 2.58 cm, 2.62 cm, 2.51 cm and 2.34 cm respectively, had lower girth than general mean (2.71 cm).

Highly significant variations were observed among the varieties for girth of pseudostem among the turmeric types grown under same cultural and agro-climatic conditions could be attributed by the genetic factors.

The girth of pseudostem was more in Waigaon followed by Krishna and Alleppey. It was at higher side right from the beginning, which might have boost up and enlarged the girth of pseudostem of turmeric plant. This increment had maintained even at 180 DAP. These results are similar to the findings of Meshram (2002) reported that the genotypes Waigaon and Krishna of turmeric had

comparatively larger radial growth of pseudostem while, Suguna and Sudarshan had thin pseudostem.

The interaction effect presented (Table-1) showed non-significant results in respect of girth of pseudostem at different days of observations after planting. This indicated no influence of the varieties over the materials used for plantings.

4.1.3 Effect of planting materials and varieties on number of leaves per plant :

Data in respect of number of leaves per plant as influenced by different varieties were recorded periodically at 30 days intervals upto 180 days and displayed in table – 3 and Fig. 3.

However, planting materials showed significant difference in production of leaves per plant only upto four months after planting. But non-significant results were observed at 150 and 180 DAP.

It is revealed from table -3 that the halves of mother rhizomes had showed, no doubt gradual increment in production of leaves upto four months. The differences at every month were found to be significant. However, as the plants reaches to maturity, the bearing of leaves found no variations. But the plant from halves of mother rhizomes (10.41) had comparative more leaves than primary rhizomes (10.24) and secondary rhizomes (10.08) at maturity.

As the plant resulting from halves of mother rhizomes gave significantly more height and more number of leaves in turmeric plant than primary and secondary rhizomes, it may be due to the fact that the height of plant was found to be positively correlated with the yield. The increase in height enhances the photosynthetic efficiency of the plant. Photosynthetic activity has already begun to decline well ahead of visual indications of impending senescence. The newly expanding leaf generally shows a sigmoidal growth curve and maximum photosynthetic activity is reaches as the leaf achieves full size. The assimilation rate, along with other anabolic processes which depends upon chloroplast function, decline as leaves age.

Table 3 : Average number of leaves

Treatment	Abbr.	Mean number of leaves					
		30 days	60 days	90 days	120 days	150 days	180 days
Planting Materials							
Halves of Mother rhizomes	M_1	2.86	5.36	6.54	8.19	8.95	10.41
Primary rhizomes	M_2	2.59	4.84	6.11	7.86	8.77	10.24
Secondary rhizomes	M_3	2.41	4.69	5.91	7.74	8.55	10.08
'F' test		Sig.	Sig.	Sig,	Sig.	N.S.	N.S.
SE m (±)		0.06	0.10	0.14	0.11	0.18	0.21
CD at 5%		0.19	0.29	0.41	0.31	-	-
Varieties							
Alleppey	V_1	2.10	5.20	6.78	8.56	9.43	11.39
Krishna	V_2	3.16	5.71	6.82	8.67	9.51	12.55
Prabha	V_3	2.63	4.98	6.54	8.36	8.96	10.35
Pratibha	V_4	3.04	5.14	6.18	8.61	9.18	10.93
Sudarshan	V_5	2.41	4.60	5.54	6.78	7.67	7.87
Suguna	V_6	2.35	3.89	5.23	6.43	7.36	7.60
Suvarna	V_7	2.65	4.83	5.77	7.61	8.45	9.38
Waigaon	V_8	2.62	5.36	6.65	8.43	9.50	11.86
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m (±)		0.11	0.23	0.28	0.16	0.38	0.43
CD at 5%		0.31	0.65	0.81	0.44	1.09	1.25
Interaction							
'F' test		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SE m (±)		0.19	0.36	0.40	0.29	0.58	0.66
CD at 5%		-	-	-	-	-	-
GM		2.62	4.96	6.18	7.93	8.75	10.24

Thus, in this investigation, the turmeric plant produced halves of mother rhizomes had more leaves than that of primary and secondary rhizomes. Similar result was reported by Philip (1983_a) in which mother rhizomes (25-34 g) produced 16.94 leaves/plant, halves of mother rhizomes (13-17 g) 17.01 and finger rhizomes (15-20 g) 16.96 leaves/plant.

The progressive increment in number of leaves was noted at the age of plant advanced irrespective of the varieties. The data in table-3 had significant variations at all intervals of observations.

The average number of leaves produced by the turmeric was 10.24 leaves and it ranged from 7.60 (Suguna) to 12.55 (Krishna). Of the varieties under studies, five of them viz. Krishna (12.55), Waigaon (11.86), Alleppey (11.39); Pratibha (10.93) and Prabha (10.35) possessed the leaves per plant in turmeric plant, more than general mean (10.24). Two varieties i.e., Sudarshan (7.87) and Suguna (7.60) had less number of leaves than mean at the full growth of plant at 180 DAP. In every month of observation variety Krishna was found significantly superior; while, rest of the varieties had abruptly bearings of leaves, in each month intervals from 30 to 180 DAP. Variety Suguna had 7.60 leaves per plant at 180 DAP and it was significantly inferior at all intervals except 30 DAP.

Thus, at full grown up stage of plant recorded at 180 DAP variety Krishna produced maximum leaves (12.55), which was significantly superior over all other treatments but at par with Waigaon (11.86) and Alleppey (11.39). Whereas, variety Suguna was significantly inferior over all the other treatments and was at par with Sudarshan.

The increase in number of leaves per plant particularly Krishna, Waigaon, and Alleppey in all the intervals attributed to the fact that these varieties mostly surpassed to rest of the other varieties and variety Krishna followed by Waigaon was found par

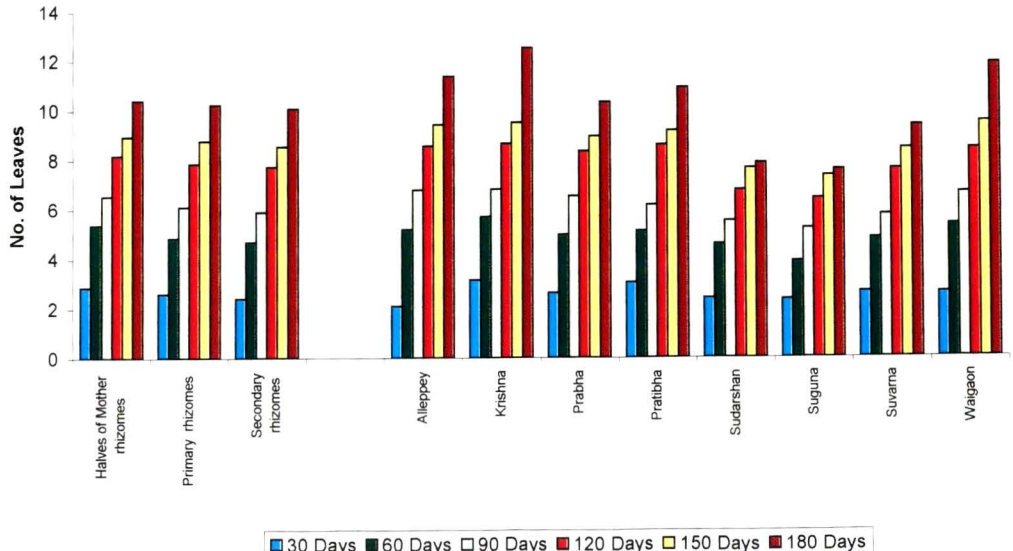


Fig.3. Number of Leaves

excellence. Secondly, there might be positive correlation between number of leaves and plant height. Obviously, therefore, the genotype Krishna recorded the maximum number of leaves per plant followed by Waigaon and Alleppey. On the contrary, variety Suguna in all the intervals produced less number of leaves. Hence, it had less leaves even at full growth. It was also inferred from the earlier data that more the height, more was the number of leaves per plant in turmeric. Since Krishna and Waigaon consequently achieved more height and borne leaves more than others.

This is in line with the finding of Pathania *et al.* (1988). Chadha (1994) found 7.38 leaves in Sudarshan cultivars. Comparatively similar results were viewed in the present investigation. 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 was also reported by Philip (1983), Philip and Nair (1983), Ramakrishna *et al.* (1995), and Hegde *et al.* (1997). The number of leaves in this investigation varies to extent from 7.60 to 12.55. These results fall in the tune with that of Meshram (2002) who obtained 7.55 to 13.79 leaves/plant, which is also in the range of present investigation.

As regards, interaction effect, treatments combination exhibited non-significant effect on number of leaves at all days of observations. This indicated that production of leaves by use of planting material had no influence over the varieties of turmeric.

4.1.4 Effect of planting materials and varieties on size of leaf :

The data in respect of length and breadth of leaves recorded at 30, 60, 90, 120, 150 and 180 DAP for each treatment are viewed in table-4 and 5 respectively.

Average leaf length and breadth was significantly influenced by the varieties of turmeric in all the monthly observations. Similarly,

upto 120 DAP, the planting material had a significant effect. But at 150 and 180 DAP, no influence was noticed. In every month of observations interaction of planting material over the varieties exhibited no differences on the size of turmeric leaves. It is evident from the data that there was progressive increment in leaf length and breadth in all the intervals as the age of plant advance. However, the rate of increment in leaf length and breadth was comparatively higher in all the varieties up to 120 DAP and there after reduced down as evident from general mean.

For planting material, (Table 4 and 5) the analysis of variance in respect of average leaf length and breadth possessed significant differences in early stage of growth and later on at 150 and 180 DAP significant was not observed. Halves of mother rhizomes were found to be significance superior over primary and secondary rhizomes at different days of observations after planting except at 150 and 180 days. While, primary rhizomes and secondary rhizomes were at par with each other. The leaves of plant produced from halves of mother rhizomes recorded significantly maximum length and breadth of leaf as compared to primary and secondary rhizomes, but at 150 and 180 DAP results were non-significant.

The extent of leaf length and breadth, the values ranged from 56.67 cm. to 55.10 cm and 15.56 cm to 14.96 cm respectively. Though, the data was non-significant however, plant resulting from halves of mother rhizomes produced more leaf length and breadth than primary and secondary rhizomes.

Rapid production and expansion of leaves are highly important in crop production in order to maximize light interception and assimilation. A full canopy also reduces weed competition. A steady increase in photosynthetic activity as the leaf expands is not simply a consequence of increased chlorophyll content because assimilation number also increases.

Table 4 : Average leaf length (cm).

Treatment	Abbr.	Mean leaf length (cm)					
		30 days	60 days	90 days	120 days	150 days	180 days
Planting Materials							
Halves of Mother rhizomes	M_1	13.27	20.13	26.48	45.91	53.07	56.67
Primary rhizomes	M_2	12.10	18.93	25.12	43.45	52.42	55.96
Secondary rhizomes	M_3	11.36	18.23	24.21	42.79	51.92	55.10
'F' test		Sig.	Sig.	Sig.	Sig.	N.S.	N.S.
SE m (±)		0.28	0.37	0.46	0.81	1.12	1.15
CD at 5%		0.81	1.09	1.34	2.39	-	-
Varieties							
Alleppey	V_1	12.14	16.54	23.68	39.77	51.81	57.30
Krishna	V_2	16.32	21.11	28.20	48.36	57.61	60.42
Prabha	V_3	11.84	19.60	24.50	38.97	45.33	47.32
Pratibha	V_4	12.75	21.09	26.95	45.46	55.47	59.89
Sudarshan	V_5	9.58	17.50	21.39	41.27	46.88	47.82
Suguna	V_6	8.48	18.36	24.02	42.04	50.04	55.44
Suvarna	V_7	15.03	20.49	25.36	45.73	54.41	58.06
Waigaon	V_8	11.81	18.09	28.06	50.80	58.26	61.05
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m (±)		0.46	0.71	0.89	1.37	2.21	2.29
CD at 5%		1.32	2.10	2.61	4.07	6.54	6.81
Interaction							
'F' test		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SE m (±)		0.78	1.12	1.36	2.23	3.35	3.47
CD at 5%		-	-	-	-	-	-
GM		12.24	19.09	25.27	44.05	52.47	55.91

Table 5 : Average leaf breadth (cm).

Treatment	Abbr.	Mean leaf breadth (cm)					
		30 days	60 days	90 days	120 days	150 days	180 days
Planting Materials							
Halves of Mother rhizomes	M_1	6.89	8.82	10.51	13.08	14.50	15.56
Primary rhizomes	M_2	6.35	8.27	9.82	12.42	14.27	15.23
Secondary rhizomes	M_3	6.07	7.92	9.58	12.07	13.83	14.96
'F' test		Sig.	Sig.	Sig.	Sig.	N.S.	N.S.
SE m (±)		0.15	0.16	0.19	0.21	0.28	0.31
CD at 5%		0.44	0.45	0.54	0.59	-	-
Varieties							
Alleppey	V_1	6.94	7.86	8.51	11.73	13.66	14.90
Krishna	V_2	7.48	9.39	11.03	13.94	15.77	16.70
Prabha	V_3	6.79	8.33	10.29	11.32	12.35	12.72
Pratibha	V_4	6.17	8.67	10.53	13.57	15.04	16.60
Sudarshan	V_5	5.39	7.03	8.78	10.86	12.66	13.66
Suguna	V_6	4.82	7.89	9.68	11.76	13.51	14.29
Suvarna	V_7	7.25	8.44	9.95	13.24	13.72	15.58
Waigaon	V_8	6.67	9.10	10.94	13.74	16.91	17.60
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m (±)		0.25	0.26	0.37	0.44	0.48	0.59
CD at 5%		0.72	0.74	1.06	1.26	1.39	1.71
Interaction							
'F' test		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
SE m (±)		0.43	0.45	0.54	0.61	0.70	0.83
CD at 5%		-	-	-	-	-	-
GM		6.43	8.33	9.97	12.52	14.20	15.25

Thus, the plants from halves of mother rhizomes had more leaf length (56.67 cm) and breadth (15.56 cm) than that of primary and secondary rhizomes. These results were in close confirmation with findings of Philip (1983_a)

As regards (Table 4 and 5) the enlargement of leaf, no consistency was noted. There was a shift over of the varieties in intervals to come. However, no definite pattern was associated in achieving the leaf length and breadth in varieties. Variety Krishna and Waigaon had larger leaf lamina (longer and broader) and found significantly superior over all other varieties at 30, 60 and 90 days of planting.

Both, leaf length and breadth were maximum in Waigaon and minimum in Prabha. At full grown stage of turmeric plant at 180 DAP the leaf of variety Waigaon was elongated to the tune of 61.05 cm and found significantly superior over all others treatment followed by Krishna (60.42 cm).

Similarly, broader lamina was noticed in variety Waigaon (17.60 cm) which was significantly superior over all the varieties but at par with Krishna (16.70 cm) and Pratibha (16.60 cm).

Thus, the data in table 4 and 5 revealed that five varieties of turmeric i.e. Waigaon (61.05 cm), Krishna (60.42 cm), Pratibha (59.89 cm), Suvarna (58.06 cm) and Alleppey (57.30 cm) had elongated leaves and the value were more than the general mean (55.91 cm) at full grown stage of turmeric plant recorded at 180 DAP. Rest of the varieties i.e. Suguna (55.44 cm), Sudarshan (47.82 cm) and Prabha (47.32 cm), the length of leaves was less than the general mean (55.91 cm) at 180 days.

The varieties producing larger leaf had also the broader leaf lamina in the similar sequence, as such varieties Waigaon (17.60 cm), Krishna (16.70 cm) Pratibha (16.60 cm) and Suvarna (15.58 cm)

had more than general mean (15.25 cm). Whereas Alleppey (14.90 cm), Suguna (14.29 cm), Sudarshan (13.66 cm) and Prabha (12.72 cm) had less values than general mean (15.25 cm) at each intervals till 180 DAP. Thus, it is interesting to note from the data that varieties identified for production of larger leaves, had produced the broader leaves in order of definite pattern.

Thus, 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 Philip and Nair (1983), Philip (1983), Radhakrishnan *et al.* (1995), Chandra *et al.* (1999), Datta *et al.* (2001) and Meshram (2002).

The leaf length, leaf breadth and leaf area index (L x b) were also found to be positively correlated. Higher length will definitely be helpful for better exposure of the leaf to the sun. The other factors directly increase the photosynthetic area and thereby increase the rate of photosynthesis, which account for higher yield.

The length and breadth of leaf were related to fresh rhizome yield per clump. The leaf size (length and breadth) variations among the different cultivars might be due to genetic characters of the cultivators and their response to particular agro-climatic conditions. This is in conformity with the findings of Philip and Nair (1983) who observed leaf breadth in range of 13.9 cm to 17.5 cm in the varieties, Rajpuri and Amruthapani Kothapeta C11-317 respectively, grown in the plains of Kerala but these were not the varieties in our studies. This result is in congruent with the present investigation where leaf breadth range was observed from 17.64 to 12.83 cm in Waigaon and Prabha respectively. Philip (1983) found maximum leaf length in the type Chayapasupa (61.90 cm) and minimum leaf length in the cultivars NBPGR/T17' (42.6 cm). These results fall in tune with that of the present investigation.

4.1.5 Effect of planting materials and varieties on number of tillers per plant :

The data on growth parameter with respect to number of tillers per plant recorded at four intervals i.e. 90,120,150 and 180 DAP and presented in table – 6 and Fig. 4.

The data in table-6 revealed that the increment in number of tillers per plant as the age progresses and that results were significant in all the intervals. The halves of mother rhizomes were found significantly superior over primary and secondary rhizomes. Whereas, the tillers produced by primary rhizomes and secondary rhizomes were at par. Halves of mother rhizomes recorded significantly maximum number of tillers in order of 0.72, 0.98, 1.22, 1.88 at 90, 120, 150 and 180 DAP respectively as against primary rhizomes as 0.64, 0.89, 1.08 and 1.72 tillers respectively and secondary rhizomes as 0.59, 0.86, 1.03, 1.60 tillers respectively at different days of observation after planting.

Thus, different planting material exhibited significant effect on number of tillers per plant at all days of observation after planting. At 180 DAP halves of mother rhizomes produced maximum number of tiller (1.88). While minimum number of tillers per plant were emerged from primary rhizomes (1.72) and secondary rhizomes (1.60).

Tillers are the outcome from pseudostem in addition to the main pseudostem. Mostly tillers arise normally after the ceasation of the growth of main pseudostem. The main pseudostem had restriction in respect of aerial growth having tiller will definitely enhance the physiological activity and increase photosynthetic rate etc.

Thus, halves of mother rhizomes found significantly superior over primary and secondary rhizomes. These results are in agreement with Philip (1983_a) who had obtained change variation in tiller per plant, the maximum number of tiller in mother rhizomes, halves of mother rhizomes (3.29 tillers/plant) and minimum in finger rhizomes (3.24 tillers/plant). These findings were similar in line with present investigation.

Table 6 : Average number of tillers per plant

Treatment	Abbr.	Mean No. of tillers per plant			
		90 days	120 days	150 days	180 days
Planting Materials					
Halves of Mother rhizomes	M_1	0.72	0.98	1.22	1.88
Primary rhizomes	M_2	0.64	0.89	1.08	1.72
Secondary rhizomes	M_3	0.59	0.86	1.03	1.60
'F' test		Sig.	Sig.	Sig.	Sig.
SE m (±)		0.02	0.02	0.03	0.05
CD at 5%		0.06	0.06	0.10	0.14
Varieties					
Alleppey	V_1	0.61	0.89	1.07	1.26
Krishna	V_2	0.80	1.04	1.29	2.73
Prabha	V_3	0.65	0.93	1.08	1.34
Pratibha	V_4	0.75	0.97	1.16	1.59
Sudarshan	V_5	0.42	0.74	1.02	1.07
Suguna	V_6	0.52	0.78	0.98	1.10
Suvarna	V_7	0.67	0.90	1.11	2.31
Waigaon	V_8	0.83	1.10	1.24	2.48
'F' test		Sig.	Sig.	Sig.	Sig.
SE m (±)		0.03	0.04	0.07	0.10
CD at 5%		0.11	0.13	0.19	0.29
Interaction					
'F' test		N.S.	N.S.	N.S.	N.S.
SE m (±)		0.07	0.08	0.12	0.17
CD at 5%		-	-	-	-
GM		0.65	0.91	1.11	1.73

Significant variation was observed among the cultivars with regards to the number of tillers per plant at all the intervals from 90 to 180 DAP. Variety Krishna was found significantly superior over all cultivars at advanced stage of growth recorded during 150 and 180 DAP, but at early growth period 90 and 120 DAP. Variety Krishna was replaced by Waigaon. There was abrupt shift among the cultivars at various intervals. However, variety Sudarshan had minimum number of tillers per plant at all intervals except at 150 DAP, where Suguna showed less number of tillers but at par with Sudarshan at all intervals. At full-grown stage i.e. at 180 DAP, the number of tillers were to the extent of 1.07 in Sudarshan to 2.73 in Krishna. Profused tillerings were produced by Krishna followed by Waigaon. However, negligible tiller was noticed in Sudarshan but it was at par with Suguna and Alleppey. Pratibha (1.59), Prabha (1.34), Alleppey (1.26), and Suguna (1.10) had the tillers lower than general mean (1.73).

Tillers are the effective way of increasing the leaf area per plant, which decreases the sensitivity of yield to plant density. Tillers are arises below the surface of the soil. The upward or apogeotropic tillers are similar in appearance to the pseudostem having fewer leaves and remain vegetative and help in increasing photosynthetic activity in plant.

The variation in emergence of tillers was to the extent of 1.07 to 2.73. Variety Krishna was followed by Waigaon and Suvarna and produced the maximum tillers per plant. Similar variations in tiller among different cultivars was investigated under different agro-climatic conditions by Philip and Nair (1983), Mukhopadhyay *et al.* (1986), Radhakrishnan *et al.* (1995), Hegde *et al.* (1997) and Datta *et al.* (2001). Meshram (2002) obtained 1.12 to 3.04 tillers per plant in Suguna and Krishna and reported that variety Krishna and Waigaon had more number of tiller per plant, whereas, less tiller were noted in Suguna and Sudarshan. This findings were similar to that of present investigation. Radhakrishnan *et al.* (1995) obtained Suvarna, Suguna and Sudarshan having 4.37, 1.18 and 1.31 tillers per plant, which

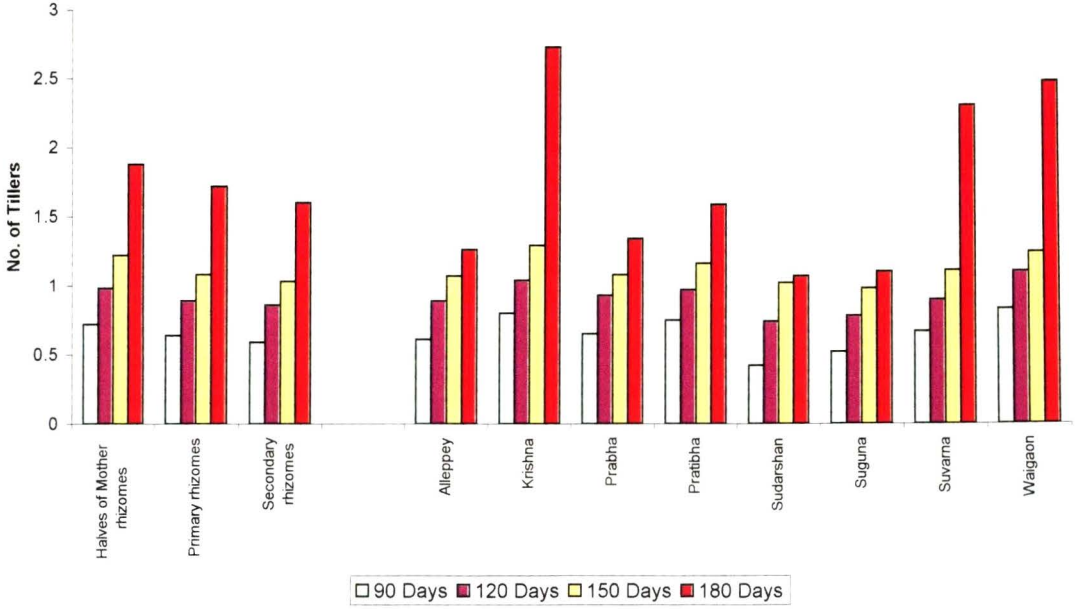


Fig.4. Number of tillers

was comparatively the same with this investigation. This result is congruent with the result of Chadha (1994) who reported 2.6 tillers per plant in Suvarna.

Regarding interaction effect, in table-6 showed non- significant results in respect of tillers/plant.

4.1.6 Effect of planting materials and varieties on number of leaves per tiller :

Average number of leaves per tillers as influenced by varieties and planting material, recorded periodically at 30 days interval from 90 DAP, till 180 days and displayed in table-7.

Data in table-7 showed successive increase in number of leaves per tillers as the age progressed. Regarding planting materials it was evident from table-7 that leaves appears out on tillers at an interval were significant except at 180 DAP. Leaves on tillers produced by halves of mother rhizomes recorded maximum number of leaves per tiller, which was significantly superior as 1.99, 2.70, 3.69 at 90, 120 and 150 DAP respectively as against primary rhizomes 1.58, 2.35, 3.47 leaves per tiller and secondary rhizomes recorded minimum number of leaves per tiller 1.51, 2.24, 3.40 at 90, 120 and 150 DAP, while primary and secondary rhizomes were at par.

It is revealed from table–7 that at 180 DAP non-significant result was obtained but halves of mother rhizomes produced maximum number of leaves (4.30) on the tiller than that of primary rhizome (4.01) and secondary rhizomes (3.98). Tillers are borne after the ceasation of main pseudostem. The efficiency of older leaves on main pseudostem did not exist. In that case, the physiological activity of leaves appeared on the tiller may take charge and help in increasing photosynthetic efficiency of the plant, which accounted for higher yield. This indicates that the number of leaves per tiller is more important with regard to the yield of turmeric plant. These results were in close confirmation with the findings of Philip (1983_a).

Table 7 : Average number of leaves per tiller.

Treatment	Abbr.	Mean number of leaves per tiller			
		90 days	120 days	150 days	180 days
Planting Materials					
Halves of Mother rhizomes	M_1	1.99	2.70	3.69	4.30
Primary rhizomes	M_2	1.58	2.35	3.47	4.01
Secondary rhizomes	M_3	1.51	2.24	3.40	3.98
'F' test		Sig.	Sig.	Sig.	N.S.
SE m (±)		0.04	0.06	0.07	0.13
CD at 5%		0.13	0.17	0.20	-
Varieties					
Alleppey	V_1	0.83	1.47	2.30	2.88
Krishna	V_2	3.32	4.14	5.25	5.99
Prabha	V_3	0.95	1.67	2.45	3.02
Pratibha	V_4	1.31	2.41	4.40	5.11
Sudarshan	V_5	1.37	1.52	2.10	2.24
Suguna	V_6	0.91	1.27	2.20	2.45
Suvarna	V_7	1.00	2.36	4.25	5.39
Waigaon	V_8	3.84	4.67	5.02	5.70
'F' test		Sig.	Sig.	Sig.	Sig.
SE m (±)		0.07	0.09	0.13	0.18
CD at 5%		0.22	0.28	0.40	0.52
Interaction					
'F' test		N.S.	N.S.	N.S.	N.S.
SE m (±)		0.13	0.17	0.22	0.33
CD at 5%		-	-	-	-
GM		1.69	2.43	3.52	4.09

It is evident from table-7 that significant variation was noticed within varieties in respect of number of leaves per tiller, variety Krishna was found significantly superior over all other cultivars in almost all the observation recorded from 150 and 180 DAP except 90 and 180 days where it was substituted by Waigaon. However, the values did not follow the regular sequence for emergence to later stage of observations, there was shift of treatments on one over the other at various intervals. But, variety Sudarshan recorded significantly meagre number of leaves per tillers in almost all the intervals except 90 and 120 days, where Alleppey and Suguna were significantly inferior.

At full-grown stage of plant recorded at 180 DAP the number of leaves per tillers indicated to the extent of 2.24 in Sudarshan to 5.99 in Krishna. Variety Krishna and Waigaon were significantly superior over all the treatments. However, less number of leaves per tiller was observed in Sudarshan but it was at par with Suguna and Alleppey.

Data in table-7 indicated that more number of leaves per tiller produced by four varieties Krishna (5.99), Waigaon (5.70), Suvarna (5.39) and Pratibha (5.11) at 180 DAP and these values were higher than general mean (4.09), whereas, variety Prabha (3.02), Alleppey (2.88), Suguna (2.45) and Sudarshan (2.24) had less number of leaves per tiller than general mean (4.09).

Thus, in variety Krishna, Waigaon, Suvarna and Pratibha had more leaves per plant and it varied from 5.11 to 5.99. So the varieties, which were higher in the magnitude of leaves per plant had also more number of leaves per tiller. The variation in number of leaves per tiller among different varieties was also investigated under different agro-climatic condition by Philip and Nair (1983), Philip (1983) found that the variation of number of leaves/tiller ranges from 5.60 to 7.60 in cultivars Mannuthy Local and 'NBPGR/T6', which are comparatively the same with this investigation. Hegde *et al.* (1997) observed in Suvarna 4.80, Suguna 2.20 and Sudarshan 2.03

number of leaves per tillers, which are in same line in represent investigation.

The interaction effect, for number of leaves per tillers showed non-significant results.

4.1.7 Effect of planting materials and varieties on leaf area :

The average leaf area as influenced by different treatments were recorded and presented in table-8 and Fig. 5.

The data viewed in table -8 indicated significant variation in respect of varieties. However non-significant differences were recorded in respect of interaction, for planting materials; Variety Waigaon (1032.61 cm^2) followed by Krishna (1015.88 cm^2) produced bigger leaves to the plants when halves of mother rhizomes were used as planting materials.

Though, data were non-significant but maximum leaf area (840.63 cm^2) was measured from leaves of plant obtained from halves of mother rhizomes as against primary rhizomes (796.42 cm^2) and secondary rhizomes (780.35 cm^2). The results are similar to the findings of Main *et al.* (1995), Philip (1983_a) who obtained no significant variation among planting materials, but maximum leaf area (568.5 cm^2) was produced by whole mother rhizomes (25-34 g) followed by halves of mother rhizomes (13-17 g) 544.5 cm^2 and than finger rhizomes 542.0 cm^2 this finding are in line with present investigation.

The leaf surface is the primary photosynthetic organ of the plant, it is sometimes desirable to express growth on the leaf area basis, as the leaf area develops, radiation interception by leaves increases leaf area index (L x b) was found to be positively correlated with yield by increasing the photosynthetic area and thereby increase the rate of photosynthesis with account for higher yield.

Table 8 : Average leaf area (cm^2).

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	810.48	750.66	736.61	765.58
Krishna	V_2	1015.88	986.33	965.02	989.07
Prabha	V_3	564.10	524.07	505.32	531.16
Pratibha	V_4	1008.04	968.64	953.23	976.63
Sudarshan	V_5	609.36	563.24	550.06	574.22
Suguna	V_6	783.48	711.57	700.69	731.91
Suvarna	V_7	901.09	870.31	853.51	874.97
Waigaon	V_8	1032.61	996.54	978.36	1002.50
Mean		840.63	796.42	780.35	
			Planting Materials	Varieties	Interaction
'F' test			NS	Sig.	NS
SE m (±)			21.57	41.85	65.14
CD at 5%			-	121.62	-

Regarding varieties, the mean area of full-grown leaf of turmeric plant at 180 DAP ranges from 1002.50 cm^2 in Waigaon to 531.16 cm^2 in Prabha varieties of turmeric. The expansion of leaf by variety Waigaon was to extend of 1002.50 cm^2, which was significantly superior over all the other cultivars and at par with Krishna (989.07 cm^2) and Pratibha (976.63 cm^2) whereas,, variety Prabha (531.16 cm^2) though significantly inferior to all other treatments but found at par with the variety Sudarshan (574.22 cm^2).

Results from table-8 indicated the significant variations among the different varieties of turmeric in respect of leaf area, investigated under same agro-climatic conditions. Leaf area is a function of leaf

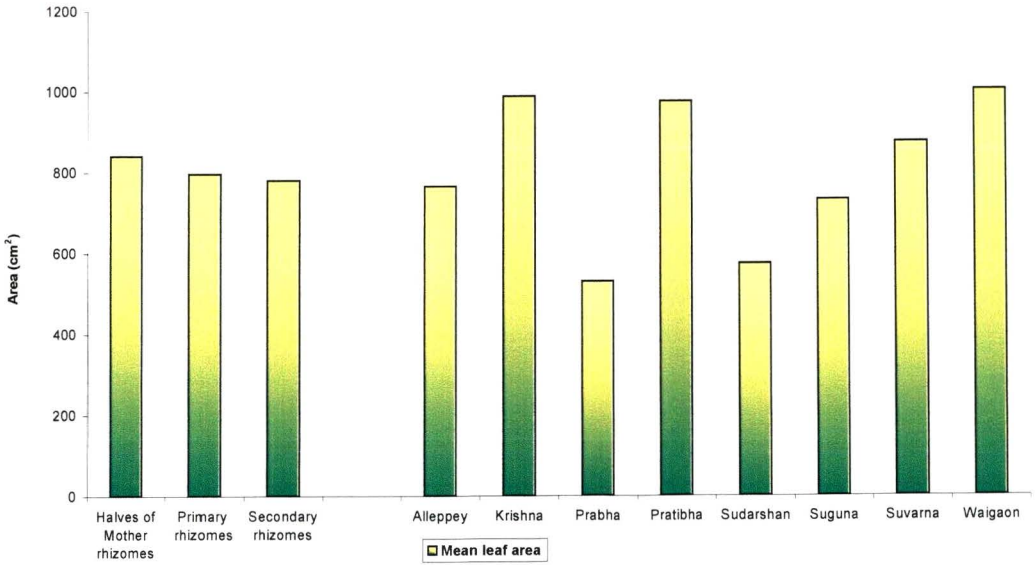


Fig. 5: Leaf area (cm^2)

length and breadth. The variety possessed larger length and broader lamina naturally computed the higher area of leaf. As a result the variety Waigaon was followed by Krishna and Pratibha had higher leaf area. Similar results in leaf area among different cultivars was investigated under various agro-climatic conditions and reported by Philip (1983), Hegde *et al.* (1997), Thankamani *et al.* (1998) and Radhakrishnan *et al.* (1995).

Philip (1983) counted 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 study but the varieties were different. Meshram (2002) however investigated that the varieties Waigaon (1033.51 cm^2) was followed by Krishna (1021.86 cm^2) and Pratibha (1002.57 cm^2) had higher leaf area. Variation in leaf area is due to genetic characters of the cultivars and their response to particular agro climatic conditions. The result is in tune with finding of Philip and Nair (1983) and Jalgaokar *et al.* (1988).

4.1.8 Effect of planting materials and varieties on number of days required for maturity :

Average number of days required for maturity as influenced by different treatments were recorded and presented in table-9.

The data in table-9 indicated significant variations in respect of varieties. However non-significant difference were recorded in respect of planting materials and Interaction.

Regardless, which planting material used, the turmeric plants achieved and completed the maturity span within seven days (205.90 to 209.78 days) and the data were found to be non-significant, this may be due to the number of days required for rhizomes maturity depends upon the period of vegetative phase of the plant. The halves of mother rhizomes plant continued to grow for a long period due to

utilizing the more carbohydrates stored in them. Thus, the vegetative growth continued for a longer period resulted in delay the maturity of the plant.

Table 9 : Average number of days required for maturity.

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	230.66	225.1	224.43	226.73
Krishna	V_2	234.00	232.2	229.86	232.02
Prabha	V_3	200.60	200.10	198.63	199.77
Pratibha	V_4	214.40	211.60	209.60	211.86
Sudarshan	V_5	192.33	190.13	188.10	190.18
Suguna	V_6	188.60	187.10	186.40	187.36
Suvarna	V_7	198.06	195.83	194.56	196.15
Waigaon	V_8	219.66	217.22	215.63	217.50
Mean		209.78	207.41	205.90	
			Planting Materials	Varieties	Interaction
'F' test			N.S.	Sig.	N.S.
SE m (±)			2.10	3.87	6.34
CD at 5%			-	12.17	-

In respect to the varieties, the mean performance in relation to number of days required for maturity indicated significant variations. Of the eight varieties tested for the days required for maturity an indicator of early, medium and late, the variety Suguna matured as early as 187.36 days and Krishna around two months late (232.02 days).

Variety Krishna, took maximum days for maturity and it was at par with. Alleppey, whereas,, Alleppey was at par with Waigaon. Variety

Suguna matured early which was at par with Sudarshan and Suvarna varieties of turmeric. Four varieties viz. Suguna, Sudarshan, Suvarna, and Prabha could be classified early whereas, 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 associated with sugar decline is an increased in other bio-chemicals. As the turmeric ripen, the aerial growth frequently undergo an active senescence drying back to the ground. The maturated turmeric rhizomes possess superior qualities for storage. Thus, the varieties under studies were grouped early viz., Suguna, Sudarshan, Suvarna and Prabha medium 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 interaction of genetical and environmental behavior of the turmeric crops. Present investigation was found in line with findings of Meshram (2002).

Hegde *et al.* (1997) revealed that variety Suguna (193 days), Sudarshan (206 days), and Suvarna (208 days) took relatively less numbers 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 the line with that of the present results.

Variety Krishna and Waigaon took relatively more number of days (Anon., 2002_a), under late duration crop. However, in the present investigation Krishna took 245.76 days (Late) while, Waigaon required 228.86 days for maturity (Medium). Chadha (2001) reported that varieties Prabha and Pratibha had duration 205 and 225 days

respectively for maturity. These results is in congruent with the present investigation and are grouped under medium duration types. Similar significant variations among various cultivars and grouped were made by Maurya (1990) Hegde *et al.* (1997) and Hegde *et al.* (1998).

Interaction effect showed non-significant results. However, the plants of Suguna from secondary rhizomes matured as early as 186.4 days whereas, Krishna with halves of mother rhizomes took 234 days.

4.2 Post harvest observations :

4.2.1 Effect of planting materials and varieties on number of fingers per plant :

Average number of fingers per plant as influenced by different treatments were recorded and presented in table -10.

Table 10 : Average number of fingers per plant.

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	7.3	5.8	5.7	6.28
Krishna	V_2	9.8	9.0	8.3	9.03
Prabha	V_3	7.1	5.9	5.5	6.16
Pratibha	V_4	7.9	7.5	7.2	7.53
Sudarshan	V_5	5.0	3.5	3.2	3.90
Suguna	V_6	6.3	4.7	4.3	5.10
Suvarna	V_7	7.6	6.3	6.0	6.63
Waigaon	V_8	8.5	7.4	7.0	7.63
Mean		7.43	6.38	5.90	
			Planting Materials	Varieties	Interaction
'F' test			Sig.	Sig.	Sig.
SE m (±)			0.18	0.32	0.57
CD at 5%			0.54	0.91	-

From table-10 the data indicated significant variations in respect of varieties and planting materials. However, non-significant

differences were recorded in respect of interaction.

Although, the planting material showed significant differences, turmeric plant from halves of mother rhizomes recorded significantly maximum number of fingers per plant (7.43) while primary rhizomes (6.38) fingers per plant and secondary rhizomes had minimum fingers per plant (5.90), though, secondary rhizomes were at par with primary rhizomes.

The production of significantly maximum number of fingers might be due to the fact that the halves of mother rhizomes helped in early establishment of turmeric plant, root development and better utilization of stored food material and thereby increase in number of fingers per plant. The significant variations among different planting materials under different agro- climatic conditions were also found by Philip (1983_a).

On bearing, of number of fingers per plant, (table-10) indicated significant variation among the different varieties of turmeric. Variety Krishna possessed 9.03 fingers per plant and next in order was the variety Waigaon (7.60). Both these varieties performed significantly excellent over all other varieties. Variety Waigaon was at par with variety Pratibha. Whereas variety Sudarshan had minimum (3.90) fingers per plant and it was significantly shy bearer than all the varieties.

Data in table-10 on number of fingers per plant indicated the range of 3.90 (Sudarshan) to 9.03 (Krishna). The varieties namely Krishna, Waigaon and Pratibha produced the fingers 9.03, 7.63 and 7.53 respectively whereas, varieties i.e., Suvarna (6.63), Alleppey (6.28) Prabha (6.16), Suguna (5.10) and Sudarshan (3.90) had minimum number of fingers. Thus, Krishna and Waigaon were adjudged as high yielder, Pratibha, Suvarna, Alleppey and Prabha as medium and Suguna and Sudarshan as low yielder. Owing to the

appearances of more number of leaves, enlarged leaf lamina in Waigaon and Krishna exposed the large leaf area for photosynthesis for more photosynthates as a result operate excellent system of source to sink phenomenon for bearing of more number of fingers.

Data in table-10 exhibited significant variations among the turmeric types. The significant variation among different varieties under different agro-climatic conditions was also reported by Philip (1983) and Philip and Nair (1983).

Chadha (1994) reported 4 to 7 primary fingers in variety Suguna. The result is in agreement with recent investigation. Meshram (2002) obtained that in Sudarshan 5.22 and variety Krishna 11.76 number of fingers.

The reasons for the significant variation in number of fingers among the turmeric types grown under the same cultural and agro-climatic condition could be attributed to the genetic factors. This result is in agreement of investigation of Subbarayudu *et al.* (1976).

Response of interactions presented in table-10 was non-significant result for average number of finger per plant. However, Krishna followed by Waigaon with halves of mother rhizomes yielded more fingers per plant. Whereas Sudarshan with secondary rhizomes used as planting material produced very less (3.2) fingers per plant.

4.2.2 Effect of planting materials and varieties on length of fingers:

Mean length of finger as influenced by different treatments were recorded and presented in table-11.

Data in table-11 revealed significant differences among varieties and use of planting material. However, no significant influence was exhibited by interaction. Nevertheless, var. Krishna

followed by Waigaon produced longer (9.81cm and 9.14 cm) fingers and shortest (4.92 cm) by Suguna.

Table 11 : Average length of fingers (cm).

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	7.24	6.21	5.94	6.46
Krishna	V_2	9.81	8.94	8.79	9.16
Prabha	V_3	7.30	5.86	5.68	6.28
Pratibha	V_4	8.15	6.48	6.15	6.92
Sudarshan	V_5	7.69	5.90	5.38	6.32
Suguna	V_6	6.05	5.10	4.92	5.35
Suvarna	V_7	8.21	5.61	5.47	6.43
Waigaon	V_8	9.14	8.32	7.93	8.46
Mean		7.94	6.55	6.27	
			Planting Materials	Varieties	Interaction
'F' test			Sig.	Sig.	N.S.
SE m (±)			0.13	0.28	0.43
CD at 5%			0.38	0.81	-

Response of planting materials on average length of fingers, implied from data (Table-11) that halves of mother rhizomes was found significantly better than primary and secondary rhizomes, significantly maximum length (7.94 cm) was produced by halves of mother rhizomes whereas, secondary rhizomes had shorter finger (6.27 cm), though, secondary rhizomes (6.27 cm) was at par with primary rhizomes (6.55 cm). Production of larger rhizomes by halves of mother rhizomes owing to early establishment of turmeric plant, root development and better utilization of stored food materials and these findings were found similar with Philip (1983_a).

Response of varieties on mean length of fingers (Table-11) indicated significant variation. Among the length of finger the different varieties of turmeric ranged in between 5.35 cm in Suguna and 9.16 cm in Krishna. Variety Krishna (9.16 cm) and Waigaon (8.46 cm) was found significantly superior overall other cultivars.

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 rhizome growth is due to cell enlargement whereas, the normal rhizome growth involves cell division. This stimulus appears to be present in large amount in the leaves during the period of tuberization. Thus it is increase manifold, Biran *et al.* (1972).

The reason for the variation in respect of length of finger might be due to agro-climatic and genetical factors. This conclusion is in agreement with the findings of Subbarayudu *et al.* (1976) and Philip and Nair (1983).

Chadha (1994) reported that varieties Alleppey, Suguna, and Sudarshan attained the length of rhizomes 7.0 cm, 6.0 cm and Sudarshan 8.8 cm respectively. The result is in line with present investigation.

In this investigation it was found that the length of primary rhizomes was attributed with the yield of turmeric, larger the rhizome higher the weight resulted in production of higher yield of turmeric.

4.2.3 Effect of planting materials and varieties on diameter of fingers :

The data on average diameter of fingers as influenced by different treatments presented in table-12.

Analysis of variance indicated significant differences in respect of planting material as well as varieties. But non-significant influence

was observed with interaction. However, diameter of finger of Krishna was higher (2.02 cm) followed by Waigaon (1.91 cm) when halves of mother rhizomes was used as planting material and least diameter in Suguna (1.24) by secondary rhizomes.

Table 12 : Average diameter of fingers (cm).

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	1.97	1.69	1.56	1.74
Krishna	V_2	2.02	1.92	1.83	1.92
Prabha	V_3	1.72	1.43	1.33	1.49
Pratibha	V_4	1.81	1.70	1.66	1.72
Sudarshan	V_5	1.85	1.38	1.30	1.50
Suguna	V_6	1.54	1.31	1.24	1.36
Suvarna	V_7	1.89	1.52	1.40	1.60
Waigaon	V_8	1.91	1.75	1.69	1.78
Mean		1.83	1.58	1.50	

	Planting Materials	Varieties	Interaction
'F' test	Sig.	Sig.	N.S.
SE m (±)	0.04	0.07	0.13
CD at 5%	0.09	0.20	-

Data in table-12 indicated that halves of mother rhizomes recorded significantly superior over primary and secondary rhizomes. Halves of mother rhizomes recorded significantly maximum diameter of finger (1.83 cm) whereas, secondary rhizomes recorded minimum diameter of finger (1.50 cm). The secondary rhizome was at par with primary rhizomes (1.58 cm), this might be due to better utilization of stored food material presented in halves of mother rhizomes. These

findings are in the line with Ong art Hanchanlert *et al.* (1996) who reported that maximum diameter (4.33 cm) of mother rhizomes were obtained from planting with whole mother rhizomes as a planting materials.

Performance of varieties on mean diameter of fingers, variety Krishna possessed maximum diameter (1.92 cm) and found superior overall the varieties, whereas, Suguna (1.36 cm) found significantly inferior over all the other varieties and at par with Prabha (1.49 cm) and Sudarshan (1.50 cm). The variety Waigaon (1.78 cm) was at par with varieties Alleppey (1.74 cm), Pratibha (1.72 cm), Suvarna (1.60 cm).

The progress curves of rhizomes growth shows an exponential character. Thus, the great bulk of rhizomes filling activity occur very near the end of growth season. Rhizomes grow very roughly equal activities of cell division and enlargement. An interesting feature of rhizome growth in the facility with whole material can be moved from one developing part 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, leaf size thereby contributed significantly to the development of thicker fingers. The pattern of growth more particularly the breadth of fingers, seen that higher the length more was the breadth of rhizomes.

The quality of the turmeric for premium price in the domestic market based on the size (length and breadth) of cured turmeric. Cured turmeric is the outcome of the processing of the raw turmeric. As such, the variety Krishna and Waigaon produced bold size of fingers, which was more important from market point of view.

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 variations in respect of breadth of finger. Meshram (2002) observed the mean breadth of fingers of turmeric was ranged from 1.64 cm in Suguna to 2.47 cm in Krishna. The reason for this might be due to agro-climatic and genetic factors. This conclusion is in line of investigation of Subbarayadu *et al.* (1976), Jalgaokar *et al.* (1988) and Philip and Nair (1983).

4.2.4 Effect of planting materials and varieties on yield of fresh turmeric per plant (g) :

Average fresh yield of turmeric per plant as influenced by different treatments were recorded and presented in table – 13 and Fig 6.

Table 13 : Average fresh yield per plant (g).

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	219.82	190.23	182.64	197.56
Krishna	V_2	323.09	303.27	301.03	309.13
Prabha	V_3	135.74	126.54	115.64	125.97
Pratibha	V_4	268.54	249.06	219.19	245.59
Sudarshan	V_5	159.30	134.44	125.64	139.79
Suguna	V_6	162.04	133.33	117.67	137.58
Suvarna	V_7	161.92	139.37	130.94	144.07
Waigaon	V_8	309.37	285.38	269.83	288.19
Mean		217.47	195.22	182.82	
			Planting Materials	Varieties	Interaction
'F' test			Sig.	Sig.	N.S.
SE m (±)			7.10	11.74	19.15
CD at 5%			19.54	31.22	-

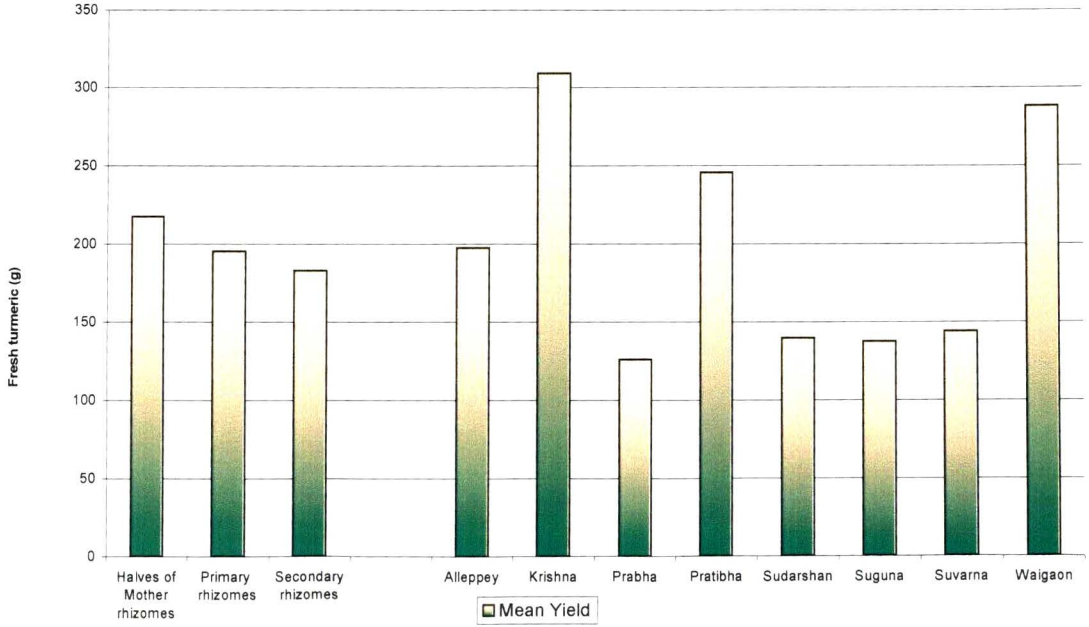


Fig. 6: Yield of fresh turmeric per plant (g)

The data depicted in table -13 revealed significant differences so far as yield of planting material used for eight varieties of turmeric. Though, interaction effect was non-significant, the higher fresh yield of turmeric was obtained from variety Krishna (323.09 g) followed by Waigaon (309.37 g) by the use of halves of mother rhizome as planting materials. Very meagre (115.64 g) fresh turmeric was harvested from the variety Prabha in which secondary rhizomes were used as planting material.

Thus, halves of mother rhizomes gave more yield, this might be due to positive correlation of growth parameters. Halves of mother rhizomes possessed a more growth contributing characters, which has a direct effect on production of rhizome on higher side.

Data presented in table-13 indicated that the plant from halves of mother rhizome of turmeric was found to produce maximum yield per plant (217.47 g) followed by primary rhizomes (195.22 g) and secondary rhizomes (182.82 g). The earlier was significantly superior, whereas, the latter two were on par with each other.

For varieties, the analysis of variance in respect of fresh yield of turmeric per plant (Table-13) exhibited significant differences and the variety Krishna produced substantial higher yield (309.13 g), which was significantly superior over all other varieties. Whereas Waigaon (288.19 g) was next in order of production Variety Prabha (125.97 g) recorded lowest yield and found significantly inferior than all other varieties and the varieties Suguna (137.58 g), Sudarshan (139.79 g) and Suvarna (144.07 g) move on par with Prabha.

Thus, on the basis of fresh yield of turmeric produced by the eight varieties under studies, two of them namely Krishna and Waigaon surpassed the rest and classified as high yielder, next in order was Pratibha and Alleppey and identified as medium types. However, remaining four varieties, which were at par with each other (Suvarna, Sudarshan, Suguna, Prabha) produced very poor yields can be categorized as poor or low yielder types.

There is no gene for yield. However, magnificent higher fresh yields of turmeric by Krishna and Waigaon might be due to the interaction of genotype and environment. Higher yield produced by the Krishna and Waigaon owing to their inherent character, secondly the production of higher yields by these varieties was the result of better performance on growth, number of rhizomes, length and breadth of fingers, weight of fingers and other yield contributory factors which were in higher side than other cultivars. Thus, Krishna and Waigaon varieties of turmeric performed par excellence so far as yield was concerned.

4.2.5 Effect of planting materials and varieties on yield of fresh turmeric per hectare(q) :

Average fresh yield of turmeric per hectare as influenced by different treatment were recorded and presented in table – 14.

Table 14 : Average yield of fresh turmeric per hectare (q).

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	237.30	192.42	188.64	206.12
Krishna	V_2	382.39	333.81	314.17	343.47
Prabha	V_3	160.55	129.47	115.24	135.08
Pratibha	V_4	329.90	263.30	250.71	281.30
Sudarshan	V_5	180.41	142.91	132.40	151.90
Suguna	V_6	173.46	133.69	120.27	142.47
Suvarna	V_7	213.05	175.78	163.03	183.95
Waigaon	V_8	352.63	305.60	295.24	317.82
Mean		253.71	209.62	197.46	
			Planting Materials	Varieties	Interaction
'F' test			Sig.	Sig.	N.S.
SE m (±)			7.01	13.04	23.18
CD at 5%			20.19	37.61	-

The data in table–14 indicated the significant variations in

turmeric varieties and planting materials, however, interaction effect was non- significant. Variety Krishna produced higher fresh yield of turmeric per hectare (382.39 q) followed by Waigaon (352.63 q) and Pratibha (329.90 q) from the plant of halves of mother rhizomes as a planting materials. Whereas Prabha gave (115.24 q) lower yield of fresh turmeric when secondary rhizomes was used as a planting material.

From data in table-14 mean yield of fresh turmeric (253.71 q/ha) from the plant of halves of mother rhizomes were significantly superior over primary (209.62 q/ha) and secondary rhizomes (197.46 q/ha). However, the production of fresh turmeric between secondary and primary rhizomes was at par with each other.

The production of fresh turmeric was around 19 per cent more than primary and secondary rhizomes by the use of halves of mother rhizomes, might be due to positive correlation of yield exists with growth parameters, as halves of mother rhizomes helped in early establishment of plant, root development and better utilization of stored food materials, there operate source to sink system by making halves of mother rhizome qualitatively and quantitatively better than others. Thus, positive correlation of yield exists with growth parameters.

However, secondary and primary rhizomes were at par. Substantially more fresh yield was obtained from secondary rhizomes owing to the planting of 2 to 3 pieces (18-22 g) per hill, which produced an individual plant with normal growth. These plant in term under diageotropically produced bigger clump with two to three corms with normal rhizomes. Clumps possessed a bold and longer with more number of fingers bound to give more fresh yield. This results is in line with the Tayde and Deshmukh (1986) obtained highest yield from mother rhizomes (30.67 t/ha) as compare to

secondary rhizomes (27.61 t/ha) and also suggested that during shortage of mother rhizomes, secondary rhizomes could be use successfully.

The performance of individual variety presented in table –14 revealed that variety Krishna produced significantly higher yield (343.47 q), over all the varieties except Waigaon (317.82 q). Variety Prabha (133.08 q) recorded significantly low yield and at par with varieties Sudarshan (151.90 q) and Suguna (142.47 q).

The results of the present investigation are in accordance with those observed by Philip (1983a), Tayde and Deshmukh (1986), Singh and Kar (1991) produced highest yield from full mother rhizomes (29.93 t/ha) followed by half mother rhizomes and finger in their descending order of weight. Barholia *et al.* (1992), Rashid *et al.* (1996) concluded that fresh yield were highest 28.67 t/ha from corms and lowest 19.43 t/ha from secondary cormels, which is in line with present investigation.

In table 13 and 14 the yield display a good deal of variation in weight of fresh turmeric per plant and per hectare. Interpreting the combined behavior of varieties with attributes it appeared in general that varieties performing better in respect of growth and yield attributing characters viz. size of rhizomes, number of rhizomes, and weight of rhizomes, significantly contributed for production of higher yield. Thus, in the experiment, varieties, which excels better for production of turmeric per plant exhibit the similar trend for the yield per hectare. Hence, Krishna and Waigaon were adjudged as high yielding varieties of turmeric.

The findings of present investigation are in congruent with the report of various research workers Philip (1983), Pujari *et al.* (1987), Pushkaran *et al.* (1985), Jalgaokar *et al.* (1988), Nandi (1990), Indiresh *et al.* (1990), Maurya (1990), Sheshagiri and Uthaiah (1994)

and Shashidhar *et al.* (1997) observed positive correlation of leaf area with rhizome yield, whereas, positive correlation of number of tillers with rhizome yield noticed by Pathania *et al.* (1988), and Hazra *et al.* (2000) found that rhizomes yields of turmeric was positively and significantly correlated with number of leaves.

The reason for positive correlation of rhizomes yield with growth attributes was also stated by Philip and Nair (1983). They reported that height of plant might helpful for better exposure of the leaves to the sun there by increasing the photosynthetic efficiency of the plant, which account for higher yields. Similarly more number of leaves, leaf size might increase the photosynthetic area and thereby accelerate the rate of photosynthesis resulted in higher yield.

In this finding variety Krishna was found significantly superior and produced 343.47 q/ha rhizomes. Pujari *et al.* (1987) also obtained maximum yield from Krishna variety (427.27 q/ha). Radhakrishnan *et al.* (1995) reported that 191.50 q/ha fresh rhizomes of variety Suguna. Similar result was also obtained in this study. Indiresh *et al.* (1990) reported fresh rhizomes yield of cultivar Waigaon 316.60 q/ha in Coastal Karnataka region is in congruent with this finding. Hegde *et al.* (1997) obtained the yield of fresh rhizomes from Sudarshan and Suguna 215.50 q/ha and 196.30 q/ha respectively under Southern dry region of Karnataka also in line with these observations, where Sudarshan and Suguna produced fresh rhizomes yield 151.90 q/ha and 142.47 q/ha respectively. Meshram (2002) reported Krishna as high yielder (411.20 q/ha) and Prabha (169.65 q/ha) the lowest, which is in similar line with present investigation.

Hazra *et al.* (2000) found only leaves/clump at 180 DAP exhibited significantly positive phenotypic correlation with rhizome yield. Path coefficient analysis also revealed that this growth character registered maximum direct contribution to rhizome yield.

The number leaves per clump at 180 DAP emerged as an important rhizome yield component of turmeric. Similarly, Philip and Nair (1983) reported 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.

The variations in yield among the turmeric varieties grown under same agro-ecological condition could be attributed to the inherent character of individual. This is confirmly with the observation of Philip and Nair (1983), Jalgaokar *et al.* (1988), Radhakrishnan *et al.* (1995), Jana and Bhattacharya (2001), Poduval *et al.* (2001) and Datta *et al.* (2001).

From table 13 and 14, exhibited non-significant results on interaction indicated thereby that the yield of turmeric varieties did not differ significantly with the planting materials used. The main effect of planting materials and the varieties were however significant. Nevertheless, excellent result was exhibited by use of halves of mother rhizomes in general and higher yield of fresh rhizomes in Krishna and Waigaon varieties of turmeric in particular.

4.2.6 Effect of planting materials and varieties on curing percentage of rhizomes :

The data on curing percentage as influenced by different treatments were computed and presented in table - 15.

The data presented in table - 15 showed significant variation of curing percentage. Rhizomes produced by halves of mother corms recorded significantly higher curing percentages (17.87%) over primary (17.42%) and secondary rhizomes (17.37%). However, curing percentage of turmeric from primary and secondary rhizomes were at par with each other.

Curing is a process of conversion of starch into gelatin and enhanced the drying procedure. Philip (1983_a) concluded that the halves of mother rhizomes followed by finger rhizomes recorded

significantly higher curing percentage than that of the whole mother rhizomes.

Table 15 : Average curing percentage of rhizomes.

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	19.50	19.25	19.22	19.32
Krishna	V_2	16.52	16.40	16.27	16.39
Prabha	V_3	19.30	19.22	19.18	19.23
Pratibha	V_4	19.53	18.66	18.63	18.94
Sudarshan	V_5	14.46	13.75	13.72	13.97
Suguna	V_6	14.63	14.17	14.15	14.31
Suvarna	V_7	22.03	21.16	21.13	21.44
Waigaon	V_8	17.00	16.75	16.73	16.82
Mean		17.87	17.42	17.37	
			Planting Materials	Varieties	Interaction
'F' test			Sig.	Sig.	N.S.
SE m (±)			0.14	0.29	0.45
CD at 5%			0.39	0.81	-

From table -15 studied that the curing percentage showed significant variations among the varieties. Variety Suvarna (21.44%) produced significantly maximum curing percentage than all the varieties. Variety Alleppey (19.32%) recorded significantly higher curing percentage next in order to the varieties Suvarna, Prabha (19.23%) and Pratibha (18.94%). However, significantly less curing percentage shown in variety Sudarshan (13.97%) and it was at par with Suguna (14.31%).

Thus, screening of varieties for curing per cent indicated that the turmeric could be cured as high as 21.44% (Suvarna) and the lowest 13.97% (Sudarshan). Variety Prabha through ranked 8th in production of fresh yield per hectare interchanged to 3rd rank in yield

of cured produce per hectare. Looking to the production side (Table 13 and 14) the variety Krishna and Waigaon found magnificently better, however, the driage of turmeric in respect of variety Krishna (16.39%) and Waigaon (16.82%) was at par and placed sixth and fifth position respectively. Variety lagging behind in production of raw turmeric was found at the top for driage per cent and *vice-versa*. It is very true in case of variety Prabha (19.23%). On the other hand some of the varieties under studies no longer maintain the same rank whether in production of raw turmeric or after processing. As such variety Suguna (14.31%) and Sudarshan (13.97%) respectively. Thus, driage of turmeric mainly depend upon size of turmeric and T.S.S. content.

Chadha (2001) reported curing percentage 19.5, 18.50 and 12.0 for Prabha, Pratibha and Sudarshan respectively, which is congruent with present investigation. Shashidhar *et al.* (1997) stated that rhizome yield was positively correlated with dry matter accumulation. Rahudkar (2002) reported that the curing percentage of Alleppey; Prabha, Pratibha, Waigaon and Krishna were 19.60%, 19.50%, 19.50%, 18.00% and 16.41% respectively.

The variation in curing percentage among various turmeric cultivars could be due to genetic factors rather than the environmental condition under which they are grown as reported by Philip (1983) and Radhakrishnan *et al.* (1995).

4.2.7 Effect of planting materials and varieties on yield of cured turmeric per hectare :

The result on yield of cured turmeric per hectare are reproduced in table-16.

Curing is an out come of processing of fresh rhizomes of turmeric and the data presented in table–16 and Fig 7) were

significant with respect to both the factors. However no influence was found on interaction.

Table 16 : Average yield of cured turmeric per hectare (q).

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	40.69	38.20	37.14	38.67
Krishna	V_2	61.17	55.16	54.83	57.05
Prabha	V_3	28.84	25.01	24.06	25.97
Pratibha	V_4	55.63	51.72	50.83	52.74
Sudarshan	V_5	22.81	21.35	21.03	21.73
Suguna	V_6	22.60	20.65	19.87	21.04
Suvarna	V_7	40.10	38.67	38.09	38.95
Waigaon	V_8	56.15	51.87	51.34	53.12
Mean		40.99	37.83	37.14	
			Planting Materials	Varieties	Interaction
'F' test			Sig.	Sig.	N.S.
SE m (±)			0.81	1.47	2.34
CD at 5%			2.38	4.32	-

It was evident from the table-16 that halves of mother rhizomes exhibited superior performance over primary and secondary rhizomes. Halves of mother rhizomes produced significantly higher yield of cured turmeric (40.99 q/ha) followed by primary (37.83 q/ha) and secondary rhizomes (37.14 q/ha) yield of cured turmeric. Curing yield of turmeric from primary and secondary rhizomes was at par with each other. Substantially more cured yield was obtained from secondary rhizomes. The production of fresh rhizomes from secondary rhizomes was equal in all respects with that of primary rhizomes.

These findings are in agreement with the observations made by several workers who tested the relative merits of various types of planting materials in turmeric and record significant improvement in the cured yield, when halves of mother rhizomes were used as planting materials (Philip 1983_a, Singh and Kar 1991, and Meenakshi *et al.*, 2001).

Studies carried out by Philip (1983_a) with different planting materials in turmeric obtained highest cured materials with the use of halves of mother rhizomes. In the present investigation similar situation could be noticed where halves of mother rhizomes significantly increased the cured or dry yield per hectare as compared to other planting materials.

From table -16 indicated recovery of cured turmeric between 21.04 q/ha in Suguna and Krishna (57.07 q/ha). Whereas Krishna (57.07 q/ha) recorded significantly maximum yield of cured turmeric overall the varieties, except Waigaon (53.12 q/ha) and Pratibha (52.74 q/ha), which were at par with variety Krishna. However, variety Suguna (21.04 q/ha) recorded significantly minimum cured yield and were at par with Sudarshan (21.73 q/ha).

Data in table -16 revealed that Krishna and Waigaon though had less per cent curing from others. However, higher fresh yield (Table-14) produced by Krishna and Waigaon resulted into more yield of cured turmeric and *vice versa*.

Thus, screening of varieties from market point of view, Krishna, Waigaon and Pratibha assessed as high yielder, Alleppey and Suvarna moderate yielder. Whereas, Prabha, Sudarshan and Suguna were the poor yielder of cured turmeric.

The variations in recovery percentage among various turmeric cultivars could be due genetic factor rather than the environmental conditions under which they are grown as reported by Philip (1983),

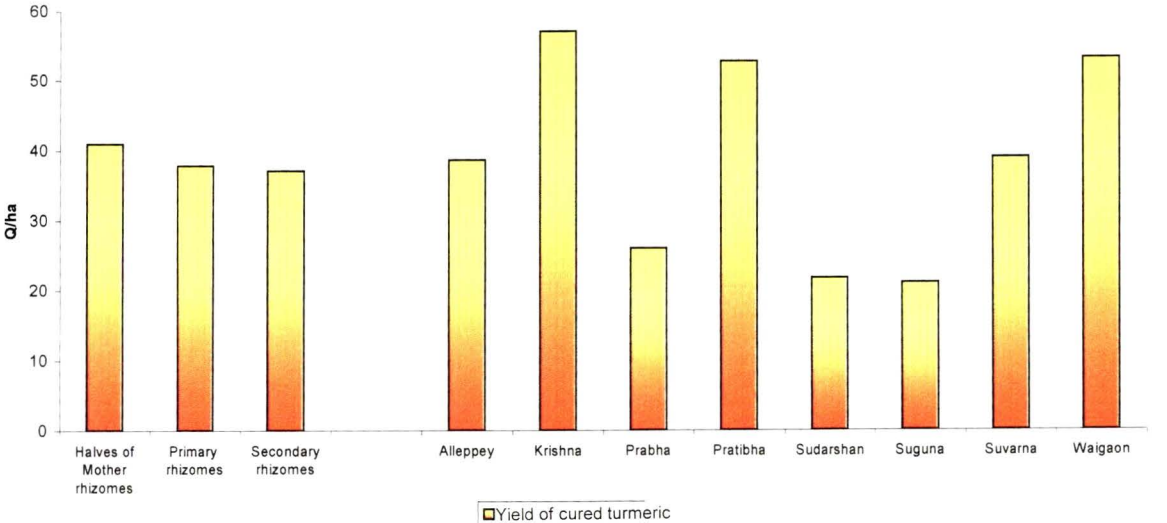


Fig.7: Average yield of cured turmeric per hectare (q)

Pujari *et al.* (1987), Reddy *et al.* (1989), Indiresh *et al.* (1990), Maurya (1990), Kurian and Valsala (1995), Hoque (1995); Ramakrishna *et al.* (1995) and Hegde *et al.* (1997).

The findings of present investigation are in line with the report of various research workers. Thankamani *et al.* (1998) reported that rhizome dry weight per hectare was highest with Suguna and Sudarshan. Indiresh *et al.* (1990) reported that Waigaon and Kasturi gave highest yield of cured turmeric 64.8 q/ha and 62.1 q/ha respectively. Pujari *et al.*(1987) produced the highest cured yield produce 70.11q/ha in cultivar Krishna. Meshram (2002) obtained the highest cured turmeric per hectare from Krishna (68.10 q) and it was closely followed by Waigaon (65.64 q) and Pratibha (64.07 q) variety Suguna and Sudarshan produced considerably less quality of cured turmeric.

The result shown by interaction between varieties and planting materials were non significant, indicating thereby that the planting material difference was not significantly affected by the varieties tested and that of the varieties used did not differ significantly with the planting materials used. However, main effect of both variety and planting materials were significant.

4.2.8 Effect of planting materials and varieties in relation to average curcumin per cent :

The mean performance of planting materials and varieties in relation to curcumin percentage presented in table -17.

Value addition is the need of the era and yellow principle with characteristic taste is curcumin. Curcumin as chemical in turmeric has a very high values and important commercially for export in European market. The quality of curcumin variation is based on its content.

Table 17 : Average curcumin per cent.

Varieties	Abbr.	Planting Materials			Mean
		Halves of Mother rhizomes M_1	Primary rhizomes M_2	Secondary rhizomes M_3	
Alleppey	V_1	2.83	2.80	2.81	2.81
Krishna	V_2	2.67	2.67	2.66	2.66
Prabha	V_3	5.02	5.00	5.01	5.01
Pratibha	V_4	4.62	4.61	4.62	4.61
Sudarshan	V_5	5.40	5.39	5.40	5.39
Suguna	V_6	4.58	4.47	4.59	4.54
Suvarna	V_7	6.42	6.41	6.14	6.29
Waigaon	V_8	3.91	3.92	3.93	3.92
Mean		4.43	4.40	4.38	
			Planting Materials	Varieties	Interaction
'F' test			N.S.	Sig.	N.S.
SE m (±)			0.06	0.09	0.17
CD at 5%			-	0.28	-

The data in table-17 seen to be very interesting to note that significant variation was in respect of curcumin per cent observed due to genotypes. It was revealed from table -17 that planting materials did not show any significant results in respect of curcumin percentage. The maximum curcumin percentage (4.43%) was estimated from the turmeric powder of rhizomes when halves of mother rhizomes had used as planting material. Whereas, primary rhizome (4.40%) and secondary rhizomes (4.38%) recorded minimum curcumin percentage. Philip (1983_a) resulted no significant variation in planting materials. Maximum curcumin percentage (7.39%) was observed in halves of mother rhizomes. These arguments are in line with the present investigation. In general, above findings resulted that the size of propagating material had no effect on the curcumin content of the rhizomes as was concluded by Maia *et al.* (1995).

Regarding varieties, it was evident from data (Table-17 and Fig. 8) on an average percentage of curcumin was estimated. Variety Suvarna (6.18%) was adjudged significantly superior variety over all the varieties. Next Sudarshan (5.39%) also found superior variety. However, Krishna (2.66%) synthesized poor percentage of curcumin, whereas, Krishna (2.66%) was at par with variety Alleppey (2.81%), next in order of Waigaon (3.92%). However, variety Prabha (5.01%) was at par with Pratibha (4.61%).

Interpreting the data presented in table 16 and 17 between variety Krishna and Waigaon from value addition point of view it was clearly seen that variety Waigaon produced twenty nine per cent more curcumin per unit area than that Krishna.

The overall values of turmeric depend upon the content of curcumin, which is very important in the export of market. Highly significant variation was found in turmeric varieties in respect of curcumin percentage. Krishnamurthy *et al.* (1975), Philip (1983), Maurya (1990), Kurian and Valsala (1995), Radhakrishnan *et al.* (1995) and Hegde *et al.* (1997) and Sadanandan *et al.* (1998). Pathania *et al.* (1988) observed the variation of curcumin content from 0.28 to 8.76%. Meshram (2002) estimated the highest percentage of curcumin in Suvarna, Sudarshan, while Alleppey, Krishna, Waigaon had less curcumin per cent. These findings are in line with present investigation.

Chadha (2001) reported lowest curcumin percentage in Krishna (2.80%), however 6.53% and 6.21% in Prabha and Pratibha respectively Rahudkar (2002) stated that the curcumin content in the variety Waigaon was 3.5% whereas, Alleppey had 3.5% curcumin which was comparatively similar with the present investigation.

In the present investigation, it was found that curcumin percentage was negatively and significantly correlated with the fresh

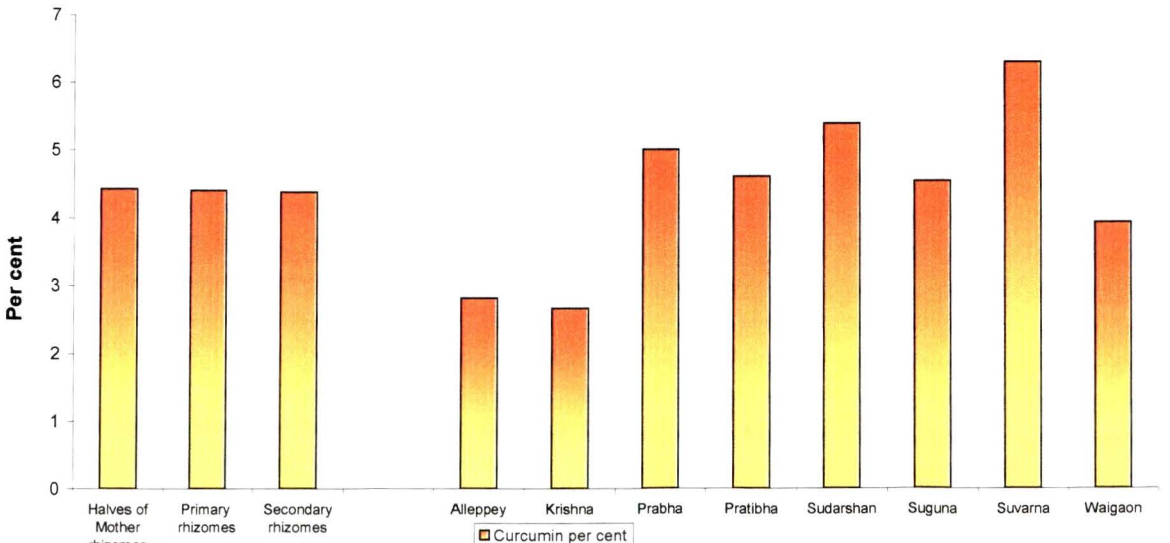


Fig. 8: Average Curcumin per cent

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 to medium content of curcumin and *vice versa.*

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

CHAPTER - V

SUMMARY AND CONCLUSION

An experiment entitled "Effect of planting material on growth, yield and quality of turmeric varieties" was conducted at College Garden, College of Agriculture, Nagpur, during 2003-2004. The study was initiated in factorial randomized block design. Three planting materials viz., halves of mother rhizomes, primary rhizomes and secondary rhizomes and eight varieties i.e., Alleppey, Krishna, Prabha, Pratibha, Sudarshan, Suguna, Suvarna and Waigaon, consist twenty four treatment combinations were replicated thrice.

Growth parameters and yield contributory characters were recorded at specific intervals to evaluate the treatment effects. Some of the important findings emerged from this investigation are summarised below.

Analysis of variance indicated significant differences in respect of varieties in all the characters. No significant variations were observed in interaction. However, there was an influence of planting materials over the yield and quality attributes.

Planting materials :

Constant weight of various planting material significantly influenced on growth and yield in turmeric. The halves of mother rhizome expressed better performance as against the use of primary and secondary rhizome.

For getting the higher yield of turmeric, the characters, which significantly contributed were the number of fingers, length of finger and diameter of finger. Significantly higher yield of fresh turmeric was obtained from the plant in which the halves of mother rhizome were used as planting material as compare to primary and secondary rhizomes.

Curcumin content in the turmeric rhizomes did not differ,

irrespective of the planting material used. Nevertheless, the extent of curcumin per cent estimated higher from the halves of mother rhizomes than primary and secondary rhizomes. However, the studies clearly indicated that the effect of primary rhizomes was at par with secondary rhizomes so far as growth and yield contributing characters were concerned. Therefore, in the time of shortage of mother and primary rhizomes, secondary rhizomes of similar weight could be used as planting material.

Varietal difference :

The most important parameter of growth is a structum from which the genotypes can be recognized. Cultivars Krishna, Waigaon and Alleppey in order were identified as taller with larger radial growth of pseudostem. Whereas, Sudarshan and Suguna had dwarf and thinner pseudostem.

The photosynthetic activity resulted as 'source' with the leaves in turmeric plant. More number of leaves were counted in Krishna followed by Waigaon and Alleppey, while Suguna recorded less number of leaves per plant.

The leaf area is a function of length and breadth and the amount of food production related to the surface of leaf. Wider with longer lamina exhibited thereby the larger leaf area, which was computed in Waigaon followed by Krishna and Pratibha. Variety Prabha however, registered comparatively smaller leaf lamina, which had short and narrow leaf with minimum area of leaf.

The canopy and area covered by the individual plant are significantly associated with the emergence of tillers and the number of leaves borne on the tiller. Variety Krishna and Waigaon had produced more number of tillers and leaves per tiller, whereas, Sudarshan noted the less.

The categorisation of turmeric varieties from the point of maturity is a vital proposition. Variety Suguna and Sudarshan as

such were identified as early types, while Waigaon and Pratibha were found medium. Whereas, cultivars like Krishna and Alleppey were grouped under late duration types.

The quality and quantity of rhizomes are directly associated with the accumulation of storage food material. The bold, plumpy, thick and larger rhizomes were produced by Krishna and next in order was Waigaon. Whereas, short and thin fingers were obtained from Suguna.

The potential of any cultivar is the basis on, the significant association of growth and yield contributing characters. The yield of fresh turmeric per plant was obtained significantly higher from Krishna followed by Waigaon and Pratibha. While, Prabha recorded lower yield of fresh turmeric. Thus, Krishna and Waigaon were adjudged as high yielding varieties of turmeric.

Turmeric is a spice crop. From the processed point of view the most important criterion is the synthesis of yellow colours, used in the form of powder or paste by the user. Cured turmeric is also one of the important attributes in grading the turmeric produce for export and domestic market. Thus, screening of varieties from market point of view Krishna, Waigaon and Pratibha, assessed as high yielder of cured turmeric. Alleppey and Suvarna placed second in order, whereas, Prabha, Sudarshan and Suguna were the poor yielder of cured turmeric.

Biosynthesis of curcumin, an aromatic taste and flavour is one of the most important factors. The turmeric varieties with high curcumin regarded as the best so far as value addition is concerned and have a great demand. Cultivars like Suvarna and Suguna recorded maximum per cent of curcumin, However, Suvarna and Pratidha produced considerably high curcumin per unit area. On the other hand, varieties Krishna and Waigaon though had less curcumin per cent, however, synthesised significantly higher yield of

cured turmeric. Production of curcumin per unit area, Variety Waigaon surpassed by 29 per cent more than Krishna.

Conclusion :

It is revealed from the results of the present investigation that the use of different planting materials affect much on growth, vigour and yield of turmeric. Highest yield per hectare of cured turmeric was obtained when halves of mother rhizomes were used as planting materials. Halves of mother rhizomes produced more curcumin per cent than fingers. However, The effect of primary rhizomes was on par with secondary rhizomes.

Apparently, the performance of variety Krishna was very closely followed by Waigaon. It was considerably better in marked yields of both fresh and cured turmeric per hectare. The cultivar Suvarna synthesized maximum curcumin. However, variety Waigaon was the largest producer of curcumin per unit area than Krishna.

Thus, it can be suggested that secondary rhizomes could be used as planting materials in the event of shortage of halves of mother or primary rhizomes. Simultaneous perusal of the data indicated the best response of Waigaon variety of turmeric. Hence variety Waigaon is suggested for cultivation in this region. This is the first year of the experiment and needs further studies for confirmation.

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THESIS ABSTRACT

1)	Title of the thesis	:	**"EFFECT OF PLANTING MATERIAL ON GROWTH, YIELD AND QUALITY OF TURMERIC VARIETIES"**
2)	Full name of student	:	**Nishant Anandrao Deshmukh**
3)	Name and address of Major Advisor	:	**Dr. S. U. Gondane**, Professor of Horticulture, College of Agriculture, Nagpur.
4)	Degree to be awarded	:	M.Sc. (Agriculture)
5)	Year of award of degree	:	2004
6)	Major subject	:	Horticulture
7)	Total number of pages in: thesis		91
8)	Number of words in the abstract	:	250
9)	Signature of student	:	
10)	Signature, Name and address of forwarding authority	:	(**Dr. S. U. Gondane**) Professor of Horticulture, College of Agriculture, Nagpur.

ABSTRACT

Investigation on the "Effect of planting material on growth, yield and quality of turmeric varieties" was undertaken in College garden, College of Agriculture, Nagpur, during 2003-2004 in factorial randomized block design (FRBD). Treatments comprised, halves of mother rhizomes, primary rhizomes and secondary rhizomes with eight varieties viz., Alleppey, Krishna, Prabha, Pratibha, Sudarshan, Suguna, Suvarna and Waigaon which combination constitute twenty four treatments replicated thrice.

The results on vegetative growth of turmeric plant from the halves of mother rhizomes found superior to the primary and secondary rhizomes. Halves of mother rhizomes recorded the highest fresh yields (253.71 q), cured rhizomes (40.99 q) per hectare and highest curcumin content (4.43%).

As regards, varieties Krishna produced the tallest (99.63 cm) plant, possessed more leaves (12.55), emerged profuse tillers (2.73) and leaves per tiller (5.99). Variety Waigaon, however, had maximum radial growth of pseudostem (3.09 cm), elongated (61.05), broader (17.60 cm) with spectacular larger size of leaf (1002.50 cm^2).

Varieties Krishna and Waigaon had better vegetative attributes resulted in production of highest yield of fresh and cured rhizomes per hectare. Maximum curcumin content (6.29%) was estimated in Suvarna.

Thus, compromise and compensation it may, therefore, be inferred that secondary rhizomes can be used as planting material in the event of shortage. Secondly, for value addition in turmeric the performance of variety Waigaon was far better than Krishna. Hence, turmeric variety Waigaon is suggested for cultivation in Vidarbha region.

The interaction effects of planting materials and varieties were non-significant with growth performance, yield and quality.

APPENDIX - 1

Weekly Meteorological Data from May 2003 to March 2004 recorded at observatory of College of Agriculture, Nagpur.

Met. Week	Date and month	Temp. °C		R. H. %		Total rainfall mm	Total rainy days	Eva. mm
		Max.	Min.	Mor.	Noon			
16	28 to 03 **June 03**	43.4	32.0	31	19			15.5
17	04 to 10	44.6	31.5	43	24			14.0
18	11 to 17	39.5	27.5	60	40	14.5	2	11.2
19	18 to 24	35.6	25.2	74	54	77.9	3	9.2
20	25 to 01 **July**	30.2	23.8	85	67	229.4	6	5.0
21	02 to 08	31.5	24.4	85	65	55.5	4	4.1
22	09 to 15	30.4	24.9	81	74	47.9	3	3.9
23	16 to 22	30.1	24.4	82	80	126.3	3	3.3
24	23 to 29	28.2	24.2	87	78	182.2	5	1.0
25	30 to 05 **Aug.**	30.4	24.5	81	65	8.6	2	4.2
26	06 to 12	31.2	24.5	83	71	33.6	3	3.0
27	13 to 09	29.7	24.3	83	71	15.8	2	3.3
28	20 to 26	28.4	23.6	87	83	196.4	3	2.7
29	27 to 02 **Sept.**	28.5	23.3	86	78	56.8	4	2.2
30	03 to 09	28.1	22.6	83	74	6.7	1	2.6
31	10 to 16	29	23.8	80	71	6.2	1	3.4
32	17 to 23	30	23.8	84	68	13.6	1	2.3
33	24 to 30	30.8	23.1	86	69	137.9	5	2.7
34	01 to 07 **Oct.**	31.7	22.1	71	53			4.2
35	08 to 14	32.4	21.3	71	43	13.7	1	3.2
36	15 to 21	31.7	20.6	67	44			3
37	22 to 28	30	19	67	46			3.8
38	29 to 04 **Nov.**	30.6	21.6	74	53	3.4	1	2.8
39	05 to 11	31.5	15.9	66	37			2.8
40	12 to 18	30.2	14.4	68	35			2.7
41	19 to 25	30.9	15.9	74	42			1.9
42	26 to 02 **Dec.**	30.1	16.8	75	48			1.9
43	03 to 09	29.9	12.1	57	25			2.8
44	10 to 16	29.2	12.8	63	37			2.8
45	17 to 23	27.4	12.0	67	33			2.7
46	24 to 31	25.0	11.5	70	40	4.6	1	2.3
1	01 to 07 **Jan 04**	26.2	12	69	62	1.7	1	2.3
2	08 to 14	27.3	9.8	6	3.1		0.8	2.5
3	15 to 21	31.8	14.3	6.5	3.5		0.8	2.4
4	22 to 28	27.2	14.8	70	46	16.2	3.3	3.5
5	29 to 04 **Feb.**	26.3	13.9	70	51	18.6	1.3	2.3
6	05 to 11	28.6	10.8	50	25		0.7	3.5
7	12 to 18	31.6	13.9	51	23		0.4	4.1
8	19 to 25	34.1	14.5	45	20		0.3	4.7
9	26 to 06 **Mar.**	36.1	16.5	39	19		0.5	5.7
10	07 to 13	36	17.6	43	17		0.8	6.4
11	14 to 20	39.1	18	31	14		0.4	6.4
12	21 to 27	41.5	19.8	31	16		0.6	7.3
13	28 to 04 **Apr.**	39.5	23.4	46	29		1	6.9

APPENDIX - II

SALIENT FEATURES OF DIFFERENT TURMERIC VARIETIES.

VARIETY	SALIENT FEATURE
1) Alleppey :	Fresh yield : 250 q/ha.; Curcumin percentage : 4.4%; Duration : 8 to 8.5 months; Curing percentage : 19%
2) Krishna :	Parent : Selection made from Cv. Tekurpet; Cured yield : 72 q/ha; Curcumin percentage : 2.8%; Duration : 8 to 8.5 month; Curing Percentage : 16.4%
3) Prabha :	Fresh yield : 370 q/ha.; Curcumin percentage : 6.72%; Duration : 205 days; Curing percentage : 18.5%
4) Pratibha :	Fresh yield : 390 q/ha; Curcumin percentage : 6.2%; Duration : 225 days; Curing percentage : 18.5%
5) Suguna :	Parent : Selection made from Cv. GL Puram-2; Fresh yield : 600 q/ha; Curcumin Percentage : 4.9%; Duration : 190 days
6) Sudarshan :	Parent : Selection made from Cv. Singat; Fresh yield : 540 q/ha.; Curcumin percentage : 7.9%; Curing percentage : 25.3%
7) Suvarna :	Parent.: Culture selection from Peruvannamazhi collections; Fresh yield : 430 q/ha.; Curcumin percentage : 8.7%
8) Waigaon :	Fresh yield : 450 q/ha.; Curcumin percentage : 4%; Duration : 7 to 8 months; Curing percentage : 17%

VITA

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