

PHYSIOLOGICAL INVESTIGATIONS IN TURMERIC
(*Curcuma longa* L.)

DILEEP I. JIRALI

**DEPARTMENT OF CROP PHYSIOLOGY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005**

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DILEEP I. JIRALI

DEPARTMENT OF CROP PHYSIOLOGY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005

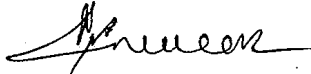
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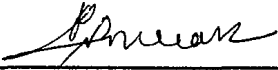
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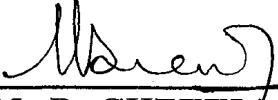
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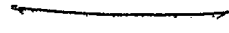
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1.


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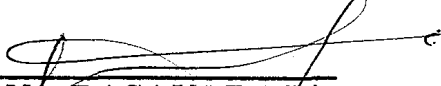
2.


(S. A. PATIL)

3.


(A. N. MOKASHI) 12/10

4.


(N. BASAVARAJ)

*Affectionately Dedicated
To*

*My Beloved Father
Shri Ishwarappa V. Jirali
And Mother
Smt. Kashibai. I. Jirali*

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Introduction

I INTRODUCTION

Turmeric (*Curcuma longa* L.), a herbacious perennial plant, belonging to the family Zinziberaceae, under the order Scitaminae is one of the most valuable spices all over the world. It is cultivated mainly in India, Jamaica, SriLanka, Indonesia, Bangladesh, Taiwan and China. The world production of turmeric is estimated to be about 1,60,000 tonnes, of which, India accounts for 80 per cent (Anon., 1999). It is grown in an area of 140 thousand hectares with an average production of 600 thousand tonnes and with a productivity of 4.29 tonnes per hectare (Anon., 1999). In India, it is mainly grown in the states of Andhra Pradesh (51900 ha), Orissa (19700 ha), Tamil Nadu (15200 ha), Assam (10,000 ha), Maharashtra (7200 ha) and Karnataka (4100 ha) (Anon., 1999). In Karnataka, it is grown in the districts of Mysore, Belgaum, Gulbarga, Bidar and Bijapur.

Turmeric, an ancient and sacred spice of India, is a major rhizomatous spice produced and exported from India. It is a herbacious perennial plant, native to tropical South-East Asia. It forms an important adjuvant in Indian culinary as it lends colour and aromatic flavour to various dishes. Turmeric is widely used as a condiment in the preparation of pickles and curries and as a colouring agent in textile, food and confectionary industries. On account of its flavour and medicinal properties, turmeric is also used in the preparation of cosmetics, soaps, ointments, face creams, tooth pastes etc. (Pujari *et al.*, 1986). Turmeric has long been used in India for the treatment of sprains and inflammatory conditions. The average composition of turmeric is moisture (6.0%), protein (6.5%), ash (6.0%), crude fibre (3.0%), starch (50.0%), fixed oil (3.5%), volatile oil (4.5%) and curcumin (3.1%) (Manjunath *et al.*, 1991).

Among the several spices, turmeric ranks second with regard to its foreign exchange earnings (Rs. 103.87 crores) being only next to chilli (Anon., 1999).

Turmeric is largely grown as a rainfed crop during *kharif* season and is also grown with protective irrigation to a limited scale. It is also known that, turmeric is a long duration (8-9 months) and nutrient responsive crop. The yield per unit area of this crop is low and the genetic potential of the cultivar and the environment are considered as the most important factors affecting the yield.

A large number of cultivars are available and considerable variability exists in this crop with regard to morphological, physiological and yield characters (Aiyer, 1954; Aiyadurai, 1966; Pillai and Nambiar, 1974; Subbarayadu *et al.*, 1976 and Cholke, 1993). In the same way considerable variability also exists with regard to quality and is mainly determined by 'Curcumin' content which is responsible for yellow colouring and resistance to leaf diseases (Reddy *et al.*, 1963 and Patil and Moniz, 1973) and processing qualities (Aiyer, 1954; Rao, 1965 and Rao *et al.*, 1975).

Yield is a complex character and is the resultant of interplay of different yield-related morpho-physiological and biochemical characters. The earlier attempts to improve the yield of turmeric were mostly based on selection for morphological parameters and less importance was given to physiological parameters.

A further increase in the yield potential of turmeric would undoubtedly be assisted by increased understanding of the physiological processes which limit yield most; photosynthesis (source), translocation and sink capacity (Kuo *et al.*, 1977). The relative impact of these limitations are, of course, vary with the variety and growing conditions, and especially with the sequence of events during development and the rhizome formation. In case of high yielding varieties, the source - sink relationship is in equilibrium and this trait assumes greater importance in increasing the productivity.

Variability with respect to physiological traits assists the plant breeders in developing desirable material for breeding programme. The analysis of factors for yield requires consideration of the distribution pattern of dry matter among various plant parts,

growth analysis parameters, photosynthetic rate, harvest index and all other related physiological parameters. Knowledge of interrelationships among yield and its components with various physiological and biochemical characters will help in understanding the yield barrier and further help to boost the productivity.

Several attempts have been made to increase the yield potential of horticultural crops, but they are primarily concerned with the use of fertilizers, pesticides and better management practices coupled with genetic improvement. Almost negligible attention has been given at the basic physiological practices, which limit the crop productivity. According to Nicklele (1978), the plant growth regulators (PGR's) are new generation chemicals and are expected to play an important role in overcoming hurdles in manifestation of biological productivity even in horticultural crops.

Growth regulators are known to improve the physiological efficiency including photosynthetic ability of plants and offer a significant role in realising higher crop yields. The PGR's are also known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates, thereby increasing the productivity.

Though, the plant growth regulators have great potential, its application and accurate assessment, etc. have to be judiciously planned in terms of optimal concentrations, stage of application, species specificity and seasons. In view of their wide spectrum of effectiveness on every aspect of plant growth, even a modest increase of 10-15 per cent could bring about an increment in the gross annual productivity by 10-15 tonnes.

Of late, they are commercially exploited to obtain higher yield and better quality in several fruit and vegetable crops. In root crops, growth regulators were advocated to hasten the rhizome development. The use of synthetic growth regulators to alter source sink relationship and promote better partitioning of dry matter into the rhizome is much emphasized (Phogat and Singh, 1987). However, information regarding the utility of plant regulators in important spice crop like turmeric with underground storage organ is limited.

In India, deficiency of micronutrients has been observed in many types of soils. With the introduction of high yielding varieties, hybrids and the intensive cropping systems, micronutrient deficiency is becoming more and more acute. Plant requirements for macronutrients are met more efficiently, without considering the micronutrients need. To obtain the higher yields, with better quality, a renewed interest on the role of micronutrients in nutrition of turmeric is very essential. The role of micronutrients (Fe and Zn) for enhancing productivity potential in turmeric has been shown by Velu (1988) and Balashanmugam *et al.* (1990) and further they indicated the importance of micronutrients in improving physiological efficiency in turmeric. Importance of micronutrients was illustrated by Beckenbach (1957) in citrus crop at Florida and Brooks (1964) on stuart pecan trees, where they realised significantly higher yields.

The information on the role of micronutrients viz., iron, zinc and manganese on morpho-physiological traits in turmeric is meagre. With this background, the present investigation was carried out with the following objectives,

1. To study the source-sink relationship as influenced by bioregulators and other agro-chemicals in turmeric
2. To study the morpho-physiological traits attributing to higher productivity in turmeric genotypes
3. To study the association of morpho-physiological, growth, biophysical and biochemical parameters in turmeric
4. To identify the plant ideotypes for higher productivity in turmeric
5. To study the effect of micronutrients and bioregulators on yield and quality of turmeric.

Review of Literature

II REVIEW OF LITERATURE

Though India is the world leader in turmeric production and large number of cultivars are being grown in different parts of the country since time immemorial, attempts made so far to improve the productivity potential are rather meagre. Further, the literature pertaining to improvement in yield potential of turmeric through physiological means is scanty. There are many approaches for yield improvement in turmeric among which, the use of growth regulators and micronutrients play an important role.

The role of plant growth regulators (PGR's) in various physiological and biochemical processes in plant is well known which enables a rapid change in the phenotype of the plant within one season to achieve desirable results. The plant growth regulators are known to affect various morpho physiological traits either by reducing the plant height (growth retardant) or by enhancing the growth (growth promoters) and better rhizome development, ultimately yield. In recent years, the use of micronutrients is gaining more importance in improving the yield potential and also the quality of the produce in several horticultural crops. Hence, there is an urgent need to identify suitable growth regulator/micronutrients for improving yield potential in different turmeric genotypes.

This chapter emphasizes the recent work on the use of plant growth regulators and micronutrients in turmeric and related tuber crops and their effect on morphological, physiological, biochemical parameters and yield attributes.

2.1 MORPHO-PHYSIOLOGICAL TRAITS

Cultivars/varieties play an important role in determining the productivity of any crop. According to Shankaracharya and Natarajan (1973), *Curcuma longa*, *C. aromatica*, *C. angustifolia*, *C. amada* and *C. caesia* are the economically important species and of the 30 species of family Zingiberaceae, only *C. longa* and *C. aromatica*

contain yellow colour pigment "curcumin". Pruthy (1976) reported 30 species under the genus *Curcuma* of which *C. longa* is commercially the most important, accounting for about 94.4 per cent of the total area under turmeric cultivation in India and the remaining 3-6 per cent of the area is under *C. aromatica*.

More than 50 turmeric types are known to exist in India belonging to *Curcuma longa* and to a smaller extent to *C. aromatica* and these types go by local names where they are grown (Nair *et al.*, 1982). Existence of wide variability in the existing cultivars with respect to morpho-physiological, growth/vegetative characters, biochemical components, yield/yield components and quality was also reported by several workers (Pillai and Nambiar, 1974; Subbarayadu *et al.*, 1976 and Cholke, 1993).

In turmeric, there exists a wide variation in plant height, among the cultivars which was attributed to genetic and environmental factors. However, a significant positive correlation between plant height and yield potential was also reported in turmeric and hence plant height may be considered as an important morphological index in the prediction of yield potential in turmeric (Cholke, 1993).

Aiyer (1954) and Parry (1962) reported that the plant height of turmeric was found to vary between 50 to 120 cm. According to Pillai and Nambiar (1975) its variation in height was from 75.0 to 81.5 cm in *C. longa* types, and they further opined that higher plant height was associated with higher productivity levels.

Philip (1983) recorded the highest plant height in the cultivar 'Chayapasupa' (41 cm) followed by Amruthapani, Kothapeta (40 cm) and Nandyal (40 cm) whereas the lowest height was recorded in NBPGR/T-17 (21 cm). Satyanarayan and Reddy (1986) also observed a wide variation in plant height among turmeric varieties. While, Pujari *et al.* (1987) recorded the highest plant height in cultivar Krishna (84.73 cm) and lowest in Duggirala (59.87).

Jalgaonkar *et al.* (1988) while evaluating ten varieties under Konkan conditions of Maharashtra, recorded the highest plant height in case of 'Sugandam'

(111.47 cm) followed by Alleppey (107.00cm) and variety waigon recorded the least (80.9 cm). Reddy *et al.* (1989) recorded maximum plant height in PCT-8 (35.7 cm) followed by PCT-15 (34.7 cm) and PCT-12 (34.6 cm). The lowest plant height was found in case of PCT-10 (19.1 cm) among the short duration cultures screened under Andhra Pradesh conditions.

On other hand, Indires *et al.* (1990) in a study under coastal region of Karnataka, recorded the maximum plant height in case of PCT-8 (98.53 cm) and the least in M-221 (46.26 cm). Cholke (1993) while evaluating the cultivars for Northern Transitional Region of Karnataka, recorded highest plant height in case of high yielding genotypes CO-1 (55.22cm) followed by Bidar-4 (53.00cm), Cuddapah (47.60 cm) and the least in low yielding genotype PCT-13 (20.65 cm). Radhakrishnan *et al.* (1995) and Hegde *et al.* (1997) also showed significant differences for plant height ranging from 30.7 to 45.0 cm among diverse turmeric genotypes. The present reviews clearly indicates a wide variability for plant height among the genotypes and it depends on cultivars and climatic conditions.

A wide genotypic variability exists among the genotypes for number of tillers per plant. Pillai and Nambiar (1975) observed 2-3 tillers in 'longa' types. Subbarayudu *et al.* (1976) reported that there is no significant differences in tiller production among short and medium duration types whereas, marginal differences was observed in long duration types. Shah *et al.* (1982) reported a range of 3.7 to 5 tillers per plant in case of CO-1.

According to Philip (1983) among the different types studied, Mannuthy Local recorded maximum number of tillers per plant (3.40) followed by 'Kasturi Tanaka' (3.05) and Duggirala (2.95) and the lowest was found in Dindrigam (2.15) thus indicating a wide variability for this trait. Satyanarayana and Reddy (1986) also observed a variation in the number of tillers per plant and clone CLS.3D recorded significantly higher values (3.2) and the least was found in C 11.326 (1.2). However, Philip and Nair

(1983), Jalgoankar *et al.* (1988) and Indiresk *et al.* (1990) observed no significant differences in tiller production among the various turmeric types studied.

Reddy *et al.* (1989) noted significant differences in tiller production among the short duration cultures. The culture PCT-8 recorded the maximum number of tillers (1.4) followed by PCT-13 (1.3), PCT-15 (1.3) and the least number of tillers was found in Kasturi (0.4).

Cholke (1993) recorded significant differences in tiller production. The cultivar Rajapuri produced maximum number of tillers (7.15) followed by Bidar-1 (7.00), Bidar-4 (6.70) and least number of tillers was found in PCT-14 (0.85) and PCT-13 (0.86). Further, he also observed a positive and non-significant correlation between yield and number of tillers per plant.

In general, leaf is considered as an important functional unit of plant which contributes to the formation of yield. Number of leaves had positive and strong association with rhizome yield at both genotypic and phenotypic levels in turmeric (Reddy *et al.*, 1988) and thus indicated a strong influence of leaf number with rhizome yield in turmeric. Rao *et al.* (1975) observed 8 to 9 leaves per plant in 'Dindigram' (aromatic type). While, Pillai *et al.* (1976) reported that the 'longa' type possessed 9-12 leaves per plant.

Shah *et al.* (1982) recorded 24.4 to 31.6 leaves per plant (clump) in CO-1 turmeric cultivar. Philip (1983) noted the highest number of leaves per plant (21.0) and per tiller (7.6) in Duggirala, Dingrigam (13.4) and Mannuthy Local (5.6) recorded the least number of leaves per plant.

Philip and Nair (1983) indicated that the number of leaves per tiller varied between 4.3 (Armoor C11-324) and 6.9 (G. L. Puram) and the total number of leaves per plant varied between 11.2 (Ca-89) and 20.7 (Mannuthy Local) under Kerala conditions. Pujuri *et al.* (1987) reported that variety Tekurpeta (improved) recorded the highest

number of leaves per plant (8.66) followed by Erode (8.50) and Krishna (8.50) and the least in case of Sugandham (8.13) in Sangli district of Maharashtra.

Jalgaonkar *et al.* (1988) observed a significant variation in the production of leaves per plant. Maximum number of leaves per plant were recorded in Erode (18.70) followed by Alleppey (17.30), Rajapuri (14.70) and the least in Waigon (11.70) under Konkan conditions of Maharashtra. Reddy *et al.* (1989) observed the highest number of leaves per plant in PCT-11 (8.2) closely followed by PCT-8 (8.0), PCT-12 (8.0) and the least in PCT-5 (7.1) among the short duration types.

Indiresch *et al.* (1990) recorded the maximum number of leaves per plant in Sugandham (24.88) followed by Duggirala (24.66), and least in PCT-8 (16.59) under Coastal Region of Karnataka. Hegde (1992) obtained the highest number of leaves per plant (main shoot) in cultivar Cuddapah and Bidar (9.10) followed by Rajapuri (8.96), and the least in Moovattupuzha (6.96). Cholke (1993) noticed maximum number of leaves per plant in Rajapuri cultivar (33.20), followed by Cuddapah (32.75), Amalapuram (32.20) and the least in case of PCT-14 (8.40) and PCT-13 (8.85) under northern transition region of Karnataka. Radhakrishnan *et al.* (1995) and Hegde *et al.* (1997) showed significant differences for number of leaves per plant and this parameter varied from 6.33 to 28.33 leaves per plant.

2.2 DRY MATTER PRODUCTION AND ITS PARTITIONING

Total dry matter production and its partitioning is the integral part of the growth over the entire growing period and is related to rhizome yield. The total dry matter increased from early vegetative phase to maturity stage and the per cent increase was more between 90 to 150 DAS (Mannikeri, 1996). He further indicated that, the total dry matter production differed significantly at 90, 150 DAS and at harvest. Similarly, Cholke (1993) studied the dry matter production and distribution in ten cultivars of turmeric and indicated significant differences in dry matter accumulation at various stages of crop growth. At maturity, the dry matter accumulation was highest in Cuddapah

(8.35 t ha⁻¹) followed by Amalapuram (7.52 t ha⁻¹) and Rajapuri (7.14 t ha⁻¹). Hegde (1992) also indicated that the dry matter production and distribution differed significantly among sixteen turmeric genotypes.

Subramanian *et al.* (1988) indicated that the genotype BSR-1 recorded significantly higher dry matter production which was due to cumulative effect of plant height, number of leaves, leaf area and leaf area index. Sivaraman and Palaniappan (1995) showed a progressive increase in the dry matter production from 60 to 270 DAP. The dry matter production at 60 DAP was 0.73 t ha⁻¹ and reached maximum value (11.77 t ha⁻¹) at maturity. They further indicated that the per cent increase in dry matter production was more between 60 to 150 DAP as compared to other stages.

2.3 GROWTH PARAMETERS

Growth analysis is a physiological probe on the development of the crop in a chronological sequence to elucidate and account the causes for differences in yield through the events that occurred at different stages of growth (Krishnamurthy *et al.*, 1973).

Leaf area fairly gives a good idea of the photosynthetic capacity of the plant. Several workers have reported a significant variation in leaf area among diverse turmeric germplasm (Pillai *et al.*, 1976, Philip and Nair, 1983; Cholke, 1993 and Mannikeri, 1996). The importance of leaf area in the determination of yield potential in turmeric has been clearly shown by Philip and Nair (1983) who indicated a significant positive association between leaf area and rhizome yield.

There is a wide variation in leaf area which is attributed to variation in length and breadth of leaf. Shankaracharya and Natarajan (1973) observed variation in leaf length among the genotypes. Pillai *et al.* (1976) observed a wide variation in leaf length and it varied from 38 to 44 cm and leaf breadth from 15 to 17 cm in 'longa' types.

Philip and Nair (1983) reported a significant variation in leaf area from 696.6 cm² (Armoor C11-324) to 1214.3 cm²/plant (Amruthapani) among the 19 types

studied in Kerala. Pujari *et al.* (1987) recorded larger leaves with greater breadth at the centre (18.53 cm) and leaf area (1177.19 dm² per plant) in improved variety Tekurpeta.

Jalgaonkar *et al.* (1988) observed a significant variation in leaf area among the different cultivars of turmeric. The cultivar 'Salem' had the maximum leaf area (433.23 cm²) followed by Tekurpet (423.89 cm²) and Krishna (421.32 cm²) and the least was in case of Waigon (256.23 cm²/plant). While, Reddy *et al.* (1989) recorded maximum leaf area in PCT-11 (1908.3 cm²), followed by PCT-12 (1606 cm²), PCT-8 (1600 cm²) and lowest in case of PCT-13 (728.7 cm²) and PCT-10 (387.2 cm²).

Cholke (1993) observed significant variation in leaf area in different cultivars. The cultivar Bidar-4 recorded maximum leaf area (1653.21 dm²) followed by Rajapuri (1641.44 dm²), BSR-1 (1601 dm²) and the leaves were smallest in case of PCT-13 (253.42 dm²) and PCT-14 (238.17 cm²). Radhakrishnan *et al.* (1995) also indicated significant differences for leaf area and it ranged from 142 to 333 cm² plant⁻¹. These reports indicated a wide variability for leaf area among different genotypes of turmeric. Several research workers have indicated that, leaf area index (LAI) varied significantly among the turmeric genotypes (Philip and Nair, 1983; Pujari *et al.*, 1987; Reddy *et al.*, 1989, Cholke, 1993 and Mannikeri, 1996). Cholke (1993) showed that among the turmeric genotypes, the LAI was significantly higher in Bidar-4 followed by Rajapuri and BSR-1.

Subramanian *et al.* (1988) showed a significant variation in LAI among the genotypes and the genotype BSR-1 possessed significantly higher LAI among the genotypes. Sivaraman and Palaniappan (1995) indicated that in turmeric, the LAI increased from 60 DAS (0.414) to 210 DAS (5.984) and decreased towards maturity (4.617). Similarly, Mannikeri (1996) also showed a progressive increase in LAI upto 150 DAS (2.45) in cultivar Amalapuram and LAI decreased at 180 DAS (2.33). Hegde *et al.* (1997) also observed significant differences for LAI among the genotypes and it ranged from 0.75 to 6.22.

Relative growth rate (RGR) represents the increase in dry matter per unit of dry matter already present per unit time. Subramanian *et al.* (1988), Cholke (1993) and Sivaraman and Palaniappan (1995) showed significant variation in RGR values among diverse genotypes of turmeric. Similarly, Mannikeri (1996) indicated that the RGR values decreased with the advancement of the crop growth in turmeric and he further showed significant differences for RGR values among various genotypes.

The average daily increment of stand biomass is an important characteristic and is called either the rate of dry matter production or crop growth rate (Watson, 1952). It is a widely used character for estimating production efficiency of crop stand and enables to make comparisons between the aspects of study. Subramanian *et al.* (1988), Cholke (1993), Sivaraman and Palaniappan (1995) and Mannikeri (1996) found significant variation in CGR values among the turmeric genotypes. Further, they also indicated that CGR values increased upto certain stage and decreased towards maturity due to senescence.

Net assimilation rate (NAR), synonymously called as unit leaf rate expresses the rate of dry weight increase at any instant on a leaf area basis with leaf representing an estimate of the size of the assimilatory surface area. Gregory (1926) suggested the use of this parameter in the analysis of growth, thereon used by several workers in different crops. In turmeric genotypes the NAR values were significantly higher during early stages of growth and declined towards maturity due to senescence and shading of leaves (Cholke, 1993; Sivaraman and Palaniappan, 1995 and Mannikeri, 1996). Cholke (1993) and Venkatesh (1994) also indicated genotypic variability for NAR values at different growth stages.

The specific leaf weight is an indicator of leaf thickness (Yoshida, 1972). Cholke (1993) found significant differences for SLW among diverse turmeric genotypes. However, the literature pertaining to SLW among the turmeric varieties is very meagre.

The leaf weight ratio (LWR) indicates the ratio of leaf dry matter to the total dry matter produced. The LWR was more during early stages and decreased towards maturity due to reduced contribution of leaf dry matter towards total dry matter (Cholke, 1993). He further showed significant variation for LWR among the varieties.

Leaf area ratio (LAR) is the leaf area per unit of plant dry weight and is an indicator of photosynthetic capacity per unit of respiring and growing tissue (Wallace *et al.*, 1972). Cholke (1993) and Mannikeri (1996) found wide variation for LAR among the genotypes tested.

Leaf area duration (LAD) indicates total amount of green leaf area present over a period of time and is an important growth parameter which influences the crop productivity, since the productivity depends on the active assimilatory surface area. Several workers have also shown significant differences in LAD among turmeric cultivated (Subramanian *et al.*, 1988; Reddy *et al.*, 1989; Cholke, 1993; Venkatesh, 1994 and Mannikeri, 1996).

The biomass duration (BMD) indicates the maintenance of dry matter over a period of time and is essential for prolonged supply of photosynthates to the developing sinks. A progressive increase of BMD was observed with an advancement of crop growth (Venkatesh, 1994 and Mannikeri, 1996). Further, they have also showed significant differences for this trait in turmeric.

2.4 BIOPHYSICAL PARAMETERS

The relationship between crop growth rate and the rate of photosynthesis is well known. The rate of photosynthesis depends on carbon diffusion process into the site of carbon assimilation and the diffusion process in turn depends mainly on stomatal and mesophyll conductances. Wong *et al.* (1978) revealed that stomatal conductance was dependent on intercellular CO₂ concentration, irradiance and assimilation rate.

$$\text{According to Sharkey (1985), } G_s = \frac{A \times P}{C_a - C_i}$$

Where, G_s is the stomatal conductance for carbon dioxide diffusion, A is the carbon dioxide assimilation rate, P is the atmospheric pressure, C_a and C_i are the ambient and internal carbon dioxide concentrations, respectively. It is clear that more the stomatal conductance, more is the assimilation rate. Stomatal conductance was found to correlate well with photosynthetic capacity in sunflower and sorghum leaves (James Jacob, 1984).

Leaf photosynthesis in soybean differed markedly due to differences in stomatal conductance (Dornhoff and Shibles, 1970). A significant correlation was observed between stomatal frequency and photosynthetic rate ($r = 0.92$) and transpiration rate ($r = 0.86$) by Yoshida (1976). Stomatal frequency is always positively correlated with conductance. Yoshida (1976) found that more the stomatal aperture size, more was the photosynthesis and hence, more yield. Wong *et al.* (1978) observed feed back control between assimilation rate and stomatal conductance. Seetharama *et al.* (1978) reported that the stomatal conductance was dependent on leaf water potential at the time of water stress.

Rao and Ghildiyal (1985) observed that the rate of photosynthesis in greengram attained its peak at 28 days after sowing and decreased subsequently. On the otherhand, Panwar *et al.* (1990) found that the rate of photosynthesis in greengram was higher at 50 days after sowing as compared to 60 days after sowing.

Venkateswarlu and Balasubramanian (1993) studied various biophysical parameters, i.e., rate of photosynthesis, transpiration and stomatal conductance among eight greengram cultivars (both traditional and high yielding) at different growth stages under rainfed condition and concluded that all the above biophysical processes showed a relatively higher rate during early pod growth stage and declined subsequently as the crop advanced to maturity.

2.5 BIOCHEMICAL PARAMETERS

2.5.1 Chlorophyll content

The genotypic variation in chlorophyll content has been reported in various crops (Singh *et al.*, 1985 and Chandrababu, 1990). Genotypic differences in chlorophyll a, chlorophyll b and total chlorophyll among twenty four cultivars of soybean (different yield groups) have also been reported (Koti, 1997). He also observed an increasing trend of these parameters from 30 to 60 days after sowing and decreased thereafter irrespective of the cultivars.

Rao and Ghildiyal (1985) found that chlorophyll a, chlorophyll b, chlorophyll a:b ratio and total chlorophyll contents reached its maximum at 28 days after sowing and decreased subsequently with an advancement of age of the crop in greengram.

Singh *et al.* (1994) found an increasing trend of both chlorophyll 'a' and chlorophyll 'b' in greengram upto 45 days after sowing and declined significantly at 60 days after sowing. Higher chlorophyll content was associated with higher yield in some promising hybrids of greengram and blackgram (Jayapragasam *et al.*, 1998).

2.5.2 Nitrate reductase activity (NRA)

Nitrate reductase, the key enzyme in nitrogen metabolism in higher plants is regulated by various environmental factors apart from its own substrate, nitrate. It is also believed that the reduction of nitrate to nitrite by nitrate reductase is the rate limiting process for the utilization of nitrogen in the form of nitrate. The peak activity of nitrate reductase coincides with the maximum chlorophyll content thereby complementing the carbon nitrogen balance in the plant.

Li *et al.* (1993) found a wide variation in nitrate reductase activity among soybean cultivars and further reported that the young leaves possessed higher activity of the enzyme than the older leaves. Khan (1994) showed that the NRA was more in shoots

than roots under both normal condition and as well as under salt stress in leguminous crops like lentil, chickpea and pea. Thakur and Panwar (1997) observed genotypic differences in leaf nitrate reductase activity among greengram genotypes (PS 16 and PUSA 105).

2.6 YIELD AND YIELD COMPONENTS

Besides the various vegetative characters, number of mother rhizomes, primary and secondary fingers, girth, weight and length of rhizomes and fingers per clump are important components in turmeric which contribute towards the yield.

Aiyer (1954) reported that while the yield of cured turmeric varied from 2 to 7 tonnes per hectare, the average yield was around 2.5 to 3.0 tonnes per hectare. Pillai and Nambiar (1974) obtained higher yields in Mydukur C11-326, Sugandham C11-328, Avanigadde C11-324, Kasturi, Amalapuram and Armoor among the 41 types of turmeric evaluated for their yield performance. According to Shankaracharya and Natarajan (1974), fresh yield of turmeric varied from 16.8 to 22.4 tonnes per hectare under irrigated conditions. Rao *et al.* (1975) recorded maximum range of yield from Mydukur C11-326 and Tekurpeta C11-327 (25-37 tonnes of fresh yield ha⁻¹) followed by Amruthapani Kothupeta C11-317 (25-35 t ha⁻¹) to Armoor C11-324 and Dindrigam C9-69 (15-20 t ha⁻¹) among the 100 types studied. Radhakrishnan *et al.* (1995) and Hegde *et al.* (1997) showed significant differences for yield potential in turmeric genotypes.

Pillai and Nambiar (1975) obtained the highest yield in Karhadi local followed by Kasturi and Tekurpeta among the 42 types of turmeric studied. In another trial, they obtained the higher yields in Nandyal type followed by Sugandham C11-328 and Rajapuri local and thus indicated wide variability for this trait.

Philip *et al.* (1979) obtained highly significant variations among 19 turmeric cultivars in respect of fresh rhizome yield. Mannuthy local was the best among the cultivars with respect to rhizome yield. Dhandar and Varde (1980) studied the

performance of 15 selected clones of turmeric under Goan conditions for two years and found that CI-24 and CI-15B recorded the highest fresh rhizome yield of 45 and 42 tonnes ha⁻¹, respectively, and CI-3 gave the lowest yield (24 t ha⁻¹). Satyanarayan and Reddy (1986) identified three high yielding cultivars viz., Cls. 9A (27.08 t ha⁻¹), Cls.2A (26.99 t ha⁻¹) and Ca.66J (25.91 t ha⁻¹). The poor yielding cultivars were Cls.3D, Cls.8D and Cls. 21A (14.04 - 14.14 t ha⁻¹).

Pujari *et al.* (1987) assessed eight *Curcuma longa* cultivars and observed that the cv. Krishna gave the highest fresh rhizome yield (42.72 t ha⁻¹) followed by cv. Duggirala (32.92 t ha⁻¹) and lowest yield was found in case of Rajapuri (21.7 t ha⁻¹).

Jalgaonkar *et al.* (1988) reported that among different varieties of turmeric studied under Konkan conditions of Maharashtra state, Krishna produced the highest fresh turmeric yield of 53.86 t ha⁻¹ followed by Waigon (48.93 t ha⁻¹), while the lowest in Kasturi (31.56 t ha⁻¹). Fresh and cured turmeric yield did not follow the same trend mainly due to the differences in curing percentage of different cultivars.

Among the short duration cultures studied under Andhra Pradesh conditions by Reddy *et al.* (1989), it was found that cultures PCT-13 and PCT-14 recorded highest fresh (28.04 t ha⁻¹ and 26.71 t ha⁻¹) and cured yield (5.69 t ha⁻¹ and 5.43 t ha⁻¹), respectively. Nandi (1990) obtained highest fresh rhizome yield of 27.0 t ha⁻¹ with PTS-25 followed by Cls.9 (24.6 t ha⁻¹).

Indiresb *et al.* (1990) reported that among different cultivars studied under coastal conditions of Karnataka, cultivar PCT-8 gave the highest yield (32.29 t ha⁻¹) followed by Waigon (31.64 t ha⁻¹) and it was lowest in the case of M-211 (4 t ha⁻¹). The highest quantity of cured turmeric was recorded in PCT-8 (6.5 t ha⁻¹) and Waigon (6.2 t ha⁻¹) and the lowest in M-211 (1.38 t ha⁻¹). Hegde (1992) observed the highest fresh rhizome yield in case of Cuddaph (22.19 t ha⁻¹) followed by Bidar (21.69 t ha⁻¹) and the lowest in Moovattupuzpha (3.73 t ha⁻¹). Fresh and cured yield did not follow the same trend due to their differences in the curing percentage.

Cholke (1993) from the experiments involving 10 cultivars under Dharwad conditions reported that cultivar Cuddapah recorded highest fresh yield (33.37 t ha^{-1}) followed by Amalapuram (31.44 t ha^{-1}), Bidar-1 (26.36 t ha^{-1}) and the lowest was in PCT-13 (10.87 t ha^{-1}). However, the cured yield was maximum in case of Amalapuram (7.30 t ha^{-1}) followed by Cuddapah (6.34 t ha^{-1}), Bidar-1 (5.75 t ha^{-1}) and lowest was in case of PCT-13 (2.26 t ha^{-1}).

Among the yield components, the number of fingers are important in the determination of yield potential in turmeric. Pujari *et al.* (1987) noticed that the variety Erode recorded the highest number of fingers per plant (20.33) whereas lowest number was found in Rajapuri (11.20). They observed no significant differences between the cultivars in respect of length of fingers, the highest being with 'Krishna' (10.83 cm).

Nandi (1990) noticed that CLS-9 produced the highest number of fingers per plant (18.93) closely followed by PTS-25 (18.87) and PTS-38 (15.67), and it was lowest in the case of 'local' (5.00). He observed longest finger length of 9.11 cm in the case of CLS-1 and shortest in CLS-2 (6.75 cm). Further he noticed largest mother rhizome in 'CLS-9 and smallest in 'CLS-15'. 'VK-5' produced the fingers of greater thickness (9.11 cm girth) while CLS-15 produced the fingers of lesser thickness (6.29 cm girth).

Muthuswamy and Shah (1982) found that the length and circumference of mother rhizomes were similar in both 'Salem' and 'Erode' turmeric types but finger rhizomes were much larger in 'Salem'. Philip and Nair (1983) noticed that the length of mother rhizome varied from 8.4 cm (Dindrigam Ca-69) to 12.6 cm (Rajapuri) and the girth at the centre varied from 11.5 cm (Armoor C11-324) to 17.3 cm (Kodur). They also observed that the number of primary fingers per plant varied from 4.2 (Tekurpeta) to 7.2 (Mannuthy local) and their girth at the centre varied from 7.1 cm (Dindrigam) to 10.5 cm (Chayapasupa). 'Mannuthy local' type recorded more number of secondary fingers per plant (20.9), whereas, G.L. Puram produced less number of secondary fingers (8.30) per plant and their girth varied from 5.10 cm to 7.40 cm.

Indires *et al.* (1990) found largest mother rhizomes in PCT-8 and smallest in Duggirala. Hegde (1992) noticed largest mother rhizome in Rajapuri and smallest in Moovattupuzha. Cholke (1993) recorded significant variation in the number and circumference of mother rhizomes. The cultivar Bidar-4 produced more number of mother rhizomes (3.85) followed by CO-1 (2.87), Bidar-1 (2.70), Cuddapah (2.65), and the lowest number in PCT-13 (1.10). Maximum circumference was observed in PCT-8 (11.70cm) followed by Rajapuri (11.62cm), Bidar-1 (11.24cm) and minimum circumference was listed in PCT-13 (9.42cm), Amalapuram (9.26 cm) and PCT-14 (9.21 cm).

The parameters associated with primary and secondary fingers are very important factors for yield determination in turmeric. Philip and Nair (1983) reported that the number of primary fingers per plant varied from 4.2 (Tekurpeta) to 7.2 (Mannuthy Local) and their girth at the centre varied from 7.1 (Dindrigam) to 10.5 cm (Ckayapasupa). Further, they noticed that the number of nodes per primary finger varied from 9.1 (Rajapuri) to 11.9 (Kuchupudi) and the internodal length varied from 0.79 cm (Duggirala) to 1.11 cm (Dindrigam CA-69) in different cultivars.

Jalgaonkar *et al.* (1988) observed no significant differences in the weight of primary fingers per plant. But they recorded significant variation in the length ranging from 5.62 cm (Salem) to 9.04 cm (Krishna). The girth was however maximum in Kasturi (8.32 cm) and minimum in the case of Erode (6.19 cm).

Reddy *et al.* (1989) recorded maximum number of primary fingers in PCG-8 (8.2) followed by PCT-5 (7.3), PCT-8 (Suvarna-3) (6.2) and minimum in PCT-12 (4.5) and PCT-13 (5.2) among various short duration cultivars.

Indires *et al.* (1990) recorded highest number of primary fingers per plant (8.61) in PCT-8 followed by Chintamani (7.33) and least in case of Duggirala (4.16). They also observed longest primary fingers in PCT-8 (9.91 cm) and shortest in case of Erode (5.50 cm). While the girth of primary fingers was maximum in PCT-8 (10.08 cm) it was least (6.24 cm) in Duggirala.

According to Hegde (1992), variety BSR-1 recorded maximum number of primary fingers (13) and the least in Moovattupuzha (3.26). Further, he noticed longest finger length of 9.07 cm in Amalapuram and shortest in 46-T (3.17 cm). While the girth of fingers was maximum in Rajapuri (7.86 cm) it was least in Moovattupuzha (5.03 cm).

Cholke (1993) recorded maximum number of primary fingers (9.80) in the cultivar Amalapuram followed by Cuddapah (8.85) and Bidar (8.80) and the lowest in PCT-13 (3.20). Further, the length and girth of primary fingers varied from 5.77 cm (Rajapuri) to 9.22 cm (Cuddapah) and 6.72 cm (BSR-1) to 8.51 cm (Rajapuri), respectively under Dharwad conditions.

Philip and Nair (1983) noticed significantly higher number of secondary fingers per plant in Mannuthy Local (20.9) followed by Chayapasupa (19.8), Armoor (19.8) and the lowest number was found in G.L. Puram (8.3) and Armoor C11-24 (7.9). The girth of the fingers varied from 5.1 cm to 7.4 cm, and the internodal length varied from 0.73 to 1.01 cm among 19 cultivars studied.

Indiresh *et al.* (1990) observed maximum number of secondary fingers in PCT-8 (9.51) followed by Allepy (8.83) and it was least in Kasturi (3.99). The length of secondary fingers varied from 4.00 cm (Erode) to 7.50 cm (PCT-8). According to Hegde (1992), highest number of secondary fingers was produced in Bidar (19.40) and the lowest in case of moovattupuzha (4.60).

According to Cholke (1993), cultivar BSR-1 (19.45) recorded significantly higher number of secondary fingers followed by PCT-8 (18.25), Cuddaph (18.10) and the least in PCT-13 (9.55) and PCT-14 (8.10). Further, the length of fingers varied from 3.04 cm (Rajapuri) to 6.30 cm in PCT-14 and the girth of fingers varied from 4.87 cm (PCT-14) to 6.37 cm (Amalapuram).

2.7 QUALITY

2.7.1 Processing and curing percentage

Curing percentage of turmeric depends upon the type of cultivars/varieties and the conditions under which they are grown. Sambasivarao (1949) reported that the mean production of cured produce to raw rhizome was 1:4 in Cuddapah and Guntur tracts of Andhra Pradesh.

The Central Food Technological Research Institute, Mysore has standardised the curing of turmeric by boiling with lime water or sodium bicarbonate solution (Aiyadurai, 1966; Pruthy, 1976). According to Natarajan and Shankaracharya (1974), boiling of turmeric is essential to reduce the drying time and to gelatinise the starch. When mechanical driers were used, the drying temperature should be kept within 50-60°C as there was loss in volatile substances beyond this temperature. The stage at which boiling is to be stopped was very critical for good quality turmeric as the over cooking spotted the color and increased percentage of broken pieces during subsequent polishing.

Aiyer (1954) obtained 17 to 25 per cent of curing in turmeric depending upon the quality and maturity of the rhizomes. The percentage of curing varied with groups of turmeric types, the highest values being recorded by early duration '*aromatica*' types and the lowest by medium duration types whereas the long duration '*longa*' types recorded medium values (Sarma and Krishnamurthy, 1965 and Subbarayudu *et al.*, 1976). Sarma and Krishnamurthy (1965) observed that the curing percentage of turmeric tended to decrease with an increase in moisture content of the raw rhizomes and there was appreciable increase in the relative density of fresh rhizomes on curing. According to Subbarayudu *et al.* (1976), the curing percentage of turmeric varied from 26.4 to 37.4 in short duration, 18.1 to 20.8 in medium and 15.7 to 23.8 in long duration types.

Rao (1965) and Aiyadurai (1966) opined that the curing quality of turmeric was largely a varietal character and the curing percentage was found to vary from 14.0 to

26.5 per cent. Pillai and Nambiar (1975) obtained higher curing percentage in Vontimitta, Kadur, Dahgi, Jahedi, C9-67 and Amalapuram among the 29 types studied. Rao *et al.* (1975) recorded the highest out-turn of cured produce when curing of fresh rhizome was done within 10 days after harvest and that the mother rhizome required a little longer time for cooking than the fingers. They recorded higher curing percentage in short duration 'aromatica' types, viz., Amalapuram Ca-73 (35.2%), and Dindrigam Ca-69 (26.7%) and the lowest in Armoor C11-324 (17.6%). Shriramarao (1980) conducted experiment with commercial varieties of turmeric in Andhra Pradesh. He obtained highest curing percentage in clone No.69 (26.7%), a promising selection from Tekurpeta, clone No. 325 (21.88%) a selection from Duggirala type and least curing percentage in clone No. 324 (17.6%), which is a Armoor type.

Shaha *et al.* (1982) obtained a curing percentage of 19.5 per cent in Co-1 turmeric. Patil and Sapkal (1983) reported highest curing percentage in cultivar Erode (19.15%) and lowest in Kasturi (14.00%). Philip and Nair (1983) observed a curing percentage varying from 14.06 to 28.17 among the 19 cultivars they studied. Pujari *et al.* (1987) studied different turmeric varieties and obtained the highest curing percentage in Salem (19.31%) followed by Erode (19.15%) and Allepy (19.00%). The low curing percentage was recorded in case of 'Krishna' and Tekurpeta (improved) (16.41% each). The yield of cured produce per hectare was found to be higher in cultivars Krishna (7.01 t ha⁻¹), Salem (6.13 t ha⁻¹), Sugandham (6.08 t ha⁻¹) and Duggirala (6.02 t ha⁻¹). The cured yield per hectare was low in cultivar Rajapuri (4.06 t ha⁻¹).

Reddy *et al.* (1989) recorded curing percentage to vary from 20.3 (PCT-14 and PCT-10) to 62.2 (PCT-8 and PCT-18) among short duration cultures studied under Andhra Pradesh conditions.

Cholke (1993) obtained higher curing percentage in cultivar PCT-8 (24.6%) followed by Amalapuram (23.24%), BSR-1 (22.42%) and the least was found in Rajapuri (19.20%) among the 10 cultivars tried under Dharwad conditions. Similarly,

Hegde *et al.*, (1997) indicated that among twelve turmeric genotypes, the curing per cent ranged from 18.47 to 28.4.

2.7.2 Curcumin content

Besides obtaining higher yields, superior quality of the produce is also important for export and to fetch premium price in the international market. Quality of the produce is largely determined by the presence of principle colouring pigment 'curcumin' besides the other characters. Rosengarten (1969) reported that 'fingers' had the best quality as compared to rounds and splits. Lewis (1973) found distinct differences in quality, quantity of oil and oleoresin in different types of turmeric grown in India. Chaurasia *et al.* (1974) reported that turmeric grown in hills was of better quality than that of the crop grown in the plains. Pruthy (1976) described the quality attributes of the commercial produce to be its colour materials (fingers and rhizomes), bulk density, length and thickness of finger and aroma.

According to Lewis (1973), Alleppey turmeric contained 6.5 per cent of curcumin as against 3-4 per cent in other varieties. Shankaracharya (1974) observed 0.2 to 3.8 per cent of curcumin in dried rhizomes of turmeric. Mathai (1974) recorded maximum curcumin content in Vontimitta (8.1%) and the lowest in Nandyal (3.0%) among the 38 types studied.

Chaurasia *et al.* (1974) conducted a study on curcumin content involving eight varieties of turmeric and reported that curcumin content varied among different cultivars, and curcumin content in Alleppey fingers (5.2%) and Alleppey bulbs (4.8%) was the highest compared to other varieties.

The agro climatic conditions were also found to influence the curcumin content. Rao *et al.* (1975) noticed a variation of 1.24 to 3.87 per cent in curcumin content among seven turmeric types grown in Andhra Pradesh. Krishnamurthy *et al.* (1976) recorded a variation of 1.8 to 5.4 per cent in curcumin content among 12 turmeric cultivars with highest in Alleppey turmeric. Pillai *et al.* (1976) noticed a variation of

8.9 to 14.5 per cent in curcumin content among 15 types of turmeric grown under Kasargod conditions and a higher content of curcumin in '*longa*' types than of '*aromatica*' types.

Murulidharan and Ramankutty (1976) obtained highest curcumin content from Alleppey (6.2%) followed by Etamulaka (5.63%), Kharadi local (4.35%), Tanuka (4.22%) and Wynad local (4.17%) among 20 selected clones they studied. Muthuswamy and Shaha (1982) stated that finger rhizome curcumin content of Salem type was 4.75 per cent as compared to 3.9 per cent in Erode type. Shaha *et al.* (1982) recorded a curcumin content of 2.65 to 3.13 per cent in CO-1 turmeric.

Philip (1983) noted significant differences in curcumin content among 32 varieties. The highest curcumin content was found in Mannuthy Local (7.58%) and lowest in Amalapuram (3.0%). While, Pujari *et al.* (1987) recorded high curcumin content from Salem (4.8%) followed by Alleppey (4.4%) and Duggirala (3.8%). Hegde (1992) obtained maximum curcumin content of 6.40 per cent in Moovattupuzha, followed by CLS No. (11)A (6.36%) and the lowest in Bidar (2.37%). Cholke (1993) studied 10 turmeric cultivars under Dharwar conditions and reported that the cultivar PCT-8 (8.16%) recorded highest curcumin content followed by PCT-14 (7.45%), PCT-13 (4.73%) BSR-1 (4.16%) and the lowest was in Bidar-4 (2.45%) and cuddaph (2.48%). Radhakrishnan *et al.* (1995) and Hegde *et al.* (1997) studied genotypic variation for curcumin content and reported that the per cent curcumin content ranged from 2.43 to 8.08 and suggested that the curcumin content is specific to genotypes.

2.8 **ROLE OF MICRONUTRIENTS ON PHYSIOLOGICAL ASPECTS IN TURMERIC**

The micronutrients play an important role in determining the yield potential of crop plants. The importance of micronutrients particularly Fe, Zn and Mn has been emphasized by Reddy and Raj (1975) in blackgram, Balashanumugam *et al.* (1990) and Tiwari *et al.* (1995) in turmeric. The application of micronutrients bring about profound

changes in various metabolic processes within the plant system and thereby, influence the yield potential in crop species (Sarma, 1995 and Tripathy *et al.*, 1999 and Prabhu, 2000).

Roy *et al.* (1992) opined that, the literature pertaining to the effect of micronutrients viz., Zn, Fe and Mn on morpo-physiological traits and yield in tuber crops is very meager. Turmeric (*Curcuma longa* L.) is an important spice of India and responds to Zn application (Shukla and Hansraj, 1980). The magnitude of response to Zn within plant species and even cultivars is quite variable (Safaya and Gupta, 1979). Velu (1988) found that the application of 1.0 per cent FeSO_4 foliar spray on 2, 3 and 4th month resulted in 46.8 per cent increase in rhizome yield (Fresh weight basis) followed by the application of 0.5 per cent ZnSO_4 as foliar spray on 2, 3 and 4th month which registered an improvement to the tune of 33.1 per cent as compared to control.

Balashanmugam *et al.* (1990) indicated the importance of zinc and iron nutrition in turmeric and showed that the deficiency generally occurs in early vegetative stage causing intervienal chlorosis, bronzing of leaves, drying of margins and stunted growth. Further they showed that the soil application of micronutrients particularly Zn and Fe was more effective in increasing the yield potential in turmeric. Among the treatments, the highest yield was found in the treatment which received 30 kg FeSO_4 ha⁻¹ as basal dose followed by application of Zn @ 15 kg ZnSO_4 ha⁻¹. Further they indicated that the increase in rhizome yield was due to increased yield of mother rhizomes and finger rhizomes.

Roy *et al.* (1992) found that among the various micronutrients application of zinc @ 0.3 per cent at 45 and 75 DAP significantly increased the plant height and number of leaves in ginger followed by treatment with Fe @ 0.2 per cent as compared to control. Further, they also indicated a significant improvement in number of tillers plant⁻¹ due to the application of Zn @ 0.3 per cent and Fe @ 0.2 per cent. Further, they found significant increase in rhizome yield of ginger due to the application of Zn @ 0.3 per cent sprayed at 45 and 75 DAP and the per cent increase in yield was to the tune of

65 per cent followed by application of Fe @ 0.2 per cent which showed an increase of 35 per cent as compared to control. Tiwari *et al.* (1995) studied the effect of foliar application of zinc sulphate (0.3%) at 60 DAP and indicated significant increase in rhizome yield, which was to the tune of 31.3 per cent as compared to control. Further, they also observed varietal difference in turmeric genotypes for response to foliar application of zinc.

2.9 **ROLE OF GROWTH REGULATORS ON PHYSIOLOGICAL TRAITS AND YIELD COMPONENTS IN TURMERIC**

There are currently five recognized groups of plant growth regulators viz., auxins, gibberellins, cytokinins, abscissic acid and ethylene. Besides the natural phytohormones that are involved in the growth and differentiation, auxillary bud growth, root elongation, shoot elongation, cell division, flower induction, etc., there are several synthetic bioregulators that regulate growth and development behaviour of plants without inducing phytotoxic or malformative effects. These bioregulators comprise of both retardants and promoters which when used in appropriate concentrations, influence the plant architecture in a typical fashion.

Exogenous application of plant growth regulators are known to influence the growth, productivity and quality of several horticultural crops (Rao *et al.*, 1989). In root vegetables, treatment with growth regulators are known to hasten the tuberization and yield of underground storage organs and encouraging results were reported in commercial vegetables viz., tapioca (Muthukrishnan *et al.*, 1974); Potato (Baijal *et al.*, 1983) and onion (Singh *et al.*, 1983). However, information regarding the utility of plant growth regulators in an important spice crop like turmeric with underground storage organs is almost scarce.

Growth retardants are the organic chemicals which retard stem elongation, increase green colour of the leaves and indirectly affect flowering. According to Cathey (1964), growth retardant is a chemical that slows down cell division and cell elongation

in shoot tissues and regulate plant height physiologically without formative effects. Growth retardants are considered as anti-metabolites rather than anti-gibberellins or anti-auxins (Cathey, 1964). They cause the inhibition of cell division in sub apical meristem. The effect of growth retardants vary with plant species, variety, concentration used, method of application, frequency of application and various other factors which influence the uptake and translocation of these chemicals.

Cycocel belongs to the group of quaternary ammonium compounds, an analogue of chlorine which is the most active compound. Its trivial name is chlorocholine chloride, abbreviated as CCC and also called as cycocel. Cycocel is one of the plant growth retardants which induces varied responses in a wide range of plant species (Tolbert, 1960). Plants treated with cycocel were generally compact and sturdy with typical shortened petioles. The plants usually remain dwarf under optimal growing conditions. The generic name is "Chloromequat".

Pandita and Hooda (1979) reported a reduced plant height with the foliar application of Cycocel @ 375 ml per ha in potato. The decrease was more pronounced when the spraying was done twice at 50 and 70 days after planting. The reduced height might be due to reduction in the growth of important sinks (all axillary buds) and therefore, might have changed the distribution pattern of assimilates.

Govindkrishnan and Sahota (1984) at Shillong found a reduction in plant height in potato with Cycocel spray but the difference between treated and untreated ones was found non-significant. But, Arora *et al.* (1988) found significant reduction in plant height as compared to control by spraying with Cycocel 250 ppm at 40 and 55 days after sowing in potato.

Govindkrishnan and Sahota (1984) opined that cycocel at 1500 ppm and 2500 ppm significantly increased the number of shoots per hill of potato, while the lowest number of stems per plant was recorded in control. Gunasena (1979) reported that CCC increased leaf area index in potato. The maximum was obtained when CCC was

given as foliar application at 500 ppm. Banerjee and Das (1984) observed the reduced plant height in banana with treatment of 1500 ppm cycocel as compared to control.

Phogat and Singh (1987) studied the effect of cycocel on growth and yield of ginger and observed a significant decrease in the plant height and significant increase in the number of leaves per plant with the application of cycocel as compared to control. Stuart *et al.* (1980) found that the application of mepiquat chloride reduced the leaf area and increased the leaf thickness in potato. This treatment increased photosynthetic capacity of cotton plant and increased dry matter. Sarkar and Singh (1984) found that the higher number of leaves per plant was due to foliar application of 500 ppm cycocel as compared to control in potato. Cycocel at 150 ppm gave the lowest number of leaves. Mannikeri (1996) studied the effect of CCC on growth of turmeric and indicated that the application of CCC @ 2000 ppm reduced the plant height and increased the number of leaves and tillers.

Madalgeri and Ganiger (1993) found that 750 ppm of CCC and 150 ppm of mepiquat chloride increased the leaf area and leaf area index. In contrast, Madalgeri (1996) reported a decrease in leaf area with growth retardants as compared to control in true potato seed variety HPS-1/13.

Banerjee and Das (1984) observed higher LAI values in potato during the active tuber bulking period (40-70 DAP) when sprayed with Cycocel (500 ppm) at 36 days after planting. Crop growth rate, net assimilation rate and tuber bulking rate were also found to be significantly higher when compared to control. Mannikeri (1996) also indicated that the application of CCC @ 2000 ppm significantly increased leaf area and leaf area index. Madalgeri and Ganiger (1993) found an increase in LAI and LAD by spraying of mepiquat chloride (150 ppm) at 45 DAP. Similar, increase in LAI was reported by Gasti (1994) in potato. Madalgeri (1996) observed an improvement in the net assimilation rate (8.3%) and harvest index (24.1%) by spraying with growth retardants cycocel, TIBA and mepiquat chloride against unsprayed control in TPS potato genotype HPS 1/13 at 30 days after transplanting.

The dry matter accumulation in turmeric was highest with the application of CCC at the rate of 4000 ppm (Satheesan and Ramadhasan, 1988). Mannikeri (1996) observed significant increase in total dry matter with spraying of 2000 ppm CCC as compared to control. He further indicated that the fresh weight and dry weight of haulm was significantly more in treatment with CCC 2000 ppm.

Pirmowicz and Sangin (1978) also found that cycocel at 500 ppm and 1000 ppm significantly increased the total tuber yield in potato either by foliar application or tuber treatment. Phogat and Singh (1987) observed significant increase in length, width of rhizomes, number of rhizome bits per rhizome and rhizome yield of ginger with the treatment of cycocel @ 250 ppm and the per cent increase was to the tune of 18.79 per cent. Application of CCC at the rate of 4000 ppm significantly increased harvest index of turmeric (Satheesan and Ramadhasan, 1988).

Similarly, Mannikeri (1996) also showed that application of CCC @ 2000 ppm significantly increased the rhizome yield due to significant improvement in number of primary, secondary and tertiary fingers and their size. He further noticed that the cured rhizome yield, curing percentage, harvest index and curcumin content were significantly higher with CCC @ 2000 ppm.

Balashanmugam and Vanagamudi (1987) studied the effect of foliar spray of planofix (10 ppm) on growth and yield of turmeric. They indicated that the application of planofix at 6 month's after planting increased the yield in turmeric to the tune of 30.93 per cent as compared to control. Further, they observed significant increase in plant height, number of leaves per plant, number of tillers per plant, number and weight of mother and finger rhizomes per plant with the application of planofix (10 ppm) as compared to control.

Similarly, Rao *et al.* (1989) studied the influence of certain plant growth regulators on growth, tuberisation and rhizome yield of turmeric. They opined that the application of NAA @ 20 ppm significantly increased the pseudostem height, number of

leaves and also leaf area per plant as compared to control. The application of NAA @ 20 ppm increased the turmeric yield by 51 per cent.

Stuart *et al.* (1980) found that the application of mepiquat chloride increased photosynthetic capacity of cotton plant and increased the dry matter.

Leaves of all the plants treated with growth retardants had much darker green leaves than those of untreated plants (Cathey, 1964). He opined that growth retardants, in addition to the inhibition of cell division, caused induction of grana and initiated the development of chloroplasts. In groundnut, foliar spray of 100, 200, 300, 400, 500 and 1000 ppm Cycocel applied at 20 days after sowing showed that with an increase in the concentration of cycocel, there was an increase in the chlorophyll content in leaves (Sorte *et al.*, 1991). Chetti (1991) reported that the application of mepiquat chloride and Lihocin increased the chl. a, chl. b and total chlorophyll contents significantly as compared to control in groundnut genotypes JL-24 and Dh-8. Similarly, Kulkarni *et al.*, (1995) found that the foliar application of mepiquat chloride (1000 ppm) at 45 DAS significantly increased the total chlorophyll content in both hybrid and variety of sunflower.

It was observed that spraying of 500 ppm Cycocel at the beginning of flowering increased the nitrate reductase activity in the leaves of 'S-8' when compared to 'Pusa Baisakhi' in greengram variety. It was further concluded that lower seed yield of 'Pusa Baisakhi' was due to lower nitrate reductase activity, whereas, the improvement in yield of 'S-8' by cycocel treatment was due to greater allocation of biomass to grain yield (Wasnik and Bagga, 1992). Similarly, Sairam *et al.* (1991) showed that the foliar application of CCC (1000 ppm) to wheat genotypes at tillering and anthesis stages, increased the nitrate reductase activity in the leaf.

Higher percentage of volatile oil, non volatile acetone extract, starch and crude protein was observed in CCC treated ginger compared to control (Shankar and Muthuswamy, 1985). The treatment, CCC (500 ppm) increased the volatile oil content of

ginger and also increased crude fibre with increase in the concentration of CCC (Jayachandran and Sethumadhavan, 1991).

2.10 CORRELATION STUDIES

According to Philip and Nair (1983), while plant height (+0.63), number of leaves per tiller (+0.59), leaf area (+0.74) and petiole length (+0.83) were highly significant and positively correlated with the yield of turmeric, the number of tillers (+0.22) and leaves per plant (+0.44) were not significantly correlated with yield. Among the yield components, while girth of mother rhizome (+0.56) and length of fingers were significant and positively correlated with yield. Internodal length, girth of primary fingers and number of nodes did not have significant correlation with the yield.

Reddy *et al.* (1988) reported that number of leaves, number of primary fingers and crop duration had positive and strong association with rhizome yield at both genotypic and phenotypic levels in turmeric.

Jalgaonkar *et al.* (1988) observed a significant and positive correlation between cured yield with girth and weight of mother rhizomes, length of primary fingers and number and girth of secondary fingers. Cholke (1993) obtained positive and significant correlation between yield and primary fingers (+0.95) and plant height (+.71). Whereas, positive and non-significant correlation was observed with number of leaves (+.58), number of tillers (+0.42), number of mother rhizomes (+0.55). Mannikeri (1996) also observed a significant positive association between number of fingers, size of fingers with rhizome yield in turmeric.

Material and Methods

III MATERIAL AND METHODS

Turmeric (*Curcuma longa* L.) is an important spice crop of India and has greater export potential. Studies on sound physiological basis of yield formation, growth and development are the utmost need of the hour in order to evolve suitable varieties for increasing the productivity. It is also worthwhile to mention here that there is a need to identify proper ideotype in turmeric for obtaining higher productivity through a sound physiological approach.

The role of plant growth regulators (PGR's) on various physiological and biochemical processes in plant is well known, which enables a rapid change in the phenotype of the plant to achieve desirable results. Similarly, in recent years, more emphasis is given on the use of micronutrients for enhancing quality and quantity. It has been shown that both growth regulators and micronutrients have a beneficial role in improving productivity and quality in turmeric. However, the effect of these compounds on various physiological and biophysical processes is not well understood. Hence, field experiments were conducted during *kharif* seasons of 1998 and 1999 at Main Research Station, College of Agriculture, University Agricultural Sciences, Dharwad to study the physiological basis of yield variation in elite turmeric genotypes and the response of turmeric genotypes to the application of growth regulators and micronutrients. The details of the material used and techniques adopted during the course of investigation are described in this chapter.

3.1 EXPERIMENTAL SITE

Field experiments were conducted in the plot number 125 of E block, at Main Research Station, University of Agricultural Sciences, Dharwad. The farm is situated at 15°12' N latitude and 75°07' E longitude with an altitude of 678 m above the mean sea level.

Table 1: Monthly meteorological data during crop growth period (*Kharif*, 1998 and 1999) and the average of 50 years (1950-1999) at Main Research Station, University of Agricultural Sciences, Dharwad

Months	1998					1999					1950-1999				
	Temperature (°C)		Mean relative humidity (%)	Rainfall (mm)		Temperature (°C)		Mean relative humidity (%)	Rainfall (mm)		Temperature (°C)		Mean relative humidity (%)	Rainfall (mm)	
	Max	Min				Max	Min				Max	Min			
Jan	30.5	15.3	73.0	0.00		29.4	12.4	75.0	0.00		30.5	14.6	66.4	0.11	
Feb	32.1	16.3	70.2	0.00		32.8	16.9	63.3	0.00		32.3	15.7	56.7	0.19	
Mar	35.7	19.0	64.4	0.00		36.2	20.2	63.0	0.00		35.8	18.8	56.6	7.45	
Apr	38.3	22.1	58.2	0.00		36.6	21.2	65.0	14.77		38.2	21.4	60.5	42.93	
May	35.8	21.8	62.0	33.21		32.2	21.3	75.2	32.80		36.6	21.5	67.3	85.92	
Jun	31.0	21.8	80.0	222.40		28.0	21.0	85.4	71.80		29.8	21.2	81.8	111.50	
Jul	27.5	21.2	86.3	82.51		36.4	20.8	89.0	113.90		27.1	21.4	88.4	156.09	
Aug	27.7	21.3	87.0	51.40		27.1	20.4	85.0	19.70		27.1	20.6	86.8	103.31	
Sep	28.2	20.9	91.0	214.40		28.3	20.0	83.0	8.80		29.4	20.2	83.3	99.47	
Oct	28.6	20.1	93.2	98.11		28.9	19.8	79.0	161.10		30.8	19.3	76.2	135.78	
Nov	29.3	11.2	75.0	40.20		29.6	16.0	59.0	0.00		25.5	16.3	68.4	34.38	
Dec	28.6	14.0	72.1	0.00		28.6	13.4	51.0	0.00		29.7	13.5	64.4	6.35	
Total				742.22					422.87				783.48		



EXPERIMENTAL DETAILS

Field experiments were conducted during the 2 years 1974 and 1975 and the results of experiments are described below. The sites of the experiments are shown in Figure 1.



PLATE 1. GENERAL VIEW OF THE EXPERIMENT

3.2 CLIMATE

Dharwad is located in the transitional belt of North Karnataka. The meteorological data during the crop growth period (*kharif* 1998 and 1999) and the mean of last 50 years (1950-1999) were collected from the Meteorological Observatory, Agriculture College, University of Agricultural Sciences, Dharwad and are presented in Table 1.

3.3 SOIL AND ITS CHARACTERISTICS

The experimental site consisted of medium black loam soil. Composite soil samples were analysed from the experimental site for various physical and chemical properties. The details along with the methods employed are presented in Table 2.

3.4 EXPERIMENTAL DETAILS

Field experiments were conducted during *kharif* 1998 and 1999 and the details of experiments are furnished below. The plan of layout of the experiments is given in Figure 1 and 2.

3.4.1 EXPERIMENT I : PHYSIOLOGICAL BASIS OF YIELD VARIATION IN ELITE TURMERIC GENOTYPES

This experiment consisted of six elite turmeric genotypes and the details are furnished hereunder.

3.4.1.1 Experimental details

Genotypes	=	6
V ₁	=	Amalapuram
V ₂	=	CO-1
V ₃	=	Bidar-4
V ₄	=	BSR-1
V ₅	=	Rajapuri

Table 2: Physical and Chemical properties of the soil from the experimental field

Particulars	Value obtained	Method employed
PHYSICAL PROPERTIES		
Coarse sand (%)	5.80	Puri's method (Sankaram, 1966)
Fine sand (%)	14.20	Puri's method (Sankaram, 1966)
Silt (%)	28.80	Puri's method (Sankaram, 1966)
Clay (%)	51.90	Puri's method (Sankaram, 1966)
Bulk density (g cc ⁻¹)	1.30	Core sample method (Dastane, 1967)
CHEMICAL PROPERTIES		
Available Nitrogen (%)	0.05	Subbiah and Asija (1956)
Available Phosphorus (P ₂ O ₅) (kg ha ⁻¹)	40.00	Olsen's method (Jackson, 1967)
Available potassium (K ₂ O) (kg ha ⁻¹)	320.00	Flame photometer (Jackson, 1967)
Organic carbon	0.76	Wet oxidation method (Jackson, 1967)
Soil phosphorus	7.50	pH meter (Piper, 1966)

LEGEND

EXPERIMENT I: Physiological Basis of Yield Variation in Turmeric

V₁ - Amalapuram

V₂ - CO-1

V₃ - Bidar-4

V₄ - BSR-1

V₅ - Rajapuri

V₆ - Cuddapah

EXPERIMENT II: Influence of Micronutrients on Productivity Potential and Quality in Turmeric Genotypes

T₁ - Bidar-4 (FeSO₄ 0.25%)

T₂ - Bidar-4 (FeSO₄ 0.50%)

T₃ - Bidar-4 (ZnSO₄ 0.25%)

T₄ - Bidar-4 (ZnSO₄ 0.50%)

T₅ - Bidar-4 (MnSO₄ 0.20%)

T₆ - Bidar-4 (MnSO₄ 0.40%)

T₇ - Bidar-4 (Control)

T₈ - Bidar-1 (FeSO₄ 0.25%)

T₉ - Bidar-1 (FeSO₄ 0.50%)

T₁₀ - Bidar-1 (ZnSO₄ 0.25%)

T₁₁ - Bidar-1 (ZnSO₄ 0.50%)

T₁₂ - Bidar-1 (MnSO₄ 0.20%)

T₁₃ - Bidar-1 (MnSO₄ 0.40%)

T₁₄ - Bidar-1 (Control)

EXPERIMENT III: Influence of Growth Regulators on Source-Sink Relationship, Productivity Potential and Quality in Turmeric Genotypes

T₁ - Amalapuram (CCC 500 ppm)

T₂ - Amalapuram (CCC 1000 ppm)

T₃ - Amalapuram (Cytozyme 1000 ppm)

T₄ - Amalapuram (Cytozyme 2000 ppm)

T₅ - Amalapuram (Miraculan 1000 ppm)

T₆ - Amalapuram (Miraculan 2000 ppm)

T₇ - Amalapuram (Control)

T₈ - Rajapuri (CCC 500 ppm)

T₉ - Rajapuri (CCC 1000 ppm)

T₁₀ - Rajapuri (Cytozyme 1000 ppm)

T₁₁ - Rajapuri (Cytozyme 2000 ppm)

T₁₂ - Rajapuri (Miraculan 1000 ppm)

T₁₃ - Rajapuri (Miraculan 2000 ppm)

T₁₄ - Rajapuri (Control)

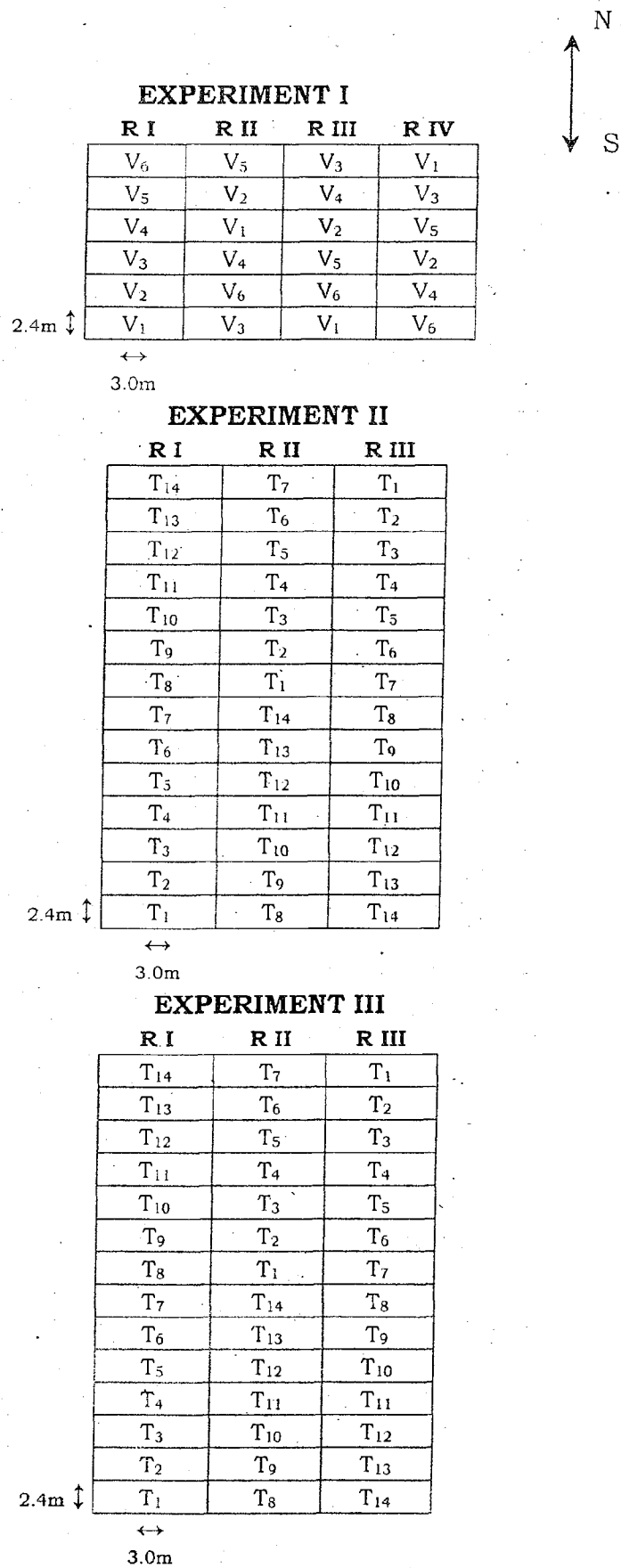


FIGURE 1. PLAN OF LAYOUT OF EXPERIMENTS (KHARIF 1998)

V_6	=	Cuddapah
Design	=	Randomised Block Design
Plot size	=	2.4 m x 3.0 m
Replications	=	4
Spacing	=	60 cm x 30 cm

The seed material was collected from the Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Dharwad.

The observations pertaining to various morpho-physiological, biochemical biophysical parameters and yield attributes were recorded at different time intervals. Growth parameters were also computed following standard procedures.

3.4.2 EXPERIMENT II : INFLUENCE OF MICRONUTRIENTS ON PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES

This experiment consisted of two genotypes viz., Bidar-1 and Bidar-4 and three micronutrients at two concentrations each and a control. The details are furnished herunder.

3.4.2.1 Experimental details

Genotypes	=	2
V_1	=	Bidar-1
V_2	=	Bidar-4

Micronutrient treatments

T_1	=	Foliar application of $FeSO_4$ (0.25%)
T_2	=	Foliar application of $FeSO_4$ (0.50%)
T_3	=	Foliar application of $ZnSO_4$ (0.25%)
T_4	=	Foliar application of $ZnSO_4$ (0.50%)

LEGEND

EXPERIMENT I: Physiological Basis of Yield Variation in Turmeric

V₁ - Amalapuram

V₂ - CO-1

V₃ - Bidar-4

V₄ - BSR-1

V₅ - Rajapuri

V₆ - Cuddapah

EXPERIMENT II: Influence of Micronutrients on Productivity Potential and Quality in Turmeric Genotypes

T₁ - Bidar-4 (FeSO₄ 0.25%)

T₂ - Bidar-4 (FeSO₄ 0.50%)

T₃ - Bidar-4 (ZnSO₄ 0.25%)

T₄ - Bidar-4 (ZnSO₄ 0.50%)

T₅ - Bidar-4 (MnSO₄ 0.20%)

T₆ - Bidar-4 (MnSO₄ 0.40%)

T₇ - Bidar-4 (Control)

T₈ - Bidar-1 (FeSO₄ 0.25%)

T₉ - Bidar-1 (FeSO₄ 0.50%)

T₁₀ - Bidar-1 (ZnSO₄ 0.25%)

T₁₁ - Bidar-1 (ZnSO₄ 0.50%)

T₁₂ - Bidar-1 (MnSO₄ 0.20%)

T₁₃ - Bidar-1 (MnSO₄ 0.40%)

T₁₄ - Bidar-1 (Control)

EXPERIMENT III: Influence of Growth Regulators on Source-Sink Relationship, Productivity Potential and Quality in Turmeric Genotypes

T₁ - Amalapuram (CCC 500 ppm)

T₂ - Amalapuram (CCC 1000 ppm)

T₃ - Amalapuram (Cytozyme 1000 ppm)

T₄ - Amalapuram (Cytozyme 2000 ppm)

T₅ - Amalapuram (Miraculan 1000 ppm)

T₆ - Amalapuram (Miraculan 2000 ppm)

T₇ - Amalapuram (Control)

T₈ - Rajapuri (CCC 500 ppm)

T₉ - Rajapuri (CCC 1000 ppm)

T₁₀ - Rajapuri (Cytozyme 1000 ppm)

T₁₁ - Rajapuri (Cytozyme 2000 ppm)

T₁₂ - Rajapuri (Miraculan 1000 ppm)

T₁₃ - Rajapuri (Miraculan 2000 ppm)

T₁₄ - Rajapuri (Control)

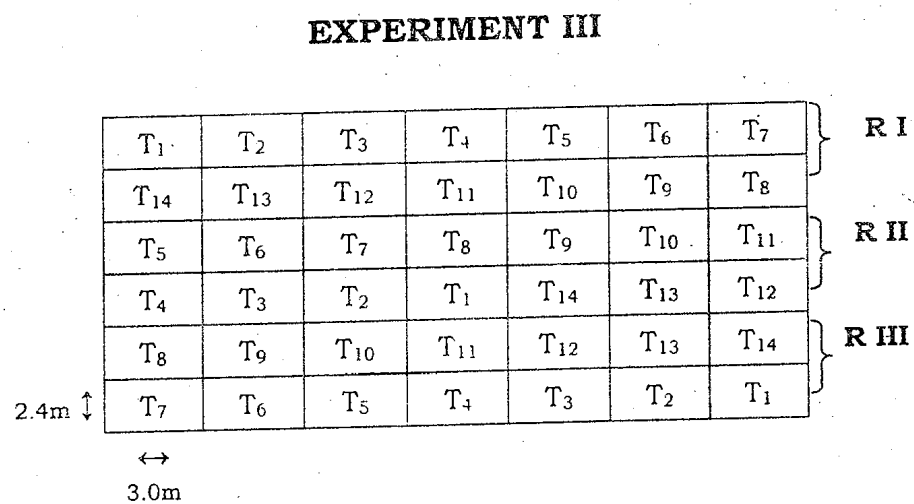
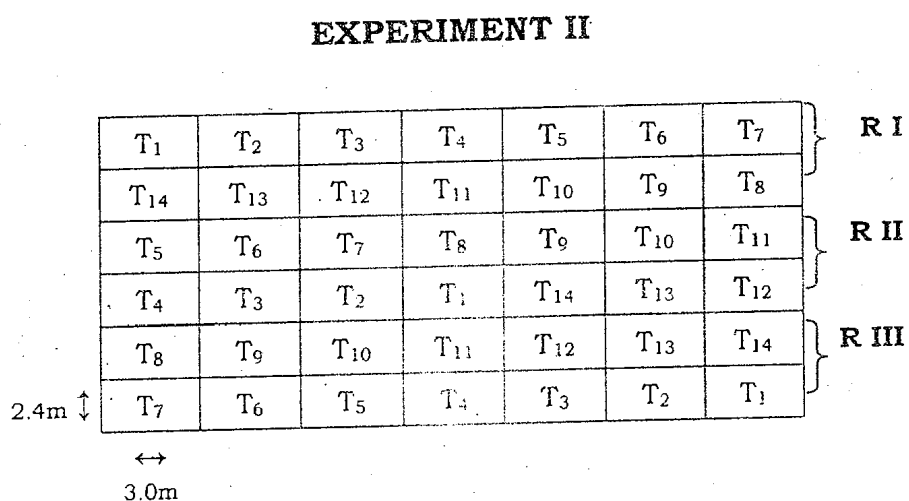
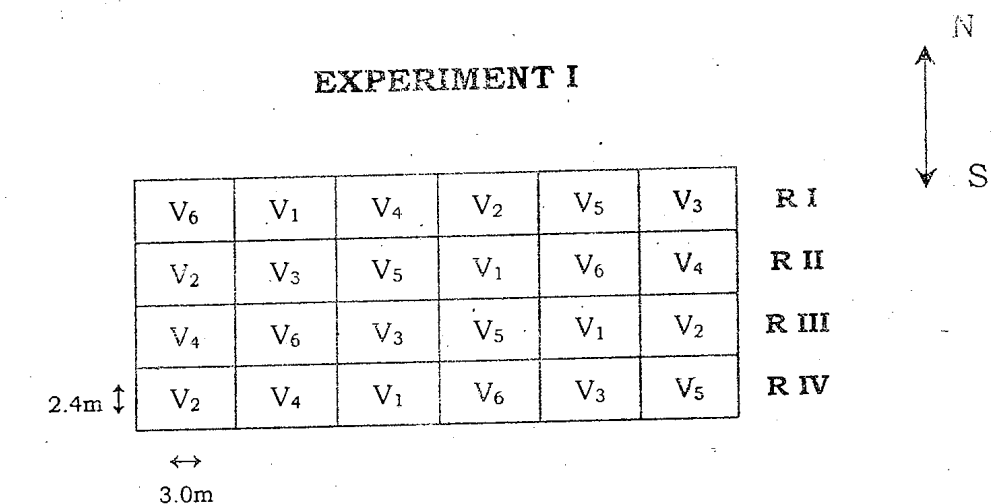


FIGURE 2. PLAN OF LAYOUT OF EXPERIMENTS (KHARIF 1999)

T_5	=	Foliar application of $MnSO_4$ (0.2%)
T_6	=	Foliar application of $MnSO_4$ (0.4%)
T_7	=	Control (Water spray)
Design	=	Factorial randomised block design
Plot size	=	2.4 m x 3.0 m
Spacing	=	60 cm x 30 cm
Replications	=	Three

The foliar application of micronutrients was done at 60 and 120 days after planting. The physiological effects of micronutrients used in the study on various physiological and metabolic processes is furnished in Table 3. The observations pertaining to various physiological, biophysical, biochemical traits, yield and yield components were recorded at regular intervals which have been described in this chapter.

3.4.3 EXPERIMENT III : INFLUENCE OF PLANT GROWTH REGULATORS ON SOURCE-SINK RELATIONSHIP AND PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES

This experiment consisted of two genotypes viz., Amalapuram and Rajapuri and three growth regulators at two concentrations each and a control. The details are furnished hereunder.

3.4.3.1 Experimental Details

Genotypes	-	2
V_1	-	Amalapuram
V_2	-	Rajapuri

Growth Regulator treatments

T_1	=	Foliar application of CCC (500 ppm)
T_2	=	Foliar application of CCC (1000 ppm)

Table 3: Salient features of the micronutrients used in the experiment

Sl. No.	Micronutrient	Physiological effects and use
1.	Iron (Fe)	It is necessary for chlorophyll synthesis. Iron is a component of flavoproteins, cytochromes peroxidases and catalases. It is active in biological oxidation.
2.	Zinc (Zn)	It is necessary for auxin synthesis. The enzyme activity of alcohol dehydrogenase, carbonic anhydrase etc., is influenced by Zinc. It may be required in protein synthesis.
3.	Manganese (Mn)	It is an activator of enzymes of respiration and nitrogen metabolism. Malic dehydrogenase, oxalosuccinic decarboxylase, nitrate reductase, hydroxylamine reductase etc., require manganese for activation.

T ₃	= Foliar application of Cytozyme (1000 ppm)
T ₄	= Foliar application of Cytozyme (2000 ppm)
T ₅	= Foliar application of Miraculan (1000 ppm)
T ₆	= Foliar application of Miraculan (2000 ppm)
T ₇	= Control (Water spray)
Design	= Factorial randomised block design
Plot size	= 2.4 m x 3.0 m
Spacing	= 60 cm x 30 cm
Replications	= Three

The foliar application of growth regulators was done at 60 and 120 days after planting. The details of growth regulators used in the experiment are presented in Table 4. The observations pertaining to various morpho-physiological, biophysical, biochemical traits, yield and yield components were recorded at regular intervals and described in this chapter.

3.5 CULTURAL OPERATIONS

The land was brought to a fine tilth by ploughing and discing followed by two harrowings. The experiments were laid out as per the plan during *kharif* 1998 and 1999.

3.5.1 Manures and manuring

Farm yard manure at the rate of 40 tonnes per hectare was applied as a basal dose. The fertilizers (N : P₂O₅ : K₂O) were applied in the form of urea, single super phosphate and muriate of potash at the rate of 180 : 90 : 90 kg of N : P₂O₅ : K₂O per hectare. Full dose of phosphorus and potassium with half dose of nitrogen were applied just before planting and mixed thoroughly in the soil. Remaining half dose of nitrogen was top dressed at 45 days after planting.

Table 4: Salient features of the growth regulators used in the experiment

Sl. No.	Common / Trade Name	Chemical group	Chemical name	Physiological effects and use
1.	Cycocel / CCC / Chlomequat	Anti-gibberellin	2-chloroethyl-trimethyl ammonium chloride	Growth retardant, prevents lodging and controls vegetative growth
2.	Cytozyme / Biozyme	Biological and product containing auxin and cytokinin	--	Growth promoter, biological product (bacterial hydrolysate) containing auxins, cytokinins, chelated micronutrients and enzymes.
3.	Miraculan	Biological product containing Triacantanol	Triacantanol (TRIA), the straight chain alcohol	Growth promoter has been found to increase the crop yields in dry beans, sweet corn, tomato, cucumber, rice, maize, cotton and sugarbeet, increases the photosynthetic activity, enhancement in the mobilization of photosynthates, rapid increase in reducing sugar, soluble protein, succinate and amino acids, increases the activity of 6-phospho gluconate hydrogenase and changes the permeability of plant membranes.

3.5.2 Seed material and planting

Healthy finger rhizomes of all the cultivars with well developed buds were utilised for planting after dipping in Dithane M-45 (0.2%) solution for five minutes. Ridges and furrows were prepared at a spacing of 60 cm. Finger rhizomes were planted half way down the edge with intra row spacing of 30 cm. Planting was done on 7th July, 1998 and 3rd July, 1999. The experimental plots were irrigated soon after planting.

3.5.3 Irrigation and after care

Irrigations were given depending on the rainfall and soil moisture condition. Irrigation was provided whenever there was long break in the monsoon and during dry period from November onwards regularly. In all, 8 irrigations were given during the crop period. Hand weeding was done at an interval of 30-40 days from planting till the formation of rhizome and a total of four weedings were done during the crop growth period.

3.5.4 Plant protection

Phosphomidon (0.5%) was sprayed 60 days after planting. This was followed by spraying of Dimecron (0.05%) and Dithane M-45 (0.2%) on 120th day after planting.

3.5.5 Harvesting

The crop was harvested by digging out the rhizomes after complete maturity as indicated by the drying up of leaves and falling down of plants, which varied with cultivars (240-270 days). The harvested produce viz., the rhizomes dug out from the soil were cleaned of adhering dirt and sticking roots.

3.5.6 Curing of rhizome

Fresh (raw) turmeric yield was recorded by taking the weight of fresh rhizomes harvested from each net plot and based on this, the yield per hectare was

computed. Fingers were separated from mother rhizomes. For observation purpose, a sample of one kilogram of fresh rhizomes from each plot was boiled in a pan containing 1 per cent alkaline solution prepared by dissolving sodium carbonate at the rate of 1 g in 1 litre water. The whole mass was boiled till the fingers became soft and froth comes out with white fumes giving out a typical odour. The boiling lasted for 45-60 minutes. Alkalinity of the boiling water helps in imparting orange tinge to the core of the turmeric. After boiling, the rhizomes were dried under sun and their dry weight was recorded. Curing percentage was worked out by the following formula and expressed as yield per hectare.

$$\text{Curing (\%)} = \frac{\text{Fresh wt. of rhizome} - \text{Dry wt. of rhizome after curing}}{\text{Fresh wt. of rhizome (kg)}} \times 100$$

3.6 COLLECTION OF EXPERIMENTAL DATA

Five plants from each plot were tagged randomly for recording various morphological observations at 60, 90, 120, 150 and 180 days after planting and at harvest. For calculating growth parameters, five plants from each plot were uprooted randomly and separated into leaves, stem and underground root portion and dried separately in hot air oven at 80°C to a constant weight. Yield and yield attributes were recorded from the five tagged plants from the net plot area.

3.6.1 Morpho-physiological traits

3.6.1.1 Plant height (cm)

The plant height was measured from the ground level to the end of petiole of the top most (youngest) leaf. The height of the plant was recorded at five stages of crop growth viz., 60, 90, 120, 150 and 180 days after planting and expressed in centimetres.

3.6.1.2 Number of leaves

Fully opened leaves were counted in each labelled plant at 60, 90, 120, 150 and 180 days after planting.

3.6.1.3 Number of tillers

The side shoots arising from the basal portion of the pseudostem were counted in labelled plant at 60, 90, 120, 150 and 180 days after planting.

3.6.2 GROWTH PARAMETERS

3.6.2.1 Leaf area ($\text{cm}^2 \text{ plant}^{-1}$)

The length of the leaf was noted from the leaf blade joint to the tip of the leaf along the midrib and the width was noted at the widest point of the leaf lamina. The leaf area was computed by multiplying the product of leaf length and width with a conversion factor 0.72 to arrive at the actual leaf area (Raghavarao and Swamy, 1984).

3.6.2.2 Dry matter production and its partitioning

Five plants in each treatment were uprooted randomly at 60, 90, 120, 150, 180 DAS and at harvest and separated into leaf, stem and root portion (underground rhizome). The cumulative weight of these separated plant parts were noted and their average was expressed as fresh weight per plant in grams. The same plants were used for estimating dry matter production.

The various plant parts were dried at 80°C in hot air oven until constant weight was attained. The average value was expressed as dry matter per plant in grams. The data was also used for the computation of total dry matter.

3.6.2.3 Leaf area index (LAI)

Leaf area index at various stages of crop growth was calculated by using the formula suggested by Sestak *et al.* (1971).

$$\text{Leaf area index} = A/P$$

Where,

A = Leaf area in dm^2

P = Ground area covered by plant or spacing (dm^2).

3.6.2.4 Absolute growth rate (AGR)

It is the dry matter production per unit time (g day^{-1}) and was calculated by using the following formula :

$$\text{AGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

$(t_2 - t_1)$ = Time interval in days

3.6.2.5 Relative growth rate (RGR)

It is the rate of increase in dry weight per unit dry weight ($\text{mg g}^{-1} \text{day}^{-1}$) already present and was calculated as suggested by Blackman (1919) by the following formula,

$$\text{RGR} = \frac{\log_e W_2 - \log_e W_1}{(t_2 - t_1)}$$

Where,

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

$(t_2 - t_1)$ = Time interval in days

3.6.2.6 Crop growth rate (CGR)

It is the rate of dry matter production per unit ground area per unit time (Watson, 1952). It was calculated by using the following formula and expressed as $\text{g m}^{-2} \text{day}^{-1}$,

$$\text{CGR} = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

Where,

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

$(t_2 - t_1)$ = Time interval in days

A = Land area (dm^2)

3.6.2.7 Net assimilation rate (NAR)

It is the rate of dry weight increase per unit leaf area per unit time ($\text{g dm}^{-2} \text{ day}^{-1}$) and was calculated as suggested by Gregory (1926).

$$\text{NAR} = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{(\log_e L_2 - \log_e L_1)}{(L_2 - L_1)}$$

Where,

L_1 and W_1 = Leaf area (dm^2) and dry weight of the plant (g),
respectively at time t_1

L_2 and W_2 = Leaf area (dm^2) and dry weight of the plant (g),
respectively at time t_2

$(t_2 - t_1)$ = Time interval between two stages (days).

3.6.2.8 Specific leaf weight (SLW)

The specific leaf weight (g dm^{-2}) indicates the leaf thickness and it was determined by the following formula.

$$\text{SLW} = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area (dm}^2\text{)}}$$

3.6.2.9 Specific leaf area (SLA)

The inverse of the specific leaf weight is the specific leaf area ($\text{dm}^2 \text{g}^{-1}$) and was calculated by using the following formula,

$$\text{SLA} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Leaf dry weight (mg)}}$$

3.6.2.10 Leaf area duration (LAD)

Leaf area duration (days) is the integral of leaf area index over a growth period (Watson, 1952). LAD for various growth phases was worked out as per the formula of Power *et al.* (1967).

$$\text{LAD (days)} = \frac{L_i + [L_{i+1}]}{2} \times (t_2 - t_1)$$

Where,

$$L_i = \text{LAI at } i^{\text{th}} \text{ stage}$$

$$L_{i+1} = \text{LAI at } (i+1)^{\text{th}} \text{ stage}$$

$$(t_2 - t_1) = \text{Time interval between } i^{\text{th}} \text{ and } (i+1)^{\text{th}} \text{ stage (days).}$$

3.6.2.11 Biomass duration (BMD)

Biomass duration (g day^{-1}) was calculated using the formula of Sestak *et al.* (1971) as follows,

$$\text{BMD} = \frac{\text{TDM}_i + \text{TDM}_{(i+1)}}{2} \times (t_2 - t_1)$$

Where,

$$\text{TDM}_i = \text{Total dry matter at } i^{\text{th}} \text{ stage}$$

$$\text{TDM}_{(i+1)} = \text{Total dry matter at } (i+1)^{\text{th}} \text{ stage}$$

$$(t_2 - t_1) = \text{Time interval between } i^{\text{th}} \text{ stage and } (i+1)^{\text{th}} \text{ stage (days)}$$

3.6.2.12 Leaf area ratio (LAR)

It is the relative size of assimilatory apparatus to total dry matter. The leaf area ratio was computed by using the following formula,

$$\text{LAR} = \frac{\text{Leaf area (cm}^2 \text{ plant}^{-1}\text{)}}{\text{Total dry matter (g plant}^{-1}\text{)}}$$

3.6.2.13 Leaf weight ratio (LWR)

Leaf weight ratio was determined by using the following formula,

$$\text{LWR} = \frac{\text{Leaf dry weight (g plant}^{-1}\text{)}}{\text{Total dry weight (g plant}^{-1}\text{)}}$$

3.6.3 BIOPHYSICAL PARAMETERS

3.6.3.1 Stomatal frequency

The number of stomates were counted at 90 and 150 days after planting in all the genotypes following leaf surface impressions by using quickfix (a commercial preparation).

The solution was smeared on both the surfaces of leaves and was allowed to solidify for 2-3 minutes. The solidified layer was peeled off and mounted on a glass slide with a drop of water and was observed under microscope (40 x 10 magnification). The number of stomata on both the leaf surfaces was counted and expressed as number per mm² of leaf area.

3.6.3.2 Photosynthetic rate, stomatal conductance and transpiration rate

These parameters were recorded on the abaxial surface of the second fully expanded leaf from the top at 90 and 180 DAS. The observations were recorded in between 9.00 A.M. and 11.00 A.M. with the help of a portable photosynthesis system (LI-COR Lincon, USA Model LI-6400) and expressed as followings :

Parameters	Units
Rate of photosynthesis	$\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$
Rate of transpiration	$\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$
Stomatal conductance	$\mu\text{mol m}^{-2} \text{ s}^{-1}$

3.6.3.3 Relative water content (RWC)

Relative water content was estimated according to the method of Barrs and Weatherly (1962). Hundred leaf discs from five plants selected randomly in each treatment were weighed accurately upto fourth decimal on single pan analytical balance. This was taken as fresh weight. The weighed leaf discs were floated in petriplates containing distilled water for four hours. After four hours, the leaves were taken out and their surface was blotted gently and weighed. This was referred to as the turgid weight. After taking turgid weight, the leaves were dried in an oven at 80°C for 48 hours and dry weight was recorded.

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

3.6.3.4 Light transmission ratio (LTR)

The measurement of PAR was made by using a quantum radiometre (canopy analyser, EMS-7 of PP system, U.K.). The PAR incident at the top of the canopy was measured by a reference sensor is fixed to a tripod stand in the middle of the field. Simultaneously with the help of sample sensor, PAR at top, middle and bottom of the canopy was measured and the values were stored in a datalogger. The ratio between the sample sensor and reference sensor is the light transmission ratio and expressed in percentage.

3.6.4 BIOCHEMICAL PARAMETERS

The following biochemical parameters were estimated at different stages of crop growth.

3.6.4.1 Chlorophyll content

Total chlorophyll, chlorophyll 'a' and chlorophyll 'b' contents were estimated at various stages by following the procedure of Arnon (1949).

Fresh leaf samples were selected from top of the canopy in each of the treatment and were brought to laboratory in an ice box from the field. About 0.25 g of leaf was weighed from each sample and homogenised with pure acetone. The extract was filtered through Whatman No.1 filter paper and washed twice with 80 per cent acetone. The final volume of the extract was made upto 25 ml and the absorbance of the extract was measured at 645 and 663 nm in spectrophotometer (Systronics, UV-VIS Model CL-54). The total chlorophyll, chlorophyll 'a' and chlorophyll 'b' contents were calculated by using the following formulae and expressed in mg g⁻¹ fresh weight of leaf..

$$\text{Total Chlorophyll} = 20.2 (A_{645}) - 2.69(A_{663}) \times \frac{V}{a \times W \times 1000}$$

$$\text{Chlorophyll 'a'} = 12.7(A_{663}) - 2.69(A_{645}) \times \frac{V}{a \times W \times 1000}$$

$$\text{Chlorophyll 'b'} = 22.9(A_{645}) - 4.68 (A_{663}) \times \frac{V}{a \times W \times 1000}$$

Where,

A_{663} = Absorbance of the extract at 663 nm

A_{645} = Absorbance of the extract at 645 nm

a = Path length of the light in the cuvette (1 cm)

V = Volume of the extract (25 ml)

W = Fresh weight of the sample (0.25 g)

3.6.4.2 Nitrate reductase activity (NRA)

The nitrate reductase activity determines the nitrogen utilization efficiency in plants. NRA in turmeric leaves was measured by the method of Saradhambal *et al.* (1978) at various stages during crop growth.

Fresh, fully expanded leaves from the top of the canopy were brought in an ice box from which, 10 leaf discs were weighed and suspended in 25 ml flasks containing 5 ml of solution having 0.1 M phosphate buffer (pH 7.6), 0.02 M KNO_3 , 5 per cent propanol and to that, two drops of chloramphenical (0.5 mg/ml) was added. The flasks were incubated at 30°C for 30 minutes, after which, the reaction was stopped by adding 0.1 ml of 1.0 M zinc acetate and 1.9 ml of ethanol (70%). The contents were centrifuged at 3000 rpm for 10 minutes and the supernatant was collected. The supernatant was transferred to test tubes and 1 ml of 1 per cent sulphanilamide and 1 ml of 0.02 per cent N-1 naphthyl ethylene diamine dihydrochloride were added. The absorbance of the pink colour developed was measured at 540 nm after incubating the contents of the tube at room temperature for 20 minutes. The activity of nitrate reductase was determined from a standard curve of KNO_2 and expressed as n moles of NO_2 formed g^{-1} fresh weight hour^{-1} .

3.6.4.3 Total sugars

The amount of total soluble sugars present in the extract was estimated by anthrone method (Dobois *et al.*, 1951).

Reagents

1. Ethanol (80%)
2. Anthrone reagent : 0.2 g of anthrone was dissolved in 100 ml of concentrated sulphuric acid.

Extraction of plant sample

Fresh leaf samples were collected randomly from each plot and one gram of sample was homogenized with 80 per cent ethanol. Homogenized leaf extract was allowed to boil for 2-3 minutes on hot water bath and filtered through Whatman No.1 filter paper. The residue was once again boiled in alcohol for two to three minutes and filtered through Whatman No.1 filter paper. The extraction process was repeated three to four times. Extracted alcohol was used for the estimation of total soluble sugars by using anthrone reagent.

Estimation of total sugars

One ml of alcohol extract was taken in the test tube and four ml of anthrone reagent was allowed to run down the side of the test tube by keeping the tubes in an ice bath. The samples were boiled on hot water for 10 minutes and allowed to cool at room temperatures. The absorbance of the green solution was measured at 625 nm and the amount of sugars present in the sample was calculated by using the standard curve prepared from glucose.

3.6.4.4 Estimation of reducing sugars

The amount of reducing sugars present in the extract was estimated by Nelson method (1944).

Reagents:

i) Alkaline copper reagent

- A. 2.5 g of anhydrous sodium carbonate, 2 g of sodium bicarbonate, 2.5 g of potassium sodium tartarate and 20 g of anhydrous sodium sulphate was dissolved in 80 ml distilled water and made up the volume to 100 ml.
- B. 15 g of copper sulphate was dissolved in a small volume of distilled water and one drop of sulphuric acid was added and the volume was made up to 100 ml.

96 ml of A and 4 ml of B solution was mixed just before use.

ii) 2.5 g of ammonium molybdate was dissolved in 4 ml of water. To this, 2.5 ml of sulphuric acid was added and mixed well. Then 0.3 g of disodium hydrogen arsenate dissolved in 25 ml of water is added.

iii) **Standard glucose solution**

100 mg of glucose was dissolved in little quantity of water and made up the volume to 100 ml to get a stock solution. 10 ml of stock solution was diluted to 100 ml with distilled water to get a working standard of 100 µg/ml of concentration.

Procedure

0.4 ml of sample aliquat was pipetted out in a test tube. Similarly, 0.2, 0.4, 0.6, 0.8 and 1.0 ml of working standard solutions were pipetted out into different test tubes. The volume was made upto 1.0 ml with distilled water. A blank was maintained by taking 1.0 ml of distilled water in a separate test tube. 1.0 ml of alkaline copper reagent was added to each tube and they were placed in a boiling water bath for 20 minutes. The tubes were cooled under running tap and 1.0 ml of arsenomolybdate reagent was added to each tube with a regular stirring to get blue colour. The volume was made upto 10 ml with distilled water and the absorbance was read at 510 nm.

3.6.4.5 Estimation of non-reducing sugars

Non-reducing sugar was estimated by subtracting the reducing sugar from total sugar content of the sample.

3.7 YIELD AND YIELD PARAMETERS

3.7.1 Fresh weight

Selected five plants in each treatment were uprooted, from which, roots

and rhizomes were separated from aerial part (leaves and pseudostem), weighed and expressed as fresh weight of rhizomes per plant in grams.

3.7.2 Number of rhizomes

The total number of mother rhizomes, primary, secondary and tertiary fingers produced in five randomly selected plants was recorded separately and their average value was expressed as number of mother rhizomes, primary and secondary fingers per plant.

3.7.3 Size of rhizomes

Mother rhizomes, primary and secondary fingers were taken from the produce of randomly selected five plants for the purpose. Diameter of each rhizome was recorded with the help of vernier calipers and circumference was computed by formula πD . Length of primary and secondary fingers was recorded and their average value were expressed in centimeters.

3.7.4 Number of mother rhizomes

Total number of mother rhizomes produced in five randomly selected plants was recorded and their average value was expressed as number of mother rhizomes per plant.

3.7.5 Circumference of mother rhizome (cm)

Five mother rhizomes were taken from the produce of randomly selected five plants for the purpose. Diameter was recorded with the help of vernier callipers and circumference was calculated by using the formula πD .

3.7.6 Number of primary fingers

The same randomly selected five plants in each treatment/variety were used for recording number of primary fingers and their mean was expressed as number of primary fingers per plant.

3.7.7 Circumference of primary finger (cm)

Five primary fingers were taken randomly from five plants in each plot and their mean diameter was recorded with the help of vernier callipers and circumference was calculated by using the formula πD .

3.7.8 Length of primary finger

Five primary fingers were taken for observation in each cultivar. Their length was recorded and the mean value was expressed as length of primary finger in centimetres.

3.7.9 Number of secondary fingers

The same randomly selected five plants in each cultivar treatment were used for recording number of secondary fingers and their average was expressed as number of secondary fingers per plant.

3.7.10 Circumference of secondary finger (cm)

Five secondary fingers were taken randomly from five plants in each plot and their average diameter was recorded with the help of vernier callipers and circumference was calculated by using the formula πD .

3.7.11 Length of secondary finger (cm)

Five secondary fingers were taken for observation in each cultivar/treatment and their length was recorded and the mean value was expressed as length of secondary finger in centimetres.

3.7.12 Harvest index (HI)

The harvest index (HI) was worked out based on the foliage and rhizome yield obtained from the net plot using the formula suggested by Donald (1962).

$$\text{Harvest index} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

3.8.1 Estimation of curcumin content

Pre-weighed (2 g) finely ground turmeric powder was extracted by refluxing over a water cooled condenser with 40 ml of distilled alcohol for two and half hours. The extract was transferred to a 100 ml volumetric flask and the volume was made up with alcohol. It was then filtered and an aliquot of 5 ml was transferred to a 100 ml volumetric flask and the volume was made up to 100 ml. It was mixed well and the absorbance of this solution was measured at 425 nm against alcohol blank, using the absorbance value of standard solution of curcumin and the curcumin percentage was calculated (Manjunath *et al.*, 1991).

$$\text{Curcumin content (\% by wt)} = \frac{0.00025 \times \text{abs. of sample} \times 100 \times 100}{\text{abs. standard} \times \text{wt. of sample} \times 5}$$

$$(0.42 \text{ absorbance at } 425 \text{ nm} = 0.00025 \text{ g curcumin})$$

3.9 STATISTICAL ANALYSIS

Fisher's method of analysis of variance was applied for the analysis and interpretation of the experimental data as given by Panse and Sukhatme (1967). The level of significance used in the 'F' and 't' tests was of $P = 0.05$.

Correlation co-efficients between yield and other morphological, growth, biochemical, biophysical and yield parameters were worked out as per the procedure outlined by Snedecor and Cochran (1967). The level of significance was tested at $P = 0.05$ and $P = 0.01$ for $n-2$ degrees of freedom.

3.10 ECONOMICS

Additional cost involved and returns obtained due to the application of growth regulators and micronutrients was worked out, taking into consideration, the market rates of all the applied inputs during experimentation on per hectare basis.

Experimental Results

IV EXPERIMENTAL RESULTS

Field experiments were conducted during *kharif* seasons of 1998 and 1999 at Main Research Station, University of Agricultural Sciences, Dharwad to study the physiological basis of yield variation in elite turmeric genotypes and the response of turmeric genotypes to the application of growth regulators and micro nutrients on morphological, physiological, biochemical and yield parameters. The crop was sprayed with different growth regulators and micro nutrients at two different concentrations at 60 and 120 days after sowing and the results of the experiments are presented in this chapter.

4.1 EXPERIMENT I : PHYSIOLOGICAL BASIS OF YIELD VARIATION IN ELITE TURMERIC GENOTYPES

4.1.1 MORPHOLOGICAL CHARACTERS

4.1.1.1 Plant height (cm)

The data on plant height (cm) at different growth stages indicated significant differences among the genotypes at both the years of study (Table 5). In general, there was progressive increase in plant height from 60 to 180 DAS during both the years. The plant height was more during *kharif* 1998 at all the stage as compared to *kharif* 1999.

At 60 DAS, the plant height was significantly higher in Amalapuram followed by Cuddapah and Rajapuri during both the years. During *kharif* 1998, the plant height ranged from 11.7 in Bidar-4 to 16.7 cm in Amalapuram while during *kharif* 1999, the plant height ranged from 8.25 in Bidar-4 to 10.61 cm in Amalapuram. During both the years the genotype, BSR-1 and Bidar-4 possessed significantly lower values for plant height as compared to other genotypes.

Table 5: Genotypic variation for plant height (cm) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	16.70	10.61	36.90	25.30	48.71	33.50	55.60	40.00	57.30	41.80
CO-1	12.70	9.22	28.48	22.80	34.40	28.00	43.80	34.00	46.60	37.30
Bidar-4	11.70	8.25	24.48	20.80	29.30	27.50	36.30	29.00	39.10	31.90
BSR-1	12.30	9.13	27.67	22.00	36.52	28.50	45.30	36.50	48.10	39.40
Rajapuri	13.00	9.51	29.30	23.80	36.63	29.00	44.80	36.50	47.30	38.20
Cuddapah	16.30	10.43	35.86	25.00	44.80	30.00	51.10	39.50	53.60	41.30
Mean	13.88	9.53	30.44	23.28	38.4	29.42	46.15	35.92	48.66	38.32
S. Em ±	0.20	0.16	0.57	0.53	0.80	0.33	1.29	1.03	1.38	1.22
C.D. (5%)	0.59	0.48	1.73	1.61	2.43	1.01	3.89	3.12	4.16	3.68



AMALAPURAM



BIDAR-4



CO-1



RAJAPURI



BSR-1



CUDDAPAH

PLATE 2. GENOTYPIC VARIATION IN TURMERIC (150 DAS)

At 90, 120 and 150 DAS, the plant height was significantly higher in Amalapuram followed by Cuddapah and Rajapuri. The genotypes BSR-1 and Bidar-4 recorded significantly lower value for plant height at all these stages during both the years. At 180 DAS during *kharif* 1998 plant height ranged from 39.1 in Bidar-4 to 57.3 cm in Amalapuram. while during *kharif* 1999 the range was 31.9 in Bidar-4 to 41.8 cm in Amalapuram.

4.1.1.2 Number of tillers per plant

Significant differences were observed with respect to number of tillers per plant at all the stages among the turmeric genotypes during both the years (Table 6). In general number of tillers per plant increased upto 150 DAS and decreased thereafter. It was seen that number of tillers per plant were more during *kharif* 1998 as compared to *kharif* 1999 at all the stages.

At 90 DAS during both the years the genotypes Rajapuri and Bidar-4 showed significantly higher values for this trait, while, the genotypes Amalapuram and Co-1 showed significantly lower values for number of tillers per plant during *kharif* 1998 while during *kharif* 1999 lowest values were recorded by Amalapuram, Co-1 and Cuddapah.

At 120 DAS during both the years the genotypes Rajapuri CO-1 and BSR-1 showed significantly higher values for this trait, while, the genotype Cuddapah showed significantly lower values for number of tillers per plant during *kharif* 1998 while during *kharif* 1999 lowest values were recorded by Cuddapah and Bidar-4.

At 150 DAS during both the years the genotype Rajapuri showed significantly higher values for this trait, while, the genotype Amalapuram showed significantly lower values for number of tillers per plant.

At 180 DAS, the number of tiller per plant was significantly higher in Rajapuri and CO-1 as compared to other genotypes during *kharif* 1998. Whereas, during

Table 6: Genotypic variation for number of tillers per plant in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing							
	90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	1.75	1.00	3.25	2.00	3.75	1.50	3.25	1.00
CO-1	1.75	1.00	4.00	3.00	4.75	2.50	4.75	2.00
Bidar-4	2.25	2.00	3.00	1.50	4.00	2.00	4.00	2.00
BSR-1	2.00	1.50	3.75	2.50	4.75	2.50	4.25	2.00
Rajapuri	2.25	2.00	4.25	3.00	5.00	3.50	4.75	2.50
Cuddapah	2.00	1.00	3.00	1.50	4.75	2.50	4.50	2.00
Mean	2.00	1.42	3.54	2.25	4.33	2.42	4.25	1.92
S. Em $\pm$	0.08	0.10	0.19	0.20	0.17	0.13	0.14	0.10
C.D. (5%)	0.25	0.31	0.56	0.61	0.51	0.40	0.41	0.30

kharif 1999 the number of tiller values were significantly more in Rajapuri. During both the years the genotype Amalapuram recorded significantly lower values.

4.1.1.3 Number of leaves per plant

The genotypic variation for number of leaves per plant at different growth stages in turmeric indicated significant differences among themselves (Table 7). In general, the number of leaves per plant from 60 to 150 DAS increased and declined afterwards during both the years of study. The number of leaves were found more during *kharif* 1998 at all the stages as compared to *kharif* 1999.

At 60 DAS the number of leaves were significantly higher in Amalapuram followed by Bidar-4 and Cuddapah during both the years. During *kharif* 1998, number of leaves ranged from 5.3 in BSR-1 to 7.0 in Amalapuram while during *kharif* 1999 number of leaves per plant ranged from 5.0 in BSR-1 to 6.1 in Amalapuram. During both the years the genotypes BSR-1 and Rajapuri possessed significantly lower values for number of leaves as compared to other genotypes.

At 90, 120 and 150 DAS, the number of leaves were significantly higher in Amalapuram, followed by Bidar-4 and Cuddapah and significantly lower values were recorded by BSR-1 and Rajapuri during both the years.

At 180 DAS, the number of leaves decreased during both the years as compared to 150 DAS and during *kharif* 1998 the number of leaves ranged from 9.9 in BSR-1 to 13.8 in Amalapuram while during *kharif* 1999, the range was 6.5 in BSR-1 to 11.0 in Amalapuram.

4.1.2 DRY MATTER ACCUMULATION AND ITS PARTITIONING

4.1.2.1 Leaf dry weight (g plant⁻¹)

The genotypic variation for leaf dry weight at different growth stages indicated significant differences among themselves (Table 8). In general, the leaf dry

Table 7: Genotypic variation for number of leaves per plant in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	7.0	6.1	12.3	10.0	16.3	13.0	21.8	18.0	13.8	11.0
CO-1	6.0	5.8	10.3	8.5	14.9	11.5	17.8	14.0	11.9	7.5
Bidar-4	6.8	6.0	11.9	9.5	15.8	12.5	20.0	17.5	12.6	9.0
BSR-1	5.3	5.0	9.6	7.0	13.4	8.0	17.1	12.5	9.9	6.5
Rajapuri	5.5	5.3	10.1	8.0	14.3	11.0	17.6	12.5	10.8	7.0
Cuddapah	6.0	5.9	10.8	9.0	15.5	12.0	18.3	15.0	12.3	8.5
Mean	6.1	5.68	10.83	8.67	15.03	11.33	18.83	14.92	11.88	8.25
S. Em $\pm$	0.13	0.10	0.19	0.18	0.31	0.27	0.40	0.45	0.34	0.48
C.D. (5%)	0.38	0.31	0.56	0.53	0.93	0.82	1.22	1.35	1.03	1.46

Table 8: Genotypic variation for leaf dry weight (g plant⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	4.86	3.65	9.91	8.43	15.20	13.13	28.10	26.49	10.22	10.07
CO-1	3.40	2.82	7.16	6.35	10.94	10.36	17.72	16.65	8.40	7.51
Bidar-4	3.70	3.10	8.56	7.98	14.42	12.52	22.06	20.98	10.00	9.55
BSR-1	2.24	1.46	6.93	5.60	9.40	7.93	16.20	15.11	7.28	6.51
Rajapuri	2.96	1.98	7.01	6.07	10.01	9.07	17.40	16.06	7.69	7.16
Cuddapah	3.52	2.90	9.17	7.48	11.68	11.24	22.00	20.48	8.86	8.03
Mean	3.35	2.65	8.12	6.99	11.94	10.71	20.58	19.30	8.74	8.14
S. Em ±	0.21	0.17	0.24	0.19	0.26	0.21	0.34	0.32	0.14	0.11
C.D. (5%)	0.63	0.51	0.71	0.56	0.78	0.63	1.03	0.05	0.41	0.33

weight increased from 60 DAS to 150 DAS and decreased afterwards, during both the years of study. The leaf dry weight was found to be more during *kharif* 1998 at all the stages as compared to *kharif* 1999.

At all the stages from 60 DAS to 180 DAS, during both the years, leaf dry weight was significantly higher in Amalapuram, Bidar-4 and Cuddapah and significantly lower values for leaf dry weight were recorded by BSR-1 followed by Rajapuri.

4.1.2.2 Stem dry weight (g plant⁻¹)

The data on stem dry weight indicated significant differences at all the stages among the turmeric genotypes during both the years (Table 9). In general stem dry weight increased upto 150 DAS and decreased thereafter. It was found that stem dry weight was more during *kharif* 1998 as compared to *kharif* 1999 at all the stages.

At 60 DAS during both the years the genotypes Bidar-4, Amalapuram and CO-1 showed significantly higher values for this trait, while, the genotype Rajapuri showed significantly lower values for stem dry weight during *kharif* 1998 while during *kharif* 1999 the lowest stem dry weight values were recorded by BSR-1.

At 90 DAS, the stem dry weight was significantly higher in Bidar-4, Amalapuram and CO-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the stem dry weight values were significantly more in BSR-1 followed by Bidar-4 and Rajapuri. During *kharif* 1998 the genotype Rajapuri recorded significantly lower values while during *kharif* 1999, the lowest values were recorded by Cuddapah.

At 120 DAS during both the years the genotypes Rajapuri, BSR-1 and Amalapuram showed significantly higher values for this trait, while, the genotype Bidar-4 showed significantly lower values for stem dry weight during *kharif* 1998 while during *kharif* 1999 the lowest stem dry weight values were recorded by Cuddapah.

At 150 DAS during both the years the genotypes BSR-1, CO-1 and Rajapuri showed significantly higher values for this trait, while, the genotype Amalapuram

Table 9: Genotypic variation for stem dry weight (g plant⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	1.55	1.58	4.58	2.47	9.40	7.07	8.15	11.77	6.10	5.09
CO-1	1.88	1.40	4.52	1.47	8.84	5.62	18.28	14.16	8.86	7.88
Bidar-4	3.04	2.67	6.38	4.18	7.58	6.94	12.74	12.18	5.18	4.41
BSR-1	1.24	0.96	3.72	4.43	10.99	11.66	19.52	19.44	7.20	6.86
Rajapuri	1.12	1.02	2.83	2.82	11.42	8.63	16.18	15.04	6.10	5.68
Cuddapah	1.51	1.28	2.86	1.01	8.16	3.42	12.23	10.84	6.72	5.73
Mean	1.72	1.49	4.15	2.73	9.40	7.22	14.52	13.91	6.69	5.94
S. Em ±	0.09	0.08	0.15	0.13	0.35	0.30	0.55	0.43	0.22	0.19
C.D. (5%)	0.26	0.24	0.46	0.40	1.05	0.91	1.66	1.31	0.65	0.56

showed significantly lower values for stem dry weight during *kharif* 1998 while during *kharif* 1999 the lowest stem dry weight values were recorded by Cuddapah.

At 180 DAS during both the years the genotypes CO-1, BSR-1 and Cuddapah showed significantly higher values for this trait, while, the genotype Bidar-4 showed significantly lower values for stem dry weight.

4.1.2.3 Rhizome dry weight (g plant⁻¹)

The data on Rhizome dry weight indicated significant differences at all the stages among the turmeric genotypes during both the years (Table 10). In general rhizome dry weight increased upto 180 DAS. It was observed that rhizome dry weight was more during *kharif* 1998 as compared to *kharif* 1999 at all the stages except during 60 DAS where it was equal in both the years.

At 60 DAS during both the years the genotypes Amalapuram, Bidar-4 and Cuddapah showed significantly higher values for this trait, while, the genotypes BSR-1 and Rajapuri showed significantly lower values for rhizome dry weight.

At 90 DAS, the rhizome dry weight was significantly higher in Amalapuram, Bidar-4 and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the rhizome dry weight values were significantly more in Amalapuram followed by Bidar-4 and CO-1. During both the years the genotype BSR-1 recorded significantly lower values.

At 120, 150 and 180 DAS during both the years the genotypes Amalapuram, Bidar-4 and Cuddapah showed significantly higher values for this trait, while, the genotype BSR-1 showed significantly lower values for rhizome dry weight.

4.1.2.4 Total dry matter (TDM, g plant⁻¹)

The genotypic variation for total dry matter (TDM) at different growth stages indicated significant differences among themselves (Table 11). In general, the

Table 10: Genotypic variation for rhizome dry weight (g plant⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	3.65	2.90	7.52	5.97	15.49	12.30	31.91	25.30	72.11	57.18
CO-1	1.92	1.56	3.90	3.20	7.92	6.50	19.96	13.20	43.72	29.98
Bidar-4	2.83	2.26	5.80	4.60	11.89	9.43	24.37	22.33	56.05	53.54
BSR-1	0.67	0.55	1.35	1.11	2.71	2.23	8.16	4.48	34.64	28.09
Rajapuri	1.39	1.14	2.81	2.30	5.68	4.65	11.47	9.39	36.64	29.44
Cuddapah	2.54	2.05	5.18	2.66	10.57	8.49	24.00	17.32	54.83	51.64
Mean	1.74	1.74	4.43	3.31	9.04	7.27	19.98	15.34	49.67	41.65
S. Em ±	0.20	0.14	0.42	0.35	0.80	0.72	1.60	1.29	2.04	1.93
C.D. (5%)	0.61	0.43	1.26	1.06	2.41	2.16	4.84	3.96	6.16	5.83

Table 11: Genotypic variation for total dry matter (g plant⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	10.06	8.13	22.01	16.87	40.09	32.50	68.16	63.56	88.43	72.34
CO-1	7.20	5.78	15.58	11.02	27.70	22.48	55.96	44.01	60.98	45.37
Bidar-4	9.57	8.03	20.74	16.76	33.89	28.89	59.17	55.49	71.33	67.50
BSR-1	4.15	2.97	12.00	11.14	23.10	21.82	43.88	39.03	49.12	41.46
Rajapuri	5.47	4.14	12.65	11.19	27.11	22.35	45.05	40.49	50.43	42.28
Cuddapah	7.57	6.23	17.21	11.15	30.41	23.15	58.23	48.64	70.41	65.40
Mean	7.34	5.88	16.70	13.02	30.38	25.20	55.08	48.54	65.17	55.73
S. Em ±	0.43	0.47	0.61	0.50	0.93	0.80	1.23	1.16	1.86	1.70
C.D. (5%)	1.31	1.42	1.83	1.51	2.81	2.43	3.72	3.51	5.63	5.12

TDM increased upto 60 to 180 DAS during both the years of study. The TDM was found to be more during *kharif* 1998 at all the stages as compared to *kharif* 1999.

At 60 DAS, the TDM was significantly higher in Amalapuram followed by Bidar-4 and Cuddapah during both the years. During *kharif* 1998, TDM ranged from 4.15 in BSR-1 to 10.06 g plant⁻¹ in Amalapuram while, during *kharif* 1999 TDM ranged from 2.97 in BSR-1 to 8.13 g plant⁻¹ in Amalapuram. During both the years the genotypes BSR-1 and Rajapuri possessed significantly lower values for TDM as compared to other genotypes.

At 90, 120, 150 and 180 DAS, the TDM was significantly higher in Amalapuram followed by Bidar-4 and Cuddapah except Rajapuri recording higher values than Cuddapah at 90 das during *kharif* 1999. The genotypes BSR-1 and Rajapuri recorded significantly lower values for TDM at all these stages during both the years. At 180 DAS, during *kharif* 1998 TDM ranged from 49.12 in BSR-1 to 88.43 g plant⁻¹ in Amalapuram while, during *kharif* 1999, the range was 41.46 in BSR-1 to 72.34 g plant⁻¹ in Amalapuram.

4.1.3 GROWTH PARAMETERS

4.1.3.1 Leaf Area (cm² plant⁻¹)

The genotypic variation for leaf area at different growth stages in turmeric indicated significant differences among themselves (Table 12). In general, the leaf area increased from 60 to 150 DAS and decreased afterwards during both the years of study. The leaf area was found more during *kharif* 1998 at all the stages as compared to *kharif* 1999.

At 60 DAS, the leaf area was significantly higher in Amalapuram followed by Bidar-4 and Cuddapah during both the years. During *kharif* 1998, leaf area ranged from 701 in BSR-1 to 1146 cm² plant⁻¹ in Amalapuram while during *kharif* 1999, it ranged from 467 in BSR-1 to 1037 cm² plant⁻¹ in Amalapuram. During both the years the

Table 12: Genotypic variation for leaf area ($\text{cm}^2 \text{ plant}^{-1}$) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	1146	1037	2155	1995	2423	2260	4257	4038	2840	2582
CO-1	852	754	1608	1489	2085	1992	2953	2812	1642	1493
Bidar-4	1038	927	1732	1604	2372	2200	3430	3330	2153	1957
BSR-1	701	467	1500	1389	1843	1535	2644	2518	1382	1256
Rajapuri	810	547	1508	1396	1870	1867	2806	2672	1484	1349
Cuddapah	875	761	1723	1596	2115	2105	3426	3297	1651	1501
Mean	904	749	1704	1578	2118	1993	3253	3111	1859	1690
S. Em $\pm$	28.81	24.50	30.46	28.15	37.09	35.10	61.59	44.04	38.41	34.11
C.D. (5%)	87	74	92	85	112	106	186	133	116	103

genotypes BSR-1 and Rajapuri possessed significantly lower values for leaf area as compared to others genotypes.

At 90, 120, 150 and 180 DAS, the leaf area was significantly higher in Amalapuram followed by Bidar-4 and Cuddapah. The genotypes BSR-1 and Rajapuri recorded significantly lower values for leaf area at all the stages during both the years. At 180 DAS, during *kharif* 1998 leaf area ranged from 1382 in BSR-1 to 2840 cm² plant⁻¹ in Amalapuram while, during *kharif* 1999 the range was 1256 in BSR-1 to 2582 cm² plant⁻¹ in Amalapuram.

4.1.3.2 Leaf Area Index (LAI)

Significant differences were observed with respect to leaf area index (LAI) at all the stages among the turmeric genotypes during both the years (Table 13). In general LAI increased upto 150 DAS and decreased thereafter. It was observed that LAI was more during *kharif* 1998 as compared to *kharif* 1999 at all the stages.

At all the stages during both the years the genotypes Amalapuram, Bidar-4 and Cuddapah showed significantly higher values for this trait, while, the genotypes BSR-1 and Rajapuri showed significantly lower values for LAI.

4.1.3.3 Absolute Growth Rate (AGR, g plant⁻¹ day⁻¹)

The absolute growth rate (AGR) indicated significant differences at all the stages among the turmeric genotypes during both the years (Table 14). In general AGR increased upto 120-150 DAS and decreased thereafter. It was seen that AGR was more during *kharif* 1998 as compared to *kharif* 1999 at all the stages.

At 60-90 DAS, the AGR was significantly higher in Amalapuram, Bidar-4 and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the AGR values were significantly more in Amalapuram followed by Bidar-4 and BSR-1. During *kharif* 1998 the genotype Rajapuri recorded significantly lower values. While during *kharif* 1999, lowest AGR values were recorded by Cuddapah.

Table 13: Genotypic variation for leaf area index (LAI) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	0.64	0.58	1.20	1.11	1.35	1.26	2.37	2.24	1.58	1.43
CO-1	0.47	0.42	0.89	0.83	1.16	1.11	1.64	1.56	0.91	0.83
Bidar-4	0.58	0.52	0.96	0.89	1.32	1.22	1.91	1.85	1.20	1.09
BSR-1	0.39	0.26	0.83	0.77	1.02	0.85	1.47	1.40	0.77	0.70
Rajapuri	0.45	0.30	0.84	0.78	1.04	1.04	1.56	1.48	0.82	0.75
Cuddapah	0.49	0.42	0.96	0.89	1.18	1.17	1.90	1.83	0.92	0.83
Mean	0.502	0.416	0.947	0.877	1.177	1.107	1.807	1.728	1.033	0.939
S. Em $\pm$	0.0001	0.0001	0.0003	0.0003	0.0003	0.0002	0.0007	0.0003	0.0007	0.0007
C.D. (5%)	0.0003	0.0003	0.001	0.0009	0.001	0.0006	0.002	0.001	0.002	0.002

Table 14: Genotypic variation for absolute growth rate (AGR, g plant⁻¹ day⁻¹) in turmeric at different growth stages (1998 and 1999)

Genotype	Days after sowing							
	60-90		90-120		120-150		150-180	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	0.40	0.29	0.60	0.52	0.94	1.04	0.68	0.29
CO-1	0.28	0.17	0.40	0.38	0.94	0.72	0.17	0.05
Bidar-4	0.37	0.29	0.44	0.40	0.84	0.89	0.41	0.40
BSR-1	0.26	0.27	0.37	0.36	0.69	0.57	0.17	0.08
Rajapuri	0.24	0.24	0.48	0.37	0.60	0.60	0.18	0.06
Cuddapah	0.32	0.16	0.44	0.40	0.93	0.85	0.41	0.56
Mean	0.312	0.238	0.456	0.406	0.823	0.778	0.335	0.240
S. Em ±	0.007	0.006	0.02	0.02	0.04	0.03	0.03	0.02
C.D. (5%)	0.021	0.019	0.07	0.06	0.11	0.10	0.08	0.07

At 90-120 DAS, the AGR was significantly higher in Amalapuram, Rajapuri and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the AGR values were significantly more in Amalapuram followed by Bidar-4 and Cuddapah. During both the years the genotype BSR-1 recorded significantly lower values.

At 120-150 DAS, the AGR was significantly higher in CO-1, Amalapuram and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the AGR values were significantly more in Amalapuram followed by Bidar-4 and Cuddapah. During *kharif* 1998 the genotype Rajapuri recorded significantly lower values. While during *kharif* 1999, lowest AGR values were registered by BSR-1.

At 150-180 DAS, the AGR was significantly higher in Amalapuram, Cuddapah and Bidar-4 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the AGR values were significantly more in Cuddapah followed by Bidar-4 and Amalapuram. During both the years the genotype CO-1 recorded significantly lower values.

4.1.3.4 Crop Growth Rate (CGR, $\text{gm}^{-2} \text{ day}^{-1}$)

The data on crop growth rate (CGR) revealed significant differences at all the stages among the turmeric genotypes during both the years (Table 15). In general, CGR increased upto 120-150 DAS and decreased thereafter. It was found that CGR was more during *kharif* 1998 as compared to *kharif* 1999 at all the stages.

At 60-90 DAS, the CGR was significantly higher in Amalapuram, Bidar-4 and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the CGR values were significantly more in Amalapuram followed by Bidar-4 and BSR-1. During *kharif* 1998 the genotype Rajapuri recorded significantly lower values. While during *kharif* 1999, lowest CGR values were recorded by Cuddapah.

Table 15: Genotypic variation for crop growth rate (CGR, g m⁻² day⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing							
	60-90		90-120		120-150		150-180	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	2.21	1.62	3.35	2.89	5.20	5.75	3.75	1.63
CO-1	1.55	0.97	2.24	2.12	5.23	3.99	0.93	0.25
Bidar-4	2.07	1.62	2.44	2.25	4.68	4.93	2.25	2.22
BSR-1	1.45	1.51	2.06	1.98	3.85	3.19	0.97	0.45
Rajapuri	1.33	1.31	2.68	2.07	3.32	3.36	1.00	0.33
Cuddapah	1.79	0.91	2.44	2.22	5.15	4.72	2.26	3.10
Mean	1.74	1.32	2.54	2.26	4.57	4.32	1.86	1.33
S. Em ±	0.03	0.03	0.07	0.07	0.14	0.12	0.07	0.06
C.D. (5%)	0.10	0.10	0.22	0.21	0.41	0.36	0.22	0.18

At 90-120 DAS, the CGR was significantly higher in Amalapuram and Rajapuri as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the CGR values were significantly more in Amalapuram followed by Bidar-4 and Cuddapah. During both the years the genotype BSR-1 recorded significantly lower values.

At 120-150 DAS, the CGR was significantly higher in CO-1, Amalapuram and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the CGR values were significantly more in Amalapuram followed by Bidar-4 and Rajapuri. During both the years, the genotypes BSR-1 and Rajapuri recorded significantly lower values.

At 150-180 DAS, the CGR was significantly higher in Amalapuram, Bidar-4 and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the CGR values were significantly more in Cuddapah followed by Bidar-4 and Amalapuram. During both the years the genotype CO-1 recorded significantly lower values.

4.1.3.5 Relative Growth Rate (RGR, $\text{gg}^{-1} \text{ day}^{-1}$)

Significant differences were observed with respect to relative growth rate (RGR) at all the stages among the turmeric genotypes during both the years (Table 16). The RGR was more 60-90 DAS as compared to other stages. It was seen that RGR was more during *kharif* 1998 as compared to *kharif* 1999 at 60-90 and 150-180 DAS.

At 60-90 DAS, the RGR was significantly higher in BSR-1, Rajapuri and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the RGR values were significantly more in BSR-1 followed by Rajapuri and Bidar-4. During *kharif* 1998 the genotype CO-1 recorded significantly lower values. While during *kharif* 1999, lowest RGR values were recorded by Cuddapah.

Table 16: Genotypic variation for relative growth rate (RGR, g g⁻¹ day⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing							
	60-90		90-120		120-150		150-180	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	0.0261	0.0243	0.0200	0.0219	0.0177	0.0224	0.0087	0.0043
CO-1	0.0257	0.0215	0.0192	0.0238	0.0234	0.0224	0.0029	0.0010
Bidar-4	0.0258	0.0245	0.0164	0.0182	0.0186	0.0218	0.0062	0.0065
BSR-1	0.0354	0.0441	0.0218	0.0224	0.0214	0.0194	0.0038	0.0020
Rajapuri	0.0279	0.0331	0.0254	0.0231	0.0169	0.0198	0.0038	0.0014
Cuddapah	0.0274	0.0194	0.0190	0.0244	0.0217	0.0247	0.0063	0.0099
Mean	0.0281	0.0278	0.0203	0.0223	0.0200	0.0218	0.0058	0.0042
S. Em ±	0.0007	0.0003	0.0007	0.0007	0.0003	0.0003	0.0007	0.0007
C.D. (5%)	0.002	0.001	0.002	0.002	0.001	0.001	0.002	0.002

At 90-120 DAS, the RGR was significantly higher in Rajapuri, BSR-1 and Amalapuram as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the RGR values were significantly more in Cuddapah followed by CO-1 and Rajapuri. During both the years the genotype Bidar-4 recorded significantly lower values.

At 120-150 DAS, the RGR was significantly higher in CO-1, Cuddapah and BSR-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the RGR values were significantly more in Cuddapah followed by Amalapuram and CO-1. During *kharif* 1998, the genotype Rajapuri recorded significantly lower values. While during *kharif* 1999, the lowest RGR values were recorded by BSR-1.

At 150-180 DAS, the RGR was significantly higher in Amalapuram, Cuddapah and Bidar-4 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the RGR values were significantly more in Cuddapah followed by Bidar-4 and Amalapuram. During both the years the genotype CO-1 recorded significantly lower values.

4.1.3.6 Net Assimilation Rate (NAR, g dm⁻² day⁻¹)

The data on net assimilation rate (NAR) indicated significant differences at all the stages among the turmeric genotypes during both the years (Table 17). In general, the NAR values were highest at 120-150 DAS and decreased thereafter. It was seen that NAR was more during *kharif* 1998 as compared to *kharif* 1999 at 60-90 and 150-180 DAS.

At 60-90 DAS, the NAR was significantly higher in Bidar-4, Cuddapah and Amalapuram as compared to other genotypes during *kharif* 1998. Whereas, during

Table 17: Genotypic variation for net assimilation rate (NAR, g dm⁻² day⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing							
	60-90		90-120		120-150		150-180	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	0.0249	0.0199	0.0264	0.0245	0.0288	0.0338	0.0193	0.0090
CO-1	0.0235	0.0162	0.0220	0.0221	0.0378	0.0302	0.0075	0.0022
Bidar-4	0.0275	0.0236	0.0215	0.0214	0.0294	0.0325	0.0148	0.0155
BSR-1	0.0249	0.0322	0.0222	0.0244	0.0312	0.0289	0.0090	0.0045
Rajapuri	0.0213	0.0259	0.0286	0.0230	0.0259	0.0269	0.8600	0.0031
Cuddapah	0.0257	0.0145	0.0230	0.0218	0.0341	0.0320	0.0167	0.0245
Mean	0.0246	0.0220	0.0193	0.0211	0.0271	0.0307	0.0126	0.0098
S. Em ±	0.0007	0.0003	0.007	0.003	0.007	0.003	0.001	0.0007
C.D. (5%)	0.002	0.001	0.02	0.01	0.02	0.01	0.003	0.002

At 90-120 DAS, the NAR was significantly higher in Amalapuram, Cuddapah and BSR-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the NAR values were significantly more in Amalapuram followed by BSR-1 and CO-1. During both the years the genotype Rajapuri recorded significantly lower values.

At 120-150 DAS, the NAR was significantly higher in CO-1, Cuddapah and BSR-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the NAR values were significantly more in Amalapuram followed by Bidar-4 and Cuddapah. During both the years, the genotype Rajapuri recorded significantly lower values.

At 150-180 DAS, the NAR was significantly higher in Amalapuram, Cuddapah and Bidar-4 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the NAR values were significantly more in Cuddapah followed by Bidar-4 and Amalapuram. During both the years the genotype CO-1 recorded significantly lower values.

4.1.3.7 Specific Leaf Weight (SLW, mg cm⁻²)

The data on specific leaf weight (SLW) indicated significant differences at all the stages among the turmeric genotypes during both the years (Table 18). In general, SLW increased upto 150 DAS and decreased thereafter. It was observed that SLW was more during *kharif* 1998 as compared to *kharif* 1999 at all the stages except 180 DAS.

At 60 DAS, the SLW was significantly higher in Amalapuram, Cuddapah and CO-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the SLW values were significantly more in Cuddapah followed by CO-1 and Rajapuri. During both the years, the genotype BSR-1 recorded significantly lower values.

At 90 DAS, the SLW was significantly higher in Bidar-4, Rajapuri and Amalapuram as compared to other genotypes during *kharif* 1998. Whereas, during *kharif*

Table 18: Genotypic variation for specific leaf weight (SLW, mg cm⁻²) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	4.24	3.52	4.60	4.23	6.27	5.81	6.60	6.56	3.60	3.90
CO-1	3.99	3.74	4.45	4.26	5.25	5.20	6.00	5.92	5.12	5.03
Bidar-4	3.56	3.34	4.94	4.98	6.08	5.69	6.43	6.30	4.69	4.88
BSR-1	3.20	3.13	4.62	4.03	5.10	5.17	6.13	6.00	5.27	5.18
Rajapuri	3.65	3.62	4.65	4.35	5.35	4.86	6.20	6.01	5.18	5.31
Cuddapah	4.02	3.81	5.32	4.69	5.52	5.34	6.42	6.21	5.37	5.35
Mean	3.78	3.53	4.76	4.42	5.60	5.35	6.30	6.17	4.87	4.94
S. Em ±	0.07	0.06	0.04	0.03	0.11	0.07	0.04	0.03	0.13	0.12
C.D. (5%)	0.22	0.19	0.11	0.10	0.32	0.22	0.11	0.10	0.41	0.36

1999 the SLW values were significantly more in Bidar-4 followed by Cuddapah and Rajapuri. During *kharif* 1998, the genotype CO-1 recorded significantly lower values. While during *kharif* 1999, lowest SLW values were recorded by BSR-1.

At 120 and 150 DAS during both the years the genotypes Amalapuram, Bidar-4 and Cuddapah showed significantly higher values for this trait, while, the genotype CO-1 showed significantly lower values for SLW.

At 180 DAS during both the years the genotypes Cuddapah, Rajapuri and BSR-1 showed significantly higher values for this trait, while, the genotype Amalapuram showed significantly lower values for SLW.

4.1.3.8 Specific Leaf Area (SLA, mg cm⁻²)

The data on specific leaf area (SLA) showed significant differences at all the stages among the turmeric genotypes during both the years (Table 19). The SLA was more at 180 DAS as compared to other stages. It was seen that SLA was more during *kharif* 1999 as compared to *kharif* 1998 at all the stages except at 180 DAS.

At 60 DAS, the SLA was significantly higher in BSR-1, Bidar-4 and Rajapuri as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the SLA values were significantly more in BSR-1 followed by Bidar-4 and Amalapuram. During *kharif* 1998, the genotype Amalapuram recorded significantly lower values. While during *kharif* 1999, the lowest SLA values were recorded by Cuddapah.

At 90 DAS, the SLA was significantly higher in CO-1, Amalapuram and BSR-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the SLA values were significantly more in BSR-1 followed by Amalapuram and CO-1. During *kharif* 1998, the genotype Cuddapah recorded significantly lower values. While during *kharif* 1999, lowest SLA values were recorded by Bidar-4.

At 120 and 150 DAS during both the years the genotypes CO-1, BSR-1 and Rajapuri showed significantly higher values for this trait, while, the genotype Amalapuram showed significantly lower values for SLA.

Table 19: Genotypic variation for specific leaf area (SLA, $\text{cm}^2 \text{mg}^{-1}$) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	0.236	0.284	0.217	0.237	0.159	0.172	0.151	0.152	0.278	0.256
CO-1	0.251	0.267	0.225	0.234	0.191	0.192	0.167	0.169	0.195	0.199
Bidar-4	0.281	0.299	0.202	0.201	0.164	0.176	0.155	0.159	0.213	0.205
BSR-1	0.313	0.320	0.216	0.248	0.196	0.194	0.163	0.167	0.190	0.193
Rajapuri	0.274	0.276	0.215	0.230	0.187	0.206	0.161	0.166	0.193	0.188
Cuddapah	0.249	0.262	0.188	0.213	0.181	0.187	0.156	0.161	0.186	0.187
Mean	0.267	0.285	0.211	0.227	0.180	0.188	0.159	0.162	0.209	0.205
S. Em $\pm$	0.0006	0.0003	0.003	0.003	0.003	0.003	0.002	0.001	0.003	0.002
C.D. (5%)	0.0020	0.0010	0.012	0.010	0.010	0.010	0.006	0.004	0.008	0.006

At 180 DAS during both the years the genotypes Amalapuram, Bidar-4 and CO-1 showed significantly higher values for this trait, while, the genotype Cuddapah showed significantly lower values for SLA.

4.1.3.9 Leaf Area Ratio (LAR, $\text{cm}^2 \text{g}^{-1}$)

The leaf area ratio (LAR) indicated significant differences at all the stages among the turmeric genotypes during both the years (Table 20). The LAR was more at 60 DAS as compared to other stages. It was observed that LAR was more during *kharif* 1999 as compared to *kharif* 1998 at all the stages.

At 60 DAS during both the years the genotypes BSR-1, Rajapuri and CO-1 showed significantly higher values for this trait, while, the genotype Bidar-4 showed significantly lower values for LAR.

At 90 DAS, the LAR was significantly higher in BSR-1, Rajapuri and CO-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LAR values were significantly more in Cuddapah followed by CO-1 and Rajapuri. During both the years the genotype Bidar-4 recorded significantly lower values.

At 120 DAS, the LAR was significantly higher in BSR-1, CO-1 and Bidar-4 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LAR values were significantly more in Cuddapah followed by CO-1 and Rajapuri. During both the years, the genotype Amalapuram recorded significantly lower values.

At 150 DAS, the LAR was significantly higher in Amalapuram, Rajapuri and BSR-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LAR values were significantly more in Cuddapah followed by Rajapuri and BSR-1. During *kharif* 1998, the genotype CO-1 recorded significantly lower values. While during *kharif* 1999, the lowest values were recorded by Bidar-4.

At 180 DAS during both the years the genotypes Amalapuram showed significantly higher values for this trait, while, the genotype Cuddapah showed significantly lower values for LAR.

4.1.3.10 Leaf Weight Ratio (LWR, g cm⁻²)

Significant differences were observed with respect to leaf weight ratio (LWR) at all the stages among the turmeric genotypes during both the years (Table 21). In general, LWR increased upto 90 DAS and decreased thereafter. It was seen that LWR was more during *kharif* 1999 as compared to *kharif* 1998 at all the stages except 60 DAS.

At 60 DAS, the LWR was significantly higher in BSR-1, Rajapuri and Amalapuram as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LWR values were significantly more in BSR-1 followed by CO-1 and Rajapuri. During both the years, the genotype Bidar-4 recorded significantly lower values.

At 90 DAS, the LWR was significantly higher in BSR-1, Rajapuri and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LWR values were significantly more in Cuddapah followed by CO-1 and Rajapuri. During both the years the genotype Bidar-4 recorded significantly lower values.

At 120 DAS, the LWR was significantly higher in Bidar-4, BSR-1 and CO-1 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LWR values were significantly more in Cuddapah followed by CO-1 and Bidar-4. During *kharif* 1998, the genotype Rajapur recorded significantly lower values. While during *kharif* 1999 the lowest LWR values were found in BSR-1.

At 150 DAS, the LWR was significantly higher in Amalapuram, Rajapuri and Cuddapah as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LWR values were significantly more in Cuddapah followed by Amalapuram and Rajapuri. During both the years the genotype CO-1 recorded significantly lower values.

At 180 DAS, the LWR was significantly higher in Rajapuri, BSR-1 and Bidar-4 as compared to other genotypes during *kharif* 1998. Whereas, during *kharif* 1999 the LWR values were significantly more in Rajapuri followed by CO-1 and BSR-1.

Table 21: Genotypic variation for leaf weight ratio (LWR, g cm⁻²) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	60		90		120		150		180	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	0.48	0.45	0.45	0.50	0.38	0.40	0.41	0.42	0.12	0.14
CO-1	0.47	0.49	0.46	0.58	0.39	0.46	0.32	0.38	0.14	0.17
Bidar-4	0.39	0.39	0.41	0.48	0.43	0.43	0.37	0.38	0.14	0.14
BSR-1	0.54	0.49	0.58	0.50	0.41	0.36	0.37	0.39	0.15	0.16
Rajapuri	0.54	0.48	0.55	0.54	0.37	0.41	0.39	0.40	0.15	0.17
Cuddapah	0.46	0.47	0.53	0.67	0.38	0.49	0.38	0.42	0.13	0.12
Mean	0.485	0.460	0.498	0.545	0.393	0.426	0.373	0.396	0.137	0.149
S. Em ±	0.02	0.02	0.01	0.006	0.006	0.003	0.02	0.01	0.006	0.003
C.D. (5%)	0.06	0.05	0.03	0.02	0.02	0.01	0.06	0.04	0.02	0.01

During *kharif* 98 the genotype Amalapuram recorded significantly lower values. While during *kharif* 1999, the lowest LWR values were recorded by Cuddapah.

4.1.3.11 Leaf Area Duration (LAD, days)

The genotypic variation for leaf area duration (LAD) at different growth stages indicated significant differences among themselves (Table 22). In general, the LAD increased from 60-90 DAS to 120-150 DAS and decreased thereafter.

At all the stages from 60-90 DAS to 150-180 DAS, during both the years, LAD was significantly higher in Amalapuram, Bidar-4 and Cuddapah and significantly lower values for LAD was recorded by BSR-1 followed by Rajapuri.

4.1.3.12 Biomass Duration (BMD, days)

The genotypic variation for biomass duration (BMD) at different growth stages indicated significant differences among themselves (Table 23). In general, the BMD increased from 60-90 DAS to 150-180 DAS during both the years of study. The BMD was found to be more during *kharif* 1998 at all the stages as compared to *kharif* 1999.

At all the stages from 60-90 DAS to 150-180 DAS during both the years, BMD was significantly higher in Amalapuram, Bidar-4 and Cuddapah and significantly lower values for BMD were recorded by BSR-1 followed by Rajapuri.

4.1.4 BIOPHYSICAL PARAMETERS

4.1.4.1 Number of Stomata (mm⁻² leaf area)

The data presented in Table 24 indicated significant differences in number of stomata on both abaxial (lower) and adaxial (upper) leaf surface in different turmeric genotypes at 150 DAS during both the years. In general, the number of stomata were found more on abaxial surface compared to adaxial surface and the values were more during *kharif* 1998 compared to *kharif* 1999.

Table 22: Genotypic variation for leaf area duration (LAD, days) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing							
	60-90		90-120		120-150		150-180	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	27.51	25.27	38.15	35.46	55.67	52.48	59.14	55.17
CO-1	20.50	18.69	30.78	29.01	41.98	40.03	38.29	35.88
Bidar-4	23.08	21.09	34.20	31.70	48.35	46.08	46.53	44.06
BSR-1	18.34	15.47	27.86	24.37	37.39	33.78	33.55	31.45
Rajapuri	19.32	16.19	28.15	27.19	38.97	37.83	35.75	33.51
Cuddapah	21.65	19.64	31.98	30.84	46.18	45.02	42.31	39.98
Mean	21.73	19.39	31.91	29.76	44.42	42.54	42.60	40.01
S. Em $\pm$	0.34	0.37	0.54	0.46	0.66	0.65	0.48	0.44
C.D. (5%)	1.03	1.12	1.65	1.41	2.01	1.98	1.46	1.35

Table 23: Genotypic variation for biomass duration (BMD, g day⁻¹) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing							
	60-90		90-120		120-150		150-180	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	481.05	375.00	931.50	740.55	1623.75	1440.9	2348.85	2038.5
CO-1	341.70	252.00	649.20	502.5	1254.90	997.35	1754.10	1340.7
Bidar-4	454.65	371.85	819.45	684.75	1395.90	1265.7	1957.50	1844.9
BSR-1	242.25	211.65	526.50	494.4	1004.70	912.75	1395.00	1207.4
Rajapuri	271.80	229.95	596.40	503.1	1082.40	942.6	1432.20	1241.6
Cuddapah	371.70	260.70	714.30	514.5	1329.60	1076.9	1929.60	1710.6
Mean	360.56	283.53	706.23	573.30	1281.88	1106.03	1802.88	1563.93
S. Em ±	10.46	7.45	20.70	18.51	28.41	23.87	33.97	30.26
C.D. (5%)	31.6	22.5	62.5	55.9	85.8	72.1	102.6	91.4

During *kharif* 1998, significantly higher number of stomata on adaxial surface were found in Amalapuram followed by Bidar-4 and Cuddapah and lowest values were observed in Rajapuri. Similar trend was observed during *kharif* 1999. On abaxial surface, during *kharif* 1998, significantly higher number of stomata were found in Bidar-4, Cuddapah and Amalapuram and the genotype Rajapuri recorded significantly lower values for this trait compared to other genotypes. Similar trend was observed during *kharif* 1999 also.

4.1.4.2 Relative Water Content (RWC)

The data presented in Table 24 indicated significant differences in relative water content (RWC) in turmeric genotypes at 150 DAS during both the years. The RWC values were found to be more during *kharif* 1998 as compared to *kharif* 1999.

During *kharif* 1998, the genotype Amalapuram recorded significantly higher RWC followed by Bidar-4 and Cuddapah. The lowest RWC was observed in Rajapuri followed by BSR-1. Similar trend was observed during *kharif* 1999 also.

4.1.4.3 Light Transmission Ratio (LTR)

The data presented in Table 24 indicated significant differences in light transmission ratio (LTR) in different turmeric genotype at 150 DAS during both the years. In general, LTR was more during *kharif* 1999 as compared to *kharif* 1998.

During *kharif* 1998, significantly higher LTR was recorded by BSR-1 followed by Rajapuri and CO-1 and lowest LTR values were recorded by Amalapuram followed by Bidar-4 and Cuddapah. Similar trend was seen during *kharif* 1999.

4.1.4.4 The photosynthetic rate ($\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ S}^{-1}$)

Significant differences were noticed among the genotypes with respect to photosynthetic rate at 150 DAS during both the years (Table 25). In general, it was observed that photosynthetic rate was more during *kharif* 1998 as compared to *kharif* 1999 at 150 DAS.

Table 24: Genotypic variation for stomatal number, relative water content (%) and light transmission ratio in turmeric at 150 DAS (1998 and 1999)

Genotype	Stomatal Number (Abaxial)		Stomatal Number (Adaxial)		Relative Water Content (%)		Light Transmission Ratio (%)	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	383	350	189	164	90.4	80.6	33.4	36.5
CO-1	322	305	178	162	82.9	74.8	39.4	43.8
Bidar-4	366	349	198	186	85.9	79.2	36.9	39.6
BSR-1	304	298	138	125	82.0	73.6	43.8	48.5
Rajapuri	241	230	122	107	79.6	72.3	41.3	46.2
Cuddapah	335	313	193	174	83.1	75.6	37.9	41.3
Mean	325	308	170	153	84	76	38.8	42.7
S. Em $\pm$	7.64	6.51	4.65	4.31	0.67	0.35	1.19	1.16
C.D. (5%)	23.0	19.6	14.0	13.0	2.03	1.04	3.6	3.5

DAS – Days after sowing

During both the years, the genotypes Amalapuram, Bidar-4 and Cuddapah maintained significantly higher rate of photosynthesis as compared to other genotypes and the genotypes BSR-1 and Rajapuri recorded significantly lower values for this trait compared to other genotypes. Among the genotypes, the rate of photosynthesis ranged from 10.29 to 15.52 $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ S}^{-1}$ during *kharif* 1998 and the range was from 8.42 to 12.83 $\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ S}^{-1}$ during *kharif* 1999.

4.1.4.5 Stomatal Conductance ($\mu \text{ mol m}^{-2} \text{ S}^{-1}$)

The data presented in Table 25 indicated significant differences of stomatal conductance at 150 DAS due to genotypes during both the years of study. In general, stomatal conductance was more during *kharif* 1998 as compared to *kharif* 1999 at 150 DAS.

The genotypes Amalapuram, Bidar-4 and Cuddapah recorded significantly more values of stomatal conductance as compared to other genotypes during both the years and significantly lower values for this trait were registered by the genotypes BSR-1 and Rajapuri as compared to the genotypes. Among the genotypes, the values of stomatal conductance ranged from 0.019 to 0.096 $\mu \text{ mol m}^{-2} \text{ S}^{-1}$ during *kharif* 1998 and the range was from 0.015 to 0.079 $\mu \text{ mol m}^{-2} \text{ S}^{-1}$ during *kharif* 1999.

4.1.4.6 Transpiration Rate ($\text{mmol H}_2\text{O m}^{-2} \text{ S}^{-1}$)

Significant differences were observed among the genotypes with respect to the rate of transpiration at 150 DAS during both the years (Table 25). In general, it was found that the rate of transpiration was more during *kharif* 1998 as compared to *kharif* 1999.

The genotypes, Amalapuram, Bidar-4 and Cuddapah maintained significantly higher rate of transpiration as compared to other genotypes during both the years and the genotypes BSR-1 and Rajapuri registered lower values for this trait as compared to other genotypes. Among the genotypes, the rate of transpiration ranged from

Table 25: Genotypic variation for photosynthetic rate, transpiration rate and stomatal conductance in turmeric at 150 DAS (1998 and 1999)

Genotype	Photosynthetic Rate		Transpiration Rate		Stomatal Conductance	
	$\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$		$\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$		$\mu\text{mol m}^{-2} \text{ s}^{-1}$	
	1998	1999	1998	1999	1998	1999
Amalapuram	15.52	12.83	3.60	2.84	0.096	0.079
CO-1	11.94	9.95	2.39	2.03	0.056	0.046
Bidar-4	14.78	11.92	3.28	2.63	0.074	0.059
BSR-1	10.29	8.42	1.20	0.89	0.019	0.015
Rajapuri	11.07	9.38	1.46	1.08	0.055	0.046
Cuddapah	13.55	10.42	3.14	2.58	0.070	0.057
Mean	12.86	10.49	0.06	0.05	2.51	2.01
S. Em $\pm$	0.31	0.29	0.01	0.01	0.08	0.07
C.D. (5%)	0.93	0.87	0.03	0.03	0.24	0.22

DAS – Days after sowing

1.20 to 3.60 mmol H₂O m⁻² S⁻¹ during *kharif* 1998 and the range was from 0.89 to 2.84 mmol H₂O m⁻² s⁻¹ during *kharif* 1999.

4.1.5 BIOCHEMICAL PARAMETERS

4.1.5.1 Chlorophyll 'a' content (mg g⁻¹ fresh weight)

The chlorophyll 'a' content indicated significant differences at both the stages among the turmeric genotypes during both the years (Table 26). The chlorophyll 'a' was more at 90 DAS as compared to 180 DAS. It was seen that chlorophyll 'a' was more during *kharif* 1998 as compared to *kharif* 1999 at both the stages.

At 90 DAS during both the years the genotypes Cuddapah, Bidar-4 and BSR-1 showed significantly higher values for this trait, while, the genotype Rajapuri showed significantly lower values for chlorophyll 'a'.

At 180 DAS during both the years the genotypes Rajapuri, Bidar-4 and Amalapuram showed significantly higher values for this trait, while, the genotype BSR-1 showed significantly lower values for chlorophyll 'a'.

4.1.5.2 Chlorophyll 'b' content (mg g⁻¹ fresh weight)

Significant differences were observed with respect to chlorophyll 'b' content at all the stages among the turmeric genotypes during both the years (Table 26). The chlorophyll 'b' was more at 90 DAS as compared to 180 DAS. It was found that chlorophyll 'b' was more during *kharif* 1998 as compared to *kharif* 1999 at all the stages.

At 90 DAS during both the years the genotypes Cuddapah, Bidar-4 and BSR-1 showed significantly higher values for this trait, while, the genotype CO-1 showed significantly lower values for chlorophyll 'b' during *kharif* 1998, while during *kharif* 1999, lowest value for chlorophyll 'b' was recorded by Rajapuri.

At 180 DAS during both the years the genotypes Rajapuri, Bidar-4 and Amalapuram showed significantly higher values for this trait, while, the genotype

Table 26: Genotypic variation for chlorophyll a and b contents (mg g⁻¹ fr.wt.) in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing							
	90		180		90		180	
	Chlorophyll 'a' content						Chlorophyll 'b' content	
	1999		1998		1999		1998	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	1.26	1.17	0.87	0.78	0.55	0.41	0.23	0.22
CO-1	1.21	1.16	0.73	0.66	0.49	0.38	0.20	0.18
Bidar-4	1.70	1.62	1.08	1.00	1.22	0.98	0.27	0.24
BSR-1	1.66	1.50	0.66	0.53	0.89	0.83	0.19	0.16
Rajapuri	1.08	1.04	1.16	1.02	0.51	0.36	0.29	0.24
Cuddapah	1.86	1.75	0.72	0.69	1.49	1.35	0.18	0.17
Mean	1.46	1.37	0.87	0.78	0.86	0.72	0.23	0.20
S. Em ±	0.04	0.03	0.05	0.04	0.04	0.04	0.04	0.03
C.D. (5%)	0.12	0.10	0.14	0.12	0.13	0.11	0.11	0.10

Cuddapah showed significantly lower values for chlorophyll 'b' during *kharif* 1998, while during *kharif* 1999, lowest values for chlorophyll 'b' were recorded by BSR-1.

4.1.5.3 Chlorophyll a:b ratio

The data on chlorophyll a:b ratio indicated significant differences at both the stages among the turmeric genotypes during both the years (Table 27). In general, chlorophyll a:b increased from 90 DAS to 180 DAS. It was found that chlorophyll a:b was more during *kharif* 1999 as compared to *kharif* 1998 at 90 and 180 DAS.

At 90 DAS during both the years the genotypes CO-1, Amalapuram and Rajapuri showed significantly higher values for this trait, while, the genotype Cuddapah showed significantly lower values for chlorophyll a:b.

At 180 DAS during both the years the genotypes Bidar-4, Rajapuri and Cuddapah showed significantly higher values for this trait, while, the genotype BSR-1 showed significantly lower values for chlorophyll a:b.

4.1.5.4 Total Chlorophyll Content (mg g⁻¹ fresh weight)

The total chlorophyll content indicated significant differences at both the stages among the turmeric genotypes during both the years (Table 27). The total chlorophyll content was more at 90 DAS as compared to 180 DAS. It was observed that total chlorophyll content was more during *kharif* 1998 as compared to *kharif* 1999 at both the stages.

At 90 DAS during both the years the genotypes Cuddapah, Bidar-4 and BSR-1 showed significantly higher values for this trait, while, the genotype Rajapuri showed significantly lower values for total chlorophyll content.

At 180 DAS during both the years the genotypes Rajapuri, Bidar-4 and Amalapuram showed significantly higher values for this trait, while, the genotype BSR-1 showed significantly lower values for total chlorophyll content.

4.1.5.5 Nitrate Reductase Activity (NRA, $\mu \text{ mol NO}_2 \text{ g}^{-1} \text{ fr.wt. hr}^{-1}$)

Significant differences were observed with respect to nitrate reductase activity (NRA) at both the stages among the turmeric genotypes during both the years (Table 28). The NRA was more at 150 DAS as compared to 180 DAS. It was seen that NRA was more during *kharif* 1998 as compared to *kharif* 1999 at both the stages.

At 150 DAS during both the years the genotypes Bidar-4, Cuddapah and Amalapuram showed significantly higher values for this trait, while, the genotype BSR-1 showed significantly lower values for NRA.

At 180 DAS during both the years the genotypes Bidar-4, Cuddapah and Amalapuram showed significantly higher values for this trait, while, the genotype BSR-1 showed significantly lower values for NRA.

4.1.5.6 Reducing sugars ($\text{mg g}^{-1} \text{ dry wt}$)

Significant differences were observed with respect to reducing sugars at 150 DAS among the turmeric genotypes during both the years (Table 28). It was observed that reducing sugar content in leaves was more during *kharif* 1998 as compared to *kharif* 1999 at 150 DAS.

During *kharif* 1998, the genotype BSR-1 recorded significantly higher reducing sugars followed by Rajapuri, Cuddapah and Amalapuram. Lowest values were found in Bidar-4 and CO-1. Similar trend was observed during *kharif* 1999.

4.1.5.7 Non-reducing sugars ($\text{mg g}^{-1} \text{ dry wt}$)

The non-reducing sugars indicated significant differences at 150 DAS among the turmeric genotypes during both the years (Table 28). It was observed that non-reducing sugar content in leaves was more during *kharif* 1998 as compared to *kharif* 1999 at 150 DAS.

Table 28: Genotypic variation for nitrate reductase activity (NRA), reducing, non-reducing and total sugars in turmeric at different stages (1998 and 1999)

Genotype	Days after sowing									
	150			180			150			150
	NRA			NRA			Reducing Sugars			Total Sugars
	$(\mu \text{ mol NO}_2\text{g}^{-1} \text{ fr. wt}^{-1}\text{hr}^{-1})$			$(\mu \text{ mol NO}_2\text{g}^{-1} \text{ fr. wt}^{-1}\text{hr}^{-1})$			mg g ⁻¹ dry wt.			
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	406.5	309.7	129.0	103.6	43.75	39.2	232.6	220.2	276.3	259.4
CO-1	261.0	296.5	123.0	93.1	37.50	35.7	184.8	167.9	222.3	203.6
Bidar-4	217.5	510.7	130.5	108.7	37.50	34.6	146.4	129.0	183.9	163.6
BSR-1	563.0	199.6	120.1	90.6	56.25	50.5	304.8	260.0	361.0	310.5
Rajapuri	333.0	225.5	118.5	82.3	50.00	46.2	249.2	233.9	299.2	280.1
Cuddapah	348.2	381.2	127.0	98.6	43.75	39.1	166.6	164.4	210.3	203.5
Mean	354.9	320.5	124.7	96.2	44.79	40.88	214.10	195.90	258.8	236.8
S. Em $\pm$	10.56	8.21	1.38	1.34	1.76	1.56	13.35	11.89	4.95	4.58
C.D. (5%)	31.8	24.7	4.16	4.02	5.3	4.70	40.20	35.80	14.9	13.8

During *kharif* 1998, the genotype BSR-1 recorded significantly higher non-reducing sugars followed by Rajapuri and Amalapuram. Lowest values were found in Bidar-4 followed by Cuddapah. Similar trend was observed during *kharif* 1999.

4.1.5.8 Total sugars (mg g^{-1} dry wt.)

The data on total sugars revealed significant differences at 150 DAS among the turmeric genotypes during both the years (Table 28). It was seen that total sugar content in leaves was more during *kharif* 1998 as compared to *kharif* 1999 at 150 DAS.

During *kharif* 1998, the genotype BSR-1 recorded significantly higher total sugar followed by Rajapuri and Amalapuram and lowest values were found in Bidar-4 followed by Cuddapah. Similar trend was observed during *kharif* 1999.

4.1.6 YIELD, YIELD COMPONENTS AND QUALITY

4.1.6.1 Fresh rhizome yield (g plant^{-1})

The data on fresh rhizome yield (g plant^{-1}) as influenced by genotypes during *kharif* 1998 and 1999 is presented in Table 29. The fresh rhizome yield differed significantly among the genotypes and during 1998 Amalapuram recorded significantly higher fresh rhizome yield ($595.1 \text{ g plant}^{-1}$) followed by Bidar-4 ($549.9 \text{ g plant}^{-1}$) and Cuddapah ($458.8 \text{ g plant}^{-1}$) as compared to other genotypes. The rhizome yield was significantly less in BSR-1 ($294.8 \text{ g plant}^{-1}$) followed by Rajapuri ($372.8 \text{ g plant}^{-1}$). During *kharif* 1999 also a similar trend was observed with respect to this parameter and the genotypes Amalapuram, Bidar-4 and Cuddapah recorded significantly higher values for fresh rhizome yield (496.6 , 492.6 and $369.1 \text{ g plant}^{-1}$, respectively). The genotype BSR-1 recorded significantly lowest values for fresh rhizome yield ($266.3 \text{ g plant}^{-1}$). In general, the yield levels were comparatively higher during *kharif* 1998 as compared to *kharif* 1999.

4.1.6.2 Fresh rhizome yield (t ha^{-1})

The fresh rhizome yield (t ha^{-1}) also differed significantly among the genotypes and during 1998 the range was from 16.4 t ha^{-1} (BSR-1) to 33.1 t ha^{-1}

Table 29: Genotypic variation for fresh and cured rhizome yield in turmeric at harvest (1998 and 1999)

Genotype	Fresh rhizome yield (g plant ⁻¹)		Fresh rhizome yield (t ha ⁻¹)		Cured rhizome yield (g plant ⁻¹)		Cured rhizome yield (t ha ⁻¹)	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	595.1	496.6	33.1	27.6	138.1	113.3	7.67	6.29
CO-1	382.3	365.3	21.2	20.3	86.4	71.6	4.80	3.98
Bidar-4	549.9	492.6	30.6	27.4	119.9	94.7	6.66	5.26
BSR-1	294.8	266.3	16.4	14.8	68.4	58.1	3.80	3.23
Rajapuri	372.8	338.5	20.7	18.8	78.3	65.7	4.35	3.65
Cuddapah	458.8	369.1	25.5	20.5	104.6	72.7	5.81	4.04
Mean	442.3	388.1	21.0	21.6	99.3	79.4	5.52	4.41
S. Em ±	16.0	14.3	0.89	0.79	2.95	3.05	0.16	0.17
C.D. (5%)	48.3	43.2	2.68	2.39	8.91	9.20	0.49	0.51

(Amalapuram) while, during 1999 it ranged from 14.8 t ha⁻¹ to 27.6 t ha⁻¹ (Table 29). The data on fresh rhizome yield (t ha⁻¹) also followed a similar trend as that of fresh rhizome yield (g plant⁻¹) and the genotypes Amalapuram, Bidar-4 and Cuddapah recorded significantly higher values for fresh rhizome yield (t ha⁻¹).

4.1.6.3 Cured rhizome yield (g plant⁻¹)

The cured rhizome yield (g plant⁻¹) differed significantly among the genotypes during both the years (Table 29). The cured rhizome yield was more during *kharif* 1998 as compared to *kharif* 1999. During *kharif* 1998 the cured rhizome yield ranged from 68.4 g plant⁻¹ in BSR-1 to 138.1 g plant⁻¹ in Amalapuram. The genotype Amalapuram recorded significantly highest values for cured rhizome yield (138.1 g plant⁻¹) followed by Bidar-4 (119.9 g plant⁻¹) and Cuddapah (104.6 g plant⁻¹). The genotype BSR-1 possessed significantly lower values for cured rhizome yield (68.4 g plant⁻¹). A similar trend was noticed during *kharif* 1999 and the cured rhizome yield ranged from 58.1 g plant⁻¹ in BSR-1 to 113.3 g plant⁻¹ in Amalapuram. The genotypes Amalapuram, Bidar-4 and Cuddapah registered significantly higher values for cured rhizome yield (g plant⁻¹).

4.1.6.4 Cured rhizome yield (t ha⁻¹)

The data on cured rhizome yield (t ha⁻¹) is presented in Table 29. The data also followed a similar trend as that of cured rhizome yield (g plant⁻¹). During *kharif* 1998 the cured rhizome yield ranged from 3.8 t ha⁻¹ in BSR-1 to 7.67 t ha⁻¹ in Amalapuram while, during 1999 the range was 3.23 in BSR-1 to 6.29 t ha⁻¹ in Amalapuram.

4.1.6.5 Number of mother rhizomes per plant

The data on genotypic variation for number of mother rhizomes per plant indicated significant differences during both the years (Table 30). In general, the number of mother rhizomes per plant were more during *kharif* 1998 as compared *kharif* 1999.

During *kharif* 1998 the number of mother rhizomes per plant were significantly higher in Bidar-4 (3.10) followed by Amalapuram (2.6) and Cuddapah (2.50). The genotype BSR-1 recorded significantly lowest values for this trait (2.10). Similarly, during *kharif* 1999 the genotypes Bidar-4 and Amalapuram also recorded significantly higher values (3.00 and 2.4 respectively) for number of mother rhizomes per plant.

4.1.6.6 Number of primary fingers per plant

The genotypic variation for number of primary finger per plant showed significant differences among themselves during both the years (Table 30). The number of primary fingers per plant were more during *kharif* 1998 as compared to *kharif* 1999. During *kharif* 1998 the genotype Amalapuram recorded significantly higher number of primary fingers per plant (12.9) followed by Bidar-4 (11.5) as compared to other genotypes and the genotype BSR-1 recorded significantly lower values (7.7). During *kharif* 1999 a similar trend was noticed and the number of primary fingers ranged from 7.35 in BSR-1 to 9.8 in Amalapuram.

4.1.6.7 Number of secondary fingers per plant

The data on number of secondary fingers per plant indicated significant differences among the genotypes (Table 30). The number of secondary fingers per plant were more during *kharif* 1998 as compared to *kharif* 1999. During *kharif* 1998 the genotype Bidar-4 recorded significantly higher number of secondary fingers per plant (14.01) followed by Cuddapah (12.22) as compared to other genotypes and the genotype BSR-1 recorded significantly lower values for this trait. During *kharif* 1999 a similar trend was noticed for this parameter and the number of secondary fingers per plant ranged from 6.01 in BSR-1 to 13.00 in Bidar-4 indicating wide variability for this trait.

4.1.6.8 Length of primary finger (cm)

The length of primary finger varied significantly among the genotypes during both the years (Table 30). The length of primary finger was relatively more during

Table 30: Genotypic variation for rhizome and finger characters in turmeric at harvest (1998 and 1999)

Genotype	Number of mother rhizome plant ⁻¹		Number of primary fingers plant ⁻¹		Number of secondary fingers plant ⁻¹		Length of primary finger (cm)	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	2.60	2.40	12.90	9.80	8.53	8.01	10.10	9.00
CO-1	2.40	2.30	10.20	8.02	8.39	8.12	9.90	9.10
Bidar-4	3.10	3.00	11.50	8.85	14.01	13.00	8.80	8.50
BSR-1	2.10	2.00	7.70	6.40	7.90	6.01	8.00	7.90
Rajapuri	2.30	2.10	8.80	7.35	9.80	7.00	8.30	8.00
Cuddapah	2.50	2.01	10.20	8.47	12.22	10.00	9.30	8.90
Mean	2.5	2.30	10.22	8.15	10.14	8.69	9.07	8.57
S. Em ±	0.1	0.07	0.41	0.36	0.45	0.40	0.23	0.14
C.D. (5%)	0.29	0.22	1.23	1.09	1.36	1.20	0.68	0.43



PLATE 3. GENOTYPIC VARIATION FOR RHIZOME AND FINGER CHARACTERS IN TURMERIC

kharif 1998 as compared to *kharif* 1999. During both the years the length of primary finger was significantly more in Amalapuram, CO-1 and Cuddapah while, this parameter was found significantly lowest in BSR-1 followed by Rajapuri.

4.1.6.9 Length of secondary finger (cm)

The results pertaining to length of secondary finger indicated significant differences among the genotypes during both years (Table 31). The length of secondary fingers was relatively more during *kharif* 1998 as compared to *kharif* 1999. During *kharif* 1998 the genotypes Amalapuram and Cuddapah possessed significantly higher length of secondary fingers (5.10 and 5.0 cm respectively) as compared to other genotypes and the genotype BSR-1 and Rajapuri recorded significantly lowest value for this trait (4.60 cm). A similar trend was noticed during *kharif* 1999 and it ranged from 3.0 cm in BSR-1 to 4.5 cm in Amalapuram.

4.1.6.10 Circumference of mother rhizome (cm)

The results pertaining to circumference of mother rhizome among different turmeric genotypes indicated significant differences among themselves during both the years (Table 31). This parameter showed relatively higher values during *kharif* 1998 (13.1 cm) as compared to *kharif* 1999 (11.4 cm). During both the years the circumference of mother rhizome was significantly higher in Cuddapah followed by Bidar-4 and CO-1 as compared to other genotypes. Among the genotypes BSR-1 recorded significantly lowest values for circumference of mother rhizome.

4.1.6.11 Circumference of primary fingers (cm)

The data on circumference of primary fingers indicated significant differences among the genotypes during both the years (Table 31). The circumference of primary fingers was more during *kharif* 1998 (7.1 cm) as compared to *kharif* 1999 (6.5 cm). During both the years the genotypes viz., Amalapuram, Bidar-4 and Cuddapah recorded significantly more circumference of primary fingers while, the genotype Rajapuri recorded significantly lowest values for this trait.

Table 31: Genotypic variation for rhizome and finger characters in turmeric at harvest (1998 and 1999)

Genotype	Length of secondary finger (cm)		Circumference of mother rhizome (cm)		Circumference of primary finger (cm)		Circumference of secondary finger (cm)	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	5.1	4.5	13.0	11.5	7.8	7.5	5.9	5.5
CO-1	4.7	3.5	14.0	11.7	7.4	6.4	6.4	6.0
Bidar-4	4.7	3.5	14.1	12.8	7.5	6.8	6.0	5.8
BSR-1	4.6	3.0	10.2	9.4	6.7	6.2	5.2	5.0
Rajapuri	4.6	3.5	12.5	10.1	5.9	5.4	4.9	4.7
Cuddapah	5.0	4.0	14.5	12.8	7.3	6.5	6.0	5.8
Mean	4.78	3.67	13.1	11.4	7.1	6.5	5.7	5.5
S. Em $\pm$	0.05	0.07	0.70	0.46	0.21	0.18	0.15	0.14
C.D. (5%)	0.14	0.21	2.12	1.38	0.63	0.55	0.46	0.41

4.1.6.12 Circumference of secondary fingers (cm)

The results pertaining to circumference of secondary fingers indicated significant differences among the genotypes during both the years (Table 31). The circumference was more during *kharif* 1998 (5.7 cm) as compared to *kharif* 1999 (5.5 cm). During both the years (*kharif* 1998 and *kharif* 1999) the genotypes viz., CO-1, Bidar-4 and Cuddapah recorded significantly higher values for this parameter and the genotype Rajapuri registered significantly lowest values for circumference of secondary fingers.

4.1.6.13 Curing per cent

The curing per cent differed significantly among different turmeric genotypes (Table 32). During *kharif* 1998 the curing per cent ranged from 21.0 per cent in Rajapuri to 23.2 per cent in Amalapuram. The genotypes Amalapuram and BSR-1 recorded significantly higher values of curing per cent (23.2%) as compared to Rajapuri which recorded lowest values (21.0%). During *kharif* 1999 a similar trend was observed with respect to curing per cent and it ranged from 19.2 in Bidar-4 to 22.8 in Amalapuram. The genotypes Amalapuram and BSR-1 recorded significantly higher values for curing per cent.

4.1.6.14 Total dry matter (g plant⁻¹) at harvest

The Total dry matter (TDM) (g plant⁻¹) at harvest varied significantly among the genotype during both the year (Table 32). The TDM at harvest was more during *kharif* 1998 as compared to *kharif* 1999. During *kharif* 1998, the TDM at harvest ranged from 85.8 (g plant⁻¹) in BSR-1 to 166.2 g plant⁻¹ in Amalapuram. The genotypes Amalapuram, Bidar-4 and Cuddapah recorded significantly higher TDM at harvest and the genotypes BSR-1 and Rajapuri recorded significantly lower TDM at harvest. During *kharif* 1999 also a similar trend was observed and the TDM at harvest ranged from 72.8 g plant⁻¹ in BSR-1 to 136.4 g plant⁻¹ in Amalapuram.

Table 32: Genotypic variation for curing per cent, total dry matter content (g plant⁻¹), harvest index (%) and curcumin content in turmeric at harvest (1998 and 1999)

Genotype	Curing (%)		Total dry matter (g plant ⁻¹)		Harvest index (%)		Curcumin content (%)	
	1998	1999	1998	1999	1998	1999	1998	1999
Amalapuram	23.2	22.8	166.2	136.4	83.10	83.09	3.16	3.03
CO-1	22.6	19.6	107.9	89.6	80.03	79.91	3.08	2.91
Bidar-4	21.8	19.2	147.7	116.6	81.18	81.20	2.42	2.33
BSR-1	23.2	21.8	85.8	72.8	79.74	79.77	4.08	3.95
Rajapuri	21.0	19.4	99.4	83.4	78.80	78.76	3.28	3.20
Cuddapah	22.8	19.7	129.6	92.8	80.72	78.32	2.65	2.51
Mean	22.4	20.4	122.8	98.6	80.60	80.18	3.11	2.99
S. Em ±	0.70	0.60	4.03	3.39	0.40	0.33	0.13	0.09
C.D. (5%)	2.10	1.69	12.16	10.22	1.20	1.00	0.38	0.26

4.1.6.15 Harvest index (%)

The harvest index (%) varied significantly among the genotype during both the year (Table 32). The harvest index was more during *kharif* 1998 as compared to *kharif* 1999. During *kharif* 1998, the harvest index ranged from 78.80 per cent in Rajapuri to 83.1 per cent in Amalapuram. The genotypes Amalapuram, Bidar-4 and Cuddapah recorded significantly higher harvest index and the genotypes BSR-1 and Rajapuri recorded significantly lower harvest index. During *kharif* 1999 also a similar trend was observed and the harvest index ranged from 78.76 per cent in Rajapuri to 83.09 per cent in Amalapuram.

4.1.6.16 Curcumin content (%)

The curcumin content varied significantly among the genotypes during both the years (Table 32). The per cent curcumin content was more during *kharif* 1998 (3.11%) as compared to *kharif* 1999 (2.99%). During *kharif* 1998 the curcumin content ranged from 2.42 per cent in Bidar-4 to 4.08 in BSR-1. The genotype BSR-1 recorded significantly higher per cent curcumin content (4.08) followed by Rajapuri (3.28) and Amalapuram (3.16) as compared to other genotypes. During *kharif* 1999 also a similar trend was observed with respect to per cent. Curcumin content and it ranged from 2.33 in Bidar-4 to 3.95 in BSR-1. The data suggested wide variability among the genotypes for this trait.

4.1.7 CORRELATION STUDIES

The correlation coefficients ('r' values) were calculated among various morpho-physiological, growth parameters, biophysical, biochemical and yield and yield components in Turmeric (Tables 33 to 36).

Table 33: Correlation co-efficients of cured rhizome yield with morphological characters and dry weight of different plant parts in turmeric (1998 and 1999)

Sl.No.	Character	"r" value	
		1998	1999
1.	Plant height at 60 DAS	0.560	0.245
2.	Plant height at 90 DAS	0.449	0.237
3.	Plant height at 120 DAS	0.417	0.630
4.	Plant height at 150 DAS	0.313	0.007
5.	Plant height at 180 DAS	0.285	-0.037
6.	Number of tillers / plant at 90 DAS	-0.222	-0.176
7.	Number of tillers / plant at 120 DAS	-0.742	-0.511
8.	Number of tillers / plant at 150 DAS	-0.897*	-0.806
9.	Number of tillers / plant at 180 DAS	-0.788	-0.804
10.	Number of leaves / plant at 60 DAS	0.967**	0.810
11.	Number of leaves / plant at 90 DAS	0.988**	0.912*
12.	Number of leaves / plant at 120 DAS	0.959**	0.785
13.	Number of leaves / plant at 150 DAS	0.965**	0.951**
14.	Number of leaves / plant at 180 DAS	0.969**	0.967**
15.	Leaf dry weight (g plant ⁻¹) at 60 DAS	0.943**	0.881*
16.	Leaf dry weight (g plant ⁻¹) at 90 DAS	0.929**	0.918**
17.	Leaf dry weight (g plant ⁻¹) at 120 DAS	0.981**	0.924**
18.	Leaf dry weight (g plant ⁻¹) at 150 DAS	0.967**	0.945**
19.	Leaf dry weight (g plant ⁻¹) at 180 DAS	0.981**	0.977**
20.	Stem dry weight (g plant ⁻¹) at 60 DAS	0.485	0.634
21.	Stem dry weight (g plant ⁻¹) at 90 DAS	0.520	-0.019
22.	Stem dry weight (g plant ⁻¹) at 120 DAS	-0.631	-0.297
23.	Stem dry weight (g plant ⁻¹) at 150 DAS	-0.944**	-0.662
24.	Stem dry weight (g plant ⁻¹) at 180 DAS	-0.509	-0.637
25.	Rhizome dry weight (g plant ⁻¹) at 60 DAS	0.982**	0.926**
26.	Rhizome dry weight (g plant ⁻¹) at 90 DAS	0.984**	0.982**
27.	Rhizome dry weight (g plant ⁻¹) at 120 DAS	0.985**	0.931**
28.	Rhizome dry weight (g plant ⁻¹) at 150 DAS	0.955**	0.936**
29.	Rhizome dry weight (g plant ⁻¹) at 180 DAS	0.982**	0.835*
30.	Total dry weight (g plant ⁻¹) at 60 DAS	0.964**	0.908**
31.	Total dry weight (g plant ⁻¹) at 90 DAS	0.984**	0.926**
32.	Total dry weight (g plant ⁻¹) at 120 DAS	0.984**	0.984**
33.	Total dry weight (g plant ⁻¹) at 150 DAS	0.944**	0.984**
34.	Total dry weight (g plant ⁻¹) at 180 DAS	0.975**	0.855*

t table "r" at 5% 0.811

t table "r" at 1% 0.917

Table 34: Correlation co-efficients of cured rhizome yield with growth parameters in turmeric (1998 and 1999)

Sl.No.	Character	"r" value	
		1998	1999
35.	Leaf area (cm ² plant ⁻¹) at 60 DAS	0.977**	0.945**
36.	Leaf area (cm ² plant ⁻¹) at 90 DAS	0.928**	0.934**
37.	Leaf area (cm ² plant ⁻¹) at 120 DAS	0.966**	0.838*
38.	Leaf area (cm ² plant ⁻¹) at 150 DAS	0.969**	0.941**
39.	Leaf area (cm ² plant ⁻¹) at 180 DAS	0.939**	0.991**
40.	Leaf area index at 60 DAS	0.977**	0.945**
41.	Leaf area index at 90 DAS	0.928**	0.934**
42.	Leaf area index at 120 DAS	0.966**	0.838*
43.	Leaf area index at 150 DAS	0.969**	0.941**
44.	Leaf area index at 180 DAS	0.939**	0.991**
45.	Absolute growth rate (60-90)	0.969**	0.495
46.	Absolute growth rate (90-120)	0.746	0.922**
47.	Absolute growth rate (120-150)	0.650	0.930**
48.	Absolute growth rate (150-180)	0.949**	0.432
49.	Crop growth rate (60-90)	0.969**	0.495
50.	Crop growth rate (90-120)	0.746	0.922**
51.	Crop growth rate (120-150)	0.650	0.930**
52.	Crop growth rate (150-180)	0.949**	0.432
53.	Relative growth rate (60-90)	-0.652	-0.506
54.	Relative growth rate (90-120)	-0.591	-0.511
55.	Relative growth rate (120-150)	-0.388	0.360
56.	Relative growth rate (150-180)	0.918**	0.309
57.	Net assimilation rate (60-90)	0.549	-0.329
58.	Net assimilation rate (90-120)	0.050	0.104
59.	Net assimilation rate (120-150)	-0.164	0.833*
60.	Net assimilation rate (150-180)	-0.377	0.252
61.	Leaf area duration (60-90)	0.970**	0.968**
62.	Leaf area duration (90-120)	0.983**	0.938**
63.	Leaf area duration (120-150)	0.990**	0.937**

Table 35: Correlation co-efficients of cured rhizome yield with growth parameters in turmeric (1998 and 1999)

Sl.No.	Character	"r" value	
		1998	1999
64.	Leaf area duration (150-180)	0.968**	0.979**
65.	Biomass duration (60-90)	0.980**	0.961**
66.	Biomass duration (90-120)	0.996**	0.970**
67.	Biomass duration (120-150)	0.977**	0.992**
68.	Biomass duration (150-180)	0.967**	0.922**
69.	Specific leaf weight at 60 DAS	0.650	0.025
70.	Specific leaf weight at 90 DAS	0.264	0.297
71.	Specific leaf weight at 120 DAS	0.966**	0.895*
72.	Specific leaf weight at 150 DAS	0.884**	0.917**
73.	Specific leaf weight at 180 DAS	-0.821*	-0.895*
74.	Specific leaf area at 60 DAS	-0.640	-0.067
75.	Specific leaf area at 90 DAS	-0.273	-0.298
76.	Specific leaf area at 120 DAS	-0.968**	-0.872*
77.	Specific leaf area at 150 DAS	-0.874*	-0.910*
78.	Specific leaf area at 180 DAS	0.809	0.886*
79.	Leaf weight ratio at 60 DAS	-0.648	-0.661
80.	Leaf weight ratio at 90 DAS	-0.751	-0.372
81.	Leaf weight ratio at 120 DAS	0.047	0.067
82.	Leaf weight ratio at 150 DAS	0.507	0.299
83.	Leaf weight ratio at 180 DAS	-0.799	-0.462
84.	Leaf area ratio at 60 DAS	-0.806	-0.587
85.	Leaf area ratio at 90 DAS	-0.817*	-0.517
86.	Leaf area ratio at 120 DAS	-0.833*	-0.418
87.	Leaf area ratio at 150 DAS	0.178	-0.517
88.	Leaf area ratio at 180 DAS	0.404	0.380

Table 36: Correlation co-efficients of cured rhizome yield with bio-physical, biochemical, quality parameters and yield components in turmeric (1998 and 1999)

Sl.No.	Character	"r" value	
		1998	1999
89.	Stomatal number (Abaxial) at 150 DAS	0.839*	0.732
90.	Stomatal number (Adaxial) at 150 DAS	0.788	0.603
91.	Relative water content at 150 DAS	0.909*	0.954**
92.	Light transmission ratio at 150 DAS	-0.977**	-0.942**
93.	Photosynthetic rate at 150 DAS	0.992**	0.980**
94.	Transpiration rate at 150 DAS	0.945**	0.811
95.	Stomatal conductance at 150 DAS	0.928**	0.875*
96.	Total chlorophyll at 90 DAS	0.148	-0.107
97.	Total chlorophyll at 180 DAS	0.200	0.375
98.	Nitrate reductase activity at 150 DAS	-0.348	0.530
99.	Nitrate reductase activity at 180 DAS	0.912*	0.775
100.	Total sugars at 150 DAS	-0.533	-0.355
101.	Fresh rhizome yield (g plant ⁻¹)	0.990**	0.949**
102.	Curing per cent	0.198	0.373
103.	Number of mother rhizomes	0.754	0.645
104.	Number of primary fingers	0.968**	0.929**
105.	Number of secondary fingers	0.391	0.461
106.	Length of primary finger	0.657	0.545
107.	Length of secondary finger	0.787	0.774
108.	Circumference of mother rhizome	0.546	0.511
109.	Circumference of primary finger	0.766	0.850*
110.	Circumference of secondary finger	0.517	0.383
111.	Curcumin content	-0.626	-0.478

4.2 EXPERIMENT II. INFLUENCE OF MICRONUTRIENTS ON PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES

4.2.1 MORPHOLOGICAL CHARACTERS

4.2.1.1 Plant height (cm)

The data on plant height indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 37). In general, the plant height increased upto 180 DAS. During both the years at all the stages the plant height values was more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the plant height at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher plant height as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the plant height followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The plant height was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher plant height as compared to Bidar-1. The treatments with FeSO_4 (0.5%), MnSO_4 (0.4%) and ZnSO_4 (0.5%) recorded significantly higher values for plant height as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values while the highest values were found in Bidar-4 with FeSO_4 .

Table 37: Effect of micronutrients on plant height (cm) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	26.9	25.4	26.2	31.2	28.8	30.0	39.7	30.2	35.0	43.6	31.8	37.7
FeSO ₄ (0.5%)	29.1	26.6	27.8	34.7	31.6	33.2	42.7	34.2	38.4	46.8	35.6	41.2
ZnSO ₄ (0.25%)	25.4	23.0	24.2	29.5	27.2	28.4	37.0	28.6	32.8	41.3	30.3	35.8
ZnSO ₄ (0.5%)	27.2	26.0	26.6	31.4	29.2	30.3	40.4	31.8	36.1	42.0	32.2	37.1
MnSO ₄ (0.2%)	26.6	24.2	25.4	30.0	28.5	29.3	38.3	29.7	34.0	42.2	31.0	36.6
MnSO ₄ (0.4%)	28.8	26.4	27.6	33.1	30.8	32.0	41.2	33.4	37.3	45.2	33.7	39.4
Control	25.0	22.7	23.9	29.4	26.5	28.0	36.2	28.7	32.5	39.0	29.2	34.1
Mean	26.99	24.90		31.33	28.94		39.34	30.94		42.87	31.96	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.43	1.23		0.46	1.32		0.23	0.65		0.45	1.29	
Treatments (T)	0.79	2.31		0.86	2.50		0.42	1.22		0.83	2.42	
Interaction (GxT)	1.12	3.26		1.22	3.52		0.59	1.72		1.18	3.42	

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	23.3	20.0	21.7	28.0	27.4	27.7	32.7	26.8	29.7	36.7	28.6	32.6
FeSO ₄ (0.5%)	25.2	22.7	23.9	30.8	30.3	30.5	34.3	30.0	32.1	38.4	32.6	35.5
ZnSO ₄ (0.25%)	21.6	18.8	20.2	27.6	25.7	26.7	30.9	25.8	28.3	32.5	26.9	29.7
ZnSO ₄ (0.5%)	24.0	21.2	22.6	28.3	28.7	28.5	33.2	27.4	30.3	37.0	29.1	33.1
MnSO ₄ (0.2%)	22.6	19.8	21.2	27.9	26.9	27.4	31.6	26.0	28.8	35.5	27.4	31.4
MnSO ₄ (0.4%)	24.6	22.4	23.5	29.6	29.8	29.7	34.0	28.8	31.4	37.7	30.0	33.9
Control	21.0	18.6	19.8	27.6	24.8	26.2	29.1	25.2	27.2	32.0	26.7	29.4
Mean	23.18	20.50		28.55	27.64		32.25	27.13		35.68	28.75	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.39	1.12		0.28	0.81		0.57	1.65		0.60	1.73	
Treatments (T)	0.73	2.11		0.52	1.52		1.07	3.10		1.12	3.25	
Interaction (GxT)	1.02	2.96		0.74	2.15		1.51	4.37		1.58	4.58	

V1 : BIDAR-4 V2: BIDAR-1

4.2.1.2 Number of tillers per plant

The number of tillers per plant indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years except at 90 DAS during 1998 where no significant differences was observed due to genotypes (Table 38). During both the years upto 120 DAS the number of tillers were more in the genotype Bidar-4 as compared to Bidar-1 and at 150 and 180 DAS during both the years the number of tillers were more in Bidar-1 as compared to Bidar-4. All the micro-nutrient treatments significantly increased the number of tillers per plant at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher number of tillers per plant as compared to Bidar-1 at 90 and 120 DAS and vice versa at 150 and 180 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the number of tillers per plant followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The number of tillers per plant was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%) upto 120 DAS and at 150 and 180 DAS lowest was with Bidar-4 with water spray and highest was with Bidar-1 with FeSO_4 (0.5%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher number of tillers per plant as compared to Bidar-1 at 90 and 120 DAS and vice-versa at 150 and 180 DAS. The treatments with FeSO_4 (0.5%), MnSO_4 (0.4%) and ZnSO_4 (0.5%) recorded significantly higher number of tillers per plant as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment showed lowest values while the highest values were found in Bidar-4 with FeSO_4 upto 120 DAS and at 150 and 180 DAS lowest was with Bidar-4 with water spray and highest was with Bidar-1 with FeSO_4 (0.5%).

Table 38 : Effect of micronutrients on number of tillers per plant at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	2.5	2.5	2.5	3.4	2.9	3.1	4.5	4.7	4.6	4.5	4.7	4.6
FeSO ₄ (0.5%)	2.6	2.6	2.6	3.7	3.2	3.4	4.8	5.0	4.9	4.8	5.0	4.9
ZnSO ₄ (0.25%)	2.3	2.2	2.3	3.2	2.7	3.0	4.3	4.4	4.3	4.3	4.4	4.4
ZnSO ₄ (0.5%)	2.5	2.5	2.5	3.5	2.9	3.2	4.6	4.8	4.7	4.6	4.8	4.7
MnSO ₄ (0.2%)	2.4	2.4	2.4	3.3	2.8	3.0	4.4	4.5	4.5	4.4	4.4	4.4
MnSO ₄ (0.4%)	2.6	2.5	2.6	3.6	3.0	3.3	4.7	4.8	4.8	4.7	4.8	4.8
Control	2.2	2.1	2.2	3.1	2.7	2.9	4.0	4.1	4.1	4.0	4.1	4.1
Mean	2.45	2.39		3.40	2.87		4.48	4.60		4.48	4.59	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.04	NS		0.07	0.21		0.04	0.10		0.04	0.10	
Treatments (T)	0.07	0.20		0.13	0.39		0.07	0.19		0.07	0.19	
Interaction (GxT)	0.10	0.29		0.19	0.56		0.09	0.27		0.10	0.27	

1999

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	2.4	2.3	2.3	1.7	1.5	1.6	2.2	2.0	2.1	2.2	2.0	2.1
FeSO ₄ (0.5%)	2.5	2.4	2.5	1.9	1.7	1.8	2.4	2.3	2.3	2.3	2.3	2.3
ZnSO ₄ (0.25%)	2.3	2.2	2.3	1.6	1.4	1.5	2.1	2.9	2.5	2.0	2.9	2.5
ZnSO ₄ (0.5%)	2.4	2.4	2.4	1.8	1.6	1.7	2.3	2.1	2.2	2.3	2.1	2.2
MnSO ₄ (0.2%)	2.3	2.3	2.3	1.7	1.5	1.6	2.1	3.0	2.5	2.1	3.0	2.5
MnSO ₄ (0.4%)	2.5	2.4	2.4	1.8	1.7	1.7	2.3	2.2	2.3	2.3	2.2	2.3
Control	2.1	2.0	2.1	1.6	1.4	1.5	2.0	1.9	2.0	2.0	1.9	2.0
Mean	2.35	2.28		1.72	1.54		2.18	2.34		2.17	2.33	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.02	0.06		0.04	0.26		0.04	0.12		0.04	0.10	
Treatments (T)	0.04	0.11		0.06	0.18		0.08	0.22		0.07	0.19	
Interaction (GxT)	0.06	0.16		0.09	0.26		0.11	0.37		0.09	0.27	

V1 : BIDAR-4 V2: BIDAR-1

4.2.1.3 Number of leaves per plant

Significant differences were observed with respect to number of leaves per plant due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 39). In general, the number of leaves per plant increased upto 150 DAS and decreased thereafter. During both the years upto 150 DAS the number of leaves were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the number of leaves per plant at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher number of leaves per plant as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the number of leaves per plant followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The number of leaves per plant was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher number of leaves per plant as compared to Bidar-1. The treatments with FeSO_4 (0.5%), MnSO_4 (0.4%) and ZnSO_4 (0.5%) registered significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values while the highest values were found in Bidar-4 with FeSO_4 (0.5%).

4.2.2 DRY MATTER PRODUCTION AND ITS PARTITIONING

4.2.2.1 Leaf dry weight (g plant^{-1})

The data on leaf dry weight indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years

Table 39 : Effect of micronutrients on number of leaves per plant at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	12.9	10.7	11.8	17.3	16.8	17.0	24.1	21.9	23.0	12.7	13.9	13.3
FeSO ₄ (0.5%)	14.4	11.6	13.0	19.3	18.7	19.0	27.0	25.8	26.4	13.9	14.6	14.2
ZnSO ₄ (0.25%)	12.5	9.8	11.2	16.4	15.9	16.1	22.0	20.2	21.1	12.5	13.1	12.8
ZnSO ₄ (0.5%)	13.0	10.9	12.0	18.3	17.4	17.8	24.8	22.8	23.8	12.9	14.0	13.5
MnSO ₄ (0.2%)	12.8	10.1	11.5	17.0	16.1	16.6	22.9	21.0	21.9	12.6	13.2	12.9
MnSO ₄ (0.4%)	13.8	11.0	12.4	19.0	18.0	18.5	25.6	23.6	24.6	13.1	14.1	13.6
Control	12.0	9.5	10.8	16.0	15.3	15.7	22.5	20.0	21.3	12.5	13.0	12.8
Mean	13.06	10.52		17.60	16.87		24.12	22.20		12.88	13.68	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.13	0.38		0.22	0.64		0.17	0.50		0.06	0.17	
Treatments (T)	0.25	0.72		0.42	1.21		0.32	0.94		0.11	0.32	
Interaction (GxT)	0.35	1.01		0.58	1.68		0.46	1.32		0.16	0.45	

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	10.6	9.2	9.9	14.1	11.0	12.5	18.8	16.9	17.8	9.7	11.4	10.6
FeSO ₄ (0.5%)	11.5	10.2	10.9	15.4	12.0	13.7	21.8	19.3	20.5	9.9	11.7	10.8
ZnSO ₄ (0.25%)	9.8	8.6	9.2	13.0	10.7	11.9	17.9	15.5	16.7	9.3	10.6	10.0
ZnSO ₄ (0.5%)	10.9	9.9	10.4	14.9	11.1	13.0	19.2	17.3	18.3	9.9	11.4	10.6
MnSO ₄ (0.2%)	10.1	8.9	9.5	13.9	10.9	12.4	18.0	16.6	17.3	9.6	10.9	10.3
MnSO ₄ (0.4%)	11.1	10.0	10.6	15.0	11.7	13.4	20.2	18.6	19.4	9.9	11.5	10.7
Control	9.6	8.4	9.0	12.6	10.7	11.7	17.6	15.4	16.5	9.0	10.5	9.8
Mean	10.52	9.32		14.12	11.15		19.06	17.08		9.62	11.15	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.1	0.3		0.2	0.5		0.2	0.5		0.1	0.6	
Treatments (T)	0.2	0.6		0.3	1.0		0.3	0.9		0.1	0.4	
Interaction (GxT)	0.3	0.8		0.5	1.4		0.4	1.3		0.2	0.6	

V1 : BIDAR-4 V2: BIDAR-1

(Table 40). In general, the leaf dry weight increased upto 150 DAS and decreased thereafter. During both the years at all the stages the leaf dry weight values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the leaf dry weight at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher leaf dry weight as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the leaf dry weight followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The LDW was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). Similar results were observed during *kharif* 1999 also.

4.2.2.2 Stem dry weight (g plant⁻¹)

Significant differences were observed with respect to stem dry weight due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 41). In general, the stem dry weight increased upto 150 DAS and decreased thereafter. During both the years at all the stages the stem dry weight values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the stem dry weight at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher stem dry weight as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the stem dry weight followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The stem dry weight was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). The results obtained during *kharif* 1999 also followed the same trend as that of *kharif* 1998.

Table 40: Effect of micronutrients on leaf dry weight pg lan^{-1}) at different stages in turmeric genotypes p1998 and 1999)

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	9.48	9.02	9.25	15.87	15.60	15.74	24.35	24.40	24.38	11.24	10.47	10.86
FeSO ₄ (0.5%)	9.81	9.33	9.57	16.43	16.13	16.28	25.22	25.23	25.23	11.64	10.83	11.24
ZnSO ₄ (0.25%)	9.34	8.89	9.12	15.64	15.37	15.51	24.00	24.05	24.03	11.08	10.32	10.70
ZnSO ₄ (0.5%)	9.65	9.16	9.41	16.16	15.83	16.00	24.80	24.77	24.79	11.44	10.63	11.04
MnSO ₄ (0.2%)	9.41	8.93	9.17	15.75	15.43	15.59	24.18	24.13	24.16	11.16	10.36	10.76
MnSO ₄ (0.4%)	9.72	9.25	9.49	16.27	15.99	16.13	24.97	25.00	24.99	11.53	10.73	11.13
Control	8.60	8.10	8.35	14.40	14.00	14.20	22.10	21.90	22.00	10.20	9.40	9.80
Mean	9.43	8.95		15.79	15.48		24.23	24.21		11.18	10.39	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.11	0.32		0.10	0.28		0.118	NS		0.21	0.62	
Treatments (T)	0.20	0.60		0.182	0.53		0.22	0.64		0.40	1.15	
Interaction (GxT)	0.29	0.85		0.26	0.74		0.31	0.90		0.56	1.62	

1999

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	8.74	8.38	8.56	13.65	13.74	13.70	22.82	22.16	22.49	10.37	10.19	10.28
FeSO ₄ (0.5%)	9.02	8.55	8.79	14.10	14.02	14.06	23.58	22.62	23.10	10.72	10.41	10.57
ZnSO ₄ (0.25%)	8.48	8.15	8.32	13.25	13.37	13.31	22.15	21.56	21.86	10.07	9.92	10.00
ZnSO ₄ (0.5%)	8.86	8.44	8.65	13.98	13.84	13.91	23.16	22.32	22.74	10.53	10.27	10.40
MnSO ₄ (0.2%)	8.60	8.18	8.39	13.44	13.42	13.43	22.47	21.64	22.06	10.21	9.95	10.08
MnSO ₄ (0.4%)	8.81	8.53	8.67	13.89	13.99	13.94	23.22	22.56	22.89	10.46	10.38	10.42
Control	8.00	7.56	7.78	12.50	12.40	12.45	20.90	20.00	20.45	9.50	9.20	9.35
Mean	8.75	8.37		13.72	13.73		22.90	22.14		10.39	10.19	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.10	0.28		0.08	NS		0.06	0.16		0.17	NS	
Treatments (T)	0.18	0.53		0.14	0.41		0.10	0.30		0.32	0.94	
Interaction (GxT)	0.26	0.74		0.20	0.58		0.15	0.47		0.46	1.33	

V1 : BIDAR-4

V2: BIDAR-1

Table 41: Effect of micronutrients on stem dry weight (g plant⁻¹) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing											
	90				120				150			
	V1	V2	Mean	S.E.m $\pm$	V1	V2	Mean	C.D. (5%)	V1	V2	Mean	S.E.m $\pm$
FeSO ₄ (0.25%)	6.92	5.83	6.38		8.71	6.84	7.78		13.46	12.00	12.73	5.42
FeSO ₄ (0.5%)	7.55	6.19	6.87		9.04	7.32	8.18		15.56	13.64	14.60	5.68
ZnSO ₄ (0.25%)	6.50	5.27	5.89		7.75	6.22	6.99		12.91	11.67	12.29	5.23
ZnSO ₄ (0.5%)	7.00	5.90	6.45		8.85	6.96	7.91		14.85	12.85	13.85	5.50
MnSO ₄ (0.2%)	6.80	5.72	6.26		8.68	6.70	7.69		13.00	11.73	12.37	5.35
MnSO ₄ (0.4%)	7.46	6.00	6.73		8.05	7.01	7.53		15.00	13.10	14.05	5.58
Control	6.40	5.20	5.80		7.60	6.10	6.85		12.76	11.00	11.88	5.16
Mean	6.95	5.73			8.38	6.74			13.93	12.28		5.42
For comparing	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)
Genotypes (G)	0.07	0.21			0.14	0.39			0.00	0.56		0.02
Treatments (T)	0.13	0.39			0.25	0.73			0.36	1.05		0.03
Interaction (GxT)	0.19	0.56			0.36	1.03			0.51	1.48		0.05

1999

Micronutrients	Days after sowing											
	90				120				150			
	V1	V2	Mean	S.E.m $\pm$	V1	V2	Mean	C.D. (5%)	V1	V2	Mean	S.E.m $\pm$
FeSO ₄ (0.25%)	4.86	4.50	4.68		8.10	6.55	7.33		13.12	11.75	12.44	4.96
FeSO ₄ (0.5%)	5.04	4.86	4.95		8.40	7.10	7.75		14.40	12.76	13.58	5.45
ZnSO ₄ (0.25%)	4.38	4.33	4.36		7.64	5.88	6.76		12.36	10.94	11.65	4.62
ZnSO ₄ (0.5%)	4.90	4.66	4.78		8.25	6.72	7.49		13.72	12.01	12.87	5.00
MnSO ₄ (0.2%)	4.71	4.42	4.57		7.93	6.00	6.97		12.85	11.16	12.01	4.74
MnSO ₄ (0.4%)	5.00	4.70	4.85		8.32	6.90	7.61		14.00	12.47	13.24	5.11
Control	4.20	4.00	4.10		7.00	5.82	6.41		12.20	10.72	11.46	4.50
Mean	4.73	4.50			7.95	6.42			13.24	11.69		4.91
For comparing	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)
Genotypes (G)	0.07	0.19			0.08	0.22			0.12	0.33		0.04
Treatments (T)	0.12	0.36			0.14	0.41			0.21	0.62		0.08
Interaction (GxT)	0.17	0.50			0.20	0.58			0.30	0.87		0.11

V2: BIDAR-1

V1: BIDAR-4

4.2.2.3 Rhizome dry weight (g plant⁻¹)

The rhizome dry weight indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 42). In general, the rhizome dry weight increased upto 180 DAS. During both the years at all the stages the rhizome dry weight were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the rhizome dry weight at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher rhizome dry weight as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the rhizome dry weight followed by MnSO_4 (0.4%) 2000 ppm and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The rhizome dry weight was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 . Similar results were observed during *kharif* 1999 also.

4.2.2.4 Total dry matter (TDM, g plant⁻¹)

The data on total dry mater (TDM) revealed significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 43). In general, the TDM increased upto 180 DAS. During both the years at all the stages the TDM values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the TDM at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher TDM as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the TDM followed by MnSO_4 (0.4%) and ZnSO_4 as compared to other micronutrient

Table 42 : Effect of micronutrients on rhizome dry weight (g plant⁻¹) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	6.11	4.87	5.49	12.80	11.76	12.28	26.50	24.96	25.73	59.12	56.45	57.79
FeSO ₄ (0.5%)	6.98	5.20	6.09	14.16	12.24	13.20	30.01	28.77	29.39	61.60	60.00	60.80
ZnSO ₄ (0.25%)	5.86	4.38	5.12	12.22	10.35	11.29	24.84	23.44	24.14	56.82	54.70	55.76
ZnSO ₄ (0.5%)	6.40	5.00	5.70	13.88	11.92	12.90	27.93	25.24	26.59	60.28	58.26	59.27
MnSO ₄ (0.2%)	5.95	4.72	5.34	12.65	11.44	12.05	25.61	24.00	24.81	57.72	55.50	56.61
MnSO ₄ (0.4%)	6.71	5.11	5.91	14.00	12.00	13.00	28.72	26.55	27.64	61.10	59.10	60.10
Control	5.72	4.20	4.96	11.90	10.20	11.05	24.40	23.20	23.80	56.00	54.60	55.30
Mean	6.25	4.78		13.09	11.42		26.86	25.17		58.95	56.94	
For comparing	S.E.m±			C.D. (5%)			S.E.m±			C.D. (5%)		
Genotypes (G)	0.06		0.17	0.20		0.59	0.26		0.75	0.32		0.91
Treatments (T)	0.11		0.32	0.38		1.10	0.48		1.41	0.59		1.71
Interaction (GxT)	0.16		0.45	0.54		1.56	0.69		1.99	0.83		2.41

1999

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	4.88	4.27	4.58	10.47	9.32	9.90	24.00	21.90	22.95	56.28	54.21	55.25
FeSO ₄ (0.5%)	5.15	4.63	4.89	10.72	9.78	10.25	25.76	23.92	24.84	62.71	61.48	62.10
ZnSO ₄ (0.25%)	4.66	4.12	4.39	10.41	8.81	9.61	22.60	20.88	21.74	53.12	52.65	52.89
ZnSO ₄ (0.5%)	4.96	4.30	4.63	10.56	9.50	10.03	24.38	22.25	23.32	58.40	56.30	57.35
MnSO ₄ (0.2%)	4.74	4.20	4.47	10.44	9.17	9.81	23.18	21.22	22.20	55.36	53.54	54.45
MnSO ₄ (0.4%)	5.00	4.45	4.73	10.60	9.68	10.14	24.75	23.00	23.88	60.00	58.82	59.41
Control	4.60	4.10	4.35	9.40	8.50	8.95	22.40	20.62	21.51	53.60	52.10	52.85
Mean	4.86	4.30		10.37	9.25		23.87	21.97		57.07	55.59	
For comparing	S.E.m±			C.D. (5%)			S.E.m±			C.D. (5%)		
Genotypes (G)	0.06		0.16	0.15		0.42	0.22		0.63	0.26		0.75
Treatments (T)	0.10		0.30	0.27		0.79	0.41		1.18	0.48		1.41
Interaction (GxT)	0.15		0.42	0.38		1.11	0.58		1.67	0.68		1.98

V1 : BIDAR-4
V2: BIDAR-1

Table 43 : Effect of micronutrients on total dry matter content (TDM, g plant⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	23.33	22.07	22.70	38.20	36.22	37.21	67.62	66.67	67.15	80.47	80.03	80.25
FeSO ₄ (0.5%)	24.45	23.24	23.85	40.04	38.14	39.09	70.86	70.21	70.54	84.32	84.27	84.30
ZnSO ₄ (0.25%)	22.56	21.53	22.05	36.95	35.33	36.14	65.40	65.03	65.22	77.83	78.05	77.94
ZnSO ₄ (0.5%)	23.81	22.66	23.24	38.99	37.18	38.09	69.00	68.44	68.72	82.11	82.15	82.13
MnSO ₄ (0.2%)	22.79	21.70	22.25	37.32	35.62	36.47	66.06	65.56	65.81	78.61	78.69	78.65
MnSO ₄ (0.4%)	24.12	22.97	23.55	39.49	37.70	38.60	69.90	69.38	69.64	83.18	83.28	83.23
Control	20.70	19.50	20.10	33.90	32.00	32.95	60.00	58.90	59.45	71.40	70.70	71.05
Mean	23.11	21.95		37.84	36.03		66.98	66.31		79.70	79.60	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.17	0.50		0.21	0.60		0.19	0.54		0.23	NS	
Treatments (T)	0.32	0.94		0.35	1.12		0.35	1.03		0.43	1.26	
Interaction (GxT)	0.45	1.30		0.54	1.59		0.49	1.43		0.61	1.78	

1999

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	18.85	17.18	18.02	32.54	31.98	32.26	61.93	61.13	61.53	76.07	74.02	75.05
FeSO ₄ (0.5%)	19.52	17.81	18.67	33.70	33.17	33.44	64.14	63.41	63.78	78.78	76.77	77.78
ZnSO ₄ (0.25%)	18.14	16.63	17.39	31.32	30.96	31.14	59.62	59.19	59.41	73.22	71.66	72.44
ZnSO ₄ (0.5%)	19.15	17.57	18.36	33.06	32.71	32.89	62.93	62.54	62.74	74.58	75.72	75.15
MnSO ₄ (0.2%)	18.41	16.74	17.58	31.78	31.16	31.47	60.50	59.56	60.03	74.31	72.12	73.22
MnSO ₄ (0.4%)	19.39	17.74	18.57	33.47	33.03	33.25	63.70	63.15	63.43	78.24	76.44	77.34
Control	16.80	15.20	16.00	29.00	28.30	28.65	55.20	54.10	54.65	67.80	65.50	66.65
Mean	18.91	17.28		32.65	32.17		62.14	61.50		75.87	74.46	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.16	0.47		0.15	0.43		0.17	0.48		0.12	0.35	
Treatments (T)	0.30	0.88		0.27	0.80		0.31	0.90		0.22	0.65	
Interaction (GxT)	0.43	1.24		0.39	1.14		0.44	1.27		0.32	0.93	

V1 : BIDAR-4

V2: BIDAR-1

treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The TDM was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). The results obtained during *kharif* 1999 also followed the same trend as that of *kharif* 1998.

4.2.3 GROWTH PARAMETERS

4.2.3.1 Leaf Area per plant ($\text{cm}^2 \text{ plant}^{-1}$)

Leaf area per plant indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 44). In general, the leaf area per plant increased upto 150 DAS and decreased thereafter. During both the years at all the stages the leaf area per plant was more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the leaf area per plant at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher leaf area per plant as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the leaf area per plant followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The leaf area per plant was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). Similar results were obtained during *kharif* 1999 also.

4.2.3.2 Leaf Area Index (LAI)

Significant differences were observed with respect to leaf area index (LAI) due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 45). In general, the LAI increased upto 150 DAS and decreased

Table 44 : Effect of micronutrients on leaf area ($\text{cm}^2 \text{ plant}^{-1}$) at different stages in turmeric genotypes (1998 and 1999)+A1

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	1947	1929	1938	2659	2561	2610	3852	3824	3838	2415	2353	2384
FeSO ₄ (0.5%)	2004	1982	1993	2737	2631	2684	3965	3929	3947	2486	2418	2452
ZnSO ₄ (0.25%)	1921	1898	1910	2624	2520	2572	3800	3763	3782	2382	2315	2349
ZnSO ₄ (0.5%)	1961	1953	1957	2678	2592	2635	3879	3871	3875	2432	2382	2407
MnSO ₄ (0.2%)	1926	1919	1923	2631	2547	2589	3811	3804	3808	2389	2340	2365
MnSO ₄ (0.4%)	1981	1967	1974	2707	2611	2659	3920	3899	3910	2458	2399	2429
Control	1735	1710	1723	2370	2270	2320	3433	3390	3412	2152	2086	2119
Mean	1925	1908		2629	2533		3809	3783		2388	2328	
For comparing	S.Em$\pm$	C.D. (5%)		S.Em$\pm$	C.D. (5%)		S.Em$\pm$	C.D. (5%)		S.Em$\pm$	C.D. (5%)	
Genotypes (G)	5.56	16.00		19.44	56.00		7.67	22.10		12.08	34.80	
Treatments (T)	10.34	30.10		36.18	105.30		14.26	41.50		22.47	65.40	
Interaction (GxT)	14.62	42.40		51.17	148.40		20.20	58.60		31.79	92.20	

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	1947	1929	1938	2659	2561	2610	3852	3824	3838	2415	2353	2384
FeSO ₄ (0.5%)	2004	1982	1993	2737	2631	2684	3965	3929	3947	2486	2418	2452
ZnSO ₄ (0.25%)	1921	1898	1910	2624	2520	2572	3800	3763	3782	2382	2315	2349
ZnSO ₄ (0.5%)	1961	1953	1957	2678	2592	2635	3879	3871	3875	2432	2382	2407
MnSO ₄ (0.2%)	1926	1919	1923	2631	2547	2589	3811	3804	3808	2389	2340	2365
MnSO ₄ (0.4%)	1981	1967	1974	2707	2611	2659	3920	3899	3910	2458	2399	2429
Control	1735	1710	1723	2370	2270	2320	3433	3390	3412	2152	2086	2119
Mean	1925	1908		2629	2533		3809	3783		2388	2328	
For comparing	S.Em$\pm$	C.D. (5%)		S.Em$\pm$	C.D. (5%)		S.Em$\pm$	C.D. (5%)		S.Em$\pm$	C.D. (5%)	
Genotypes (G)	5.56	16.00		19.44	56.00		7.67	22.10		12.08	34.80	
Treatments (T)	10.34	30.10		36.18	105.30		14.26	41.50		22.47	65.40	
Interaction (GxT)	14.62	42.40		51.17	148.40		20.20	58.60		31.79	92.20	

V2: BIDAR-1

V1: BIDAR-4

Table 45: Effect of micronutrients on leaf area index (LAI) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	1.08	1.07	1.08	1.48	1.42	1.45	2.14	2.12	2.13	1.34	1.31	1.32
FeSO ₄ (0.5%)	1.11	1.10	1.11	1.52	1.46	1.49	2.20	2.18	2.19	1.38	1.34	1.36
ZnSO ₄ (0.25%)	1.07	1.05	1.06	1.46	1.40	1.43	2.11	2.09	2.10	1.32	1.29	1.30
ZnSO ₄ (0.5%)	1.09	1.09	1.09	1.49	1.44	1.46	2.16	2.15	2.15	1.35	1.32	1.34
MnSO ₄ (0.2%)	1.07	1.07	1.07	1.46	1.42	1.44	2.12	2.11	2.12	1.33	1.30	1.31
MnSO ₄ (0.4%)	1.10	1.09	1.10	1.50	1.45	1.48	2.18	2.17	2.17	1.37	1.33	1.35
Control	0.96	0.95	0.96	1.32	1.26	1.29	1.91	1.88	1.90	1.20	1.16	1.18
Mean	1.07	1.06		1.46	1.41		2.12	2.10		1.33	1.29	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.003	0.008		0.010	0.031		0.004	0.012		0.007	0.019	
Treatments (T)	0.005	0.016		0.020	0.059		0.008	0.023		0.012	0.036	
Interaction (GxT)	0.008	0.024		0.028	0.082		0.011	0.033		0.018	0.051	

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.95	0.94	0.95	1.31	1.29	1.30	1.99	1.98	1.98	1.17	1.17	1.17
FeSO ₄ (0.5%)	0.98	0.96	0.97	1.35	1.35	1.35	2.04	2.03	2.04	1.20	1.20	1.20
ZnSO ₄ (0.25%)	0.95	0.93	0.94	1.30	1.31	1.31	1.97	1.97	1.97	1.16	1.16	1.16
ZnSO ₄ (0.5%)	0.97	0.95	0.96	1.33	1.33	1.33	2.01	2.00	2.01	1.18	1.18	1.18
MnSO ₄ (0.2%)	0.95	0.94	0.94	1.31	1.31	1.31	1.98	1.97	1.98	1.17	1.16	1.16
MnSO ₄ (0.4%)	0.97	0.95	0.96	1.34	1.34	1.34	2.02	2.01	2.02	1.19	1.18	1.19
Control	0.89	0.87	0.88	1.22	1.22	1.22	1.85	1.83	1.84	1.09	1.08	1.08
Mean	0.96	0.95		1.32	1.32		2.00	1.99		1.18	1.17	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0007	0.0020		0.0007	0.0020		0.0030	0.0100		0.0010	0.0040	
Treatments (T)	0.0013	0.0038		0.0013	0.0038		0.0070	0.0190		0.0030	0.0075	
Interaction (GxT)	0.0018	0.0053		0.0053	0.0053		0.0090	0.0270		0.0040	0.0110	

V1 : BIDAR-4 V2: BIDAR-1

thereafter. During both the years at all the stages the LAI values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the LAI at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher LAI as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the LAI followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The LAI was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 . The results obtained during *kharif* 1999 also followed the same trend as that of *kharif* 1998.

4.2.3.3 Absolute Growth Rate (AGR, g plant⁻¹ day⁻¹)

The data on absolute growth rate (AGR) indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 46). In general, the AGR increased upto 120-150 DAS and decreased thereafter. All the micronutrient treatments significantly increased the AGR at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher AGR as compared to Bidar-1. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the AGR followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The AGR was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 .

Whereas, during *kharif* 1999 the genotype Bidar-4 recorded significantly higher AGR as compared to Bidar-1 at 120-150 and 150-180 DAS. The treatments with

Table 46 : Effect of micronutrients on absolute growth rate (AGR, g plant⁻¹ day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.50	0.47	0.48	0.98	1.02	1.00	0.43	0.45	0.44
FeSO ₄ (0.5%)	0.52	0.50	0.51	1.03	1.07	1.05	0.45	0.47	0.46
ZnSO ₄ (0.25%)	0.48	0.46	0.47	0.95	0.99	0.97	0.41	0.43	0.42
ZnSO ₄ (0.5%)	0.51	0.48	0.50	1.00	1.04	1.02	0.44	0.46	0.45
MnSO ₄ (0.2%)	0.48	0.46	0.47	0.96	1.00	0.98	0.42	0.44	0.43
MnSO ₄ (0.4%)	0.51	0.49	0.50	1.01	1.06	1.03	0.44	0.46	0.45
Control	0.44	0.42	0.43	0.87	0.90	0.88	0.38	0.39	0.39
Mean	0.49	0.47		0.97	1.01		0.42	0.44	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.007	0.021		0.009	0.028		0.003	0.010	
Treatments (T)	0.013	0.039		0.018	0.053		0.007	0.019	
Interaction (GxT)	0.019	0.056		0.026	0.074		0.009	0.027	

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.46	0.49	0.47	0.98	0.97	0.98	0.47	0.43	0.45
FeSO ₄ (0.5%)	0.47	0.51	0.49	1.01	1.01	1.01	0.49	0.45	0.47
ZnSO ₄ (0.25%)	0.44	0.48	0.46	0.94	0.94	0.94	0.45	0.42	0.43
ZnSO ₄ (0.5%)	0.46	0.50	0.48	1.00	0.99	1.00	0.39	0.44	0.41
MnSO ₄ (0.2%)	0.45	0.48	0.46	0.96	0.95	0.95	0.46	0.42	0.44
MnSO ₄ (0.4%)	0.47	0.51	0.49	1.01	1.00	1.01	0.48	0.44	0.46
Control	0.41	0.44	0.42	0.87	0.86	0.87	0.42	0.38	0.40
Mean	0.458	0.496		0.983	0.978		0.458	0.432	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0070	0.0190		0.0007	0.0020		0.0035	0.0100	
Treatments (T)	0.0120	0.0350		0.0014	0.0040		0.0070	0.0190	
Interaction (GxT)	0.0170	0.0500		0.0018	0.0053		0.0090	0.0270	

V1 : BIDAR-4 V2: BIDAR-1

FeSO₄ (0.5%), MnSO₄ (0.4%) and ZnSO₄ recorded significantly higher values for AGR as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values while the highest values were found in Bidar-4 with FeSO₄ (0.5%).

4.2.3.4 Crop Growth Rate (CGR, gm⁻² day⁻¹)

The crop growth rate (CGR) revealed significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 47). In general, the CGR increased upto 120-150 DAS and decreased thereafter. All the micronutrient treatments significantly increased the CGR at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher CGR as compared to Bidar-1 at 90-120 DAS. However, among the micronutrient treatments application of FeSO₄ (0.5%) was very effective and significantly increased the CGR followed by MnSO₄ (0.4%) and ZnSO₄ (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The CGR was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO₄ (0.5%) at 90-120 DAS and at 120-150, 150-180 DAS, Bidar-4 with water spray recorded lowest CGR whereas Bidar-1 with FeSO₄ (0.5%) recorded highest CGR.

Whereas, during *kharif* 1999 the genotype Bidar-4 recorded significantly higher CGR as compared to Bidar-1 at 120-150 and 150-180 DAS. The treatments with FeSO₄ (0.5%), MnSO₄ (0.4%) and ZnSO₄ (0.5%) recorded significantly higher values for CGR as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values were found in Bidar-4 with FeSO₄ (0.5%) at 120-150 DAS and 150-180 DAS and at 90-120 DAS Bidar-4 with water spray recorded lowest CGR while Bidar-1 with FeSO₄ (0.5%) recorded highest CGR.

Table 47: Effect of micronutrients on crop growth rate (CGR, g m⁻¹ day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Days after sowing							
	90-120			120-150			150-180	
	V1	V2	Mean	V1	V2	Mean	V1	Mean
FeSO ₄ (0.25%)	2.75	2.62	2.69	5.45	5.64	5.54	2.38	2.43
FeSO ₄ (0.5%)	2.89	2.76	2.82	5.71	5.94	5.82	2.49	2.55
ZnSO ₄ (0.25%)	2.67	2.56	2.61	5.27	5.50	5.38	2.30	2.36
ZnSO ₄ (0.5%)	2.81	2.69	2.75	5.56	5.79	5.67	2.43	2.48
MnSO ₄ (0.2%)	2.69	2.58	2.63	5.32	5.54	5.43	2.32	2.38
MnSO ₄ (0.4%)	2.85	2.73	2.79	5.63	5.87	5.75	2.46	2.52
Control	2.44	2.32	2.38	4.83	4.98	4.91	2.11	2.15
Mean	2.73	2.61		5.40	5.61		2.36	2.46
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)
Genotypes (G)	0.035	0.100		0.056	0.160		0.038	NS
Treatments (T)	0.062	0.180		0.103	0.300		0.076	0.220
Interaction (GxT)	0.093	0.270		0.144	0.420		0.100	0.290

1999

Micronutrients	Days after sowing							
	90-120			120-150			150-180	
	V1	V2	Mean	V1	V2	Mean	V1	Mean
FeSO ₄ (0.25%)	2.54	2.74	2.64	5.44	5.40	5.42	2.62	2.50
FeSO ₄ (0.5%)	2.63	2.84	2.74	5.64	5.60	5.62	2.71	2.59
ZnSO ₄ (0.25%)	2.44	2.65	2.55	5.24	5.23	5.23	2.52	2.41
ZnSO ₄ (0.5%)	2.58	2.80	2.69	5.53	5.52	5.53	2.16	2.30
MnSO ₄ (0.2%)	2.48	2.67	2.57	5.32	5.26	5.29	2.56	2.44
MnSO ₄ (0.4%)	2.61	2.83	2.72	5.60	5.58	5.59	2.69	2.58
Control	2.26	2.43	2.34	4.85	4.78	4.82	2.33	2.22
Mean	2.54	2.76		5.46	5.43		2.54	2.40
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)
Genotypes (G)	0.038	0.110		0.007	0.020		0.035	0.100
Treatments (T)	0.072	0.210		0.010	0.030		0.065	0.190
Interaction (GxT)	0.100	0.290		0.017	0.050		0.093	0.270

V1 : BIDAR-4

V2: BIDAR-1

4.2.3.5 Relative Growth Rate (RGR, $\text{g g}^{-1} \text{ day}^{-1}$)

The data on relative growth rate (RGR) is presented in Table 48. During *kharif* 1998, non-significant differences were observed due to micronutrient treatment and interaction at all the stages and significant differences in RGR due to genotypes was observed at 120-150 and 150-180 DAS. Among the genotype Bidar-4 recorded higher RGR compared to Bidar-1 at 90-120 DAS and it was significantly more in Bidar-4 at 120-150 and 150-180 DAS.

During *kharif* 1999 non-significant differences in RGR due to genotype micronutrient treatment and interaction was observed at both 90-120 and 120-150 DAS and at 150-180 DAS significant differences were observed in RGR due to genotype micronutrient treatments and their interaction. At 150-180 DAS, the genotype Bidar-4 recorded significantly higher RGR compared to Bidar-1.

4.2.3.6 Net Assimilation Rate (NAR, $\text{g dm}^{-2} \text{ day}^{-1}$)

The data on net assimilation rate (NAR) indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years except the non-significant differences due to micronutrient treatments and interaction at 120-150 and 150-180 DAS during *kharif* 1998 (Table 49).

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher NAR at 90-120 DAS and at 120-150 and 150-180 DAS, the genotype Bidar-1 recorded significantly higher NAR. Significant differences due to micronutrient treatments and interaction were observed at 90 DAS and among the micronutrient treatment application of FeSO_4 (0.5%) significantly increased the NAR followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%).

During *kharif* 1999 the genotype Bidar-1 recorded significantly higher NAR at 90-120 DAS and at 120-150 and 150-180 DAS, no significant differences were observed between the genotypes for NAR. Significant differences in NAR due to micronutrient

Table 48: Effect of micronutrients on relative growth rate (RGR, g g⁻¹ day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.016	0.017	0.017	0.019	0.020	0.020	0.006	0.006	0.006
FeSO ₄ (0.5%)	0.016	0.017	0.017	0.019	0.020	0.020	0.006	0.006	0.006
ZnSO ₄ (0.25%)	0.016	0.017	0.017	0.019	0.020	0.020	0.006	0.006	0.006
ZnSO ₄ (0.5%)	0.016	0.017	0.017	0.019	0.020	0.020	0.006	0.006	0.006
MnSO ₄ (0.2%)	0.016	0.017	0.017	0.019	0.020	0.020	0.006	0.006	0.006
MnSO ₄ (0.4%)	0.016	0.017	0.017	0.019	0.020	0.020	0.006	0.006	0.006
Control	0.016	0.017	0.017	0.019	0.020	0.020	0.006	0.006	0.006
Mean	0.016	0.017		0.019	0.020		0.006	0.006	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0006	NS		0.0003	0.0010		0.0001	0.0002	
Treatments (T)	0.0013	NS		0.0007	NS		0.0001	NS	
Interaction (GxT)	0.0018	NS		0.0022	NS		0.0002	NS	

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.018	0.021	0.019	0.021	0.022	0.022	0.007	0.006	0.007
FeSO ₄ (0.5%)	0.018	0.021	0.019	0.021	0.022	0.022	0.007	0.006	0.007
ZnSO ₄ (0.25%)	0.018	0.021	0.019	0.021	0.022	0.022	0.007	0.006	0.007
ZnSO ₄ (0.5%)	0.018	0.021	0.019	0.021	0.022	0.022	0.006	0.006	0.006
MnSO ₄ (0.2%)	0.018	0.021	0.019	0.021	0.022	0.022	0.007	0.006	0.007
MnSO ₄ (0.4%)	0.018	0.021	0.019	0.021	0.022	0.022	0.007	0.006	0.007
Control	0.018	0.021	0.019	0.021	0.022	0.022	0.007	0.006	0.007
Mean	0.018	0.021		0.021	0.022		0.007	0.006	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0013	NS		0.0007	NS		0.0001	0.0001	
Treatments (T)	0.0026	NS		0.0013	NS		0.0001	0.0002	
Interaction (GxT)	0.0038	NS		0.0018	NS		0.0001	0.0003	

V1 : BIDAR-4

V2: BIDAR-1

1999

Table 49 : Effect of micronutrients on net assimilation rate (NAR, g dm⁻² day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing									
	90-120			120-150			150-180			Mean
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	
FeSO ₄ (0.25%)	0.022	0.021	0.021	0.030	0.032	0.031	0.014	0.015	0.014	0.014
FeSO ₄ (0.5%)	0.022	0.022	0.022	0.031	0.033	0.032	0.014	0.015	0.015	0.015
ZnSO ₄ (0.25%)	0.021	0.021	0.021	0.030	0.032	0.031	0.014	0.015	0.014	0.014
ZnSO ₄ (0.5%)	0.022	0.021	0.022	0.031	0.033	0.032	0.014	0.015	0.015	0.015
MnSO ₄ (0.2%)	0.021	0.021	0.021	0.030	0.032	0.031	0.014	0.015	0.014	0.014
MnSO ₄ (0.4%)	0.022	0.022	0.022	0.031	0.033	0.032	0.014	0.015	0.015	0.015
Control	0.022	0.021	0.021	0.030	0.032	0.031	0.014	0.015	0.014	0.014
Mean	0.022	0.021		0.031	0.032		0.014	0.015		
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		
Genotypes (G)	0.0001	0.0002		0.0004	0.0011		0.0002	0.0006		0.0006
Treatments (T)	0.0001	0.0004		0.0007	NS		0.0004	NS		NS
Interaction (GxT)	0.0002	0.0005		0.0010	NS		0.0006	NS		NS

Micronutrients	Days after sowing									
	90-120			120-150			150-180			Mean
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	
FeSO ₄ (0.25%)	0.023	0.025	0.024	0.033	0.034	0.034	0.017	0.016	0.016	0.016
FeSO ₄ (0.5%)	0.023	0.025	0.024	0.034	0.034	0.034	0.017	0.016	0.016	0.016
ZnSO ₄ (0.25%)	0.022	0.024	0.023	0.032	0.032	0.032	0.016	0.015	0.016	0.016
ZnSO ₄ (0.5%)	0.023	0.025	0.024	0.034	0.034	0.034	0.014	0.016	0.015	0.015
MnSO ₄ (0.2%)	0.022	0.024	0.023	0.033	0.032	0.033	0.017	0.015	0.016	0.016
MnSO ₄ (0.4%)	0.023	0.025	0.024	0.034	0.034	0.034	0.017	0.016	0.016	0.016
Control	0.022	0.024	0.023	0.032	0.032	0.032	0.016	0.015	0.016	0.016
Mean	0.022	0.025		0.033	0.033		0.016	0.016		
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		
Genotypes (G)	0.0001	0.0001		0.0001	0.0001		0.0001	0.0002		0.0002
Treatments (T)	0.0001	0.0002		0.0001	0.0002		0.0001	0.0004		0.0004
Interaction (GxT)	0.0001	0.0003		0.0001	0.0003		0.0002	0.0005		0.0005

V1 : BIDAR-4
V2: BIDAR-1

treatments and interaction was observed at all the stages and all the micronutrient treatments significantly increased the NAR compared to control.

4.2.3.7 Specific Leaf Weight (SLW, mg cm⁻²)

The data on specific leaf weight (SLW) indicated significant differences due to genotypes at all the stage except 150 DAS and non-significant differences due to micronutrient treatments and interaction at all stages during *kharif* 1998 (Table 50). Significant difference due to genotypes micronutrient treatments and their interaction was observed at all the stages except at 120 DAS where there was no-significant differences due to genotype during *kharif* 1999.

During *kharif* 1998, the genotype Bidar-4 recorded significantly higher SLW at 90 and 180 DAS and at 120 and 150 DAS, the genotype Bidar-1 recorded significantly higher SLW. None of the micronutrient was found effective in improving the SLW.

During *kharif* 1999, the genotype Bidar-4 recorded significantly higher SLW as compared to Bidar-1 at all the growth stages except at 120 DAS where there was no significant differences between the SLW due to genotypes. However, all the micronutrient treatments significantly increased the SLW except ZnSO₄ 0.25% at all the growth stages.

4.2.3.8 Specific Leaf Area (SLA, cm² mg⁻¹)

The data on specific leaf area (SLA) indicated significant differences due to genotypes at all stages during both the years (Table 51) and significant differences due to micronutrient treatments and interaction at all the stages except at 90, 120 and 180 DAS during *kharif* 1998.

During *kharif* 1998, the genotype Bidar-4 recorded significantly higher SLA as compared to Bidar-1 at 120 and 150 DAS and Bidar-1 recorded significantly higher SLA compared to Bidar-4 at 90 and 180 DAS. Among the micronutrient

Table 50: Effect of micronutrients on specific leaf weight (SLW, mg cm⁻²) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	4.87	4.68	4.77	5.97	6.09	6.03	6.32	6.38	6.35	4.65	4.45	4.55
FeSO ₄ (0.5%)	4.90	4.71	4.80	6.00	6.13	6.07	6.36	6.42	6.39	4.68	4.48	4.58
ZnSO ₄ (0.25%)	4.86	4.68	4.77	5.96	6.10	6.03	6.32	6.39	6.35	4.65	4.46	4.55
ZnSO ₄ (0.5%)	4.92	4.69	4.81	6.03	6.11	6.07	6.39	6.40	6.40	4.70	4.46	4.58
MnSO ₄ (0.2%)	4.89	4.65	4.77	5.99	6.06	6.02	6.34	6.34	6.34	4.67	4.43	4.55
MnSO ₄ (0.4%)	4.91	4.70	4.80	6.01	6.12	6.07	6.37	6.41	6.39	4.69	4.47	4.58
Control	4.96	4.74	4.85	6.08	6.17	6.12	6.44	6.46	6.45	4.74	4.51	4.62
Mean	4.90	4.69		6.01	6.11		6.36	6.40		4.68	4.47	
For comparing	S.E.m±			C.D. (5%)			S.E.m±			C.D. (5%)		
Genotypes (G)	0.038			0.110			0.021			0.045		
Treatments (T)	0.072			NS			0.038			0.082		
Interaction (GxT)	0.099			NS			0.055			0.117		

1999

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	5.10	4.96	5.03	5.78	5.94	5.86	6.39	6.21	6.30	4.94	4.85	4.89
FeSO ₄ (0.5%)	5.12	4.93	5.02	5.82	5.76	5.79	6.43	6.18	6.30	4.97	4.83	4.90
ZnSO ₄ (0.25%)	4.98	4.85	4.92	5.65	5.67	5.66	6.24	6.09	6.16	4.83	4.76	4.79
ZnSO ₄ (0.5%)	5.09	4.95	5.02	5.83	5.79	5.81	6.39	6.21	6.30	4.94	4.85	4.90
MnSO ₄ (0.2%)	5.02	4.85	4.94	5.70	5.67	5.69	6.30	6.09	6.20	4.87	4.75	4.81
MnSO ₄ (0.4%)	5.04	4.97	5.01	5.78	5.81	5.79	6.38	6.23	6.31	4.89	4.87	4.88
Control	5.00	4.85	4.92	5.68	5.66	5.67	6.27	6.08	6.17	4.85	4.75	4.80
Mean	5.06	4.92		5.76	5.77		6.35	6.17		4.90	4.82	
For comparing	S.E.m±			C.D. (5%)			S.E.m±			C.D. (5%)		
Genotypes (G)	0.010			0.030			0.017			0.011		
Treatments (T)	0.021			0.060			0.032			0.021		
Interaction (GxT)	0.027			0.079			0.048			0.029		

V1 : BIDAR-4

V2: BIDAR-1

Table 51: Effect of micronutrients on specific leaf area (SLA, $\text{cm}^2 \text{ mg}^{-1}$) at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.205	0.214	0.210	0.168	0.164	0.166	0.158	0.157	0.157	0.215	0.225	0.220
FeSO ₄ (0.5%)	0.204	0.212	0.208	0.167	0.163	0.165	0.157	0.156	0.156	0.214	0.223	0.218
ZnSO ₄ (0.25%)	0.206	0.213	0.210	0.168	0.164	0.166	0.158	0.156	0.157	0.215	0.224	0.220
ZnSO ₄ (0.5%)	0.203	0.213	0.208	0.166	0.164	0.165	0.156	0.156	0.156	0.213	0.224	0.218
MnSO ₄ (0.2%)	0.205	0.215	0.210	0.167	0.165	0.166	0.158	0.158	0.158	0.214	0.226	0.220
MnSO ₄ (0.4%)	0.204	0.213	0.208	0.166	0.163	0.165	0.157	0.156	0.156	0.213	0.224	0.218
Control	0.202	0.211	0.206	0.165	0.162	0.163	0.155	0.155	0.155	0.211	0.222	0.216
Mean	0.204	0.213		0.167	0.164		0.157	0.156		0.213	0.224	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.002	0.006		0.001	0.002		0.001	0.002		0.002	0.007	
Treatments (T)	0.004	NS		0.001	NS		0.001	0.004		0.005	NS	
Interaction (GxT)	0.006	NS		0.002	NS		0.002	0.005		0.007	NS	

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.196	0.202	0.199	0.173	0.168	0.171	0.157	0.161	0.159	0.203	0.206	0.204
FeSO ₄ (0.5%)	0.195	0.203	0.199	0.172	0.174	0.173	0.156	0.162	0.159	0.201	0.207	0.204
ZnSO ₄ (0.25%)	0.201	0.206	0.203	0.177	0.176	0.177	0.160	0.164	0.162	0.207	0.210	0.209
ZnSO ₄ (0.5%)	0.197	0.202	0.199	0.171	0.173	0.172	0.157	0.161	0.159	0.202	0.206	0.204
MnSO ₄ (0.2%)	0.199	0.206	0.203	0.175	0.176	0.176	0.159	0.164	0.161	0.205	0.210	0.208
MnSO ₄ (0.4%)	0.198	0.201	0.200	0.173	0.172	0.173	0.157	0.160	0.159	0.205	0.205	0.205
Control	0.200	0.206	0.203	0.176	0.177	0.176	0.159	0.165	0.162	0.206	0.211	0.208
Mean	0.198	0.203		0.174	0.173		0.157	0.162		0.204	0.208	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.001	0.004		0.001	NS		0.001	0.001	0.001	0.001	0.002	0.002
Treatments (T)	0.003	0.008		0.001	0.002		0.001	0.002	0.002	0.001	0.004	0.004
Interaction (GxT)	0.004	0.011		0.001	0.003		0.001	0.003	0.003	0.002	0.005	0.005

V1 : BIDAR-4V2: BIDAR-1

treatments the application of FeSO_4 (0.25%), and MnSO_4 (0.2%) recorded significantly higher SLA as compared to other micronutrient treatments at 150 DAS.

During *kharif* 1999, the genotype Bidar-1 recorded significantly higher SLA compared to Bidar-4 at all the stages except at 120 DAS. None of the micronutrient treatment was found effective in increasing the SLA.

4.2.3.9 Leaf Area Ratio (LAR, $\text{cm}^2 \text{g}^{-1}$)

The data on leaf area ratio (LAR) indicated significant differences due to genotypes and non-significant differences due to micronutrient treatments and their interaction at all stages during both the years (Table 52). In general, the LAR showed a decreasing from 90 to 180 DAS. During both the years at all the stages the LAR values were more in the genotype Bidar-1 as compared to Bidar-4 except at 180 DAS during 1998.

During *kharif* 1998 the genotype Bidar-1 recorded significantly higher LAR as compared to Bidar-4 at all the growth stages except at 180 DAS. However, among the micronutrient treatments application of ZnSO_4 (0.25%) was very effective and significantly increased the LAR followed by MnSO_4 (0.2%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The LAR was found lowest in Bidar-4 with FeSO_4 (0.5%) and this parameter was found highest in Bidar-1 with MnSO_4 0.2 per cent.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-1 recorded significantly higher LAR as compared to Bidar-4. None of the micronutrient was found effective in increasing the LAR as compared to control. The interaction effects were found significant and the treatment combination of Bidar-4 with MnSO_4 0.4 per cent treatment combination of Bidar-4 with MnSO_4 (0.4%) treatment recorded lowest values while the highest values were found in Bidar-1 with ZnSO_4 (0.25%).

Table 52 : Effect of micronutrients on leaf area ratio (LAR, $\text{cm}^2 \text{g}^{-1}$) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	83.45	87.40	85.43	69.61	70.71	70.16	56.97	57.36	57.16	30.01	29.40	29.71
FeSO ₄ (0.5%)	81.96	85.28	83.62	68.36	68.98	68.67	55.96	55.96	55.96	29.48	28.69	29.09
ZnSO ₄ (0.25%)	85.15	88.16	86.65	71.01	71.33	71.17	58.10	57.87	57.98	30.61	29.66	30.13
ZnSO ₄ (0.5%)	82.36	86.19	84.27	68.68	69.71	69.20	56.22	56.56	56.39	29.62	29.00	29.31
MnSO ₄ (0.2%)	84.51	88.43	86.47	70.50	71.50	71.00	57.69	58.02	57.86	30.39	29.74	30.06
MnSO ₄ (0.4%)	82.13	85.63	83.88	68.55	69.26	68.90	56.08	56.20	56.14	29.55	28.81	29.18
Control	83.82	87.69	85.75	69.91	70.94	70.42	57.22	57.56	57.39	30.14	29.50	29.82
Mean	83.34	86.97		69.52	70.35		56.89	57.07		29.97	29.26	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.780	2.250		0.160	0.530		0.063	0.180		0.142	0.410	
Treatments (T)	1.450	NS		0.340	0.990		0.113	0.330		0.265	0.770	
Interaction (GxT)	2.060	5.960		0.480	1.400		0.166	0.480		0.376	1.090	

1999

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	90.98	98.43	94.70	72.56	72.36	72.46	57.69	58.33	58.01	27.62	28.38	28.00
FeSO ₄ (0.5%)	90.27	97.42	93.84	71.93	73.41	72.67	57.22	57.69	57.45	27.39	28.07	27.73
ZnSO ₄ (0.25%)	93.94	100.96	97.45	74.87	76.10	75.49	59.54	59.81	59.68	28.50	29.10	28.80
ZnSO ₄ (0.5%)	90.91	96.98	93.95	72.47	73.10	72.79	57.62	57.45	57.54	28.59	27.95	28.27
MnSO ₄ (0.2%)	92.99	100.66	96.83	74.13	75.90	75.02	58.94	59.65	59.30	28.22	29.02	28.62
MnSO ₄ (0.4%)	90.10	96.73	93.41	71.86	72.93	72.39	57.14	57.31	57.23	27.35	27.89	27.62
Control	95.24	102.63	98.93	75.93	77.39	76.66	60.38	60.81	60.60	28.91	29.59	29.25
Mean	91.53	98.53		72.97	73.97		58.03	58.37		27.95	28.40	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.430	1.230		0.190	0.560		0.073	0.210		0.115	0.330	
Treatments (T)	0.790	2.310		0.360	1.050		0.134	0.390		0.213	0.620	
Interaction (GxT)	1.120	3.260		0.510	1.480		0.193	0.560		0.300	0.870	

V1 : BIDAR-4

V2: BIDAR-1

4.2.3.10 Leaf Weight Ratio (LWR, g, cm⁻²)

The data on leaf weight ratio (LWR) indicated significant differences due to genotypes at all the stages except at 90, 150 DAS during *kharif* 1998 and at 180 DAS during *kharif* 1999 (Table 53). Significant difference in LWR due to micronutrient treatment and interaction were observed at all the stages during 1999 and non-significant differences during *kharif* 1998.

During *kharif* 1998, the genotype Bidar-1 recorded significantly higher LWR as compared to Bidar-4 at 120 DAS and the genotype Bidar-4 recorded significantly higher LWR as compared to Bidar-1 at 180 DAS. And the non-significant differences were observed in LWR due to micronutrient treatments and interaction.

During *kharif* 1999, the genotype Bidar-1 recorded significantly higher LWR as compared to Bidar-4 at 90 and 120 DAS. At 150 DAS, Bidar-4 recorded significantly higher LAR compared to Bidar-1 and at 180 DAS the value of LWR was same in both the genotypes. All the micronutrient treatments significantly decreased the LWR at all the growth stages.

4.2.3.11 Leaf Area Duration (LAD, days)

The data on leaf area duration (LAD) revealed significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 54). In general, the LAD increased upto 120-150 DAS stage and decreased thereafter. During both the years at all the stages the LAD values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the LAD at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher LAD as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO₄ (0.5%) was very effective and significantly increased the LAD followed by MnSO₄ (0.4%) and ZnSO₄ (0.5%) as compared to other micronutrient

Table 53 : Effect of micronutrients on leaf weight ratio (LWR, g cm⁻²) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.406	0.409	0.408	0.415	0.431	0.423	0.360	0.366	0.363	0.140	0.131	0.135
FeSO ₄ (0.5%)	0.401	0.401	0.401	0.410	0.423	0.417	0.356	0.359	0.358	0.138	0.129	0.133
ZnSO ₄ (0.25%)	0.414	0.413	0.413	0.423	0.435	0.429	0.367	0.370	0.368	0.142	0.132	0.137
ZnSO ₄ (0.5%)	0.405	0.404	0.405	0.414	0.426	0.420	0.359	0.362	0.361	0.139	0.129	0.134
MnSO ₄ (0.2%)	0.413	0.412	0.412	0.422	0.433	0.428	0.366	0.368	0.367	0.142	0.132	0.137
MnSO ₄ (0.4%)	0.403	0.403	0.403	0.412	0.424	0.418	0.357	0.360	0.359	0.139	0.129	0.134
Control	0.415	0.415	0.415	0.425	0.438	0.431	0.368	0.372	0.370	0.143	0.133	0.138
Mean	0.408	0.408		0.417	0.430		0.362	0.365		0.140	0.131	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0420	NS		0.0038	0.0110		0.0014	NS		0.0028	0.0080	
Treatments (T)	0.0769	NS		0.0072	NS		0.0026	NS		0.0050	NS	
Interaction (GxT)	0.1080	NS		0.0099	NS		0.0038	NS		0.0072	NS	

1999

Micronutrients	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	0.464	0.488	0.476	0.419	0.430	0.425	0.368	0.363	0.365	0.136	0.138	0.137
FeSO ₄ (0.5%)	0.462	0.480	0.471	0.418	0.423	0.421	0.368	0.357	0.362	0.136	0.136	0.136
ZnSO ₄ (0.25%)	0.467	0.490	0.479	0.423	0.432	0.427	0.372	0.364	0.368	0.138	0.138	0.138
ZnSO ₄ (0.5%)	0.463	0.480	0.472	0.423	0.423	0.423	0.368	0.357	0.362	0.141	0.136	0.138
MnSO ₄ (0.2%)	0.467	0.489	0.478	0.423	0.431	0.427	0.371	0.363	0.367	0.137	0.138	0.138
MnSO ₄ (0.4%)	0.454	0.481	0.468	0.415	0.424	0.419	0.365	0.357	0.361	0.134	0.136	0.135
Control	0.476	0.497	0.487	0.431	0.438	0.435	0.379	0.370	0.374	0.140	0.140	0.140
Mean	0.463	0.485		0.420	0.427		0.369	0.360		0.137	0.137	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0030	0.0100		0.0010	0.0030		0.0013	0.0040		0.0003	NS	
Treatments (T)	0.0060	0.0180		0.0019	0.0056		0.0026	0.0075		0.0007	0.0019	
Interaction (GxT)	0.0090	0.0270		0.0027	0.0079		0.0038	0.0110		0.0009	0.0027	

V1 : BIDAR-4 V2: BIDAR-1

Table 54 : Effect of micronutrients on leaf area duration (LAD, days) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	38.38	37.42	37.90	54.26	53.21	53.73	52.23	51.48	51.85
FeSO ₄ (0.5%)	39.51	38.44	38.98	55.85	54.67	55.26	53.76	52.89	53.33
ZnSO ₄ (0.25%)	37.88	36.82	37.35	53.53	52.36	52.95	51.52	50.65	51.08
ZnSO ₄ (0.5%)	38.66	37.88	38.27	54.64	53.86	54.25	52.59	52.11	52.35
MnSO ₄ (0.2%)	37.98	37.22	37.60	53.68	52.93	53.30	51.67	51.20	51.43
MnSO ₄ (0.4%)	39.07	38.15	38.61	55.23	54.25	54.74	53.15	52.48	52.82
Control	34.21	33.17	33.69	48.36	47.17	47.76	46.54	45.63	46.09
Mean	37.95	37.01		53.65	52.63		51.64	50.92	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.19	0.54		0.19	0.56		0.23	0.65	
Treatments (T)	0.35	1.01		0.36	1.05		0.42	1.23	
Interaction (GxT)	0.49	1.43		0.51	1.48		0.60	1.72	

1999

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	33.97	33.38	33.67	49.45	49.00	49.23	47.28	47.23	47.25
FeSO ₄ (0.5%)	34.88	34.75	34.82	50.78	50.78	50.78	48.57	48.44	48.50
ZnSO ₄ (0.25%)	33.74	33.63	33.68	49.13	49.13	49.13	46.98	46.88	46.93
ZnSO ₄ (0.5%)	34.48	34.13	34.30	50.18	49.87	50.03	47.98	47.58	47.78
MnSO ₄ (0.2%)	33.90	33.75	33.83	49.35	49.32	49.33	47.19	47.05	47.12
MnSO ₄ (0.4%)	34.60	34.38	34.49	50.38	50.23	50.30	48.17	47.93	48.05
Control	31.68	31.25	31.47	46.13	45.67	45.90	44.11	43.57	43.84
Mean	34.26	34.00		49.88	49.72		47.69	47.52	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.07	0.20		0.04	0.10		0.07	0.20	
Treatments (T)	0.13	0.38		0.07	0.19		0.13	0.38	
Interaction (GxT)	0.18	0.53		0.09	0.27		0.18	0.53	

V1 : BIDAR-4 V2: BIDAR-1

treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The LAD was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher LAD as compared to Bidar-1. The treatments with FeSO_4 (0.5%), MnSO_4 (0.4%) and ZnSO_4 (0.5%) recorded significantly higher values for LAD as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values while the highest values were found in Bidar-4 with FeSO_4 (0.5%).

4.2.3.12 Biomass duration (BMD, days)

The data on biomass duration (BMD) indicated significant differences due to genotypes, micronutrient treatments and their interaction at all stages during both the years (Table 55). In general, the BMD increased upto 150-180 DAS. During both the years at all the stages the BMD values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the BMD at all the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher BMD as compared to Bidar-1 at all the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the BMD followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at all the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The BMD was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher BMD as compared to Bidar-1. The treatments

Table 55 : Effect of micronutrients on biomass duration (BMD, g day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	922	874	898	1587	1543	1565	2221	2200	2210
FeSO ₄ (0.5%)	967	920	944	1663	1625	1644	2327	2317	2322
ZnSO ₄ (0.25%)	892	852	872	1535	1505	1520	2148	2146	2147
ZnSO ₄ (0.5%)	942	897	919	1619	1584	1602	2266	2258	2262
MnSO ₄ (0.2%)	901	859	880	1550	1517	1534	2170	2163	2166
MnSO ₄ (0.4%)	954	910	932	1640	1606	1623	2296	2289	2293
Control	819	772	795	1408	1363	1386	1971	1944	1957
Mean	914	869		1572	1535		2200	2188	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	4.83	13.90		3.92	11.28		5.39	NS	
Treatments (T)	8.94	26.10		7.26	21.20		10.03	29.20	
Interaction (GxT)	12.79	36.84		10.38	29.89		14.14	41.15	

1999

Micronutrients	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	770	737	754	1417	1396	1406	2070	2027	2048
FeSO ₄ (0.5%)	798	764	781	1467	1448	1458	2143	2102	2123
ZnSO ₄ (0.25%)	741	713	727	1364	1352	1358	1992	1962	1977
ZnSO ₄ (0.5%)	783	754	768	1439	1428	1434	2062	2073	2068
MnSO ₄ (0.2%)	752	718	735	1384	1360	1372	2022	1975	1998
MnSO ₄ (0.4%)	792	761	777	1457	1442	1450	2129	2093	2111
Control	687	652	669	1263	1236	1249	1845	1794	1819
Mean	773	741		1421	1404		2070	2039	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	4.90	14.10		7.85	22.60		19.50	56.20	
Treatments (T)	9.11	26.50		14.60	42.50		36.30	105.60	
Interaction (GxT)	12.89	37.40		20.68	60.00		51.30	148.90	

V1 : BIDAR-4

V2: BIDAR-1

with FeSO_4 (0.5%), MnSO_4 (0.4%) and ZnSO_4 (0.5%) recorded significantly higher values for BMD as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment registered lowest values while the highest values were found in Bidar-4 with FeSO_4 (0.5%).

4.2.4 BIOPHYSICAL PARAMETERS

4.2.4.1 Number of stomata on abaxial surface

The data on number of stomata on abaxial surface indicated significant differences due to genotypes, micronutrient treatments and their interaction 150 DAS during both the years (Table 56). During both the years at 150 DAS the number of stomata on abaxial surface was more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the number of stomata on abaxial surface at 150 DAS.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher number of stomata on abaxial surface as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the number of stomata on abaxial surface followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The number of stomata on abaxial surface was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). Similar results were obtained during *kharif* 1999 also.

4.2.4.2 Number of stomata on adaxial surface

The number of stomata on adaxial surface indicated significant differences due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 56). During both the years at 150 DAS the number of stomata on adaxial surface were more in the genotype Bidar-4 as compared to Bidar-1. All the

micronutrient treatments significantly increased the number of stomata on adaxial surface at 150 DAS.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher number of stomata on adaxial surface as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the number of stomata on adaxial surface followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The number of stomata on adaxial surface was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). The results of *kharif* 1999 also followed the same trend as that of *kharif* 1998.

4.2.4.3 Relative Water Content (RWC)

Significant differences were observed with respect to relative water content (RWC) due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 56). During both the years at 150 DAS the RWC values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the RWC at 150 DAS.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher RWC as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the RWC followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The RWC was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). Similar results were obtained during *kharif* 1999 also.

Table 56 : Effect of micronutrients on stomatal number, relative water content and light transmission ratio at 150 DAS in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Stomatal number per mm ² Abaxial Surface			Stomatal number per mm ² Adaxial Surface			Relative water content RWC (%)			Light transmission ratio LTR (%)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	401	391	396.00	215	212	213.50	85.9	83.8	84.85	41.4	37.3	39.35
FeSO ₄ (0.5%)	437	430	433.50	236	234	235.00	86.8	84.7	85.75	43.8	42.7	43.25
ZnSO ₄ (0.25%)	372	374	373.00	203	197	200.00	85.1	82.6	83.85	37.2	35.8	36.50
ZnSO ₄ (0.5%)	411	403	407.00	222	220	221.00	86.5	84.0	85.25	42.5	38.5	40.50
MnSO ₄ (0.2%)	385	378	381.50	208	205	206.50	85.6	83.1	84.35	40.0	36.4	38.20
MnSO ₄ (0.4%)	425	418	421.50	228	226	227.00	86.7	84.3	85.50	43.0	40.2	41.60
Control	370	362	366.00	200	192	196.00	85.0	82.4	83.70	36.6	35.0	35.80
Mean	400.14	393.71		216.00	212.29		85.94	83.56		40.64	37.99	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	0.03	5.00		1.04	3.00		0.39	1.06		0.42	1.22	
Treatments (T)	3.23	9.40		1.94	5.64		0.68	1.99		0.79	2.29	
Interaction (GxT)	4.56	13.25		2.76	8.00		0.97	2.81		1.11	3.23	

1999

Micronutrients	Stomatal Number per mm ² Abaxial Surface			Stomatal Number per mm ² Adaxial Surface			Relative Water Content RWC (%)			Light Transmission Ratio LTR (%)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	374	367	370.50	196	196	196.00	87.8	80.6	84.20	43.1	42.7	42.90
FeSO ₄ (0.5%)	411	409	410.00	214	214	214.00	97.2	90.1	93.65	47.6	47.2	47.40
ZnSO ₄ (0.25%)	353	348	350.50	187	182	184.50	81.5	74.2	77.85	40.2	39.5	39.85
ZnSO ₄ (0.5%)	387	384	385.50	201	203	202.00	90.9	83.5	87.20	44.6	44.2	44.40
MnSO ₄ (0.2%)	365	356	360.50	191	188	189.50	84.6	77.4	81.00	41.8	41.2	41.50
MnSO ₄ (0.4%)	398	396	397.00	208	206	207.00	93.8	86.9	90.35	46.1	45.6	45.85
Control	350	346	348.00	185	182	183.50	80.0	73.8	76.90	40.0	38.7	39.35
Mean	376.86	372.29		197.43	195.86		87.97	80.93		43.34	42.73	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	1.25	3.60		0.52	1.50		0.73	2.10		0.35	1.01	
Treatments (T)	2.32	6.76		0.97	2.82		1.35	3.94		0.65	1.89	
Interaction (GxT)	3.29	9.54		1.37	3.97		1.92	5.56		0.92	2.67	

V1 : BIDAR-4

V2: BIDAR-1

DAS – Days after sowing

4.2.4.4 Light transmission ratio (LTR)

The data on light transmission ratio (LTR) revealed significant differences due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 56). During both the years at 150 DAS the LTR were more in the genotype Bidar-1 as compared to Bidar-4. All the micronutrient treatments significantly increased the LTR at 150 DAS.

During *kharif* 1998 the genotype Bidar-1 recorded significantly higher LTR as compared to Bidar-4 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the LTR followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The LTR was found lowest in Bidar-4 with water spray and this parameter was found highest in Bidar-1 with FeSO_4 (0.5%). The results obtained during *kharif* 1999 also followed the same trend as that of *kharif* 1998.

4.2.4.5 Photosynthetic rate ($\mu \text{ mol CO}_2 \text{ m}^{-2} \text{ S}^{-1}$)

The data on photosynthetic rate indicated significant differences due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 57). During both the years at 150 DAS the photosynthetic rate was more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the photosynthetic rate at 150 DAS.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher photosynthetic rate as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the photosynthetic rate followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction

effects between genotypes and micronutrient treatments were found significant. The photosynthetic rate was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.4.6 Stomatal conductance ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$)

Significant differences were obtained with respect to stomatal conductance due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 57). During both the years at 150 DAS the stomatal conductance values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the stomatal conductance at 150 DAS.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher stomatal conductance as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the stomatal conductance followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The stomatal conductance was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.4.7 Transpiration rate ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$)

The transpiration rate revealed significant differences due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 57). During both the years at 150 DAS the transpiration rate values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the transpiration rate at 150 DAS.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher transpiration rate as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly

Table 57: Effect of micronutrients on photosynthetic rate, stomatal conductance and transpiration rate at 150 DAS in turmeric genotypes (1998 and 1999)

Micronutrients	Photosynthetic rate			Stomatal conductance			Transpiration rate		
	$\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$			$\mu\text{mol m}^{-2} \text{ s}^{-1}$			$\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	16.38	14.53	15.46	0.0838	0.0824	0.0831	3.89	3.66	3.78
FeSO ₄ (0.5%)	18.06	16.24	17.15	0.0897	0.0866	0.0882	4.06	3.86	3.96
ZnSO ₄ (0.25%)	15.17	13.38	14.28	0.0808	0.0795	0.0802	3.79	3.32	3.56
ZnSO ₄ (0.5%)	16.87	15.10	15.99	0.0845	0.0845	0.0845	3.93	3.73	3.83
MnSO ₄ (0.2%)	15.73	13.93	14.83	0.0823	0.0809	0.0816	3.86	3.60	3.73
MnSO ₄ (0.4%)	17.41	15.64	16.53	0.0867	0.0859	0.0863	3.99	3.76	3.88
Control	14.80	13.20	14.00	0.0748	0.0710	0.0729	3.30	3.20	3.25
Mean	16.35	14.57		0.08	0.08		3.83	3.59	
For comparing Genotypes (G)	S.Em $\pm$	C.D. (5%)		S.Em $\pm$	C.D. (5%)		S.Em $\pm$	C.D. (5%)	
Treatments (T)	0.36	1.03		0.0004	0.0011		0.042	0.12	
Interaction (GxT)	0.67	1.94		0.0007	0.0021		0.079	0.23	
	0.94	2.73		0.0010	0.0029		0.110	0.32	

Micronutrients	Photosynthetic rate			Stomatal conductance			Transpiration rate		
	$\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$			$\mu\text{mol m}^{-2} \text{ s}^{-1}$			$\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	13.89	11.79	12.84	0.0682	0.0666	0.0674	3.01	2.83	2.92
FeSO ₄ (0.5%)	14.30	12.34	13.32	0.0731	0.0702	0.0717	3.17	2.98	3.08
ZnSO ₄ (0.25%)	13.30	10.92	12.11	0.0668	0.0642	0.0655	2.93	2.57	2.75
ZnSO ₄ (0.5%)	13.98	11.98	12.98	0.0711	0.0679	0.0695	3.08	2.90	2.99
MnSO ₄ (0.2%)	13.44	11.65	12.55	0.0673	0.0648	0.0661	2.95	2.72	2.84
MnSO ₄ (0.4%)	14.12	12.07	13.10	0.0725	0.0686	0.0706	3.12	2.95	3.04
Control	11.90	10.20	11.05	0.0590	0.0580	0.0585	2.60	2.48	2.54
Mean	13.56	11.56		0.07	0.07		2.98	2.78	
For comparing Genotypes (G)	S.Em $\pm$	C.D. (5%)		S.Em $\pm$	C.D. (5%)		S.Em $\pm$	C.D. (5%)	
Treatments (T)	0.36	1.03		0.0003	0.0010		0.038	0.11	
Interaction (GxT)	0.66	1.93		0.0006	0.0018		0.072	0.21	
	0.94	2.72		0.0009	0.0027		0.100	0.29	

V1 : BIDAR-4 V2: BIDAR-1 DAS – Days after sowing

increased the transpiration rate followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The transpiration rate was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.5 BIOCHEMICAL PARAMETERS

4.2.5.1 Chlorophyll 'a' content in leaf (mg g^{-1} fr.wt.)

The data on Chlorophyll 'a' content in leaf indicated significant differences due to genotypes, micronutrient treatments and their interaction at both the stages during both the years (Table 58). In general, the Chlorophyll 'a' content decreased at 180 DAS. During both the years at both the stages the Chlorophyll 'a' content was more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the Chlorophyll 'a' content at both the growth stages.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher Chlorophyll 'a' content as compared to Bidar-1 at both the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the Chlorophyll 'a' content followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at both the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The Chlorophyll 'a' content was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.5.2 Chlorophyll 'b' content in leaf (mg g^{-1} fr.wt.)

Significant differences were observed with respect to chlorophyll 'b' content in leaf due to genotypes, micronutrient treatments and their interaction at both the stages during both the years (Table 58). In general, the Chlorophyll 'b' content decreased

Table 58: Effect of micronutrients on chlorophyll a and b contents (mg g fr. wt⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Chlorophyll "a" content (mg g fr. wt ⁻¹)						Chlorophyll "b" content (mg g fr. wt ⁻¹)					
	120 DAS			180 DAS			120 DAS			180 DAS		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	1.86	1.86	1.86	1.20	1.15	1.18	1.30	1.17	1.24	0.31	0.30	0.31
FeSO ₄ (0.5%)	2.07	2.01	2.04	1.35	1.27	1.31	1.45	1.29	1.37	0.35	0.32	0.34
ZnSO ₄ (0.25%)	1.75	1.68	1.72	1.12	1.06	1.09	1.22	1.13	1.21	0.29	0.29	0.29
ZnSO ₄ (0.5%)	1.92	1.90	1.91	1.27	1.18	1.23	1.33	1.20	1.25	0.32	0.31	0.32
MnSO ₄ (0.2%)	1.83	1.72	1.78	1.17	1.10	1.14	1.27	1.16	1.26	0.31	0.29	0.30
MnSO ₄ (0.4%)	1.98	1.97	1.98	1.30	1.22	1.26	1.38	1.25	1.24	0.33	0.32	0.33
Control	1.70	1.64	1.67	1.10	1.04	1.07	1.20	1.10	0.60	0.28	0.27	0.28
Mean	1.87	1.83		1.22	1.15		1.31	1.19		0.31	0.30	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.007	0.020		0.010	0.030		0.035	0.100		0.003	0.008	
Treatments (T)	0.013	0.038		0.019	0.056		0.065	0.190		0.005	0.015	
Interaction (GxT)	0.018	0.053		0.027	0.079		0.093	0.270		0.001	0.021	

1999

Micronutrients	Chlorophyll "a" content (mg g fr. wt ⁻¹)						Chlorophyll "b" content (mg g fr. wt ⁻¹)					
	120 DAS			180 DAS			120 DAS			180 DAS		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	1.81	1.69	1.75	1.00	1.01	1.01	1.11	0.93	1.02	0.27	0.24	0.26
FeSO ₄ (0.5%)	1.95	1.87	1.91	1.19	1.12	1.16	1.21	1.04	1.13	0.29	0.25	0.27
ZnSO ₄ (0.25%)	1.64	1.58	1.61	0.99	0.96	0.98	1.02	0.89	0.96	0.25	0.22	0.24
ZnSO ₄ (0.5%)	1.88	1.74	1.81	1.05	1.06	1.06	1.15	0.97	1.06	0.28	0.26	0.27
MnSO ₄ (0.2%)	1.75	1.61	1.68	0.99	0.98	0.99	1.08	0.91	1.00	0.25	0.22	0.24
MnSO ₄ (0.4%)	1.92	1.80	1.86	1.10	1.10	1.10	1.18	1.00	1.09	0.28	0.26	0.27
Control	1.60	1.56	1.58	0.98	0.95	0.97	1.00	0.88	0.94	0.24	0.21	0.23
Mean	1.79	1.69		1.04	1.03		1.11	0.95		0.27	0.24	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.021	0.06		0.003	0.008		0.002	0.007		0.007	0.02	
Treatments (T)	0.038	0.11		0.005	0.015		0.004	0.013		0.013	0.038	
Interaction (GxT)	0.055	0.16		0.007	0.021		0.006	0.018		0.018	0.053	

DAS – Days after sowing

V2: BIDAR-1

V1 : BIDAR-4

at 180 DAS. During both the years at both the stages the Chlorophyll 'b' content was more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the Chlorophyll 'b' content at both the growth stages.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher Chlorophyll 'b' content as compared to Bidar-1 at both the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the Chlorophyll 'b' content followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at both the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The Chlorophyll 'b' content was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.5.3 Chlorophyll a:b ratio

The Chlorophyll a:b ratio indicated significant differences due to genotypes, micronutrient treatments and their interaction at both the stages during both the years (Table 59). In general, the ratio increased from 120 to 180 DAS. Some of the micronutrient treatments significantly decreased the Chlorophyll a:b ratio at both the growth stages.

During *kharif* 1998 the genotype Bidar-4 recorded significantly lower Chlorophyll a:b ratio as compared to Bidar-1 at 120 DAS whereas at 180 DAS lower ratio was recorded by Bidar-1. However, among the micronutrient treatments application of ZnSO_4 (0.25%) and MnSO_4 (0.2%) were very effective and significantly decreased the ratio of Chlorophyll a:b as compared to other micronutrient treatments and control at 180 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The Chlorophyll a:b ratio was found lowest in Bidar-4 with water spray and this parameter was found highest in Bidar-1 with FeSO_4 (0.25%) and ZnSO_4 (0.5%) at 120 DAS and at 180 DAS, the ratio was lowest in Bidar-1 with ZnSO_4 (0.25%) and highest in Bidar-4 with ZnSO_4 (0.5%).

Table 59: Effect of micronutrients on chlorophyll a:b ratio and total chlorophyll content at different stages in turmeric genotypes (1998 and 1999)

Micronutrients	1998									
	Chlorophyll a : b					Total Chlorophyll Content (mg g ⁻¹ fr.wt ⁻¹)				
	120 DAS		180 DAS		Mean	120 DAS		180 DAS		Mean
	V1	V2	V1	V2		V1	V2	V1	V2	
FeSO ₄ (0.25%)	1.43	1.58	3.87	3.83	3.85	3.16	3.03	1.51	1.45	1.48
FeSO ₄ (0.5%)	1.42	1.55	3.85	3.96	3.91	3.52	3.30	1.70	1.59	1.65
ZnSO ₄ (0.25%)	1.43	1.48	3.86	3.65	3.76	2.97	2.81	1.41	1.35	1.38
ZnSO ₄ (0.5%)	1.44	1.58	3.96	3.81	3.89	3.25	3.10	1.59	1.49	1.54
MnSO ₄ (0.2%)	1.44	1.48	3.77	3.79	3.78	3.10	2.88	1.48	1.39	1.44
MnSO ₄ (0.4%)	1.43	1.57	3.93	3.81	3.87	3.36	3.22	1.63	1.54	1.59
Control	1.41	1.49	3.93	3.85	3.89	2.90	2.74	1.38	1.31	1.35
Mean	1.43	1.53	3.88	3.81		3.18	3.01	1.53	1.45	
For comparing	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	C.D. (5%)
Genotypes (G)	0.007	0.020	0.014	0.040	0.040	0.035	0.10	0.010	0.030	0.030
Treatments (T)	0.013	0.038	0.026	0.075	0.075	0.065	0.19	0.019	0.056	0.056
Interaction (GxT)	0.018	0.053	0.038	0.110	0.110	0.093	0.27	0.027	0.079	0.079

Micronutrients	1999									
	Chlorophyll a : b					Total Chlorophyll Content (mg g ⁻¹ fr.wt ⁻¹)				
	120 DAS		180 DAS		Mean	120 DAS		180 DAS		Mean
	V1	V2	V1	V2		V1	V2	V1	V2	
FeSO ₄ (0.25%)	1.63	1.82	3.70	4.21	3.96	2.92	2.62	1.27	1.25	1.26
FeSO ₄ (0.5%)	1.61	1.79	4.10	4.48	4.29	3.16	2.91	1.48	1.37	1.43
ZnSO ₄ (0.25%)	1.60	1.77	3.96	4.36	4.16	2.66	2.47	1.24	1.18	1.21
ZnSO ₄ (0.5%)	1.63	1.79	3.75	4.08	3.92	3.03	2.71	1.33	1.32	1.33
MnSO ₄ (0.2%)	1.62	1.76	3.96	4.45	4.21	2.83	2.52	1.24	1.20	1.22
MnSO ₄ (0.4%)	1.62	1.80	3.93	4.23	4.08	3.10	2.80	1.38	1.36	1.37
Control	1.60	1.77	4.08	4.52	4.30	2.60	2.44	1.22	1.16	1.19
Mean	1.616	1.786	3.926	4.333		2.900	2.639	1.309	1.263	
For comparing	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	C.D. (5%)
Genotypes (G)	0.003	0.010	0.003	0.009	0.009	0.038	0.110	0.038	0.110	0.110
Treatments (T)	0.007	0.020	0.006	0.016	0.016	0.072	0.210	0.072	0.210	0.210
Interaction (GxT)	0.009	0.026	0.008	0.022	0.022	0.100	0.290	0.100	0.290	0.290

V1 : BIDAR-1 V2: BIDAR-4 DAS – Days after sowing

Whereas, during *kharif* 1999 the genotype Bidar-4 recorded significantly lower Chlorophyll a:b ratio as compared to Bidar-1 at both the stages. The treatments with FeSO_4 (0.25%), ZnSO_4 (0.5%) and MnSO_4 (0.4%) recorded significantly decreased values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-4 with water spray treatment recorded lowest values while the highest values were found in Bidar-1 with FeSO_4 .

4.2.5.4 Total Chlorophyll (mg g^{-1} fr.wt.)

The data on Total chlorophyll indicated significant differences due to genotypes, micronutrient treatments and their interaction at both the stages during both the years (Table 59). In general, the total chlorophyll decreased from 120 to 180 DAS. During both the years at both the stages the total chlorophyll values were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the total chlorophyll at both stages.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher total chlorophyll content as compared to Bidar-1 at both the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the total chlorophyll followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at both the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The total chlorophyll was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.5.5 Nitrate reductase activity (NRA, $\mu \text{mol NO}_2 \text{ g}^{-1} \text{ fr.wt.hr}^{-1}$)

The data on nitrate reductase activity (NRA) indicated significant differences due to genotypes, micronutrient treatments and their interaction at both the stages during both the years (Table 60). In general, the NRA increased at 180 DAS. During both the years at both the stages the NRA values were more in the genotype

Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the NRA at both the growth stages.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher NRA as compared to Bidar-1 at both the growth stages. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the NRA followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at both the growth stages. The interaction effects between genotypes and micronutrient treatments were found significant. The NRA was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.5.6 Reducing sugars (mg g^{-1} dry wt)

The data on reducing sugars revealed significant differences due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 60). During both the years at 150 DAS the reducing sugars were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the reducing sugars at 150 DAS.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher reducing sugars as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the reducing sugars followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The reducing sugars was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%). Similar results were obtained during *kharif* 1999 also.

4.2.5.7 Non-reducing sugars (mg g^{-1} dry wt)

Significant differences were observed with respect to non-reducing sugars due to genotypes, micronutrient treatments and their interaction at 150 DAS during both

Table 60 : Effect of micronutrients on nitrate reductase activity, reducing, non-reducing and total sugar at different stages in turmeric genotypes (1998 and 1999)

1998

Micronutrients	Nitrate reductase activity (μ moles g^{-1} fr. wt. hr^{-1})						Reducing Sugars		Non-Reducing sugars (mg g^{-1} dry wt ⁻¹)				Total Sugars	
	150 DAS						180 DAS		150 DAS					
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2
	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)
FeSO ₄ (0.25%)	621	604	613	142	139	141	49	40	44.5	162	126	144.0	204	166
FeSO ₄ (0.5%)	692	668	680	157	152	155	45	43	44.0	178	170	174.0	223	213
ZnSO ₄ (0.25%)	576	564	570	134	131	133	36	38	37.0	153	118	135.5	190	156
ZnSO ₄ (0.5%)	644	625	635	147	143	145	43	41	42.0	166	130	148.0	210	171
MnSO ₄ (0.2%)	597	583	590	139	135	137	41	39	40.0	156	122	139.0	197	161
MnSO ₄ (0.4%)	668	644	656	152	148	150	44	42	43.0	172	134	153.0	216	176
Control	562	557	560	131	130	131	38	37	37.5	146	145	145.5	184	182
Mean	622.86	606.43		143.14	139.71		42.29	40.00		161.86	135.00		203.43	175.00
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)
Genotypes (G)	3.38	9.72		0.90	2.6		0.40	1.16		1.43	4.12		0.56	1.6
Treatments (T)	6.28	18.27		1.68	4.9		0.75	2.18		2.66	7.75		1.05	3.0
Interaction (GxT)	8.88	25.76		2.38	6.9		1.06	3.07		3.76	10.9		1.48	4.3

1999

Micronutrients	Nitrate reductase activity (μ moles g^{-1} fr. wt. hr^{-1})						Reducing Sugars		Non-Reducing sugars (mg g^{-1} dry wt ⁻¹)				Total Sugars	
	150 DAS						180 DAS		150 DAS					
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2
	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)
FeSO ₄ (0.25%)	563	553	558	119	112	116	38	36	37.0	139	132	135.5	177	168
FeSO ₄ (0.5%)	622	603	613	132	123	128	42	40	41.0	155	145	150.0	196	184
ZnSO ₄ (0.25%)	517	514	516	111	105	108	35	34	34.5	130	123	126.5	164	157
ZnSO ₄ (0.5%)	587	567	577	123	116	120	39	37	38.0	144	136	140.0	184	174
MnSO ₄ (0.2%)	542	535	539	115	108	112	36	35	35.5	134	127	130.5	170	162
MnSO ₄ (0.4%)	604	584	594	128	119	124	41	38	39.5	150	141	145.5	190	179
Control	510	506	508	109	104	107	35	34	34.5	128	123	125.5	163	156
Mean	563.57	551.71		119.57	112.43		38.00	36.29		140.00	132.43		177.71	168.57
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)
Genotypes (G)	2.88	8.3		1.49	4.3		0.42	1.20		0.74	2.13		1.77	5.1
Treatments (T)	5.36	15.6		2.77	8.1		0.77	2.26		1.37	4.00		3.30	9.6
Interaction (GxT)	7.55	21.9		3.92	11.3		1.10	3.18		1.94	5.64		4.69	13.5

V2: BIDAR-1

DAS – Days after sowing

V1 : BIDAR-4

the years (Table 60). During both the years at 150 DAS the non-reducing sugars were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the non-reducing sugars at 150 DAS.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher non-reducing sugars as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the non-reducing sugars followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The non-reducing sugars was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.5.8 Total sugars (mg g^{-1} dry wt⁻¹)

Significant difference were observed with respect to total sugar due to genotypes, micronutrient treatments and their interaction at 150 DAS during both the years (Table 60). During both the years at 150 DAS the total sugars were more in the genotype Bidar-4 as compared to Bidar-1. All the micronutrient treatments significantly increased the total sugars at 150 DAS.

During *kharif* 1998 and 1999 the genotype Bidar-4 recorded significantly higher total sugars as compared to Bidar-1 at 150 DAS. However, among the micronutrient treatments application of FeSO_4 (0.5%) was very effective and significantly increased the total sugars followed by MnSO_4 (0.4%) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control at 150 DAS. The interaction effects between genotypes and micronutrient treatments were found significant. The total sugars was found lowest in Bidar-1 with water spray and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%).

4.2.6 YIELD, YIELD COMPONENTS AND QUALITY

4.2.6.1 Fresh rhizome yield (g plant⁻¹)

The data on fresh rhizome yield (g plant⁻¹) indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 61). During both the years the genotype Bidar-4 registered higher values for this trait. All the micronutrient treatments significantly increased the fresh rhizome yield.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher fresh rhizome yield (614 g plant⁻¹) as compared to Bidar-1 (560.0 g plant⁻¹). However, among the treatments application of FeSO₄ (0.5%) (619.2 g plant⁻¹) and ZnSO₄ (0.5%) (604.9 g plant⁻¹) was very effective and significantly increased fresh rhizome yield as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The fresh rhizome yield was found lowest in Bidar-1 with water spray (496 g plant⁻¹) and this parameter was found highest in Bidar-4 with FeSO₄ (0.5%) (647.2 g plant⁻¹).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher fresh rhizome yield (545.2 g plant⁻¹) as compared to Bidar-1 (494.8 g plant⁻¹). The treatments with FeSO₄ (0.5%) (548.9 g plant⁻¹), MnSO₄ (0.4%) (540.5 g plant⁻¹) and ZnSO₄ (0.5%) (535.5 g plant⁻¹) recorded significantly higher values for fresh rhizome yield as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (442.0 g plant⁻¹) while the highest values were found in Bidar-4 with FeSO₄ (0.5%) (575.8 g plant⁻¹).

4.2.6.2 Fresh rhizome yield (t ha⁻¹)

Significant differences were observed with respect to fresh rhizome yield (t ha⁻¹) due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 61). During both the years the genotype Bidar-4 registered higher values for this trait. All the micronutrient treatments significantly increased the fresh rhizome yield (t ha⁻¹).

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher fresh rhizome yield (34.11 t ha^{-1}) as compared to Bidar-1 (31.10 t ha^{-1}). However, among the treatments application of FeSO_4 (0.5%) (34.4 t ha^{-1}) was very effective and significantly increased the fresh rhizome yield (33.60 t ha^{-1}) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The fresh rhizome yield (t ha^{-1}) was found lowest in Bidar-1 with water spray (27.56 t ha^{-1}) and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%) (35.96 t ha^{-1}).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher fresh rhizome yield (30.29 t ha^{-1}) as compared to Bidar-1 (27.49 t ha^{-1}). The treatments with FeSO_4 (0.5%) (30.49 t ha^{-1}), MnSO_4 (0.4%) (30.03 t ha^{-1}) and ZnSO_4 (0.5%) (29.73 t ha^{-1}) recorded significantly higher values for fresh rhizome yield (t ha^{-1}) as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (24.56 t ha^{-1}) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) (31.98 t ha^{-1}).

4.2.6.3 Cured rhizome yield (g plant^{-1})

The cured rhizome yield (g plant^{-1}) showed significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 61). During both the years the genotype Bidar-4 registered higher values for this trait. All the micronutrient treatments significantly increased the cured rhizome yield (g plant^{-1}).

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher cured rhizome yield ($133.2 \text{ g plant}^{-1}$) as compared to Bidar-1 ($126.0 \text{ g plant}^{-1}$). However, among the micronutrient treatments application of FeSO_4 (0.5%) ($136.7 \text{ g plant}^{-1}$) was very effective and significantly increased the cured rhizome yield (g plant^{-1}) followed by MnSO_4 (0.4%) ($134.8 \text{ g plant}^{-1}$) and ZnSO_4 (0.5%) ($133.6 \text{ g plant}^{-1}$) as compared to other

Table 61 : Effect of micronutrients on fresh and cured rhizome yield at harvest in turmeric genotypes (1998 and 1999)

Micronutrients	Fresh rhizome yield (g plant ⁻¹)			Fresh rhizome yield (t ha ⁻¹)			Cured rhizome yield (g plant ⁻¹)			Cured rhizome yield (t ha ⁻¹)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	618.1	563.5	590.8	34.34	31.30	32.82	134.1	126.8	130.5	7.45	7.04	7.25
FeSO ₄ (0.5%)	647.2	591.2	619.2	35.96	32.84	34.40	140.4	133.0	136.7	7.79	7.38	7.59
ZnSO ₄ (0.25%)	603.3	550.6	577.0	33.52	30.59	32.06	130.9	123.9	127.4	4.27	6.88	5.58
ZnSO ₄ (0.5%)	632.4	577.3	604.9	35.13	32.07	33.60	137.2	129.9	133.6	7.62	7.22	7.42
MnSO ₄ (0.2%)	609.4	559.5	584.5	33.86	31.08	32.47	132.2	125.8	129.0	7.34	6.99	7.17
MnSO ₄ (0.4%)	639.5	581.3	610.4	35.53	32.29	33.91	138.8	130.7	134.8	7.71	7.26	7.49
Control	548.0	496.0	522.0	30.44	27.56	29.00	118.9	111.6	115.3	6.61	6.20	6.41
Mean	614.0	559.9		34.11	31.10		133.2	126.0		6.97	7.00	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	2.26	6.52		0.13	0.36		0.78	2.25		0.07	0.21	
Treatments (T)	4.19	12.20		0.23	0.68		1.45	4.24		0.14	0.41	
Interaction (GxT)	5.94	17.28		0.33	0.96		2.07	5.96		0.19	0.56	

Micronutrients	Fresh rhizome yield (g plant ⁻¹)			Fresh rhizome yield (t ha ⁻¹)			Cured rhizome yield (g plant ⁻¹)			Cured rhizome yield (t ha ⁻¹)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	546.8	496.8	521.8	30.38	27.60	28.99	103.9	97.9	100.9	5.77	5.44	5.61
FeSO ₄ (0.5%)	575.8	522.0	548.9	31.98	29.00	30.49	109.4	102.8	106.1	6.08	5.71	5.90
ZnSO ₄ (0.25%)	534.1	487.1	510.6	29.67	27.06	28.37	101.5	96.0	98.8	5.64	5.33	5.49
ZnSO ₄ (0.5%)	559.6	510.5	535.1	31.09	28.36	29.73	106.3	100.6	103.5	5.91	5.59	5.75
MnSO ₄ (0.2%)	542.9	491.9	517.4	30.16	27.33	28.75	103.2	96.9	100.1	5.73	5.38	5.56
MnSO ₄ (0.4%)	567.4	513.6	540.5	31.52	28.53	30.03	107.8	101.2	104.5	5.99	5.62	5.81
Control	490.0	442.0	466.0	27.22	24.56	25.89	93.1	87.1	90.1	5.17	4.84	5.01
Mean	545.2	494.8		30.29	27.49		103.6	97.5		5.76	5.42	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	6.47	18.62		0.42	1.20		0.88	2.52		0.07	0.21	
Treatments (T)	12.03	35.00		0.78	2.26		1.63	4.73		0.13	0.39	
Interaction (GxT)	17.00	49.30		1.10	3.18		2.30	6.68		0.19	0.56	

V1 : BIDAR-4
V2: BIDAR-1

micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The cured rhizome yield (g plant⁻¹) was found lowest in Bidar-1 with water spray (111.6 g plant⁻¹) and this parameter was found highest in Bidar-4 with FeSO₄ (0.5%) (140.4 g plant⁻¹).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher cured rhizome yield (103.6 g plant⁻¹) as compared to Bidar-1 (97.5 g plant⁻¹). The treatments with FeSO₄ (0.5%) (106.1 g plant⁻¹), MnSO₄ (0.4%) (104.5 g plant⁻¹) and ZnSO₄ (0.5 %) (103.5 g plant⁻¹) recorded significantly higher values for cured rhizome yield (g plant⁻¹) as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment showed lowest values (87.1 g plant⁻¹) while the highest values were found in Bidar-4 with FeSO₄ (0.5%) (109.4 g plant⁻¹).

4.2.6.4 Cured rhizome yield (t ha⁻¹)

The data on cured rhizome yield (t ha⁻¹) indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 61). During both the years the genotype Bidar-4 recorded higher values for this trait. All the micronutrient treatments significantly increased the cured rhizome yield (t ha⁻¹).

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher cured rhizome yield (7.4 t ha⁻¹) as compared to Bidar-1 (7.0 t ha⁻¹). However, among the treatments application of FeSO₄ (0.5%) (7.59 t ha⁻¹) was very effective and significantly increased the cured rhizome yield (t ha⁻¹) followed by MnSO₄ (7.49 t ha⁻¹) and ZnSO₄ (0.5%) (7.42 t ha⁻¹) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The cured rhizome yield (t ha⁻¹) was found lowest in Bidar-1 with water spray (6.20 t ha⁻¹) and this parameter was found highest in Bidar-4 with FeSO₄ (0.5%) (7.79 t ha⁻¹).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher cured rhizome yield (5.76 t ha^{-1}) as compared to Bidar-1 (5.42 t ha^{-1}). The treatments with FeSO_4 (5.9 t ha^{-1}), MnSO_4 (0.4%) (5.81 t ha^{-1}) and ZnSO_4 (0.5%) (5.75 t ha^{-1}) registered significantly higher values for cured rhizome yield (t ha^{-1}) as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (4.84 t ha^{-1}) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) (6.08 t ha^{-1}).

4.2.6.5 Number of mother rhizomes per plant

The data on number of mother rhizomes per plant indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 62). During both the years the genotype Bidar-4 recorded higher values for this trait. All the micronutrient treatments significantly increased the number of mother rhizomes per plant.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher number of mother rhizome per plant (3.87) as compared to Bidar-1 (3.34). However, among the micronutrient treatments application of FeSO_4 (0.5%) and MnSO_4 (0.4%) (4.10) was very effective and significantly increased the number of mother rhizome per plant followed by ZnSO_4 (0.5%) (3.90) as compared to other micronutrient and control. The interaction effects between genotypes and micronutrient treatments were found non-significant. The number of mother rhizome per plant was found lowest in Bidar-1 with water spray (2.80) and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%) and MnSO_4 (0.5%) (4.5).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher number of mother rhizome (3.77) as compared to Bidar-1 (3.24). The treatments with FeSO_4 (0.5%), MnSO_4 (0.4%) (4.00) and ZnSO_4 (0.5%) (3.80) recorded significantly higher values for number of mother rhizome per

plant as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (2.70) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) and MnSO_4 (0.4%) (4.4).

4.2.6.6 Number of primary fingers per plant

Significant differences were observed with respect to number of primary fingers per plant due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 62). During both the years the genotype Bidar-4 registered higher values for this trait. All the micronutrient treatments significantly increased the number of primary fingers per plant.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher number of primary finger (13.97) as compared to Bidar-1 (12.99). However, among the treatments application of FeSO_4 (0.5%) (15.75) was very effective and significantly increased the number of primary fingers per plant followed by MnSO_4 (0.4%) (14.60) and ZnSO_4 (0.5%) (14.20) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The number of primary fingers per plant was found lowest in Bidar-1 with water spray (11.40) and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%) (16.3).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher number of primary fingers per plant (10.57) as compared to Bidar-1 (9.86). The treatments with FeSO_4 (0.5%) (12.0), MnSO_4 (0.4%) (11.10) and ZnSO_4 (0.5%) (10.80) registered significantly higher values for number of primary fingers per plant as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment registered lowest values (8.65) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) (12.4).

4.2.6.7 Number of secondary fingers per plant

The number of secondary fingers per plant revealed significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 62). During the year 1998 the genotype Bidar-1 registered higher values for this trait. All the micronutrient treatments significantly increased the number of secondary fingers per plant.

During *kharif* 1998 the genotype Bidar-1 recorded significantly higher number of secondary finger per plant (18.47) as compared to Bidar-4 (16.99). However, among the treatments application of FeSO_4 (0.5%) (22.25) was very effective and significantly increased the number of secondary fingers per plant followed by MnSO_4 (0.4%) (21.15) and ZnSO_4 (0.5%) (18.65) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The number of secondary fingers per plant was found lowest in Bidar-1 with water spray (13.70) and this parameter was found highest in Bidar-1 with FeSO_4 (0.5%) (23.2).

Whereas, during *kharif* 1999 the genotype Bidar-1 recorded significantly higher number of secondary fingers per plant (17.54) as compared to Bidar-4 (15.90). The treatments with FeSO_4 (0.5%) (21.00), MnSO_4 (0.4%) (19.90) and ZnSO_4 (0.5%) (17.60) recorded significantly higher values (10.6) for number of secondary finger per plant as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (13.00) while the highest values were found in Bidar-1 with FeSO_4 (0.5%) (22.0).

4.2.6.8 Length of primary finger (cm)

The data on length of primary finger (cm) indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 62). During both the years the genotype Bidar-4 recorded higher values for

Table 62 : Effect of micronutrients on rhizome and finger characters at harvest in turmeric genotypes (1998 and 1999)

Micronutrients	Number of mother Rhizomes			Number of primary fingers			Number of secondary fingers			Length of primary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	3.9	3.5	3.70	14.5	12.7	13.60	16.0	19.0	17.50	9.5	9.8	9.65
FeSO ₄ (0.5%)	4.5	3.7	4.10	16.3	15.2	15.75	21.3	23.2	22.25	12.5	11.1	11.80
ZnSO ₄ (0.25%)	3.2	3.1	3.15	12.0	11.6	11.80	15.6	14.7	15.15	9.0	9.0	9.00
ZnSO ₄ (0.5%)	4.3	3.5	3.90	14.7	13.7	14.20	16.7	20.6	18.65	10.5	10.0	10.25
MnSO ₄ (0.2%)	3.7	3.1	3.40	13.7	12.1	12.90	15.8	15.3	15.55	9.4	9.7	9.55
MnSO ₄ (0.4%)	4.5	3.7	4.10	15.0	14.2	14.60	19.5	22.8	21.15	10.7	10.2	10.45
Control	3.0	2.8	2.90	11.6	11.4	11.50	14.0	13.7	13.85	8.8	8.7	8.75
Mean	3.87	3.34		13.97	12.99		16.99	18.47		10.06	9.79	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.14	0.41		0.15	0.44		0.39	1.13		0.05	0.15	
Treatments (T)	0.26	0.77		0.29	0.83		0.73	2.12		0.10	0.28	
Interaction (GxT)	0.37	1.08		0.40	1.17		1.03	2.99		0.13	0.39	

Micronutrients	Number of mother Rhizomes			Number of primary fingers			Number of secondary fingers			Length of primary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	3.8	3.4	3.60	11.0	9.6	10.30	15.0	18.0	16.50	9.1	9.2	9.15
FeSO ₄ (0.5%)	4.4	3.6	4.00	12.4	11.6	12.00	20.0	22.0	21.00	11.9	10.5	11.20
ZnSO ₄ (0.25%)	3.1	3.0	3.05	8.8	8.8	8.80	14.6	14.0	14.30	8.6	8.5	8.55
ZnSO ₄ (0.5%)	4.2	3.4	3.80	11.2	10.4	10.80	15.6	19.6	17.60	10.0	9.5	9.75
MnSO ₄ (0.2%)	3.6	3.0	3.30	10.4	9.2	9.80	14.8	14.6	14.70	9.0	9.1	9.05
MnSO ₄ (0.4%)	4.4	3.6	4.00	11.4	10.8	11.10	18.2	21.6	19.90	10.2	9.6	9.90
Control	2.9	2.7	2.80	8.8	8.7	8.73	13.1	13.0	13.05	8.4	8.2	8.30
Mean	3.77	3.24		10.57	9.86		15.90	17.54		9.60	9.23	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.08	0.22		0.13	0.36		0.36	1.03		0.06	0.16	
Treatments (T)	0.14	0.41		0.23	0.68		0.67	1.94		0.10	0.30	
Interaction (GxT)	0.20	0.58		0.33	0.95		0.94	2.73		0.15	0.42	

V2: BIDAR-1

V1: BIDAR-4

this trait. All the micronutrient treatments significantly increased the length of primary finger.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher length of primary finger (10.06 cm) as compared to Bidar-1 (9.79 cm). However, among the treatments application of FeSO_4 (0.5%) (11.80 cm) was very effective and significantly increased the length of primary finger followed by MnSO_4 (0.4%) (10.45 cm) and ZnSO_4 (0.5%) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The length of primary finger was found lowest in Bidar-1 with water spray (8.70 cm) and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%) (12.50 cm).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher length of primary finger (9.60 cm) as compared to Bidar-1 (9.23 cm). The treatments with FeSO_4 (0.5%) (11.20 cm), MnSO_4 (0.4%) (9.90 cm) and ZnSO_4 (0.5%) (9.75 cm) registered significantly higher values for length of primary finger as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment showed lowest values (8.20 cm) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) (11.90 cm).

4.2.6.9 Length of secondary finger (cm)

Significant differences were observed with respect to length of secondary fingers (cm) due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 63). During both the years the genotype Bidar-1 registered higher values for this trait. All the micronutrient treatments significantly increased the length of secondary fingers.

During *kharif* 1998 the genotype Bidar-1 recorded significantly higher length of secondary fingers (7.30 cm) as compared to Bidar-4 (6.97 cm). However, among the treatments application of FeSO_4 (0.5%) (9.70 cm) was very effective and



M₁ = FeSO₄ (0.25%)

M₂ = FeSO₄ (0.50%)

M₃ = ZnSO₄ (0.25%)

M₄ = ZnSO₄ (0.50%)

M₅ = MnSO₄ (0.20%)

M₆ = MnSO₄ (0.40%)

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significantly increased the length of secondary fingers followed by MnSO_4 (0.4%) (8.10 cm) and ZnSO_4 (0.5%) (7.45 cm) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The length of secondary fingers was found lowest in Bidar-4 with water spray (4.80 cm) and this parameter was found highest in Bidar-1 with FeSO_4 (0.5%) (10.5 cm).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-1 recorded significantly higher length of secondary fingers (5.23 cm) as compared to Bidar-4 (5.09 cm). The treatments with FeSO_4 (0.5%) (7.00 cm), MnSO_4 (0.4%) (5.85 cm) and ZnSO_4 (0.5%) (5.40 cm) recorded significantly higher values for length of secondary finger as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment registered lowest values (3.30 cm) while the highest values were found in Bidar-1 with FeSO_4 (0.5%) (7.50 cm).

4.2.6.10 Circumference of mother rhizome (cm)

The data on circumference of mother rhizome (cm) indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 63). All the micronutrient treatments significantly increased the circumference of mother rhizome.

During *kharif* 1998 the genotype Bidar-1 recorded significantly higher circumference of mother rhizome (14.16 cm) as compared to Bidar-4 (14.13 cm). However, among the treatments application of FeSO_4 (0.5%) (14.25 cm) was very effective and significantly increased the circumference of mother rhizome (13.5 cm) followed by MnSO_4 (0.4%) (14.24 cm) and ZnSO_4 (0.5%) (14.20 cm) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The circumference of mother rhizome was found lowest in Bidar-1 and Bidar-4 with water spray (14.00 cm each) and this parameter was found highest in Bidar-1 with FeSO_4 (0.5%) (14.30 cm).

Whereas, during *kharif* 1999 the genotype Bidar-4 recorded significantly higher circumference of mother rhizome (12.82 cm) as compared to Bidar-1 (12.64 cm). The treatments with FeSO_4 (0.5%) (12.82 cm), MnSO_4 (0.4%) (12.82 cm) and FeSO_4 (0.25%) (12.73 cm) recorded significantly higher values for circumference of mother rhizome as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (12.50 cm) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) and MnSO_4 (0.4%) (12.88 cm each).

4.2.6.11 Circumference of primary finger (cm)

Significant difference were revealed with respect to circumference of primary finger due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 63). During both the years the genotype Bidar-4 registered higher values for this trait. All the micronutrient treatments significantly increased the circumference of primary finger.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher circumference of primary finger (8.16 cm) as compared to Bidar-1 (8.00 cm). However, among the micronutrient treatments application of FeSO_4 (0.5%) (9.05 cm) was very effective and significantly increased the circumference of primary finger (8.19 cm each) followed by MnSO_4 (0.4%) (8.40 cm) and ZnSO_4 (0.5%) (8.05 cm) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The circumference of primary finger was found lowest in Bidar-1 with water spray (7.50 cm) and this parameter was found highest in Bidar-4 with FeSO_4 and FeSO_4 (0.5%) (9.1 cm).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher circumference of primary finger (7.53 cm) as compared to Bidar-1 (7.16 cm). The treatments with FeSO_4 (0.5%) (8.20 cm), MnSO_4 (0.4%) (7.60 cm) and ZnSO_4 (0.5%) (7.35 cm) registered significantly higher values for

Table 63 : Effect of micronutrients on rhizome and finger characters at harvest in turmeric genotypes (1998 and 1999)

Micronutrients	Length of secondary finger (cm)			Circumference of mother rhizome (cm)			Circumference of primary finger (cm)			Circumference of secondary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	6.9	7.8	7.35	14.16	14.11	14.14	7.9	7.9	7.90	6.6	6.8	6.71
FeSO ₄ (0.5%)	8.9	10.5	9.70	14.20	14.30	14.25	9.1	9.0	9.05	7.3	7.2	7.25
ZnSO ₄ (0.25%)	6.3	5.9	6.10	14.10	14.10	14.10	7.8	7.7	7.75	6.3	6.3	6.28
ZnSO ₄ (0.5%)	7.1	7.8	7.45	14.17	14.22	14.20	8.1	8.0	8.05	6.9	7.0	6.95
MnSO ₄ (0.2%)	6.7	6.4	6.55	14.11	14.10	14.11	7.9	7.8	7.85	6.4	6.5	6.45
MnSO ₄ (0.4%)	8.1	8.1	8.10	14.19	14.28	14.24	8.7	8.1	8.40	7.2	7.0	7.12
Control	4.8	4.6	4.70	14.00	14.00	14.00	7.6	7.5	7.55	6.2	6.0	6.10
Mean	6.97	7.45		14.13	14.16		8.16	8.00		6.70	6.69	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.07	0.21		0.007	0.02		0.042	0.12		0.003	0.008	
Treatments (T)	0.13	0.39		0.013	0.04		0.079	0.23		0.005	0.015	
Interaction (GxT)	0.19	0.56		0.018	0.05		0.110	0.32		0.007	0.021	

1999

Micronutrients	Length of secondary finger (cm)			Circumference of mother rhizome (cm)			Circumference of primary finger (cm)			Circumference of secondary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
FeSO ₄ (0.25%)	5.0	5.6	5.30	12.85	12.60	12.73	7.3	7.1	7.20	6.2	6.2	6.20
FeSO ₄ (0.5%)	6.5	7.5	7.00	12.88	12.75	12.82	8.4	8.0	8.20	6.8	8.5	7.65
ZnSO ₄ (0.25%)	4.6	4.2	4.40	12.75	12.55	12.65	7.2	6.9	7.05	5.9	5.8	5.85
ZnSO ₄ (0.5%)	5.2	5.6	5.40	12.86	12.70	12.78	7.5	7.2	7.35	6.5	7.1	6.80
MnSO ₄ (0.2%)	4.9	4.6	4.75	12.80	12.60	12.70	7.3	7.0	7.15	6.0	6.0	6.00
MnSO ₄ (0.4%)	5.9	5.8	5.85	12.88	12.75	12.82	8.0	7.2	7.60	6.8	7.5	7.15
Control	3.5	3.3	3.40	12.70	12.50	12.60	7.0	6.7	6.85	5.8	5.5	5.65
Mean	5.09	5.23		12.82	12.64		7.53	7.16		6.29	6.66	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.04	0.11		0.035	0.10		0.056	0.16		0.073	0.210	
Treatments (T)	0.07	0.21		0.065	0.19		0.103	0.30		0.134	0.390	
Interaction (GxT)	0.10	0.29		0.093	0.27		0.144	0.42		0.193	0.560	

V1 : BIDAR-4 V2: BIDAR-1

circumference of primary finger as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (6.70 cm) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) (8.40 cm).

4.2.6.12 Circumference of secondary finger (cm)

The data on circumference of secondary finger indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 63). All the micronutrient treatments significantly increased the circumference of secondary finger.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher circumference of secondary finger (6.70 cm) as compared to Bidar-1 (6.69 cm). However, among the micronutrient treatments application of FeSO_4 (0.5%) (7.25 cm) was very effective and significantly increased the circumference of secondary finger followed by MnSO_4 (0.4%) (7.12 cm) and ZnSO_4 (0.5%) (6.95 cm) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The circumference of secondary finger was found lowest in Bidar-1 with water spray (6.0 cm) and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%) (7.30 cm).

Whereas, during *kharif* 1999 the genotype Bidar-1 recorded significantly higher circumference of secondary finger (6.66 cm) as compared to Bidar-4 (6.29 cm). The treatments with FeSO_4 (0.5%) (7.65 cm), MnSO_4 (0.4%) (7.15 cm) and ZnSO_4 (0.5%) (6.80 cm) recorded significantly higher values for circumference of secondary finger as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment registered lowest values (5.5 cm) while the highest values were found in Bidar-1 with FeSO_4 (0.5%) (8.50 cm).

4.2.6.13 Curing per cent

The data on curing per cent indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 64). During both the years the genotype Bidar-1 registered higher values for this trait. All the micronutrient treatments significantly increased the curing content.

During *kharif* 1998 the genotype Bidar-1 recorded significantly higher curing per cent (24.41) as compared to Bidar-4 (23.64). However, among the treatments application of FeSO_4 (0.5%) (26.30) was very effective and significantly increased the curing per cent followed by MnSO_4 (0.4%) (25.49) and ZnSO_4 (0.5%) (25.03) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The curing per cent was found lowest in Bidar-4 with water spray (21.7) and this parameter was found highest in Bidar-1 with FeSO_4 (0.5%) (26.55).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-1 (3.35) recorded significantly higher curing per cent (21.92) as compared to Bidar-4 (21.67). The treatments with FeSO_4 (0.5%) (23.53), MnSO_4 (0.4%) (23.45) and ZnSO_4 (0.5%) (23.05) recorded higher values for curing per cent as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-4 with water spray treatment registered lowest values (19.00) while the highest values were found in Bidar-1 with FeSO_4 (0.5%) (23.88).

4.2.6.14 Total dry matter (g plant⁻¹) at harvest

Significant differences were observed with total dry matter (TDM) at harvest due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 64). During both the years the genotype Bidar-4 registered higher values for this trait. All the micronutrient treatments significantly increased the total dry matter at harvest.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher total dry matter at harvest (159.3 g plant⁻¹) as compared to Bidar-1 (152.59 g plant⁻¹). However, among the treatments application of FeSO₄ (0.5%) (170.4 g plant⁻¹) was very effective and significantly increased the total dry matter at harvest followed by MnSO₄ (0.4%) (165.1 g plant⁻¹) and ZnSO₄ (0.5%) (160.5 g plant⁻¹) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The total dry matter at harvest was found lowest in Bidar-1 with water spray (139.0 g plant⁻¹) and this parameter was found highest in Bidar-4 with FeSO₄ (0.5%) (173.4 g plant⁻¹).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher total dry matter at harvest (128.2 g plant⁻¹) as compared to Bidar-1 (121.2 g plant⁻¹). The treatments with FeSO₄ (0.5%) (136.6 g plant⁻¹), MnSO₄ (0.4%) (132.4 g plant⁻¹) and ZnSO₄ (0.5%) (128.6 g plant⁻¹) recorded significantly higher values for total dry matter at harvest as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (113.8 g plant⁻¹) while the highest values were found in Bidar-4 with FeSO₄ (0.5%) (140.4 g plant⁻¹).

4.2.6.15 Harvest Index (%)

The harvest index revealed significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 64). During both the years the genotype Bidar-4 registered higher values for this trait. All the micronutrient treatments significantly increased the harvest index.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher harvest index (83.6%) as compared to Bidar-1 (82.7%). However, among the treatments application of ZnSO₄ (0.25%) was very effective and significantly increased the harvest index (87.1%) followed by MnSO₄ (0.2%) (85.5%) and FeSO₄ (0.25%) (83.8%) as compared to other micronutrient treatments and control. The interaction effects between

Table 64 : Effect of micronutrients on curing percent, total dry matter content (g plant⁻¹), harvest index (%) and curcumin content at harvest in turmeric genotypes (1998 and 1999)

Micronutrients	Curing percent			TDM at harvest (g plant ⁻¹)			Harvest index (%)			Curcumin content		
	V1		Mean	V1		Mean	V1		Mean	V1		Mean
	V2	V2		V2	V2		V2	V2		V2	V2	
FeSO ₄ (0.25%)	23.82	24.04	23.93	159.2	152.2	155.7	84.2	83.3	83.8	2.61	2.55	2.58
FeSO ₄ (0.5%)	26.04	26.55	26.30	173.4	167.4	170.4	80.9	79.5	80.2	2.93	2.81	2.87
ZnSO ₄ (0.25%)	21.00	23.16	22.08	150.5	142.0	146.3	86.9	87.3	87.1	2.48	2.38	2.43
ZnSO ₄ (0.5%)	25.12	24.94	25.03	163.7	157.2	160.5	83.8	82.6	83.2	2.72	2.60	2.66
MnSO ₄ (0.2%)	22.93	23.92	23.43	154.1	147.4	150.8	85.7	85.3	85.5	2.54	2.41	2.48
MnSO ₄ (0.4%)	25.24	25.74	25.49	168.0	162.2	165.1	82.6	80.6	81.6	2.81	2.72	2.77
Control	21.70	22.50	22.10	146.2	139.0	142.6	81.3	80.3	80.8	2.40	2.30	2.35
Mean	24.03	24.73		161.5	154.7		84.0	83.1		2.68	2.58	
For comparing	S.E.m±		C.D. (5%)	S.E.m±		C.D. (5%)	S.E.m±		C.D. (5%)	S.E.m±		C.D. (5%)
Genotypes (G)	0.160		0.45	1.23		2.31	0.38		0.72	0.021		0.06
Treatments (T)	0.290		0.85	1.49		4.34	0.47		1.35	0.038		0.11
Interaction (GxT)	0.410		1.19	2.07		6.12	0.64		1.91	0.055		0.16

Micronutrients	Curing percent			TDM at harvest (g plant ⁻¹)			Harvest index (%)			Curcumin content		
	V1		Mean	V1		Mean	V1		Mean	V1		Mean
	V2	V2		V2	V2		V2	V2		V2	V2	
FeSO ₄ (0.25%)	22.00	22.08	22.04	127.6	120.9	124.3	81.4	80.9	81.2	2.62	2.40	2.51
FeSO ₄ (0.5%)	23.18	23.88	23.53	140.4	132.7	136.6	77.9	77.5	77.7	2.81	2.69	2.75
ZnSO ₄ (0.25%)	20.70	19.58	20.14	119.5	113.1	116.3	84.9	84.9	84.9	2.45	2.30	2.38
ZnSO ₄ (0.5%)	22.60	23.50	23.05	132.4	124.8	128.6	80.3	84.6	82.5	2.70	2.46	2.58
MnSO ₄ (0.2%)	21.20	20.80	21.00	124.1	117.5	120.8	83.2	82.5	82.9	2.54	2.33	2.44
MnSO ₄ (0.4%)	23.00	23.90	23.45	136.2	128.6	132.4	79.1	78.7	78.9	2.72	2.54	2.63
Control	19.00	19.70	19.35	117.0	110.6	113.8	79.6	78.8	79.2	2.34	2.28	2.31
Mean	21.67	21.92		128.2	121.2		80.9	81.1		2.60	2.43	
For comparing	S.E.m±		C.D. (5%)	S.E.m±		C.D. (5%)	S.E.m±		C.D. (5%)	S.E.m±		C.D. (5%)
Genotypes (G)	0.056		0.16	1.13		2.13	0.11		0.20	0.038		0.11
Treatments (T)	0.103		0.30	1.38		4.00	0.13		0.38	0.072		0.21
Interaction (GxT)	0.145		0.42	1.94		5.64	0.18		0.53	0.100		0.29

V1 : BIDAR-4 V2: BIDAR-1

genotypes and micronutrient treatments were found significant. The harvest index was found lowest in Bidar-1 with FeSO_4 (0.5%) (79.5%) and this parameter was found highest in Bidar-1 with ZnSO_4 (0.25%) (87.3%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 recorded significantly higher harvest index (80.9%) as compared to Bidar-1 (80.6%). The treatments with ZnSO_4 (0.25%) (84.9%), MnSO_4 (0.2%) (82.9%) and FeSO_4 (0.25%) (81.2%) recorded significantly higher values for harvest index as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with FeSO_4 (0.5%) treatment recorded lowest values (77.5%) while the highest values were found in Bidar-1 and Bidar-4 with ZnSO_4 (0.25%) (84.9% each).

4.2.6.16 Curcumin content

The data on curcumin content indicated significant differences due to genotypes, micronutrient treatments and their interaction effects during both the years (Table 64). During both the years the genotype Bidar-4 recorded higher values for this trait. All the micronutrient treatments significantly increased the curcumin content.

During *kharif* 1998 the genotype Bidar-4 recorded significantly higher curcumin (2.64) as compared to Bidar-1 (2.54). However, among the treatments application of FeSO_4 (0.5%) (2.87) was very effective and significantly increased the curcumin followed by MnSO_4 (0.4%) (2.77) and ZnSO_4 (0.5%) (2.66) as compared to other micronutrient treatments and control. The interaction effects between genotypes and micronutrient treatments were found significant. The curcumin was found lowest in Bidar-1 with water spray (2.30) and this parameter was found highest in Bidar-4 with FeSO_4 (0.5%) (2.93%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Bidar-4 (2.60) recorded significantly higher curcumin as compared to Bidar-1 (2.43).

Table 65: Effect of micronutrients on B: C ratio in turmeric genotypes (pooled)

Treatments	Dry rhizome yield (t/ha)	Gross returns (Rs./ha)	Cost of treatment (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B:C ratio
V₁ (Bidar-4)						
T ₁ - FeSO ₄ (0.25%)	6.61	1,18,980	330	20,450	98,530	1:4.82
T ₂ - FeSO ₄ (0.5%)	6.94	1,24,920	510	20,630	1,04,290	1:5.06
T ₃ - ZnSO ₄ (0.25%)	6.46	1,16,280	450	20,570	95,710	1:4.65
T ₄ - ZnSO ₄ (0.5%)	6.77	1,21,860	750	20,870	10,090	1:4.84
T ₅ - MnSO ₄ (0.2%)	6.54	1,17,720	810	20,930	96,790	1:4.62
T ₆ - MnSO ₄ (0.4%)	6.85	1,23,300	1470	21,590	1,01,710	1:4.71
T ₇ - Control	5.89	1,06,020	-	20,120	85,900	-
V₂ (Bidar-1)						
T ₁ - FeSO ₄ (0.25%)	6.24	1,12,320	330	20,450	91,870	1:4.49
T ₂ - FeSO ₄ (0.5%)	6.55	1,17,900	510	20,630	97,270	1:4.71
T ₃ - ZnSO ₄ (0.25%)	6.11	1,09,980	450	20,570	89,410	1:4.35
T ₄ - ZnSO ₄ (0.5%)	6.41	1,15,380	750	20,870	94,510	1:4.35
T ₅ - MnSO ₄ (0.2%)	6.19	1,11,420	810	20,930	90,490	1:4.53
T ₆ - MnSO ₄ (0.4%)	6.44	1,15,920	1470	21,590	94,330	1:4.32
T ₇ - Control	5.52	99,360	-	20,120	79,240	1:4.37

Cost of cultivation = Rs.20,120/ha
 Market price of dry rhizome = Rs.18,000/t
 Cost of micronutrients
 4) FeSO₄ = Rs.120/kg
 5) ZnSO₄ = Rs.200/kg
 6) MnSO₄ = Rs.550/kg

The treatments with FeSO_4 (0.5%) (2.75), MnSO_4 (0.4%) (2.63) and ZnSO_4 (0.5%) (2.58) recorded significantly higher values for curcumin as compared to other treatments. The interaction effects were found significant and the treatment combination of Bidar-1 with water spray treatment recorded lowest values (2.28) while the highest values were found in Bidar-4 with FeSO_4 (0.5%) (2.81).

4.2.7 ECONOMICS

The data on economics of micronutrients presented in Table 65 indicated that among the various treatment application of FeSO_4 @ 0.5 per cent at 60 and 120 DAS in Bidar-4 recorded the highest benefit cost ratio of 5.06 followed by ZnSO_4 @ 0.50 per cent (4.84) and FeSO_4 @ 0.25 per cent (4.82). A similar trend was also observed in Bidar-1 wherein the B:C ratio was found highest with FeSO_4 @ 0.5 per cent (4.71) followed by ZnSO_4 @ 0.50 per cent (4.53) and FeSO_4 @ 0.25 per cent (4.49).

4.3 EXPERIMENT III. INFLUENCE OF GROWTH REGULATORS ON SOURCE-SINK RELATIONSHIP, PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES

4.3.1 MORPHOLOGICAL CHARACTERS

4.3.1.1 Plant height (cm)

The data on plant height indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 66). In general, the plant height increased upto 180 DAS. During both the years at all the stages the plant height values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the plant height at all the growth stages except CCC 500 and 1000 ppm which decreased the plant height significantly at all the growth stages in both the genotype during both the years.

Table 66 : Effect of growth regulators on plant height (cm) at different stages in turmeric genotypes (1998 and 1999)

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	34.9	27.3	31.1	44.9	33.1	39.0	48.8	39.2	44.0	48.6	39.4	44.0
CCC (1000 ppm)	34.1	26.8	30.5	43.9	33.0	38.5	48.0	38.3	43.1	48.3	39.0	43.6
Cytozime (1000 ppm)	40.1	32.5	36.3	54.4	41.3	47.9	61.9	50.4	56.1	64.5	53.2	58.8
Cytozime (2000 ppm)	40.7	33.1	36.9	55.1	42.1	48.6	62.7	51.4	57.1	65.3	54.3	59.8
Miraculan (1000 ppm)	40.0	32.3	36.2	54.2	41.1	47.7	61.6	50.2	55.9	64.2	53.0	58.6
Miraculan (2000 ppm)	40.6	32.8	36.7	55.1	41.7	48.4	62.4	50.9	56.7	65.2	53.7	59.5
Control (Water spray)	36.0	29.0	32.5	48.8	36.7	42.8	55.5	45.0	50.3	57.8	47.5	52.7
Mean	38.06	30.54		50.91	38.45		57.28	46.47		59.11	48.57	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.68	1.98		1.25	3.60		0.88	2.32		0.81	2.33	
Treatments (T)	1.28	3.72		2.32	6.76		1.63	4.74		1.51	4.38	
Interaction (GxT)	1.80	5.25		3.25	9.36		2.30	6.68		2.12	6.18	

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	24.1	21.5	22.8	30.9	26.4	28.7	35.0	32.1	33.6	34.3	31.2	32.8
CCC (1000 ppm)	23.8	21.3	22.5	30.5	26.0	28.2	34.6	31.3	32.9	34.0	30.8	32.4
Cytozime (1000 ppm)	28.0	25.9	27.0	37.9	32.9	35.4	44.6	41.7	43.2	46.0	42.8	44.4
Cytozime (2000 ppm)	28.5	26.5	27.5	38.5	33.6	36.1	45.4	42.6	44.0	46.7	43.7	45.2
Miraculan (1000 ppm)	27.9	25.8	26.9	37.8	32.7	35.2	44.5	41.5	43.0	45.8	42.6	44.2
Miraculan (2000 ppm)	28.4	26.4	27.4	38.4	33.5	35.9	45.2	42.5	43.8	46.5	43.6	45.1
Control (Water spray)	25.0	23.0	24.0	33.8	29.2	31.5	39.8	37.0	38.4	41.0	38.0	39.5
Mean	26.80	24.56		35.66	30.86		41.53	38.60		42.22	39.13	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.23	NS		0.30	0.87		0.51	1.49		0.58	1.66	
Treatments (T)	0.42	1.22		0.56	1.63		0.96	2.81		1.07	3.13	
Interaction (GxT)	0.60	1.73		0.79	2.31		1.36	3.95		1.52	4.39	

V2: RAJAPURI

V1 : AMALAPURAM

During *kharif* 1998 the genotype Amalapuram recorded significantly higher plant height as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of Cytozyme 2000 ppm was very effective and significantly increased the plant height followed by Miraculan 2000 ppm and Cytozyme 1000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The plant height was found lowest in Rajapuri with CCC 1000 ppm spray and this parameter was found highest in Amalapuram with Cytozyme 2000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher plant height as compared to Rajapuri at all the growth stages except 90 DAS. The treatments with Cytozyme 2000 ppm, Miraculan 2000 ppm and Cytozyme 1000 ppm recorded significantly higher values for plant height as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with CCC 1000 ppm spray treatment showed lowest values while the highest values were found in Amalapuram with Cytozyme 2000 ppm.

4.3.1.2 Number of tillers per plant

The number of tillers per plant indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 67). In general, the number of tillers per plant increased upto 150 DAS. During both the years at all the stages the number of tillers per plant were more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the number of tillers per plant at all the growth stages except CCC 500 and 1000 ppm which decreased the plant height only at all the growth stage in both the genotype during both the years.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher number of tillers per plant as compared to Amalapuram at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very

Table 67 : Effect of growth regulators on number of tillers per plant at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2.0	2.3	2.2	3.7	4.8	4.3	4.0	5.7	4.9	3.7	5.0	4.4
CCC (1000 ppm)	2.1	2.6	2.3	3.9	5.1	4.5	4.5	6.1	5.3	3.9	5.8	4.8
Cytozyme (1000 ppm)	2.0	2.3	2.1	3.7	2.7	3.2	3.9	5.6	4.8	3.6	4.8	4.2
Cytozyme (2000 ppm)	2.1	2.5	2.3	3.8	5.0	4.4	4.3	6.0	5.1	3.8	5.2	4.5
Miraculan (1000 ppm)	2.0	2.3	2.1	3.5	4.6	4.1	3.8	5.6	4.7	6.5	4.8	5.7
Miraculan (2000 ppm)	2.0	2.4	2.2	3.8	5.0	4.4	4.2	5.8	5.0	3.7	5.1	4.4
Control (Water spray)	1.8	2.3	2.0	3.3	4.3	3.8	3.8	5.0	4.4	3.3	4.8	4.0
Mean	1.99	2.38		3.66	4.50		4.07	5.67		4.07	5.07	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.02	0.07		0.05	0.13		0.07	0.19		0.04	0.11	
Treatments (T)	0.05	0.13		0.09	0.25		0.12	0.36		0.07	0.20	
Interaction (GxT)	0.06	0.18		0.12	0.35		0.18	0.51		0.10	0.29	

1999

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2.0	2.6	2.3	3.7	4.9	4.3	4.2	5.7	5.0	3.7	5.5	4.6
CCC (1000 ppm)	2.1	2.7	2.4	3.8	5.0	4.4	4.4	5.9	5.1	3.8	5.6	4.7
Cytozyme (1000 ppm)	2.0	2.6	2.3	3.7	4.9	4.3	4.2	5.7	4.9	3.7	5.4	4.6
Cytozyme (2000 ppm)	2.0	2.7	2.3	3.8	5.0	4.4	4.3	5.8	5.1	3.8	5.6	4.7
Miraculan (1000 ppm)	2.0	2.6	2.3	3.6	4.8	4.2	4.2	5.7	4.9	3.7	5.4	4.5
Miraculan (2000 ppm)	2.0	2.6	2.3	3.7	4.9	4.3	4.3	5.8	5.0	3.7	5.6	4.6
Control (Water spray)	1.8	2.3	2.0	3.3	4.3	3.8	3.8	5.0	4.4	3.3	4.8	4.0
Mean	2.01	2.61		3.72	4.91		4.26	5.76		3.73	5.52	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.04	0.11		0.06	0.18		0.08	0.22		0.09	0.25	
Treatments (T)	0.07	0.21		0.11	0.33		0.14	0.41		0.16	0.47	
Interaction (GxT)	0.10	0.29		0.17	0.48		0.20	0.58		0.22	0.65	

V1 : AMALAPURAM

V2: RAJAPURI

effective and significantly increased the number of tillers per plant followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The number of tillers per plant was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher number of tillers per plant as compared to Amalapuram. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for number of tillers per plant as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment showed lowest values while the highest values were found in Rajapuri with CCC 1000 ppm.

4.3.1.3 Number of leaves per plant

Significant differences were observed with respect to number of leaves per plant due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 68). In general, the number of leaves per plant increased upto 150 DAS stage and decreased thereafter. During both the years at all the stages the number of leaves per plant were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the number of leaves per plant at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher number of leaves per plant as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the number of leaves per plant followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and

Table 68: Effect of growth regulators on number of leaves per plant at different stages in turmeric genotypes (1998 and 1999)

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	13.5	11.0	12.3	18.0	15.0	16.5	24.6	19.8	22.2	14.8	11.8	13.3
CCC (1000 ppm)	14.3	12.2	13.3	19.6	17.0	18.3	26.2	21.8	24.0	16.4	12.8	14.6
Cytozyme (1000 ppm)	13.0	10.8	11.9	17.4	14.8	16.1	24.1	18.6	21.4	14.0	11.2	12.6
Cytozyme (2000 ppm)	14.0	12.0	13.0	19.0	16.8	17.9	25.5	21.0	23.3	16.0	12.6	14.3
Miraculan (1000 ppm)	12.7	10.7	11.7	17.1	14.6	15.9	23.5	18.5	21.0	13.9	11.0	12.5
Miraculan (2000 ppm)	13.8	11.9	12.8	18.5	15.7	17.1	25.0	20.6	22.8	15.2	12.0	13.6
Control (Water spray)	12.0	10.0	11.0	16.5	14.5	15.5	22.0	18.0	20.0	13.8	10.6	12.2
Mean	13.33	11.22		18.01	15.49		24.41	19.77		14.87	11.72	
For comparing	S.E.m±			S.E.m±			S.E.m±			S.E.m±		
Genotypes (G)	0.22			0.28			0.19			0.19		
Treatments (T)	0.41			0.52			0.35			0.35		
Interaction (GxT)	0.58			0.73			0.50			0.49		
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)		
	0.64			0.81			0.55			0.54		
	1.20			1.52			1.03			1.01		
	1.66			2.11			1.46			1.43		

1999

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	11.6	9.4	10.5	15.3	13.6	14.5	21.1	14.6	17.9	12.8	8.5	10.6
CCC (1000 ppm)	11.9	9.6	10.8	15.7	14.0	14.9	21.8	15.0	18.4	12.9	8.9	10.9
Cytozyme (1000 ppm)	11.6	9.3	10.4	15.3	13.5	14.4	21.1	14.5	17.8	12.7	8.3	10.5
Cytozyme (2000 ppm)	11.9	9.5	10.7	15.6	13.8	14.7	21.7	14.8	18.3	12.8	8.8	10.8
Miraculan (1000 ppm)	11.4	9.2	10.3	15.2	13.4	14.3	21.0	14.2	17.6	12.6	8.2	10.4
Miraculan (2000 ppm)	11.7	9.2	10.5	15.5	13.8	14.7	21.6	14.7	18.2	12.8	8.6	10.7
Control (Water spray)	10.0	8.0	9.0	13.2	11.6	12.4	18.2	12.5	15.4	11.0	7.2	9.1
Mean	11.68	9.39		15.44	13.68		21.40	14.64		12.77	8.55	
For comparing	S.E.m±			S.E.m±			S.E.m±			S.E.m±		
Genotypes (G)	0.19			0.31			0.39			0.19		
Treatments (T)	0.34			0.56			0.73			0.34		
Interaction (GxT)	0.49			0.80			1.03			0.51		
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)		
	0.54			0.88			1.13			0.56		
	1.01			1.65			2.12			1.04		
	1.43			2.33			2.99			1.48		

V1 : AMALAPURAM

V2: RAJAPURI

growth regulator treatments were found significant. The number of leaves per plant was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher number of leaves per plant as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for number of leaves per plant as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.2 DRY MATTER ACCUMULATION AND ITS PARTITIONING

4.3.2.1 Leaf dry weight (g plant⁻¹)

The data on leaf dry weight revealed significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 69). In general, the leaf dry weight increased upto 150 DAS and decreased thereafter. During both the years at all the stages the leaf dry weight values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the leaf dry weight at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher leaf dry weight as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the leaf dry weight followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The leaf dry weight was found lowest in Rajapuri with water spray and it was found highest in Amalapuram with CCC 1000 ppm.

Table 69 : Effect of growth regulators on leaf dry weight (g plant⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	11.30	8.02	9.66	17.46	11.46	14.46	33.09	20.63	26.86	11.66	8.82	10.24
CCC (1000 ppm)	11.70	8.44	10.07	18.08	12.05	15.07	34.28	20.63	27.46	12.08	9.28	10.68
Cytosyme (1000 ppm)	11.22	8.01	9.62	17.33	11.44	14.39	32.86	20.63	26.75	11.58	8.81	10.20
Cytosyme (2000 ppm)	11.52	8.21	9.87	17.81	11.73	14.77	33.76	20.63	27.20	11.90	9.03	10.47
Miraculan (1000 ppm)	11.14	7.92	9.53	17.21	11.32	14.27	32.63	20.63	26.63	11.50	8.72	10.11
Miraculan (2000 ppm)	11.44	8.06	9.75	17.69	11.51	14.60	33.52	20.63	27.08	11.81	8.86	10.34
Control (Water spray)	9.90	7.00	8.45	15.30	10.00	12.65	29.00	20.63	24.82	10.22	7.70	8.96
Mean	11.17	7.95		17.27	11.36		32.73	20.63		11.54	8.75	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.06	0.16		0.12	0.35		0.23	0.65		0.07	0.23	
Treatments (T)	0.11	0.31		0.22	0.65		0.42	1.22		0.15	0.44	
Interaction (GxT)	0.14	0.42		0.32	0.92		0.59	1.72		0.21	0.60	

1999

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	9.68	6.91	8.30	15.07	10.47	12.77	30.37	18.53	24.45	12.03	8.29	10.16
CCC (1000 ppm)	9.93	7.09	8.51	15.45	10.76	13.11	31.14	19.03	25.09	12.34	8.51	10.43
Cytosyme (1000 ppm)	9.58	6.86	8.22	14.91	10.40	12.66	30.05	18.40	24.23	11.92	8.23	10.08
Cytosyme (2000 ppm)	9.23	7.04	8.14	15.29	10.68	12.99	30.82	18.90	24.86	12.21	8.45	10.33
Miraculan (1000 ppm)	9.48	6.81	8.15	14.75	10.33	12.54	29.73	18.27	24.00	11.78	8.17	9.98
Miraculan (2000 ppm)	9.73	7.00	8.37	15.14	10.61	12.88	30.50	18.77	24.64	12.09	8.40	10.25
Control (Water spray)	8.45	6.00	7.23	13.15	9.10	11.13	26.50	16.10	21.30	10.50	7.20	8.85
Mean	9.61	6.95		15.10	10.54		30.44	18.65		12.06	8.34	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.15	0.44		0.23	0.67		0.49	1.41		0.15	0.43	
Treatments (T)	0.29	0.83		0.43	1.26		0.91	2.65		0.27	0.80	
Interaction (GxT)	0.39	1.14		0.61	1.78		1.29	3.74		0.38	1.12	

V1 : AMALAPURAM

V2: RAJAPURAM

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher leaf dry weight as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for leaf dry weight as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.2.2 Stem dry weight (g plant⁻¹)

The stem dry weight indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 70). In general, the stem dry weight increased upto 120 DAS and decreased thereafter. During both the years at all the stages the stem dry weight were more in the genotype Rajapuri as compared to Amalapuram except at 90 DAS during *kharif* 1998. All the growth regulator treatments significantly increased the stem dry weight at all the growth stages.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher stem dry weight as compared to Amalapuram at all the growth stages except 90 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the stem dry weight followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The stem dry weight was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher stem dry weight as compared to Amalapuram at all the growth stages. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and

Table 70 : Effect of growth regulators on stem dry weight (g plant⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	4.78	3.22	4.00	10.76	12.86	11.81	9.00	17.60	13.30	6.70	6.95	6.83
CCC (1000 ppm)	5.40	3.54	4.47	11.31	14.03	12.67	9.78	19.70	14.74	7.20	7.56	7.38
Cytozyme (1000 ppm)	4.70	3.18	3.94	10.70	12.10	11.40	8.60	17.14	12.87	6.52	6.78	6.65
Cytozyme (2000 ppm)	5.00	3.50	4.25	11.01	13.90	12.46	9.60	18.82	14.21	7.00	7.20	7.10
Miraculan (1000 ppm)	4.65	3.01	3.83	10.65	11.68	11.17	8.25	16.86	12.56	6.27	6.49	6.38
Miraculan (2000 ppm)	4.92	3.34	4.13	10.92	13.00	11.96	9.45	18.00	13.73	6.86	7.04	6.95
Control (Water spray)	4.60	2.90	3.75	9.50	11.50	10.50	8.15	16.20	12.18	6.00	6.20	6.10
Mean	4.86	3.24		10.69	12.72		8.98	17.76		6.65	6.89	
For comparing	S.E.m±			S.E.m±			S.E.m±			S.E.m±		
Genotypes (G)	0.07			0.12			0.16			0.07		
Treatments (T)	0.12			0.22			0.30			0.13		
Interaction (GxT)	0.17			0.30			0.42			0.19		
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)		
	0.19			0.34			0.47			0.21		
	0.35			0.63			0.88			0.39		
	0.49			0.88			1.22			0.56		

1999

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2.76	3.06	2.91	7.62	9.22	8.42	12.86	16.80	14.83	5.80	6.00	5.90
CCC (1000 ppm)	2.90	3.40	3.15	8.19	9.80	9.00	13.70	17.80	15.75	6.40	6.70	6.55
Cytozyme (1000 ppm)	2.60	3.00	2.80	7.50	9.00	8.25	12.75	16.20	14.48	5.62	5.90	5.76
Cytozyme (2000 ppm)	2.86	3.29	3.08	8.00	9.72	8.86	13.52	17.65	15.59	6.28	6.52	6.40
Miraculan (1000 ppm)	2.52	3.00	2.76	7.32	8.86	8.09	12.14	15.60	13.87	5.28	5.72	5.50
Miraculan (2000 ppm)	2.80	3.17	2.99	7.84	9.64	8.74	13.00	17.50	15.25	6.10	6.40	6.25
Control (Water spray)	2.50	2.90	2.70	7.00	8.70	7.85	11.80	15.00	13.40	5.10	5.68	5.39
Mean	2.74	3.15		7.75	9.37		13.00	16.93		5.91	6.21	
For comparing	S.E.m±			S.E.m±			S.E.m±			S.E.m±		
Genotypes (G)	0.04			0.06			0.07			0.04		
Treatments (T)	0.07			0.11			0.14			0.08		
Interaction (GxT)	0.09			0.16			0.19			0.11		
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)		
	0.11			0.18			0.22			0.12		
	0.21			0.33			0.41			0.22		
	0.29			0.47			0.57			0.31		

V1 : AMALAPURAM

V2: RAJAPURI

Miraculan 2000 ppm recorded significantly higher values for stem dry weight as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment registered lowest values while the highest values were found in Rajapuri with CCC 1000 ppm.

4.3.2.3 Rhizome dry weight (g plant⁻¹)

Significant differences were observed with respect to Rhizome dry weight due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 71). In general, the rhizome dry weight increased upto 180 DAS. During both the years at all the stages the rhizome dry weight were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the rhizome dry weight at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher rhizome dry weight as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the rhizome dry weight followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The rhizome dry weight was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher rhizome dry weight as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for rhizome dry weight as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

Table 71 : Effect of growth regulators on rhizome dry weight (g plant⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	8.10	3.00	5.55	16.90	6.70	11.80	34.70	12.26	23.48	75.76	37.82	56.79
CCC (1000 ppm)	9.12	3.40	6.26	18.40	7.05	12.73	38.08	14.03	26.06	86.40	44.70	65.55
Cytozime (1000 ppm)	8.00	2.90	5.45	16.20	6.11	11.16	33.50	12.00	22.75	74.62	37.00	55.81
Cytozime (2000 ppm)	9.00	3.22	6.11	18.00	6.92	12.46	36.40	13.50	24.95	85.20	43.10	64.15
Miraculan (1000 ppm)	7.94	2.82	5.38	15.86	5.82	10.84	32.80	11.64	22.22	73.10	36.80	54.95
Miraculan (2000 ppm)	8.40	3.25	5.83	17.60	6.88	12.24	35.10	12.80	23.95	80.80	40.90	60.85
Control (Water spray)	7.50	2.80	5.15	15.50	5.70	10.60	32.00	11.50	21.75	72.20	36.70	54.45
Mean	8.29	3.06		16.92	6.45		34.65	12.53		78.30	39.57	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.04	0.11		0.06	0.18		0.10	0.28		0.26	0.75	
Treatments (T)	0.07	0.21		0.11	0.33		0.18	0.53		0.48	1.41	
Interaction (GxT)	0.10	0.29		0.16	0.47		0.25	0.73		0.67	1.95	

1999

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	6.70	2.86	4.78	13.20	5.00	9.10	26.60	10.60	18.60	59.20	32.50	45.85
CCC (1000 ppm)	7.10	3.20	5.15	14.60	5.40	10.00	30.20	11.60	20.90	65.50	36.20	50.85
Cytozime (1000 ppm)	6.54	2.70	4.62	13.00	4.84	8.92	25.90	10.32	18.11	58.00	31.80	44.90
Cytozime (2000 ppm)	7.00	3.11	5.06	14.25	5.27	9.76	28.40	11.42	19.91	63.30	35.80	49.55
Miraculan (1000 ppm)	6.42	2.50	4.46	12.72	4.22	8.47	25.50	10.00	17.75	57.50	31.00	44.25
Miraculan (2000 ppm)	6.89	3.00	4.95	14.00	5.10	9.55	27.20	11.00	19.10	60.80	33.45	47.13
Control (Water spray)	6.00	2.32	4.16	12.40	4.70	8.55	25.30	9.40	17.35	57.20	30.00	43.60
Mean	6.78	2.90		13.63	4.97		27.30	10.82		60.72	33.46	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.07	0.22		0.06	0.20		0.11	0.34		0.20	0.60	
Treatments (T)	0.14	0.41		0.13	0.38		0.21	0.63		0.38	1.13	
Interaction (GxT)	0.19	0.57		0.17	0.52		0.30	0.88		0.54	1.56	

V1 : AMALAPURAM

V2: RAJAPURI

4.3.2.4 Total dry matter (TDM, g plant⁻¹)

The data on total dry matter (TDM) revealed significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 72). In general, the TDM increased upto 180 DAS. During both the years at all the stages the TDM was more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the TDM at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher TDM as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the TDM followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The TDM was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher TDM as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for TDM as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.3 GROWTH PARAMETERS

4.3.3.1 Leaf Area (cm² plant⁻¹)

Leaf area (LA) per plant indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years

Table 72 : Effect of growth regulators on total dry weight (g plant⁻¹) at different stages in turmeric genotypes (1998 and 1999)

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	25.09	15.05	20.07	47.19	31.27	39.23	78.49	52.11	65.30	102.44	58.42	80.43
CCC (1000 ppm)	25.94	15.73	20.84	48.79	32.67	40.73	81.16	54.45	67.81	105.91	61.04	83.48
Cytozyme (1000 ppm)	24.98	14.99	19.99	46.98	31.31	39.15	78.15	51.89	65.02	101.99	58.17	80.08
Cytozyme (2000 ppm)	25.62	15.37	20.50	48.18	31.91	40.05	80.14	53.19	66.67	104.58	59.63	82.11
Miraculan (1000 ppm)	24.74	14.82	19.78	46.54	30.78	38.66	77.41	51.30	64.36	101.02	57.51	79.27
Miraculan (2000 ppm)	25.35	15.13	20.24	47.68	31.43	39.56	79.32	52.38	65.85	103.51	58.72	81.12
Control (Water spray)	21.80	13.00	17.40	41.00	27.00	34.00	68.20	45.00	56.60	89.00	50.45	69.73
Mean	24.79	14.87		46.62	30.91		77.55	51.47		101.21	57.71	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.36	1.03		0.22	0.64		0.34	0.97		0.34	0.97	
Treatments (T)	0.66	1.93		0.41	1.21		0.63	1.83		0.62	1.82	
Interaction (GxT)	0.92	2.68		0.59	1.70		0.89	2.57		0.89	2.52	

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	19.28	12.67	15.98	37.65	25.92	31.79	72.56	46.66	59.61	82.49	48.84	65.67
CCC (1000 ppm)	19.84	12.99	16.42	38.74	26.57	32.66	74.67	47.83	61.25	84.89	50.07	67.48
Cytozyme (1000 ppm)	19.13	12.58	15.86	37.36	25.74	31.55	72.00	46.33	59.17	81.84	48.51	65.18
Cytozyme (2000 ppm)	19.74	12.96	16.35	38.54	26.51	32.53	74.28	47.71	61.00	84.45	49.95	67.20
Miraculan (1000 ppm)	18.93	12.49	15.71	36.96	25.54	31.25	71.23	45.97	58.60	80.98	48.12	64.55
Miraculan (2000 ppm)	19.44	12.84	16.14	37.95	26.26	32.11	73.14	47.26	60.20	83.15	49.48	66.32
Control (Water spray)	16.90	11.00	13.95	33.00	22.50	27.75	63.60	40.50	52.05	72.30	42.40	57.35
Mean	19.39	12.76		37.87	26.09		72.98	46.96		82.97	49.16	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.30	0.87		0.39	1.14		0.84	2.42		0.95	2.76	
Treatments (T)	0.55	1.62		0.73	2.13		1.55	4.53		1.77	5.17	
Interaction (GxT)	0.77	2.26		1.02	2.96		2.16	6.29		2.47	7.17	

V2: RAJAPURI

V1: AMALAPURAM

(Table 73). In general, the leaf area increased upto 150 DAS and decreased thereafter. During both the years at all the stages the leaf area were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the leaf area at all the growth stages except CCC 500 and 1000 ppm which decreased the leaf area at all the growth stages in both the genotypes during both the years.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher leaf area as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of Cytozyme 2000 ppm was very effective and significantly increased the leaf area followed by Miraculan 2000 ppm and Cytozyme 1000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The leaf area was found lowest in Rajapuri with CCC 1000 ppm spray and this parameter was found highest in Amalapuram with Cytozyme 2000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher leaf area as compared to Rajapuri at all the growth stages except - DAS. The treatments with Cytozyme 2000 ppm, Miraculan 2000 ppm and Cytozyme 1000 ppm recorded significantly higher values for leaf area as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with CCC 1000 ppm spray treatment showed lowest values while the highest values were found in Amalapuram with Cytozyme 2000 ppm.

4.3.3.2 Leaf Area Index (LAI)

Significant differences were observed with respect to leaf area index (LAI) due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 74). In general, the LAI increased upto 150 DAS and decreased thereafter. During both the years at all the stages the LAI were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly

Table 73 : Effect of growth regulators on leaf area ($\text{cm}^2 \text{ plant}^{-1}$) at different stages in turmeric genotypes (1998 and 1999)

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2084	1407	1746	2214	1692	1953	3747	2436	3092	2383	1221	1802
CCC (1000 ppm)	2052	1388	1720	2183	1675	1929	3696	2374	3035	2371	1204	1788
Cytozyme (1000 ppm)	2419	1692	2056	2710	2112	2411	4769	3165	3967	3192	1675	2434
Cytozyme (2000 ppm)	2462	1725	2094	2759	2153	2456	4854	3227	4041	3249	1708	2479
Miraculan (1000 ppm)	2408	1680	2044	2698	2097	2398	4748	3143	3946	3178	1663	2421
Miraculan (2000 ppm)	2454	1722	2088	2749	2149	2449	4837	3221	4029	3238	1705	2472
Control (Water spray)	2160	1500	1830	2420	1872	2146	4258	2806	3532	2850	1485	2168
Mean	2291	1588		2533	1964		4416	2910		2923	1523	
For comparing	S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)	
Genotypes (G)	10.34	29.78		38.78	111.70		79.96	230.30		41.74	120.20	
Treatments (T)	19.24	56.00		71.92	210.00		148.29	433.00		77.66	226.00	
Interaction (GxT)	26.61	77.45		100.14	290.40		206.55	599.00		107.76	312.50	

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	1918	1316	1617	2075	1687	1881	3531	2303	2917	2170	1112	1641
CCC (1000 ppm)	1894	1268	1581	2043	1655	1849	3495	2266	2881	2126	1087	1607
Cytozyme (1000 ppm)	2308	1624	1966	2610	2165	2388	4666	3110	3888	2987	1571	2279
Cytozyme (2000 ppm)	2370	1663	2017	2680	2217	2449	4791	3185	3988	3067	1609	2338
Miraculan (1000 ppm)	2286	1608	1947	2585	2145	2365	4622	3081	3852	2958	1557	2258
Miraculan (2000 ppm)	2344	1653	1999	2651	2204	2428	4739	3166	3953	3033	1600	2317
Control (Water spray)	1998	1395	1697	2260	1860	2060	4040	2672	3356	2586	1350	1968
Mean	2187	1522		2441	2012		4307	2852		2724	1423	
For comparing	S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)	
Genotypes (G)	16.31	47.00		2.15	62.00		49.30	142.00		28.47	82.00	
Treatments (T)	29.90	87.00		39.73	116.00		91.40	266.00		52.92	154.00	
Interaction (GxT)	42.36	122.00		55.90	161.00		127.20	369.00		73.20	213.00	

V1 : AMALAPURAM

V2: RAJAPURI

Table 74 : Effect of growth regulators on leaf area index (LAI) at different stages in turmeric genotypes (1998 and 1999)

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	1.16	0.78	0.97	1.23	0.94	1.09	2.08	1.35	1.72	1.32	0.68	1.00
CCC (1000 ppm)	1.14	0.77	0.96	1.21	0.93	1.07	2.05	1.32	1.69	1.32	0.67	0.99
Cytozyme (1000 ppm)	1.34	0.94	1.14	1.51	1.17	1.34	2.65	1.76	2.20	1.77	0.93	1.35
Cytozyme (2000 ppm)	1.37	0.96	1.16	1.53	1.20	1.36	2.70	1.79	2.24	1.81	0.95	1.38
Miraculan (1000 ppm)	1.34	0.93	1.14	1.50	1.17	1.33	2.64	1.75	2.19	1.77	0.92	1.34
Miraculan (2000 ppm)	1.36	0.96	1.16	1.53	1.19	1.36	2.69	1.79	2.24	1.80	0.95	1.37
Control (Water spray)	1.20	0.83	1.02	1.34	1.04	1.19	2.37	1.56	1.96	1.58	0.83	1.20
Mean	1.27	0.88		1.41	1.09		2.45	1.62		1.62	0.85	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	0.005	0.016		0.022	0.062		0.040	0.128		0.023	0.067	
Treatments (T)	0.010	0.031		0.040	0.117		0.080	0.241		0.043	0.126	
Interaction (GxT)	0.015	0.043		0.056	0.161		0.110	0.333		0.060	0.174	

1999

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	1.07	0.73	0.90	1.15	0.94	1.05	1.96	1.28	1.62	1.21	0.62	0.91
CCC (1000 ppm)	1.05	0.70	0.88	1.14	0.92	1.03	1.94	1.26	1.60	1.18	0.60	0.89
Cytozyme (1000 ppm)	1.28	0.90	1.09	1.45	1.20	1.33	2.59	1.73	2.16	1.66	0.87	1.27
Cytozyme (2000 ppm)	1.32	0.92	1.12	1.49	1.23	1.36	2.66	1.77	2.22	1.70	0.89	1.30
Miraculan (1000 ppm)	1.27	0.89	1.08	1.44	1.19	1.31	2.57	1.71	2.14	1.64	0.87	1.25
Miraculan (2000 ppm)	1.30	0.92	1.11	1.47	1.22	1.35	2.63	1.76	2.20	1.69	0.89	1.29
Control (Water spray)	1.11	0.78	0.94	1.26	1.03	1.14	2.24	1.48	1.86	1.44	0.75	1.09
Mean	1.21	0.85		1.36	1.12		2.39	1.58		1.51	0.79	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	0.008	0.025		0.012	0.034		0.028	0.080		0.013	0.040	
Treatments (T)	0.016	0.048		0.022	0.064		0.052	0.150		0.029	0.086	
Interaction (GxT)	0.022	0.065		0.030	0.088		0.069	0.200		0.026	0.104	

V1 : AMALAPURAM

V2: RAJAPURI

increased the LAI at all the growth stages except CCC 500 and 1000 ppm which decreased the LAI at all the growth stages in both the genotypes during both the years.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher LAI as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of Cytozyme 2000 ppm was very effective and significantly increased the LAI followed by Miraculan 2000 ppm and Cytozyme 1000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The LAI was found lowest in Rajapuri with CCC 1000 ppm spray and it was found highest in Amalapuram with Cytozyme 2000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher LAI as compared to Rajapuri. The treatments with Cytozyme 2000 ppm, Miraculan 2000 ppm and Cytozyme 1000 ppm registered significantly higher values for LAI as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with CCC 1000 ppm spray treatment showed lowest values while the highest values were found in Amalapuram with Cytozyme 2000 ppm.

4.3.3.3 Absolute Growth Rate (AGR, g plant⁻¹ day⁻¹)

The data on absolute growth rate (AGR) indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 75). In general, the AGR increased upto 150 DAS and decreased thereafter. During both the years at all the stages the AGR were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the AGR at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher AGR as compared to Rajapuri at all the growth stages. However, among the growth

Table 75 : Effect of growth regulators on absolute growth rate (AGR, g plant⁻¹ day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	0.74	0.54	0.64	1.04	0.69	0.87	0.80	0.21	0.50
CCC (1000 ppm)	0.76	0.56	0.66	1.08	0.73	0.90	0.83	0.22	0.52
Cytozyme (1000 ppm)	0.73	0.54	0.64	1.04	0.69	0.86	0.79	0.21	0.50
Cytozyme (2000 ppm)	0.75	0.55	0.65	1.07	0.71	0.89	0.81	0.21	0.51
Miraculan (1000 ppm)	0.73	0.53	0.63	1.03	0.68	0.86	0.79	0.21	0.50
Miraculan (2000 ppm)	0.74	0.54	0.64	1.05	0.70	0.88	0.81	0.21	0.51
Control (Water spray)	0.64	0.47	0.55	0.91	0.60	0.75	0.69	0.18	0.44
Mean	0.73	0.53		1.03	0.69		0.79	0.21	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	0.010	0.030		0.013	0.038		0.012	0.035	
Treatments (T)	0.018	0.050		0.024	0.071		0.022	0.065	
Interaction (GxT)	0.027	0.080		0.034	0.098		0.031	0.091	

1999

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	0.61	0.44	0.53	1.16	0.69	0.93	0.33	0.07	0.20
CCC (1000 ppm)	0.63	0.45	0.54	1.20	0.71	0.95	0.34	0.07	0.21
Cytozyme (1000 ppm)	0.61	0.44	0.52	1.15	0.69	0.92	0.33	0.07	0.20
Cytozyme (2000 ppm)	0.63	0.45	0.54	1.19	0.71	0.95	0.34	0.07	0.21
Miraculan (1000 ppm)	0.60	0.44	0.52	1.14	0.68	0.91	0.33	0.07	0.20
Miraculan (2000 ppm)	0.62	0.45	0.53	1.17	0.70	0.94	0.33	0.07	0.20
Control (Water spray)	0.54	0.38	0.46	1.02	0.60	0.81	0.29	0.06	0.18
Mean	0.62	0.44		1.17	0.70		0.33	0.07	
For comparing	S.Em±	C.D. (5%)		S.Em±	C.D. (5%)		S.Em±	C.D. (5%)	
Genotypes (G)	0.007	0.020		0.013	0.040		0.003	0.010	
Treatments (T)	0.017	0.050		0.031	0.090		0.007	0.020	
Interaction (GxT)	0.017	0.050		0.079	0.230		0.010	0.030	

V1 : AMALAPURAM

V2: RAJAPURI

regulator treatments application of CCC 1000 ppm was very effective and significantly increased the AGR followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The AGR was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher AGR as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for AGR as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.3.4 Crop Growth Rate (CGR, $\text{gm}^{-2} \text{ day}^{-1}$)

Crop growth rate (CGR) indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 76). In general, the CGR increased upto 150 DAS and decreased thereafter. During both the years at all the stages the CGR were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the CGR at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher CGR as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the CGR followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The CGR was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Table 76 : Effect of growth regulators on crop growth rate (CGR, g m⁻² day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	4.09	3.00	3.55	5.80	3.86	4.83	4.44	1.17	2.80
CCC (1000 ppm)	4.23	3.14	3.68	5.99	4.03	5.01	4.58	1.22	2.90
Cytozyme (1000 ppm)	4.07	3.02	3.55	5.77	3.81	4.79	4.42	1.16	2.79
Cytozyme (2000 ppm)	4.18	3.06	3.62	5.92	3.94	4.93	4.53	1.19	2.86
Miraculan (1000 ppm)	4.04	2.96	3.50	5.72	3.80	4.76	4.37	1.15	2.76
Miraculan (2000 ppm)	4.14	3.02	3.58	5.86	3.88	4.87	4.48	1.17	2.83
Control (Water spray)	3.56	2.59	3.07	5.04	3.33	4.19	3.85	1.01	2.43
Mean	4.04	2.97		5.73	3.81		4.38	1.15	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.076	0.220		0.094	0.270		0.049	0.140	
Treatments (T)	0.140	0.410		0.176	0.510		0.089	0.260	
Interaction (GxT)	0.198	0.570		0.241	0.700		0.124	0.360	

1999

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	3.40	2.45	2.93	6.47	3.84	5.15	1.84	0.40	1.12
CCC (1000 ppm)	3.50	2.52	3.01	6.65	3.94	5.30	1.89	0.41	1.15
Cytozyme (1000 ppm)	3.38	2.44	2.91	6.42	3.81	5.11	1.82	0.40	1.11
Cytozyme (2000 ppm)	3.48	2.51	3.00	6.62	3.93	5.27	1.88	0.41	1.15
Miraculan (1000 ppm)	3.34	2.42	2.88	6.35	3.78	5.07	1.81	0.40	1.10
Miraculan (2000 ppm)	3.43	2.49	2.96	6.52	3.89	5.20	1.85	0.41	1.13
Control (Water spray)	2.98	2.13	2.56	5.67	3.33	4.50	1.61	0.35	0.98
Mean	3.42	2.47		6.50	3.87		1.85	0.41	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.038	0.110		0.021	0.060		0.021	0.060	
Treatments (T)	0.072	0.210		0.038	0.110		0.041	0.170	
Interaction (GxT)	0.100	0.290		0.055	0.160		0.107	0.310	

V1 : AMALAPURAM

V2: RAJAPURI

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher CGR as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for CGR as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.3.5 Relative Growth Rate (RGR, $\text{g g}^{-1} \text{ day}^{-1}$)

The data on relative growth rate (RGR) indicated significant differences due to genotypes at 90-120 and 150-180 DAS during the year 1998 and 120-150 and 150-180 DAS during the year 1999 and the non-significant differences due to genotype at 120-150 DAS during the year 1998 and at 90-120 DAS during the year 1999 and due to growth regulator treatments and their interaction at all the growth stages during both the year (Table 77). In general the RGR decreased from 120-150 DAS during both the years in both the genotypes.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher RGR at 90-120 as compared to Amalapuram. The effect of growth regulator and their interaction was non-significant at all the stages. During *kharif* 1999, the genotype Amalapuram recorded significantly higher RGR as compared to Rajapuri at 120-150 and 150-180 DAS and the effect of growth regulator and their interaction was non-significant at all the stages.

4.3.3.6 Net Assimilation Rate (NAR, $\text{g dm}^{-2} \text{ day}^{-1}$)

Net assimilation rate (NAR) indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years except at 90 DAS during 1998 the NAR being non-significant due to genotypes (Table 78). During both the years at all the stages except at 90 DAS during 1998 the

Table 77: Effect of growth regulators on relative growth rate (RGR, $\text{g g}^{-1} \text{ day}^{-1}$) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing						
	90-120			120-150			150-180
	V1	V2	Mean	V1	V2	Mean	V1 V2 Mean
CCC (500 ppm)	0.021	0.024	0.023	0.017	0.017	0.017	0.009 0.004 0.006
CCC (1000 ppm)	0.021	0.024	0.023	0.017	0.017	0.017	0.009 0.004 0.006
Cytozyme (1000 ppm)	0.021	0.025	0.023	0.017	0.017	0.017	0.009 0.004 0.006
Cytozyme (2000 ppm)	0.021	0.024	0.023	0.017	0.017	0.017	0.009 0.004 0.006
Miraculan (1000 ppm)	0.021	0.024	0.023	0.017	0.017	0.017	0.009 0.004 0.006
Miraculan (2000 ppm)	0.021	0.024	0.023	0.017	0.017	0.017	0.009 0.004 0.006
Control (Water spray)	0.021	0.024	0.023	0.017	0.017	0.017	0.009 0.004 0.006
Mean	0.021	0.024	0.023	0.017	0.017	0.017	0.009 0.004 0.006
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$ C.D. (5%)
Genotypes (G)	0.0010	0.0030		0.0007	NS		0.0014 0.0040
Treatments (T)	0.0020	NS		0.0013	NS		0.0026 NS
Interaction (GxT)	0.0030	NS		0.0018	NS		0.0060 NS

1999

Treatments	Days after sowing						
	90-120			120-150			150-180
	V1	V2	Mean	V1	V2	Mean	V1 V2 Mean
CCC (500 ppm)	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
CCC (1000 ppm)	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
Cytozyme (1000 ppm)	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
Cytozyme (2000 ppm)	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
Miraculan (1000 ppm)	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
Miraculan (2000 ppm)	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
Control (Water spray)	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
Mean	0.022	0.024	0.023	0.022	0.020	0.021	0.004 0.002 0.003
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$ C.D. (5%)
Genotypes (G)	0.0070	NS		0.0003	0.0010		0.0007 0.0020
Treatments (T)	0.0140	NS		0.0006	NS		0.0010 NS
Interaction (GxT)	0.0190	NS		0.0009	NS		0.0020 NS

V1 : AMALAPURAM

V2: RAJAPURI

Table 78: Effect of growth regulators on net assimilation rate (NAR, g dm⁻² day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing						
	90-120			120-150			150-180
	V1	V2	Mean	V1	V2	Mean	V1 V2 Mean
CCC (500 ppm)	0.034	0.035	0.035	0.036	0.034	0.035	0.026 0.012 0.019
CCC (1000 ppm)	0.036	0.037	0.037	0.038	0.036	0.037	0.028 0.013 0.021
Cytozyme (1000 ppm)	0.029	0.029	0.029	0.029	0.026	0.028	0.020 0.009 0.015
Cytozyme (2000 ppm)	0.029	0.029	0.029	0.029	0.027	0.028	0.020 0.009 0.015
Miraculan (1000 ppm)	0.028	0.028	0.028	0.028	0.026	0.027	0.020 0.009 0.015
Miraculan (2000 ppm)	0.029	0.028	0.029	0.029	0.026	0.028	0.020 0.009 0.015
Control (Water spray)	0.028	0.028	0.028	0.028	0.026	0.027	0.020 0.009 0.015
Mean	0.030	0.031		0.031	0.029		0.022 0.010
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m± C.D. (5%)
Genotypes (G)	0.0001	NS		0.0005	0.0015		0.0004 0.0011
Treatments (T)	0.0002	0.0006		0.0010	0.0030		0.0007 0.0020
Interaction (GxT)	0.0003	0.0001		0.0010	0.0039		0.0010 0.0029

1999

Treatments	Days after sowing						
	90-120			120-150			150-180
	V1	V2	Mean	V1	V2	Mean	V1 V2 Mean
CCC (500 ppm)	0.031	0.030	0.031	0.042	0.035	0.039	0.012 0.004 0.008
CCC (1000 ppm)	0.032	0.031	0.032	0.044	0.036	0.040	0.012 0.005 0.009
Cytozyme (1000 ppm)	0.025	0.023	0.024	0.033	0.026	0.030	0.009 0.003 0.006
Cytozyme (2000 ppm)	0.025	0.023	0.024	0.033	0.026	0.030	0.009 0.003 0.006
Miraculan (1000 ppm)	0.025	0.023	0.024	0.033	0.026	0.030	0.009 0.003 0.006
Miraculan (2000 ppm)	0.025	0.023	0.024	0.033	0.026	0.030	0.009 0.003 0.006
Control (Water spray)	0.025	0.024	0.025	0.033	0.027	0.030	0.009 0.003 0.006
Mean	0.027	0.026		0.036	0.029		0.010 0.004
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m± C.D. (5%)
Genotypes (G)	0.0003	0.0010		0.0007	0.0020		0.0003 0.0010
Treatments (T)	0.0007	0.0020		0.0014	0.0040		0.0009 0.0020
Interaction (GxT)	0.0010	0.0030		0.0017	0.0050		0.0010 0.0030

V1 : AMALAPURAM

V2: RAJAPURI

NAR values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the NAR at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher NAR as compared to Rajapuri at all the growth stages except at 90 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the NAR followed by CCC 500 ppm and Cytozyme 1000 and 2000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher NAR as compared to Rajapuri. The treatments with CCC 1000 ppm and CCC 500 ppm recorded significantly higher values for NAR as compared to other treatments. The interaction effects were found significant.

4.3.3.7 Specific Leaf Weight (SLW, mg cm⁻²)

The data on specific leaf weight (SLW) indicated significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years except at 90 DAS during 1998 the SLW being non-significant due to genotypes (Table 79). In general, the SLW increased upto 150 DAS and decreased thereafter.

During *kharif* 1998 CCC 1000 ppm was found very effective and significantly increased the SLW followed by CCC 500 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The SLW was found lowest in Amalapuram with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Table 79 : Effect of growth regulators on specific leaf weight (SLW, mg cm⁻²) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	5.42	5.70	5.56	7.89	6.77	7.33	8.83	8.47	8.65	4.89	7.22	6.06
CCC (1000 ppm)	5.70	6.08	5.89	8.28	7.19	7.74	9.27	8.69	8.98	5.09	7.71	6.40
Cytozyme (1000 ppm)	4.64	4.73	4.69	6.39	5.42	5.91	6.89	6.52	6.70	3.63	5.26	4.44
Cytozyme (2000 ppm)	4.68	4.76	4.72	6.46	5.45	5.95	6.96	6.39	6.67	3.66	5.29	4.47
Miraculan (1000 ppm)	4.63	4.71	4.67	6.38	5.40	5.89	6.87	6.56	6.72	3.62	5.24	4.43
Miraculan (2000 ppm)	4.66	4.68	4.67	6.44	5.36	5.90	6.93	6.40	6.67	3.65	5.20	4.42
Control (Water spray)	4.58	4.67	4.63	6.32	5.34	5.83	6.81	7.35	7.08	3.59	5.19	4.39
Mean	4.90	5.05		6.88	5.85		7.51	7.20		4.02	5.87	
For comparing	S.E.m±			S.E.m±			S.E.m±			S.E.m±		
Genotypes (G)	0.022			0.042			0.063			0.056		
Treatments (T)	0.041			0.075			0.117			0.107		
Interaction (GxT)	0.058			0.128			0.166			0.145		
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)		
	NS			0.120			0.180			0.160		
	0.120			0.220			0.340			0.310		
	0.170			0.310			0.480			0.420		

1999

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	5.05	5.25	5.15	7.26	6.21	6.73	8.60	8.05	8.32	5.54	7.46	6.50
CCC (1000 ppm)	5.24	5.59	5.42	7.56	6.50	7.03	8.91	8.40	8.65	5.80	7.83	6.82
Cytozyme (1000 ppm)	4.15	4.22	4.19	5.71	4.80	5.26	6.44	5.92	6.18	3.99	5.24	4.61
Cytozyme (2000 ppm)	3.89	4.23	4.06	5.71	4.82	5.26	6.43	5.93	6.18	3.98	5.25	4.62
Miraculan (1000 ppm)	4.15	4.24	4.19	5.71	4.82	5.26	6.43	5.93	6.18	3.98	5.25	4.61
Miraculan (2000 ppm)	4.15	4.23	4.19	5.71	4.81	5.26	6.44	5.93	6.18	3.99	5.25	4.62
Control (Water spray)	4.23	4.30	4.27	5.82	4.89	5.36	6.56	6.03	6.29	4.06	5.33	4.70
Mean	4.44	4.63		6.28	5.33		7.21	6.69		4.55	6.05	
For comparing	S.E.m±			S.E.m±			S.E.m±			S.E.m±		
Genotypes (G)	0.028			0.108			0.115			0.152		
Treatments (T)	0.052			0.203			0.213			0.286		
Interaction (GxT)	0.072			0.283			0.300			0.403		
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)		
	0.080			0.310			0.330			0.440		
	0.150			0.590			0.620			0.830		
	0.210			0.820			0.870			1.170		

V1 : AMALAPURAM

V2: RAJAPURI

Whereas, during *kharif* 1999 a similar trend was followed and the application of CCC 1000 and 500 ppm recorded significantly higher SLW as compared to other growth regulator treatments and control at all the growth stages.

4.3.3.8 Specific Leaf Area (SLA, $\text{cm}^2 \text{mg}^{-1}$)

No significant differences were observed with respect to specific leaf area (SLA) due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 80). In general, the SLA decreased upto 150 DAS and increased thereafter. The SLA values were more during 1999 as compared to 1998 upto 150 DAS in both the genotypes.

During *kharif* 1998 the genotype Amalapuram recorded higher SLA as compared to Rajapuri at 90 and 180 DAS. No significant differences were observed with respect to growth regulator treatment and their interaction.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded higher SLA as compared to Rajapuri. No significant differences were observed with respect to growth regulator treatment and their interaction.

4.3.3.9 Leaf Area Ratio (LAR, $\text{cm}^2 \text{g}^{-1}$)

The data on leaf area ratio (LAR) indicated significant differences due to genotypes and non-significant differences due to growth regulator treatments and their interaction at all stages during both the years (Table 81). In general, the LAR showed a decreasing trend from 90 to 180 DAS in both the genotypes during both the years except at 150 DAS in Amalapuram during 1998. None of the growth regulator was found to influence the LAR significantly.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher LAR as compared to Amalapuram at 90 and 120 DAS and at 150 and 180 DAS Amalapuram recorded significantly higher LAR as compared to Rajapuri. No significant differences were observed with respect to growth regulator treatment and their interactions.

Table 80 : Effect of growth regulators on specific leaf area (SLA, $\text{cm}^2 \text{mg}^{-1}$) at different stages in turmeric genotypes (1998 and 1999)

Treatments	1998											
	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	0.184	0.175	0.180	0.127	0.148	0.137	0.113	0.118	0.116	0.204	0.138	0.171
CCC (1000 ppm)	0.175	0.164	0.170	0.121	0.139	0.130	0.108	0.115	0.111	0.196	0.130	0.163
Cytozyme (1000 ppm)	0.216	0.211	0.213	0.156	0.185	0.170	0.145	0.153	0.149	0.276	0.190	0.233
Cytozyme (2000 ppm)	0.214	0.210	0.212	0.155	0.184	0.169	0.144	0.156	0.150	0.273	0.189	0.231
Miraculan (1000 ppm)	0.216	0.212	0.214	0.157	0.185	0.171	0.146	0.152	0.149	0.276	0.191	0.234
Miraculan (2000 ppm)	0.215	0.214	0.214	0.155	0.187	0.171	0.144	0.156	0.150	0.274	0.192	0.233
Control (Water spray)	0.218	0.214	0.216	0.158	0.187	0.173	0.147	0.136	0.141	0.279	0.193	0.236
Mean	0.205	0.200		0.147	0.173		0.135	0.141		0.254	0.175	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.004	NS		0.006	NS		0.003	NS		0.004	NS	
Treatments (T)	0.007	NS		0.011	NS		0.006	NS		0.007	NS	
Interaction (GxT)	0.009	NS		0.016	NS		0.009	NS		0.010	NS	

Treatments	1999											
	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	0.198	0.190	0.194	0.138	0.161	0.149	0.116	0.124	0.120	0.180	0.134	0.157
CCC (1000 ppm)	0.191	0.179	0.185	0.132	0.154	0.143	0.112	0.119	0.116	0.172	0.128	0.150
Cytozyme (1000 ppm)	0.241	0.237	0.239	0.175	0.208	0.192	0.155	0.169	0.162	0.251	0.191	0.221
Cytozyme (2000 ppm)	0.257	0.236	0.246	0.175	0.208	0.191	0.155	0.169	0.162	0.251	0.190	0.221
Miraculan (1000 ppm)	0.241	0.236	0.239	0.175	0.208	0.191	0.155	0.169	0.162	0.251	0.191	0.221
Miraculan (2000 ppm)	0.241	0.236	0.239	0.175	0.208	0.191	0.155	0.169	0.162	0.251	0.190	0.221
Control (Water spray)	0.236	0.233	0.234	0.172	0.204	0.188	0.152	0.166	0.159	0.246	0.188	0.217
Mean	0.228	0.219		0.162	0.191		0.142	0.153		0.226	0.171	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.003	NS		0.005	NS		0.004	NS		0.006	NS	
Treatments (T)	0.006	NS		0.010	NS		0.007	NS		0.012	NS	
Interaction (GxT)	0.010	NS		0.015	NS		0.010	NS		0.017	NS	

V2: RAJAPURI

V1 : AMALAPURAM

Table 81: Effect of growth regulators on leaf area ratio (LAR, $\text{cm}^2 \text{g}^{-1}$) at different stages in turmeric genotypes (1998 and 1999)

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	83.06	93.49	88.27	46.92	54.11	50.51	47.74	46.75	47.24	23.26	20.90	22.08
CCC (1000 ppm)	79.11	88.24	83.67	44.74	51.27	48.01	45.54	43.60	44.57	22.39	19.72	21.06
Cytozyme (1000 ppm)	96.84	112.88	104.86	57.68	67.45	62.57	61.02	60.99	61.01	31.30	28.79	30.05
Cytozyme (2000 ppm)	96.10	112.23	104.16	57.26	67.47	62.37	60.57	60.67	60.62	31.07	28.64	29.86
Miraculan (1000 ppm)	97.33	113.36	105.35	57.97	68.13	63.05	61.34	61.27	61.30	31.46	28.92	30.19
Miraculan (2000 ppm)	96.80	113.81	105.31	57.66	68.37	63.01	60.98	61.49	61.24	31.28	29.04	30.16
Control (Water spray)	99.08	115.36	107.23	59.02	69.33	64.18	62.43	62.36	62.39	32.02	29.44	30.73
Mean	92.62	107.06		54.47	63.73		57.09	56.73		28.97	26.49	
For comparing	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)
Genotypes (G)	1.53	4.42	1.95	5.63	0.07	0.21	0.49	1.43				
Treatments (T)	2.86	NS	3.66	NS	0.13	NS	1.08	NS				
Interaction (GxT)	4.01	NS	3.14	NS	0.19	NS	1.31	NS				

Treatments	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	99.48	103.87	101.67	55.11	65.08	60.10	48.66	49.36	49.01	26.31	22.77	24.54
CCC (1000 ppm)	95.46	97.61	96.54	52.74	62.29	57.51	46.81	47.38	47.09	25.04	21.71	23.38
Cytozyme (1000 ppm)	120.65	129.09	124.87	69.86	84.11	76.99	64.81	67.13	65.97	36.50	32.39	34.44
Cytozyme (2000 ppm)	120.06	128.32	124.19	69.54	83.63	76.58	64.50	66.76	65.63	36.32	32.21	34.26
Miraculan (1000 ppm)	120.76	128.74	124.75	69.94	83.99	76.96	64.89	67.02	65.96	36.53	32.36	34.44
Miraculan (2000 ppm)	120.58	128.74	124.66	69.86	83.93	76.89	64.79	66.99	65.89	36.48	32.34	34.41
Control (Water spray)	118.22	126.82	122.52	68.48	82.67	75.58	63.52	65.98	64.75	35.77	31.84	33.80
Mean	112.83	119.40		64.51	77.17		59.08	60.77		32.86	28.96	
For comparing	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)	S.E.m $\pm$	C.D. (5%)
Genotypes (G)	1.88	5.42	2.07	5.95	0.53	1.53	0.77	2.23				
Treatments (T)	3.51	NS	3.85	NS	0.98	NS	1.44	NS				
Interaction (GxT)	4.91	NS	5.43	NS	1.39	NS	1.99	NS				

V1 : AMALAPURAM

V2: RAJAPURI

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher LAR as compared to Amalapuram at 90, 120 and 150 DAS and at 180 DAS Amalapuram recorded significantly higher LAR as compared to Rajapuri. No significant differences were observed with respect to growth regulator treatment and their interaction.

4.3.3.10 Leaf Weight Ratio (LWR, g, cm⁻²)

Leaf weight ratio (LWR) indicated significant differences due to genotypes and non-significant differences due to growth regulator treatments and their interaction at all stages during both the years (Table 82). In general, the LWR showed a decreasing trend in both the genotypes in both the years at all stages except at 150 DAS in Amalapuram during both the years and at 150 DAS in Rajapuri during the year 1998.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher LWR as compared to Amalapuram at 90 and 180 DAS and at 120 and 150 DAS Amalapuram recorded significantly higher LWR as compared to Rajapuri. No significant differences were observed with respect to growth regulator treatment and their interaction.

Whereas, during *kharif* 1999 the genotype Rajapuri recorded significantly higher LWR as compared to Amalapuram at 90, 120 and 180 DAS and at 150 DAS Amalapuram recorded significantly higher LWR as compared to Rajapuri. No significant differences were observed with respect to growth regulator treatment and their interaction.

4.3.3.11 Leaf Area Duration (LAD, days)

Significant differences were observed with respect to leaf area duration (LAD) due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 83). In general, the LAD increased upto 180 DAS in Amalapuram in both the years whereas, it decreased at 150-180 DAS in Rajapuri in both the years. During both the years at all the stages the LAD values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the LAD at all the growth stages.

Table 82: Effect of growth regulators on leaf weight ratio (LWR, g cm⁻²) at different stages in turmeric genotypes (1998 and 1999)

Treatments	1998											
	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	0.450	0.533	0.492	0.370	0.366	0.368	0.422	0.396	0.409	0.114	0.151	0.132
CCC (1000 ppm)	0.451	0.537	0.494	0.371	0.369	0.370	0.422	0.379	0.401	0.114	0.152	0.133
Cytozime (1000 ppm)	0.449	0.534	0.492	0.369	0.365	0.367	0.420	0.398	0.409	0.114	0.151	0.132
Cytozime (2000 ppm)	0.450	0.534	0.492	0.370	0.368	0.369	0.421	0.388	0.405	0.114	0.151	0.133
Miraculan (1000 ppm)	0.450	0.534	0.492	0.370	0.368	0.369	0.422	0.402	0.412	0.114	0.152	0.133
Miraculan (2000 ppm)	0.451	0.533	0.492	0.371	0.366	0.369	0.423	0.394	0.408	0.114	0.151	0.132
Control (Water spray)	0.454	0.538	0.496	0.373	0.370	0.372	0.425	0.458	0.442	0.115	0.153	0.134
Mean	0.451	0.535		0.370	0.368		0.422	0.402		0.114	0.152	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0240	0.0700		0.0003	0.0010		0.0069	0.0200		0.0100	0.0300	
Treatments (T)	0.0450	NS		0.0006	0.0018		0.0129	NS		0.0190	NS	
Interaction (GxT)	0.0640	NS		0.0008	0.0026		0.0182	NS		0.0270	NS	

Treatments	1999											
	Days after sowing											
	90			120			150			180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	0.502	0.545	0.524	0.400	0.404	0.402	0.419	0.397	0.408	0.146	0.170	0.158
CCC (1000 ppm)	0.501	0.546	0.523	0.399	0.405	0.402	0.417	0.398	0.407	0.145	0.170	0.158
Cytozime (1000 ppm)	0.501	0.545	0.523	0.399	0.404	0.402	0.417	0.397	0.407	0.146	0.170	0.158
Cytozime (2000 ppm)	0.468	0.543	0.505	0.397	0.403	0.400	0.415	0.396	0.406	0.145	0.169	0.157
Miraculan (1000 ppm)	0.501	0.545	0.523	0.399	0.404	0.402	0.417	0.397	0.407	0.145	0.170	0.158
Miraculan (2000 ppm)	0.501	0.545	0.523	0.399	0.404	0.401	0.417	0.397	0.407	0.145	0.170	0.158
Control (Water spray)	0.500	0.545	0.523	0.398	0.404	0.401	0.417	0.398	0.407	0.145	0.170	0.158
Mean	0.495	0.545		0.399	0.404		0.417	0.397		0.145	0.170	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.0020	0.0060		0.0010	0.0040		0.0010	0.0040		0.0030	0.0080	
Treatments (T)	0.0040	0.0120		0.0020	NS		0.0020	NS		0.0050	NS	
Interaction (GxT)	0.0050	0.0160		0.0030	NS		0.0030	NS		0.0070	NS	

V1: AMALAPURAM
V2: RAJAPURI

Table 83 : Effect of growth regulators on leaf area duration (LAD, days) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	35.82	25.83	30.82	49.68	34.40	42.04	51.08	30.48	40.78
CCC (1000 ppm)	35.29	25.53	30.41	48.99	33.74	41.37	50.56	29.82	40.19
Cytozyme (1000 ppm)	42.74	31.70	37.22	62.33	43.98	53.15	66.34	40.33	53.34
Cytozyme (2000 ppm)	43.51	32.32	37.91	63.44	44.83	54.14	67.53	41.13	54.33
Miraculan (1000 ppm)	42.55	31.48	37.01	62.05	43.67	52.86	66.05	40.05	53.05
Miraculan (2000 ppm)	43.36	32.26	37.81	63.22	44.75	53.98	67.29	41.05	54.17
Control (Water spray)	38.17	28.10	33.13	55.65	38.98	47.32	59.23	35.76	47.50
Mean	40.20	29.60		57.91	40.62		61.15	36.94	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.42	1.23		0.70	2.04		0.88	2.52	
Treatments (T)	0.79	2.31		1.32	3.84		1.63	4.73	
Interaction (GxT)	1.10	3.19		1.83	5.30		2.26	6.55	

1999

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	33.28	25.03	29.15	46.72	33.25	39.98	47.51	28.46	37.98
CCC (1000 ppm)	32.81	24.36	28.58	46.15	32.68	39.41	46.84	27.94	37.39
Cytozyme (1000 ppm)	40.98	31.58	36.28	60.63	43.96	52.30	63.78	39.01	51.39
Cytozyme (2000 ppm)	42.08	32.33	37.21	62.26	45.02	53.64	65.48	39.95	52.72
Miraculan (1000 ppm)	40.59	31.28	35.93	60.06	43.55	51.80	63.17	38.65	50.91
Miraculan (2000 ppm)	41.63	32.14	36.88	61.58	44.75	53.17	64.77	39.72	52.24
Control (Water spray)	35.48	27.13	31.30	52.50	37.77	45.13	55.22	33.52	44.37
Mean	38.56	29.45		56.23	40.53		58.59	35.62	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.48	1.40		1.15	3.31		0.95	2.73	
Treatments (T)	0.89	2.60		2.14	6.23		1.76	5.13	
Interaction (GxT)	1.24	3.60		3.02	8.77		2.46	7.09	

V1 : AMALAPURAM
V2: RAJAPURI

During *kharif* 1998 the genotype Amalapuram recorded significantly higher LAD as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of Cytozyme 2000 ppm was very effective and significantly increased the LAD followed by Miraculan 2000 ppm and Cytozyme 1000 ppm as compared to other growth regulator treatments and control at all the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The LAD was found lowest in Rajapuri with CCC 1000 ppm and this parameter was found highest in Amalapuram with Cytozyme 2000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher LAD as compared to Rajapuri. The treatments with Cytozyme 2000 ppm, Miraculan 2000 ppm and Cytozyme 1000 ppm recorded significantly higher values for LAD as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with CCC 1000 ppm treatment recorded lowest values while the highest values were found in Amalapuram with Cytozyme 2000 ppm.

4.3.3.12 Biomass duration (BMD, g days)

The data on biomass duration (BMD) revealed significant differences due to genotypes, growth regulator treatments and their interaction at all stages during both the years (Table 84). In general, the BMD increased upto 180 DAS. During both the years at all the stages the BMD values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the BMD at all the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher BMD as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the BMD followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at all the growth stages.

Table 84: Effect of growth regulators on biomass duration (BMD, g day⁻¹) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	1084	694	889	1885	1250	1567	2713	1657	2185
CCC (1000 ppm)	1120	726	923	1949	1306	1628	2806	1732	2269
Cytozyme (1000 ppm)	1079	694	886	1876	1248	1562	2702	1650	2176
Cytozyme (2000 ppm)	1107	709	908	1924	1276	1600	2770	1692	2231
Miraculan (1000 ppm)	1069	684	876	1859	1231	1545	2676	1632	2154
Miraculan (2000 ppm)	1095	698	896	1905	1257	1581	2742	1666	2204
Control (Water spray)	942	600	771	1638	1080	1359	2358	1431	1894
Mean	1071	686		1862	1235		2681	1637	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	16	55		26	75		39	113	
Treatments (T)	35	103		48	142		73	212	
Interaction (GxT)	49	143		68	197		101	293	

1999

Treatments	Days after sowing								
	90-120			120-150			150-180		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	853	578	716	1653	1088	1370	2325	1432	1879
CCC (1000 ppm)	878	593	736	1701	1116	1408	2393	1468	1930
Cytozyme (1000 ppm)	847	574	711	1640	1081	1360	2307	1422	1865
Cytozyme (2000 ppm)	874	592	733	1692	1113	1402	2380	1464	1922
Miraculan (1000 ppm)	838	570	704	1622	1072	1347	2283	1411	1847
Miraculan (2000 ppm)	860	586	723	1666	1102	1384	2344	1451	1897
Control (Water spray)	748	502	625	1449	945	1197	2038	1243	1641
Mean	858	582		1662	1095		2339	1441	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	10	30		15	46		20	60	
Treatments (T)	19	56		29	86		39	113	
Interaction (GxT)	26	78		42	122		57	157	

V1 : AMALAPURAM

V2: RAJAPURI

The interaction effects between genotypes and growth regulator treatments were found significant. The BMD was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher BMD as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for BMD as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment registered lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.4 BIOPHYSICAL PARAMETERS

4.3.4.1 Number of stomata on abaxial surface

The number of stomata on abaxial surface indicated significant differences due to genotypes, growth regulator treatments and their interaction 150 DAS during both the years (Table 85). During both the years at 150 DAS the number of stomata on abaxial surface was more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the number of stomata on abaxial surface at 150 DAS.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher number of stomata on abaxial surface as compared to Rajapuri at 150 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the number of stomata on abaxial surface followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The number of stomata on abaxial surface was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher number of stomata on abaxial surface as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.4.2 Number of stomata on adaxial surface

Significant differences were observed with respect to number of stomata on adaxial surface due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 85). During both the years at 150 DAS the number of stomata on adaxial surface was more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the number of stomata on adaxial surface at 150 DAS.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher number of stomata on adaxial surface as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the number of stomata on adaxial surface followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The number of stomata on adaxial surface was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher number of stomata on adaxial surface as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for number of stomata on

adaxial surface as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.4.3 Relative Water Content (RWC)

The data on relative water content (RWC) indicated significant differences due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 85). During both the years at 150 DAS the RWC values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the RWC at 150 DAS.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher RWC as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the RWC followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The RWC was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher RWC as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for RWC as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.4.4 Light transmission ratio (LTR)

The light transmission ratio (LTR) indicated significant differences due to genotypes, growth regulator treatments and their interaction 150 DAS during both the

Table 85 : Effect of growth regulators on stomatal number, relative water content and light transmission ratio at 150 DAS in turmeric genotypes (1998 and 1999)

1998

Treatments	Stomatal Number per mm ²						Relative water content			Light transmission ratio		
	Abaxial Surface			Adaxial Surface			RWC (%)			LTR (%)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	401	252	326.50	211	127	169.00	90.9	80.7	85.80	35.7	45.2	40.45
CCC (1000 ppm)	450	289	369.50	228	145	186.50	91.8	82.7	87.25	40.8	48.4	44.60
Cytozyme (1000 ppm)	490	249	369.50	200	125	162.50	90.7	80.5	85.60	35.4	42.8	39.10
Cytozyme (2000 ppm)	432	272	352.00	220	138	179.00	91.5	82.1	86.80	37.2	48.0	42.60
Miraculan (1000 ppm)	388	247	317.50	192	122	157.00	90.4	80.5	85.45	34.5	41.5	38.00
Miraculan (2000 ppm)	422	260	341.00	217	131	174.00	91.0	81.0	86.00	36.0	47.1	41.55
Control (Water spray)	385	245	315.00	190	120	155.00	90.0	80.0	85.00	34.0	41.2	37.60
Mean	424.00	259.14		208.29	129.71		90.90	81.07		36.23	44.89	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	1.56	4.50		1.14	3.30		0.22	0.64		0.58	1.66	
Treatments (T)	2.93	8.50		2.13	6.20		0.42	1.21		1.08	3.13	
Interaction (GxT)	4.03	11.70		2.96	8.60		0.57	1.66		1.49	4.32	

1999

Treatments	Stomatal Number per mm ²						Relative water content			Light transmission ratio		
	Abaxial Surface			Adaxial Surface			RWC (%)			LTR (%)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	372	243	307.50	173	112	142.50	83.5	77.4	80.45	37.2	48.2	42.70
CCC (1000 ppm)	407	271	339.00	194	127	160.50	89.1	81.1	85.10	40.4	51.5	45.95
Cytozyme (1000 ppm)	363	238	300.50	170	109	139.50	83.0	76.7	79.85	37.0	47.4	42.20
Cytozyme (2000 ppm)	395	258	326.50	188	121	154.50	87.4	80.2	83.80	39.2	50.0	44.60
Miraculan (1000 ppm)	352	232	292.00	166	109	137.50	82.8	74.2	78.50	36.9	46.8	41.85
Miraculan (2000 ppm)	380	250	315.00	180	116	148.00	85.4	79.5	82.45	38.6	49.1	43.85
Control (Water spray)	348	230	289.00	165	107	136.00	81.0	73.1	77.05	36.8	46.0	41.40
Mean	378.17	248.67		178.50	115.67		85.20	78.18		38.22	48.83	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	2.69	7.75		2.24	6.44		0.49	1.43		0.20	0.59	
Treatments (T)	4.98	14.50		4.14	12.10		0.92	2.68		0.38	1.12	
Interaction (GxT)	6.94	20.20		5.93	17.07		1.30	3.78		0.53	1.53	

V1 : AMALAPURAM V2: RAJAPURI

years (Table 85). During both the years 150 DAS the LTR were more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the LTR at 150 DAS.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher LTR as compared to Amalapuram at 150 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the LTR followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The LTR was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher LTR as compared to Amalapuram. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for LTR as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values while the highest values were found in Rajapuri with CCC 1000 ppm.

4.3.4.5 Photosynthetic rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ S}^{-1}$)

Significant differences were observed with respect to photosynthetic rate due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 86). During both the years at 150 DAS the photosynthetic rate was more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the photosynthetic rate at 150 DAS.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher photosynthetic rate as compared to Rajapuri at 150 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly

increased the photosynthetic rate followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The photosynthetic rate was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher photosynthetic rate as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.4.6 Stomatal conductance ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$)

The data on stomatal conductance revealed significant differences due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 86). During both the years at 150 DAS the stomatal conductance values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the stomatal conductance at 150 DAS.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher stomatal conductance as compared to Rajapuri at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the stomatal conductance followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The stomatal conductance was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher stomatal conductance as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.4.7 Transpiration rate ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$)

The transpiration rate indicated significant differences due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 86). During both the years at 150 DAS the transpiration rate was more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the transpiration rate at 150 DAS.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher transpiration rate as compared to Rajapuri at 150 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the transpiration rate followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The transpiration rate was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher transpiration rate as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

Table 86 : Effect of growth regulators on photosynthetic rate, stomatal conductance and transpiration rate at 150 DAS in turmeric genotypes (1998 and 1999)

Treatments	Photosynthetic rate			Stomatal Conductance			Transpiration Rate		
	$\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$			$\mu\text{mol m}^{-2} \text{ s}^{-1}$			$\text{m mol H}_2\text{O m}^{-2} \text{ s}^{-1}$		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	17.98	12.99	15.49	0.112	0.065	0.089	4.18	1.65	2.92
CCC (1000 ppm)	18.45	13.43	15.94	0.115	0.068	0.092	4.28	1.71	3.00
Cytozyme (1000 ppm)	17.83	12.88	15.36	0.111	0.065	0.088	4.14	1.64	2.89
Cytozyme (2000 ppm)	18.29	13.21	15.75	0.113	0.067	0.090	4.25	1.68	2.97
Miraculan (1000 ppm)	17.21	12.54	14.88	0.107	0.063	0.085	4.00	1.60	2.80
Miraculan (2000 ppm)	17.98	13.10	15.54	0.112	0.066	0.089	4.18	1.67	2.93
Control (Water spray)	15.50	11.10	13.30	0.096	0.055	0.076	3.60	1.41	2.51
Mean	17.61	12.75		0.109	0.064		4.09	1.62	
For comparing	S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)	
Genotypes (G)	0.26	0.76		0.001	0.004		0.06	0.17	
Treatments (T)	0.49	1.43		0.003	0.008		0.11	0.32	
Interaction (GxT)	0.68	1.98		0.003	0.010		0.15	0.44	

1999

Treatments	Photosynthetic rate			Stomatal Conductance			Transpiration Rate		
	$\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$			$\mu\text{mol m}^{-2} \text{ s}^{-1}$			$\text{m mol H}_2\text{O m}^{-2} \text{ s}^{-1}$		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	14.73	10.96	12.85	0.091	0.054	0.073	3.28	1.26	2.27
CCC (1000 ppm)	15.18	11.28	13.23	0.093	0.056	0.075	3.38	1.29	2.34
Cytozyme (1000 ppm)	14.59	10.87	12.73	0.090	0.054	0.072	3.25	1.25	2.25
Cytozyme (2000 ppm)	14.98	11.13	13.06	0.092	0.055	0.074	3.33	1.28	2.31
Miraculan (1000 ppm)	14.10	10.49	12.30	0.087	0.052	0.070	3.14	1.20	2.17
Miraculan (2000 ppm)	14.75	10.96	12.86	0.093	0.054	0.074	3.28	1.27	2.28
Control (Water spray)	12.80	9.42	11.11	0.078	0.046	0.062	2.85	1.08	1.97
Mean	14.72	10.95		0.091	0.054		3.28	1.26	
For comparing	S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)		S.E.m$\pm$	C.D. (5%)	
Genotypes (G)	0.23	0.65		0.002	0.005		0.04	0.11	
Treatments (T)	0.42	1.23		0.003	0.010		0.07	0.21	
Interaction (GxT)	0.59	1.72		0.005	0.013		0.01	0.29	

V1 : AMALAPURAM

V2: RAJAPURI

4.3.5.1 Chlorophyll 'a' content in leaf (mg g⁻¹ fr.wt.)

The data on Chlorophyll 'a' content in leaf revealed significant differences due to genotypes, growth regulator treatments and their interaction at 120 and 180 DAS during both the years (Table 87). In general, the Chlorophyll 'a' content decreased at 180 DAS. During both the years at both the stages the Chlorophyll 'a' content values were more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the Chlorophyll 'a' content at both growth stages.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher Chlorophyll 'a' content as compared to Amalapuram at both the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm and Cytozyme 2000 ppm was very effective and significantly increased the Chlorophyll 'a' content followed by Cytozyme 2000 ppm and Miraculan 1000 and 2000 ppm as compared to other growth regulator treatments and control at both the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The Chlorophyll 'a' content was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm at 120 DAS and at 180 DAS it was highest in Rajapuri with Cytozyme 2000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher Chlorophyll 'a' content as compared to Amalapuram. The treatments with Cytozyme 2000 ppm, Miraculan 2000 ppm and CCC 1000 ppm recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values while the highest values were found in Rajapuri with Miraculan 1000 ppm at 120 DAS and it was highest in Rajapuri with Cytozyme 2000 ppm at 180 DAS.

4.3.5.2 Chlorophyll 'b' content in leaf (mg g⁻¹ fr.wt.)

The chlorophyll 'b' content in leaf showed significant differences due to genotypes, growth regulator treatments and their interaction at 120 and 180 DAS during both the years (Table 87). In general, the Chlorophyll 'b' content decreased at 180 DAS. During *kharif* 1998, the values of Chlorophyll 'b' content were more in the genotype Rajapuri at both the stages whereas during *kharif* 1999 at 120 DAS the value of Chlorophyll 'b' content were more in Amalapuram and at 180 DAS it was more in Rajapuri. All the growth regulator treatments significantly increased the Chlorophyll 'b' content at both the stages.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher Chlorophyll 'b' content as compared to Amalapuram at both the growth stages. However, among the growth regulator treatments application of Cytozyme 2000 ppm was very effective and significantly increased the Chlorophyll 'b' content as compared to other growth regulator treatments and control at both the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The Chlorophyll 'b' content was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with Cytozyme 1000 ppm and also Amalapuram with Cytozyme 2000 ppm

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher Chlorophyll 'b' content as compared to Rajapuri at 120 DAS and at 180 DAS Rajapuri recorded highest Chlorophyll 'b' content compared to Amalapuram. The treatments with Cytozyme 2000 ppm recorded significantly higher values for Chlorophyll 'b' content as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values while the highest values were found in Amalapuram with Cytozyme 2000 ppm.

Table 87: Effect of growth regulators on chlorophyll a and b content (mg g^{-1} fr. wt.) at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Chlorophyll "a" content (mg g^{-1} fr. wt.)						Chlorophyll "b" content (mg g^{-1} fr. wt.)					
	120 DAS			180 DAS			120 DAS			180 DAS		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	1.10	1.24	1.17	0.87	1.04	0.96	0.54	0.59	0.57	0.26	0.32	0.29
CCC (1000 ppm)	1.21	1.40	1.31	0.85	1.21	1.03	0.50	0.58	0.54	0.31	0.38	0.35
Cytozyme (1000 ppm)	1.28	1.20	1.24	0.92	1.23	1.08	0.52	0.53	0.53	0.30	0.42	0.36
Cytozyme (2000 ppm)	1.12	1.22	1.17	0.86	1.34	1.10	0.48	0.60	0.54	0.42	0.36	0.39
Miraculan (1000 ppm)	1.34	1.28	1.31	0.98	1.10	1.04	0.49	0.44	0.47	0.35	0.39	0.37
Miraculan (2000 ppm)	1.08	1.35	1.22	0.95	1.20	1.08	0.56	0.58	0.57	0.36	0.31	0.34
Control (Water spray)	1.06	1.12	1.09	0.85	1.12	0.99	0.39	0.40	0.40	0.24	0.27	0.26
Mean	1.17	1.26		0.90	1.18		0.50	0.53		0.32	0.35	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.022	0.064		0.007	0.022		0.007	0.020		0.004	0.012	
Treatments (T)	0.041	0.120		0.014	0.041		0.013	0.038		0.007	0.023	
Interaction (GxT)	0.058	0.169		0.020	0.058		0.018	0.053		0.011	0.032	

1999

Treatments	Chlorophyll "a" content (mg g^{-1} fr. wt.)						Chlorophyll "b" content (mg g^{-1} fr. wt.)					
	120 DAS			180 DAS			120 DAS			180 DAS		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	1.00	1.21	1.11	0.86	1.02	0.94	0.45	0.46	0.46	0.22	0.26	0.24
CCC (1000 ppm)	1.10	1.35	1.23	0.84	1.19	1.02	0.43	0.45	0.44	0.24	0.33	0.29
Cytozyme (1000 ppm)	1.24	1.15	1.20	0.89	1.26	1.08	0.46	0.40	0.43	0.24	0.38	0.31
Cytozyme (2000 ppm)	1.08	1.18	1.13	0.78	1.30	1.04	0.50	0.48	0.49	0.36	0.31	0.34
Miraculan (1000 ppm)	1.30	1.20	1.25	0.91	1.08	1.00	0.39	0.32	0.36	0.30	0.34	0.32
Miraculan (2000 ppm)	1.06	1.28	1.17	0.92	1.19	1.06	0.48	0.46	0.47	0.30	0.26	0.28
Control (Water spray)	0.98	1.10	1.04	0.77	1.00	0.89	0.32	0.30	0.31	0.20	0.24	0.22
Mean	1.13	1.23		0.87	1.17		0.45	0.43		0.28	0.31	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.015	0.043		0.017	0.048		0.003	0.010		0.003	0.010	
Treatments (T)	0.027	0.080		0.030	0.090		0.007	0.020		0.007	0.020	
Interaction (GxT)	0.038	0.110		0.044	0.127		0.010	0.030		0.010	0.030	

V1 : AMALAPURAM

V2: RAJAPURI

DAS – Days after sowing

4.3.5.3 Chlorophyll a:b ratio

Significant differences were observed with respect to Chlorophyll a:b ratio due to genotypes, growth regulator treatments and their interaction at both 120 and 180 DAS during both the years (Table 88). In general, the Chlorophyll a:b ratio increased from 120 to 180 DAS. During both the years at all the stages the Chlorophyll a:b ratio was more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly decreased the Chlorophyll a:b ratio at both the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly lower Chlorophyll a:b ratio as compared to Rajapuri at both the growth stages. However, among the growth regulator treatments application of CCC 500 ppm was very effective and significantly decreased the Chlorophyll a:b ratio followed by Cytozyme 2000 ppm as compared to other growth regulator treatments and control at 120 DAS. At 180 DAS, Miraculan 1000 ppm and Cytozyme 2000 ppm decreased the chlorophyll a:b ratio. The interaction effects between genotypes and growth regulator treatments were found significant. The Chlorophyll a:b ratio was found lowest in Amalapuram with Miraculan 2000 ppm and this parameter was found highest in Rajapuri with water spray.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly lower Chlorophyll a:b ratio as compared to Rajapuri at both the growth stages. The treatments with Cytozyme 2000 ppm recorded significantly lower values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with Cytozyme 2000 ppm treatment recorded lowest values while the highest values were found in Rajapuri with Miraculan 2000 ppm.

4.3.5.4 Total Chlorophyll content in leaf (mg g⁻¹ fr.wt.)

The data on Total chlorophyll content in leaf indicated significant differences due to genotypes, growth regulator treatments and their interaction at both

Table 88: Effect of growth regulators on chlorophyll a:b ratio and total chlorophyll content at different stages in turmeric genotypes (1998 and 1999)

1998

Treatments	Chlorophyll a : b						Total Chlorophyll Content (mg g ⁻¹ fr. wt ⁻¹)					
	120 DAS			180 DAS			120 DAS			180 DAS		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2.04	2.10	2.07	3.35	3.25	3.30	1.64	1.83	1.74	1.13	1.36	1.25
CCC (1000 ppm)	2.42	2.41	2.42	2.74	3.18	2.96	1.71	1.98	1.85	1.16	1.59	1.38
Cytozyme (1000 ppm)	2.46	2.26	2.36	3.07	2.93	3.00	1.80	1.73	1.77	1.12	1.65	1.39
Cytozyme (2000 ppm)	2.33	2.03	2.18	2.05	3.72	2.89	1.60	1.82	1.71	1.28	1.70	1.49
Miraculan (1000 ppm)	2.73	2.91	2.82	2.80	2.82	2.81	1.83	1.72	1.78	1.33	1.49	1.41
Miraculan (2000 ppm)	1.93	2.33	2.13	2.64	3.87	3.26	1.64	1.91	1.78	1.31	1.51	1.41
Control (Water spray)	2.72	2.80	2.76	3.54	4.15	3.85	1.45	1.52	1.49	1.09	1.39	1.24
Mean	2.38	2.41		2.88	3.42		1.67	1.79		1.20	1.53	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.006	0.020		0.063	0.160		0.034	0.100		0.020	0.060	
Treatments (T)	0.013	0.038		0.082	0.340		0.065	0.190		0.040	0.110	
Interaction (GxT)	0.018	0.053		0.165	0.480		0.076	0.270		0.050	0.160	

1999

Treatments	Chlorophyll a : b						Total Chlorophyll Content (mg g ⁻¹ fr. wt ⁻¹)					
	120 DAS			180 DAS			120 DAS			180 DAS		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2.22	2.72	2.47	3.91	3.92	3.92	1.45	1.67	1.56	1.08	1.28	1.18
CCC (1000 ppm)	2.56	3.00	2.78	3.50	3.61	3.56	1.53	1.80	1.67	1.08	1.52	1.30
Cytozyme (1000 ppm)	2.70	2.88	2.79	3.71	3.32	3.52	1.70	1.55	1.63	1.13	1.64	1.39
Cytozyme (2000 ppm)	2.16	2.46	2.31	2.17	4.19	3.18	1.58	1.66	1.62	1.14	1.61	1.38
Miraculan (1000 ppm)	3.33	3.75	3.54	3.03	3.18	3.11	1.69	1.52	1.61	1.21	1.42	1.32
Miraculan (2000 ppm)	2.21	1.78	2.00	3.07	4.58	3.83	1.54	1.74	1.64	1.22	1.45	1.34
Control (Water spray)	3.06	3.67	3.37	3.85	4.17	4.01	1.32	1.40	1.36	0.97	1.24	1.11
Mean	2.53	2.77		3.23	3.80		1.58	1.66		1.14	1.49	
For comparing	S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)		S.E.m $\pm$	C.D. (5%)	
Genotypes (G)	0.045	0.130		0.097	0.280		0.010	0.030		0.010	0.110	
Treatments (T)	0.082	0.240		0.182	0.530		0.020	0.060		0.072	0.210	
Interaction (GxT)	0.117	0.340		0.255	0.740		0.230	0.080		0.100	0.290	

V1 : AMALAPURAM

V2: RAJAPURI

DAS -- Days after sowing

120 and 180 DAS during both the years (Table 88). In general, the total chlorophyll content decreased at 180 DAS. During both the years at both the stages the total chlorophyll content values were more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the Total chlorophyll content at both the growth stages.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher total chlorophyll content as compared to Amalapuram at both the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm and Miraculan 1000 ppm and Miraculan 2000 ppm significantly increased the total chlorophyll content as compared to other growth regulator treatments and control at both the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The total chlorophyll content was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher total chlorophyll content as compared to Amalapuram at both growth stages. The treatments with Cytozyme 1000 and 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values while the highest values were found in Rajapuri with Cytozyme 1000 ppm.

4.3.5.5 Nitrate reductase activity (NRA, μ mol NO_2 g^{-1} fr.wt.hr $^{-1}$)

The data on nitrate reductase activity (NRA) indicated significant differences due to genotypes, growth regulator treatments and their interaction at both 150 and 180 DAS during both the years (Table 89). In general, the NRA increased at 150 DAS and decreased thereafter. During both the years at both the stages the NRA values were more in the genotype Amalapuram as compared to Rajapuri. All the growth regulator treatments significantly increased the NRA at both the growth stages.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher NRA as compared to Rajapuri at both the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the NRA followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at both the growth stages. The interaction effects between genotypes and growth regulator treatments were found significant. The NRA was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher NRA as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.5.6 Reducing sugars (mg g^{-1} dry wt.)

Significant differences were observed with respect to reducing sugars due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 89). During both the years at 150 DAS the reducing sugars were more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the reducing sugars at 150 DAS.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher reducing sugars as compared to Amalapuram at 150 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the reducing sugars followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found

significant. The reducing sugars was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher reducing sugars as compared to Amalapuram. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values while the highest values were found in Rajapuri with CCC 1000 ppm.

4.3.5.7 Non-reducing sugars (mg g^{-1} dry wt⁻¹)

The data on non-reducing sugars indicated significant differences due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 89). During both the years at both the stages the non-reducing sugars values were more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the non-reducing sugars at 150 DAS.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher non-reducing sugars as compared to Amalapuram at 150 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the non-reducing sugars followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The non-reducing sugars was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher non-reducing sugars as compared to Amalapuram. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm

registered significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values while the highest values were found in Rajapuri with CCC 1000 ppm.

4.3.5.8 Total sugars (mg g^{-1} dry wt)

The total sugars indicated significant differences due to genotypes, growth regulator treatments and their interaction at 150 DAS during both the years (Table 89). During both the years at 150 DAS the total sugars were more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the total sugars at 150 DAS.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher total sugars as compared to Amalapuram at 150 DAS. However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the total sugars followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control at 150 DAS. The interaction effects between genotypes and growth regulator treatments were found significant. The total sugars was found lowest in Amalapuram with water spray and this parameter was found highest in Rajapuri with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri recorded significantly higher total sugars as compared to Amalapuram. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for total sugars as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values while the highest values were found in Rajapuri with CCC 1000 ppm.

Table 89: Effect of growth regulators on nitrate reductase activity (NRA), reducing, non-reducing and total sugars at different stages in turmeric genotypes (1998 and 1999)

Treatments	1998													
	Nitrate reductase activity				Reducing sugars				Non-reducing sugars					
	μ moles g ⁻¹ fr. wt. hr ⁻¹				mg g ⁻¹ dry wt				mg g ⁻¹ dry wt					
	180 DAS				150 DAS				150 DAS					
	V1	V2	Mean		V1	V2	Mean		V1	V2	Mean			
CCCC (500 ppm)	371	271	321		139	127	133		48	54	51.1			
CCCC (1000 ppm)	407	308	358		156	145	151		53	62	57.2			
Cytozyme (1000 ppm)	362	264	313		134	122	128		47	53	49.6			
Cytozyme (2000 ppm)	392	295	344		147	138	143		51	59	55.3			
Miraculan (1000 ppm)	350	262	306		134	120	127		45	52	48.6			
Miraculan (2000 ppm)	380	280	330		141	132	137		50	57	53.4			
Control (Water spray)	348	261	305		130	119	125		44	51	47.3			
Mean	372.86	277.29		140.14	129.00			48.20	55.36			302.71		
For comparing	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			C.D. (5%)	
Genotypes (G)	2.40			1.91			0.60			3.40			1.90	
Treatments (T)	4.47			3.55			0.89			6.32			3.56	
Interaction (GxT)	6.31			5.03			1.58			8.79			5.01	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	6.91			5.50			1.73			9.80			5.48	
	13.00			10.34			3.26			18.40			10.32	
	18.30			14.58			4.58			25.50			14.52	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
Mean	336.667	240.667		115.833	91.333			41.417	50.383			274.833	298.67	
For comparing	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
Genotypes (G)	1.90			0.98			0.85			1.26			1.35	
Treatments (T)	3.54			1.82			1.58			2.34			2.51	
Interaction (GxT)	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	
	1.90			0.98			0.85			1.26			1.35	
	3.54			1.82			1.58			2.34			2.51	
	4.98			2.57			2.23			3.30			3.54	
	C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)			C.D. (5%)	
	5.48			2.82			2.45			3.63			3.88	
	10.30			5.30			4.60			6.80			7.30	
	14.52			7.48			6.49			9.59			10.30	
	S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$			S.E.m $\pm$	

4.3.6.1 Fresh rhizome yield (g plant⁻¹)

The data on fresh rhizome yield revealed significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 90). During both the years the genotype Amalapuram recorded higher values for this trait. All the growth regulator treatments significantly increased the fresh rhizome yield.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher fresh rhizome yield (685 g plant⁻¹) as compared to Rajapuri (447 g plant⁻¹). However, among the treatments application of CCC 1000 ppm was very effective and significantly increased the fresh rhizome yield (595.9 g plant⁻¹) followed by Cytozyme 2000 ppm (588.2 g plant⁻¹) and Miraculan 2000 ppm (579.8 g plant⁻¹) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The fresh rhizome yield was found lowest in Rajapuri with water spray (387.9 g plant⁻¹) and this parameter was found highest in Amalapuram with CCC 1000 ppm (719.8 g plant⁻¹).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher fresh rhizome yield (572.1 g plant⁻¹) as compared to Rajapuri (390.7 g plant⁻¹). The treatments with CCC 1000 ppm (505.8 g plant⁻¹), Cytozyme 2000 ppm (499.2 g plant⁻¹) and Miraculan 2000 ppm (491.6 g plant⁻¹) recorded significantly higher values for fresh rhizome yield as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment registered lowest values (343.0 g plant⁻¹) while the highest values were found in Amalapuram with CCC 1000 ppm (601.1 g plant⁻¹).

4.3.6.2 Fresh rhizome yield (t ha⁻¹)

The fresh rhizome yield indicated significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 90).

During both the years the genotype Amalapuram recorded higher values for this trait. All the growth regulator treatments significantly increased the fresh rhizome yield.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher fresh rhizome yield (38.1 t ha^{-1}) as compared to Rajapuri (24.9 t ha^{-1}). However, among the treatments application of CCC 1000 ppm was very effective and significantly increased the fresh rhizome yield (33.1 t ha^{-1}) followed by Cytozyme 2000 ppm (32.7 t ha^{-1}) and Miraculan 2000 ppm (32.3 t ha^{-1}) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The fresh rhizome yield was found lowest in Rajapuri with water spray (21.6 t ha^{-1}) and this parameter was found highest in Amalapuram with CCC 1000 ppm (40.0 t ha^{-1}).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher fresh rhizome yield (31.8 t ha^{-1}) as compared to Rajapuri (21.7 t ha^{-1}). The treatments with CCC 1000 ppm (22.8 t ha^{-1}), Cytozyme 2000 ppm (27.8 t ha^{-1}) and Miraculan 2000 ppm (27.4 t ha^{-1}) registered significantly higher values for fresh rhizome yield as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values while the highest values were found in Amalapuram with CCC 1000 ppm (33.4 t ha^{-1}).

4.3.6.3 Cured rhizome yield (g plant^{-1})

Significant differences were observed with respect to cured rhizome yield due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 90). During both the years the genotype Amalapuram registered higher values for this trait. All the growth regulator treatments significantly increased the cured rhizome yield.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher cured rhizome yield ($159.8 \text{ g plant}^{-1}$) as compared to Rajapuri ($95.0 \text{ g plant}^{-1}$). However,

among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the cured rhizome yield ($135.2 \text{ g plant}^{-1}$) followed by Cytozyme 2000 ppm ($133.2 \text{ g plant}^{-1}$) and Miraculan 2000 ppm ($130.6 \text{ g plant}^{-1}$) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The cured rhizome yield was found lowest in Rajapuri with water spray ($81.5 \text{ g plant}^{-1}$) and this parameter was found highest in Amalapuram with CCC 1000 ppm ($169.3 \text{ g plant}^{-1}$).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher cured rhizome yield ($130.9 \text{ g plant}^{-1}$) as compared to Rajapuri ($79.1 \text{ g plant}^{-1}$). The treatments with CCC 1000 ppm ($111.5 \text{ g plant}^{-1}$), Cytozyme 2000 ppm ($109.2 \text{ g plant}^{-1}$) and Miraculan 2000 ppm ($108.1 \text{ g plant}^{-1}$) registered significantly higher values for cured rhizome yield as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment registered lowest values ($66.5 \text{ g plant}^{-1}$) while the highest values were found in Amalapuram with CCC 1000 ppm ($138.3 \text{ g plant}^{-1}$).

4.3.6.4 Cured rhizome yield (t ha^{-1})

The data on cured rhizome yield (t ha^{-1}) indicated significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 90). During both the years the genotype Amalapuram registered higher values for this trait. All the growth regulator treatments significantly increased the cured rhizome yield (t ha^{-1}).

During *kharif* 1998 the genotype Amalapuram recorded significantly higher cured rhizome yield (8.88 t ha^{-1}) as compared to Rajapuri (5.28 t ha^{-1}). However, among the treatments application of CCC 1000 ppm was very effective and significantly increased the cured rhizome yield (7.52 t ha^{-1}) followed by cytozyme 2000 ppm (7.41 t ha^{-1}) and miracular 2000 ppm (7.26 t ha^{-1}) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator

Table 90: Effect of growth regulators on fresh and cured rhizome yield at harvest in turmeric genotypes (1998 and 1999)

Treatments	Fresh rhizome yield (g plant ⁻¹)			Fresh rhizome yield (t ha ⁻¹)			Cured rhizome yield (g plant ⁻¹)			Cured rhizome yield (t ha ⁻¹)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
CCC (500 ppm)	698.7	454.7	576.7	38.80	25.30	32.05	162.8	96.8	129.8	9.05	5.38	7.22
CCC (1000 ppm)	719.8	472.0	595.9	40.00	26.20	33.10	169.3	101.0	135.2	9.41	5.62	7.52
Cytosyme (1000 ppm)	695.2	450.4	572.8	38.70	25.00	31.85	161.8	95.3	128.6	9.00	5.30	7.15
Cytosyme (2000 ppm)	711.3	465.1	588.2	39.50	25.90	32.70	167.0	99.3	133.2	9.29	5.52	7.41
Miraculan (1000 ppm)	668.1	438.8	553.5	37.10	24.40	30.75	154.7	93.0	123.9	8.60	5.17	6.89
Miraculan (2000 ppm)	699.8	459.7	579.8	38.90	25.60	32.25	163.1	98.0	130.6	9.07	5.45	7.26
Control (Water spray)	601.8	387.9	494.9	33.50	21.60	27.55	139.6	81.5	110.6	7.76	4.53	6.15
Mean	685.0	446.9		38.07	24.86		159.8	95.0		8.88	5.28	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	2.72	7.83		0.31	0.88		1.03	2.96		0.05	0.15	
Treatments (T)	5.05	14.72		0.57	1.65		1.90	5.56		0.10	0.28	
Interaction (GxT)	7.02	20.35		2.76	8.03		2.72	7.84		0.13	0.39	

Treatments	Fresh rhizome yield (g plant ⁻¹)			Fresh rhizome yield (t ha ⁻¹)			Cured rhizome yield (g plant ⁻¹)			Cured rhizome yield (t ha ⁻¹)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
CCC (500 ppm)	583.3	398.9	491.1	32.40	22.20	27.30	133.3	81.8	107.6	7.41	4.55	5.98
CCC (1000 ppm)	601.1	410.6	505.9	33.40	22.80	28.10	138.3	84.6	111.5	7.69	4.56	6.13
Cytosyme (1000 ppm)	578.4	395.8	487.1	32.20	22.00	27.10	132.2	80.8	106.5	7.35	4.49	5.92
Cytosyme (2000 ppm)	592.9	405.4	499.2	33.00	22.50	27.75	135.8	82.5	109.2	7.55	4.70	6.13
Miraculan (1000 ppm)	558.5	381.9	470.2	31.10	21.20	26.15	127.3	75.6	101.5	7.08	4.20	5.64
Miraculan (2000 ppm)	583.8	399.3	491.6	32.50	22.20	27.35	133.6	82.5	108.1	7.43	4.59	6.01
Control (Water spray)	506.8	343.0	424.9	28.20	19.10	23.65	115.6	66.5	91.1	6.43	3.70	5.07
Mean	583.0	398.7		32.43	22.15		133.4	81.3		7.42	4.52	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	6.70	19.30		0.48	1.39		1.41	4.06		0.15	0.43	
Treatments (T)	12.47	36.30		0.90	2.62		2.62	7.63		0.28	0.81	
Interaction (GxT)	17.62	51.10		12.65	3.68		3.71	10.80		0.39	1.14	

V1 : AMALAPURAM

V2: RAJAPURI

treatments were found significant. The cured rhizome yield was found lowest in Rajapuri with water spray (4.53 t ha^{-1}) and this parameter was found highest in Amalapuram with CCC 1000 ppm (9.41 t ha^{-1}).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher cured rhizome yield (7.28 t ha^{-1}) as compared to Rajapuri (4.40 t ha^{-1}). The treatments with CCC 1000 ppm (6.13 t ha^{-1}), cytozyme 2000 ppm (6.13 t ha^{-1}) and Miraculan 2000 ppm (6.01 t ha^{-1}) recorded significantly higher values for cured rhizome yield (t ha^{-1}) as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values (3.70 t ha^{-1}) while the highest values were found in Amalapuram with CCC 1000 ppm (7.69 t ha^{-1}).

4.3.6.5 Number of mother rhizomes per plant

Significant differences were observed with respect to number of mother rhizomes per plant during 98 and due to genotypes, growth regulator treatments and their interaction effects during 99 (Table 91). During both the years the genotype Amalapuram recorded higher values for this trait.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher number of mother rhizome per plant (2.63) as compared to Rajapuri (2.44). However, among the treatments application of CCC 1000 ppm was very effective and increased the number of mother rhizome per plant (2.80) followed by cytozyme 2000 ppm (2.60) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found non-significant. The number of mother rhizome per plant was found lowest in Rajapuri with Miraculan (2.40) and this parameter was found highest in Amalapuram with CCC 1000 ppm (2.80).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher number of mother rhizome per plant (2.49) as compared to Rajapuri (2.13). The treatments with CCC 1000 ppm (2.8), cytozyme

2000 ppm (2.7) and Miraculan 2000 ppm (2.5) registered significantly higher values for number of mother rhizome per plant as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values (2.0) while the highest values were found in Rajapuri with CCC 1000 ppm (3.0).

4.3.6.6 Number of primary fingers per plant

The data on number of primary fingers per plant indicated significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 91). During both the years the genotype Amalapuram registered higher values for this trait. All the growth regulator treatments significantly increased the number of primary fingers per plant.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher number of primary finger per plant (13.03) as compared to Rajapuri (9.23). However, among the treatments application of CCC 1000 ppm was very effective and significantly increased the number of primary fingers per plant (11.6) and as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The number of primary fingers per plant was found lowest in Rajapuri with Miraculan (8.9) and this parameter was found highest in Amalapuram with CCC 1000 ppm (13.4).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher number of primary fingers per plant (11.07) as compared to Rajapuri (8.15). The treatments with CCC 1000 ppm recorded significantly higher values (10.6) for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values (7.40) while the highest values were found in Amalapuram with CCC 1000 ppm (12.2).



G₁ = CCC 500 ppm

G₂ = CCC 1000 ppm

G₃ = Cytozyme 1000 ppm

G₄ = Cytozyme 2000 ppm

G₅ = Miraculan 1000 ppm

G₆ = Miraculan 2000 ppm

PLATE 5. INFLUENCE OF GROWTH REGULATORS ON RHIZOME CHARACTERS IN TURMERIC

4.3.6.7 Number of secondary fingers per plant

The number of secondary fingers per plant indicated significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 91). During the year 1998 the genotype Rajapuri and during 1999 the genotype Amalapuram recorded higher values for this trait. All the growth regulator treatments significantly increased the number of secondary fingers per plant.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher number of secondary finger per plant (10.01) as compared to Amalapuram (8.55). However, among the treatments application of CCC 1000 ppm was very effective and significantly increased the number of secondary fingers per plant (9.66) followed by cytozyme 2000 ppm (9.40) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The number of secondary fingers per plant was found lowest in Amalapuram with water spray (8.55) and this parameter was found highest in Rajapuri with CCC 1000 ppm (10.7).

Whereas, during *kharif* 1999 the genotype Amalapuram recorded significantly higher number of secondary fingers per plant (12.75) as compared to Rajapuri (10.53). The treatments with CCC 1000 ppm (16.2), cytozyme 2000 ppm (14.7) and Miraculan 2000 ppm (12.65) registered significantly higher values (10.6) for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri (7.20) with water spray treatment showed lowest values (7.20) while the highest values were found in Amalapuram with CCC 1000 ppm (16.3).

4.3.6.8 Length of primary finger (cm)

Significant differences were observed with respect to length of primary fingers due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 91). During both the years the genotype Amalapuram recorded

Table 91 : Effect of growth regulators on rhizome and finger characters at harvest in turmeric genotypes (1998 and 1999)

Treatments	Number of mother Rhizomes			Number of primary fingers			Number of secondary fingers			Length of primary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2.6	2.4	2.50	12.9	9.2	11.05	8.5	9.9	9.22	10.5	9.3	9.90
CCC (1000 ppm)	2.8	2.7	2.75	13.4	9.8	11.60	8.6	10.7	9.66	11.6	10.5	11.05
Cytosyme (1000 ppm)	2.6	2.4	2.50	13.0	9.0	11.00	8.6	9.8	9.18	10.2	9.3	9.75
Cytosyme (2000 ppm)	2.7	2.5	2.60	13.1	9.5	11.30	8.6	10.2	9.40	11.2	9.7	10.45
Miraculan (1000 ppm)	2.6	2.3	2.45	13.0	8.9	10.95	8.5	9.8	9.17	10.1	9.2	9.65
Miraculan (2000 ppm)	2.6	2.4	2.50	13.0	9.3	11.15	8.5	10.0	9.27	11.0	9.6	10.30
Control (Water spray)	2.5	2.4	2.45	12.8	8.9	10.85	8.5	9.7	9.11	10.1	8.2	9.15
Mean	2.63	2.44		13.03	9.23		8.55	10.01		10.67	9.40	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.06	0.18		0.07	0.21		0.04	0.11		0.21	0.60	
Treatments (T)	0.12	NS		0.14	0.40		0.08	0.22		0.38	1.12	
Interaction (GxT)	0.16	NS		0.19	0.56		0.10	0.29		0.55	1.59	

Treatments	Number of mother Rhizomes			Number of primary fingers			Number of secondary fingers			Length of primary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	2.5	2.3	2.40	11.5	8.1	9.80	12.5	9.5	11.00	10.0	9.4	9.68
CCC (1000 ppm)	2.6	3.0	2.80	12.2	9.0	10.62	16.3	16.0	16.15	11.4	9.8	10.62
Cytosyme (1000 ppm)	2.5	2.2	2.35	10.0	7.8	8.89	12.3	8.4	10.35	9.1	8.9	9.00
Cytosyme (2000 ppm)	2.5	2.8	2.65	12.0	8.7	10.37	15.8	13.6	14.70	10.6	9.7	10.13
Miraculan (1000 ppm)	2.6	2.1	2.35	10.0	7.5	8.74	10.0	8.0	9.00	9.1	8.6	8.86
Miraculan (2000 ppm)	2.4	2.6	2.50	11.9	8.6	10.25	14.3	11.0	12.65	10.5	9.5	9.99
Control (Water spray)	2.3	2.0	2.15	9.9	7.4	8.63	8.1	7.2	7.63	9.0	8.5	8.75
Mean	2.52	2.50		11.27	8.28		13.53	11.08		10.11	9.31	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.03	0.08		0.08	0.22		0.28	0.82		0.04	0.12	
Treatments (T)	0.05	0.15		0.14	0.42		0.53	1.55		0.08	0.22	
Interaction (GxT)	0.07	0.21		0.20	0.58		0.73	2.13		0.11	0.31	

V1 : AMALAPURAM

V2: RAJAPURI

higher values for this trait. All the growth regulator treatments significantly increased the length of primary finger.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher length of primary finger (10.53 cm) as compared to Rajapuri (9.40). However, among the treatments application of CCC 1000 ppm was very effective and increased the length of primary finger (11.1 cm) followed by cytozyme 2000 ppm (10.5 cm) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The length of primary finger was found lowest in Rajapuri with water spray (8.2 cm) and this parameter was found highest in Amalapuram with CCC 1000 ppm (11.6 cm).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher length of primary finger (9.95 cm) as compared to Rajapuri (9.20 cm). The treatments with CCC 1000 ppm (10.6 cm), cytozyme 2000 ppm (10.1 cm) and Miraculan 2000 ppm (9.99) recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values (8.50 cm) while the highest values were found in Rajapuri with CCC 1000 ppm (11.40 cm).

4.3.6.9 Length of secondary finger (cm)

The data on length of secondary fingers revealed significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 92). During both the years the genotype Amalapuram registered higher values for this trait. All the growth regulator treatments significantly increased the length of secondary fingers.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher length of secondary fingers as compared to Rajapuri. However, among the treatments application of CCC 1000 ppm and cytozyme 2000 ppm (5.13 cm) was very effective and

significantly increased the length of secondary fingers followed by Miraculan 2000 ppm (5.2 cm) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The length of secondary fingers was found lowest in Rajapuri with water spray (4.8 cm) and this parameter was found highest in Amalapuram with CCC 1000 ppm (5.7 cm).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher length of secondary fingers as compared to Rajapuri (5.64 cm). The treatments with CCC 1000 ppm (6.8 cm), Cytozyme 2000 ppm (6.5 cm) and Miraculan 2000 ppm (6.2 cm) registered significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment showed lowest values (3.50 cm) while the highest values were found in Rajapuri with CCC 1000 ppm (7.0 cm).

4.3.6.10 Circumference of mother rhizome (cm)

The circumference of mother rhizome revealed significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 92). During both the years the genotype Amalapuram registered higher values for this trait. All the growth regulator treatments significantly increased the circumference of mother rhizome.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher circumference of mother rhizome (13.21 cm) as compared to Rajapuri (12.42 cm). However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the circumference of mother rhizome (13.5 cm) followed by Cytozyme 2000 ppm (13.2 cm) and Miraculan 2000 ppm (12.9 cm) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The circumference of mother rhizome was found lowest in Rajapuri with Miraculan 1000

ppm and with water spray (12.0 cm) and this parameter was found highest in Amalapuram with CCC 1000 ppm (13.9 cm).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher circumference of mother rhizome (11.99 cm) as compared to Rajapuri (10.96 cm). The treatments with CCC 1000 ppm (12.4 cm), Cytozyme 2000 ppm (11.8 cm) and Miraculan 2000 ppm (11.5 cm) recorded significantly higher values for circumference of mother rhizome as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values (10.3 cm) while the highest values were found in Amalapuram with CCC 1000 ppm (13.2 cm).

4.3.6.11 Circumference of primary finger (cm)

Significant difference were observed with respect to circumference of primary finger due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 92). During both the years the genotype Amalapuram recorded higher values for this trait. All the growth regulator treatments significantly increased the circumference of primary finger.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher circumference of primary finger (8.17 cm) as compared to Rajapuri (7.40 cm). However, among the growth regulator treatments application of CCC 1000 ppm and cytozyme 2000 ppm very effective and significantly increased the circumference of primary finger (8.19 cm each) followed by CCC 500 ppm (7.89 cm) and Miraculan 2000 ppm (7.87 cm) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The circumference of primary finger was found lowest in Rajapuri with water spray (6.00 cm) and this parameter was found highest in Amalapuram with CCC 1000 ppm and Miraculan 1000 ppm (8.0 cm each).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher circumference of primary finger as compared to Rajapuri (7.31 cm). The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm registered significantly higher values for circumference of primary finger as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri (6.00 cm) with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm (8.5 cm).

4.3.6.12 Circumference of secondary finger (cm)

The data on circumference of secondary finger indicated significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 92). During the year 1998 the genotype Amalapuram and during the year 1999 Rajapuri registered higher values for this trait. All the growth regulator treatments significantly increased the circumference of secondary finger.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher circumference of secondary finger (6.21 cm) as compared to Rajapuri (5.30 cm). However, among the growth regulator treatments application of CCC 1000 ppm was very effective and significantly increased the circumference of secondary finger (6.2 cm) followed by Cytozyme 2000 ppm and Miraculan 2000 ppm (5.9 cm each) and CCC 500 ppm (5.8 cm) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The circumference of secondary finger was found lowest in Rajapuri with water spray (5.0 cm) and this parameter was found highest in Amalapuram with CCC 1000 ppm (6.5 cm).

Whereas, during *kharif* 1999 the genotype Rajapuri recorded significantly higher circumference of secondary finger (6.51 cm) as compared to Amalapuram (6.23 cm). The treatments with CCC 1000 ppm (7.2 cm), Cytozyme 2000 ppm (7.0 cm)

Table 92 : Effect of growth regulators on rhizome and finger characters at harvest in turmeric genotypes (1998 and 1999)

Treatments	Length of secondary finger (cm)			Circumference of mother Rhizome (cm)			Circumference of primary finger(cm)			Circumference of secondary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
CCC (500 ppm)	5.1	5.0	5.05	13.00	12.40	12.70	8.2	7.6	7.89	6.2	5.3	5.75
CCC (1000 ppm)	5.7	5.5	5.60	13.90	13.00	13.45	8.5	7.9	8.19	6.5	5.8	6.15
Cytosyme (1000 ppm)	5.1	5.0	5.05	13.10	12.20	12.65	8.0	7.5	7.76	6.0	5.1	5.55
Cytosyme (2000 ppm)	5.6	5.5	5.55	13.50	12.90	13.20	8.5	7.9	8.19	6.4	5.4	5.90
Miraculan (1000 ppm)	5.0	4.9	4.95	13.00	12.00	12.50	8.0	7.4	7.70	6.1	5.1	5.60
Miraculan (2000 ppm)	5.2	5.2	5.20	13.20	12.50	12.85	8.2	7.5	7.87	6.4	5.4	5.90
Control (Water spray)	5.0	4.8	4.90	12.80	12.00	12.40	7.8	6.0	6.90	5.9	5.0	5.45
Mean	5.24	5.13		13.21	12.43		8.17	7.40		6.21	5.30	
For comparing Genotypes (G)	0.04			0.06			0.03			0.04		
Treatments (T)	0.07			0.11			0.05			0.07		
Interaction (GxT)	0.10			0.15			0.07			0.10		

1999

Treatments	Length of secondary finger (cm)			Circumference of mother Rhizome (cm)			Circumference of primary finger(cm)			Circumference of secondary finger (cm)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
CCC (500 ppm)	6.0	6.0	6.00	11.80	11.00	11.40	7.9	6.9	7.40	6.4	6.9	6.65
CCC (1000 ppm)	6.5	7.0	6.75	13.20	11.50	12.35	8.5	8.5	8.50	6.9	7.5	7.20
Cytosyme (1000 ppm)	5.5	5.4	5.45	11.80	10.80	11.30	7.8	6.9	7.35	6.2	6.5	6.35
Cytosyme (2000 ppm)	6.5	6.5	6.50	12.00	11.50	11.75	8.0	8.5	8.25	6.7	7.3	7.00
Miraculan (1000 ppm)	5.0	4.9	4.95	11.60	10.60	11.10	7.5	7.1	7.30	5.8	5.7	5.75
Miraculan (2000 ppm)	6.2	6.2	6.20	12.00	11.00	11.50	7.9	7.3	7.60	6.6	7.0	6.80
Control (Water spray)	4.6	3.5	4.05	11.50	10.30	10.90	7.4	6.0	6.70	5.0	4.7	4.85
Mean	5.95	6.00		12.07	11.07		7.93	7.53		6.43	6.82	
For comparing Genotypes (G)	0.04			0.11			0.10			0.10		
Treatments (T)	0.07			0.21			0.19			0.35		
Interaction (GxT)	0.09			0.30			0.26			0.50		

V1 : AMALAPURAM

V2: RAJAPURI

and Miraculan 2000 ppm (6.8 cm) recorded significantly higher values for circumference of secondary finger as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values (4.7 cm) while the highest values were found in Rajapuri with CCC 1000 ppm (7.5 cm).

4.3.6.13 Curing per cent

The curing percentage indicated significant differences due to genotypes during both the years (Table 93). During both the years the genotype Amalapuram recorded higher values for this trait. No significant difference were observed with respect to growth regulator treatments.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher curing per cent (23.32%) as compared to Rajapuri (21.24%). However, among the treatments application of CCC 1000 ppm was very effective and increased the curing per cent (22.46%) followed by cytozyme 2000 ppm (22.42%) and Miraculan 2000 ppm (22.31%) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found non-significant. The curing per cent was found lowest in Rajapuri with water spray (21.00%) and this parameter was found highest in Amalapuram with CCC 1000 ppm (23.52%).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher curing per cent (22.87%) as compared to Rajapuri (20.23%). The treatments with CCC 1000 ppm (21.50%), cytozyme 2000 ppm (21.88%) and Miraculan 2000 ppm (21.77%) recorded higher values for curing per cent as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment registered lowest values (19.40%) while the highest values were found in Amalapuram with CCC 1000 ppm (23.00%).

4.3.6.14 Total dry matter (g plant⁻¹)

The data on total dry matter indicated significant differences due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 93). During both the years the genotype Amalapuram recorded higher values for this trait. All the growth regulator treatments significantly increased the total dry matter at harvest.

During *kharif* 1998 the genotype Amalapuram recorded significantly higher total dry matter at harvest as compared to Rajapuri. However, among the treatments application of CCC 1000 ppm was very effective and significantly increased the total dry matter at harvest followed by Cytozyme 2000 ppm and Miraculan 2000 ppm as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The total dry matter at harvest was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher total dry matter at harvest as compared to Rajapuri. The treatments with CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm recorded significantly higher values for total dry matter at harvest as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with CCC 1000 ppm.

4.3.6.15 Harvest Index (%)

Significant differences were observed with respect to harvest index due to genotypes, growth regulator treatments and their interaction effects during both the years (Table 93). During both the years the genotype Amalapuram recorded higher values for this trait. All the growth regulator treatments significantly increased the harvest index.

Table 93 : Effect of growth regulators on curing per cent, total dry matter content (g plant⁻¹), harvest index (%) and curcumin content at harvest in turmeric genotypes (1998 and 1999)

1998

Treatments	Curing percent			TDM at harvest (g plant ⁻¹)			Harvest index (%)			Curcumin content		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	23.30	21.28	22.29	178.3	107.8	143.1	91.3	89.8	90.6	3.36	3.42	3.39
CCC (1000 ppm)	23.52	21.40	22.46	195.0	120.2	157.6	86.8	84.0	85.4	3.69	3.87	3.78
Cytozyme (1000 ppm)	23.28	21.16	22.22	173.2	104.6	138.9	93.4	91.1	92.3	3.23	3.37	3.30
Cytozyme (2000 ppm)	23.48	21.35	22.42	189.2	115.3	152.3	88.3	86.1	87.2	3.58	3.72	3.65
Miraculan (1000 ppm)	23.16	21.20	22.18	167.4	99.7	133.6	92.4	93.3	92.8	3.20	3.33	3.27
Miraculan (2000 ppm)	23.30	21.32	22.31	184.7	111.9	148.3	88.3	87.6	87.9	3.45	3.60	3.53
Control (Water spray)	23.20	21.00	22.10	165.2	98.5	131.9	84.5	82.7	83.6	3.15	3.28	3.22
Mean	23.32	21.24		179.0	108.3		89.3	87.8		3.38	3.51	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.392	1.130		0.038	0.110		1.880	5.440		0.390	1.130	
Treatments (T)	0.725	NS		0.072	0.210		3.520	10.230		0.730	2.120	
Interaction (GxT)	1.010	NS		0.100	0.290		4.960	14.420		1.030	2.990	

1999

Treatments	Curing percent			TDM at harvest (g plant ⁻¹)			Harvest index (%)			Curcumin content		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
CCC (500 ppm)	22.86	20.50	21.68	147.0	90.1	118.6	90.7	90.8	90.7	3.25	3.30	3.28
CCC (1000 ppm)	23.00	20.84	21.92	160.2	98.7	129.5	86.3	85.7	86.0	3.36	3.63	3.50
Cytozyme (1000 ppm)	22.85	20.42	21.64	142.8	87.8	115.3	92.6	92.0	92.3	3.18	3.25	3.22
Cytozyme (2000 ppm)	22.90	20.86	21.88	155.5	95.9	125.7	87.3	86.0	86.7	3.30	3.51	3.41
Miraculan (1000 ppm)	22.80	19.80	21.30	137.7	84.3	111.0	92.4	89.7	91.1	3.10	3.21	3.16
Miraculan (2000 ppm)	22.88	20.65	21.77	151.6	93.2	122.4	88.1	88.5	88.3	3.28	3.42	3.35
Control (Water spray)	22.80	19.40	21.10	136.0	83.5	109.8	85.0	79.6	82.3	3.00	3.20	3.10
Mean	22.88	20.51		149.1	91.7		89.6	88.8		3.25	3.39	
For comparing	S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)		S.E.m±	C.D. (5%)	
Genotypes (G)	0.420	1.210		0.030	0.090		1.350	3.880		0.420	1.210	
Treatments (T)	0.770	NS		0.050	0.160		2.510	7.310		0.780	2.270	
Interaction (GxT)	1.110	3.210		0.080	0.230		3.530	10.280		1.110	3.210	

V1 : AMALAPURAM

V2: RAJAPURI

During *kharif* 1998 the genotype Amalapuram recorded significantly higher harvest index as compared to Rajapuri. However, among the treatments application of Miraculan 1000 ppm was very effective and significantly increased the harvest index followed by Cytozyme 1000 ppm and CCC 500 ppm as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator treatments were found significant. The harvest index was found lowest in Rajapuri with water spray and this parameter was found highest in Amalapuram with CCC 1000 ppm.

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Amalapuram recorded significantly higher harvest index as compared to Rajapuri. The treatments with cytozyme 1000 ppm, Miraculan 2000 ppm and CCC 500 ppm recorded significantly higher values for this trait as compared to other treatments. The interaction effects were found significant and the treatment combination of Rajapuri with water spray treatment recorded lowest values while the highest values were found in Amalapuram with cytozyme 1000 ppm.

4.2.6.16 Curcumin content

The curcumin content in rhizome revealed significant differences due to genotypes, growth regulator treatments and their interaction during both the years (Table 93). During both the years the curcumin content was more in the genotype Rajapuri as compared to Amalapuram. All the growth regulator treatments significantly increased the curcumin content.

During *kharif* 1998 the genotype Rajapuri recorded significantly higher curcumin content (3.51) as compared to Amalapuram (3.38) at all the growth stages. However, among the growth regulator treatments application of CCC 1000 ppm (3.78) was very effective and significantly increased the curcumin content followed by Cytozyme 2000 ppm (3.65) and Miraculan 2000 ppm (3.53) as compared to other growth regulator treatments and control. The interaction effects between genotypes and growth regulator

Table 94: Effect of plant growth regulators on B: C ratio in turmeric genotypes (pooled)

Treatments	Dry rhizome yield (t/ha)	Gross returns (Rs./ha)	Cost of treatment (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B:C ratio
V₁ (Amalapuram)						
T ₁ - CCC @ 500 ppm	8.23	1,48,140	3,750	23,870	1,24,270	1:5.21
T ₂ - CCC @ 1000 ppm	8.56	1,54,080	7,350	27,470	1,26,610	1:4.61
T ₃ - Cytozyme @ 1000 ppm	8.18	1,47,240	390	20,510	1,26,730	1:6.18
T ₄ - Cytozyme @ 2000 ppm	8.42	1,51,560	630	20,750	1,30,810	1:6.30
T ₅ - Miraculan @ 1000 ppm	7.84	1,41,120	285	20,405	1,20,715	1:5.92
T ₆ - Miraculan @ 2000 ppm	8.25	1,48,500	420	20,540	1,27,960	1:6.23
T ₇ - Control	7.10	1,27,800	-	20,120	1,07,680	-
V₂ (Rajapuri)						
T ₁ - CCC @ 500 ppm	4.97	89,460	3750	23,870	65,590	1:2.75
T ₂ - CCC @ 1000 ppm	5.09	91,620	7350	27,470	64,150	1:2.34
T ₃ - Cytozyme @ 1000 ppm	4.90	88,200	390	20,510	67,690	1:3.30
T ₄ - Cytozyme @ 2000 ppm	5.11	91,980	630	20,750	71,230	1:3.43
T ₅ - Miraculan @ 1000 ppm	4.69	84,420	285	20,405	64,015	1:3.14
T ₆ - Miraculan @ 2000 ppm	5.02	90,360	420	20,540	69,820	1:3.39
T ₇ - Control	4.12	74,160	-	20,120	54,040	-

Cost of cultivation = Rs.20,120/ha
 Market price of dry rhizome = Rs.18,000/t
 Cost of growth regulators
 1) CCC = Rs.300/25 g
 2) Cytozyme = Rs.400/lit
 3) Miraculan = Rs.225/lit

treatments were found significant. The curcumin content was found lowest in Amalapuram with water spray (3.15) and this parameter was found highest in Rajapuri with CCC 1000 ppm (3.87).

Whereas, during *kharif* 1999 a similar trend was followed and the genotype Rajapuri (3.35) recorded significantly higher curcumin content as compared to Amalapuram (3.21). The treatments with CCC 1000 ppm (3.50), Cytozyme 2000 ppm (3.41) and Miraculan 2000 ppm (3.35) recorded significantly higher values for curcumin content as compared to other treatments. The interaction effects were found significant and the treatment combination of Amalapuram with water spray treatment recorded lowest values (3.00) while the highest values were found in Rajapuri with CCC 1000 ppm (3.63).

4.3.7 ECONOMICS

The data on the economics of growth regulators presented in Table 94 indicated that among the various treatments application of cytozyme @ 2000 ppm at 60 and 120 DAS in Amalapuram recorded the higher Benefit cost ratio of 6.30 followed by Miraculan @ 2000 ppm (6.23) and cytozyme @ 1000 ppm (6.18). A similar trend was observed in Rajapuri wherein the B:C ratio was found highest with cytozyme @ 2000 ppm (3.43) followed by Miraculan @ 2000 ppm (3.39) and Cytozyme @ 1000 ppm (3.30).

Discussion

V DISCUSSION

An understanding of the physiological changes that have occurred in cultivar development in the past would be helpful in the continued production of high yielding cultivars of various crop species.

Plant growth and development is a complex process and two classes of mechanisms that can influence and regulate the developmental pattern of a plant have been well recognized. The first is a system of endogenous chemical messengers, called hormones, that co-ordinate the development of individual organs as well as the plant as a whole. The second class of mechanism is comprised of extrinsic factors, such as light, water, temperature and gravity which originate outside the organism and convey the information about the environment. Thus, the final pattern of development and behaviour of each individual plant is the result of complex interplay between genetic, hormonal and environmental factors.

Although India is leading in turmeric production the average productivity and quality are not satisfactory and this limit to our export to about 10-15 per cent of our production. This suggests the immediate need to improve the productivity and quality of turmeric through physiological means (Anon., 2000).

In light of this, the present investigation was undertaken to study the physiological basis of yield variation in elite turmeric genotypes and the response of turmeric genotypes to the application of growth regulators and micronutrients on morpho-physiological traits, biochemical and biophysical parameters, yield and quality attributes.

5.1 EXPERIMENT I: PHYSIOLOGICAL BASIS OF YIELD VARIATION IN TURMERIC GENOTYPES

Crop growth and yield are under the control of genes which are modulated by their continuous interaction with the environment. It was observed that the crop

performance with respect to morphological, physiological, biophysical, yield attributes and quality parameters were better during *kharif* 1998 as compared to *kharif* 1999. Such a differential behaviour was attributed to favourable environmental conditions particularly with respect to total rainfall and its distribution pattern during *kharif* 1998. During *kharif* 1998, the amount of rainfall received was 486.62 mm and was well distributed from July to November. Whereas, during *kharif* 1999, the total rainfall from July to November was 403.50 mm with erratic distribution pattern and there was moisture stress during the months of August and September which affected the crop growth and development and finally lead to decreased yield levels as compared to *kharif* 1998.

5.1.1 MORPHOLOGICAL CHARACTERS

It was observed that in general, the expression of most of the morphological characters was better during *kharif* 1998 as compared to *kharif* 1999.

The present study indicated that at all the stages of crop growth, different cultivars varied significantly in respect of plant height, number of leaves per plant and number of tillers per plant. Several research workers have shown significant variation in plant among different turmeric genotypes (Indiresh *et al.*, 1990, Radakrishan *et al.*, 1995 and Hegde *et al.*, 1997). The present study indicated that the plant height increased from 60-180 DAS during both the years. The high yielding genotypes Amalapuram and Cuddapah maintained relatively higher plant height at all the stages while, the low yielding genotype BSR-1 recorded significantly lower plant height at all the stages. Thus from the data it appears that height is one of the important parameters which influences yield potential in turmeric. Plant height and number of tillers are influenced by the interaction between the environmental variables and genetic make up of the plant (Evans, 1975).

The present studies also indicated that the number of tillers differed significantly among the genotypes during both the years and number of tillers increased upto 150 DAS and decreased thereafter. In general, the low yielding genotype Rajapuri

recorded significantly higher number of tillers while, high yielding genotypes Amalapuram and Cuddapah possessed significantly lower values. This suggests that there is negative correlation between number of tillers and yield potential in turmeric and this parameter is genetically controlled. Reddy *et al.* (1989) and Cholke (1993) also observed significant differences in tiller production among the genotypes with the cv. Rajapuri producing maximum number of tillers. Further, the correlation study revealed a significant negative correlation between number of tillers and yield during both the years.

Leaf is considered as an important functional unit of plant which contributes to the formation of yield. Reddy *et al.* (1988) indicated that the number of leaves had a positive and strong association with rhizome yield at both genotypic and phenotypic levels in turmeric. The present study indicated that the genotypes differed significantly for number of leaves during both the years and the number of leaves increased upto 150 DAS and declined thereafter which may be attributed to senescence and shading of leaves. It is evident that, the high yielding genotypes Amalapuram, Bidar-4 and Cuddaph possessed significantly higher number of leaves at all the stages while, the low yielding genotypes BSR-1 and Rajapuri had significantly lower number of leaves. This clearly indicates that the higher number of leaves is very essential for increasing productivity potential in turmeric.

Further, the correlation studies also indicated a significant positive association between number of leaves and rhizome yield during both the years. Similarly, several research workers have also indicated a significant variation in number of leaves among turmeric genotypes and have also shown positive association of this parameter with yield (Jalagaonkar *et al.*, 1988; Indiresk *et al.*, 1990; Radhakrishnan *et al.*, 1995 and Hegde *et al.*, 1997).

5.1.2 DRY MATTER PRODUCTION AND ITS PARTITIONING

Total dry matter production is the integral of crop growth rate over the entire growing period and is related to yield, harvest index, assimilatory surface area, leaf

area duration and other growth attributes (Yoshida, 1972). Although, the dry matter production in general, is indicative of the efficiency of the genotypes, the pattern in which it is distributed in different plant parts would give a better understanding of the genotype (Bhoite, 2000). For instance, if the leaf dry matter is more, it is evident that photosynthetic system is efficient.

It was observed in the present study that the leaf dry weight increased upto 150 DAS and decreased thereafter due to senescence, leaf drying and shedding. Leaf dry weight was significantly higher in Amalapuram, Bidar-4 and Cuddapah at all the stages during both the years and these genotypes also recorded significantly higher rhizome yield. Whereas, the low yielding genotypes BSR-1 and Rajapuri had significantly lower values for leaf dry matter at all the stages. Further, the correlation studies also indicated a significant positive correlation between leaf dry matter and rhizome yield indicating the importance of this parameter in yield determination. Similarly, Subramanian *et al.* (1988) and Sivaraman and Palaniappan (1995) also indicated significant variation for leaf dry matter production among the turmeric genotypes and showed a positive association of leaf dry matter with rhizome yield.

The present study revealed that the stem dry weight increased upto 150 DAS and decreased thereafter due to the translocation of reserve food material towards rhizome development. The stem dry weight differed significantly among the genotypes during both the years. At 150 DAS, during both the years the stem dry weight was significantly higher in BSR-1, CO-1 and Rajapuri. The data also suggested that there was no definite correlation between stem dry weight and rhizome yield. Cholke (1993) and Mannikeri (1996) also found significant variation for stem dry weight among the genotypes.

The high yielding genotypes viz., Amalapuram, Bidar-4 and Cuddapah possessed significantly higher rhizome dry weight at all the stages during both the years and the low yielding genotypes BSR-1 and Rajapuri possessed significantly lower values.

Further, the correlation studies also indicated a significant positive association between rhizome dry weight at different stages and final rhizome yield. Similarly, several research workers have also indicated significant differences among the genotypes for rhizome dry weight at different stages and also showed a significant positive association with final rhizome yield (Cholke, 1993 and Mannikeri, 1996).

The total dry matter production (TDM) is an indication of the overall efficiency of the utilization of resources and better light interception. The present study revealed that the TDM increased from 60 DAS to harvest. It is interesting to note that, the high yielding genotypes viz., Amalapuram, Bidar-4 and Cuddapah possessed significantly higher TDM at all the stages during both the years. Further, the low yielding genotypes BSR-1 and Rajapuri maintained significantly lower TDM at all the stages. This clearly showed that TDM is an important criteria in the determination of yield potential in turmeric. The correlation values between TDM at various stages and rhizome yield was also found positive and significant. Similarly, Cholke (1993) and Mannikeri (1996) also observed a positive association between TDM and rhizome yield.

5.1.3 GROWTH PARAMETERS

It is well established that the plant infrastructure is decided by the growth parameters such as leaf area, leaf index (LAI), leaf area duration (LAD), crop growth rate (CGR), relative growth rate (RGR), absolute growth rate (AGR), net assimilation rate (NAR), specific leaf weight (SLW), specific leaf area (SLA), leaf weight ratio (LWR), leaf area ratio (LAR) and biomass duration (BMD). The growth analysis technique has been adopted as one of the standard approaches in the absence of sophisticated instruments to analyse the structure of grain yield. The concept not only involves the final crop yield and its components but also probes into the physiological events that have occurred during different growth stages causing variation in yield potential.

Leaf area fairly gives a good idea of the photosynthetic capacity of the plant. In general, leaf area increased upto 150 DAS and decreased thereafter which was

due to ageing and senescence of leaves. The present studies indicated significant differences among the genotypes for leaf area during both the years and the high yielding genotypes viz., Amalapuram, Bidar-4 and Cuddapah possessed significantly higher leaf area at the all the stages and the low yielding genotypes BSR-1 and Rajapuri recorded significantly lower leaf area. Further, the correlation values between leaf area and rhizome yield were found to be positive and significant during both the years. Cholke (1993) and Mannikeri (1996) also indicated a significant positive association between leaf area and rhizome yield.

Another parameter which is determined by the leaf area index of two consecutive growth stages is leaf area duration (LAD). Leaf area duration indicates total amount of green leaf area present over a period of time and is an important growth parameter which influence the crop productivity. It has been observed in the present study that the LAI and LAD increased with the crop age, attaining the peak at 150 DAS and decreasing thereafter with crop age thereby indicating a decline in the capacity of the plant to produce and maintain assimilates. Both these parameters were significantly higher in the genotypes, Amalapuram, Bidar-4 and Cuddapah while, the genotypes BSR-1 and Rajapuri possessed significantly lower values at all the stages during both the years. This data clearly indicated the importance of these parameters in the determination of yield.

The correlation of these parameters with rhizome yield was positive and highly significant. Hence, more attention has to be given for these parameters for increasing yield potential in turmeric. Similarly, Sivaraman and Palaniappan (1995), Mannikeri (1996) and Hegde *et al.* (1997) also indicated a wide genotypic variability for LAI and LAD among the turmeric genotypes and also showed a positive correlation of rhizome yield with LAI and LAD. Further, Chetti and Sirohi (1995) also indicated that, LAD is an useful parameter not only in depicting the efficiency of photosynthetic system but also in showing a linear relationship with dry matter accumulation.

It is very difficult to account for yield variation in terms of growth and development, since it involves the effect of both intrinsic and extrinsic factors on all the physiological processes of plant. Various empirical relationships such as CGR, RGR, NAR, SLW, SLA, LWR and LAR describe the connections between the end point of a long chain of interdependent processes in the environment and the plant (Watson, 1952).

Absolute growth rate (AGR) and crop growth rate (CGR) are important growth parameters which influence the productivity of crop plants. Crop growth rate is influenced by LAI, leaf photosynthetic rate and leaf angle and is an index of the light intercepted. The average daily increment of stand biomass is an important characteristic and is called either the rate of dry matter production or crop growth rate (Watson, 1952). It is a widely used character for estimating production efficiency of crop stand and enables to make comparisons between the aspects of study. Present studies indicated that, the AGR and CGR increased upto 150 DAS and decreased thereafter. The high yielding genotypes viz., Amalapuram, Bidar-4 and Cuddapah possessed significantly higher values for AGR and CGR during both the years. The low yielding genotypes viz., BSR-1 and Rajapuri recorded significantly lower values. This suggests that these parameters are very important in the determination of yield potential. During *kharif* 1998 the correlation studies indicated a significant positive association of rhizome yield with AGR and CGR (60-90 and 150-150 DAS). Whereas, during *kharif* 1999, the relationship was found positive and significant at 90-120 DAS and 120-150 DAS. Similarly, Subramanian *et al.* (1988), Cholke (1993), Sivaraman and Palaniappan (1995) and Mannikeri (1996) also indicated significant differences among the turmeric genotypes and showed a positive association between rhizome yield and CGR.

Relative growth rate (RGR) is an important physiological parameter which reflects the ability of the plants to produce dry matter per unit dry matter already existing. Present studies indicated that, RGR was maximum at 60-90 DAS and decreased with age of the crop. The high yielding genotypes Amalapuram, Bidar-4 and Cuddapah showed

significantly higher values for RGR (150-180 DAS) during both the years. Further, the correlation between RGR (150-180 DAS) and rhizome yield was positive and significant during *kharif* 1998. Mannikeri (1996) also indicated that in turmeric, the RGR values decreased with the advancement of crop growth and also showed significant differences among the genotypes.

Net assimilation rate (NAR) refers to the capacity of green leaves to produce the dry matter and it depends on leaf area and the rate of photosynthesis. NAR was maximum during 120-150 DAS and decreased thereafter due to mutual shading in the canopy and senescence of leaves. In the present study also a wide genotypic variations were observed for NAR at all the stages during both the years. The genotypes Amalapuram, Cuddapah and Bidar-4 possessed significantly higher NAR during 150-180 DAS. The correlation between NAR (120-150 DAS) and rhizome yield was found positive and significant during *kharif* 1999. Cholke (1993), Venkatesh (1994), Shivaraman and Palaniappan (1995) and Mannikeri (1996) also indicated wide genotypic variability for NAR among the turmeric genotypes.

The leaf weight ratio (LWR) indicates the ratio of leaf dry matter to the total dry matter and it decreased after 120 DAS. Cholke (1993) also indicated that in turmeric, the LWR was more during early stages and decreased towards maturity due to reduced contribution of leaf dry matter towards total dry matter. The present study indicated significant differences for LWR and no definite correlation was found between LWR and rhizome yield.

Leaf area ratio (LAR) is an indicator of photosynthetic capacity per unit of respiring and growing tissue (Wallace *et al.*, 1972). The present study indicated significant differences among the genotypes for LAR and the genotype Amalapuram recorded significantly higher LAR at 180 DAS during both the years, while, Cuddapah possessed significantly lower values. The LAR decreased with age of the crop.

The correlation between LAR (90, 120 DAS) and rhizome yield was negative and significant during *kharif* 1998. Cholke (1993) and Mannikeri (1996) also found a wide variation in LAR among the turmeric genotypes.

The Biomass duration (BMD) is essential for prolonged supply of photosynthates to the developing sinks. In the present study, a progressive increase of BMD was observed upto 180 DAS. The present study also indicated that the high yielding genotypes, Amalapuram, Bidar-4 and Cuddapah possessed significantly higher BMD at all the growth stages during both the years. This clearly shows the importance of BMD in yield determination. The low yielding genotype had significantly lower values for BMD. Further, the correlation studies indicated a significant positive association between BMD and rhizome yield during both the years. Venkatesh (1994) also showed significant differences for BMD in turmeric genotypes.

5.1.4 BIOPHYSICAL PARAMETERS

The arrangement and the frequency of the stomata vary widely among the species and within the species. The resistance to diffusion of CO₂ and water vapour between the leaf and the atmosphere is a function of stomatal frequency and degree of opening. A change in stomatal resistance has a greater effect on transpiration than on photosynthesis, because it constitutes a relatively larger proportion of the total resistance to water vapour diffusion than to CO₂ diffusion (Gaastra, 1959). Moreover, the stomata being one of the controlling factors in photosynthesis and transpiration, the stomatal frequency differences among cultivars could be related to varietal differences in gas exchange which inturn, might constitute a worthy objective to improve yield (Chia and Brun, 1975). In addition to stomatal conductance, stomatal frequency also plays an important role in determining the leaf conductance and transpiration rate.

The number and distribution of stomata on leaves gives an indication about the rate of transpiration, photosynthetic efficiency and productivity of crops. Genotypes differed significantly for stomatal number (Abaxial and adaxial). In the present

investigation, the number of stomata were more on abaxial leaf surface as compared to adaxial leaf surface and these results are in agreement with the reports of Dornhoff and Shibles (1970) in soybean and Devendra (1986) in greengram. The present studies also indicated that the high yielding genotypes viz., Amalapuram, Bidar-4 and Cuddapah possessed significantly higher number of stomata (Abaxial and adaxial) while, the low yielding genotype Rajapuri had less number of stomata.

The correlation studies further showed a significant positive correlation between stomatal number (Abaxial) with rhizome yield during *kharif* 1998. Goswami (2000) also indicated a positive association between number of stomata (abaxial and adaxial) and seed yield in greengram.

Relative water content (RWC) is an important physiological parameter associated with maintenance of leaf turgidity. The RWC values were significantly more in high yielding genotypes (Amalapuram, Bidar-4 and Cuddapah) while the low yielding genotype Rajapuri recorded significantly lower values. The correlation studies also showed a significant positive association between RWC and rhizome yield during both the years. This suggests that maintenance of higher RWC is an important aspect in improving yield potential in turmeric.

Light transmission ratio (LTR) is an indicator of the amount of light distribution within the crop canopy. LTR depends on leaf orientation and LAI. The low yielding genotypes viz., BSR-1, Rajapuri and CO-1 showed significantly higher values for LTR while high yielding genotype Amalapuram recorded significantly lower values for LTR. A significant negative correlation was also found between LTR and rhizome yield.

Photosynthesis is the primary process which forms the basis for yield determination. Single leaf photosynthesis is the basis for dry matter production, which in turn determine the yield. However, under field conditions, the crop growth rate is dependent on total canopy photosynthesis rather than the photosynthetic rate per unit area. The high yielding genotypes Amalapuram, Bidar-4 and Cuddapah had the higher

photosynthetic rate during both the years. The low yielding genotype BSR-1 had significantly lower values for photosynthetic rate. The correlation studies also indicated a significant positive association between photosynthetic rate and rhizome yield during both the years. This clearly indicates that for improving yield potential in turmeric it is necessary to select the genotypes with higher photosynthetic rate. Goswami (2000) also found a significant positive correlation between photosynthetic rate and seed yield in greengram.

Significant variation was also observed with respect to stomatal conductance and the rate of transpiration among the genotypes. Like the photosynthetic rate, stomatal conductance and transpiration rate were significantly higher in high yielding genotypes (Amalapuram, Bidar-4 and Cuddapah) during both the years. The low yielding genotype BSR-1 recorded significantly lower values for these traits. Venkateshwarlu and Balsubramanian (1993) also observed significant variations with respect to stomatal conductance and transpiration rate among the greengram genotypes. The correlation studies also revealed a significant positive association of these parameters with rhizome yield and thus indicated the importance of these two parameters in yield determination.

5.1.5 BIOCHEMICAL PARAMETERS

Crop yield is mainly dependent on the interplay of various physiological and biochemical functions of the plants in addition to the impact of the environment. The cause and effect relationship is necessary to understand the interplay of several processes and functions affecting crop yield.

The data on chlorophyll 'a', 'b', a:b ratio and total chlorophyll content varied significantly among the genotypes. In general, the chlorophyll 'a', 'b' and total chlorophyll contents were more during *kharif* 1998 as compared to *kharif* 1999. The chlorophyll contents (a, b, total) were found to be more at 90 DAS and declined at later stages (180 DAS). The genotypes Cuddapah, Bidar-4 and BSR-1 recorded significantly higher values for chlorophyll 'a', 'b' and total chlorophyll contents at 90 DAS during both

the years. Whereas, the genotypes Rajapuri, Bidar-4 and Amalapuram possessed significantly higher values for chlorophyll 'a', 'b' and total chlorophyll content at 180 DAS during both the years. The chlorophyll 'a' and total chlorophyll contents were significantly less in Rajapuri (at 90 DAS) and in BSR-1 (at 180 DAS). The ratio of chlorophyll a:b was more at 180 DAS as compared to 90 DAS and the genotypes differed significantly for this trait. Watnable and Yoshida (1970) indicated that higher chlorophyll content is one of the important factors responsible for better yields. However, Janardhan (1977) opined that higher chlorophyll content may not necessarily bear a strong relationship with photosynthetic rate under normal conditions. The present data indicated that, high yielding genotypes maintained relatively higher chlorophyll 'a' and total chlorophyll content. Hence, it is inferred that, these components may play an important role for higher photosynthetic rate in turmeric and further help in improving productivity.

The activity of nitrate reductase is dependent on several variables such as light, temperature, nutrition, water availability and plant age. The present study indicated significant differences in nitrate reductase activity among the genotypes during both the years. The NR activity was more at 150 DAS and declined thereafter. In general, the NR activity was more in high yielding genotypes (Bidar-4, Amalapuram and Cuddapah) at 150 DAS and 180 DAS during both the years. The genotypes BSR-1 and Rajapuri recorded significantly lower values for NR activity. Similarly, Li *et al.* (1993) also reported a wide genotypic variability in nitrate reductase activity among soybean genotypes and also noticed that the younger leaves possessed higher nitrate reductase activity than the older leaves, which is in agreement with the results of the present investigation. The present data also indicated a significant positive association between NR activity and rhizome yield at 180 DAS during *kharif* 1998. Jayapragasam *et al.* (1998) also reported that higher nitrate reductase activity was associated with higher yield in greengram and blackgram.

The data on reducing, non-reducing and total sugars revealed significant differences among the genotypes. The genotypes BSR-1, Rajapuri and Amalapuram

recorded significantly higher values for these traits which also had higher yield while the low yielding genotype Bidar-4 possessed significantly lower values. No definite correlation was found between sugar fractions and rhizome yield.

5.1.6 YIELD, YIELD COMPONENTS AND QUALITY

In general, crop yield depends on the accumulation of photo assimilates during the growing period and the way in which they are partitioned between the desired storage organs of the plants. Yield is mainly governed by the genetic potential of the crop and also by the environmental factors. The yield components in turmeric are number of mother rhizomes, primary fingers, secondary fingers, length of primary and secondary fingers, circumference of mother rhizome, primary fingers and secondary fingers.

Improvement in yield could happen in two ways i.e. by adopting the existing varieties to grow better in their environment or by altering the relative proportion of different plant parts so as to increase the yield of economically important parts (Humphries, 1979).

In the present study, it was observed that the fresh rhizome yield and cured rhizome yield was significantly higher in Amalapuram, Bidar-4 and Cuddapah during both the years. Further, these genotypes also possessed significantly higher values for number of primary and secondary fingers, circumference of primary fingers and harvest index. The low yielding genotypes (BSR-1 and Rajapuri) possessed significantly lower values for number of mother rhizomes and primary fingers, length of primary and secondary fingers, circumference of mother rhizome, primary and secondary fingers.

The cured rhizome yield during *kharif* 1998 ranged from 68.4 g plant⁻¹ (BSR-1) to 138.1 g plant⁻¹ (Amalapuram). The genotypes Amalapuram (138.1 g plant⁻¹), Bidar-4 (119.9 g plant⁻¹) and Cuddapah (104.6 g plant⁻¹) recorded significantly higher cured turmeric yield and also possessed significantly higher values for all yield components. Whereas, during *kharif* 1999, the cured rhizome yield, ranged from 56.1 g plant⁻¹ (BSR-1) to 113.3 g plant⁻¹ (Amalapuram). The variation in yield levels during

khari 1998 and 1999 was attributed to total rainfall and distribution of rainfall. Several research workers have also reported significant variation in yield and yield components among the turmeric genotypes (Pujari *et al.*, 1987; Indires *et al.*, 1990; Cholke, 1993 and Mannikeri, 1996).

The curing per cent was significantly higher in Amalapuram, BSR-1 and Cuddapah during both the years and significantly lower in Rajapuri and Bidar-4. The correlation studies indicated a significant positive association between number of primary fingers and cured rhizome yield. While, it indicated a positive and non-significant association of cured rhizome yield with all other yield components. This clearly indicated that for yield improvement in turmeric, more attention has to be given for increasing the number of primary fingers. Reddy (1988), Cholke (1993) and Mannikeri (1996) also found significant positive association between yield and number of primary fingers.

The quality of the produce is largely determined by the presence of principle colouring pigment 'Curcumin'. Several workers have reported significant variation in curcumin content among different cultivars of turmeric (Lewis, 1973; Philip, 1983; Cholke, 1993; Mannikeri, 1996 and Hegde *et al.*, 1997). The present study indicated that, curcumin content was significantly higher in BSR-1 followed by Rajapuri and Amalapuram. While, Bidar-4 and Cuddapah recorded significantly lower values during both the years. From the data it is clear that low yielding genotypes possessed significantly higher values for curcumin content. The correlation studies also revealed a negative association between cured rhizome yield and curcumin content. The present study clearly indicated that there is a need to improve curcumin content in high yielding genotypes.

Based on the above discussion, it is inferred that the following morpho-physiological, growth, biophysical, biochemical and yield components can be considered for yield improvement in turmeric.

I. Morphological traits

- (i) Number of leaves.

II. Growth parameters

- (i) TDM (ii) Leaf dry matter (iii) leaf area (iv) LAI, CGR, NAR (60-90 and 150-180 DAS), LAD, BMD, SLW (120 DAS).

III. Biophysical parameters

Stomatal number (Abaxial and Adaxial), RWC, Photosynthetic rate, Transpiration rate, stomatal conductance.

IV. Biochemical parameters

Total chlorophyll content (180 DAS), Nitrate reductase activity.

V. Yield and yield components

Number of primary fingers

Length of primary and secondary fingers

Circumference of primary fingers

Harvest index

5.2 EXPERIMENT II. INFLUENCE OF MICRONUTRIENTS ON PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES

The importance of micronutrients particularly Fe, Zn and Mn has been emphasized by Reddy and Raj (1975) in black gram, Tiwari *et al.* (1995) in turmeric and Gollagi (1999) in chilli. The application of micronutrients particularly, iron, Zinc and Manganese bring about profound changes in various metabolic processes within the plant system and thereby influence the yield potential (Tripathy *et al.*, 1999). However,

Roy *et al.* (1992) opined that the literature pertaining to the effect of micronutrients viz., Zn, Fe and Mn on morpho-physiological traits, growth parameters, biochemical components, yield attributes and quality aspects is very meager in tuber crops. Hence, the present investigation was undertaken to study the influence of micronutrients on morpho-physiological traits, growth parameters, biophysical and biochemical parameters and yield and yield components in turmeric genotypes (Bidar-4 and Bidar-1) during *kharif* 1998 and *kharif* 1999 and the results obtained are discussed in this chapter.

5.2.1 MORPHOLOGICAL CHARACTERS

The application of micronutrients significantly influenced the morphological characters such as plant height, number of tillers and number of leaves per plant. All the parameters were more during *kharif* 1998 due to higher total rainfall and better distribution of rainfall during the crop growth period as compared to *kharif* 1999.

In general, number of tillers per plant and number of leaves per plant increased upto 150 DAS and decreased thereafter at later stages. The plant height, number of tillers and number of leaves per plant were significantly higher in Bidar-4 as compared to Bidar-1 during 90 and 120 DAS. Further, it was also found that the application of micronutrients viz., FeSO_4 @ 0.5 per cent, MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent were very effective and significantly improved all these morphological parameters.

Roy *et al.* (1992) also reported significant increase in plant height and number of leaves in ginger due to the application of FeSO_4 @ 0.2 per cent as compared to control. Similarly, Balashanumugam *et al.* (1990) and Tiwari *et al.* (1995) also found increased morphological characters with the application of micronutrients in turmeric. Similarly, Gollagi (1999) also found increased plant height, number of branches and number of leaves due to the application of micronutrients (Fe, Zn and Mn), and further he indicated that these micronutrients affect various physiological processes and thereby helped to improve morphological parameters.

5.2.2 DRY MATTER PRODUCTION AND DISTRIBUTION

Application of micronutrients improve canopy structure and increase the productivity through the manipulation of source-sink relationship and physiological attributes.

The present data indicated that leaf and stem dry matter increased upto 150 DAS and decreased thereafter during both the years while, rhizome dry weight, total dry matter (TDM) increased progressively. All these parameters were significantly higher in Bidar-4 as compared to Bidar-1 suggesting differential distribution of dry matter in different plant parts. Further, the micronutrient treatments FeSO_4 @ 0.5 per cent, MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent significantly increased all these characters to a greater extent. For improving yield potential in turmeric, it is very essential to improve the TDM, since, this parameter bears a positive correlation with yield potential in turmeric.

Dry matter production, particularly of reproductive parts is an important yield contributing character and the basic vegetative phase is essential for the development of reproductive organs. Although, the dry matter production in general is the indication of the efficiency of the genotype, the pattern in which it is distributed in different plant parts would give a better understanding of the genotype. The enhanced dry weight of reproductive parts by micronutrients may be due increased translocation of assimilates from leaf and stem to the reproductive parts. Balashanumugam *et al.* (1990) and Tiwari *et al.* (1995) also found increased dry matter of leaf, stem, rhizome and total dry matter due to the application of micronutrients in turmeric. Similarly, Gollagi (1999) also observed significant increase in dry matter production due to the application of micronutrients (Fe, Zn and Mn). The increased dry matter was also reported in blackgram due to the application of micronutrients (Prabhu, 2000). Thus it is clear that, micronutrients had profound influence on the production of dry matter and its partitioning between various organs of the plant.

5.2.3 GROWTH PARAMETERS

Leaf area and leaf area index gives a good idea of the photosynthetic capacity of the plant. In the present study the leaf area and LAI increased upto 150 DAS and decreased at later stages due to senescence and aging of leaves. These parameters were significantly higher in Bidar-4 as compared to Bidar-1. The application of micronutrients FeSO_4 @ 0.5 per cent, MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent significantly increased leaf area and LAI. The Leaf area and LAI possess a significant positive correlation with rhizome yield. Hence, any attempt to increase these parameters is a worth rewarding exercise. Balashanmugam *et al.* (1990) and Tiwari *et al.* (1995) also found increased LA and LAI in turmeric due to the application of Fe, Zn and Mn. Gollagi (1999) also reported increased LA and LAI due to the application of micronutrients (Fe, Mn and Zn) in chilli.

The growth analysis parameters viz., AGR, CGR, RGR, NAR AND LAD increased upto 150 DAS and decreased at later stages whereas, LAR and LWR were more during early stages and decreased at later stages. While, BMD increased progressively from 90 to 180 DAS. The genotype Bidar-4 possessed significantly higher values for AGR, CGR, NAR, LAD and BMD as compared to Bidar-1. The application of micronutrients viz., FeSO_4 @ 0.5 per cent, MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent significantly increased AGR, CGR, NAR, SLW, LAD and BMD and the LAR values were found to be significantly higher in control as compared to micronutrient treatments. It is known that in turmeric, there exist a positive association of turmeric yield with AGR, CGR, LAD and BMD. Similarly, Gollagi (1999) also found higher values for growth parameters with the application of micronutrients in chilli (Fe, Mn and Zn). While, Prabhu (2000) observed significant increase in growth parameters due to the application of micronutrients in blackgram. The present data clearly indicated the role of micronutrients in enhancing growth parameters and thus helped to increase the yield potential in turmeric.

5.2.4 BIOPHYSICAL PARAMETERS

The important biophysical parameters viz., photosynthetic rate, transpiration rate, stomatal conductance, relative water content, number of stomata (abaxial and adaxial) and LTR showed significant differences due to genotypes and micronutrient treatments. Further it was also found that, Bidar-4 possessed significantly higher values for all these traits and this genotypes also showed significantly higher rhizome yield. A positive correlation was found between all these biophysical parameters and rhizome yield in turmeric. Further, these biophysical parameters were significantly higher with foliar application of FeSO_4 @ 0.5 per cent followed by MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent. Similar reports have been made in chilli (Gollagi, 1999) and blackgram (Prabhu, 2000). Hence, for improving yield potential in turmeric there is a need to improve biophysical parameters which is possible with the use of micronutrients.

5.2.5 BIOCHEMICAL PARAMETERS

The important biochemical parameters viz., chlorophyll 'a' chlorophyll 'b' total chlorophyll, NRA, reducing, non-reducing and total sugars differed significantly due to genotypes and micronutrient treatments. From the data it is clear that the application of micronutrients (FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5%) significantly increased chlorophyll 'a', 'b' and total chlorophyll in both the genotypes. This suggests that the micronutrients play an important role in the synthesis and maintenance of chlorophyll pigments. It is also well known that Fe and Zn play an important role in the synthesis of chlorophyll (Lincoln Taiz and Eduardo Zeiger, 1991). Gollagi (1999) also found increased chlorophyll content due to the application of micronutrients in chilli.

The activity of NRA was more upto 150 DAS and decreased at later stages. Since, nitrate reductase is a key enzyme in nitrogen metabolism, its activity should always be higher to have higher nitrogenous compounds in the plants. The activity of NRA increased significantly due to the application of micronutrients (Fe, Mn and Zn). The micronutrients viz., Iron, Manganese and Zinc are known to influence the

activity of various enzymes in the plants and thus bring about profound changes in plant growth and development (Lincoln Taiz and Eduardo Zeiger, 1991). Similarly, Gollagi (1999) also reported increased activity of NRA due to the application of micronutrients (Fe, Mn and Zn) in chilli.

The reducing, non-reducing and total sugars were significantly higher in high yielding genotype Bidar-4 and the application of FeSO_4 @ 0.5 per cent, MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent significantly increased these constituents as compared to control. Thus it is clear that micronutrients play an important role in enhancing biochemical parameters in turmeric.

5.2.6 YIELD, YIELD COMPONENTS AND QUALITY

The yield in turmeric was found to be strongly influenced by the application of micronutrients indicating the role of these elements in increasing the yield through their effect on various morpho-physiological and biochemical traits.

The fresh and cured rhizome yield were significantly higher in Bidar-4 as compared to Bidar-1. The application of Micronutrients (FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5%) significantly increased yield and yield components in both the genotypes. These treatments also resulted in significantly higher curing percentage, Number of mother rhizomes, primary and secondary fingers per plant, length of primary and secondary fingers, circumference of mother rhizome, primary and secondary fingers, TDM and finally harvest index. Velu (1988), Balashanmugam *et al.* (1990) Tiwari *et al.* (1995) also reported increased yield and yield components due to the application micronutrients (Zn, Fe and Mn).

The curcumin content was more in Bidar-4 as compared to Bidar-1. The application of micronutrients significantly increased the curcumin content and the effect was more pronounced with the application of FeSO_4 @ 0.5 per cent followed by MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent.

From the above discussion, it is very clear that the foliar application of FeSO_4 @ 0.5 per cent (60 and 120 DAS) was very effective in turmeric followed by MnSO_4 @ 0.4 per cent and ZnSO_4 @ 0.5 per cent and significantly improved yield and yield components due to higher values for morpho-physiological traits, growth parameters, biophysical and biochemical parameters. However, the benefit:cost ratio was highest with FeSO_4 @ 0.5 per cent followed by ZnSO_4 @ 0.5 per cent and FeSO_4 @ 0.25 per cent in both the genotypes.

5.3 **EXPERIMENT III. INFLUENCE OF GROWTH REGULATORS ON SOURCE-SINK RELATIONSHIP, PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES**

Plant produces a number of endogenous growth hormones which co-ordinate and control the various phases of plant growth and development. The discovery of growth promoters and growth retardants gave impetus to research on control of plant growth and development. Cathey (1964) reported a number of chemically diverse classes of compounds such as nicotinus quaternary ammonium carbonates, hydrozines phosphoniums, substituted cholines, succinic acids and a number of other compounds tested and used as growth retardants. He defined growth retardant as a chemical that slows down cell division and cell elongation in shoot tissues and regulates plant height physiologically without formative effects.

Treatments with growth retardants bring about certain changes in both the morphology and physiology of plants. Cycocel is one of the plant growth retardants which induces varied responses in wide range of plant species. Tolbert, (1960) reported that plants treated with cycocel were generally compact and sturdy with typical shortened petioles. The plants usually remained almost under optimal growth conditions.

Exogenous application of growth regulators are known to influence the growth, productivity and quality of several horticultural crops (Rao *et al.*, 1989). In root vegetables, treatment with growth regulators are known to hasten the tuberization and

yield of underground storage organs and encouraging results were reported in commercial vegetables viz., tapioca (Muthukrishan *et al.*, 1974); potato (Baijal *et al.*, 1983) and in onion (Singh *et al.*, 1983)

In the recent past, many growth regulator combinations are commercially available. Among them, miraculan and cytozyme are known to affect various physiological traits and increase the yield potential in sesamum (Chougale, 1997). Cytozyme is a biological product containing auxin and cytokinin, whereas, Miraculan is a biological product containing triacontanol. These growth promoting substances were very effective in increasing the yield potential of chilli (Gollagi, 1999). However, the information regarding the use of cycocel and other growth promoting substances in turmeric is almost scarce. Cycocel is a growth retardant which controls vegetative growth and increases the chlorophyll synthesis (Setia *et al.*, 1991).

The present study was undertaken to study the effect of growth regulators (promoters and retardants) on morpho-physiological traits, biophysical traits, source-sink relationship, yield and yield components and quality parameters in turmeric genotypes (Amalapuram and Rajapuri) and the results obtained are discussed in this chapter.

5.3.1 MORPHOLOGICAL CHARACTERS

The growth regulator treatments significantly influenced the morphological characters such as plant height, leaf area, dry matter production and its distribution into different plant parts. Basically, plant height is a genetically controlled character. But, several studies have indicated that the plant height is either increased or decreased by the application of synthetic growth regulators.

Number of tillers and number of leaves per plant showed an increasing trend upto 150 DAS and decreased at later stages during both the years. Further, the values for these parameters were more during *kharif* 1998 as compared to *kharif* 1999 due to higher total rainfall and better distribution of rainfall during *kharif* 1998.

Significant differences in plant height were noticed among growth regulator treatments at various stages. It is interesting to note that there was a significant increase in plant height over control in treatments with growth promoters (Cytozyme 2000 ppm and Miraculan 2000 ppm) but in cycocel treatment there was a significant decrease in plant height. It clearly indicated that the mode of action of these two growth regulators is quite different. Cathey (1964) reported that the growth retardants cause inhibition of cell elongation in the sub-apical meristem resulting in reduced plant height. Similar effect of reduced plant height in potato with mepiquat chloride and CCC was also reported by many workers (Shadeque and Pandita, 1982; Varela and Yellejo, 1982; Ganiger, 1992; Sychora *et al.*, 1973 and Choudhary *et al.*, 1976). Similarly, Mannikeri (1996) also indicated that the application of CCC @ 2000 ppm reduced the plant height significantly in turmeric genotypes.

The mechanism of reduction in plant height appears to be due to slowing down of cell division and reduction in cell expansion. It has been suggested that cycocel is an anti gibberellin dwarfing agent, leading to a deficiency of gibberellin in the plant and reduced growth, that is, blocking the conversion of geranyl pyrophosphate to copalyl pyrophosphate which is the first step of gibberellin synthesis (Moore, 1980). Thus, the reduced plant height is due to retardation of transverse cell division particularly in steelar cambium, which is the zone of meristematic activity at the base of the internode (Grossman, 1990).

Number of tillers were significantly higher in Rajapuri as compared Amalapuram. The number of tillers and leaves were significantly more in treatments with CCC @ 1000 ppm, cytozyme @ 2000 ppm and Miraculan @ 2000 ppm as compared to control. This suggests that the application of growth regulators (Promoters and retardants) are very effective in turmeric and thus increased morphological parameters significantly. Similar observations were also made in turmeric genotypes (Mannikeri, 1996).

5.3.2 DRY MATTER PRODUCTION AND ITS PARTITIONING

Application of growth regulators improves canopy structure and increases the productivity through the manipulation of source-sink relationship.

Dry matter production, particularly of reproductive parts is an important yield contributing character. Although, the dry matter production in general is the indicative of the efficiency of the genotype, the pattern in which it is distributed in different plant parts would give a better understanding of the genotype. It is well documented that growth regulators and nutrients will have their influence on the production of dry matter and its partitioning between various organs of the plant.

The data pertaining to total dry weight per plant indicated that it increased continuously from 90 to 180 DAS. At later stages of crop growth, the dry matter accumulated at a decreasing rate, which could be attributed to reduced source activity leading to lesser dry matter accumulation in leaf and stem.

The total dry matter and rhizome dry weight increased with age of the crop and these parameters were significantly more in Amalapuram as compared to Rajapuri. The application of growth regulators viz., Cycocel @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm were very effective and significantly increased dry weight of leaf, stem and reproductive parts and thus increased TDM also. This clearly indicates that growth regulators have the capacity to alter source-sink relationship. Pando and Srivastava (1985) reported that the application of Cycocel was found to increase the RUBP Carboxylase enzyme activity, photosynthesis and dry matter partitioning in sunflower, while the application of N-tricontanol increased the dry matter accumulation in *Brassica juncea* (Ghosh *et al.*, 1991). The effectiveness of CCC in increasing the total dry matter production in turmeric was also reported by Mannikeri (1996). Similarly, Gollagi (1999) also found increased dry matter production in chilli due to the application of CCC, miraculan and cytozyme.

The dry matter accumulation in leaf and stem maintained increasing trend upto 150 DAS and declined thereafter which may be attributed to translocation of stored photoassimilates towards the development of reproductive organs.

5.3.3 GROWTH PARAMETERS

Growth analysis is a physiological probe on the development of the crop in a chronological sequence to elucidate and account the causes for differences in yield through the events that occurred at different stages of growth (Krishnamurthy *et al.*, 1973).

Several workers have reported significant variation in leaf area and leaf area index among diverse turmeric genotypes (Philip and Nair, 1983; Cholke, 1993 and Mannikeri, 1996).

In general, leaf area and LAI increased upto 150 DAS and decreased thereafter due to ageing and senescence of leaves. The leaf area and LAI was significantly higher in Amalapuram as compared to Rajapuri. The application of growth promoters (Cytosyme @ 2000 ppm and Miraculan @ 2000 ppm) significantly increased these parameters while, the application of CCC (500 and 1000 ppm) significantly decreased these parameters. The cycocel inhibits cell elongation resulting in reduced leaf expansion without any anatomical changes in leaf (Lovette and Campwell, 1973). Papravoco (1976), Stuart *et al.* (1980) and Madalgeri (1996) also found decreased leaf area in potato due to the application of CCC. Similarly, Gollagi (1999) also reported that in chilli the application of miraculous and cytozyme significantly increased leaf area and LAI while, CCC reduced leaf area and LAI significantly. Rao *et al.* (1989) opined that the application of NAA @ 20 ppm significantly increased leaf area and LAI in turmeric.

Growth parameters showed significant differences due to genotypes and growth regulator treatments. The growth parameters viz., AGR, CGR, LAD and BMD increased significantly due to the application of Cycocel @ 1000 ppm followed by Cytosyme @ 2000 ppm and Miraculan @ 2000 ppm as compared to control. AGR, CGR

and LAD showed an increasing trend upto 150 DAS and decreased thereafter while, BMD increased upto 180 DAS.

Net assimilation rate and SLW increased significantly due to the application of Cycocel (500 and 1000 ppm) as compared to other treatments. The LAR and LWR were significantly higher in control as compared to growth regulator treatments.

RGR and SLA did not show any definite trend due to the application of growth regulators. However, all the growth parameters were significantly more in high yielding genotype Amalapuram as compared to low yielding genotype Rajapuri. The data suggested that the application of growth regulators (CCC, Miraculan, Cytozyme) were very effective in increasing important growth parameters (AGR, CGR, LAD and BMD) and thus helped in increased production potential in these treatments. Similarly, Mannikeri (1996) also indicated significant improvement in growth parameters due to the application of growth regulators. Gollagi (1999) also observed significant improvement in growth parameters due to the application of CCC, Cytozyme and miraculan in chilli. Thus, from the data it is clear that, the use of growth regulators help in improving growth parameters and improve the yield potential in turmeric.

5.3.4 BIOPHYSICAL PARAMETERS

Photosynthesis is the primary process which forms the basis for yield determination. Several workers have reported increased rate of photosynthesis, transpiration and stomatal conductance with the application of growth regulators in soybean (Pankaj Kumar, 1998), Onion (Padmavati, 1998) and Sesamum (Chougale, 1997). In the present investigation, it is clear that the growth regulator (CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm) treatments significantly increased the photosynthetic rate, transpiration rate and stomatal conductance and thus indicated the role of these chemicals in increasing the biophysical parameters. It was further observed that these parameters were significantly higher in high yielding genotype Amalapuram as compared to low yielding genotype Rajapuri.

Number of stomata (abaxial and adaxial surface), relative water content and light transmission ratio significantly increased due to the application of growth regulators (CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 1000 ppm). The genotype Amalapuram possessed significantly higher values for stomatal number and RWC as compared to Rajapuri. The data clearly indicated significant improvement in biophysical parameters due to the application of growth regulators.

5.3.5 BIOCHEMICAL PARAMETERS

The application of growth regulators significantly increased chlorophyll 'a', 'b' and total chlorophyll contents, nitrate reductase activity, reducing, non-reducing and total sugars. In general, the application of CCC @ 1000 ppm was more effective in increasing NRA, reducing, non-reducing and total sugars followed by Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm. Chetti (1991) reported that the application of Lihocin increased the Chlorophyll 'a', 'b' and total chlorophyll contents in groundnut. Kulkarni *et al.* (1995) also found increased chlorophyll content in sunflower due to the application of Mepiquat chloride @ 1000 ppm. Sairam *et al.* (1991) also showed that the foliar application of CCC to wheat genotypes significantly increased the NRA activity in wheat. Further, Gollagi (1999) also found higher chlorophyll content, NRA, and total sugars in chilli plants treated with Cycocel, Cytozyme and Miraculan. This clearly showed that growth regulators have profound influence on biochemical parameters.

5.3.6 YIELD, YIELD COMPONENTS AND QUALITY

Improvement in yield according to Humphries (1979) could happen in two ways i.e., by adopting the existing varieties to grow better in their environment or by altering the relative proportion of different plant parts so as to increase the yield of economically important parts. The growth regulators are capable of redistribution of dry matter in the plant thereby bringing about an improvement in yield (Reddy and Patil, 1981; Chetti, 1991 and Chandrababu *et al.*, 1995). In addition, crop yield depends not only on the accumulation of photosynthates during the crop growth and development, but

also on its partitioning in the desired storage organs. These in turn are influenced by the efficiency of metabolic processes within the plant.

The rhizome yield in turmeric depends on the accumulation of photoassimilates and partitioning in different plant parts. The yield in turmeric was found to be strongly influenced by the application of different growth regulators indicating the role of these chemicals in increasing the yield through their effect on various morpho-physiological and biochemical traits.

The present studies revealed that the fresh and cured rhizome yield was significantly higher with CCC @ 1000 ppm followed by cytozyme @ 2000 ppm and Miraculan @ 2000 ppm. These growth regulator treatments also significantly increased TDM, harvest index, curing per cent, number of mother rhizomes per plant, number of primary and secondary fingers per plant, length of primary and secondary fingers, circumference of mother rhizome, primary and secondary fingers. The high yielding genotype Amalapuram showed significantly higher values for all these parameters as compared to Rajapuri except for number of secondary fingers which was more in Rajapuri. The present data clearly indicated that growth regulators are very effective in increasing the yield potential through increased yield components.

Similarly Mannikeri (1996) also indicated that the application of CCC @ 1000 ppm was very effective in turmeric and significantly increased yield and yield components. Rao *et al.* (1989) showed that the application of NAA @ 20 ppm increased the turmeric yield by 51 per cent. Satheesan and Ramadhasan (1988) also found increased harvest index with the application of CCC @ 4000 ppm. Gollagi (1999) also showed increased yield and yield components in chilli due to the application of CCC, Cytozyme and Miraculan.

The curcumin content was more in Rajapuri as compared to Amalapuram. The application of growth regulators (CCC 1000 ppm, Cytozyme 2000 ppm and Miraculan 2000 ppm) significantly improved this parameter.

From the above discussion, it is very clear that the application of CCC @ 1000 ppm (60 and 120 DAS) was very effective in turmeric followed by Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm which significantly increased yield and yield components due to improved morpho-physiological traits, growth parameters, biophysical and biochemical parameters. However, the benefit:cost ratio was highest with Cytozyme @ 2000 ppm followed by Miraculan @ 2000 ppm and Cytozyme @ 1000 ppm in both the genotypes.

5.4 FUTURE LINE OF WORK

Based on the results obtained in the present investigation, following suggestions have been indicated for further studies.

1. There is an urgent need to screen large number of commercial growth regulators and micronutrients on different turmeric genotypes which have profound influence on yield and quality.
2. It is necessary to identify suitable growth regulators and micronutrients for improving physiological and biochemical parameters in turmeric.
3. Several studies have indicated that photoassimilate distribution within the plant is under the hormonal control and hence there is a scope for detailed anatomical and histochemical studies regarding the effect of plant hormones and micronutrients on vascular connections.
4. Little is known about the influence of different growth regulators and micronutrients on enzyme activity and synthesis of curcumin and there is ample scope for such studies.
5. It is also important to study the interaction between the externally applied growth regulators and endogenous hormones and the role of growth regulators and micronutrients in the manipulation of source-sink relationship.
6. There is also a need to initiate research studies pertaining to specific quality attributes which are important for increasing export potential.

Summary

VI SUMMARY

Three field experiments were conducted to study the physiological basis of yield variation in turmeric genotypes and also to study the effect of different growth regulators and micronutrients on productivity potential and quality in turmeric during *kharif* 1998 and *kharif* 1999 at the Main Research Station, College of Agriculture, University of Agricultural Sciences, Dharwad. It was aimed to elicit information on variability for morpho-physiological, biophysical and biochemical parameters among different turmeric genotypes and their relationship with productivity and to identify ideal plant type characters for higher productivity. To achieve this, field experiments were conducted during *kharif* seasons of 1998 and 1999 with six turmeric genotypes (Amalapuram, CO-1, Bidar-4, BSR-1, Rajapuri and Cuddapah) and were laid out in randomised block design with four replications. The second experiment on "Influence of micronutrients on productivity potential and quality in turmeric genotypes" included two genotypes (Bidar-1 and Bidar-4) and three micronutrients at two concentrations (FeSO_4 0.25% and 0.5%; ZnSO_4 0.25% and 0.50%; MnSO_4 0.20% and 0.40%) and a control. This experiment was laid out in factorial randomised block design with three replications. Similarly, the third experiment on "Influence of plant growth regulators on source-sink relationship and productivity potential and quality in turmeric genotypes" included two genotypes (Amalapuram and Rajapuri) and three growth regulators at two concentrations (CCC @ 500 and 1000 ppm; Cytosyme @ 1000 and 2000 ppm; Miraculan @ 1000 and 2000 ppm) and a control. The experiment was laid out in factorial randomised block design with three replications. The results obtained from the investigation are summarised experimentwise in this chapter.

EXPERIMENT I : PHYSIOLOGICAL BASIS OF YIELD VARIATION IN TURMERIC GENOTYPES

1. The performance of the genotypes with respect to morpho-physiological, growth

parameters, biophysical and biochemical parameters, yield and yield attributes was better, during *kharif* 1998 as compared to *kharif*, 1999

2. Among the genotypes, Amalapuram, Cuddapah and Rajapuri recorded significantly higher plant height as compared to BSR-1 which recorded lowest values at all the stages.
3. The number of tillers and number of leaves increased from 60 to 150 DAS and declined thereafter. The number of tillers were significantly more in Rajapuri during both the years and a significant negative association was found between number of tillers and rhizome yield. Whereas, the number of leaves were significantly more in high yielding genotypes viz., Amalapuram, Bidar-4 and Cuddapah at all the stages. A significant positive association was found between number of leaves (150 and 180 DAS) and rhizome yield.
4. The total dry matter production and its distribution in different plant parts (leaf, stem and rhizome dry weight) differed significantly among the genotypes. A progressive increase in leaf and stem dry weight was observed with an advancement of crop growth from 60 to 150 DAS and decreased thereafter. While, TDM and rhizome dry weight increased progressively from 60 to 180 DAS. The leaf dry weight, rhizome dry weight and TDM was significantly more in Amalapuram, Bidar-4 and Cuddapah. While, the genotypes BSR-1 and Rajapuri registered significantly lower values and these parameters possessed significant positive association with turmeric yield. However, stem dry matter (150 DAS) had a significant positive association with turmeric yield during *kharif* 1998.
5. The genotypes differed significantly with respect to all the growth parameters. Among the genotypes, Amalapuram, Bidar-4 and Cuddapah recorded significantly higher values for leaf area, LAI, AGR (150-180 DAS), CGR, RGR (150-180 DAS), NAR (150-180 DAS), LAD, BMD and SLW (120 and 150 DAS).

The SLA was significantly more Co-1, BSR-1 and Rajapuri while it was less in Amalapuram. The low yielding genotypes viz., BSR-1 and Rajapuri possessed significantly lower values for leaf area, LAI, CGR, LAD and BMD. Further the correlation studies indicated a significant positive association between rhizome yield and growth parameters viz., LA, LAI, AGR, CGR, RGR (150- 180 DAS), NAR (120-150 DAS), LAD, BMD and SLW (120 & 150 DAS) while, SLA showed a significant negative association.

6. The biophysical parameters viz., number of stomata (Abaxial and Adaxial), Relative water content, photosynthetic rate, transpiration rate, stomatal conductance and light transmission ratio differed significantly among the genotypes. The high yielding genotypes Amalapuram, Bidar-4 and Cuddapah recorded significantly higher values for photosynthetic rate, transpiration rate, stomatal conductance, number of stomata (Abaxial and Adaxial) and RWC. However, the LTR values were significantly more in BSR-1, Rajapuri and Co-1. The correlation studies indicated a significant positive association between rhizome yield and photosynthetic rate, transpiration rate, stomatal conductance, stomatal number (Abaxial) and RWC. However, LTR showed a significant negative association with rhizome yield.
7. The high yielding genotypes Cuddapah and Bidar-4 registered significantly higher chlorophyll a and b contents, total chlorophyll and NRA. In general, chlorophyll 'a', 'b', total chlorophyll contents and NRA activity was more during early stages and decreased at later stages (180 DAS). The total sugars, reducing sugars and non reducing sugars were significantly more in BSR-1 and Rajapuri while the genotype Bidar-4 registered significantly higher values.
8. The fresh and cured rhizome yield, curing per cent, harvest index, number of mother rhizomes, primary and secondary fingers, length of primary and secondary fingers, circumference of mother rhizome, primary and secondary fingers and

harvest index differed significantly among the genotypes. The high yielding genotypes viz., Amalapuram, Bidar-4 and Cuddapah recorded significantly higher values for fresh and cured rhizome yield, harvest index, number of primary fingers per plant, length of secondary fingers and circumference of primary fingers. The low yielding genotypes BSR-1 and Rajapuri registered significantly lower values for cured rhizome yield, number of mother rhizomes, number of primary fingers, length of primary and secondary fingers, circumference of mother rhizome and primary fingers.

9. The curcumin content was significantly higher in BSR-1 followed by Rajapuri and Amalapuram and significantly lower values were found in Bidar-4.
10. The genotypes Amalapuram, Bidar-4 and Cuddapah were found to be physiologically efficient and may be used as a genetic source for improvement of yield in turmeric.

EXPERIMENT II: INFLUENCE OF MICRONUTRIENTS ON PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES

1. The morpho-physiological, growth parameters, biophysical and biochemical parameters, yield and yield components were less in *kharif* 1999 due to less amount of total rainfall coupled with erratic distribution during the crop growth period as compared to *kharif* 1998.
2. Among the genotypes, Bidar-4 recorded significantly higher height as compared to Bidar-1. The application of micronutrients significantly increased plant height and the effect was more with FeSO_4 @ 0.5% followed by MnSO_4 @ 0.4% and ZnSO_4 @ 0.5%.
3. The number of tillers and number of leaves increased significantly due to micronutrients and genotypes. The application of FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% significantly increased these parameters as compared to control.

4. The total dry matter production and its distribution in different plant parts (leaf; stem and rhizome dry weight) differed significantly due to genotypes and micronutrients. All these parameters were significantly more in treatments with FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% as compared to control.. Among the genotypes, Bidar-4 recorded significantly higher values for all these traits.
5. All the growth parameters differed significantly due to genotypes and micronutrients. Among the genotypes, Bidar-4 recorded significantly higher values for LAI, AGR, CGR, SLW, LAD and BMD. The application of micronutrients viz., FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% significantly increased LAI, AGR, CGR, NAR, SLW, LAD and BMD as compared to control.
6. The biophysical parameters viz., number of stomata (Abaxial and adaxial), relative water content, photosynthetic rate, transpiration rate, stomatal conductance and light transmission ratio differed significantly due to genotypes and micronutrients. The genotype Bidar-4 recorded significantly higher values for all these traits as compared to Bidar-1. Among the micronutrient treatments, the application of FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% was more effective and significantly increased all these biophysical traits as compared to control.
7. The biochemical parameters viz., chlorophyll 'a', 'b', total chlorophyll, chlorophyll a:b ratio, NRA, total sugars, reducing sugars and non reducing sugars showed significant differences due to genotypes and micronutrient treatments. All these biochemical parameters were significantly higher in Bidar-4 as compared to Bidar-1 except for chlorophyll a:b ratio. Among the micronutrient treatments, the application of FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% was more effective and significantly increased all the biochemical parameters except chlorophyll a:b ratio which decreased significantly.

8. The fresh and cured rhizome yield, curing per cent, number of mother rhizomes, primary and secondary fingers, length of primary and secondary fingers, circumference of mother rhizome, primary and secondary fingers, TDM and harvest index differed significantly due to genotypes and micronutrients. The high yielding genotype Bidar-4 recorded significantly higher values for TDM, fresh and dry rhizome yield, number of mother rhizomes and primary fingers, length and circumference of primary fingers and harvest index as compared to Bidar-1. The treatment with FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% significantly increased important yield and yield components as compared to control.
9. The curcumin content was significantly more in Bidar-4 as compared to Bidar-1. The application of micronutrients viz., FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% significantly improved the quality trait as compared to control.
10. The use of micronutrients viz., FeSO_4 @ 0.5%, MnSO_4 @ 0.4% and ZnSO_4 @ 0.5% was found very effective and improved all the important morpho-physiological traits, biophysical and biochemical parameters and yield and yield attributes. The benefit : cost ratio was highest with FeSO_4 @ 0.5 per cent followed by ZnSO_4 @ 0.25 per cent and FeSO_4 @ 0.25 per cent.

EXPERIMENT III: INFLUENCE OF PLANT GROWTH REGULATORS ON SOURCE SINK RELATIONSHIP AND PRODUCTIVITY POTENTIAL AND QUALITY IN TURMERIC GENOTYPES

1. The morpho-physiological, growth parameters, biophysical and biochemical parameters, yield and yield components were less in *kharif* 1999 due to less amount of total rainfall coupled with erratic distribution during the crop growth period as compared to *kharif* 1998.
2. The application of growth regulators significantly increased plant height except CCC (500 and 1000 ppm) and the effect was more with Cytozyme @ 2000 ppm

followed by Miraculan @ 2000 ppm. Among the genotypes Amalapuram recorded significantly higher plant height as compared to Rajapuri.

3. The number of tillers and number of leaves increased significantly due to growth regulators and genotypes. The application of CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm significantly increased these parameters as compared to control.
4. The total dry matter production and its distribution in different plant parts (leaf, stem and rhizome dry weight) differed significantly due to genotypes and growth regulators. All these parameters were significantly more in treatments with CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm as compared to control. Among the genotypes, Amalapuram recorded significantly higher values for all these traits.
5. The growth parameters differed significantly due to genotypes and growth regulators. The application of growth regulators viz., CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm significantly increased LAI, AGR, CGR, NAR, LAD and BMD as compared to control.
6. The biophysical parameters viz., number of stomata (Abaxial and adaxial), relative water content, photosynthetic rate, transpiration rate and stomatal conductance differed significantly due to genotypes and growth regulators. The genotype Amalapuram recorded significantly higher values for all these traits as compared to Rajapuri. Among the growth regulator treatments application of CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm was more effective and significantly increased all the biophysical traits as compared to control.
7. The application of CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm was more effective and significantly increased NRA, reducing, non-reducing and total sugars as compared to control. All these biochemical

parameters were significantly more in Rajapuri as compared to Amalapuram except for NRA.

8. The treatment with CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm significantly increased important yield and yield components as compared to control. The high yielding genotype Amalapuram recorded significantly higher values for TDM, fresh and dry rhizome yield, number of mother rhizomes and primary and secondary fingers, length and circumference of primary and secondary fingers, curing per cent and harvest index as compared to Rajapuri.
9. The curcumin content was significantly more in Rajapuri as compared to Amalapuram. The application of growth regulators viz., CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm significantly improved the quality trait as compared to control.
10. The use of growth regulators viz., CCC @ 1000 ppm, Cytozyme @ 2000 ppm and Miraculan @ 2000 ppm was very effective and improved all the important morpho-physiological traits, biophysical and biochemical parameters and yield and yield attributes. The benefit:cost ratio was more with Cytozyme @ 2000 ppm followed by Miraculan @ 2000 ppm and Cytozyme @ 1000 ppm.

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PHYSIOLOGICAL INVESTIGATIONS IN TURMERIC (*Curcuma longa* L.)

DILEEP I. JIRALI

2001

Dr. S. M. HIREMATH
Major Advisor

ABSTRACT

Field experiments were conducted at Main Research Station, University of Agricultural Sciences, Dharwad during *Kharif* seasons of 1998 and 1999 to study the physiological basis of yield variation in turmeric genotypes (Amalapuram, Co-1, Bidar-4, BSR-1, Rajapuri and Cuddapah and also to find out the effect of different micronutrients (FeSO_4 @ 0.25 and 0.50%, ZnSO_4 @ 0.25 and 0.50% and MnSO_4 @ 0.20 and 0.40%, with two genotypes, Bidar-4 and Bidar-1) and growth regulators (CCC @ 500 and 1000 ppm, cytozyme @ 1000 and 2000 ppm and miraculan @ 1000 and 2000 ppm with two genotypes, Amalapuram and Rajapuri) on productivity potential and quality in turmeric genotypes.

The high yielding genotypes possessed significantly higher values for number of leaves, LAI, CGR, NAR, LAD, BMD, SLW, TDM, Reproductive dry matter and photosynthetic rate. The important yield components viz., number of primary fingers per plant, length of secondary finger, circumference of primary finger and harvest index were significantly higher in high yielding genotypes. Among the genotypes, Amalapuram, Bidar-4 and Cuddapah were found physiologically efficient and possessed significantly higher values for all physiological traits.

Foliar application of FeSO_4 @ 0.50% (at 60 and 120 DAS) was very effective followed by MnSO_4 @ 0.40% and ZnSO_4 @ 0.50% and these treatments significantly improved yield and yield components and quality attributes due to higher values for morpho-physiological traits, growth parameters, biophysical and biochemical parameters. However, the benefit:cost ratio was highest with FeSO_4 @ 0.50%.

Foliar application of CCC @ 1000 ppm (at 60 and 120 DAS) was very effective followed by cytozyme @ 2000 ppm and miraculan @ 2000 ppm and these treatments significantly improved yield and yield components and quality attributes due to higher values for morpho-physiological traits, growth parameters, biophysical and biochemical parameters. However, the benefit:cost ratio was highest with cytozyme @ 2000 ppm.