

STUDIES ON COMPANION CROPPING IN TURMERIC
(*Curcuma longa* L.)

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DECEMBER, 1992

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STUDIES ON COMPANION CROPPING IN TURMERIC
(*Curcuma longa* L.)

Thesis Submitted to the
University of Agricultural Sciences, Dharwad,
in partial fulfilment of the requirements for the
Degree of

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by

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DECEMBER, 1992

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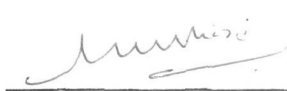
This is to certify that the thesis entitled "STUDIES ON COMPANION CROPPING IN TURMERIC (*Curcuma longa* L.)" submitted by Mr. M. N. NARAYANPUR, for the degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE, of the University of Agricultural Sciences, Dharwad, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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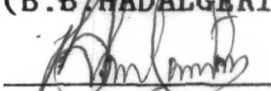
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AFFECTIONATELY DEDICATED
TO MY
BELOVED PARENTS,
TEACHERS AND BROTHERS

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In all closely, knit, complex, interwoven and intricate social system such as ours, it is obvious that nothing of significance can ever be accomplished without the acts of assistance, words of encouragement and the gestures of helpfulness from the other members of the society. This work of mine is no exception.

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(Manjunath/N. Narayanpur)

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CHAPTER - I

INTRODUCTION

I INTRODUCTION

India has been regarded as the home of spices and cultivation of spices in the country dates back to 500 B.C. The important annual spices which are cultivated in the country are turmeric, ginger, onion, garlic, coriander, chilli, etc.

Turmeric (*Curcuma longa* L.) a herbaceous perennial plant belonging to the family, Zingiberaceae, under the order Scitaminae, is one of the most valuable and important spices all over the world. It is also used as condiment, drug and cosmetic. The colouring pigment called 'curcumin' and the volatile oil called 'Turmerol' are exclusively present in the turmeric rhizomes. It contains appreciable quantities of proteins (6.3%), fats (5.1%), carbohydrate (68.4%) and fibre (2.8%) and is rich in minerals like phosphorus, calcium, iron and vitamin A.

India is one of the important turmeric growing countries in the world. Besides India, it is cultivated in Sri Lanka, Indonesia, China, Peru, Jamaica and other tropical and subtropical countries. In India it is mainly grown in the states of Andhra Pradesh, Orissa, Tamil Nadu, Assam, Kerala, Maharashtra and Karnataka, totally occupying approximately an area of 108 thousand hectares with an annual production of 295 thousand tonnes (Anon., 1990).

The onion (*Allium cepa* L.) and garlic (*Allium sativa* L.) belong to the family Amaryllidaceae. Origin of onion and garlic is said to be Central Asia and Mediterranean region is considered as secondary centre. In India, onion and garlic are grown over an area of 267 and 58 thousand hectares with an annual production of 2720 and 206 thousand tonnes, respectively.

In Karnataka, onion and garlic occupy an area of 38.17 and 2.10 thousand hectares with annual production of 183.80 and 2.00 thousand tonnes, respectively (Anon., 1988).

The coriander (*Coriandrum sativum* L.) belonging to the family Umbeliferae (Daucaceae) is an important seed spice and said to be originated in Mediterranean region. It is grown in India, U.S.S.R., Hungary, Rumania and U.S.A. on large scale. In India, it is grown over an area of 2.86 lakh hectares with an annual production of 1.02 lakh tonnes (Srinivasamurthy and Narayanswamy, 1989).

Soybean (*Glycine max* L.) is a short duration crop belonging to family Leguminaceae. It is more suitable as intercrop in long duration annuals. It is a multipurpose crop with many advantages viz., food value, industrial use and as legume it is known to increase the soil fertility. It also contains about 20 per cent oil. In India it is grown in Madhya Pradesh, Maharashtra, Uttar Pradesh and Gujarat. It is also

grown in small acreage in Himachal Pradesh, Punjab, Delhi and Karnataka. It occupies about 7.0 lakh hectares in the country with an annual production of 8.5 lakh tonnes. The average production is 950 kg per ha.

Turmeric is an important commercial crop. In Karnataka, turmeric is grown under irrigated condition as sole crop or mixed crop. Turmeric takes about 8-9 months from the date of planting to harvesting and therefore the small farmers can hardly afford to grow it as sole crop. The practice of inter or companion cropping is important especially in turmeric because the initial growth of turmeric is rather slow and takes about 4-5 months to cover the interspace. Hence the space between the rows of turmeric can be efficiently utilised by growing some short duration crops like annual spices, vegetables, cereals and pulses.

With growing population and increasing pressure on land, possibility of extensive cultivation is limited. Therefore the available land has to be more intensively utilised for maximum production.

Turmeric is a deep rooted crop compared to onion or garlic. Thus growing of various species of crops having different rooting habits helps in utilising soil moisture and nutrients at different depths of soil. The periods of growth of these crops is also different. The peak period of growth of onion, garlic and coriander is around 40-45 days after

planting whereas the peak period of growth of turmeric is between 120 and 150 days after planting. As a result of this, there will not be much competition either for soil moisture or for the sunlight among the different crops.

To ensure higher net income, it is worth while to explore the possibilities of growing compatible crops with turmeric. Since turmeric occupies the field for about seven to eight months, the interspace can best be utilised by growing suitable short duration crops mixed with turmeric.

Raising of these additional short duration crops will increase the cost of cultivation proportionately but it is compensated by additional income. The performance of companion crops depends on soil moisture, fertilizer management, crop canopy, duration of crops and incidence of pests and diseases.

For the cultivation of these annual spices, fertilizer is the main item of the expenditure, the cost of which is increasing day by day. Therefore, reduction in cost of cultivation is necessary under present situation through proper fertilizer management.

The present investigation was therefore under taken at the Agricultural College, Dharwad during 1991-1992 with the following objectives.

1. To find out the compatible companion crop in turmeric.
2. To study the effect of N.P.K. under companioncropping system, and
3. To study the uptake of nutrients in turmeric and in companion crops under companioncropping system.

CHAPTER - II

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Review of literature pertaining to importance of mixed or companion cropping, basic principles involved in mixed or companion cropping, situations involving two or more crop combinations, nutritional aspects and economics of mixed or companion cropping are cited in this chapter.

2.1 Importance of mixed or intercropping

The importance of mixed cropping in Indian agriculture has been reported by many workers. The system of mixed cropping, so common in India, has done more to uphold the fertility of soils than any other practice and it confers the benefits similar to that of crop rotation with regard to the effect on soil fertility (Mollison, 1901).

Mixed cropping is mainly practiced to overcome the risks associated with crop failures due to vagaries of weather or pest and disease incidence. The periodical returns and distribution of labour throughout the year in mixed cropping is of great help to the small growers (Ayyangar and Ayyar, 1942 and Singh and Katyal, 1966). Christidis and Harrison (1955) opined that intercropping presents all the benefits ordinarily attending by crop diversification.

Intercropping of short duration crops in long duration ones, has been a regular practice followed by farmers in India, Africa, Sri Lanka, Malaysia and the West Indies (Ayyangar and Ayyar, 1942). Mixed cropping practice is as ancient as agriculture itself (Anon., 1960).

Thompson and Kelly (1959) discussed in detail the systems of intercropping or companion cropping. When two or more crops are grown together on the same land, the system is known as intercropping or companion cropping. Intercropping is practiced mainly in market gardeners on high priced land and where much of work is done by manual labour. The main advantages of intercropping are:

- (i) economy of space which is important with high priced land,
- (ii) saving in tillage as the same ploughing and fitting of the land serves for two or more crops,
- (iii) more efficient utilization of the nutrients, any surplus applied to one crop being available for another and
- (iv) increased gross returns from the area cultivated.

These advantages may be more than offset by the following disadvantages:

- (i) increase in labour costs due to the necessity for large amount of manual labour and impracticability of using large cultivating implements,

- (ii) larger demand for nutrients and moisture and
- (iii) greater difficulty in controlling pests and diseases.

Mixed cropping might increase production per unit area per unit time without affecting the production of main crop to a great extent. It also helps in correcting the nutritional imbalance in cultivators' diet (Aiyar, 1963).

Aiyar (1949) reported that the resources with regard to plant nutrients present in the soil are added to it as manures are utilised to the fuller extent in mixed cropping than under sole cropping system. Mixed cropping utilises all the space available for raising a crop rather than to leave uncovered by the crop (Aiyar, 1963).

Aiyar (1953) discussed the advantages and disadvantages of mixed cropping in India and concluded that the mixed cropping is very beneficial for small holdings and the advantages of mixed cropping easily outweigh its disadvantages. He has listed the principles, based on which the mixed cropping has been found to be a sound practice. They are:

- (i) insurance against crop failure,
- (ii) balanced use of water and nutrient,
- (iii) efficient use of water and nutrients,
- (iv) reduced incidence of certain diseases and pests and
- (v) economy of space, manure, water and labour.

There is a possibility of utilising the solar energy to a greater extent by growing intercrops on the vacant space available between rows of main crop (Prabhakar and Shetty, 1973). Ogunfawara and Norman (1974) reported that mixed cropping would ensure less yield fluctuations than sole cropping even under unfavourable conditions. The following advantages of intercropping are also reported (Anon., 1974).

- (i) It confers the same benefits as a crop rotation with regard to the effect on the soil.
- (ii) It meets the varied requirements of cultivators and
- (iii) Risk of total failure of crops is less.

Intercropping is a type of mixed cropping where the different crops are planted, with an advantage that mixed crops grow during those stages of vegetative cycle, without impairing much each other's growth (Anon., 1974).

Intercropping system involves growing of crops together two or more species with the assumption that two species could exploit the environment better than one (Tarhalkar and Rao, 1975). Lal and Verma (1970), studied in detail regarding the adaptation of companion - cropping in vegetable crops. Intercropping and companion cropping are the methods of intensive cultivations of vegetables where in more than one crop are grown simultaneously on the same piece of land. Intercropping is done in the open spaces between

perennial or long term crops while companion cropping of vegetables may be done between rows of other vegetables or grain crops.

2.2 Basic concepts involved in inter or mixed cropping

The basic concept of intercropping is that, two or more species of contrasting habit with respect to branching, leaf distribution, height, root distribution, mineral uptake or other morphological and physiological characters which together be able to exploit the total environment more efficiently than a monoculture and will thereby give increased overall yield per unit area (Donald, 1963 and Willey and Osiru, 1972). Co-operation results when the two species grown are mutually beneficial, on the contrary competition results are obtained when they tend to be mutually harmful. The relationships viz. co-operation and competition are density dependent. At low plant densities, there is co-operation and finally active competition begins to operate as the density increases (Donald, 1983).

Competition begins when the immediate supply of a single necessary factor falls below the combined demands of the plants. Competition between the species grown together results when they tend to be mutually competitive and this competition is mainly for water, light and nutrients (Donald, 1983).

Andrews (1970) gave general criteria to obtain increased returns from inter or mixed cropping.

- (i) Intercrop competition must be less than intra crop competition.
- (ii) The arrangement and relative number of contributing crop plants will affect the expression of the differences in competition.
- (iii) The effect of competition between crops is generally alleviated when their demands on the environment occur at different times.
- (iv) The legumes may be necessary component crops under conditions of poor fertility.

An intercropping system needs to be designed in such a way that in case of unfavourable weather at least one crop will survive to give economic yield or in a normal year the inter cropping system as a whole should prove to be more profitable than growing either of the crops (Tarhalkar and Rao, 1975). Swaminathan (1980) stated that intercropping system should be based on complementarity between the companion crops and the components of complementarity.

Proper management of intercropping systems can play a definite role in making the traditional system of agriculture a success in India. Choice of crops which have to be grown in an intercropping system plays a vital role in this

regard. Growing crops of dissimilar growth patterns are such that the peak period of growth do not coincide, would ensure optimum productivity of the two crops growing in association.

For long duration crops with a slow initial growth rate, solar energy utilization can be optimised by interplanting quick maturing crops, keeping the plant population constant and altering the row orientation for a paired or tribled row plantings offers more space for accommodating the companion crops (De and Singh, 1981).

2.2.1 Competition for nutrients

Whittington and O'Erein (1988) experimented with different grain mixtures and observed that the deeper rooting component is forced even deeper by the presence of a shallow rooting component. This makes the component crops of a crop mixture to exploit the resources present in the deeper layers of soil.

While working with the uptake of solutes by multiple root systems from soil, Baldwin et al. (1972) observed that there was a tendency for a crop to avoid areas that have already been depleted of resources by an associated crop. This was attributed to mutual avoidance of different root systems on account of differences in rooting patterns.

Any consideration of the use of below ground resources inevitably involves a consideration of rooting

patterns. One possibility is that component crops may exploit different soil layers, thus in combination they may exploit a greater total volume of soil. Osiru and Willey (1972) also concluded from their studies with mixture of dwarf sorghum and beans that higher yields were largely achieved by better utilization of soil resources because of large differences in rooting depths which are known to exist between sorghum and beans.

However, there were many reports to indicate maximum benefits from intercropping could be accured only when the component crops are supplied with full recommended doses of fertilizers for respective crops.

The best understood and perhaps the most important mechanism that can cause the biomass of plants of a genotype to differ between mixed crops and monocultures is the process of competition. Plants are conceived as 'competing' for the limited supplies of environmental resources necessary for growth. In a mixed crops, difference of morphology and physiology between the mixed crop components cause their individuals to experience different micro-environments and hence different resource availabilities from those experienced by plants of the same genotypes in monoculture (Trenbath, 1974).

The experimental out-come of Kumaraswamy and Hosamani (1978) is a case in point wherein the yields of main

crop and intercrops were not reduced in cotton + chilli or cotton + onion mixed cropping when recommended dose of fertilizers were applied to the main crop and the intercrops.

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14

Maximum profit was obtained when both potato and sugarcane were fertilized with recommended dose of fertilizers. Even when sugarcane was grown without P and K with potato (companion crop) has always resulted in higher profit than when grown alone (Chatterjee et al., 1978).

2.2.2 Competition for water

Slater (1955) reported that the differences in the advent of competition for water between crops in a common environment may be due to their patterns of horizontal or vertical distribution of roots or due to internal physiology of plants or both. The success of any species in competition for water will depend on the rate and competitiveness with which it can make use of soil moisture supply.

The practice of mixed cropping also helps to conserve soil moisture in addition to being an antierosion device (Anon., 1980). Water deficiency restricts the growth of crops considerably. The competition for water usually occurs together with other forms of competition especially for nitrogen and light (Donald, 1983).

2.2.3 Competition for light

Clements *et al.* (1929) emphasised that competition for light may begin in very dense communities almost immediately after seedlings emerge. The competition for light differs from that of nutrients and water, in that their supplies is depleted. Hence light energy must be instantaneously intercepted. Donald (1963) stated the successful plant is not necessarily the plant with more foliage, but the plant which has its foliage in an advantageous position relative to the foliage of its competitors for light interception. If water and nutrients are available in adequate supply, competition for these factor ceases, then light becomes the sole limiting factor for production (Donald, 1951) and Blackman and Black, 1959). Leaf layer density dispersion of leaves, leaf angle and vertical distribution of foliage are also important in interception of light.

Greater improvement in spatial use of light is possible when there are greater canopy differences. It is possible to have sparse energy (tall cereal) for higher light intensities at the top of the canopy and a more dense canopy (compact leaves) for lower light intensities at the bottom. There is also possibility of combining crops which have different inherent responses to light (Willey, 1979).

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2.3 Effect of companion crops on the growth, yield and quality of component crop

Eid (1970) found that cotton yield was reduced when it was sown in onion lines spaced at 35 cm but the reduction in the yield was compensated by the yield of onion.

Meenakshi *et al.* (1974) reported that none of the vegetable like bhendi, cowpea, onion, clusterbean, lablab, beetroot, knolkhol and carrot had any adverse effect on the yield of the main crop of maize. In addition, the cultivation of bhendi along with maize gave an additional return of Rs.2,832 per ha during monsoon and Rs.934 per ha during summer season. This was followed by cowpea with maize (Rs.1,934/ha in monsoon and Rs.700/ha during summer).

Yield of seed cotton was 1,580 kg per ha when grown alone and yield of cotton when it was grown with chilli was 1,810 kg per ha and the dry chilli yield was 840 kg per ha. Growing of chilli or chilli + onion as a mixed crop with Varalaxmi cotton did not reduce the yield of seed cotton as compared to Varalaxmi cotton grown alone (Sheelavantar *et al.*; 1974).

Raghumurthy *et al.* (1974) found that growing of onion in paired rows at 25 cm apart as intercrop in cotton was best among all combinations tried. It gave maximum monetary returns.

Kumarswamy (1975) studied intercropping in Varalaxmi cotton. Several intercrops (groundnut, soybean, fodder, cowpea, greengram, blackgram, coriander, chilli, chilli+onion, sorghum, setaria and fodder maize) were tried with protective irrigation. He reported that the seed cotton yield was reduced in all the treatments except in cotton + chilli and cotton + chilli + onion. Plant height, number of branches and dry matter production in cotton grown with chilli or chilli + onion did not differ significantly, from growing of cotton alone. Further, he reported that growing groundnut, chilli + onion, or soybean as intercrops was more beneficial than growing cotton alone. The highest net profit per hectare was obtained from cotton + groundnut followed by cotton + chilli and cotton + chilli + onion. However, labour requirement was maximum for cotton + chilli + onion intercropping followed by cotton+chilli and cotton+groundnut.

Thamburaj and Muthukrishnan (1976) observed that at Coimbatore "Bellary red" onion was the suitable intercrop in tapioca which fetched an additional net profit of Rs.1,036 per ha. The yield of tapioca crop was not much reduced by 'Bellary' onion. The reduction in yield being only one per cent, but with other intercrops like small onion 'CO-2', cowpea-"PUC-2", bhendi-'Pusa Sawani', groundnut and greengram, the reduction ranged between 32 per cent with bhendi to 18.9 per cent with small onion.

Quimio et al. (1977) reported that best results were obtained when ginger was intercropped with soybean followed by sweetcorn and cabbage.

When sugarcane was intercropped with several crops (carrot, peas, garlic, cauliflower, onion and radish) the greatest yield reduction occurred when garlic was intercropped and least reduction with onion. The profits per hectare were greatest on plots with sugarcane + carrot (Parashar et al., 1979).

Bhutad and Parashar (1981) at I.A.R.I., New Delhi, found that the sugarcane cv.CO-1148 was (1) grown alone or intercropped with (2)onion, (3) mungbeans (*Phaseolus aureus*), (4) cowpea (*vignaunqui calata*) or (5) urd (*vigna munga*). The cane received N at 100 or 150 kg per ha and the intercrops were fertilized separately according to the schedule for each crop. Cane yield in (1), (2), (3), (4) and (5) was 59.16, 51.3, 57.5, 51.9 and 50.0 tons per ha respectively.

Maharana and Das (1981) studied the effects of different intercrops in banana (onion, tomatoes, capsicum or potatoes) with different spacings (1.8 x 1.8, 2.5 x 2.5, 2.7 x 1.2 or 3.0 x 3.0 m) on shooting time of banana crop. They found that shooting and harvesting of banana were earliest in plants spaced at 1.8 x 1.8 m and intercropped with onion.

Patil (1981) made study on intercropping in chilli + cotton mixed cropping under rainfed conditions at Dharwad. Several intercrops (groundnut, soybean, green gram, cowpea, pea, Hebbalaware and spotted beans) were tried to find out the suitable intercrop. Except greengram (683.46 kg/ha) other intercrops reduced the yield of chilli.

Rathore *et al.* (1981) reported that onion gave the best results with regard to cane yield and sugar production when sugarcane was planted in rows of 60 or 90 cm apart, potatoes and garlic gave the next best results and wheat depressed the cane yield by 30 per cent. The highest net return was obtained from the potato + sugarcane plot followed closely by plots with cane rows 90 cm apart + 4 rows of onion and plots with cane rows 60 cm apart + 2 rows of garlic under Karnal conditions.

Verma *et al.* (1981) opined that with sugarcane cv. CO-1148, garlic gave higher net returns than sole cane.

Kundu and Chatterjee (1982) studied the growth and yield of turmeric as a sole crop and in mixture with other crops. They reported that biomass production was slow at the early stage of turmeric (70-110 g/m²) at 80-100 days after sowing) than in the mixed crops pigeonpea (900 g/m²) because the cereals and pulses had a faster rate of growth initially. The leaf area indices (6 to 7) in the mixed crop of turmeric with maize or pigeonpea were higher than in the sole crop of

maize or pegeonpea (5) and turmeric (1 to 2). The total yield of processed rhizomes per unit area at 14 per cent moisture was maximum (7.7 t/ha) when 2 rows of turmeric were grown 30 cm apart in between 2 rows of maize planted 80 cm apart. The yield of turmeric was significantly reduced by intercropping; the reduction was less where turmeric was grown with a short duration crop. The wider the gaps between the harvests of 2 companion crops, the lesser was the reduction in yield of turmeric.

In a three year trial the cv. Basrai, grown alone or intercropped with *Curcuma longa*, *Curcuma amada* or *Dioscorea alata*, gave average yields of 55.19, 54.29, 50.20 and 49.08 tonnes per hectare respectively, and the yields of the intercrops were 5543, 1915 and 1380 kg per ha respectively. Only *Curcuma longa* is recommended for intercropping (Chandawat *et al.* 1984).

Umrani *et al.* (1984) studied the profit potentials of different intercropping systems with turmeric. They reported that, association of *moong*, radish and coriander improved the yields of turmeric, though not significantly over sole turmeric. Maize and french bean, however, affected the yield of turmeric adversely. This was particularly so, when maize was grown for grain. The decrease in turmeric yields appeared due to competition by maize. Improved cultivar of maize being vigorous in vegetative growth had shading effect.

This was evident from high fodder yields of maize compared to local. Short duration crops had no adverse effect on turmeric (coriander and radish). The total monetary returns due to various treatments revealed that differences were not significant. Turmeric + radish gave the highest monetary returns (Rs.40,200/ha) followed by turmeric + french bean (Rs.38,304/ha). They yielded Rs.7,487 and Rs.5,681 per ha more than turmeric alone. This worked out to 22.8 and 14 per cent increase over sole turmeric, respectively. Maximum decrease in monetary returns (Rs.415 /ha) was due to intercropping of maize for grain.

Chavan et al. (1985) reported that head weight of cabbages intercropped with radish, palak, *Trigonella foenumgraceum*, Chakwat (*Atriplex hortensis*) and kohlrabi and curd weight of cauliflowers intercropped with beetroot, radish, lettuces, *Romex vesicarius*, onions, *Coriandrum sativum*, chakwat, palak and *Trigonella foenum-graceum* were reduced particularly with cabbages + kohlrabi and cauliflowers + beetroots. Total yield and monetary returns were increased by intercropping cabbages or cauliflower with radish or palak but they were reduced with all the other crop combinations.

Halepyati (1985) reported that higher monetary returns can be obtained by intercropping of sorghum with garlic and groundnut than the traditional cropping system of sorghum + pigeonpea.

Maheshwari *et al.* (1985) tried several intercrops with *Rauwolfia serpentina*, a root crop. Although, the yield of dry roots was higher under monoculture, the net returns were highest on plots where *R. serpentina* was intercropped with soyabeans and onions or soyabeans and garlic.

Abidin *et al.* (1986) tried 10 crop combinations in garlic and they were as follows, (1) garlic + capsicum (one row of capsicum along the edges of the plot), (2) garlic alone in rows, (3) garlic + capsicum (two rows of capsicum along the edges of the plot), (4) capsicum alone, (5) alternate rows of garlic and *Phaseolus vulgaris*, (6) *P. vulgaris*, alone (8) garlic and *P. vulgaris* in separate beds side by side, (9) garlic alone in a single bed, and (10) garlic and capsicum in separate beds side by side. Treatment (2) gave the highest yield of garlic, but the highest monetary returns were with treatment (1). Comparing the two garlic + *P. vulgaris* planting systems, treatment (5) gave higher *P. vulgaris* and lower garlic yields than treatment (8).

Nigam *et al.* (1986) studied the feasibility of intercropping poppy (*Papaver somniferum*) and garlic at two fertility levels in black cotton soil. All intercropping systems were more productive in *toto* than the single crop, but only where garlic was grown on the bunds of poppy plots, the latex yield was as good as that of poppy grown alone.

Asandhi *et al.* (1987) tried the different planting arrangements to study the effect of intercropping of garlic

and red pepper on their growth, yield and land productivity. 23
The planting arrangements were as follows (A) Monocropped garlic planted at 15 cm x 15 cm, (B) Monocropped red pepper (*Capsicum* cv Losari) planted at 60 cm x 60 cm and four intercropping treatments with garlic planted at 15 cm x 15 cm and red peppers planted (c) at 60 cm x 60 cm one months later (D) at 60 cm x 90 cm, one months later, (E) at 80 cm x 80 cm, two months later, or (F) at 80 cm x 80 cm, two months later. The plant height, stem diameter, fresh weight and weight after drying of garlic were unaffected by intercropping, but peppers produced significantly lower yields with treatments (C), (D) and (F) than monocropped peppers. The highest combined yield was with treatment (E), with garlic yielding 2.11 t per ha (85 % of monocropped yield) and pepper yielding 2.72 t per ha (87 % of monocropped yield), giving a Land equivalent ratio of 1.82.

Halepyati *et al.* (1987) reported that when sorghum was intercropped with garlic, there was significant decrease in shootfly incidence on sorghum which was attributed to the presence of antibiotics (garlicin, allicin, diallyl disulphide and diallyl trisulphide) in the garlic bulbs. Sorghum grain yield was significantly higher on intercropped plots (3,215 kg/ha) compared to monoculture (2850 kg/ha) with garlic yield being 605 kg per ha.

Shankaraih *et al.* (1987) studied the different intercrops (maize, chilli, okra and castor) in turmeric crop.

The highest net returns were with two rows of turmeric with one row of maize followed by two rows of turmeric with one row of chilli.

Siddeswaran *et al.* (1987) reported that, the light available to and dry matter production by, finger millet (*Eleusine coracana*) intercropped with sorghum and especially sunflowers was reduced during later growth stages compared with *E. coracana* in pure stands. The light availability was decreased to cluster beans (*Cyanopsis tetragonoloba*), onions and bhendi (okra) as intercrops in *E. coracana*. The light interception by *E. coracana* and the intercrops increased with crop growth.

Balashanmugan *et al.* (1988) studied the five intercropping combinations in turmeric and compared with turmeric in monoculture (control). The highest yield of fresh turmeric rhizomes (28.5 t/ha) was obtained in the combination turmeric + coriander (*Coriandrum sativum*) + onions. Turmeric in monoculture yielded only 15.75 t per ha. The higher yields on intercropped plots were attributed to the beneficial effect of cultivation and earthing up of soil after harvest of the intercrops.

Chowdhary (1988) tried different intercrops (Capsicum, lady's finger, maize, French beans, soybean or sunflower) in ginger. He reported that the monoculture yield

of ginger was highest than the yield obtained from intercropping system. Further the net return from ginger + lady's finger was highest followed by ginger + maize.

Jagrupsingh and Randhawa (1988) studied the effect of intercropping on yield and quality of turmeric. They found that intercropping with pigeon pea (*Cajanus cajan*), maize or green gram (*Vigna radiata*) reduced the availability of light and rhizome yield. However, net returns were higher under intercropping compared with monoculture.

Kadalli et al. (1988) found that, yield of main crop was 48.53 tonnes per ha when capsicum cv Byadagi was intercropped with onion and with onion + beans it was 44.45 tonnes per ha. The yield of the main crop alone was 46.78 tonnes per ha.

2.3.2 Effects of intercrops on the quality of component crops

Rathi and Singh (1978) reported that the sugarcane ratoon yields were enhanced by most of the intercrops tested, either alone or in sequence. The highest yields being obtained with sugarcane + potatoes followed by onion. Juice quality of sugarcane was not affected.

Nigam et al. (1986) studied the feasibility of several intercrops with papaya. All intercropping systems were more productive than sole cropping but the quality of papaya latex was unaffected only when it was grown along with garlic.

Ravishankar and Muthuswamy (1987) found that, intercropping had no adverse effect on quality of rhizomes, when ginger cv Rio-de-Janerio was raised as an intercrop in two and six year old arecanut plantations in which the trees were spaced at 2.75 m x 2.75 m.

Jagrup singh and Randhwa (1988) observed that, the oil and curcumin contents were not affected when turmeric was intercropped with piegion pea (*Cajanus cajan*) maize or green gram (*Vigna radiata*).

2.4 Economics of intercropping system

Balasubramaniam and Sundaram (1947) observed that irrespective of periodical partial failures of chilli crop, the monetary returns per acre were always on the higher side for the mixture of chilli and cotton.

Mathur (1963) suggested from his investigation of the study region of Vidarbha that intercropping gave higher and more dependable gross returns per unit of labour employed. Intercropping was found to ensure greater as well as more even employment of labour in Vidarbha. He reported that the value of sole crops of cotton, jowar, groundnut and wheat per acre was Rs.40.24, Rs.25.00, Rs.53.00 and Rs.87.88, respectively as compared to Rs.59.78, Rs.36.52, Rs.85.03 and Rs.77.23 respectively, for the related combinations of crops per acre.

He noted that there was no increase in the yield of wheat combinations as compared to sole crop due to lack of complementary effect.

Hunsigi (1969) opined that in the assured rainfall areas of Dharwad, the mixed cropping of groundnut with cotton gave maximum monetary returns.

Negi and Singh (1971) from their study on mixed cropping of soybean with maize and sorghum reported that highest return of Rs.2872 per hectare was obtained from maize and soybean combination in single alternate rows.

In an experiment conducted at Pantanagar on mixed cropping of soyabean with maize, maximum return of Rs.5,183 per hectare in 2:2 proportion followed in soybean and combination in single alternate rows was obtained (Anon., 1972).

Laxman singh et al. (1973) reported that sorghum and pigeon pea yielded 1.91 tons and 0.56 ton per hectare, respectively, when four rows of sorghum were alternated with two rows of pigeonpea. When sorghum and pigeonpea in 4:1 seed mixture were sown in the same row; the respective yields were found to be 1.67 tons and 0.42 ton only.

Raghumurthy et al. (1974) found that growing of onion in paired rows of 25 cm apart as intercrop in cotton was the best among all the combinations tried (Rs.11,412/ha net return).

In an experiment conducted at Dharwad, the highest net profit per hectare was obtained from cotton + groundnut, followed by cotton + chilli and cotton + chilli + onion. The net profit per hectare was Rs.4,986/-, Rs.3,714/- and Rs.3,425/-, respectively. However, labour requirement was maximum for cotton + chilli + onion, followed by cotton + chilli and cotton + groundnut (Kumarswamy et al., 1977).

Overlapping of cotton in onion, chilli and groundnut would be more remunerative than growing of entire cotton, although yield of cotton would be decreased by 20 per cent (Anon., 1978).

Chandravounshi (1978) reported that growing pigeon pea and soybean with sorghum gave higher yields and better returns, compared to solecrops.

Tarhalkar and Rao (1978) observed for sole sorghum, sorghum paired rows (80-30 cm), sorghum/soybean, sorghum/groundnut, sorghum/castor, sorghum/pigeon pea, the total monetary returns to be Rs.6772, 7571, 7806, 7521, 7614 and 8422 per hectare respectively.

Sanandachari *et al.* (1980) observed that the gross income was maximum (Rs.3430/ha) when two rows of blackgram were grown as intercrop over normally sown cotton without intercrop (Rs.3222/ha).

When the turmeric was intercropped with okra, onion, radish, phaseolus beans, fenugreek or coriander as the first intercrop and with one of the above crops (except beans and okra) or amaranthus or beetroot as the second crop, the highest net income was obtained from the combination of turmeric (main crop)+ fenugreek (1st intercrop) + onion (2nd intercrop), and the next highest from turmeric + beans + beetroot (Sekar and Muthuswamy, 1985).

Soybean intercropped with maize in 1:1 rows and 2:2 alternate paired rows fetched Rs.4300 to Rs.5800 and Rs.2500 to Rs.4600 per hectare respectively as returns over sole crop of maize (Patra and Chatterjee, 1986).

Mallangouda (1991) from his study on companion cropping in chilli cv. Byadgi reported that maximum gross monetary returns were obtained from chilli + garlic companion cropping (Rs.17,050/ha) followed by chilli + coriander (Rs.17,931/ha) and chilli + onion (Rs.14,725/ha).

CHAPTER - III

MATERIAL AND METHODS

III. MATERIALS AND METHODS

A field experiment on companion cropping in turmeric was carried out during *Kharif* season, 1981 on medium black soils at the college of Agriculture Dharwad. Details of the materials used and methods adopted for the study are described in this chapter.

3.1 Experimental site

The experiment was carried out on medium black soils in the plantation crops unit of the Department of Horticulture, College of Agriculture, Dharwad.

3.2 Climate and weather

The plantation crops unit is situated in the transitional tract at 15°-28' north latitude 76°-07' east longitude at an altitude of 878m., from the M.S.L. It receives a mean annual rainfall of 840.8 mm, fairly well distributed from April to November with two peaks, one in July and another in October. The mean maximum temperature varies from 26.5°C in July to 36.3°C in April whereas mean minimum temperature varies from 14.4°C in January to 21°C in May. The mean relative humidity is the highest (86%) during the month of July and the lowest (50%) during the month of February. The meteorological data of the past 40 years and the data pertaining to the year of investigation as recorded at the

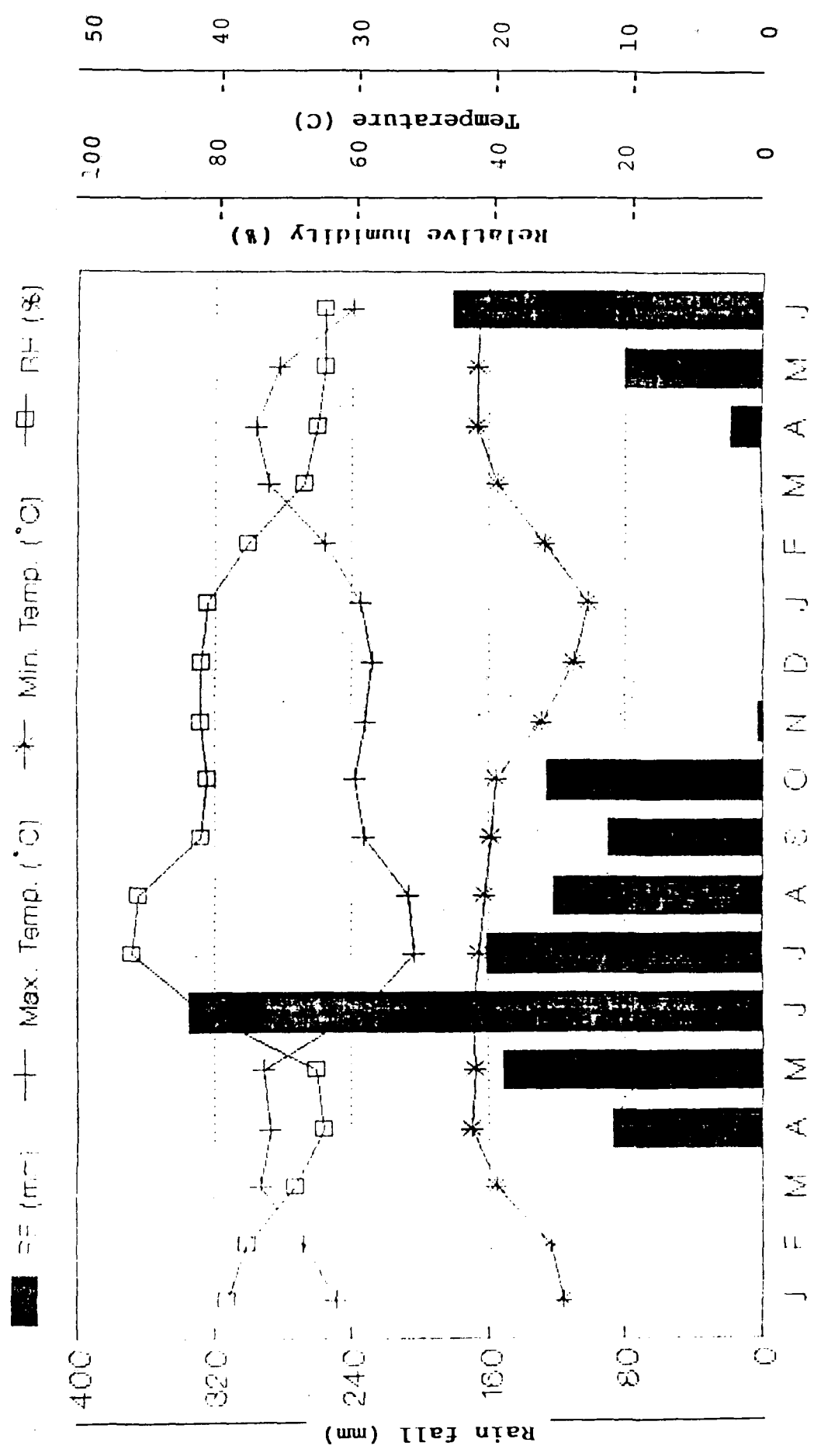


FIG. 1 METEOROLOGICAL DATA OF AGRICULTURAL COLLEGE FARM, DHARWAD, FOR THE YEAR 1991-92

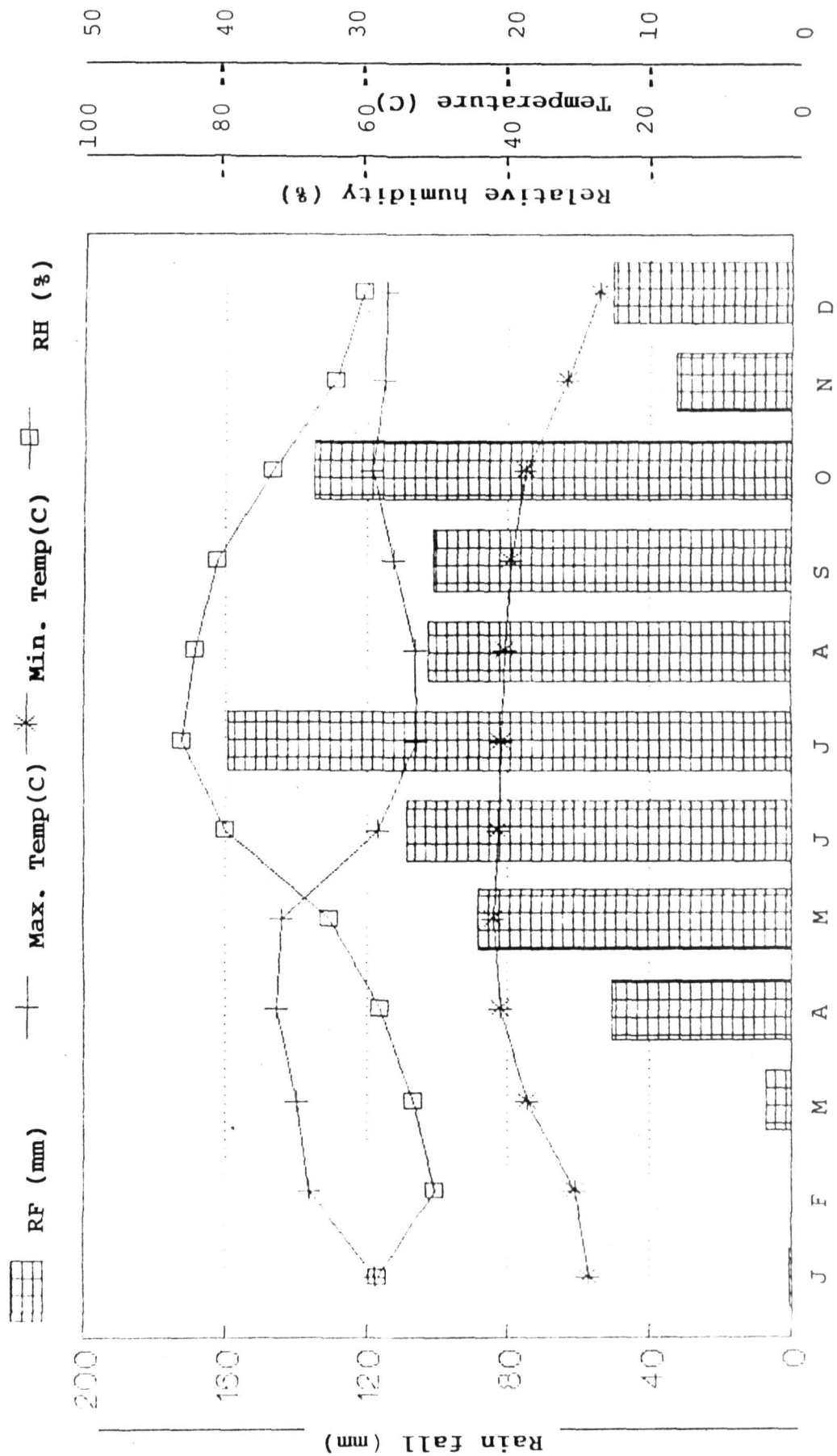


FIG. 2 METEOROLOGICAL DATA OF AGRICULTURAL COLLEGE FARM,
DHARWAD (AVERAGE OF 40 YEARS, 1951-1990)

meteorological observatory of the Agricultural College Farm, Dharwad are presented in Appendix-I, Figure 1 and 2.

2.3 Soil and its characteristics

The experimental site comprised of black soil. The fertility status of the soil was estimated prior to the lay out of an experiment by analysing the soil for its physico-chemical characteristics and the data are furnished in Table-1.

3.4 Experimental details

3.4.1 Treatments

There were thirteen treatment combinations comprising of four companion crops involving turmeric as main crop. For companion crops three fertilizer levels were tried.

A. Treatment details

- 1) Turmeric alone
- 2) Turmeric + Onion
- 3) Turmeric + Garlic
- 4) Turmeric + Coriander
- 5) Turmeric + Soybean

B. Fertilizer levels for companion crops

- 1) No fertilizer for companion crops.
- 2) 50 % recommended dose of fertilizer for companion crops.
- 3) Recommended dose of fertilizer for companion crops.

Table 1 Physical and chemical properties of the soil of experimental site

Particulars	Characterization (10-30 cm)	Method employed
I Physical properties :		
Clay (%)	53.00	Hydrometer method (Piper, 1950)
Silt (%)	28.00	Hydrometer method (Piper, 1950)
Fine sand (%)	13.00	Hydrometer method (Piper, 1950)
Coarse sand (%)	6.00	Hydrometer method (Piper, 1950)
II Chemical properties :		
Total carbon (%)	0.73	Modified Kjeldahl's method (Jackson, 1967)
Total nitrogen (%)	0.13	Modified Kjeldahl's method (Jackson, 1967)
Available phosphorus (Kg/ha)	54.34	Olsen's method (Muhr <i>et al.</i> , 1965)
Available potassium (Kg/ha)	672.00	Flame photometer method (Mohr <i>et al.</i> , 1965)
III pH (1:2.5 soil:water)	7.7	pH meter (Piper, 1950)

For turmeric, fertilizer dose was common and recommended dose was applied.

Recommended dose of fertilizers

Turmeric	:	180 Kg N	+	90 Kg P_2O_5	+	90 Kg K_2O /ha
Onion	:	125 Kg N	+	50 Kg P_2O_5	+	125 Kg K_2O /ha
Garlic	:	125 Kg N	+	62.5 Kg P_2O_5	+	62.5 Kg K_2O /ha
Coriander	:	37.5 Kg N	+	37.5 Kg P_2O_5	+	37.5 Kg K_2O /ha
Soybean	:	37.5 Kg N	+	37.5 Kg P_2O_5	+	37.5 Kg K_2O /ha

Treatment combinations

In all, there were 13 treatment combinations as indicated below.

- T₁ - Turmeric alone (check).
- T₂ - Turmeric + onion with no fertilizer to companion crop.
- T₃ - Turmeric + onion with 50 per cent recommended dose of fertilizer to companion crop.
- T₄ - Turmeric + onion with recommended dose of fertilizer to companion crop.
- T₅ - Turmeric + garlic with no fertilizer to companion crop.
- T₆ - Turmeric + garlic with 50 per cent recommended dose of fertilizer to companion crop.
- T₇ - Turmeric + garlic with recommended dose of fertilizer to companion crop.
- T₈ - Turmeric + coriander with no fertilizer to companion crop.

Plate 1. General view of experimental site



- T₉ - Turmeric + coriander with 50 per cent recommended dose of fertilizer to companion crop.
- T₁₀ - Turmeric + coriander with recommended dose of fertilizer to companion crop.
- T₁₁ - Turmeric + soybean with no fertilizer to companion crop.
- T₁₂ - Turmeric + soybean with 50 per cent recommended dose of fertilizer to companion crop.
- T₁₃ - Turmeric + soybean with recommended dose of fertilizer to companion crop.

3.4.2 Design and layout

The experiment was laid out in simple randomised block design with three replications. The plan of lay out is given in Figure 2.

Plot size : 1. Gross : 3.6 m x 2.4 m = 8.64 m².
 2. Net : 2.4 m x 1.8 m = 4.32 m².

3.5 Cultivars used in the experiment

3.5.1 Turmeric

High yielding cultivar PCT-8 released from Central Plantation Crops Research Institute, Regional Station Calicut, Kerala, which is a medium duration turmeric culture (220-240 days) was used for the study.

LEGEND

- T₁ Turmeric alone (check)
- T₂ Turmeric + onion with no fertilizer to companion crop
- T₃ Turmeric + onion with 50% recommended dose of fertilizer to companion crop
- T₄ Turmeric + onion with recommended dose of fertilizer to companion crop
- T₅ Turmeric + garlic with no fertilizer to companion crop
- T₆ Turmeric + garlic with 50% recommended dose of fertilizer to companion crop
- T₇ Turmeric + garlic with recommended dose of fertilizer to companion crop
- T₈ Turmeric + coriander with no fertilizer to companion crop
- T₉ Turmeric + coriander with 50% recommended dose of fertilizer to companion crop
- T₁₀ Turmeric + coriander with recommended dose of fertilizer to companion crop
- T₁₁ Turmeric + soybean with no fertilizer to companion crop
- T₁₂ Turmeric + soybean with 50% recommended dose of fertilizer to companion crop
- T₁₃ Turmeric + soybean with recommended dose of fertilizer to companion crop

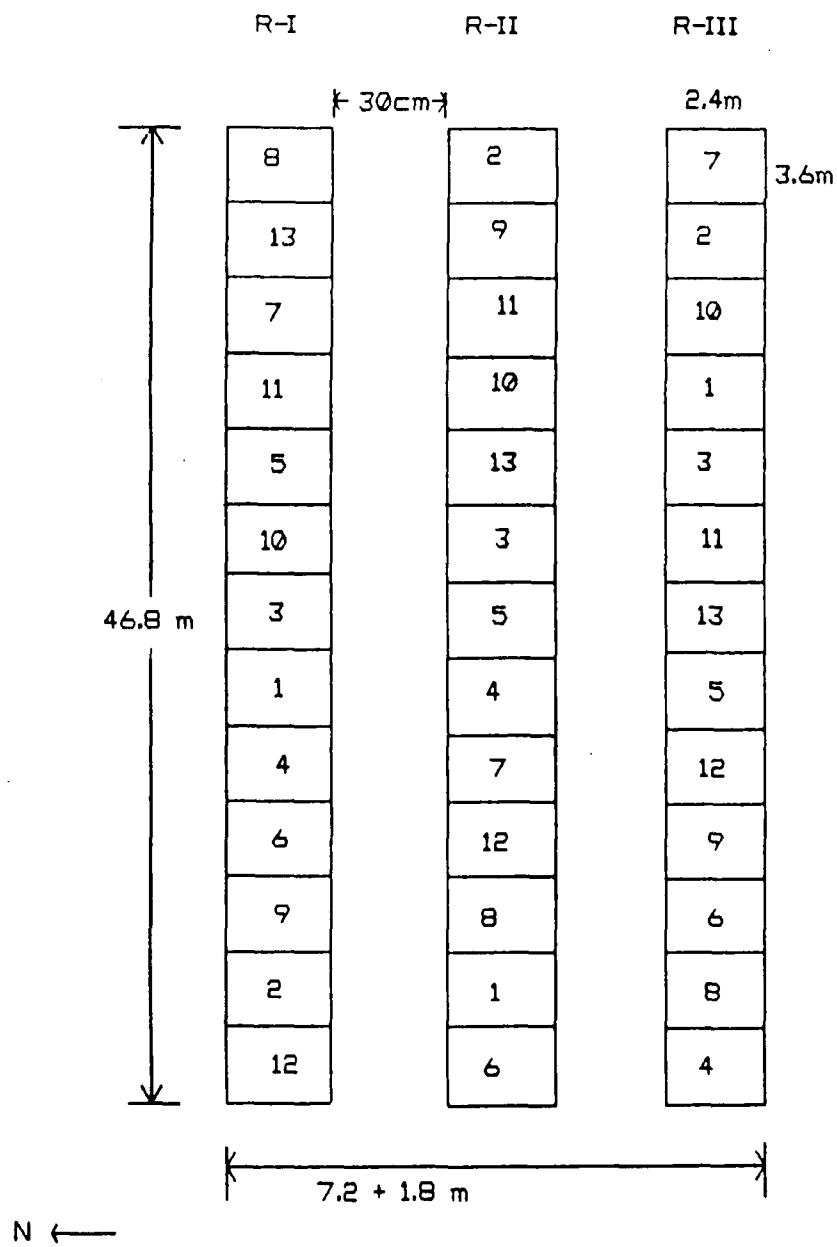


FIG. 3 PLAN OF LAYOUT

3.5.2 Onion

The Nasik Red onion was selected for the trial. It is high yielding variety with medium to large size bulbs.

3.5.3 Garlic

The local high yielding cultivar was used for the trial. It has small to medium size bulbs with medium size cloves.

3.5.4 Coriander

The local high yielding cultivar with high branching character was selected for the trial.

3.5.5 Soybean

The PK-471 soybean was used for trial.

3.6 Cultural operations

The land was brought to fine tilth by ploughing and discing followed by two harrowing. The experiment was laid out as per the plan.

3.6.1 Manures and manuring

Farm yard manure at the rate of 30 tonnes per hectare was applied as a basal dose. The nutrients (NPK) were applied in the form of urea., super phosphate and murate of potash. Half dose of nitrogen was applied at the time of planting as per treatment combination and remaining half dose

of nitrogen was applied 45 days after planting for turmeric and 30 days after sowing for companion crops. The fertilizers were placed in the form of band, 5 cm deep from the soil surface and 5 cm away from the seed rows.

3.6.2 Seed material and planting

Healthy finger rhizomes of PCT-8 turmeric with well developed buds were utilized for planting.

Ridges and furrows were prepared at a spacing of 60 cm in each plot lengthwise. Planting of rhizomes of turmeric and sowing of onion, garlic, coriander and soybean were done on the nineteenth day of June 1991.

Rhizomes of turmeric were planted on one side of the ridge. Sowing of onion, garlic, coriander and soybean was done on the other side of the ridge as per treatment combinations. The seed rate and spacing followed was as follows.

3.6.3 Planting and spacing

One row of companion crop in between the two rows of turmeric was planted.

Crop	Spacing
Turmeric	60 cm x 30 cm
Onion	60 cm x 15 cm
Garlic	60 cm x 10 cm
Coriander	60 cm x 7.5 cm
Soybean	60 cm x 10 cm

3.6.4 Irrigation and after cultivation

Irrigations were given depending on the soil moisture conditions and the rainfall. Hand weeding was done at monthly interval from planting and a total of six weeding were done during the crop growth period of turmeric.

After sowing of onion, garlic, coriander and soybean gap filling was done on seventh day. The thinning was done 15 days after sowing, so as to maintain one plant per spot in a row. Earthing up was done to all crops.

3.7 Harvesting

3.7.1 Harvesting of main crop

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, (230 days after planting). Rhizomes dug out from the soil were cleaned of adhering dirt and the sticking roots.

3.7.2 Harvesting of companion crops

In case of onion and garlic, the bulbs were harvested when the leaves turned yellow and tops had fallen. The bulbs were uprooted and cured in the sun for a week.

In case of coriander, the crop was harvested when the grains attained maturity as indicated by changing of grain

colour to yellowish tinge. The plants were uprooted and sundried for three days. The grains were threshed and again sundried for two days.

In case of soybean, the crop was harvested after attaining physiological maturity. The plants were uprooted and pods were separated from the plants. Seeds were extracted from the pods and sundried for a day.

3.8 Observations recorded

All the observations were made on the randomly selected five plants in each treatment combination and their mean was expressed in all the cases.

3.8.1 Turmeric

3.8.1.1 Plant height

The plant height was measured from the ground level to the end of the petiole of the top most (youngest) leaf. The height of the plant was recorded at three stages of growth viz., 90, 120, 150 days after planting. As indicated earlier five plants were taken for observations in each treatment and their average value was taken. Height of the plant was expressed in centimeter.

Plate 2 Turmeric alone



Plate 2

3.8.1.2 Number of leaves

Fully opened leaves were counted in each labelled plant on main shoot at 90, 120 and 150 days after planting and mean was worked out.

3.8.1.3 Leaf area

The length of the leaf was noted from the leaf blade joint to the tip of the leaf along the midrib and width was recorded 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. The conversion factor was arrived at by dividing the actual leaf area recorded on a graph sheet by computed leaf area (length x width) (Raghava Rao and Swamy, 1984).

3.8.1.4 Fresh weight

Five plants in each treatment were uprooted randomly and partitioned into aerial parts (leaves+pseudostem), rhizome and roots. The cumulative weight of these separated plant parts, was noted and their average was expressed as fresh weight of plant in gram.

3.8.1.5 Dry matter production

From these five plants the aerial part, root and rhizomes were separately dried at 70°C in hot air oven until constant weight was attained. The average value was expressed as dry matter per plant in gram.

3.8.1.6 Yield of fresh rhizomes

At the time of harvest, rhizomes from each net plot were weighed and recorded separately.

3.8.1.7 Number of mother rhizomes, primary fingers and secondary fingers

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

3.8.1.8 Circumference of mother rhizome, primary fingers and secondary fingers

Five mother rhizomes, primary fingers and secondary fingers were taken from the produce of randomly selected five plants for the purpose, diameter was recorded with the help of vernier calipers and circumference was computed by the formula $\pi \times D$.

3.8.1.9 Length of primary and secondary fingers

Five primary and secondary fingers were taken for observations in each treatment and their average length was recorded and expressed in terms of centimeter.

3.8.2.1 Tissue composition of plants and uptake of nutrients (N, P and K)

Plant samples collected to estimate the dry matter accumulation were partitioned into aerial part (Pseudostem + leaves), roots and rhizomes and N, P and K content were estimated separately in each of the above mentioned parts. The uptake of major nutrients in different parts of the plant and also in the whole plant was worked out by multiplying the per cent content of respective nutrient with dry matter of respective part.

3.8.2.2 Nitrogen

Nitrogen content in rhizome, root and aerial portions was estimated by following modified Kjeldahl's procedure as described by Jackson (1967).

3.8.2.3 Phosphorus

Phosphorus content in rhizome, root and aerial part was determined calorimetrically as suggested by Jackson (1967) employing Vanidomolybdate yellow colour method. Yellow colour intensity was read in spectrophotometer at 470 nm.

3.8.2.4 Potassium

Potassium content in rhizome, root and aerial part was recorded with the help of Flame photometer.

3.8.2.5 Curing percentage of rhizomes

Fresh turmeric yield was recorded by taking the weight of rhizomes harvested from each plot which was used for computation of per hectare yield. Fingers were separated from mother rhizomes. A sample of one Kg of fresh rhizomes from each plot was boiled in the perforated trough containing the alkaline solution prepared by dissolving 100 g of sodium bicarbonate in 100 liters of water, so as to immerse the turmeric fingers. The whole mass was boiled till the fingers become soft to finger pressure and froth comes out with white fumes appeared giving out a typical odour. The boiling lasted for 45-60 minutes. It was thought that alkalinity of the boiling water helps in imparting the average yellow tinge to the core of turmeric. After boiling, rhizomes were dried under sun. Curing percentage was worked out and expressed as yield per hectare.

3.8.2.6 Estimation of curcumin content

About 0.2 g of fine ground turmeric powder was extracted by refluxing over a water cooled condenser with 40 ml of distilled alcohol for 2 hour 30 min. The extract was transferred to a 100 ml volumetric flask and made to volume with alcohol. It was then filtered and aliquot of 5 ml was transferred to a 100 ml vol. flask and made to volume. 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, the curcumin percentage was calculated.

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

Procedure suggested by Manjunath et al. (1991) was followed for the estimation of curcumin content.

3.8.3 Statistical analysis of the data

Fishers method of analysis of variance as given by Panse and Sukhatme (1967) was applied for analysis and interpretation of data. The level of significance used in 'F' and 't' tests were at $P = 0.05$. Critical differences (CD) were worked out wherever 'F' test was significant. The results are presented in tabular form.

3.8.4 Onion

3.8.4.1 Plant height

In each plot, five plants were tagged randomly and plant height was recorded from the ground level to the tip of the longest leaf of the plant.

3.8.4.2 Number of leaves per plant

The number of total green leaves per plant was recorded.

3.8.4.3 Fresh weight of plant

In each plot, five plants were uprooted randomly and weighed. Average of this was taken as fresh weight of plant in gram.

Plate 3. Onion as companion crop in turmeric



3.8.4.4 Total dry matter accumulation

Five plants at random were uprooted for this purpose. Total dry matter accumulation in plant was recorded in gram after drying the samples in hot air oven at 85°C for 48 hours.

3.8.4.5 Neck diameter

From the five randomly selected plants, neck diameter was taken using vernier calipers and was expressed in cm, then average neck diameter was worked out.

3.8.4.6 Yield components

i) Diameter of the bulb

From the produce harvested from each plot, five bulbs were taken randomly and diameter (girth) of the bulbs was determined by using a vernier calipers and diameter was expressed in cm.

ii) Fresh weight of bulb

Five bulbs were taken from each plot and fresh weight was noted and expressed as gram per bulb.

iii) Bulb yield

The bulbs from net plot area were harvested and the weight of bulbs in each plot was recorded and yield was expressed in Kg per ha.

3.8.5 Garlic

3.8.5.1 Plant height

In each plot, five plants were taken randomly and tagged and plant height was recorded from the ground level to the tip of the longest leaf of the plant.

3.8.5.2 Number of leaves per plant

The number of total green leaves per plant was recorded.

3.8.5.3 Fresh weight of plant

Five randomly selected plants in each plot were weighed immediately after uprooting and recorded as fresh weight of plant.

3.8.5.4 Dry weight per plant

Aerial portion and bulbs of the five plants were oven dried at 60°C for 48 hours and weighed to note the dry weight of plant. Average was calculated and expressed as dry weight per plant in gram.

3.8.5.5 Neck thickness

Neck thickness was recorded by using vernier calipers. Average of five plants was taken as neck thickness per plant and expressed in cm.

Plate 4. Garlic as companion crop in turmeric



Plate 4

3.8.5.6 Yield components

i) Diameter of the bulb

From the bulbs harvested in each plot, 10 bulbs were selected randomly and diameter of the bulbs was determined by using a vernier calipers and expressed in cm.

ii) Fresh weight of bulb

Ten bulbs were taken from each plot, fresh weight was noted and the weight of the bulb was expressed in gram.

iii) Dry weight of bulb

After recording the fresh weight, the bulbs were air dried for 15 days, dry weight of bulbs was recorded and expressed in gram.

iv) Number of cloves per bulb

Ten garlic bulbs were taken and cloves were counted. Average of these was taken as number of bulbils per bulb.

v) Bulb yield per hectare

The total yield per net plot was recorded and on the basis of this yield per hectare was computed.

3.8.8 Coriander

3.8.6.1 Plant height

In each plot, five plants were tagged randomly and height was recorded by measuring from the ground level to the tip of the longest branch and expressed in cm.

3.8.6.2 Number of primary branches

Randomly selected five plants were used for counting primary branches on main stalk. Total number of branches was counted and average worked out was taken.

3.8.6.3 Number of secondary branches

Plants selected for counting primary branches were used for counting secondary branches on primary branches. Total number of such branches were pooled and average of secondary branches were recorded.

3.8.6.4 Fresh weight of plant (g)

Five randomly selected plants in each plot were weighed immediately after uprooting from ground and recorded as fresh weight of plant.

3.8.6.5 Dry weight per plant (g)

The plants used for recording fresh weight were dried for a week and then they were oven-dried. The dry weight was recorded immediately after drying.

Plate 5. Coriander as companion crop in turmeric



Plate 5

3.8.6.6 Yield components

i) Number of umbels per plant

Total number of umbels on five plants were counted, summed up and average of these umbels was recorded as umbels per plant.

ii) Number of seeds per umbel

For expressing number of seeds per umbel, umbel produced only on main stem were considered. Average values obtained with five plants was expressed as number of seeds per umbel.

iii) Seed yield

Sundried seeds from each net plot were winnowed, cleaned and weighed. On the basis of per plot yield, yield per hectare was worked out and expressed in terms of kilogram.

3.8.7 Soybean

3.8.7.1 Plant height

In each plot, five plants were tagged randomly and plant height was recorded by measuring from the ground level to the tip of the longest branch and expressed in cm.

3.8.7.2 Number of leaves per plant

The number of total leaves per plant was recorded from five plants and average was taken.

Plate 6. Soybean as companion crop in turmeric



3.8.7.3 Number of primary branches per plant

Randomly selected five plants were used for counting primary branches on main stalk. Total number of branches was counted and average worked out was taken.

3.8.7.4 Number of secondary branches per plant

Plants selected for counting primary branches were used for counting secondary branches on primary branches. Total number of such branches were pooled and average of secondary branches was recorded.

3.8.7.5 Fresh weight of plant

Five randomly selected plants from each plot were weighed immediately after uprooting from the ground and recorded as fresh weight of plant.

3.8.7.6 Dry weight of plant

Five randomly selected plants from each plot were dried in oven at 60°C for 48 hours and dry weight was recorded immediately after drying.

3.8.7.7 Yield components

i) Number of pods per plant

The number of pods from the five tagged plants were counted. The average of five plants was taken as the number of pods per plant.

ii) Weight of the pods per plant

Pods separated from five plants were pooled and sundried (15 per cent moisture) and weighed, then mean weight was recorded.

iii) Number of grains per pod

Pods from five randomly selected plants were threshed and number of grains was counted. This number was divided by the number of pods to get number of grains per pod.

iv) Thousand grain weight

From the grains obtained from the sample plants, 250 grams of soybean were taken at random and the weight was recorded. This was converted to thousand grain weight.

v) Grain yield

The weight of seeds obtained from the net plot including seeds obtained from the sample plants was recorded. Later seed yield of each plot was converted to kilogram per hectare.

3.9 Chemical analysis

3.9.1 Nitrogen

The nitrogen content was estimated on whole plant basis by adopting micro-kj-eldahl method as described by Jackson (1967). The nitrogen uptake per hectare was calculated by multiplying the percentage with total dry matter production.

3.9.2 Phosphorus

The phosphorus content of plant was determined by using tri-acid mixture for digestion and developing colour with vanedomolybdate as described in case of nitrogen (Jackson, 1967).

3.9.3 Potassium

The potassium content of plant sample was determined by Flame photometer by using tri-acid digested aliquot as described by Jackson (1967). The potassium uptake was calculated as narrated in case of nitrogen.

3.10 Economics

The cost of cultivation of companion cropping system was calculated by taking the following inputs into account.

1. Labour (from land preparation to harvest of crops).
2. Seeds.
3. Fertilizers and manures.
4. Miscellaneous (land rent, marketing charges etc.).

The prices of the inputs that were prevailing at the time of their use and prices of crop commodities at harvest were taken to work out the cost of cultivation and gross income.

The prices of crop commodities and different inputs used in calculation are given in Appendix-II.

The net income per hectare was calculated by deducting the cost of cultivation per hectare from the gross income per hectare.

CHAPTER - IV

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results obtained from the studies on companion cropping in turmeric conducted at the college of Agriculture, Dharwad are presented in this chapter.

4.1 Growth parameters of turmeric

4.1.1 Plant height

Data pertaining to plant height of turmeric at different growth stages as influenced by companion crops with different fertilizer levels to companion crops are presented in Table 2.

90 days after planting

Companion crops significantly affected the plant height of main crop. Turmeric recorded maximum plant height (17.5 cm) when it was grown alone. It was significantly higher than that of turmeric grown along with coriander and soybean with recommended dose of fertilizer for companion crops. Turmeric + garlic (16.0 cm) and turmeric + onion (15.5 cm) with recommended dose of fertilizer for companion crops recorded higher plant height compared to turmeric + coriander (14.4 cm) and turmeric + soybean (13.9 cm).

Table 2 Plant height (cm) of turmeric as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Days after planting		
		90	120	150
T ₁	Turmeric alone (check)	17.58	19.88	23.98
T ₂	Turmeric + onion with no fertilizer to companion crop	14.14	16.44	20.54
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	15.38	17.68	21.78
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	15.56	17.86	21.96
T ₅	Turmeric + garlic with no fertilizer to companion crop	15.15	17.45	21.55
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	15.52	17.82	21.92
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	16.01	18.41	22.61
T ₈	Turmeric + coriander with no fertilizer to companion crop	12.97	15.07	19.07
T ₉	Turmeric + coriander withh 50 % recommended dose of fertilizer to companion crop	13.53	15.66	19.63
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	14.39	16.49	20.65
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	11.50	13.30	17.45
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	13.17	15.17	19.32
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	13.95	15.98	20.10
S.E.m. ±		0.94	0.94	0.94
C.D at 5%		2.74	2.75	2.75

Difference in the plant height of turmeric due to different fertilizer levels to companion crops was non-significant. However, application of recommended dose of fertilizer to companion crops recorded higher plant height.

120 days after planting

Plant height of turmeric was significantly affected by companion crops. Turmeric alone (check) recorded significantly higher plant height (19.8 cm) as compared to turmeric + coriander (16.4 cm) and turmeric + soybean (15.9 cm) with recommended dose of fertilizer for companion crops, but it did not differ significantly from turmeric + garlic (18.4 cm) and turmeric + onion (17.8 cm) with recommended dose of fertilizer for companion crops.

Non-significant difference in the plant height of turmeric due to varying fertilizer levels to companion crops was observed. However, higher plant height was recorded with the application of recommended dose of fertilizer to companion crop.

150 days after planting

At 150 days after planting also similar trend was observed. Significantly higher plant height was noticed in turmeric alone (23.8 cm) as compared to turmeric + coriander (20.6 cm) and turmeric + soybean (20.1 cm) with recommended dose of fertilizer for companion crops. However, it did not

differ significantly from turmeric + garlic (22.6 cm) and turmeric + onion (21.8 cm) with recommended dose of fertilizer for companion crops.

Variation in the plant height of turmeric due to different fertilizer levels to companion crops was non-significant. Application of recommended dose of fertilizer to companion crops recorded higher plant height and lowest was in the treatment without fertilizer.

4.1.2 Number of leaves per plant

The data on number of leaves per plant in turmeric as influenced by companion crops with different fertilizer levels are presented in Table 3.

90 days after planting

Number of leaves per plant in turmeric was significantly affected by companion crops viz., coriander and soybean. Turmeric alone (check) (7.0) and turmeric + garlic (6.7) with recommended dose of fertilizer for garlic recorded significantly higher number of leaves per plant as compared to turmeric + coriander (6.2) and turmeric + soybean (6.0) with recommended dose of fertilizer for companion crops, where as turmeric + onion (6.5) with recommended dose of fertilizer for onion was on par with turmeric + garlic (6.7).

Application of recommended dose of fertilizer to companion crops recorded significantly higher number of leaves per plant as compared to the treatment without fertilizer.

120 days after planting

Number of leaves per plant in turmeric varied significantly due to companion crops. Turmeric alone (check) produced the highest number of leaves per plant (8.8) and was significantly higher as compared to turmeric + onion (8.3), turmeric + coriander (7.9) and turmeric + soybean (7.7) with recommended dose of fertilizer for companion crops but it did not differ significantly from turmeric + garlic (8.5) with recommended dose of fertilizer for garlic.

Significantly higher number of leaves per plant was observed with the application of recommended dose of fertilizer to companion crops compared to the treatment without fertilizer.

150 days after planting

The variation in the number of leaves per plant due to companion crops was significant. Turmeric + garlic (10.6) with recommended dose of fertilizer for garlic recorded significantly higher number of leaves per plant compared to turmeric + coriander (10.0) and turmeric + soybean (9.8) and it was at par with turmeric alone (11.0). Turmeric + onion (10.4) and turmeric + garlic with recommended dose of fertilizer were on par with each other.

Table 3 Number of leaves and leaf area per plant in turmeric as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Number of leaves per plant			Leaf area (dm ²) per plant		
		Days after planting			Days after planting		
		90	120	150	90	120	150
T ₁	Turmeric alone (check)	7.00	8.86	11.08	22.20	32.06	43.55
T ₂	Turmeric + onion with no fertilizer to companion crop	5.86	7.53	9.56	14.64	23.31	34.63
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	6.33	8.03	10.30	15.93	25.17	37.5-
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	6.53	8.33	10.46	15.24	25.87	38.75
T ₅	Turmeric + garlic with no fertilizer to companion crop	6.20	7.66	9.73	15.20	24.37	36.4-
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	6.63	8.33	10.33	15.28	25.97	39.39
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	6.73	8.50	10.56	15.58	26.39	40.44
T ₈	Turmeric + coriander with no fertilizer to companion crop	5.73	7.30	9.40	9.11	19.30	34.12
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	6.06	7.80	9.83	13.02	21.11	36.65
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	6.26	7.96	10.03	13.44	21.52	37.95
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	5.60	7.23	9.16	9.00	19.51	31.05
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	5.70	7.35	9.46	9.81	21.09	34.33
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	6.10	7.78	9.80	10.28	21.63	35.14
S.E.m. ±		0.16	0.17	0.16	0.53	0.50	1.43
C.D at 5%		0.47	0.51	0.47	1.58	1.46	4.20

Application of recommended dose of fertilizer to companion crops recorded significantly higher number of leaves per plant as compared to treatment without fertilizer.

4.1.3 Leaf area (dm^2) per plant

Data pertaining to leaf area of turmeric per plant at different growth stages as influenced by companion crops with different fertilizer levels are presented in Table 3.

90 days after planting

Significant difference in the leaf area of turmeric per plant was noticed due to companion crops. Highest leaf area was recorded in turmeric alone (check) (22.2 dm^2) and lowest leaf area was with turmeric + soybean (9.0 dm^2) without fertilizers for soybean. Turmeric + garlic (16.5 dm^2) and turmeric + onion (16.2 dm^2) with recommended dose of fertilizer recorded significantly higher leaf area compared to turmeric + coriander (10.4 dm^2) and turmeric + soybean (10.2 dm^2) and were on par with each other. There was no significant difference between turmeric+coriander and turmeric+ soybean.

Application of recommended dose of fertilizer to companion crops recorded higher leaf area compared to other two treatments, but there was no significant difference.

120 days after planting

Leaf area in turmeric per plant varied significantly due to companion crops. Turmeric alone (check) achieved the

LEGEND

- T₁ Turmeric alone (check)
- T₂ Turmeric + onion with no fertilizer to companion crop
- T₃ Turmeric + onion with 50% recommended dose of fertilizer to companion crop
- T₄ Turmeric + onion with recommended dose of fertilizer to companion crop
- T₅ Turmeric + garlic with no fertilizer to companion crop
- T₆ Turmeric + garlic with 50% recommended dose of fertilizer to companion crop
- T₇ Turmeric + garlic with recommended dose of fertilizer to companion crop
- T₈ Turmeric + coriander with no fertilizer to companion crop
- T₉ Turmeric + coriander with 50% recommended dose of fertilizer to companion crop
- T₁₀ Turmeric + coriander with recommended dose of fertilizer to companion crop
- T₁₁ Turmeric + soybean with no fertilizer to companion crop
- T₁₂ Turmeric + soybean with 50% recommended dose of fertilizer to companion crop
- T₁₃ Turmeric + soybean with recommended dose of fertilizer to companion crop

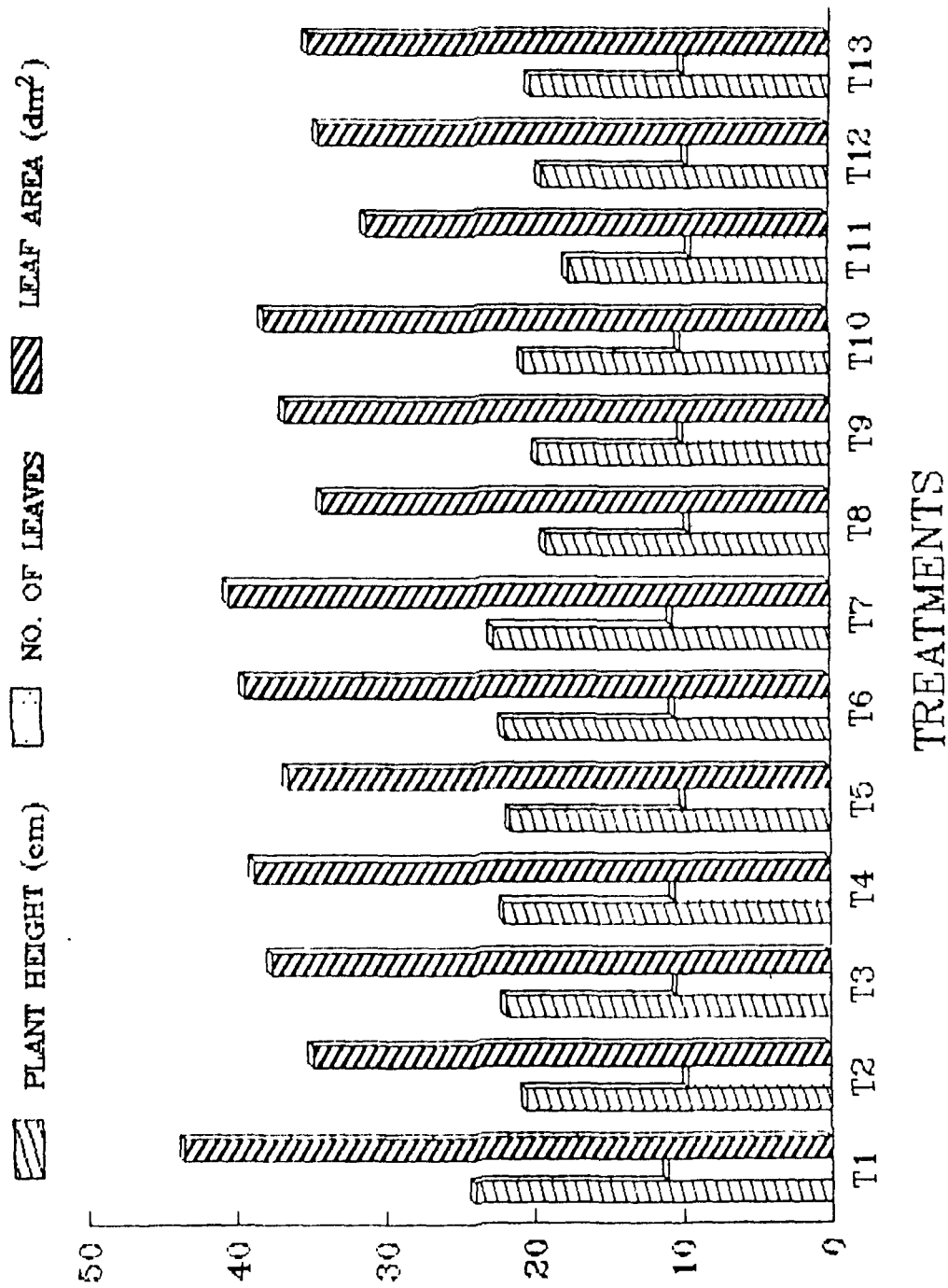


FIG. 4 PLANT HEIGHT, NUMBER OF LEAVES AND LEAF AREA OF TURMERIC PLANT AS INFLUENCED BY COMPANION CROPS WITH THEIR FERTILIZER LEVELS.

highest leaf area of 32.0 dm² which was significantly higher than all other treatments. Turmeric + garlic (26.3 dm²) and turmeric + onion (25.8 dm²) with recommended dose of fertilizer were found to be next in the order while lowest leaf area was observed in turmeric + coriander (19.3 dm²) without fertilizers for coriander and it was on par with turmeric + soybean (19.5 dm²) without fertilizer for soybean.

Application of recommended dose of fertilizer to companion crops recorded significantly higher leaf area compared to the treatment without fertilizer and was on par with 50 per cent recommended dose of fertilizer.

150 days after planting

Difference in the leaf area of turmeric per plant due to various companion crops was significant. Highest leaf area of turmeric per plant was observed in turmeric alone (check) (43.5 dm²) and lowest leaf area was in turmeric + soybean (31.0 dm²) without fertilizer for soybean which did not differ significantly from turmeric + coriander (34.1 dm²). Non significant difference was observed between turmeric alone (check) (43.5 dm²) and turmeric + garlic (40.4 dm²) with recommended dose of fertilizer for garlic.

Variation in the leaf area of turmeric per plant due to different fertilizer levels to companion crops was non-significant. However, numerically highest leaf area was

observed with the application of recommended dose of fertilizer to companion crops followed by 50 per cent recommended dose of fertilizer.

4.2 Fresh and dry weight of turmeric plant

The data pertaining to fresh and dry weight of turmeric plant as influenced by companion crops with different fertilizer levels are presented in Table 4.

4.2.1 Aerial part

4.2.1.1 Fresh weight

The fresh weight of the aerial part of the turmeric plant was significantly affected by companion crops. Turmeric + onion with recommended dose of fertilizer for onion produced the significantly higher fresh weight of the aerial part (201.6 g/plant) compared to turmeric+coriander (175.3 g/plant) and turmeric + soybean (174.3 g/plant) with recommended dose of fertilizer for companion crops and was on par with turmeric + garlic (201.0 g/plant) with recommended dose of fertilizer for garlic. However, turmeric alone (check) recorded significantly higher fresh weight (211.3 g/plant) compared to all other treatments.

Application of recommended dose of fertilizer to companion crops produced the significantly higher fresh weight of the aerial part compared to the treatment without

fertilizer to companion crops, but it did not differ from 50 per cent recommended dose of fertilizer.

4.2.1.2 Dry weight.

The variation in the dry weight of the aerial part of turmeric plant due to companion crops was significant. Turmeric alone (check) produced the significantly higher dry weight of the aerial part (28.9 g/plant) compared to all other treatments. Turmeric + onion (27.6 g/plant) and turmeric + garlic (27.5 g/plant) with recommended dose of fertilizer for companion crops were found to be next in the order and were significantly superior over turmeric+coriander (24.0 g/plant) and turmeric + soybean (23.8 g/plant).

Application of recommended dose of fertilizer to companion crops recorded higher dry weight and it was on par with 50 per cent recommended dose of fertilizer.

4.2.2 Root

4.2.2.1 Fresh weight

Differences in the fresh weight of turmeric roots due to companion crops was significant. Turmeric + garlic with recommended dose of fertilizer for garlic produced significantly higher fresh weight of the roots (71.1 g/plant) as compared to turmeric + onion (68.2 g/plant), turmeric + coriander (57.7 g/plant) and turmeric + soybean (53.5 g/plant) but it was significantly lower than turmeric alone (check) (75.5 g/plant).

Table 4 Fresh and dry weight of turmeric plant as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Aerial part (g/plant)		Root (g/plant)		Rhizome (g/plant)		Dry satter production g/plant	Total dry satter production (tonnes/ha)
		Fresh wt.	Dry wt.	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.		
T ₁	Turmeric alone (check)	211.33	28.94	75.50	12.49	293.33	60.42	101.86	5.56
T ₂	Turmeric + onion with no fertilizer to companion crop	178.33	24.42	60.56	10.01	246.66	50.79	86.23	4.73
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	197.66	27.07	65.10	10.77	275.00	55.62	93.46	5.21
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	201.66	27.62	68.20	11.28	282.00	58.16	97.06	5.38
T ₅	Turmeric + garlic with no fertilizer to companion crop	181.33	24.53	60.83	10.56	257.33	52.98	88.38	4.88
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	195.66	25.43	68.43	11.31	278.33	57.31	94.05	5.32
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	201.00	27.53	71.13	11.76	286.66	59.43	98.73	5.48
T ₈	Turmeric + coriander with no fertilizer to companion crop	165.66	22.68	44.10	7.29	191.33	37.39	67.37	3.85
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	174.66	23.92	54.20	8.76	206.33	42.89	75.78	4.20
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	175.33	24.01	57.73	9.54	215.00	44.47	78.03	4.33
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	162.33	22.23	43.73	7.23	153.33	31.56	61.03	3.39
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	170.00	23.28	51.10	8.44	169.00	34.39	66.12	3.61
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	174.33	23.97	53.53	8.85	176.00	35.82	68.55	3.79
S.E.m. ±		2.88	0.37	0.80	0.13	2.37	0.48	0.51	0.03
C.D at 5%		8.41	1.15	2.35	0.38	6.92	1.42	2.35	0.09

Application of recommended dose of fertilizer to companion crops produced significantly higher fresh weight of the roots per plant as compared to other two treatments.

4.2.2.2 Dry weight

Dry weight of the roots of turmeric plant differed significantly due to companion crops. Turmeric alone (check) produced the highest and significantly higher dry weight (12.4 g/plant) over all other treatments. This was followed by turmeric + garlic with recommended dose of fertilizers which produced significantly higher dry weight (11.7 g/plant) as compared to turmeric + onion, turmeric + coriander (9.5 g/plant) and turmeric+ soybean (8.8 g/plant).

Different fertilizer levels to companion crops influenced the dry weight of the roots of turmeric plant significantly. Application of recommended dose of fertilizer to companion crops produced significantly higher dry weight of the roots per plant.

4.3.1 Rhizome

4.3.1.1 Fresh weight

Fresh weight of turmeric rhizomes was significantly affected by companion crops such as onion, coriander and soybean. Turmeric alone (check) (293.3 g/plant) and turmeric + garlic (288.6 g/plant) with recommended dose of fertilizer

were on par with each other. But turmeric + garlic with 50 per cent fertilizer recorded significantly less fresh weight of rhizome (278.38 g/plant).

Application of varying levels of NPK to companion crops showed significant difference in the fresh weight of the rhizomes. Application of recommended dose of fertilizer to companion crops produced significantly higher fresh weight of the rhizomes of turmeric per plant.

4.3.1.2 Dry weight

The data on the dry weight of rhizomes of turmeric per plant obtained from the plots with different companion crops was significant. Highest dry weight of rhizome was observed in turmeric when grown alone (60.4 g/plant) and was closely followed by turmeric + garlic with recommended dose of fertilizer (59.4 g/plant). Lowest dry weight of rhizome was observed with turmeric + soybean without fertilizer (31.5 g/plant). There was no significant difference between turmeric + garlic (59.4 g/plant) and turmeric + onion (58.1 g/plant) at recommended dose of fertilizers.

Dry weight of rhizome per plant also varied significantly due to different fertilizer levels for companion crops. Application of recommended dose of fertilizer to companion crops achieved highest dry weight of rhizome and lowest was with the treatment without fertilizer.

4.4.1 Total dry matter production

The data pertaining to total dry matter production of turmeric per plant as influenced by companion crops with different fertilizer levels are presented in table 4.

Different companion crops affected the total dry matter production of turmeric significantly. The total dry matter production of turmeric per plant was significantly more when turmeric was grown alone. Turmeric + garlic (98.73 g/plant) and turmeric + onion (97.06 g/plant) with recommended dose of fertilizer were found to be next best combination differing significantly from each other. Both combinations were significantly superior over turmeric + coriander and turmeric + soybean. The lowest dry matter accumulation was with turmeric + soybean without fertilizer for soybean.

Significant influence on the total dry matter production per plant was noticed due to varying fertilizer levels to companion crops. Application of recommended dose of fertilizer to companion crops produced significantly higher total dry matter production of turmeric per plant when compared to 50 per cent fertilizer dose and without fertilizer.

Similar trend was observed in the dry matter production per hectare.

4.5 Tissue composition

4.5.1 N, P and K composition in different parts of turmeric plant

The data pertaining to N, P and K content in aerial part, root and rhizome portions are accomplished in Table 5.

4.5.1.1 Nitrogen

Difference in the N content of aerial part of turmeric due to companion crops was non-significant. However, highest nitrogen content was recorded in turmeric alone (check) (1.62 %) followed by turmeric + soybean (1.61 %) and turmeric + garlic (1.58%) with recommended dose of fertilizer. Lowest nitrogen content was observed in turmeric + coriander without fertilizer for coriander (1.41 %).

Application of recommended dose of fertilizer to companion crops recorded significantly higher nitrogen content compared to treatment without fertilizer but it did not differ from 50 per cent fertilizer dose.

Companion crops viz., coriander showed significant effect on root nitrogen content. Higher N content was recorded in turmeric alone (check) (1.357%) followed by turmeric + soybean (1.354 %) and turmeric + garlic (1.352 %) with recommended dose of fertilizer which were significantly superior over turmeric + coriander (1.27 %). Turmeric + onion and turmeric + garlic were on par with each other.

Application of recommended dose of fertilizer and 50 per cent recommended dose of fertilizer to companion crops achieved significantly higher N content over the treatment without fertilizer.

There were significant differences in respect of N content in rhizome portion due to different companion crops. Turmeric + soybean (1.68 %) and turmeric + garlic (1.67 %) with recommended dose of fertilizers showed significantly higher N content over turmeric + coriander (1.53 %) but these were significantly lower than turmeric alone (check) (1.76 %). Turmeric + garlic and turmeric + onion were on par with each other. The lowest N content was with turmeric + coriander without fertilizer (1.25 %).

Application of recommended dose of fertilizer to companion crops recorded significantly higher nitrogen content in rhizome over other two treatments.

4.5.1.2 Phosphorus

Non-significant difference was observed in P content in aerial part of turmeric plant due to various companion crops. However, turmeric alone (check) recorded comparatively higher phosphorus content (0.42 %) as compared to all other treatment combinations. Lowest was in turmeric + coriander without fertilizer for coriander (0.26 %).

Table 5 NPK content in different parts of turmeric plant as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Aerial part (%)			Root (%)			Rhizome (%)		
		N	P	K	N	P	K	N	P	K
T ₁	Turmeric alone (check)	1.627	0.423	3.190	1.357	0.383	3.627	1.767	0.530	2.917
T ₂	Turmeric + onion with no fertilizer to companion crop	1.413	0.260	2.757	1.217	0.173	2.543	1.293	0.273	2.433
T ₃	Turmeric + onion with 50 % recommended fertilizer to companion crop	1.543	0.383	2.917	1.313	0.297	3.383	1.580	0.440	2.793
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	1.593	0.411	3.153	1.340	0.360	3.510	1.650	0.510	2.853
T ₅	Turmeric + garlic with no fertilizer to companion crop	1.453	0.293	2.727	1.210	0.190	2.720	1.317	0.287	2.490
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	1.547	0.390	2.920	1.310	0.290	3.403	1.587	0.440	2.800
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	1.597	0.413	3.160	1.353	0.347	3.520	1.677	0.497	2.890
T ₈	Turmeric + coriander with no fertilizer to companion crop	1.417	0.267	2.740	1.147	0.183	2.687	1.250	0.270	2.433
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	1.517	0.387	2.927	1.263	0.273	3.267	1.483	0.410	2.683
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	1.567	0.390	3.107	1.273	0.310	3.330	1.550	0.463	2.743
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	1.470	0.297	2.773	1.227	0.200	2.533	1.317	0.260	2.473
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	1.570	0.390	2.890	1.320	0.270	3.250	1.610	0.427	2.700
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	1.610	0.410	3.117	1.354	0.303	3.293	1.680	0.457	2.760
S.E.m. $\pm$		0.022	0.012	0.030	0.022	0.010	0.042	0.018	0.012	0.018
C.D at 5%		0.063	0.036	0.087	0.065	0.030	0.123	0.054	0.035	0.052

Application of recommended dose of fertilizer and 50 per cent of recommended dose of fertilizers were on par with each other but these were significantly superior over treatment without fertilizer.

There was significant difference in root P content due to different companion crops. Turmeric + onion (0.36%) and turmeric+garlic (0.34%) with recommended dose of fertilizer recorded significantly higher P content as compared to turmeric+coriander (0.31%) and turmeric+soybean (0.30%) with recommended dose of fertilizer and turmeric + garlic was on par with turmeric + onion. However, turmeric alone (check) achieved the highest P content of root (0.38 %) over all other treatments.

Significant difference was observed in root P content due to different fertilizer levels to companion crops. Highest P content was obtained when recommended dose of fertilizer was applied to companion crops.

Companion crops showed significant effect on rhizome P content. Highest P content was obtained in turmeric alone (check) (0.53 %) followed by turmeric + onion (0.51 %) and turmeric + garlic (0.49 %) with recommended dose of fertilizer and were significantly superior over turmeric + coriander (0.46%) and turmeric + soybean (0.45 %) with recommended dose of fertilizer.

Variation in rhizome P content due to different fertilizer levels to companion crops was significant. Application of recommended dose of fertilizer recorded significantly higher P content over other two treatments.

4.5.1.3 Potassium

The data on K content of aerial part of turmeric clearly indicated the non-significant difference due to companion crops. However, K content was higher in aerial part of turmeric plant when grown alone as check (3.19 %). The next in order were turmeric + garlic (3.16 %) and turmeric + onion (3.15 %) with recommended dose of fertilizer.

Non-significant difference was observed between the recommended dose of fertilizer and 50 per cent recommended dose of fertilizer with regard to K content but both were significantly higher over the treatment without fertilizer.

Potassium content in root portion of turmeric plant varied significantly due to companion crops. The maximum K content was recorded in turmeric alone (check) (3.62 %) which differed significantly from turmeric + coriander (3.33%) and turmeric+soybean (3.29%), but it did not differ significantly from turmeric + garlic (3.52 %) and turmeric + onion (3.51 %) with recommended dose of fertilizer.

Significantly higher K content in root portion was observed with the application of recommended dose of

fertilizer to companion crops as compared to treatment without fertilizer but it did not differ from 50 per cent recommended dose of fertilizer.

Similarly, potassium content in rhizome portion varied significantly due to companion crops. The highest K content was obtained in turmeric alone (check) (2.91 %) and it differed significantly from all other treatments. The lowest K content was observed in turmeric + coriander (2.43 %) without fertilizer for coriander.

Potassium content in rhizome portion of turmeric plant was significantly influenced due to varying fertilizer levels adopted for companion crops. Application of recommended dose of fertilizer achieved the maximum K content which was significantly superior over other two treatments.

4.6 Uptake of nutrients

Data on the uptake of major nutrients by aerial part, root and rhizome portion as influenced by companion crops and their fertilizer levels are presented in Table 6.

4.6.1 Uptake of N, P and K by aerial part, root and rhizome

4.6.1.1 Nitrogen

Companion crops affected the uptake of N by aerial part significantly. Uptake of N was highest when turmeric was

grown alone (check). Turmeric + onion (24.45 kg/ha) and turmeric + garlic (24.41 kg/ha) with recommended dose of fertilizer recorded significantly higher uptake of N when compared to turmeric + soybean (21.35 kg/ha) and turmeric + coriander (20.83 kg/ha). Turmeric + onion and turmeric + garlic were at par with each other at recommended dose of fertilizer. Lowest uptake of N was seen in turmeric + coriander without fertilizer for coriander (17.84 kg/ha).

Different fertilizer levels to companion crops influenced the N uptake significantly. Highest N uptake was observed with recommended dose of fertilizer followed by 50 per cent recommended dose of fertilizer, which were on par with each other and significantly superior over the treatment without fertilizer for companion crops.

Companion crops showed significant effect on uptake of N by root portion. Highest N uptake was registered by turmeric alone (check) (9.40 kg/ha) and was significantly superior over all other treatments. Turmeric + garlic (8.84 kg/ha) and turmeric + onion (8.39 kg/ha) were at par with each other at recommended dose of fertilizer and were next in order to turmeric alone (check). Lowest N uptake was noticed in turmeric + coriander without fertilizer for coriander (4.64 kg/ha).

Application of recommended dose of fertilizer to companion crops registered maximum uptake of N by root and was significantly higher than other two treatments.

Similarly, uptake of N by rhizome portion was significantly affected by different companion crops. Turmeric + garlic (55.35 kg/ha) with recommended dose of fertilizer for garlic recorded significantly higher N uptake by rhizome portion when compared to turmeric + onion (53.2 kg/ha), turmeric + coriander (37.81 kg/ha) and turmeric + soybean (33.43 kg/ha) but it was significantly lower than turmeric alone (check) (59.29 kg/ha). Lowest uptake of N was recorded with turmeric + soybean (23.09 kg/ha) without fertilizer for soybean.

With regard to different fertilizer levels to companion crops, application of recommended dose of fertilizer registered maximum uptake of N by rhizome portion and was significantly superior over other two treatments.

4.6.1.2 Phosphorus

Uptake of phosphorus by aerial portion of turmeric plant was affected significantly due to different companion crops. Highest P uptake was recorded in turmeric alone (check) (6.64 kg/ha) followed by turmeric + onion (6.49 kg/ha) and turmeric + garlic (6.32 kg/ha) with recommended dose of fertilizer and were significantly superior over

turmeric + soybean (5.43 kg/ha) and turmeric + coriander (5.19 kg/ha). Lowest uptake of P in turmeric + coriander without fertilizer for coriander (3.23 kg/ha).

Application of recommended dose of fertilizer and 50 per cent fertilizer dose were at par with each other and were significantly superior to treatment without fertilizer.

Companion crops affected the phosphorus uptake in root portion of turmeric plant significantly. Uptake was significantly higher with turmeric alone (check) (2.66 kg/ha) than all other treatments. Turmeric + garlic (2.26 kg/ha) and turmeric + onion (2.25 kg/ha) with recommended dose of fertilizer stood next in order and were significantly superior over turmeric + coriander (1.64 kg/ha) and turmeric + soybean (1.49 kg/ha) with recommended dose of fertilizer. Lowest P uptake was with turmeric + coriander without fertilizer for coriander (0.77 kg/ha).

Uptake of phosphorus by root portion was significantly influenced by fertilizer levels for companion crops. Application of recommended dose of fertilizer achieved maximum uptake of P and significantly higher than two treatments.

Uptake of phosphorus in case of rhizome portion was significantly affected by different companion crops. Turmeric + onion (16.45 kg/ha) registered significantly higher uptake

Table 6 Uptake of nutrients (NPK) by different parts of turmeric plant as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Aerial part (kg/ha)			Root (kg/ha)			Rhizome (kg/ha)			Total uptake of	
		N	P	K	N	P	K	N	P	K	N (Kg/ha)	P (Kg/ha)
T ₁	Turmeric alone (check)	26.157	6.643	51.297	9.407	2.660	25.160	59.297	17.750	97.803	94.860	27.093
T ₂	Turmeric + onion with no fertilizer to companion crop	19.163	3.387	37.403	5.760	0.970	14.140	36.473	7.703	68.673	62.397	12.233
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	22.757	5.767	43.873	7.857	1.770	20.063	48.123	13.840	87.873	78.737	21.377
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	24.450	6.493	48.380	8.373	2.253	21.990	53.220	16.450	93.013	86.363	25.197
T ₅	Turmeric + garlic with no fertilizer to companion crop	20.013	4.030	37.597	6.763	1.060	15.197	38.750	8.440	73.257	65.527	13.530
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	21.803	5.507	41.253	8.233	1.820	21.397	50.517	14.000	89.143	80.553	21.327
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	24.413	6.320	48.397	8.643	2.267	23.137	55.357	16.410	95.627	88.613	24.997
T ₈	Turmeric + coriander with no fertilizer to companion crop	17.847	3.233	34.533	4.640	0.773	10.880	27.337	5.903	53.243	49.823	9.910
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	20.017	5.133	38.920	6.287	1.460	16.277	35.333	9.760	63.953	61.633	16.353
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	20.633	5.197	41.460	6.857	1.643	17.663	37.810	11.450	67.753	65.300	18.290
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	18.150	3.660	33.257	4.923	0.803	10.173	23.090	4.563	43.357	46.150	9.027
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	20.300	5.040	37.383	6.193	1.330	15.240	30.763	8.247	52.260	57.250	14.620
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	21.350	5.437	41.333	6.660	1.490	16.197	33.430	9.033	54.617	61.440	15.960
S.E.m. ±		0.420	0.17	0.765	0.134	0.060	0.279	0.575	0.356	0.877	0.587	0.411
C.D at 5%		1.225	0.495	2.233	0.390	0.176	0.816	1.679	1.039	2.618	2.064	1.199

of phosphorus over turmeric + coriander (11.45 kg/ha) and turmeric + soybean (9.03 kg/ha) at recommended dose of fertilizer. However the highest and significantly higher uptake of phosphorus was recorded in turmeric alone (check) (17.79 kg/ha) as compared to all other treatments. Turmeric + soybean without fertilizer for soybean recorded lowest P uptake (4.56 kg/ha).

Highest uptake of P in rhizome portion was recorded with application of recommended dose of fertilizer to companion crops and was significantly superior over other two treatments.

4.6.1.3 Potassium

Potassium uptake in aerial part of turmeric plant was significantly affected due to companion crops. Turmeric + garlic with recommended dose of fertilizer for garlic recorded significantly higher uptake of potassium (48.39 kg/ha) than turmeric + coriander (41.46 kg/ha) and turmeric + soybean (41.33 kg/ha) but it was significantly lower than turmeric alone (check) (51.29 kg/ha). Turmeric + onion (48.38 kg/ha) was on par with turmeric + garlic at recommended dose of fertilizer. The lowest uptake of potassium was with turmeric + soybean without fertilizer for soybean (33.25 kg/ha).

Application of varying fertilizer levels to companion crops also influenced the K uptake significantly.

Highest K uptake was observed with recommended dose of fertilizer which was significantly higher than other two treatments.

Uptake of K by root portion was significantly affected by companion crops. Turmeric alone (check) recorded highest and significantly higher uptake of potassium (25.16 kg/ha) followed by turmeric + garlic (23.13 kg/ha) and turmeric + onion (21.99 kg/ha) with recommended dose of fertilizer. Lowest uptake of potassium was observed in turmeric+soybean without fertilizer for soybean (10.17 kg/ha).

Higher uptake of potassium was observed with application of recommended dose of fertilizer to different companion crops and it was significantly higher than other two treatments.

Similarly, uptake of K by rhizome portion was significantly affected by different companion crops. Turmeric alone (check) achieved maximum uptake of K (97.80 kg/ha) which was significantly higher than turmeric + onion (93.01 kg/ha), turmeric + coriander (67.79 kg/ha) and turmeric + soybean (54.81 kg/ha) with recommended dose of fertilizer for companion crops. There was no significant difference between turmeric alone (check) and turmeric + garlic (95.42 kg/ha) with recommended dose of fertilizer for garlic. Lowest uptake of K was in turmeric + soybean without fertilizer for soybean (43.35 kg/ha).

Application of recommended dose of fertilizer to companion crops recorded significantly higher uptake of K by rhizome portion than other two treatment combinations.

4.6.2 Total uptake of nutrients

4.6.2.1 Nitrogen

Companion crops showed significant effect on total uptake of nitrogen by turmeric plant. Highest total uptake of N was recorded in turmeric alone (check) (94.86 kg/ha) which was found to be significantly higher over all other treatments. Lowest total uptake of N was observed in turmeric+soybean without fertilizer for soybean (46.16 kg/ha).

Application of recommended dose of fertilizer to companion crops recorded significantly higher total uptake of N when compared to other two treatments.

4.6.2.2 Phosphorus

Uptake of phosphorus was significantly affected due to different companion crops. Highest total uptake of P was recorded in turmeric alone (check) (27.09 kg/ha) followed by turmeric + onion (25.19 kg/ha) and turmeric + garlic (24.99 kg/ha) with recommended dose of fertilizer. Lowest uptake of P was observed in turmeric + soybean without fertilizer for soybean (9.02 kg/ha).

LEGEND

- T₁ Turmeric alone (check)
- T₂ Turmeric + onion with no fertilizer to companion crop
- T₃ Turmeric + onion with 50% recommended dose of fertilizer to companion crop
- T₄ Turmeric + onion with recommended dose of fertilizer to companion crop
- T₅ Turmeric + garlic with no fertilizer to companion crop
- T₆ Turmeric + garlic with 50% recommended dose of fertilizer to companion crop
- T₇ Turmeric + garlic with recommended dose of fertilizer to companion crop
- T₈ Turmeric + coriander with no fertilizer to companion crop
- T₉ Turmeric + coriander with 50% recommended dose of fertilizer to companion crop
- T₁₀ Turmeric + coriander with recommended dose of fertilizer to companion crop
- T₁₁ Turmeric + soybean with no fertilizer to companion crop
- T₁₂ Turmeric + soybean with 50% recommended dose of fertilizer to companion crop
- T₁₃ Turmeric + soybean with recommended dose of fertilizer to companion crop

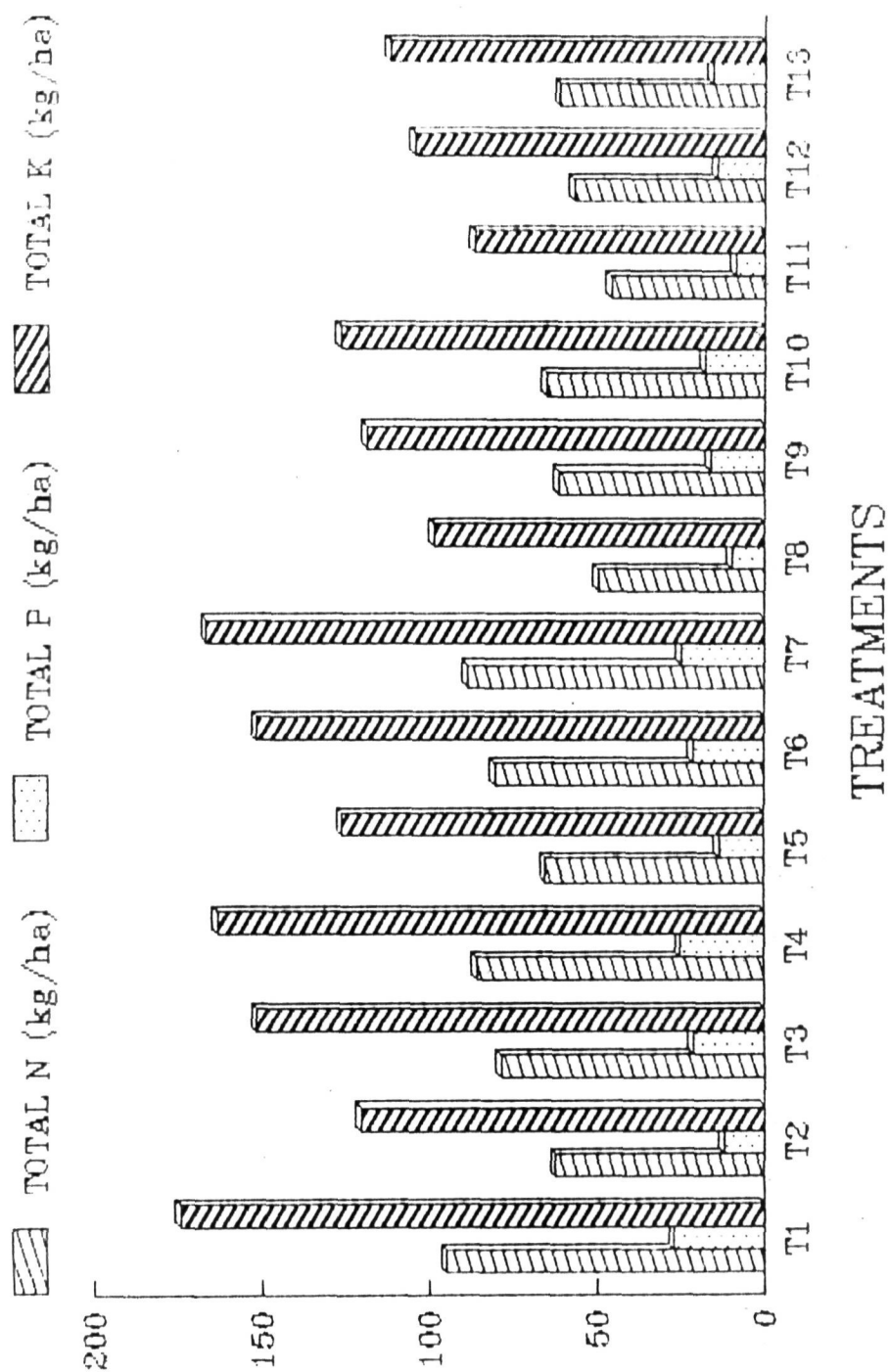


FIG.5. UPTAKE OF NUTRIENTS (NPK) BY TURM-
ERIC PLANT AS INFLUENCED BY COMPANION
CROPS WITH THEIR FERTILIZER LEVELS

Varying levels of fertilizers to companion crops showed significant difference in respect of total P uptake. Maximum uptake of P was registered with the recommended dose of fertilizer to companion crops.

4.6.2.3 Potassium

Total uptake of K was significantly affected due to companion crops. Similar to N and P the highest total uptake of K was recorded in turmeric alone (check) (174.36 kg/ha) which differed significantly from all other treatments. Turmeric + garlic (166.89 kg/ha) and turmeric + onion (163.38 kg/ha) with recommended dose of fertilizer were found to be next in the order. Lowest total uptake of K was observed in turmeric + soybean (86.79 kg/ha) without fertilizer for soybean.

Application of recommended dose of fertilizer to companion crops recorded maximum total uptake of K followed by 50 per cent recommended dose of fertilizer.

4.7 Yield attributing characters in turmeric

Data pertaining to the yield attributing characters like number of mother rhizomes, primary and secondary fingers as well as size of rhizomes recorded at harvest are furnished in Table 7 and 8.

4.7.1 Number of mother rhizomes per plant

The number of mother rhizomes per plant was not affected by companion crops. Turmeric alone (check) recorded the highest number of mother rhizomes (1.86/plant) and it was closely followed by turmeric + garlic (1.80/plant). Lowest number of mother rhizomes was in turmeric + soybean without fertilizer for soybean (1.20/plant).

Number of mother rhizomes per plant was also not influenced by varying fertilizer levels to companion crops.

4.7.2 Number of primary fingers per plant in turmeric

The number of primary fingers per plant as influenced by companion crops was highly significant. Turmeric alone (check) recorded highest and significantly higher number of primary fingers per plant (10.8/plant) compared to other treatments. Turmeric+garlic with recommended dose of fertilizer for garlic produced significantly higher number of primary fingers per plant (9.2/plant) than turmeric + coriander (8.4/plant) and turmeric + soybean (8.2/plant). There was no significant difference between turmeric + garlic and turmeric + onion (9.0). Lowest number of primary fingers per plant was observed in turmeric + coriander without fertilizer for coriander (7.0).

There was no significant difference with regard to number of primary fingers per plant due to varying fertilizer levels to companion crops.

Table 7 Number of mother rhizomes, primary and secondary fingers in turmeric (per plant) as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	No. of mother rhizomes/ plant	No. of primary fingers/ plant	No. of secondary fingers/ plant
T ₁	Turmeric alone (check)	1.86	10.80	15.17
T ₂	Turmeric + onion with no fertilizer to companion crop	1.40	7.60	8.97
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	1.53	8.53	11.56
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	1.66	9.00	12.17
T ₅	Turmeric + garlic with no fertilizer to companion crop	1.40	7.67	9.13
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	1.53	8.80	12.29
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	1.80	9.20	12.70
T ₈	Turmeric + coriander with no fertilizer to companion crop	1.26	7.00	7.55
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	1.46	8.07	9.67
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	1.66	8.40	10.09
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	1.20	7.06	7.51
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	1.40	8.06	9.57
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	1.66	8.26	10.08
	S.E.m. ±	0.20	0.27	0.12
	C.D at 5%	NS	0.79	0.36

NS- Non significant

4.7.3 Number of secondary fingers per plant in turmeric

The difference in the number of secondary fingers per plant due to companion crops was significant. Turmeric alone produced the significantly higher number of secondary fingers per plant (15.1/plant) as compared to all other treatments whereas turmeric + garlic with recommended dose of fertilizer for garlic recorded higher number of secondary fingers per plant (12.7/plant) compared to turmeric + onion (12.1/plant), turmeric + coriander (10.0/plant) and turmeric + soybean.

Varying fertilizer levels to companion crops also influenced the number of secondary fingers per plant significantly. Recommended dose of fertilizer recorded significantly higher number of secondary fingers per plant compared to other two treatments.

4.7.4 Length of primary fingers of turmeric

The length of primary fingers was significantly affected by companion crops. Turmeric + garlic with recommended dose of fertilizer for garlic recorded significantly higher length of primary fingers (9.0 cm) compared to turmeric + coriander (8.2 cm) and turmeric + soybean (7.3 cm) but it was inferior to turmeric alone (check) (9.5 cm). There was no significant difference between turmeric + garlic (9.0 cm) and turmeric + onion (8.8 cm) at recommended dose of fertilizer.

Application of recommended dose of fertilizer to companion crops recorded higher length of primary fingers of turmeric and it was on par with 50 per cent recommended dose of fertilizer.

4.7.5 Length of secondary fingers of turmeric

Companion crops affected the length of secondary fingers of turmeric significantly. Turmeric alone (check) recorded significantly higher length of secondary fingers (6.3 cm) as compared to turmeric + onion (5.5 cm), turmeric + coriander (4.5 cm) and turmeric + soybean (4.5 cm) with recommended dose of fertilizer to companion crops. But there was no significant difference between turmeric + garlic (5.7 cm) with recommended dose of fertilizer to garlic and turmeric alone. Turmeric + onion (5.5 cm) was on par with turmeric + garlic (5.7 cm) at recommended dose of fertilizer.

Application of recommended dose of fertilizer was on par with 50 per cent recommended dose of fertilizer.

4.7.6 Circumference of mother rhizome

Circumference of mother rhizome of turmeric differed significantly due to various companion crops. Highest circumference of mother rhizome was achieved in turmeric alone (check) (8.44 cm) and was found significantly superior to all other treatment combinations. Turmeric + garlic (8.41 cm) and

Table B Size of turmeric rhizomes as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Circumference of mother rhizome (cm)	Length of primary finger (cm)	Circumference of primary finger (cm)	Length of secondary finger (cm)	Circumference of secondary finger (cm)
T ₁	Turmeric alone (check)	9.44	9.56	8.45	6.36	4.39
T ₂	Turmeric + onion with no fertilizer to companion crop	6.89	7.69	6.22	4.20	2.93
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	7.28	8.52	6.99	5.08	3.24
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	8.37	8.88	7.26	5.52	3.66
T ₅	Turmeric + garlic with no fertilizer to companion crop	6.86	7.52	6.20	4.03	3.03
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	7.55	8.68	7.18	5.14	3.34
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	8.41	9.08	7.49	5.74	3.76
T ₈	Turmeric + coriander with no fertilizer to companion crop	6.19	7.06	5.61	3.81	2.61
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	7.03	8.06	6.33	4.36	3.03
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	7.27	8.27	6.55	4.50	3.34
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	6.15	6.31	5.38	3.40	2.72
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	7.11	6.88	6.42	4.32	3.24
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	7.41	7.34	6.53	4.54	3.42
S.E.m. $\pm$		0.17	0.24	0.18	0.23	0.21
C.D at 5 %		0.52	0.70	0.54	0.69	0.60

turmeric + onion (8.37 cm) with recommended dose of fertilizer were found to be next in the order. While lowest circumference of mother rhizome was observed with turmeric + soybean (6.15 cm) without fertilizer for soybean which was at par with turmeric + coriander without fertilizer for coriander (6.19 cm).

Application of recommended dose of fertilizer and 50 per cent recommended dose of fertilizer to companion crops were found to be superior over the treatment without fertilizer for companion crops.

4.7.7 Circumference of primary fingers of turmeric

Differences in the circumference of primary fingers of turmeric due to companion crops were significant. Turmeric alone (check) recorded the highest circumference (8.45 cm) which was significantly higher than all other treatments combinations. Turmeric + garlic with recommended dose of fertilizer for garlic (7.49 cm) recorded significantly higher circumference of primary finger over turmeric + coriander (6.55 cm) and turmeric+soybean (6.53 cm) and was on par with turmeric + onion (7.26 cm).

Difference in the circumference of primary finger of turmeric was non-significant between recommended dose of fertilizer and 50 per cent recommended dose of fertilizer to companion crops.

4.7.8 Circumference of secondary fingers

Companion crops affected the circumference of secondary fingers significantly. Circumference of secondary fingers was significantly higher in turmeric alone (check) (4.3 cm) when compared to other treatment combinations. Turmeric + garlic (3.7 cm) and turmeric + onion (3.6 cm) with recommended dose of fertilizer were found to be next in the order and turmeric + soybean without fertilizer for soybean recorded lowest circumference of secondary fingers (2.7 cm).

Non-significant differences were observed in the circumference of secondary fingers of turmeric due to varying fertilizer levels to companion crops.

4.8 Fresh rhizome yield of turmeric

Data pertaining to the fresh rhizome yield are presented in Table-9.

4.8.1 Fresh rhizome yield per plant

The data on fresh rhizome yield of turmeric per plant revealed that companion crops affected the fresh rhizome yield of turmeric per plant significantly. Turmeric alone (check) produced significantly higher fresh rhizome yield (310.2 g/plant) as compared to all other treatments. Turmeric + garlic with recommended dose of fertilizer for garlic (287.0 g/plant) was found significantly superior over

Table 9 Fresh rhizome yield of turmeric as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Per plant (g)	Per plot (2.4 x 1.8m) (kg)	Per hectare (tonnes)
T ₁	Turmeric alone (check)	310.27	7.447	17.237
T ₂	Turmeric + onion with no fertilizer to companion crop	263.33	6.320	14.629
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	265.27	6.367	14.737
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	281.66	6.760	15.647
T ₅	Turmeric + garlic with no fertilizer to companion crop	267.49	6.420	14.680
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	270.55	6.493	15.030
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	287.08	6.890	15.948
T ₈	Turmeric + coriander with no fertilizer to companion crop	256.52	6.157	14.048
T ₉	Turmeric + coriander withh 50 % recommended dose of fertilizer to companion crop	264.16	6.340	14.351
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	266.66	6.400	14.536
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	251.11	6.027	13.701
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	256.52	6.157	13.901
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	263.05	6.313	14.384
S.E.m. $\pm$		5.853	0.140	0.317
C.D at 5%		17.085	0.410	0.924

turmeric + coriander (266.6 g/plant) and turmeric + soybean (263.0 g/plant) with recommended dose of fertilizer but it was on par with turmeric + onion (281.6 g/plant). Lowest yield was observed in turmeric + soybean without fertilizer for soybean (251.1 g/plant) and it was on par with turmeric + coriander without fertilizer for coriander (256.5 g/plant). Fresh rhizome yield was 264.1 and 256.5 g per plant in turmeric + coriander and turmeric + soybean respectively at 50 per cent recommended dose of fertilizer.

Fresh rhizome yield of turmeric per plant as influenced by varying fertilizer levels to companion crops was non-significant. However, fresh rhizome yield of turmeric was higher in the treatment with recommended dose of fertilizer followed by 50 per cent recommended dose of fertilizer.

Similar trend was observed in the fresh rhizome of turmeric per plot and per hectare also.

4.9 Curing percentage and cured rhizome yield

Data pertaining to curing percentage and cured rhizome yield of turmeric are presented in Table 10.

4.9.1 Curing percentage

Difference in the curing percentage due to companion crops with their varying fertilizer levels was significant. Turmeric + soybean (25.24 %) and turmeric + coriander (25.23 %) without fertilizer for companion crops recorded

Table 10 Curing percentage and cured rhizome yield of turmeric as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Curing percentage	Cured rhizome yield (t/ha)
T ₁	Turmeric alone (check)	24.84	4.28
T ₂	Turmeric + onion with no fertilizer to companion crop	25.09	3.66
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	24.94	3.68
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	24.69	3.86
T ₅	Turmeric + garlic with no fertilizer to companion crop	25.09	3.73
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	24.93	3.75
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	24.71	3.96
T ₈	Turmeric + coriander with no fertilizer to companion crop	25.23	3.54
T ₉	Turmeric + coriander withh 50 % recommended dose of fertilizer to companion crop	25.03	3.57
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	24.91	3.65
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	25.24	3.45
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	25.05	3.47
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	24.87	3.57
	S.Em. $\pm$	0.069	0.076
	C.D at 5%	0.202	0.222

significantly higher curing percentage as compared to turmeric alone (check) (24.84 %). However, they did not differ significantly from turmeric + garlic (25.09 %) and turmeric + onion (25.09 %) without fertilizer for companion crops. Turmeric alone (check) was found to be significantly inferior to the treatments where the companion crops were grown without fertilizers with regard to curing percentage.

Among the fertilizer levels, contrary to the rhizome yield, the curing percentage was highest in treatments without fertilizer for companion crops and it decreased as the fertilizer levels increased.

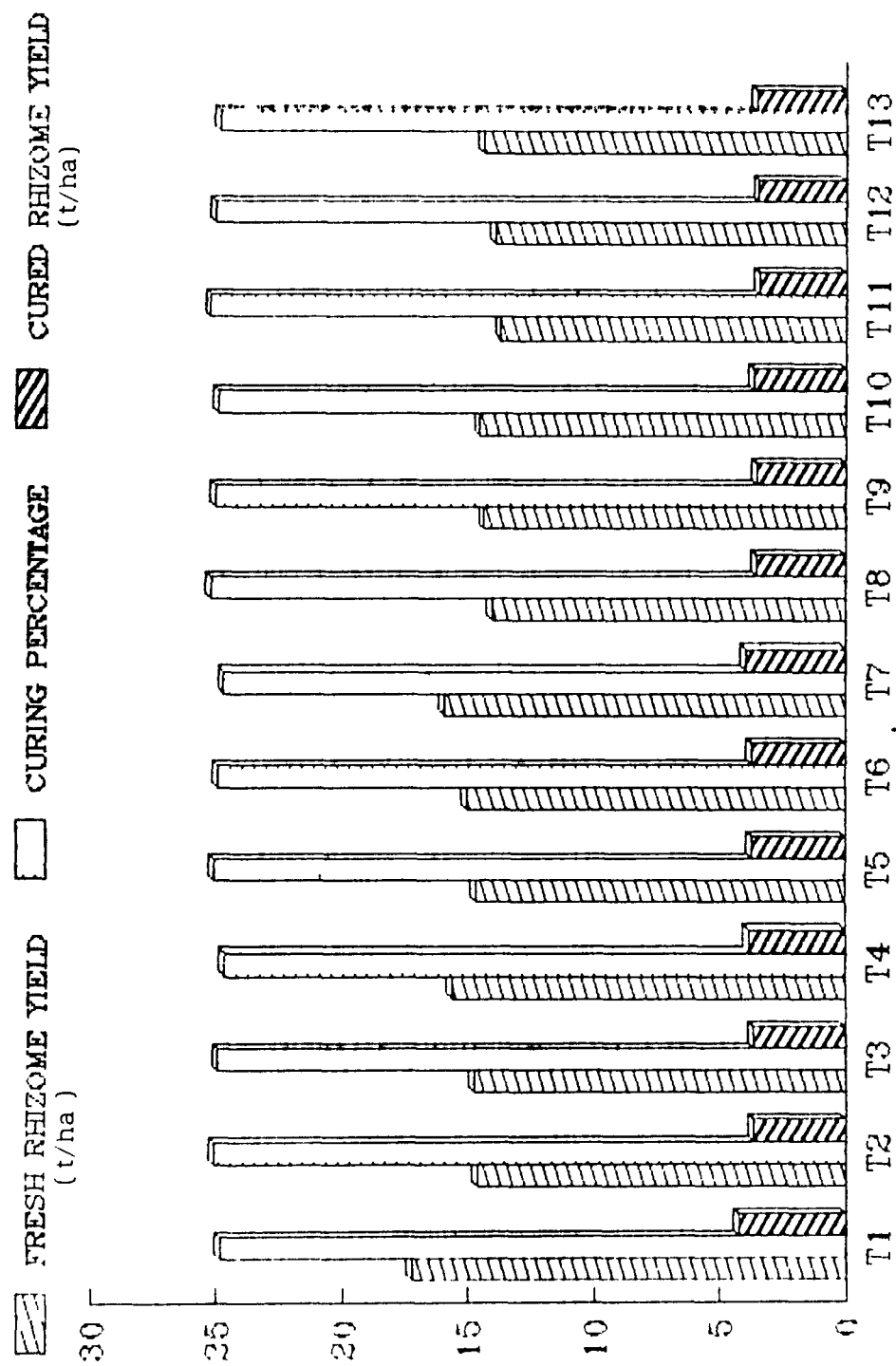
4.9.2 Cured rhizome yield (t/ha)

Difference in the cured rhizome yield due to companion crops was significant. Significantly higher cured rhizome yield was noticed in turmeric alone (check) (4.28 t/ha) as compared to all other treatments. Turmeric + garlic (3.9 t/ha) and turmeric + onion (3.8 t/ha) with recommended dose of fertilizers were found to be next in the order. Lowest cured rhizome yield was with turmeric + soybean without fertilizer for soybean (3.4 t/ha).

Non-significant difference in the cured rhizome yield due to varying fertilizer levels to companion crops was observed. However, application of recommended dose of fertilizer to companion crops recorded maximum cured rhizome yield.

LEGEND

- T₁ Turmeric alone (check)
- T₂ Turmeric + onion with no fertilizer to companion crop
- T₃ Turmeric + onion with 50% recommended dose of fertilizer to companion crop
- T₄ Turmeric + onion with recommended dose of fertilizer to companion crop
- T₅ Turmeric + garlic with no fertilizer to companion crop
- T₆ Turmeric + garlic with 50% recommended dose of fertilizer to companion crop
- T₇ Turmeric + garlic with recommended dose of fertilizer to companion crop
- T₈ Turmeric + coriander with no fertilizer to companion crop
- T₉ Turmeric + coriander with 50% recommended dose of fertilizer to companion crop
- T₁₀ Turmeric + coriander with recommended dose of fertilizer to companion crop
- T₁₁ Turmeric + soybean with no fertilizer to companion crop
- T₁₂ Turmeric + soybean with 50% recommended dose of fertilizer to companion crop
- T₁₃ Turmeric + soybean with recommended dose of fertilizer to companion crop



TREATMENTS

FIG. 6 FRESH RHIZOME YIELD, CURING PERCENTAGE AND CURED RHIZOME YIELD OF TURMERIC AS INFLUENCED BY COMPANION CROPS WITH THEIR FERTILIZER LEVELS.

4.10 Curcumin content in turmeric

Data pertaining to curcumin content are presented in Table 11.

Curcumin content in the rhizomes of turmeric as influenced by companion crops was non significant. However, comparatively higher curcumin content was observed in turmeric alone (check) (2.74 %) followed by turmeric + garlic (2.71 %) and turmeric + onion (2.70 %) with recommended dose of fertilizer. Curcumin content was lowest in the combination of turmeric + soybean.

The variation in the curcumin content due to varying fertilizer levels to companion crops was also non-significant.

4.11 Correlation studies

Correlation coefficients between growth and yield characters are presented in Table 12.

All the characters under study showed significant positive correlation between each other. Correlation coefficients between circumference of mother rhizome and yield per ha were maximum (+0.93), while that between number of mother rhizomes per plant and yield per ha was minimum (+0.82).

Table 11 Curcumin content of turmeric as influenced by companion crops with their fertilizer levels

Treatment code	Treatment	Curcumin content (%)
T ₁	Turmeric alone (check)	2.74
T ₂	Turmeric + onion with no fertilizer to companion crop	2.59
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	2.67
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	2.70
T ₅	Turmeric + garlic with no fertilizer to companion crop	2.62
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	2.69
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	2.71
T ₈	Turmeric + coriander with no fertilizer to companion crop	2.58
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	2.65
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	2.69
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	2.57
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	2.66
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	2.69
	S.Em. $\pm$	0.09
	C.D at 5%	0.29

Table 12 Correlation coefficients (+) between growth and yield parameters

Sl. No.	Characters	No. of leaves/plant	No. of mother rhizomes /plant	No. of primary fingers /plant	No. of secondary fingers /plant	Length of primary fingers	Length of secondary fingers	Circumference of mother rhizome	Circumference of primary finger	Yield per ha
1	Plant height	0.93	0.81	0.86	0.90	0.92	0.90	0.85	0.92	0.92
2	Number of leaves per plant	--	0.89	0.94	0.97	0.96	0.97	0.93	0.96	0.92
3	Number of mother rhizomes per plant	0.89	--	0.90	0.88	0.85	0.90	0.92	0.90	0.92
4	Number of primary fingers per plant	0.94	0.90	--	0.98	0.88	0.96	0.98	0.98	0.91
5	Number of secondary fingers per plant	0.97	0.88	0.98	--	0.91	0.98	0.95	0.99	0.90
6	Length of primary fingers	0.96	0.85	0.88	0.91	--	0.93	0.87	0.92	0.88
7	Length of secondary fingers	0.97	0.90	0.96	0.98	0.93	--	0.97	0.99	0.91
8	Girth of mother rhizome	0.93	0.92	0.98	0.95	0.87	0.97	--	0.97	0.93
9	Circumference of primary finger	0.96	0.90	0.98	0.99	0.92	0.99	0.97	--	0.92
10	Yield per ha	0.92	0.82	0.91	0.90	0.88	0.91	0.93	0.92	--

Note: All the values were significant at 5% level.

4.12 Growth and yield parameters of companion crops in turmeric as influenced by fertilizer levels

4.12.1 Onion

The data on growth parameters (plant height, number of leaves and neck diameter) and yield and yield contributing parameters (bulb diameter fresh and dry weight of plant), nutrient content and their uptake as influenced by fertilizer levels are presented in Table 13 and 14.

Growth parameters such as plant height, number of leaves per plant and neck diameter were higher at recommended dose of fertilizer followed by 50 per cent recommended dose of fertilizer. Growth parameters were lowest in the treatment without fertilizer.

Higher values for yield components (bulb diameter, fresh and dry weight of plant) and higher yield were recorded in the treatment with recommended dose of fertilizer. This was followed by 50 per cent recommended dose of fertilizer. Lowest yield components and yield were recorded in the treatment without fertilizer. Nutrient content (N,P and K) and their uptake were also higher in the treatment with recommended dose of fertilizer. Lowest was observed in the treatment without fertilizer.

Table 13 Growth and yield parameters of onion grown as companion crop with turmeric as influenced by fertilizer levels

Tr. code	Treatment	Growth parameters								Yield components				Yield	
		Plant height (cm)		Number of leaves (per plant)				Neck diameter (cm)		Fresh weight of plant (g/plant)	Dry weight of plant (g/plant)	Dry matter of bulb (kg/ha)	Diameter of bulb (cm)	Fresh weight of bulb (kg/ha)	Bulb yield (kg/ha)
T ₂	Turmeric + onion with no fertilizer to companion crop	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	8.63	4.81	534.44	4.45	3007.00	1354.40
		20.48	35.10	43.93	47.93	3.53	5.93	7.13	7.33						
		40.83	49.68	53.72	57.72	4.93	7.27	8.67	8.80						
T ₃	Turmeric+onion with 50 % recommended dose of fertilizer to companion crop	26.35	40.83	49.68	53.72	4.93	7.27	8.67	8.80	13.68	7.53	547.78	5.37	3813.00	2331.55
T ₄	Turmeric+onion with recommended dose of fertilizer to companion crop	33.19	45.88	56.83	60.91	5.46	7.73	10.13	10.27	14.93	8.32	924.44	5.89	4028.00	2428.33

Table 14 NPK content and their uptake in onion grown as companion crop with turmeric as influenced by fertilizer levels.

Tr. code	Treatment	Leaf			Bulb			Uptake of nutrients (kg/ha)		
		N(%)	P(%)	K(%)	N(%)	P(%)	K(%)	N	P	K
T ₂	Turmeric + onion									
	with no fertilizer to companion crop	1.58	0.12	0.98	2.17	0.24	1.13	70.03	6.72	39.13
T ₃	Turmeric + onion									
	with 50 % recommended dose of fertilizer to companion crop	1.69	0.15	1.05	2.29	0.31	1.17	114.53	13.24	63.92
T ₄	Turmeric + onion									
	with recommended dose of fertilizer to companion crop	1.80	0.24	1.14	2.51	0.37	1.35	147.03	20.81	84.97

4.12.2 Garlic

The data on growth parameters (plant height, number of leaves per plant and neck thickness), yield, yield contributing characters (bulb diameter, number of cloves per bulb, fresh and dry weight of plant) nutrient content and their uptake as influenced by fertilizer levels are furnished in Table 15 and 16.

Recommended dose of fertilizer recorded maximum plant height, number of leaves per plant and neck thickness and minimum was in the treatment without fertilizer.

Yield and yield component values (bulb diameter, number of bulbils per bulb, fresh and dry weight of plant) were higher at recommended dose of fertilizer followed by 50 per cent recommended dose of fertilizer. Lowest yield and yield components were observed in the treatment without fertilizer.

Higher nutrient content and their uptake was noticed with the application of recommended dose of fertilizer which was followed by 50 per cent recommended dose of fertilizer.

4.12.3 Coriander

The data with regard to growth parameters (Plant height, number of primary and secondary branches per plant), yield components (number of umbels per plant, number of

Table 15 Growth and yield parameters of garlic grown as companion crop with turmeric as influenced by fertilizer levels

Tr. code	Treatment	Growth parameters										Yield components				Yield	
		Plant height (cm)		Number of leaves (per plant)				Neck thickness (cm)		Fresh weight of plant (g/plant)	Dry weight of plant (Kg/ha)	Diameter of bulb (cm)	No. of cloves per bulb	Fresh yield (Kg/ha)	Dry yield (Kg/ha)		
				30 DAS	60 DAS	At Harvest	At Harvest										
T ₅	Turmeric + garlic with no fertilizer to companion crop	24.94	31.62	36.66	3.2	5.3	7.13	0.49	0.62	0.78	17.23	7.81	1301.66	2.72	20.17	949.00	475.50
T ₆	Turmeric + garlic with 50 per cent recommended dose of fertilizer to companion crop	33.93	37.55	43.62	4.27	8.5	9.13	0.78	0.93	1.02	19.50	8.88	1479.99	3.01	20.98	1292.00	833.57
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	35.15	41.17	51.40	5.20	7.00	10.1	0.89	1.01	1.21	21.17	9.60	1599.99	3.35	23.17	1503.00	752.12

Table 16 NPK content and their uptake in garlic grown as companion crop with turmeric as influenced by fertilizer levels.

Tr. code	Treatment	Leaf			Bulb			Uptake of nutrients (kg/ha)		
		N(%)	P(%)	K(%)	N(%)	P(%)	K(%)	N	P	K
T ₅	Turmeric + garlic									
	with no fertilizer to companion crop	1.52	0.16	1.10	2.19	0.21	1.13	65.96	6.58	39.65
T ₆	Turmeric + garlic									
	with 50 % recommended dose of fertilizer to companion crop	1.67	0.20	1.22	2.34	0.29	1.24	84.73	10.35	51.98
T ₇	Turmeric + garlic									
	with recommended dose of fertilizer to companion crop	1.80	0.25	1.31	2.54	0.34	1.32	102.08	13.87	61.86

Table 17 Growth and yield parameters of coriander grown as companion crop with turmeric as influenced by fertilizer levels

S. No.	Treatment	Growth parameters										Yield components				Yield	
		Plant height (cm)		Number of primary branches (per plant)		Number of secondary branches (per plant)		Fresh weight of plant (g/plant)	Dry weight of plant (g/plant)	Dry matter production (Kg/ha)	Number of umbels per plant	Number of umbels per plant	Seed yield per plant (g)	Seed yield per plant (g)	Seed yield (Kg/ha)		
T ₈	Turmeric + coriander with no fertilizer to companion crop	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest										
		20.27	35.73	40.31	4.27	6.2	7.10	6.8	9.33	10.14	24.75	3.58	2128.38	24.46	6.13	9.23	730.32
T ₉	Turmeric + coriander with 50 per cent recommended dose of fertilizer to companion crop	26.97	43.80	49.27	6.27	9.20	9.97	8.33	13.00	14.27	38.57	16.96	3768.88	29.87	5.67	14.29	859.30
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	30.47	47.53	53.41	7.10	10.00	10.56	9.40	14.60	15.71	41.48	18.24	4053.33	35.60	5.38	16.77	1226.30

Table 18 NPK content and their uptake in coriander grown as companion crop with turmeric as influenced by fertilizer levels

Tr. code	Treatment	Nutrient (%)			Uptake of nutrients (kg/ha)		
		N	P	K	N	P	K
T ₈	Turmeric - coriander with no fertilizer to companion crop	1.36	0.25	2.20	28.95	5.32	46.83
T ₉	Turmeric - coriander with 50 % recommended dose of fertilizer to companion crop	1.51	0.36	2.27	56.91	13.56	85.55
T ₁₀	Turmeric - coriander with recommended dose of fertilizer to companion crop	1.64	0.41	2.51	66.47	16.61	101.73

umbelets per umbel, seed yield per plant) yield, nutrient content and their uptake are presented in Table 17 and 18.

Growth parameters such as plant height and number of primary and secondary branches were higher at recommended dose of fertilizer followed by 50 per cent recommended dose of fertilizer. Plant height and number of primary and secondary branches were lowest in the treatment without fertilizer.

Recommended dose of fertilizer resulted in higher yield and higher values of yield components and was followed by 50 per cent recommended dose of fertilizer. Lowest yield and lower values of yield components were observed in the treatment without fertilizer. Nutrient content (N,P and K) and their uptake was also higher at recommended dose of fertilizer. This was followed by 50 per cent recommended dose of fertilizer.

4.12.4 Soybean

The data with regard to growth parameters (plant height, number of leaves per plant, number of primary and secondary branches per plant and weight of plant), yield components (Number of pods per plant, weight of pods per plant, Number of grains per pod, thousand grain weight), grain yield, nutrient content and their uptake are furnished in Table 19 and 20.

Table 19 Growth and yield parameters of soybean grown as companion crop with turmeric as influenced by fertilizer levels

Tr. code	Treatment	Growth parameters												Yield components											
		Plant height (cm)		Number of leaves (per plant)				Number of primary branches (per plant)				Number of secondary branches (per plant)				No. of pods per plant at harvest	Fresh weight of plant (g)	Dry weight of plant (g)	Total dry matter production (kg/ha)	Weight of pods per plant	No. of grains per pod	Thousand grain weight (kg/ha)	Grain yield (kg/ha)		
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS									90 DAS	At harvest
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	8.58	16.09	18.59	18.76	5.47	14.1	17.1	18.73	1.5	3.30	4.70	4.80	2.8	4.93	5.53	5.60	24.13	21.24	5.68	1563.33	7.78	1.40	103.17	1098.0
T ₁₂	Turmeric + soybean with 50 per cent recommended dose of fertilizer to companion crop	12.97	20.15	22.65	22.87	7.13	17.8	20.8	21.4	2.6	4.46	5.73	5.90	4.4	6.93	7.53	7.60	28.86	28.64	12.55	2105.33	9.54	1.68	116.82	1389.0
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	13.67	21.04	23.54	23.72	7.40	18.8	21.8	24.3	2.8	5.27	6.53	6.62	4.6	7.20	7.80	8.00	30.40	36.97	16.33	2721.66	10.67	2.09	125.34	1612.0

Table 20 NPK content and their uptake in soybean grown as companion crop with turmeric as influenced by fertilizer levels.

S. code	Treatment	Nutrient content(%)			Uptake of nutrients (kg/ha)		
		N	P	K	N	P	K
T-1	Turmeric + soybean						
	with no fertilizer	2.42	0.62	4.13	37.93	9.69	33.56
	to companion crop						
T-2	Turmeric + soybean						
	with 50 % recommended dose of fertilizer	2.91	0.75	4.44	61.35	15.81	33.60
	to companion crop						
T-3	Turmeric + soybean						
	with recommended dose of fertilizer	3.07	0.91	4.73	63.55	24.76	33.71
	to companion crop						

LEGEND

- T₁ Turmeric alone (check)
- T₂ Turmeric + onion with no fertilizer to companion crop
- T₃ Turmeric + onion with 50% recommended dose of fertilizer to companion crop
- T₄ Turmeric + onion with recommended dose of fertilizer to companion crop
- T₅ Turmeric + garlic with no fertilizer to companion crop
- T₆ Turmeric + garlic with 50% recommended dose of fertilizer to companion crop
- T₇ Turmeric + garlic with recommended dose of fertilizer to companion crop
- T₈ Turmeric + coriander with no fertilizer to companion crop
- T₉ Turmeric + coriander with 50% recommended dose of fertilizer to companion crop
- T₁₀ Turmeric + coriander with recommended dose of fertilizer to companion crop
- T₁₁ Turmeric + soybean with no fertilizer to companion crop
- T₁₂ Turmeric + soybean with 50% recommended dose of fertilizer to companion crop
- T₁₃ Turmeric + soybean with recommended dose of fertilizer to companion crop

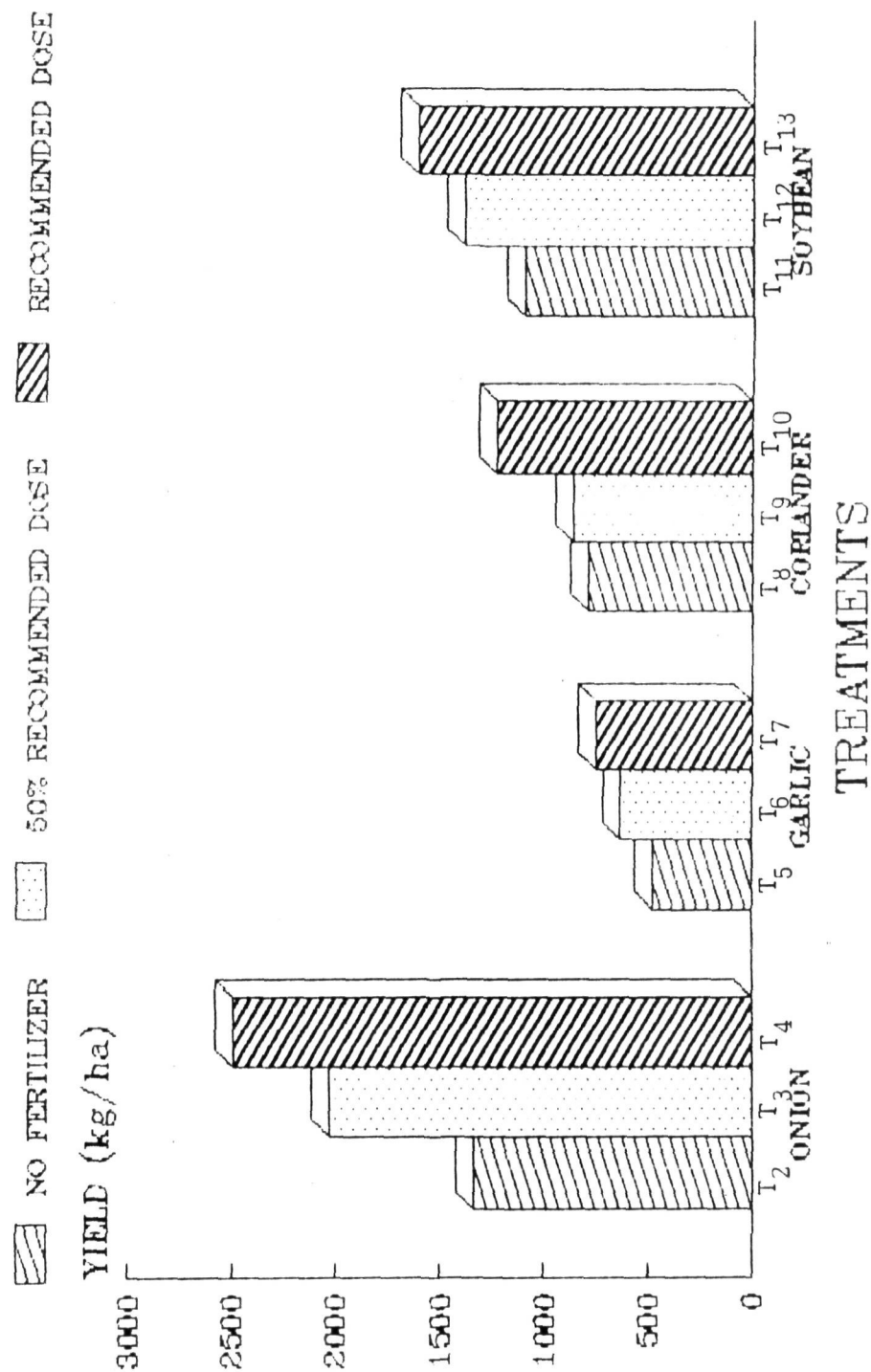


FIG. 7 YIELD OF COMPANION CROPS IN
TURMERIC AS INFLUENCED BY FERTILIZER
LEVELS

LEGEND

- T₁ Turmeric alone (check)
- T₂ Turmeric + onion with no fertilizer to companion crop
- T₃ Turmeric + onion with 50% recommended dose of fertilizer to companion crop
- T₄ Turmeric + onion with recommended dose of fertilizer to companion crop
- T₅ Turmeric + garlic with no fertilizer to companion crop
- T₆ Turmeric + garlic with 50% recommended dose of fertilizer to companion crop
- T₇ Turmeric + garlic with recommended dose of fertilizer to companion crop
- T₈ Turmeric + coriander with no fertilizer to companion crop
- T₉ Turmeric + coriander with 50% recommended dose of fertilizer to companion crop
- T₁₀ Turmeric + coriander with recommended dose of fertilizer to companion crop
- T₁₁ Turmeric + soybean with no fertilizer to companion crop
- T₁₂ Turmeric + soybean with 50% recommended dose of fertilizer to companion crop
- T₁₃ Turmeric + soybean with recommended dose of fertilizer to companion crop

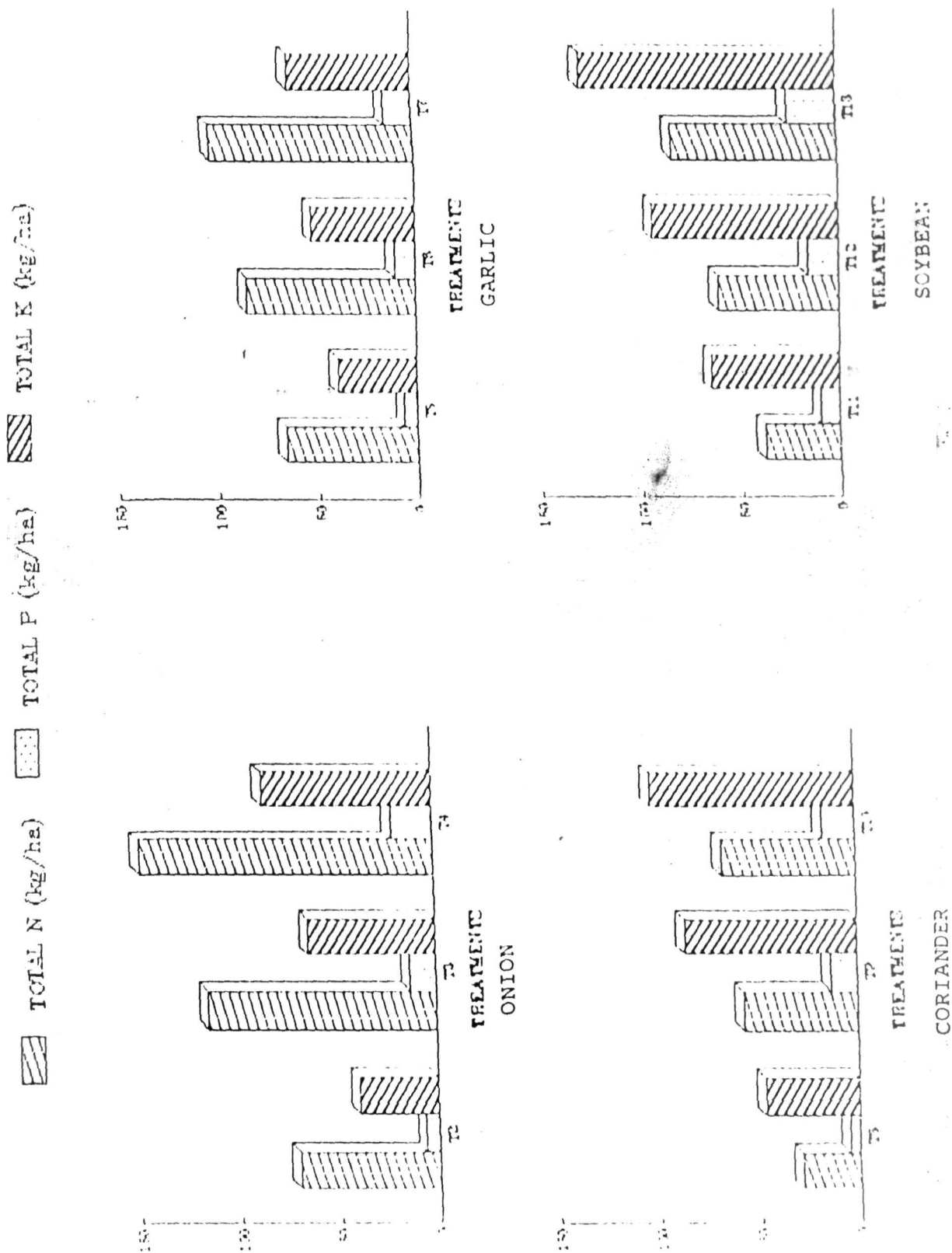


FIG. 8 UPTAKE OF NUTRIENTS (NPK) BY COMPANION CROPS IN TURMERIC AS INFLUENCED BY FERTILIZER LEVELS

Growth parameters were higher at recommended dose of fertilizer followed by 50 per cent recommended dose of fertilizer. Lower values of growth parameters were observed in the treatment without fertilizer.

Application of recommended dose of fertilizer resulted in higher yield and higher values for yield components. Lowest yield was in the treatment without fertilizer.

Nutrient content and their uptake was higher in the treatment with recommended dose of fertilizer followed by 50 per cent recommended dose of fertilizer. Nutrient content and their uptake was lowest in the treatment without fertilizer.

4.13 Economics

The data pertaining to the cost of cultivation, gross income and net returns are tabulated in Table 21.

The perusal of the data revealed that cost of cultivation was highest in turmeric + garlic (Rs.20339.32/ha) followed by turmeric + onion (Rs. 19099.95/ha) at recommended dose of fertilizer, while lowest cost of cultivation was registered by turmeric + coriander.

The maximum gross returns were realised from turmeric + garlic combination with recommended dose of

Table 21 Economics of different companion cropping system in turmeric

Treatment code	Treatment	Yield		Gross returns per ha Rs.	Cost of cultivation per ha. Rs.	Net return per ha Rs.	Cost/Benefit ratio
		Main crop t/ha	Companion crop kg/ha				
T ₁	Turmeric alone (check)	4.28	--	1,07,050.00	17539.59	89400.41	5.07
T ₂	Turmeric + onion with no fertilizer to companion crop	3.86	3007	102024.5	18383.54	83641.96	4.63
T ₃	Turmeric + onion with 50 % recommended dose of fertilizer to companion crop	3.88	3613	104645.50	18607.02	86038.48	4.63
T ₄	Turmeric + onion with recommended dose of fertilizer to companion crop	3.86	4028	110533.00	15093.95	95439.05	4.79
T ₅	Turmeric + garlic with no fertilizer to companion crop	3.73	949	101731.00	19666.43	82064.57	4.17
T ₆	Turmeric + garlic with 50 % recommended dose of fertilizer to companion crop	3.75	1292	105379.00	19335.93	86043.07	4.27
T ₇	Turmeric + garlic with recommended dose of fertilizer to companion crop	3.94	1503	112027.00	20339.32	91687.68	4.50
T ₈	Turmeric + coriander with no fertilizer to companion crop	3.54	790	97190.00	17775.09	79414.91	4.46
T ₉	Turmeric + coriander with 50 % recommended dose of fertilizer to companion crop	3.57	859	98699.00	17846.66	80852.34	4.53
T ₁₀	Turmeric + coriander with recommended dose of fertilizer to companion crop	3.65	1226	104735.00	18637.23	86097.77	4.80
T ₁₁	Turmeric + soybean with no fertilizer to companion crop	3.45	1098	99755.4	13163.31	86592.09	4.49
T ₁₂	Turmeric + soybean with 50 % recommended dose of fertilizer to companion crop	3.47	1389	103834.47	18282.89	85551.61	4.67
T ₁₃	Turmeric + soybean with recommended dose of fertilizer to companion crop	3.57	1612	109077.5	18444.02	90633.50	4.91

LEGEND

- T₁ Turmeric alone (check)
- T₂ Turmeric + onion with no fertilizer to companion crop
- T₃ Turmeric + onion with 50% recommended dose of fertilizer to companion crop
- T₄ Turmeric + onion with recommended dose of fertilizer to companion crop
- T₅ Turmeric + garlic with no fertilizer to companion crop
- T₆ Turmeric + garlic with 50% recommended dose of fertilizer to companion crop
- T₇ Turmeric + garlic with recommended dose of fertilizer to companion crop
- T₈ Turmeric + coriander with no fertilizer to companion crop
- T₉ Turmeric + coriander with 50% recommended dose of fertilizer to companion crop
- T₁₀ Turmeric + coriander with recommended dose of fertilizer to companion crop
- T₁₁ Turmeric + soybean with no fertilizer to companion crop
- T₁₂ Turmeric + soybean with 50% recommended dose of fertilizer to companion crop
- T₁₃ Turmeric + soybean with recommended dose of fertilizer to companion crop

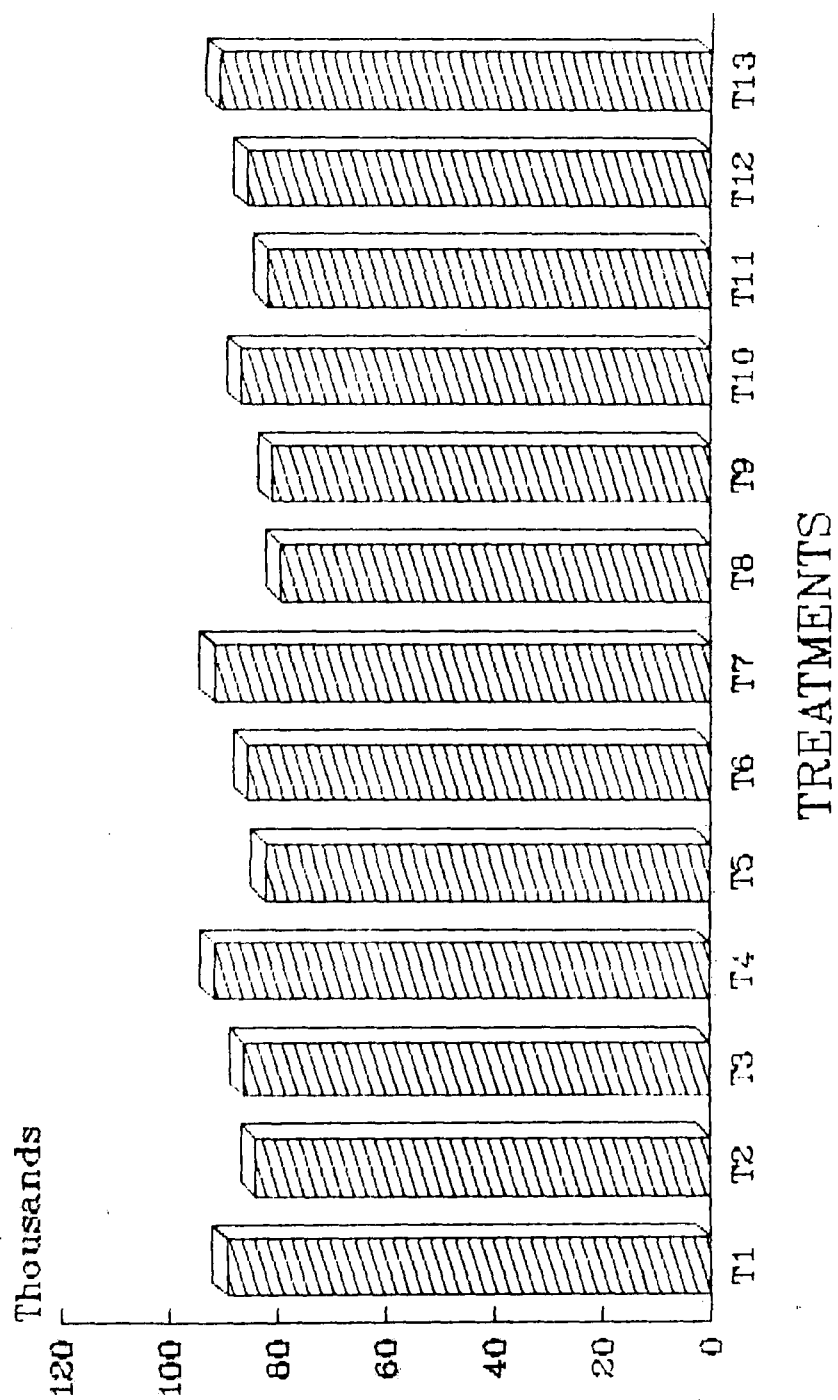


FIG.9 ECONOMICS OF DIFFERENT COMPANION
CROPPING SYSTEM IN TURMERIC
(Net return/ha.)

fertilizer for garlic. This was followed by turmeric + onion with recommended dose of fertilizer for onion. The lowest gross returns were obtained from turmeric + coriander.

Net returns were also higher in turmeric + garlic with recommended dose of fertilizer (Rs.91,687.68/ha) followed by turmeric + onion with recommended dose of fertilizer (Rs.91,498.05 /ha). Turmeric + soybean with recommended dose of fertilizer for soybean recorded net return of Rs. 90,633.58 per ha. Net return was lowest in turmeric + coriander without fertilizer for coriander (Rs.79,414.91 /ha).

CHAPTER - V

DISCUSSION

V DISCUSSION

The system of companioncropping is very common in some of the crops and it has done more to uphold the fertility of soils than any other practice. It is mainly practiced to overcome the risks associated with crop failures due to vagaries of weather or pest and disease incidence. The periodical returns and distribution of labour throughout the year in companion cropping is of great help to the small growers. Companion cropping system has several advantages viz., economy of space, saving in tillage, more efficient utilization of nutrients and increased gross returns from the area cultivated.

Results obtained from the studies on companion cropping in turmeric with onion, garlic, coriander and soybean are discussed in this chapter.

5.1 Weather and crop growth

The total rainfall received during the cropping period from June 1991 to February 1992, was 846.0 mm. It was more by 156.6 mm compared to the corresponding average of past 40 years. During the month of planting (June 1991) the rainfall was higher by 235.9 mm as compared to the mean of previous 40 years, which helped for the better establishment of crops. The rainfall distribution during the following

months viz., July, August, September, October, November and December 1981 was low when compared to mean of the past 40 years. This affected the growth of crops, eventually affecting yield potential of main as well as companion crops.

Mean minimum and maximum temperature during the experimental period did not vary much when compared with past 40 years mean data.

Relative humidity was higher during experimental period when compared to the corresponding average of past 40 years.

5.2 Performance of turmeric as influenced by companion crops

In the present study, the fresh rhizome yield of turmeric was significantly affected by companion crops. The highest yield was recorded when turmeric was grown alone. Among the different companion crops, when turmeric was grown with garlic and onion the yield of turmeric was significantly higher when compared to turmeric + coriander and turmeric + soybean (Table 9).

The differences in the fresh rhizome yield of turmeric were attributed to the influence of companion crops. The higher fresh rhizome yields of turmeric in garlic and onion as companion crops than that of coriander and soybean were due to the higher number of mother, primary and secondary

fingers per plant. The increase in the yield of turmeric with garlic and onion over turmeric + coriander and turmeric + soybean was also due to significantly increase in the length of primary and secondary fingers.

Further, this fresh rhizome yield was influenced by the periodic increment growth of turmeric plant in garlic and onion as companion crops than that of periodical growth of turmeric with coriander and soybean as companion crops (Table 1). The decrease in the yield of turmeric with coriander and soybean may be due to the more competition between the plants and also lower photosynthetic efficiency of turmeric leaves due to high degree of shading.

Number and size of the mother rhizomes, primary and secondary fingers were more in turmeric + garlic and turmeric + onion when compared to turmeric + coriander and turmeric + soybean. This may be because of more availability of space, nutrients, moisture and better interception of sunlight for better development of rhizomes in turmeric + garlic and turmeric + onion.

Uptake of all the three major nutrients had significant influence on rhizome yield. Higher uptake NPK was attained in turmeric when it was grown with garlic and onion when compared to the turmeric grown with coriander soybean. This may be due to better exposure of turmeric leaf canopy to sunlight which might have resulted in the more transpiration

thus aiding uptake of NPK in the treatments, turmeric + garlic and turmeric + onion. This may also be due to less competition between plants for nutrients or moisture which might be due to different rooting habits and different feeding zone.

Significantly lower dry matter production in different parts of plant (aerial part, root and rhizome portion) and whole plant in turmeric was observed with coriander and soybean as companion crops, which registered lower yields than that of garlic and onion as companion crops.

It is known that garlic and onion plants are less voluminous or rather plant spread is less when compared to coriander and soybean. As a result of this, growth of turmeric was better where, garlic and onion were grown as companion crops of turmeric.

Curing percentage of turmeric was more with turmeric + coriander and turmeric + soybean. This may be due to less availability of nutrients in turmeric + coriander and turmeric + soybean. In the present study curing percentage decreased as the fertilizer level increased. Bhuti (1991) also reported the decrease in the curing percentage of turmeric with increase in the fertilizer level.

Significantly higher cured rhizome yield of turmeric was obtained in the combination of turmeric + garlic and

turmeric + onion when compared to turmeric + coriander and turmeric + soybean. This may be due to more fresh rhizome yield in turmeric + garlic and turmeric + onion.

In case of coriander and soybean as companion crops, growth parameters of turmeric like plant height and number of leaves per plant were less as compared to garlic and onion, so also the values of all the yield components. These growth parameters and yield components were influenced by more spread or good vegetative growth of coriander and soybean crops.

In turn, the reduced growth and comparatively lower values for all the yield components of turmeric with coriander and soybean as companion crops have reflected on the yield. Similarly it has been reported that companion/inter crops have reduced the yield of main crops in turmeric (Kundu and Chatterji, 1982) and in sorghum (Halepyati *et al.*, 1987). Contrary to this, beneficial effects of companion/inter crops have been reported by Kumaraswamy and Hosamani (1978) where in not only the total monetary returns were more but also cotton yield was comparatively higher when it was grown with chilli. On the similar lines Rathore *et al.*, (1981) reported that sugarcane yield was significantly higher when sugarcane was grown with onion compared to sugarcane alone (check).

5.3 Effect of NPK levels of companion crops on turmeric

5.3.1 Effect on turmeric

The differences in fresh rhizome yield of turmeric due to application of varying levels of fertilizers to companion crops were significant. Significantly higher fresh rhizome yield of turmeric were realised from the treatment, where the recommended dose of fertilizers were applied to companion crops, while significantly lower yields were observed where, no fertilizers were applied to companion crops.

The differences in the rhizome yield of turmeric may be related to the differences in rhizome number. Number of rhizomes per plant increased significantly with increase in the fertilizer levels to companion crops. This might be due to the fact that the leaf area per plant increased significantly with increase in the NPK levels to companion crops. The net photosynthesis might be higher to supply adequate amount of photosynthates to the sinks.

The differences in number of mother rhizomes, primary and secondary fingers per plant and length and circumference of rhizomes obtained as a result of application of varying levels of N, P and K to companion crops might be the main cause for such a difference noticed with fresh rhizome yields. This fact could be supported with the significant correlation observed between the yield attributes and rhizome yield (Table 12).

In the present study, the highest number of rhizomes was recorded in the treatment, where, recommended dose of fertilizer was applied to companion crops. Similar results were obtained in case of length and circumference of rhizome and fresh weight of rhizome yield leading to the conclusion that application of recommended dose of fertilizer to companion crops resulted in higher fresh rhizome yield through the production of higher number of rhizomes and more length and circumference of rhizomes. Increase in the values of yield attributing characters were due to the higher dry matter accumulation per plant, the highest periodic growth of plants in terms of height and number of leaves per plant at all the stages of growth and higher nutrient uptake.

Similar results were also reported by Kumaraswamy and Hosamani (1978) in chilli where recommended dose of fertilizers was required for obtaining maximum yields in companion cropping system with cotton.

The increased values of yield attributing characters may also be due to better availability of nutrients when recommended dose of fertilizer was applied.

The differences in the N, P and K content in different parts of the plant due to different levels of fertilizer to companion crops were significant. Highest nitrogen, phosphorus and potassium concentration in aerial part, root and rhizome portion of turmeric plant was recorded in the treatments where full recommended dose of fertilizers

were applied to companion crops. Increase in the availability of nitrogen, phosphorus and potassium might be responsible for increased NPK content in different parts of turmeric plant.

Nitrogen, phosphorus and potassium uptake was highest in different parts of turmeric plant in treatment where recommended dose of fertilizer was applied to companion crops. The higher uptake of NPK in turmeric plant may be due to good growth which is reflected in higher dry matter accumulation.

Uptake of K was more when compared to N and P in different parts of plant, because initial available K in the soil was more and secondly the rhizomatous plants require more of potash. Perhaps, this might be the reason why uptake of K was more.

Differences in the total uptake of nutrients contribute towards the differences noted with dry matter production.

At all the stages of crop growth, application of varying levels of fertilizer significantly influenced the plant height and number of leaves of turmeric per plant and also a significant positive correlation was observed between plant height, number of leaves versus yield. Increased plant height and number of leaves were found with increased NPK levels to companion crops. Application of recommended dose of fertilizer to companion crops produced the highest plant

height and number of leaves per plant at all stages of crop growth (Table 1). Number of leaves per plant increased with increase in plant height as more area was available for leaf production. Increase in leaf production with the application of higher level of NPK to companion crops especially nitrogen may be attributed to the increased uptake of nitrogen which being the constituent of protein and component of protoplasm might have favourably affected the chlorophyll content in leaves resulting in increased synthesis of carbohydrates which are further utilized in building up of new cells. This process might have led the plants towards better vigour reflected through increased height with more number of leaves, higher fresh weight and dry matter accumulation.

Curing percentage decreased with increase in the fertilizers levels to companion crops. This might be due to higher moisture content and less lignification of the rhizome under higher levels of N, P and K to companion crops. Similar decrease in curing percentage with increase in N, P and K levels was also reported (Anon, 1972, Raghava Rao and Swamy 1984 and Bhuti 1991).

5.3.2 Effect on companion crops

5.3.2.1 Onion as companion crop

Marked differences were observed in the bulb yield of onion with varying levels of fertilizers. The highest bulb

yield was recorded with recommended dose of fertilizer and lowest bulb yields in treatment where no fertilizer was applied.

The increase in the yield of onion might be due to increase in the values of yield contributing characters such as bulb weight, bulb diameter (bulb size) and also due to increase in the dry matter accumulation which depends upon the photosynthetic area of onion leaves, which might be higher in the treatment where recommended dose of fertilizers was applied.

The increased plant height and number of leaves might have resulted in the higher yield and yield contributing characters (Table 13).

Further, the higher yield in the treatment where the recommended dose of fertilizer was applied might be attributed to the higher content of nutrients in leaf and bulb and their uptake by the plant (Table 14).

5.3.2.2 Garlic as companion crop

The highest yield of garlic bulbs was obtained in the treatment where the recommended dose of fertilizer was applied to garlic, while the lowest bulb yield was observed in treatment, where no fertilizer was applied. Increase in yield of garlic might be due to increase in growth and yield inturn, might be due to sufficient availability of nutrients.

5.3.2.3 Coriander as companion crop

Maximum yield was recorded in the treatment where the recommended dose of fertilizer was applied and the minimum in the treatment where, no fertilizer was applied.

Increase in the yield may be attributed to the increase in growth, dry matter production and better yield components of coriander grown with recommended dose of fertilizers.

As the dry matter production depends on the photosynthetic area, the higher dry matter production in coriander when grown with recommended dose of fertilizer may be attributed to the higher periodical growth parameters which might have produced the more leaf area when compared to treatment where, no fertilizer was applied.

5.3.2.4 Soybean as companion crop

The yield of soybean was maximum in the treatment where the full recommended dose of fertilizer was applied and minimum yield was observed in the treatment where no fertilizer was applied.

The increase in the yield might be due to the increase in growth and better development of yield components of soybean when grown with recommended dose of fertilizer.

The increase in the yield may also be related to the increase in the nutrient content of plant and their uptake.

5.4 Economics

Maximum gross monetary return was obtained in turmeric + garlic with recommended dose of fertilizers to companion crop (garlic) (Rs.1,12,027/ha). The treatment of turmeric + onion with recommended dose of fertilizers for companion crop (onion) was found to be next best combination (Rs.1,10,598/ha). Turmeric + soybean with recommended dose of fertilizer to companion crop gave the gross returns of Rs.1,09,077.6/ha.

In the treatment turmeric + garlic with recommended dose of fertilizers for companion crop, the higher gross returns were mainly due to higher yield of main crop (turmeric).

Maximum net return was obtained from turmeric + garlic with recommended dose of fertilizer for garlic (Rs.91,687.68/ha) followed by turmeric + onion with recommended dose of fertilizer for onion (Rs.91498.05/ha). The higher net returns were mainly due to higher gross returns..

Although the net returns are higher in turmeric + garlic, turmeric + onion and turmeric + soybean, cost benefit ratio is lower in these combinations as compared to turmeric alone (check) (Table 21). Therefore it appears that companion cropping with onion, garlic, coriander and soybean is not feasible in turmeric.

CHAPTER - VI

SUMMARY

VI SUMMARY

A field experiment entitled "Studies on companion cropping in turmeric" was conducted at the Agricultural College, Dharwad, during 1991-92. The experiment consisting of 13 treatments was laid out in randomised block design with three replications. The findings of the study are summarised below.

1. The companion crops viz., coriander and soybean affected the height of turmeric plant significantly. Height of the turmeric plant was maximum when it was grown alone. However, it did not differ significantly from turmeric + garlic and turmeric + onion at recommended dose of fertilizer. The lowest plant height was with turmeric + soybean.

Application of full recommended dose of fertilizer to companion crops recorded higher plant height of the turmeric.

2. Number of leaves per plant was significantly affected by companion crops at all the stages of the growth. Turmeric alone produced the highest number of leaves per plant and it was significantly superior over all other treatments. Turmeric + garlic combination recorded significantly higher

number of leaves per plant over turmeric + coriander and 121
turmeric + soybean, whereas, turmeric + onion was on par with
turmeric + garlic.

Application of recommended dose of fertilizer to
different companion crops recorded higher number of leaves per
plant and it was on par with 50 per cent recommended dose of
fertilizer.

3. Leaf area per plant was significantly affected by
companion crops at all stages of the crop growth. Maximum leaf
area of turmeric per plant was recorded in turmeric alone
which was found to be significantly superior over other
treatments except turmeric + garlic at 150 days. The lowest
leaf area was recorded in turmeric + soybean which was at par
with turmeric + coriander.

Higher leaf area per plant was recorded with the
application of recommended dose of fertilizer to companion
crops in all the combinations but it did not differ
significantly from 50 per cent recommended dose of fertilizer.

4. Fresh weight of turmeric plant differed significantly due
to companion crops with their fertilizer levels. Of all
treatments, turmeric alone (check) resulted in the maximum
fresh weight followed by turmeric + garlic and
turmeric + onion which produced significantly higher fresh
weight over turmeric + coriander and turmeric + soybean.

Application of recommended dose of fertilizer to companion crops resulted in significantly higher fresh weight of turmeric plant compared to the treatment without fertilizer but it was on par with 50 per cent recommended dose of fertilizer.

5. Dry matter accumulation in the turmeric plant was significantly affected due to companion crops with their fertilizer levels. The highest dry matter accumulation in the turmeric plant was observed with turmeric alone (check). Turmeric + garlic and turmeric + onion were found to be next in the order and they were significantly superior than turmeric + coriander and turmeric + soybean.

The maximum dry matter accumulation in turmeric plant was observed with the application of recommended dose of fertilizer to companion crops.

Application of recommended dose of fertilizer to companion crops recorded significantly higher total dry matter production per hectare compared to other two treatments in all the companion crops.

6. Companion crops and their varying fertilizer levels significantly changed the nitrogen, phosphorus and potassium content in turmeric plant. The highest NPK content was found where turmeric was grown alone (check) followed by

turmeric + garlic and turmeric + onion. The lowest NPK content was observed in turmeric plant when it was grown with soybean.

The highest NPK content was with the application of full recommended dose of fertilizer to companion crops and this was followed by 50 per cent recommended dose of fertilizer.

Application of recommended dose of fertilizer to companion crops resulted in the higher uptake of NPK by different parts of the turmeric plant followed by 50 per cent recommended dose of fertilizer in all the combinations.

7. Companion crops and their varying fertilizer levels affected significantly the total uptake of NPK in the main crop. Highest total uptake of N, P and K was obtained in turmeric alone (check) followed by turmeric + garlic and turmeric + onion which were significantly superior over turmeric + coriander and turmeric + soybean.

Significantly higher uptake of NPK was obtained with the application of recommended dose of fertilizer to companion crops.

8. Production of mother rhizomes of turmeric per plant was not significantly affected due to different companion crops with their fertilizer levels. But on the contrary, companion crops significantly affected the production of primary and

secondary fingers per plant. Turmeric alone (check) recorded significantly higher number of primary and secondary fingers of turmeric per plant followed by turmeric + garlic and turmeric + onion.

Application of varying fertilizer levels to companion crops did not influence the production of primary fingers of turmeric per plant but influenced the production of secondary fingers.

9. Length of primary and secondary fingers varied significantly due to companion crops with their fertilizer levels. Maximum length of primary and secondary fingers was noticed with turmeric + garlic in which the values were significantly higher than turmeric + coriander and turmeric + soybean, but it was on par with turmeric + onion.

Application of recommended dose of fertilizer to companion crops recorded higher length of primary and secondary fingers of turmeric and it was on par with 50 per cent recommended dose of fertilizer.

Circumference of mother rhizome, primary and secondary fingers was significantly changed by different companion intercrops with their fertilizer levels. The highest circumference was seen when turmeric was grown alone (check) followed by turmeric + garlic and these were significantly

higher than turmeric + coriander and turmeric + soybean. Turmeric + onion was on par with turmeric + garlic.

Application of varying levels of fertilizer to companion crops did not influence the circumference of primary and secondary fingers but influenced the circumference of mother rhizome.

10. Fresh rhizome yield of turmeric was greatly influenced by companion crops with their fertilizer levels. Turmeric + garlic combination produced significantly higher fresh rhizome yield of turmeric over turmeric + coriander and turmeric + soybean and was on par with turmeric + onion. However, turmeric alone (check) produced significantly higher fresh rhizome yield over all other treatments.

Higher fresh rhizome yield was obtained with the application of the recommended dose of fertilizer to companion crops compared to the treatment without fertilizer but it did not differ significantly from 50 per cent recommended dose of fertilizer.

11. Curing percentage differed significantly due to companion crops with their varying fertilizer levels. Turmeric + soybean and turmeric + coriander without fertilizer for companion crops recorded significantly higher curing percentage as compared to turmeric alone (check). However, they did not differ significantly from turmeric + garlic and

turmeric + onion without fertilizer for companion crops. Turmeric alone (check) was found to be significantly inferior to the treatments where the companion crops were grown without fertilizer with regard to curing percentage.

Among the fertilizer levels, treatment without fertilizer for companion crop recorded highest curing percentage and it decreased as the fertilizer levels increased in all the combinations.

12. Difference in the cured rhizome yield due to companion crops was significant. Turmeric alone (check) recorded significantly higher cured rhizome yield as compared to all other treatments. Turmeric + garlic and turmeric + onion with recommended dose of fertilizer were found to be next in the order. Lowest cured rhizome yield was with turmeric + soybean without fertilizer for soybean.

Variation in the cured rhizome yield due to varying fertilizer levels to companion crops was non significant. However, recommended dose of fertilizer to companion crops recorded comparatively higher cured rhizome yield.

13. There was significant positive correlation between growth parameters viz., plant height, number of leaves and yield attributing characters like number of mother rhizomes, primary and secondary fingers per plant, length of primary and

secondary fingers, circumference of mother, primary and secondary fingers, and fresh rhizome yield in all treatment combinations.

14. The gross and net returns per hectare were highest in turmeric + garlic with recommended dose of fertilizer for garlic followed by turmeric + onion with recommended dose of fertilizer for onion. But cost benefit ratio was highest in turmeric alone (check).

CHAPTER VII

REFERENCES

VII REFERENCES

- *ABIDIN, Z., SUBHAN AND BASUKI, R.S., 1986, Experiments on multiple cropping of garlic with red bean and red pepper. Buletin penelitian Hortikultura, 13(4):1-8.
- AIYAR, A.K.Y.N., 1949, Mixed cropping in India. Indian J. Agric Sci., 19:454.
- AIYAR, A.K.Y.N., 1953, Principles of crop husbandry in India. Bangalore press, pp. 341-349.
- AIYAR, A.K.Y.N., 1963, Principles of crop husbandry in India. Bangalore press, ed. 4th, pp.250-257.
- ANDREWS, D.J., 1970, Intercropping with sorghum. Sorghum in seventies, Oxford and IBH Publ. New Delhi. pp.545-546.
- ANONYMOUS, 1960, Mixed cropping bring higher returns to the farmer. Indian Cotton Grow., Rev., 14:226-227.
- ANONYMOUS, 1972, Annual Report, IRRI (International Rice Research Institute) Los Benos, Phillipines, pp.21-24.
- ANONYMOUS, 1974, Package of practices for high yield (Field crops). University of Agricultural Sciences, Bangalore, pp.97-100.

- ANONYMOUS, 1978, Annual Report for 1978 of the Inst. Trop. Agron. Res., Food Crops Paris, France, p.219.
- ANONYMOUS, 1988, Agriculturall situation in India, October, November and December, 1988 issues.
- ANONYMOUS, 1990, Agricultural situation in India, Directorate of Economics and Statistics Dept., of Agril. and Co-operation Ministry of Agriculture, New Delhi, pp.861-863.
- ASANDHI, A.A., GUNADHI, N. AND WIJAYA, A., 1987, Effect of intercropping of garlic and red pepper on growth, yield and land productivity. Buletin Penelitan Hortikultura, 15(1):79-84.
- AYYANGAR, G.N.R. AND AYYAR SHANKAR, 1942, Mixed cropping - a review. Madras Agric. J., 30:3-13.
- BALASUBRAMANIAM, R. AND SUNDARAM, S., 1947. A review of experiments with legumes proceeding cotton in the Madras Province. Indian Cotton Grow. Rev., 1: 87-95.
- BALASHANMUGAN, P.V., AHAMED SHAH AND CHEZHIYAN, M., 1988, Studies on relay intercropping in turmeric. South Indian Horticulture, 38(4):207-208.
- BALDWIN, J.P., TINKAR, P.B. AND NYE, P.H., 1972, Uptake of solutes by multiple root systems from soil-I. The theorotical effects of rooting density and pattern on uptake of nutrients from soil. Pl. Soil, 36:693-708.

- BHUTAD, J.C. AND PARASHAR, K.S., 1981, Studies on the effect of intercropping and N fertilizer on the yield and quality of sugarcane first ratoon. Indian Sugar, 31:273-279.
- BHUTI, S.C., 1991, Effect of planting density and NPK levels on growth and yield of turmeric (*Curcuma longa* L.). M.Sc. (Agri) Thesis, Uni. of Agril. Sci., Dharwad.
- BLACKMAN, G.S. AND BLACK, J.N., 1959, Ann. Bot. (London) 23:131. Quoted from Donald, C.M., 1963, Competition among crop and pasture plants. Adv. Agron., 15:1-118.
- CHANDRAVOUNSHI, B.R., 1978, "Intercropping in sorghum in Malwa plateau", Indian Emb., 18:13.
- CHATTERJEE, B.N., BANERJEE, N.C. AND GHOSH, D.C., 1978, Fertilizer application in intercropping of sugarcane and wheat with potato. Fertl. News, 23:35-37.
- CHAVAN, T.L., KHAN, A.H., JOSHI, A.T., KULWAL, L.V. AND KALE, P.B., 1985, Intercropping in cole crops. PKV Research J., 9(2):26-32.
- CHANDAWAT, B.S., JOSHI, H.H. AND PATEL, N.L., 1984, Studies on intercropping Basari banana. South Indian Horticulture, 32(1):23-25.
- CHOWDHARY, P.C., 1988, Intercropping short duration summer crops with ginger in Darjeeling hills. Indian Farming, 37(11):4-5.

- CHRISTIDIS, B.G. AND HARRISON, J.S., 1955, Cotton growing problems, McGraw Hill Book Co., New York pp.159-160.
- CLEMENTS, F.E., VEAVER, J.N. AND HANSON, H., 1929, Carnegie Inst. Wash. Publ. 398, Quoted from Donald, C.M., 1963, Competition among crop and pasture plants. Adv. Agron., 15:1-119.
- De, R. AND SINGH, S.P., 1981, Management practices for intercropping systems. In Proceedings of International Workshop on Intercropping. Hyderabad, India, 10-13, January.
- DONALD, C.M., 1951, Competition among pasture plants-I. interspecific competitions among annual pasture plants. Australian J. Agric. Res., 2:355-376.
- DONALD, C.M., 1963, Competition among crop and pasture plant. Adv. Agron., 15:1-18.
- *BID, A.A.R., 1970, Effect of interplanting onion, in cotton rows under different nitrogen levels on the growth and yield of cotton. Meddelingh Van de Faquiteit Landbouwet arachaopen Biskrueversitet Gent., 35:1019-1024 (Field crop abstracts 1971:24).
- HALKPYATI, A.S., 1985, Studies on sorghum (*Sorghum bicolor* L.) based cropping system in relation to time of sowing and land shaping methods. M.Sc.(Agri). thesis, Univ. Agric. Sci., Bangalore.

- HALKPYATI, A.S., HOSAMANI, S.A. AND HUNSHAL, S.S. 1987, An important intercrop-garlic. Journal of Maharashtra Agricultural Universities, 12(3):395-396.
- HUNSIGI, G., 1969, "Mixed Cropping of cotton," Proceeding of the seminar on the cotton Gram sevak Training Centre, Dharwad, pp.33-35.
- JACKSON, M.L., 1967, Soil chemical Analysis. Prentice Hall of India Pvt. Ltd., New-Delhi, pp.111-192.
- JAGRUPSINGH AND RANDHAWA, G.S., 1988, Effect of intercropping and mulch on yield and quality of turmeric (Curcuma longa L.) Acta Horticulturae No. 188A:188-186.
- KADALLI, V.G., BANAKPUR, V.M., PATIL, A.A. AND HULAMANI, N.C., 1988, Studies on growth and yield of green chilli with onion and French bean as companion crops. South Indian Horticulture, 36(3):148-151.
- KUMARASWAMY, A.S., 1975, Intercropping in Varalaxmi Cotton. M.Sc. (Agri). Thesis, Univ. Agric. Sci., Bangalore.
- KUMARASWAMY, A.S., GUMASTE, S.K. AND PRABHAKAR, A.S., 1977, Intercropping in Varalaxmi cotton, Cotton Seminar held at Raichur, on Dec.28, 1977.
- KUMARASWAMI, A.S. AND HOSAMANI, M.R., 1978, Intercropping in Varalaxmi Cotton. Mysore J. agric. Sci., 12:212-216.

- KUNDU, A.L. AND CHATERJEE, B.N., 1982, Growth analysis of turmeric as a sole crop and in mixture with other crops. *Indian J. agric. Sci.*, 52(9):584-9.
- LAL, T. AND VERMA, 1970, Intercropping and companion cropping in summer vegetables. *Pnr. Farlism.*, 5:33-36.
- LAXMANSINGH, SHARMA, D. AND MAHESHWARI, S.K., 1973, "Pigeonpea does better in Aixtures with Dwarf Sorghum", *JNKVV Res. J.*, 7:100-101.
- MAHARANA, T. AND DAS, A.K., 1981, Effect of spacing and intercrop on the shooting and harvesting of Banana cv Robusta. *Orissa J. Hort.*, 9:34-39.
- MAHESHWARI, S.K., DANATONDE, B.N., YADAV, S. AND GANGRADE, S.K., 1985, Intercropping of *Reuvolfia serpentina* for higher monetary returns. *Indian J. Agric. Sciences*, 55:332-334.
- MALLANGOUDA, G., 1991, Studies on companion cropping in chilli (*Capsicum annum* L.) cv. Byadagi. *M.Sc. (Agri) Thesis*, Uni. of Agril. Sci., Dharwad.
- MANJUNATH, M.N., SATTIGERI, V.V. AND NAGARAJ, K.V., 1991, Curcumin in turmeric, *Spice India*, 4(3):7-9.
- MATHUR, P.N., 1963, "Cropping pattern and Employment in Vidarbha". *Indian J. agric. Econ.*, 18(1):38-43.

- MEENAKSHI, K., PASIGLIIAT KHAN, A.K. AND APPADURAI, R., 1974, Studies on intercropping of short duration vegetables with maize. Madras agric. J., 61:398-401.
- MOLLISON, J., 1901, Text Book of Agriculture Vol.I. Publ. by Bombay Government quoted from AYYANGAR, G.N.R. and SHAWKARA AYYAR, 1942, Mixed cropping review. Madras agric. J., 30:3-13.
- MUHR, G.R., DUTTA, N.P., SHANKARAMBRAMONEY, H., LELBY, V.R. AND DONAHUE, R.L., 1965, Soil Testing in India, USAID, New Delhi, pp.39-41.
- NEGI, S.K. AND SINGH, S.N., 1971, "Mixed cropping of soybean with maize and sorghum", An. Rep. Expt. Std. Govind Ballabb Pant University of Agriculture and Technology, Pantnagar, India, pp.633.
- NIGAM, K.B., BHAGWAT, PRASAD, RAWAT, G.S. AND KAHAR, L.S., 1986, Studies on intercropping of poppy with garlic in black cotton soil. Indian J. Agronomy, 31:219-221.
- OGUNFOWARA, O. AND NORMAN, D.M., 1974, An optimisation model for evaluating the stability of sole cropping and mixed cropping systems under changing resources and technology levels. Somaru Res. Bull., p.216.
- OSIRU, D.S.O. AND WILKY, R.W., 1972, Studies on mixtures of dwarf sorghum and beans (Phaseolus vulgaris) with particular reference to plant population. J. Agric. Sci., Camb., 79:531-540.

- PANSE, V.C. AND SUKHATME, P.V., 1967, Statistical methods for Agricultural workers, ICAR, New Delhi.
- PARASHAR, K.S., ARORA, P.N. AND SHARMA, R.P., 1979, Effect of short duration winter vegetables as intercrops grown in autumn planted cane on the yield of milliable canes, juice quality and economics. Indian sugar. 29:217-223.
- PATIL, S.B., 1981, Intercropping in chilli (*Capsicum annum* L.) and cotton (*Gossypium herbaceum* L.) mixed cropping under rainfed condition. M.Sc. (Agri.) thesis, Univ. Agric. Sci. Bangalore.
- PATRA, A.P. AND CHATTERJEE, B.N., 1986, Intercropping of soybean with rice, maize and pigeon pea in the plains of West Bengal. Indian J. Agric. Sci., 56(6):413-417.
- PIPER, C.S., 1950, Soil and plant analysis. Academic Press, New York, pp.366.
- PRABHAKAR, A.S. AND SHETTY, T.K.P., 1973, Economics of intercropping of Hybrid sorghum and soybean. Agric. Agron. Ind. J., 6:17-18.
- QUINIO, M.J., CADIZ, T.G. AND AYCARDO, H.B., 1977, Intercropping catch crops with ginger under semi water-logged soils. Phillipine Journal of Crop Science, 2(2):103-108.
- RAGHAVA RAO, D.V. AND SWAMY, G.S., 1984, Studies on the effect of N, P and K on growth, yield and quality of turmeric. South Indian Hort., 32(5):288-91.

- RAGHUMURTHY, M., SHAKUNTALARAJU AND KULKARNI, K.R., 1974, Mixed cropping in irrigated cotton. Curr. Res., 4:115-116.
- RATHI, K.S. AND SINGH, R.A., 1979, Effect of companion cropping sequence on the yield and quality of sugarcane ratoon. Indian Sugar, 29:15-18.
- RATHORE, D.M., KODIAN, V.S. AND PANWAR, B.S., 1981, Parallel multiple cropping in autumn planted sugarcane and its effect on cane yield and quality. Haryana Agric. Univ. J. Res., 11:355-360.
- RAVISHANKAR, C. AND MUTHUSWAMY, S., 1987, Study on the quality of ginger (Zingiber officinale Roscoe) grown in different light intensities. South Indian Horticulture, 35(3) : 226-231.
- SANANDACHARI, A., PADAKI, G.R. AND APPARAO, 1980, Intercropping rice fallows cotton with pulses. Cotton Development, 10 (1 and 2) : 5-6.
- SEKAR, K. AND MUTHUSWAMI, S., 1985, Economics of double intercropping in turmeric. Indian Cocoa, Arecanut and Spices J., 8(3):67-69.
- SHANKARAIAH, V., REDDY, I.P. AND RAO, R.R., 1987, Studies on intercropping in turmeric with maize, chilli, castor and okra. Indian cocoa, Arecanut and Spices Journal, 11(2) : 50-52.

- SHEBLAVANTAR, M.N., GOUD REDDY, B.S., MELI, S.S. AND GOPAL REDDY, G., 1974, Mixed cropping in chilli with Varalaxmi, H-4 and Bhagya is highly profitable Curr. Res., 3:103-104.
- SIDDESWARAN, K., RAMASWAMY, C. AND MORACHAN, Y., 1987, Light interception and dry matter production under finger millet based cropping systems. Madras Agricultural Journal, 74(8-9) : 413-417.
- SINGH, K. AND KATYAL, S.K., 1966, Effect of mixed cropping of wheat and gram with varying levels of nitrogen and phosphorus on yield. J. Res. Punjab Agril. Univ., 3:364-367.
- *SLATER, R.O., 1955, Aust. J. Agric. Res. 6:365. Quoted from DONALD, C.M., 1963, Competition among crop and pasture plant. Adv. Agron., 15:1-118.
- SRINIVASA MURTHY, B.N. AND NARAYANSWAMY, P., 1989, Coriander, a multipurpose aromatic herb. Indian Farming, pp.13-15.
- SWAMINATHAN, M.S., 1980, Present and future trend in tropical agriculture. Perspectives in world agriculture. Commonwealth Agricultural Bureaux England, pp.1-43.
- TARHALKAR, P.P. AND RAO, N.G.P., 1975, Changing concepts and practices of cropping systems. Indian Eng., 25:3-7.
- TARHALKAR, P.P. AND RAO, N.G.P., 1979, Genotype plant density considerations in the development of an efficient intercropping system for sorghum. Paper presented at the international inter cropping workshop, ICRISAT, Hyderabad, India.

THAMBURAJ, S. AND MUTHUKRISHNAN, C.R., 1976, Inter cropping Bellary onion with tapioca. Indian Hort., 21:15.

THOMPSON, H.C. AND KELLY, W.C., 1959, Vegetable crops. McGraw Hill Publishing Company Ltd.

TRENBATH, B.T., 1974, Biomass productivity of mixture. Adv. Agron., 26 : 179-210.

UMRANI, N.K., PATIL, R.B. AND PAWAR, H.K., 1984, Studies on profit potentials of different intercropping systems with turmeric. Indian J. Agron., 29(3):383-385.

VERMA, R.S., MOTIWALE, H.P., CHAUHAN, R.S. AND TEWARI, R.K., 1981, Studies on inter cropping of spices and tobacco with autumn sugarcane. Indian sugar, 31:451-456.

*WHITTINGTON, W.T. AND O'ERBIN, T.A., 1968, A comparison of yield from plots sown with a single spices or a mixture of grass species. J. Applied. Ecol., 5:209-213. (Field crop Abstract, 1979, 32:1-10).

*WILLEY, R.W., 1979, Intercropping- its importance and research needs-Part I. Competition yield advantages. Field Crop Abstr., 32:1-10.

WILLEY, R.W. AND OSIRU, D.S.O., 1972, Studies on mixtures of maize and beans with particular reference to plant population. J. Agril. Sci. Cambridge, 70:519-529.

* Originals not seen

APPENDICES

APPENDIX I Monthly meteorological data for the year 1991 and the average of past 40 years (1951-1990) recorded at the meteorological observatory of Agricultural College Farm, Dharwad (Karnataka)

Months	Rain fall (mm)			Temperature (°C)			Relative Humidity (%)				
	1951-1990	1991	1992	Maximum	1991	1992	1951-1990	1991	1992		
January	0.72	0.00	0.00	29.43	31.00	29.40	14.36	14.50	58.40	78.00	81.00
February	0.08	0.00	0.00	34.08	33.50	32.00	15.30	15.40	50.40	75.00	75.00
March	7.31	0.00	0.00	34.90	36.51	36.10	18.66	19.32	53.35	68.00	67.00
April	50.73	87.00	18.10	36.33	35.90	37.00	20.46	21.20	58.10	64.00	65.00
May	88.49	151.10	81.40	35.91	36.30	35.30	20.98	20.90	65.07	65.00	64.00
June	108.60	344.50	181.60	29.25	29.30	29.90	20.69	21.10	80.02	82.00	64.00
July	159.09	160.50	-	26.49	25.40	-	20.48	20.60	86.05	92.00	-
August	102.68	122.20	-	26.58	25.80	-	20.19	20.30	84.20	91.00	-
September	101.05	89.80	-	28.09	29.10	-	19.72	19.80	81.10	82.00	-
October	134.76	125.60	-	29.60	29.70	-	18.68	19.40	73.27	81.00	-
November	32.52	3.40	-	28.71	29.00	-	15.81	16.10	64.40	82.00	-
December	50.70	0.00	-	28.62	26.50	-	13.61	13.80	60.52	82.00	-

APPENDIX II

Prices of inputs and outputs

A. Fertilizers

1) Urea	Rs.315 / qtl
2) Single superphosphate	Rs.100 / qtl
3) Muriate of potash	Rs.174 / qtl

B. Seeds

1) Turmeric rhizomes	Rs.2500 / qtl
2) Onion seeds	Rs.120 / qtl
3) Garlic bulbs	Rs.8 / Kg
4) Coriander seeds	Rs.10 / Kg
5) Soybean seeds	Rs.12.30/ Kg

C. Labour

1) Men labour	Rs.12-60 / day
2) Women labour	Rs.12-00 / day
3) Bullock pair	Rs.20-00 / day
4) Land rent	Rs.150.00/year
5) Marketing charges	2 % of the income

D. Output

1) Turmeric	Rs.2500 / qtl
2) Onion	Rs.350 / qtl
3) Garlic	Rs.900 / qtl
4) Coriander	Rs.1100 / qtl
5) Soybean	Rs,1230 / qtl

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- 5 JAN 1996

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