

**EFFECT OF TREE HEDGEROWS AND MANURES  
ON GROWTH AND PRODUCTION BEHAVIOUR OF  
*Ocimum basilicum* L. AND *Tagetes minuta* L.**

**Thesis**

by

**SANDEEP SEHGAL**

*Submitted in partial fulfilment of the requirements  
for the degree of*

**DOCTOR OF PHILOSOPHY**

in

**AGROFORESTRY**



**COLLEGE OF FORESTRY  
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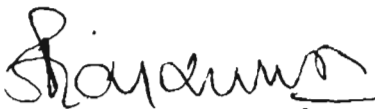
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## **CERTIFICATE-I**

This is to certify that the thesis entitled, “**Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.**”, submitted in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY in AGROFORESTRY** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) is a record of bonafide research work carried out by **Mr. Sandeep Sehgal (F-2003-9-D)** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

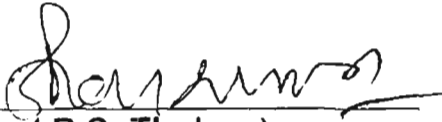
The assistance and help received during the course of investigations has been fully acknowledged.

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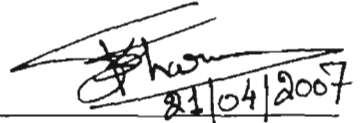
  
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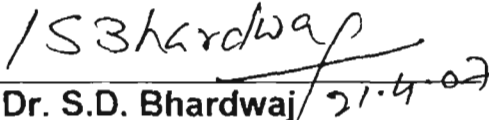


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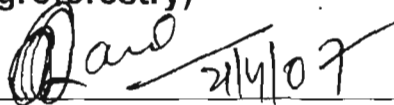
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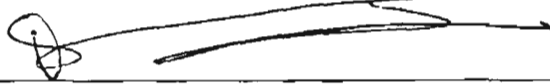
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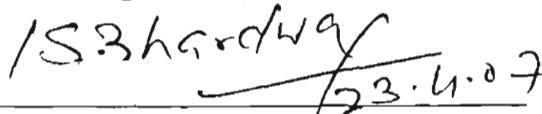
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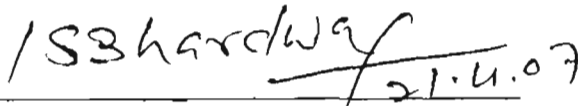
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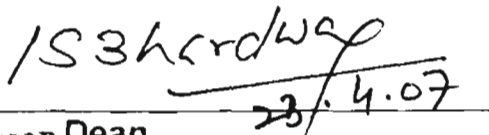
  
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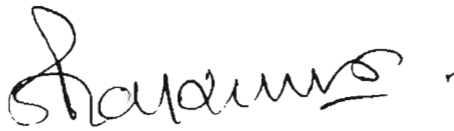
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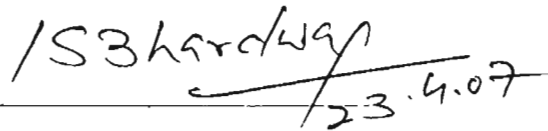
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This is to certify that all the mistakes and errors pointed out by the external examiner have been incorporated in the thesis entitled, "Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.", submitted to Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) by **Mr. Sandeep Sehgal (F-2003-9-D)** in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY** in **AGROFORESTRY**.



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**Dr. P.S. Thakur**  
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**Dr. S.D. Bhardwaj**  
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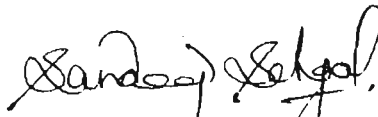
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*Needless to mention, errors and omissions are mine.*

Nauni, Solan  
Dated: 27 January, 2007.

  
(SANDEEP SEHGAL)

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# **INTRODUCTION**

## *Chapter-1*

# INTRODUCTION

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Increasing population pressure and eventual constraints in the availability of food, fodder, fuel, timber and other minor forest produce are among the major concerns of the society today. Environment security is another area of concern. In India, the situation is very critical. For example, with 2.3% of global area and 1.6% of the area under forest, the requirements to be met are 16% of the world's population. This calls for an increase in area, both under agriculture as well as forest, which do not seem to be feasible *per se* for land being a limited resource. The improvement and modernization of agriculture did help to meet these ever increasing demands, but this capital and technology intensive farming system resulted in the decline in quality and accessibility of natural resource. This proposition led to numerous environmental problems. Sustainable agriculture is a relatively recent response to this decline in quality of natural resource base associated with the modern agriculture, leading to major adjustments in conventional agriculture and thus resulting in evolution of alternative farming systems. The main focus is the reduction or elimination of agrochemical inputs to assure adequate plant nutrition and plant protection through organic nutrient sources and integrated pest management. Diversification methods like agroforestry and intercropping mimic natural ecological processes, and by designing farming systems like these, natural resources like sunlight, moisture and soil nutrients can be put to optimum use.

Incorporating trees into farming systems lead to greater prosperity and diversification at the farm level. Trees provide farmers with marketable products, such as fuelwood, fodder, fiber, fruits and medicines, all of which earn extra income. Trees improve soil fertility by fixing atmospheric nitrogen and recycling nutrients from the soil, thereby helping to increase crop yields and ensure stability of future production. Trees on farm help hold moisture, where it is needed, reduce soil erosion and keep valuable top soil in place, reduce intensity

of downstream flooding and maintain watershed functions. Trees increase ecosystem biodiversity and can help ameliorate global climate change by sequestering carbon.

A strictly scientific definition of agroforestry should stress two characteristics, common to all agroforestry practices viz: the deliberate growth of woody perennials on the same unit of land along with agricultural crops and/or animals either in some form of spatial mixture and in some temporal sequence. There is bound to be significant interaction ecological and / or economic (positive or negative) between the woody and other components of the system. While they clearly offer economic and ecological advantages, the components also involve complex biological interactions, which complicate their management. Farmers generally believe that when trees are grown in combination with agricultural crops, the latter are adversely affected in the vicinity of trees due to competition. Even researchers often believe that competition between trees and crops is an inherent negative aspect of agroforestry systems. This mindset may adversely affect the adoption of agroforestry. It is a natural fact that there is bound to be competition between trees and crops for critical resources, when grown together on the same piece of land. Moreover, it has been seen that the competition between trees and crops can be minimized by using appropriate management practices. Agroforestry requires new management practices and technologies, which take into consideration the intricate interactions of the various components of the system. So, before integrating trees with crops, it is very important to understand the nature as well as the management practices of the tree and crop species. The reasons why certain trees and crops are compatible, while others are not, need to be understood, before short and long term strategies for improving the productivity potential of any agroforestry system are planned. The major management options for manipulating trees in agroforestry are based on the alteration of light and moisture distribution as in case of the taungya system or home gardens or when they are scattered in croplands or planted on boundaries or as hedgerows. The options for managing trees are numerous, but the time, intensity and their effects need to be studied carefully because these can result in the success or failure of any agroforestry system. Beside management, the

selection of a particular tree crop combination depends on a number of factors. In principle, there could be as many ways to combine woody perennials and annual crops and/or livestock as there are sites in different parts of the world and farmers with different ways of working, resources and production goals. Out of a numerous options available for integrating trees on the farmland, one potential agroforestry system is alley cropping. Alley cropping integrates hedgerows, preferably nitrogen fixing trees or other fast growing plants with arable crops in the alleys of hedgerows. The trees are periodically pruned to minimize shading of associated annual crop and the pruned biomass can be used as green manure or as mulch *in-situ*, or as fodder.

It has been proved in the last couple of decades that agroforestry also has the potential to improve the socio-economic conditions of the farmers. Different agroforestry systems have been developed and numerous tree crop combinations have been tried by researchers all over the world, with an eye on increasing the economic situation of the farmers. In the recent years, there has been a shift from growing traditional food crops towards high value cash crops such as medicinal and aromatic plants, which are in great demand by the pharmaceutical industries in India and abroad. Besides securing the healthcare needs of a large number of people, medicinal plants are the exclusive source of some drugs even for the modern medical treatment. The global importance of medicinal and aromatic plants is evident from a huge volume of trade at national and international levels. There is an increasing demand for the raw materials by the pharmaceutical and cosmetic industry all over the world. In India, approximately 9000 species of medicinal and aromatic plants are used in Indian system of medicine. There extensive use has led to supply concerns as most of the material is wild harvested, with little cultivation activity. This approach has resulted in dwindling bio resource availability year after year, erosion of genetic stocks and unscientific and unsustainable harvests. Cultivation of these crops on the other hand has many benefits like protection/conservation of natural resources, regular and assured supply, and purity of the product, easy processing and timely harvest. But, cultivating medicinal and aromatic plants also faces certain constraints; most important being the availability of land needed to be diverted from growing food

crops. Growing medicinal and aromatic plants in agroforestry systems, therefore, can be a viable and promising option for better economic returns to the farmers. However, not much research efforts have been done in this field and there is a need for developing suitable cultural practices for successful cultivation of medicinal and aromatic plants in association with multipurpose tree species for better financial returns to the farmers. Secondly, the information with regards to minimizing the competition between medicinal and aromatic plants and fuel, fodder tree species will be highly useful. There are reports, which indicate cultivation of some medicinal and aromatic plants with the tree species. However, there is practically no information available on the use of organic fertilizers for growing medicinal herbs with different multipurpose tree species. Such combinations, integrating fuel and fodder woody perennials and high value cash crops need to be explored for better returns, diversified produce and resource sharing. There is need to find out the effectiveness of organic fertilizers in the production ability of medicinal and aromatic plant species. This study, therefore, intends to evaluate the growth and production ability of medicinal and aromatic herb species grown as alley crops with and without the organic manures along with hedgerows of *Morus alba* and *Leucaena leucocephala*.

### **Objectives**

- i) Effect of manures on growth and productivity of *Ocimum basilicum* and *Tagetes minuta* grown with and without hedgerows.
- ii) Hedgerow and manure influence on the oil content in medicinal and aromatic plants.
- iii) Effect on physiological parameters of medicinal and aromatic plants under alley arrangement.
- iv) Root characteristics of medicinal and aromatic plants growing as alley crops.

# **REVIEW OF LITERATURE**

## Chapter-2

# REVIEW OF LITERATURE

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For more than a decade, hedge-intercrop agroforestry, also called as alley cropping, has been tested and promoted in various regions all over the world. Hedgerow intercropping offers farmers the possibility of increasing yields, decreasing risk and maintaining or improving their resource base. The general practice under alley cropping type of agroforestry world over has been to integrate conventional agricultural crops with different tree species. Now with growing demand for medicinal and aromatic plants, the integration of these crops in agroforestry systems is being advocated. As far as the integration of medicinal and aromatic plants in alley cropping is concerned, not much research efforts have gone into this direction and consequently the literature available on this aspect of agroforestry is insufficient. The relevant literature pertaining to the present study on “Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.” is reviewed under the following heads:

- 2.1 Growth and yield attributes of medicinal and aromatic plants
- 2.2 Growth and yield attributes of Hedgerow intercropping

### **2.1 Growth and yield attributes of medicinal and aromatic plants**

Medicinal and Aromatic plants constitute a segment of flora that provides raw material to the pharmaceutical, cosmetic, fragrance and flavour industries. With the rapid growth of herbal industry and decreasing natural resources of medicinal and aromatic plants, there is no option but to take up their intensive cultivation. Good amount of literature is available reporting the growth and yield of these crops under cultivation. It is true that when medicinal and aromatic crops are grown along with trees, growth and yield of plants are affected by numerous factors. The presence of tree species influences the performance of medicinal and aromatic plants. The growth may be affected in a positive or a negative way (Rao

*et al.*, 2004). Singh (2003) reported the effect of Coconut and Casuarina plants on growth, herbage and oil yield of Palmarosa and Lemongrass under rainfed conditions. It was observed that both herbage and oil yield were affected by the coconut plantation upto four meters distance from the plant, whereas the effect of Casuarina plantation was observed up to five meters distance from the plant.

Rao *et al.*, (2005) studied the best harvesting time for two varieties of *Ocimum basilicum* grown in semi-arid tropics of South India. It was observed that the variety Vikar Sudha having 0.40 - 0.55 per cent oil is best harvested at eighty days after planting, whereas the local variety having 0.10 per cent oil is best harvested hundred days after planting. Ram *et al.*, (2002) reported that the plants of *O. sanctum* and *O. basilicum* harvested at full flowering gave higher essential oil yields than the crop harvested at 50% flowering and ten days after full flowering. At full flowering, the increase in the oil yield of *O. sanctum* and *O. basilicum* was higher by 179 and 49.4%, respectively, than at 50% flowering.

Nurzynska (2002) studied the effects of methods of cultivation (from seed and transplants) on the growth and yield of basil with green or purple leaves. Basil plants with green leaves were characterized by stronger growth, more abundant flowering, and higher and better quality of yield compared to basil with purple leaves. The methods of cultivation had no significant effects on the morphology of both basil types. The highest fresh and dry weight (23.7 and 4.6 t/ha, respectively) was obtained from plants grown from transplants. Basil grown from seeds was characterized by a higher content of essential oil (0.58%). Ziombra (2001) reported the effects of two cultivation methods, i.e. transplanting and direct sowing on the yield and essential oil content of three basil cultivars, i.e. Sweet basil, Mittelgross and Dark Opal. The highest yield was obtained with transplanting, irrespective of the date of planting. On the other hand, the highest essential oil content was observed when seeds were sown directly in the field. Sweet Basil gave the highest herb yield and Dark Opal gave the highest essential oil content, independently of the cultivation method and planting/sowing date.

Hassani and Beighi (2002) studied the effects of water stress on some morphological, physiological and metabolical characteristics of basil (*O.*

*basilicum*). In order to study the effects of different levels of water stress on growth, yield, leaf chlorophylls and essential oil content of basil, a pot experiment in randomized complete block design with four treatments and four replications was conducted. Water stress treatments were: 100% of field capacity (non-stress), 85% of field capacity (mild water stress), 70% of field capacity (moderate water stress) and 55% of field capacity (severe water stress). Water stress had significant effect on growth, yield, and amounts of chlorophyll and essential oil. As the soil water content decreased, the plant height, leaf number and area, number and length of axillary shoots, leaves, stem and root fresh and dry weight, yield, leaf area index (LAI), specific leaf area (SLA), leaf area ratio (LAR), leaf chlorophyll (a, b and total) content and essential oil yield decreased but the root to shoot ratio and essential oil content increased. The highest amounts of essential oil yield and content were in non-stressed and moderately stressed plants, respectively.

Noguchi and Ichimura (2004) reported the effects of day length, growing temperature, and shading on the growth, flowering, and essential oil concentration and composition of Sweet basil (*O. basilicum*) and Spearmint (*Mentha spicata*). The main essential oil components were analyzed by gas chromatography. Sweet basil and spearmint are recognized as quantitative and qualitative long day plants, respectively. The number of leaves, fresh top weight, and essential oil concentrations were increased by growing at a high temperature of 30/25 degrees C. The optimum conditions for fresh herb production in sweet basil and spearmint were 30/25 degrees C and 12-h day length.

An experiment was conducted by Silva *et al.*, (2003) to determine the effect of environmental factors on *O. basilicum* essential oil yield and composition. Harvests were done during August for two consecutive years at 08.00 and 16.00 h. The essential oil content was higher on January harvest at 08.00 h compared to August harvest at 08.00 and 16.00 h and January harvest at 16.00 h. The major compounds were eugenol and linalool, regardless of harvesting date and time. Omidbaigi *et al.*, (2003) conducted an experiment to study the essential oil content and composition of *O. basilicum* at different

irrigation regimes. For this purpose, the essential oil content and chemical composition of potted seedlings was determined at different irrigation regimes (55, 70, 85 and 100% of field capacity). The essential oil was obtained by hydro distillation of herb, and was analyzed by GC and GC-MS. The essential oil content of herb increased from 1.12 to 1.26% as plant water deficit increased till 70% of field capacity. The number of components of the oil of *O. basilicum* increased as water stress increased. The amount of the main constituents of the oil such as linalool, methyl chavicol, 1, 8-cineole [eucalyptol] and trans alpha-bergamotene were significantly affected by water stress.

Jerez and Barroso (2002) studied the effect of water deficit on the growth of *O. basilicum* and the growth disorders and water relations under reduced water conditions. Basil seeds were placed in 6-litre pots with soil and organic matter substrates (3:1 v/v). Water was differentially applied at 3 phases, namely from sowing to first branch, from first branch to inflorescence in the main shoot, and from the main shoot to the inflorescence in the lateral branches (harvest). Water differentially applied during the first phase showed the highest height reduction, smallest dry matter production, and lowest leaf water potential with reduction in stomatal conductance. Yao *et al.*, (2000) reported the effects of salt stress on the growth, water relations and essential oil content of *O. basilicum* leaves. Salt was added at a high concentration to the nutrient solution. Leaf water potential decreased, stomatal resistance increased and transpiration rates decreased in response to salinity. The essential oil content increased under salt stress. Growth and yield of sweet basil cultivated with different percentages of soil humidity, with 100, 75, 50 or 25% of evaporation/precipitation balance applied one week before irrigation. Plants with 75% evaporation/precipitation had the greatest stem and leaf fresh (20 and 40 g, respectively) and dry (6 and 9 g) biomass. Essential oil increased when soil moisture decreased (Barroso *et al.*, 2003)

Singh *et al.*, (2004) studied the effect of harvest date and nitrogen rates on a methyl chavicol-rich Indian basil (*O. basilicum*). Treatments comprised: 3 harvest dates (75 days after planting (DAP) + 60 days after first harvest (DAFH); 90 DAP + 60 DAFH; and 105 DAP + 60 DAFH) and 5 nitrogen rates (0, 40, 80

120 and 160 kg/ha). Basil harvested at 75 DAP + 60 DAFH and supplied with 80 kg N/ha recorded the highest biomass, oil yields and nitrogen uptake compared to other treatments. Harvest dates and nitrogen rates did not affect the oil content and quality and nitrogen concentration in biomass. Rakic *et al.*, (2002) reported the influence of environmental factors (including UV-B radiation) on the composition of the essential oil of basil. Three cultivars of basil were evaluated for essential oil composition in a period of 1 year under controlled conditions: broad-leaf sweet basil (1); small-leaf sweet bush basil (2); and small-leaf Greek cultivar (3). Plants were also treated with UV light for 1 h. Cultivars 1 and 3 had higher oil content than cultivar 2. In cultivar 1, linalool and 1, 8-cineole were the major components; in cultivar 2, linalool; and in cultivar 3, 1, 8-cineole. Monoterpene contents in the cultivars were more abundant in the essential oils in the summer and autumn than winter and spring. Only cultivar 1 showed significant response to UV light. UV-B increased monoterpene and phenylpropanoids. The effect of UV-B on phenylpropanoids was more during summer than in spring. Goncalves *et al.*, (2003) studied the production and composition of essential oil of "Alfavaquinha" (*Ocimum selloi* Benth.) in response to two levels of solar radiation. An experiment was conducted to determine the effects of solar radiation (full exposure and 50% shading) on the production and composition of *O. selloi* essential oils. There was no observed difference in the content and percentage of the major oil components, namely estragole and anethole. However, during oil extraction, a partial conversion of estragole to anethole was observed. Loannidis *et al.*, (2002) reported that UV-B is required for normal development of oil glands in basil.

Rocha *et al.*, (2000) studied the phytochrome and light influence on germination and vigor of *Ocimum gratissimum* L. seeds under high irradiance conditions. *O. gratissimum* seed germination (% germination and vigour) has been found to be phytochrome-dependent, having a typical high irradiance response. Seven light treatments were tested: daylight (DL), red (R), far-red (FR), blue (B), green (G), dark (DK), and reversible (RVB) lights, in Ceara, Brazil, during the 1999 harvest season. No statistical differences among DL, R, FR, B, and G were found. DK and RVB were statistically equal and presented the lowest

results. Germination also occurred in the DK treatment but negligible, and it was nonreversible in the RVB treatment, which classifies seeds as positively photoblastic. The minimum energy needed to initiate germination was evaluated by a fluency-response curve. It plotted four different exposure times to R light (1 second, 60 seconds, 1 h, and 13 h) against percentage germination. Significant germination occurred only after 1 h, confirming the high energy needed to initiate the process. Germination rate increased with the increase in photoequilibrium (psi). The high positive correlation index found confirms the phytochrome influence in this process. Based on the results, it was suggested that seeds should be sown under direct and highly intense sunlight. It is preferable to avoid places exposed to variations in shading, because inhibition induced by dense shade effects (low R/FR ration and consequently low psi established) is irreversible, and leads to undesirable loss of germination capacity.

Sam *et al.*, (2002) studied the leaf anatomical characterization of basil (*O. basilicum*). The plants were cultivated in pots. Leaf tissue samples were free-handed cut, and epidermis impressions were taken. It was appreciated that between chlorophyllic parenchymas in both leaf surfaces, cavities containing essential basil oils are observed. One important cavity characteristic is that they are in both surfaces. In the analyzed leaves, glands can be observed in different growth stages; this is a very important characteristic, because they could vary according to plant development conditions.

Singh *et al.*, (2002) studied the production behaviour of *Tagetes minuta* in the Western Himalayan region. Data recorded at different growth stages showed that the maximum herb yield and essential oil yield were obtained at full bloom stage. Bharadwaj (1998) reported that the herb and oil yield of *T. minuta* grown as a sole crop was correlated to the leaf area, number of flower heads plant<sup>-1</sup>, yield of flowering branches plant<sup>-1</sup>, leaf yield plot<sup>-1</sup>, herb yield plot<sup>-1</sup>, and oil contents in flowers (%). He also observed that the leaf area, yield of flowering branches plant<sup>-1</sup>, leaf yield plot<sup>-1</sup> had the major contribution in the attainment of high herb yield and oil content in flowers.

The demand for organically grown herbal products has grown over the past few years, especially in Europe. In order to meet the increasing demand, various organic manures as well as bio-fertilizers are being used to increase the production of medicinal and aromatic crops. At present, the reports on the use of organic manures are limited. However, a few studies carried out so far have reported the effect of organic manures and bio-fertilizers on the growth and yield of medicinal and aromatic crops. Ajimoddin *et al.*, (2005) studied integrated nutrient management studies in *O. basilicum*. The treatments included various levels of N, P, K in combination with bio-fertilizers as *Azotobactor* species, Phosphorous solubilizing bacteria and VAM fungi. The study showed that seventy five per cent dose of N, P, K with bio-fertilizers recorded significant increase in plant height, number of branches, herbage yield and essential oil. Singh and Ramesh (2004) reported the effect of nitrogen and harvesting stage on oil content of *O. basilicum*. It was observed that application of nitrogen at the rate of 200 kg ha<sup>-1</sup> increased the herbage and oil yields. At the full bloom stage nitrogen application slightly reduced the oil concentration and reverse trend was noted at seed setting stage.

Anwar *et al.*, (2005) studied the effect of organic manures and inorganic fertilizer on growth, herb and oil yield of French basil. A field trial was conducted with six different combinations of organic manure (FYM and Vermicompost) and inorganic fertilizers (N, P, K). Results revealed that among six treatments compared, the combination of Vermicompost @ 5 t ha<sup>-1</sup>+ fertilizer NPK, 50:25:25, performed the best with respect to growth, herb, dry matter, oil content and oil yield. Zohra *et al.* (2005) reported the effect of fertilization on growth and solasodine content of four natural *Solanum sodomium* L. populations. The experiment was carried out on two sites: S1 fertilized by manure and S2 enriched by mineral N fertilizer. There was a significant variability in the average weight of ripe fruits between the sites. The site S2 was more productive. The variation in average solasodine percentage in fresh ripe fruits was also significant. The fruits grown on site S1 where the nutrition was of organic nature, were richer in their solasodine content as compared to the site S2, where the nutrition was of inorganic origin.

Tanu *et al.*, (2004) studied the effect of different organic manures/composts on the herbage and essential oil yield of *Cymbopogon winterianus*. Four organic amendments: leaf compost (LC), vegetable compost (VC), poultry manure (PM) and sewage sludge (SSL) applied at four doses (40, 80, 100 and 120 t ha<sup>-1</sup>) were evaluated for their effect on the herbage yield, essential oil content and inoculum potential (IP) of native arbuscular mycorrhizal fungi (AMF) on three varieties of *Java citronella*, *Cymbopogon winterianus* (Manjusha, Mandakini, and Bio-13). PM applied at 100 t ha<sup>-1</sup> followed by SSL increased the herbage, essential oil content and dry matter yield significantly. Singh and Singh (2003) studied the leaf nutrient status, growth and flower yield in rose as influenced by organic and inorganic sources. The aim was to partially substitute the chemical fertilizers by organic manures and bio-fertilizers. The treatments consisted of a control (T0), full dose of NPK at 50, 40, 30 g/m<sup>2</sup> (T1), 4 kg farmyard manure (FYM)+remaining required dose of NPK (T2), T2+*Azotobacter chroococcum* (T3), T2+phosphorus solubilizing bacterium (PSB; *Pseudomonas striata*) (T4), 2 kg poultry manure+remaining required dose of NPK (T5), T5+A. *chroococcum* (T6), and T5+PSB (T7). T3 treatment significantly increased the leaf N concentration, whereas the maximum leaf P and K contents was recorded with T4. T1 significantly increased the leaf area index, whereas T3 resulted in the maximum plant height. T1 also significantly increased individual flower weight during winter and summer seasons, number of flowers (175.85 ha<sup>-1</sup> year<sup>-1</sup>) and yield of flowers (455.80 q ha<sup>-1</sup> year<sup>-1</sup>). The number of flowers and yield were at par with T3 treatment. Manonmani (1992) reported an increase in the plant height, number of tertiary branches, shoot and leaf area, dry weight, root biomass, flower weight and yield in *Jasminum sambac* as a result of inoculation of *Azospirillum* along with application of nitrogenous fertilizers.

Paturde *et al.*, (2002) reported the effect of organic manures and plant population on the yield of safed musli (*Chlorophytum borivallianum*). Treatments included: no manure (control); farmyard manure (FYM) at 10 t/ha; vermicompost at 5 t/ha; and spacing at 30 x 10 (3.33 lakh), 30 x 15 (2.22 lakh) and 30 x 20 cm<sup>2</sup> (1.66 lakh). The number of tubers, fresh and dry tuber yield and steroid content increased with the application of organic manures. No significant differences in

yield were observed with the application of FYM and vermicompost. The steroid content was highest with vermicompost application. The fresh and dry tuber yield was highest in dense population (3.33 lakh).

Bhaskar *et al.*, (2001) studied the response of *Pelargonium graveolens* to farmyard manure (FYM; 0 and 30 t/ha), N fertilizer (90, 135 and 180 kg/ha) and method of N fertilizer application (foliar and soil-based). The application of FYM produced significantly higher number of shoots in the third and fourth harvests, while no significant differences were observed in this parameter due to N fertilizer application. The total number of shoots per plant was highest for 30 t FYM ha<sup>-1</sup> and for foliar fertilizer application. The application of 30 t FYM/ha and 180 kg N/ha resulted in the highest leaf: stem ratio (2.03 and 2.15, respectively). The method of N application did not significantly affect the leaf: stem ratio. The oil content ranged between 0.31 and 0.32% in the first harvest, and between 0.23 and 0.26% in the second harvest, without being altered by any of the treatments (first harvest). The application of FYM resulted in higher oil content only in the fourth harvest, suggesting that organic manures have favourable effects on oil content in the long run. The highest fresh herbage yields were obtained with 30 t FYM/ha (95.5 t/ha), 180 kg N/ha (96.4 kg N/ha) and N foliar application (92.8 t/ha). The essential oil yields were also highest for these treatments (224.3, 206.0 and 220.3 liters/ha, respectively).

Joshi *et al.*, (2005) studied the composition of essential oil of *O. basilicum* grown organically using compost manure of cow dung at the rate of ten tones ha<sup>-1</sup> and reported the presence of forty three compounds. The oil yield reported was 0.1 per cent. Sundharaiya *et al.*, (2003) studied the effect of FYM, sulphur and different nitrogen sources on herbage and seed yield of *Ocimum*. The combined application of FYM (12.5 t), wettable sulphur (20 kg) and Urea (60 kg) per hectare produced the highest plant height, number of branches per plant, number of inflorescence per plant, herbage and seed yield per hectare, as compared to their individual application.

Singh *et al.*, (2002) reported the response of sweet basil (*O. basilicum*) to organic and inorganic fertilizer in semi-arid tropical conditions. Two field

experiments were carried out to determine the effect of N levels and combined effect of NPK and vermicompost on the growth, herbage, and oil yield and quality of basil. The oil yields were higher as compared to the control. In another experiment, Kandeel *et al.*, (2002) studied the effect of bio-fertilizers on the growth, volatile oil yield and chemical composition of *O. basilicum*. The obtained results showed that dual inoculation with a symbiotic N<sub>2</sub>-fixers (*Azotobacter*+*Azospirillum*) supplemented with half or full dose of inorganic-N fertilizer significantly increased plant height, number of branches/plant, fresh and dry weights of both the herb and roots/plant and yearly oil yield/plot compared with the control treatment.

Kumar and Murugesh (2002) studied ten medicinal plants (*Abrus precatorius*, *Cynodon dactylon*, *Euphorbia tirucalli*, *Gymnema elegans*, *Hemidesmus indicus*, *Ocimum basilicum*, *Plumbago zeylanica*, *Phyllanthus amarus* [*P. niruri*], *Sida acuta* and *S. rhombifolia*) inoculated with 3 vesicular arbuscular mycorrhiza (VAM; *Glomus mosseae*, *G. fasciculatum* and *G. monosporum*) to determine the effects of VAM on the plants. *Abrus precatorius* recorded the highest VAM infection (86%), whereas *Phyllanthus amarus* recorded the lowest (36%). Plants inoculated with VAM spores were taller compared to those of the control, with inoculation with *G. fasciculatum* resulting in the tallest plants. VAM improved the seedling growth, dry weight and phosphorus uptake of the medicinal plants.

Singh and Singh (2003) studied the effect of nitrogen and irrigation regimes on the growth, herbage, yield and quality of oil of *O. basilicum*. It was observed that an application of nitrogen at 200 kg/ha significantly increased plant height, plant spread, herbage and oil yield compared with the control (no nitrogen). Irrigation at 0.75 irrigation water: cumulative pan evaporation (IW: CPE) ratio increased the plant spread, herbage and oil yield compared with that of 0.25 IW: CPE ratio. Oil content and quality were not influenced by nitrogen and irrigation regime. Water use efficiency (WUE) was maximum at 0.25 IW: CPE ratio (0.337 kg oil ha<sup>-1</sup> mm<sup>-1</sup> water used) compared with 0.75 IW: CPE ratio

(0.196 kg oil ha<sup>-1</sup> mm<sup>-1</sup> water used). Similarly, nitrogen application increased the water use efficiency compared with that of the control.

Blank *et al.*, (2003) studied the effects of substrate composition on *Ocimum gratissimum* L. seedling production. *O. gratissimum* seedlings were grown on earthworm manure (EM), coconut dust + EM (1:1), soil + EM (1:1 or 1:2), soil + coconut dust + EM (1:1:1), and soil with limestone + coconut dust + EM (1:1:1). EM singly or in combination with coconut dust resulted in the greatest plant height, and leaf, root, aerial and total dry weight per plant. EM incorporated at a lower rate slightly enhanced the aforementioned parameters.

Golcz *et al.*, (2002) studied the effect of increasing nitrogen doses and harvest terms on the quantitative and qualitative parameters of *O. basilicum*. Studies were carried out in pots filled with mineral soil and peat in volumetric proportion (4:1) in unheated greenhouse. Nitrogen was applied at 0.0, 0.3, 0.6, 0.9 and 1.2 g N/plant using NH<sub>4</sub>NO<sub>3</sub> before the vegetation period. The plants were harvested at the beginning of, and at, flowering stages. Application of 0.9 g N/plant resulted in the highest yield and essential oil content (0.7%). Higher essential oil content was obtained from the plants harvested at the beginning of flowering than at flowering period, independently of the applied N levels. Yeo *et al.*, (2004) reported the effects of NO<sub>3</sub><sup>-</sup>-N and NH<sub>4</sub><sup>+</sup>-N ratio in the nutrient solution on the growth, yield and quality of sweet basil. The shoot and root fresh weight increased with high NO<sub>3</sub><sup>-</sup>-N ratio, while the addition of NH<sub>4</sub><sup>+</sup>-N decreased the fresh and dry weights.

Chaves *et al.*, (2002) reported the effect of organic fertigation (manure at 0, 4, 8 and 12 kg/m<sup>2</sup>) on the leaves and essential oil production of *Ocimum gratissimum*. Fertilizer application increased the dry mass production of the leaves. The maximum leaf production was obtained with 8 and 12 kg/m<sup>2</sup> manure rates. Leaf production was high during winter, but leaves contained less essential oil during this time. Eugenol ratio was significantly higher in autumn than in winter, while that of 1; 8-cineole, beta-selinene and trans-cariophyllene were higher during winter.

Singh (2002) conducted a field experiment for 2 years during 1998 and 1999 at Bangalore, to study the effect of plant spacings (30×20, 30×30, 40×20, 40×30 and 40×40 cm) and nitrogen levels (0, 100 and 200 kg ha<sup>-1</sup>) on herbage, oil yield and quality of South American marigold grown on Alfisol. A plant spacing of 40×20 cm resulted in higher herbage and oil yields compared to wider spacing of 40×40 cm. Application of 200 kg N ha<sup>-1</sup> gave significantly higher herbage and oil yields compared with 0 and 100 kg N ha<sup>-1</sup>. The oil content and quality was not influenced by spacing.

A study on dry matter production, nutrient uptake and quality in *Tagetes minuta* (Senthilkumar *et al.*, 2003) was conducted with four levels of nutrient sources (100% inorganic, 25% organic+75% inorganic, 50% organic+50% inorganic and 100% organic) at three levels of planting density (30 cm × 30 cm, 45 cm × 30 cm and 45 cm × 45 cm). The results showed that dry matter production and essential oil contents were maximum under the combination of 25% organic+75% inorganic sources.

Haripriya and Sriramachandrasekharan (2002) studied the effect of organic manures and plant population on the yield of marigold. Thirty-day-old marigold seedlings were transplanted in pots and supplemented with organic manures viz., leaf mould, press mud and farmyard manure (FYM) in combination with lignite mine spoils in a 1:0.5, 1:1 and 2:1 ratio to determine the effects of lignite mine spoil on the growth and yield of marigold. All the treatments resulted in better growth and yield of marigold compared to the control. Among the organic manures, application of FYM at all ratios resulted in better growth and yield compared to application of leaf mould and press mud. FYM+mine spoil application at 1:2 ratio resulted in the tallest plants (72.28 cm) and highest number of laterals (9.33), leaf production (59.58), dry matter content (68.63 g), number of flowers per plant (6.66), size of flowers (5.33), number of seeds per flower (87.67) and yield per plant (47.33).

Zhong *et al.*, (2003) laid out cultivation experiments on several kinds of herbaceous flowers for a comparative study on the cultivation of *Tagetes erecta*,

*Dahlia pinnata*, *Zinnia elegans*, and *Coleus blumei* under greenhouse conditions. The plants were cultivated on big shallow and 72 x 24-hole pots supplemented with different combinations of growing media. Seedlings planted in hole pots with turf and vermiculite (3:1) showed > 90% germination and survival rates. NAA had a positive effect on rooting and increased survival rate by > 20%.

An experiment was conducted by Khalighi and Padasht (2000) to investigate the effect of growing media on the growth and flowering of marigold cv. Golden Boy. As substitute for peat, the media was composed of tree bark, tea waste and rice hull mixed at different concentrations (0, 25, 75 and 100% by volume) with *azolla* and composted in 1-m<sup>3</sup> woody containers. Data were recorded for different growth parameters, including the fresh and dry weight of root and top parts, plant height, number of lateral shoots and number of opened flowers. The highest growth rate was recorded for plants grown in the medium containing 100% *azolla* and the medium containing 25% tree bark+75% *azolla*. The tree bark and tea waste composts were considered as a good substitute for peat for the cultivation of marigold plants.

Freeman and Cawthon (1999) studied the use of composted dairy cattle solid biomass, poultry litter and municipal biosolids as greenhouse growth media. Dwarf marigold (*Tagetes patula*) cv. Bonanza Yellow was grown in the different types of media. Media containing poultry litter co-composted with hay had low C:N ratios, high porosity and low water-holding capacity, and produced poor quality plants with high mortality rates. Biosolids and poultry litter co-composted with sawdust produced the tallest plants and the largest dry weight accumulation. Composted dairy biomass and the peat moss control produced plants of similar growth and appearance. Biosolids, poultry litter co-composted with sawdust, and dairy biomass were effective peat moss substitutes. Singhal (1999) reported that among growth and yield parameters of *Tagetes minuta*, number of flower heads per plant and oil content in flowers had strong direct positive effects on oil yield per hectare. It was also observed that all the growth and yield parameters except oil content in leaves followed increasing trend with the application of nitrogen and phosphorus at wider spacing.

Maheshwari *et al.*, (1991) conducted field experiments on *Cymbopogon martini* var. motia and reported that applying *Azotobactor* and 80 kg nitrogen per hectare resulted in an increase in herb yield of 20 and 22 per cent as compared to control. *Azotobactor* was found to enhance the herbage biomass by 16 per cent, whereas *Azotobactor* along with 80 kg N per hectare resulted in 29 per cent increment. It was concluded that the use of *Azotobactor* entirely or 80 kg N per hectare singly proved to be the most optimum and economic media for higher monetary returns.

Gupta and Janardhanan (1991) conducted a glasshouse experiment by inoculating *Glomus aggregatum* to *Cymbopogon martini* var. motia. They recorded two fold increase in growth and three fold biomass production in inoculated plants as compared to the non mycorrhizal plants. Similarly, in *C. martini* var. motia, dual inoculation of VAM fungus viz. *Glomus aggregatum* and *Azospirillum brasilense* increased growth, yield and oil content as compared to uninoculated control (Rathi and Janardhanan, 1996).

Chauhan (2000) studied the performance of Poplar based agroforestry system using aromatic crops like Lemongrass, Citronella java, Palmarosa and Japanese mint for five consecutive years. In general, the herb and oil yield from sole crop was higher in comparison to the intercrop. Significant reduction in herb and oil yield started after the third year in case of Citronella java, Palmarosa and Japanese mint, while that of Lemongrass yield decreased slightly after fourth year of crop cycle. Performance of Lemongrass was observed to be the best with respect to sustained herb and oil yield during the entire growth period. Chauhan *et al.*, (1997) reported that the herb and oil yield of interplanted aromatic crops decreased under *Eucalyptus*. The extent of reduction was 61.6 and 67.13 per cent in Japanese mint, 30.71 and 42.22 per cent in Palmarosa, 42.9 and 51.60 per cent in Citronella java and 16.60 and 22.70 per cent in Lemongrass as compared to their sole cropping. The extent of reduction under Poplar was low as compared to *Eucalyptus*.

Yadava and Singh (1996) reported the performance of Lemon grass under Poplar based agroforestry systems. The treatments consisted of three spacings and four fertilizer levels. The spacing of 45×45 cm and fertility level N<sub>250</sub> P<sub>100</sub> K<sub>80</sub> proved to be superior with regard to herbage and oil yield as compared to other treatments in the first and second year, respectively. A sixty month study on the productivity of aromatic grasses viz. *Cymbopogon flexuosus* and *C. martini* grown under Poplar and *Eucalyptus* by Singh *et al.*, (1989) reported that the oil yield decreased significantly under trees as compared to the sole crop. The decrease was more in *Populus deltoides* than *Eucalyptus hybrid*. The herbage yield of intercrops under *E. hybrid* was significantly at par with that of the sole crop.

Jaswal *et al.*, (1993) studied the intercropping of ginger and turmeric with poplar. Both the crops performed better as intercrops than as pure crops. Plant height, tillers per plant and leaves per plant in ginger and leaf length and leaf breadth besides plant height in turmeric were significantly enhanced when intercropped. In ginger, the yield per plant exceeded under Poplar whereas in case of turmeric, the yield per plant was slightly greater in the open.

Jha and Gupta, (1991) studied intercropping of medicinal plants with Poplar and their phenology. Out of sixty four plants studied, 21 were found suitable for the purpose. Mishra and Pandey, 1998 reported intercropping of turmeric under different tree species viz., *Leucaena leucocephala*, *Eucalyptus camaldulensis* and *Melia azadirachta*. Highest mean yield of turmeric was observed under *Leucaena leucocephala*. Mean yield of turmeric decreased with increasing tree age and increasing density of planting of trees. Singh *et al.*, (1990) studied the growth of aromatic crops like *Mentha arvensis*, *M. spicata*, *M. citrate*, *C. flexuosus*, *C. martini* and *C. winterianus* under *P. deltoides*. It was observed that the poplar trees had no adverse effect on the herb and oil yield of different *Mentha* species in the first year but the yields kept on decreasing in the succeeding years. However, in case of *Cymbopogon* species, there was very little reduction in both herb and oil yield. Thakur and Dutt, (2006) have studied in depth the impact of poplar plantation at spacing of 8×3, 6×4, 5×5 and 4×6 m on

the performance, production ability and bioeconomics of four medicinal and aromatic plants. They have reported that *O. sanctum*, *T. minuta*, *Withania somnifera* and *Spilanthus acmella* can be grown successfully with populus. Poplar spacing of 8×3 m and 6×4 m found most suitable, which exerted no adverse effect on the production ability of all the four medicinal herbs.

## 2.2 Growth and yield attributes of hedgerow intercropping

Hedgerow intercropping or alley cropping is an agroforestry system in which annual crops are grown in alleys formed by hedgerows of trees and shrubs. Although the advantages of agroforestry systems are numerous, but in simultaneous agroforestry systems such as alley cropping, strong competition has been observed between annual and perennial crops which can seriously reduce crop yields (Sanchez, 1995). Management of hedgerow systems is very important and continuous efforts are being made to improve the efficiency of these systems.

Kaushal *et al.*, (2003) in hedge row management studies on growth and production of crops with *Leucaena leucocephala* reported that in hedgerow management of alley cropping system, two interrow spacings (4.0 and 6.0 m), three intra-row spacings (0.5, 1.0 and 1.5 m), two moisture conservation practices i.e., no addition of *L. leucocephala* (control) and *in situ* application of *L. leucocephala* biomass were studied to determine the suitable spacing and moisture conservation practices for obtaining higher growth and yield of crops (maize and Indian mustard) sown in between hedgerows of *L. leucocephala*. The plant count, plant height, number of functional leaves, days to maturity and crop yield in both maize and Indian mustard, as well as plant girth in maize and primary branch number in Indian mustard, were highest under the 6.0-m inter-row spacing and 0.5-m intra-row spacing and mulch-treated plots. However, *L. leucocephala* biomass was higher in closely spaced (4.0 m) *Leucaena* and organic mulch-treated plots than in other treatments.

Okun *et al.*, (2001) reported the effects of inter-hedgerow spacing of *Albizia niopoides* on maize performance. It was observed that the pruning of *A. niopoides* in 4-m wide alleys significantly improved height, leaf number, leaf

area, and stover and grain yields of maize. However, maize yield from 4- and 3-m wide alleys did not significantly vary with pruning of *A. niopoides*. This was due to the similarity in biomass production. Thakur and Dutt (2003) studied the growth and production of wheat grown in *Morus* alleys. It was observed that the *Morus* hedgerows during second and third year of establishment, adversely affected wheat yield, especially at closer spacings and nearer to the hedgerow line, whereas the impact of hedgerows at wider plant spacing (2.0 and 2.5 m) in the hedgerows was negligible.

Solomon *et al.*, (2003) studied the yield of groundnut under different alley cropping systems and integrated nutrient management practices. Treatments comprised: *Dalbergia* alley cropping (DAC), *Leucaena* alley cropping (LAC), sole cropping with *Dalbergia* green leaf manuring (SCD) and sole cropping with *Leucaena* green leaf manuring (SCL), green leaf manuring (GLM), no green leaf manuring (NGLM) and 0, 20 and 40 kg N/ha. GLM application increased pod yield and nitrogen uptake. Among the rates, 20 kg N/ha recorded the highest pod yield. The mean pod yield was 1159, 1149, 1002 and 1001 kg/ha in DAC, LAC, SCD and SCL systems, respectively. Nitrogen uptake increased with increasing N rate. The mean N uptake was 98, 82, 54 and 54 kg/ha in DAC, LAC, SCD and SCL systems, respectively. GLM application increased the organic carbon, available nitrogen, phosphorus and potassium in the soil. DAC and LAC systems at 40 kg N/ha with GLM recorded higher soil properties than SCD and SCL systems.

A field study was conducted for 4 years (1994-95 to 1997-98) to determine the effect of substitution of nitrogen (N) fertilizer in bread wheat (*Triticum aestivum*) through subabul (*Leucaena leucocephala*) leaf biomass on growth, yield of wheat and residual effect on yield of subsequent crop of pearl millet (*Pennisetum glaucum*), residual soil fertility and economic returns. Five treatments comprising 100 kg N/ha either applied all through urea fertilizer or *Leucaena* green biomass or combination of urea fertilizer and green biomass at 75:25 and 50:50 and the control, were tried. Green *Leucaena* leaves containing 3% N on dry weight basis were incorporated into the soil 15 days before wheat

crop sowing. Wheat yield was at par in 100 kg N applied through urea fertilizer without *Leucaena* hedgerows (3137 kg/ha) and 100 kg N through urea fertilizer with *Leucaena* hedgerows (3047 kg/ha), indicating that well-managed, pruned at 75 cm above the ground *Leucaena* trees in alley cropping did not show any suppressing effect on the growth, grain and straw yields of wheat and pearl millet. Among substitution of N fertilizer treatments, 25% substitution of N resulted in significantly higher grain yield (3418 kg/ha) than 50% (2937 kg/ha) and 100% substitution (2529 kg/ha). Plant height and yield-contributing characters were also higher in 25% substitution treatment compared to 50 and 100% substitution. Residual effect of incorporation of *Leucaena* biomass to wheat crop was observed on pearl millet yield. Substitution of 100% N through *Leucaena* leaves resulted in higher grain yield (2055 kg/ha) than 25% substitution (1987 kg/ha). Organic carbon (0.29%), available N (164.6), P (23.4), K (17.2) kg/ha were increased with the application of 100% substitution of N fertilizer through *Leucaena* biomass after 4 years (Prakash and Bhushan, 2003).

Mugendi *et al.*, (1999) studied the integration of *Calliandra* (*Calliandra calothyrsus*) and *Leucaena* (*L. leucocephala*) in Maize (*Zea mays*) production system. The experiment consisted of maize plots to which three prunings obtained from hedgerows grown either *in situ* (alley cropping) or *ex situ* (biomass transfer from outside) were applied. When alley cropped with *Leucaena*, maize produced significantly higher yields compared to maize monoculture (both non fertilized and fertilized) treatments, but when alley cropped with *Calliandra*, the yield of maize was less than that of the monocropped unfertilized control. Application of *ex situ* grown *Calliandra* and *Leucaena* prunings with or without fertilizer resulted in higher maize grain yield than in nonfertilized and fertilized treatments. Yields of *Calliandra* alley cropped maize were 11% to 51% lower than those of nonalley cropped treatments receiving *Calliandra* pruning from *ex situ* grown trees. The decrease was 2% to 17% with *Leucaena* indicating that *Calliandra* hedges are more competitive than *Leucaena* hedges.

Singh *et al.*, (2002) conducted a study to investigate if the application of N fertilizer reduces the competition between *L. leucocephala* and wheat, and as a

result the crop yield reduction in an alley cropping system. Three competition treatments were used: sole wheat crop (having no hedgerow); wheat with *L. leucocephala* hedge (neighbour having only root system); and wheat with *L. leucocephala* shrub (neighbour having both root and shoot systems). Half of the portion of each competition treatment was fertilized with urea at 80 kg N/ha. Photosynthetically active radiation (PAR) differed significantly among the competition treatments ( $P < 0.01$ ). Wheat yield varied due to the competition treatments ( $P < 0.001$ ) in both fertilizer conditions. Fertilizer application increased the yield under shrub neighbour by 1.64 times compared with the no fertilizer treatment. The reduction in crop yield under the shrub neighbour was maximum (76%) due to aboveground competition and minimum (24%) due to belowground competition. The crop and shrub neighbour differed greatly in height and time of establishment, as a result, growth and yield of the crop under the shrub was inhibited due to aboveground competition for light. When crop yield in the crop and hedge neighbour treatment was compared with the crop and shrub neighbour treatment under fertilized condition, it was observed that belowground competition declined by 6% due to N application, whereas aboveground competition increased by 2%. N uptake by wheat under the shrub neighbour was 28% greater in the fertilized condition than in the non-fertilized condition. Results indicate that fertilizer application can reduce the overall tree/crop competition under moderate shade condition (50% reduction in PAR).

A study was conducted on a sandy loam alluvial (Entisol) soil in West Bengal, under rainfed condition to determine the effect of frequency of pruning and tree spacing of *Leucaena* on the growth and productivity of turmeric, when grown under alley cropping system with *Leucaena leucocephala* (Pradhan *et al.*, 2003). Both, leaf area indices and dry matter accumulation of turmeric increased with the increasing age of the plant. The maximum rhizome yield of turmeric was recorded when grown within the rows of *Leucaena* planted 4 x 1.0 m apart and pruned 5 times/annum. Girth of bole increased with increasing age of the tree as well as with increasing tree spacing. The maximum biomass production was recorded under 4 x 0.5 m spacing and when pruned 3 times/annum. The yield of intercrop per unit area slightly increased with

increasing tree spacing and frequency of pruning, whereas the yield of *Leucaena* decreased with increasing both the spacing and frequency of pruning. The highest profit was recorded under 4 x 1.0 or 4 x 0.75 m spacing and when pruned 5 times/annum. Pal *et al.*, (2000) studied the effect of N and K fertilizers on turmeric under sole and alley cropping system. Fertilizer application in the alley cropping of turmeric within 2m distance from 5 years old established tree plantation of *Leucaena leucocephala* and in sole crop of turmeric for successive years revealed that the turmeric yield was increased in Sole cropping system by 28.40%, 27.40% and 69.88%, 33.08% in the treatments receiving 0 (control) and N120 kg and K120 kg, respectively, than alley cropping system. Low yield of turmeric in the alley cropping system was mainly due to shading by trees. On an average 20% light was available to the intercropped turmeric.

Pradhan *et al.*, (2003) reported the effect of frequency of pruning and tree spacing of *Leucaena* on the growth and productivity of elephant foot yam (*Amorphophallus campanulatus*) grown under alley cropping system with *Leucaena leucocephala*. In *A. campanulatus*, leaf area index and dry matter accumulation increased with plant age. Corm yield increased with the increase in tree spacing and pruning frequency. The mean corm yields were highest (43.3 and 7.7 t/ha fresh and dry yields, respectively) when *L. leucocephala* was grown at a spacing of 4.0 x 0.5 m and pruned five times. In *L. leucocephala*, bole girth increased with plant age and row spacing, but decreased with pruning frequency. The increase in pruning frequency and row spacing increased green leaf and fuel wood yields, as well as total biomass production, but reduced yield. The highest biomass production (28.2 t/ha) was obtained with a spacing of 4.0 x 0.5 m and pruning three times per year.

Kolekar *et al.*, (2002) studied the effect of alley cropping with *L. leucocephala* and fertilizer application on the growth and yield of tomato. A field experiment was conducted to determine the impact of incorporating *Leucaena* loppings (5 t/ha) and varying levels of recommended rates of N (25, 50, 75, 100 and 150% RDN) on the morphological features, yield components and yield of tomato, raised in the interspace of 9-year-old *Leucaena* hedgerows. Alley-grown

tomato supplied with loppings and 100% RDN recorded the highest values for plant height (159.3 cm), number of branches (30.08), number of functional leaves (221.1), leaf area (114.9 dm<sup>2</sup>), leaf area index (2.56), stem thickness (1.90 cm), fruit set (85.9%), fruit weight (84.0 g), fruit diameter (6.17 cm) and economic yield (43.96 t/ha).

A field experiment was conducted in Hyderabad, Andhra Pradesh, to investigate the effects of alley cropping, green leaf manuring and nitrogen application on the growth and yield of rainfed groundnut (Rao *et al.*, 2000). The experiment consisted of two cropping systems (alley cropping and intercropping with *Albizia lebbek*) and two levels of green manuring (20 and 40 kg N/ha) and no green manuring. Pod yields of groundnut were significantly higher under alley cropping as compared to yields under intercropping. Application of green leaf manuring produced significantly higher yields 1411 kg/ha and 1369 kg/ha during the first and second year of experimentation and low without green leaf manuring (1043 and 1083 kg/ha) under alley cropping.

Pandey *et al.*, (2001) reported the relative influence of above- and below-ground competition on the growth and productivity of *Linum usitatissimum* in a *Leucaena leucocephala* based alley cropping system at a sub-humid site in central India. To examine the relative impact of above and below ground competition, three competition situations were created: Crop+*Leucaena* shrub neighbour, Crop + *Leucaena* hedge neighbour, and sole crop in 4 m and 8 m alley-sizes. Sunlight at ground, soil organic C and total N in soil were measured in all the competition treatments at different distances from shrub and hedge neighbours. Sunlight did not differ in crop+hedge treatment compared to that in sole crop plot; whereas, it was reduced by 36 to 82%, across the alley sizes, in crop+shrub treatment compared to that in sole crop plot. Moreover, reduction in sunlight was greater in 4 m alley. Soil organic C was high but total N was low in crop+hedge neighbour and crop+shrub neighbour treatments compared to that in sole crop plot. Growth rate in *Leucaena* shrub, across the alley-sizes, ranged from 5.6 to 11.8 g m<sup>-2</sup> day<sup>-1</sup>. Above ground biomass and grain yield of the crop were reduced by 9 to 37% and 17 to 26%, respectively, in crop+hedge treatment and

64 to 98% and 89 to 96%, respectively in crop+shrub treatment compared to that of sole crop. Comparing the two competition treatments (crop+hedge and crop+shrub neighbour) it was observed that above ground biomass was reduced to the maximum by 55-60%, growth rate by 42-55% and crop yield by 71-72% due to above-ground competition. Below-ground competition was 3.6 times greater in 4 m compared to that in 8 m alley. Intensity of competition ranged, across the alley-sizes, from 0.10 to 0.37 in crop+hedge and from 0.64 to 0.77 in crop+shrub neighbour competition treatment. Intensity of competition was greater in 4 m alley.

Bhatia and Kanaujia (2000) studied the performance of pearl millet and barley in *Leucaena*-based alley cropping system on alluvial soils. The effect of varying inter-row (4.0 and 6.0 m) and intra-row (0.5, 1.0 and 1.5 m) spacings of *L. leucocephala* with field crops of pearl millet (*Pennisetum typhoides* [*P. glaucum*]) and barley (*Hordeum vulgare*) was compared at Kanpur, Uttar Pradesh, India. Results showed that closer inter-row spacing of 4.0 m resulted in higher *Leucaena* biomass (50.8%) and better yield attributes of pearl millet (4.7%) and barley (2.8%) compared with 6.0 m spacing. However, the grain yield of crops was significantly higher (8.8%) under 6.0 m than under 4.0 m spacing. Closest intra-row spacing of 0.5 m gave the highest grain yield (24.8 q ha<sup>-1</sup>), *Leucaena* biomass (87.1 q ha<sup>-1</sup>) and net returns (Rs. 6963 per annum). Although crop yield was significantly higher under sole cropping, alley cropping proved more economical.

Palled *et al.*, (2000) studied the integrated nutrient management in alley cropped maize (*Zea mays*)-groundnut (*Arachis hypogaea*) system with subabul (*L. leucocephala*). An investigation was conducted in Karnataka, India, to study the response of subabul green manuring in alley cropped maize -groundnut system with alleys at 6-m distance having paired rows 30-cm apart. The NPK recommended rate (RR) for groundnut and maize was 25:75:37.5 and 150:75:75 kg/ha, respectively. Treatments comprised: green manuring (GM) alone for maize and groundnut; GM + 50% N for maize and 25% NPK for groundnut; GM + 50% N for maize and 50% NPK for groundnut; GM + 75% N for maize and 75% NPK

for groundnut; GM + 100% N for maize and 100% NPK for groundnut; RR alone for maize and groundnut (no *L. leucocephala*); and RR (*L. leucocephala* taken out for forage). On average, treatment with RR of fertilizer + GM recorded an 8.84% higher maize grain yield and a 9.18% higher groundnut pod yield than treatment with the RR alone. The maize grain yield at the RR of fertilizer alone was at par with that of 75% N with GM during the 3 years. The pod yield at 50% RR of fertilizer with GM was on par with that of recommended rate of fertilizer alone. On an average, organic nitrogen added from subabul to different treatments ranged from 35.01 to 41.37 kg/ha. Adedire (1998) conducted an experiment under rain-fed conditions to study the effects of *Leucaena leucocephala* hedgerow with and without fertilizer on the yield of maize (*Zea mays*). The experimental design was a randomized block with four treatments and three replications. The treatments were: alley cropping with *L. leucocephala* hedgerows, with or without fertilizer application, and the control (no hedgerows) with or without fertilizer application. The experimental plots received 30N-13P-24K kg/ha at two rates, three and six weeks after planting. The *L. leucocephala* hedgerows were pruned twice to 0.75 m during each cropping season, and the pruning were evenly spread on the alley plots as mulch. Maize yield was determined at 12% moisture content. Grain yield was very low under the control without fertilizer application (0.38 and 0.22 t/ha) for the two cropping seasons, respectively, while grain yield in the alley averaged 1.25 t/ha. The general performance of the crop during the two cropping seasons was in the order of alley cropped with fertilizer application > alley cropped without fertilizer application > control without fertilizer application.

Field studies were conducted in Hyderabad, Andhra Pradesh, on sandy loam soils during 1997-99 to investigate the nitrogen requirement of rose scented geranium (bourbon type) grown in two-year-old *Eucalyptus citriodora* alleys (Singh *et al.*, 2000). The treatments consisted of five levels of nitrogen application (0, 150, 300, 450 and 600 kg N ha<sup>-1</sup> year<sup>-1</sup>). Plant height, plant spread, green herb yield and oil yield significantly increased up to application of 450 kg N ha<sup>-1</sup> year<sup>-1</sup>. Application of N beyond 450 kg ha<sup>-1</sup> year<sup>-1</sup> did not influence the herb and oil yields. On the contrary, application of N significantly leaf: stem ratio and oil

concentration in green herb, particularly with application of N beyond 450 kg ha<sup>-1</sup> year<sup>-1</sup>. These negative effects of N were primarily due to the formation of dense canopy leading to yellowing and shedding of mature leaves situated at the lower and middle segments of the canopy. The geranium oil quality measured in terms of hydroxycitronellol, geraniol, linalool, 10 epi-gamma-eudesmol, and (Z) and (E) rose oxides did not vary appreciably due to application of varying levels of N.

Costa *et al.*, (2000) studied the effects of tree root competition on availability of soil and plant nutrients, soil water and light interception in hedgerow intercrops with different tree species in the mid-country intermediate zone. The experiment determined the inter-species differences in root competition exerted by six tree species (*Calliandra calothyrsus*, *Desmodium rensonii*, *Flemingia congesta* [*F. macrophylla*], *Gliricidia sepium*, *Cassia spectabilis* and *Tithonia diversifolia*) on mung bean (*Vigna radiata*) growing as hedgerow intercrops in the mid-country intermediate zone of Sri Lanka. The experiment was carried out under rainfed conditions. All intercrops had significantly lower plant nutrient (N, P, K) contents than sole mung bean indicating significant competition by hedges for nutrients. This was confirmed by increased plant nutrient contents, when a 1.5 m deep trench was cut between hedges and crop rows. Competition was lowest by *Gliricidia* and highest by *Cassia*. This was confirmed by soil nutrient analysis at sowing and harvesting of mung bean. All intercrops showed increased exchangeable soil K and available P (except with *Gliricidia*) during the cropping season. The fraction of incoming radiation intercepted was higher near hedges than in mid-plot indicating competition for light, which was highest by *Tithonia* (greater canopy spread) and lowest by *Desmodium* and *Flemingia* (lower canopy spread). Soil water content (SWC) was greater in sole mung bean than in intercrops indicating root competition for water. This was confirmed by increased SWC with trenching. Competition for water was mitigated to some extent by soil water conservation via the shading effect of canopies such as *Tithonia*. It was concluded that tree roots of hedgerow intercrops exerted significant competition with the annual crop for absorption of nutrients and water. Out of the tree species tested; *Gliricidia* exerted the least competition for nutrients, while *Tithonia* exerted the least competition for water.

Reddy *et al.*, (2000) reported the performance of radish (*Raphanus sativus* L.) in relation to tree alley orientation in ber-based agri-horticultural system. Intercropping of radish (cv. Pusa Chetki) in north-south (N-S) alleys between 7-year-old ber cv. Gola adversely affected radish growth and yield compared to intercropping in east-west (E-W) alleys. Radish yields were 38 and 31% of those from sole crops in N-S and E-W alleys, respectively, in the strip closer to ber trees and 19 and 12%, respectively, in the strip further from the ber trees. PAR availability was much lower in the strip closer to the trees than in the strip further away. Differences between intercrop positions in transpiration rates were only significant at midday when they were lowest in strips close to trees in N-S alleys.

Friday and Fownes, (2002) studied the competition for light between hedgerows and maize in an alley cropping system. In this study, field experiments, conducted in Hawaii, USA, and a simulation model were used to distinguish between tree-crop competition for light and belowground competition in an alley cropping system. Maize (*Zea mays*) was harvested periodically in three treatments: between vertical barriers of shade cloth, hedgerows of *Flemingia macrophylla*, and sole maize. Radiation intercepted by the maize was calculated using a simulation model based on measured values for direct and diffuse light, hedgerow dimensions and leaf area, and solar trajectory. Radiation use efficiency was calculated as biomass production per unit of intercepted radiation. Maize biomass and yield in both the alley crop and the shade cloth treatment were greatest in the centre of the alleys. Grain yield between hedgerows was 3.5 tonnes ha<sup>-1</sup> (averaged across the alley), significantly less than in the shade cloth (7.4 tonnes ha<sup>-1</sup>) or the sole maize (7.7 tonnes ha<sup>-1</sup>) treatments. Light intercepted by the maize in the alley crop was about half that intercepted by the maize in the sole crop. The shade cloth intercepted less light than the hedgerows because it did not have an appreciable width. Radiation use efficiency in the three treatments was 0.75 g mol<sup>-1</sup> PAR and did not differ significantly among treatments. Tree-crop competition was overwhelmingly for light.

Chattopadhyay *et al.*, (2003) studied the growth and productivity of different tree species and mustard grown under alley cropping system. Different

tree species (*Leucaena leucocephala*, *Lagerstroemia speciosa*, *Dalbergia sissoo*, *Delonix regia*, *Ceiba pentandra*, *Acacia auriculiformis* and *Gmelina arborea*) and mustard crop grown under the alley cropping system. Among the seven tree species; *Leucaena leucocephala*, *A. auriculiformis* and *Dalbergia sissoo* showed better rate of increment of plant height and basal girth during the growing period. *Delonix regia* and *C. pentandra* showed very poor performance. *Leucaena leucocephala* showed the maximum rate of increment in girth at breast height, while the highest number of branches was observed in *Dalbergia sissoo*. *Acacia auriculiformis* had a maximum yield of 8.52 tonnes/ha, while *Delonix regia* and *C. pentandra* showed very poor performance. The maximum stand count was observed in *Leucaena leucocephala* at 25 days after sowing (DAS) but was adversely affected due to shading at harvest. The highest plant population under *Delonix regia*, *Lagerstroemia speciosa*, *A. auriculiformis* and *G. arborea* tree cover were more or less equal. Results also showed that the stand count of mustard at both 25 and 90 DAS in the alleys of *Leucaena leucocephala* and *Dalbergia sissoo* differed significantly from the alleys of other trees but did not differ significantly among them. The grain yield of mustard was also influenced. From the experimental data, it was found that the number of seeds per siliqua in the alleys of *Dalbergia sissoo* differed significantly with the alleys of *Leucaena leucocephala* and *Lagerstroemia speciosa* and did not differ with the other alleys. The grain yield of mustard was more when grown within the alleys of *Dalbergia sissoo*. On the contrary, the grain yields were low when grown in the alleys of *Leucaena leucocephala*, *C. pentandra*, *A. auriculiformis* and *G. arborea* due to shading effect.

Wanvestraut *et al.*, (2004) studied the competition for water in a pecan (*Carya illinoensis*) - cotton (*Gossypium hirsutum* L.) alley cropping system in the southern United States. The root systems of the two species were separated by trenching to 120 cm depth. A polyethylene barrier was installed in half of the plots. Spatial and temporal variations in soil water content, root distribution and water uptake by both species, and leaf area development and height of cotton were measured. Interspecific competition for water was greater in the non-barrier treatment near tree rows than at the alley center. Competition became evident 3 to

4 weeks after emergence of cotton and increased during the following 7 to 8 weeks. Compared with the non-barrier treatment, the barrier treatment had higher soil water content and better growth of cotton (height, leaf area, and fine root biomass). Cotton lint yield in the barrier treatment (677 kg ha<sup>-1</sup>) was similar to that in a sole-crop stand, but higher than in the non-barrier (502 kg ha<sup>-1</sup>) treatment. Lint production efficiency of plants was higher in the interior rows in the non-barrier treatment (0.197 kg lint per square meter of leaf area, compared to 0.117 kg in the barrier treatment). The results suggest that trenching or even deep disking parallel to the tree row may reduce competition for water, but the impact on tree growth cannot be established from this study.

Unkovich *et al.*, (2003) reported the water use, competition, and crop production in low rainfall, alley farming systems of south-eastern Australia. Annual crops (lupins, barley, oats, rape, triticale, wheat, phalaris, subterranean clover, perennial ryegrass and lucerne) were grown in alleys between belts of perennial shrubs or trees (including *Acacia saligna*, *Atriplex nummularia*, *Atriplex amnicola*, *Eucalyptus leucoxydon*, *E. camaldulensis*, *E. maculata* and *E. microcarpa*) over 3-4 years at 3 sites across low rainfall (< 450 mm) south-eastern Australia. At the two lower rainfall sites Pallamana (South Australia) and Walpeup (Victoria), crop grain yields within 2-5 m of shrub belts declined significantly with time, with a reduction equivalent to 45% over 9 m in the final year of cropping. At the third, wetter site (Bridgewater, South Australia), the reduction in crop grain yields adjacent to tree belts was not significant until the final year of the study (12% over 11 m) when the tree growth rates had increased. The reductions in crop yield were associated with increased competition for water between the shrub or tree belts and the crops once the soil profile immediately below the perennials had dried. At all 3 sites during the establishment year, estimates of water use under the woody perennials were less than under annual crops, but after this, trends in estimates of water use of alley farming systems varied between sites. At Pallamana, the perennial shrubs used a large amount of stored soil water in the second summer after establishment and, subsequently, were predominantly dependent on rainfall plus what they could scavenge from beneath the adjacent crop. After the establishment year at the Walpeup site, water

use under the perennial shrubs was initially 67 mm greater than under the annual crop, declining to be only 24 mm greater in the final year. Under the trees at Bridgewater, water use consistently increased to be 243 mm greater than under the adjacent annual crop by the final year. Although the shrub belts used more water than adjacent crop systems at Walpeup and Pallamana, this was mostly due to the use of stored soil water, and since the belts occupied only 7-18% of the land area, increases in total water use of these alley farming systems compared with conventional crop monocultures were quite small, and in terms of the extent of recharge control this was less than the area of crop yield loss. At the wetter, Bridgewater site, alley farming appeared to be using an increasing amount of water compared with conventional annual cropping systems. Overall, the data support previous work that indicates that in lower rainfall environments (< 350 mm), alley farming is likely to be dogged by competition for water between crops and perennials.

A study was conducted in Machakos, Kenya, over six growing seasons with contrasting rainfall, to investigate the microclimatic and competitive effects of *Cassia siamea* hedgerows and the mulching effects of its prunings on the growth and yield of maize under semiarid conditions (Mungai *et al.*, 2001). The potential of this alley cropping combination was assessed. Results showed that above 150 mm of rainfall, maize yields per row in alley cropped 'replacement' agroforestry (AF) plots, may be expected to exceed those in the control (sole maize) plots. Such yields were insufficient to compensate for the area 'lost' to the hedgerows. Below 150 mm, the control plots may be expected to perform better. This result was due to the competition for water. Greater association for the fine roots of *Cassia* and maize was observed in the middle of the alleys than near the hedgerows. Photosynthetic consequences of shading were insignificant, relative to other factors. Soil moisture extraction was higher in the AF than in the control plots. In the AF plots, moisture extraction was greater under the central maize rows than under those nearest the *Cassia*. Maize transpiration and photosynthetic rates were significantly higher in the control than in the AF plots during a below-average rainy season but not during above-average rainy seasons. It is concluded that alley cropping under semiarid conditions should have a different approach

from the system investigated. It must provide strong physical protection of crops and/or soils and have a high economic incentive to be of interest to the farmers.

Miller *et al.*, (2001) studied the resource competition across the crop-tree interface in a maize-silver maple temperate alley cropping stand in Missouri (USA). To study the growth and physiological responses of plants arising from competition across the crop-tree interface, maize (*Zea mays*) was established between rows of seven-year-old silver maple (*Acer saccharinum*) trees in north-central Missouri, USA with four imposed treatments: (1) an unmodified control with a standard rate of N fertilizer at 179.2 kg N/ha, (2) trenching with root barrier installed, (3) supplemental fertilizer treatment (standard N + 89.6 kg N/ha), and (4) a combination of trenching with root barrier and supplemental fertilization. Whereas soil N status had little effect on maize physiology and yield at the interface, competition for soil water was substantial in both years. Soil water content, predawn and midday water potential, and midday net photosynthesis of maize plants adjacent to the tree row without a root barrier, were reduced compared with those of plants in the alley centre, but no differences across the maize crop were evident in the presence of a barrier. The grain yield of border row maize plants lacking an adjacent barrier was depressed compared with that for maize plants with a root barrier present. However, the barrier did not completely restore yield to that in the alley centre, suggesting that reductions in light near the tree row also limited production. Top ear height showed a similar pattern of response to the presence of a root barrier. Silver maple trees responded to root barrier installation with reduced annual diameter growth and reduced water status on some sample days.

# **MATERIALS AND METHODS**

## Chapter-3

# MATERIALS AND METHODS

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The present investigation entitled “Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.” was conducted at the experimental field of Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.) during the year 2005 and 2006. The details of experimental site, materials used and the methodologies adopted for conducting this investigation are given below.

### 3.1 Experimental site

#### 3.1.1 Location

The experimental site is located at Nauni 30°51'N latitude and 76°11'E longitude, with an elevation of 1200 m above mean sea level, 15 km south east of Solan and represents transitional zone between subtropical and sub-temperate region of the state of Himachal Pradesh.

#### 3.1.2 Climate

The climate of the study site is sub-tropical to sub-temperate. The area receives an annual rainfall of 1150 mm, most of which is received during the months from July to August each year. Details of meteorological information collected for experimental year 2005 and 2006 are shown in table 1.

#### 3.1.3 Soil and organic manure analysis

Prior to laying out the experiments a composite soil sample from 0-20 cm i.e. representative of the entire experimental area was drawn and subjected to physico-chemical analysis. The results obtained are presented in Table 2. Three different types of organic manures viz, vermicompost, FYM and a commercially available organic manure with trade name not being mentioned and is called as enriched manure were used in the present study. The details of the physico-chemical characters of the organic manures used are presented in the Table 3.

**Table 1. Meteorological data (January to December 2005 and January to October 2006)**

	Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
<b>Year 2005</b>				
January	18.0	2.7	61.00	67.8
February	17.9	4.7	67.00	147.4
March	24.0	8.5	69.00	56.9
April	28.5	11.2	42.50	5.0
May	31.9	15.3	41.50	11.4
June	34.9	19.0	47.00	27.0
July	29.0	20.3	81.00	168.6
August	29.0	19.4	74.50	58.7
September	29.1	17.8	79.00	157.6
October	27.1	10.4	63.50	
November	24.6	5.0	51.0	
December	21.8	1.4	61.0	11.4
<b>Year 2006</b>				
January	20.6	3.4	59.00	68.0
February	26.1	7.8	51.50	4.4
March	23.9	8.2	57.00	106.7
April	29.2	12.2	38.50	24.6
May	32.1	17.3	50.50	78.8
June	31.4	17.9	21.90	103.4
July	29.0	20.9	79.00	243.9
August	29.0	19.8	76.00	252.2
September	29.6	16.6	68.80	47.8
October	28.1	11.3	56.50	9.4

Source: Meteorological Observatory, Department of Soil Science and Water Management, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.) – 173 230 INDIA

**Table 2 Physico- chemical characters of the study site**

Sr. No.	Parameter	Value
1.	Texture	Sandy loam
2.	pH	6.5
3.	Organic carbon (%)	1.53
4.	Available nitrogen (kg ha <sup>-1</sup> )	257.15
5.	Available phosphorus (kg ha <sup>-1</sup> )	67.20
6.	Available potassium (kg ha <sup>-1</sup> )	145.60

**Table 3 Physico- chemical characters of Organic manures**

Sr. No.	Name of Organic manure	Enriched manure	Vermicompost	FYM
1.	pH	7.0	8.10	7.68
2.	Organic carbon (%)	17	13.5	28
3.	Available nitrogen (%)	1.5	1.3	0.9
4.	Available phosphorus (%)	1.5	0.56	0.70
5.	Available potassium (%)	2	0.84	1.50

### 3.2 Experimental methodology

This study under alley cropping consisted of hedgerows in combination with medicinal and aromatic herbs in the alleys and the effect of various manures on the growth and production ability of these herbs.

#### 3.2.1 Structural components

##### A) Hedgerow tree species

Number of species	-	2
Name of species	-	i) <i>Leucaena leucocephala</i> ii) <i>Morus alba</i>
Alley width	-	7 m

##### Spacings

###### a) *Leucaena leucocephala*

i) 0.50 m

ii) 0.75 m

iii) 1.50 m

###### b) *Morus alba*

i) 1.50 m

ii) 2.00 m

iii) 2.50 m

Planting geometry - Row planting

Planting direction - East-West

Date of planting - July 2001

## B) Medicinal and aromatic plants (alley crops)

Number of species	-	2
Name of species	-	i) <i>Ocimum basilicum</i> ii) <i>Tagetes minuta</i>
Plant spacing	-	Row to Row = 40 cm Plant to plant = 30 cm
Sowing time	-	April
Transplanting time	-	June/July

C) Organic manures	i)	Farm Yard Manure (FYM)
	ii)	Vermicompost (VC)
	iii)	Enriched Manure (EM)

### 3.2.2 Treatments

#### *Morus alba*

Tree spacing in *Morus* (1.50m) + Vermicompost  
Tree spacing in *Morus* (2.00m) + Vermicompost  
Tree spacing in *Morus* (2.50m) + Vermicompost  
Tree spacing in *Morus* (1.50m) + Enriched Manure  
Tree spacing in *Morus* (2.00m) + Enriched Manure  
Tree spacing in *Morus* (2.50m) + Enriched Manure  
Tree spacing in *Morus* (1.50m) + FYM  
Tree spacing in *Morus* (2.00m) + FYM  
Tree spacing in *Morus* (2.50m) + FYM  
Control (without hedgerows, without manures)

#### *Leucaena leucocephala*

Tree spacing in *Leucaena* (0.50m) + Vermicompost  
Tree spacing in *Leucaena* (0.75m) + Vermicompost  
Tree spacing in *Leucaena* (1.50m) + Vermicompost  
Tree spacing in *Leucaena* (0.50m) + Enriched Manure  
Tree spacing in *Leucaena* (0.75m) + Enriched Manure  
Tree spacing in *Leucaena* (1.50m) + Enriched Manure  
Tree spacing in *Leucaena* (0.50m) + FYM  
Tree spacing in *Leucaena* (0.75m) + FYM  
Tree spacing in *Leucaena* (1.50m) + FYM  
Control (without hedgerows, without manures)

Replications	-	3
Design	-	RBD (Factorial)

### **3.2.3 Nursery seedling raising**

The seeds of *Ocimum basilicum* L. and *Tagetes minuta* L. were procured from the Department of Forest Products, UHF, Nauni, Solan (H.P.). Raised nursery beds of size 3 x 1.5 m were prepared. Hundred gram seeds of *Ocimum basilicum* L. and *Tagetes minuta* L. each were sown in lines with 15 cm space between the lines in the second week of May 2005 and 2006, respectively. Seeds were covered with thin layer of soil and light irrigation was given regularly. Nursery beds were kept moist by sprinkling water and were kept free from weeds. The seedlings were ready for transplanting within 45-50 days after nursery sowing.

### **3.2.4 Field preparation**

Experimental field was prepared by 2 ploughings and made smooth by harrowing, followed by planking.

### **3.2.5 Transplanting of seedlings**

Uniform and healthy seedlings of *Ocimum basilicum* L. and *Tagetes minuta* L. were lifted from the nursery in the last week of June, and transplanted in the experimental field in rows by maintaining 40 x 30 cm spacing between rows and plants. Light irrigations after transplanting were given to facilitate the establishment of seedlings. Hand weeding was done after one and two months of transplanting and hoeing was done after each weeding. The experimental plots were maintained properly and kept free of weeds.

### **3.2.6 Application of Organic manures**

Organic manures viz., Vermicompost, Farm Yard Manure and Enriched Manure were applied to all the respective plots of *Ocimum basilicum* L. and *Tagetes minuta* L. except control. The manures were applied after fifteen days of transplanting. These were applied at the rate of 100 grams per plant. Hundred grams of each manure was evenly spread around the individual plant, followed by hoeing. After hoeing, light irrigation was done. Parallel control without organic manure was maintained for comparison among the treatments.

### **3.2.7 Harvesting**

Harvesting of *Ocimum basilicum* L. and *Tagetes minuta* L. was done at full bloom stage during the month of October, 2005 and 2006, respectively.

### **3.3 Observation procedure**

During the present study, the following methodologies were adopted to quantify the impact of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.

#### **3.3.1 Medicinal and aromatic herbs (alley components)**

##### **3.3.1.1 Plant height**

Plant height of *Ocimum basilicum* L. and *Tagetes minuta* L. was determined with the help of scale from the ground level to the top of the highest shoot of the plant for all the treatments. Plant height was measured 90 days after transplanting. Each value is the mean of three replications, five plants per replication. Plant height is expressed in centimeters.

##### **3.3.1.2 Leaf area index (LAI)**

The Leaf area index (LAI) of *Ocimum basilicum* L. and *Tagetes minuta* L. was measured with the help of pre-calibrated programmed LAI 2000 Plant Canopy Analyzer (LI-COR, USA). Each value was computed on the basis of one open and four beneath canopy readings. The open reading was taken away from the canopy by holding the sensor of the canopy analyzer above the canopy of the alley crops for this purpose. Thereafter, the sensor was held underneath the alley crop canopy near the base of the crops, 3-5 cm above the ground level to take 4 below canopy readings. Each value of LAI is the mean of three replications and has been expressed as unit less quantity.

##### **3.3.1.3 Number of flower heads per plant**

The number of flower heads per plant of two herb species viz., *Ocimum basilicum* L. and *Tagetes minuta* L. were recorded for each treatment before harvesting. Each value is the mean of three replications within each treatment.

#### **3.3.1.4 Length of flower head**

The length of flower heads of *Ocimum basilicum* L. and *Tagetes minuta* L. was measured with the help of a scale. Each value is the mean of three replications within each treatment.

#### **3.3.1.5 Fresh weight of shoot**

Randomly chosen medicinal and aromatic plants of *Ocimum basilicum* L. and *Tagetes minuta* L. were uprooted for each treatment. They were cut into two parts i.e. roots and shoots and the fresh weight of each part measured with the help of electronic balance. Each value is the mean of three replications, with five plants per replication within each treatment.

#### **3.3.1.6 Weight of flower heads per plant**

The fresh weight of flowering heads of *Ocimum basilicum* L. and *Tagetes minuta* L. was measured by removing the flowering heads from the rest of the plant and weighing it on an electronic balance. The weight of flowering heads per plant is expressed in grams. Five randomly selected plants per replication were used to determine the fresh weight of the flowering heads.

#### **3.3.1.7 Yield of economic parts**

The yield of economic parts of *Ocimum basilicum* L. and *Tagetes minuta* L. refers to the fresh weight of flowering heads and the fresh weight of the leaves, respectively. The yield of economic parts was calculated by adding the fresh weight of the flowering heads and the fresh weight of leaves. It is expressed in grams.

#### **3.3.1.8 Production efficiency**

The production efficiency for herb/plants grown with and without hedgerows was calculated by dividing total biological yield with duration of crop in days, which has been expressed as kg/ha/day. Production efficiency was

calculated for all the treatments including plants grown with and without organic manures and hedgerows.

### **3.3.1.9 Oil yield**

The leaves and flower heads inflorescence of *Ocimum basilicum* L. and *Tagetes minuta* L. were harvested from three randomly selected plants for each treatment. The fresh weight of the leaves and inflorescence was recorded in the laboratory. The oil extraction of the herb was carried out by Hydro distillation using Clevenger apparatus. The oil so recovered was measured in a calibrated measuring cylinder. The oil content was recorded on volume/weight basis. The estimated oil yield ( $L\ ha^{-1}$ ) was estimated on the basis of per cent oil content in the herb (leaves and flower heads together) yield per plant and was converted into  $litre\ ha^{-1}$  on the basis of estimated herb yield ( $q\ ha^{-1}$ ).

### **3.3.2 Physiological attributes**

The medicinal and aromatic plant species integrated with hedgerow tree species under alley cropping were analyzed for their physiological characteristics. Efforts were made to understand the influence of organic manures and hedgerows on physiological status of medicinal and aromatic herbs.

#### **3.3.2.1 Photosynthetic rate**

The photosynthetic rate of medicinal and aromatic plants was measured with the help of LCA4 portable photosynthesis system (ADC.UK.). The portable pre-programmed system included a leaf chamber, incorporated with humidity, temperature and PAR sensors. The measurements for photosynthesis were made between 10:00 to 13:00 hours. The instrument was carried to the field with all the accessories and attachments. The leaf was enclosed in the leaf chamber and a record was taken. The leaf was then removed from the leaf chamber, which was replaced by a new leaf sample. For each reading a fully expanded leaf was enclosed and the same procedure was followed for each sample. Leaves from each plant were randomly selected for measuring the photosynthetic rate. After completion of readings in the field, the instrument was brought to the laboratory

and the data was downloaded into the computer. The rate of photosynthesis for medicinal and aromatic plants is expressed as  $\mu \text{ mol m}^{-2} \text{ s}^{-1}$ . Five young leaves per replication were selected for the determination of photosynthetic rate. Each value is the mean of three replications within each treatment.

### 3.3.2.2 Transpiration rate

LCA4 portable photosynthesis system was used to measure the transpiration rate. The rate of transpiration was also measured using the same procedure as followed for recording the rate of photosynthesis. Each value is the mean of three replications and expressed as  $\text{m mol m}^{-2} \text{ s}^{-1}$ . The samples used for the estimation of photosynthetic rate were used for the determination of transpiration rate.

### 3.3.2.3 Water use efficiency (WUE)

Water use efficiency for alley crops was calculated on the basis of data recorded for photosynthesis and transpiration as under:

$$\text{WUE} = \frac{\text{Number of molecules of CO}_2 \text{ fixed}}{\text{Number of molecules of H}_2\text{O transpired}}$$

### 3.3.2.4 Light transmission ratio/Interception of solar radiation

In order to calculate the light transmission ratio, photosynthetically active radiations (PAR) was measured both above canopy and below canopy of *Ocimum basilicum* L. and *Tagetes minuta* L. The measurements were made with the help of PAR sensor attached to a portable photosynthesis system (LCA4, ADC.UK). The measurements were made on cloudless days. Three readings were taken per replication out of which, one reading was taken in the open, away from any shade causing object and two readings were taken below the canopy of the herbs. Light transmission ratio was calculated by using the following formula:

$$\text{LTR (\%)} = \frac{\text{Total solar radiation beneath canopy}}{\text{Total solar radiation in open}} \times 100$$

### 3.3.3 Root characteristics

The root characteristics of *Ocimum basilicum* L. and *Tagetes minuta* L. were studied at the time of harvesting. Five randomly selected plants for each replication under each treatment were uprooted from the soil with minimum damage to the root system. The uprooted plants were then used to study the influence of hedgerow tree spacings and manures on different root parameters. Each value is the mean of three replications.

#### 3.3.3.1 Number of roots

The numbers of primary roots with more than 1 mm diameter were recorded per plant within each treatment for medicinal and aromatic plant species by ocular observation. The final value is the mean of three replications, computed for plants growing between the hedgerows, with and without organic manures.

#### 3.3.3.2 Dry weight of roots

The fresh roots were dried in the oven at 60°C. The dry weight of roots was determined with the help of electronic balance and expressed in terms of grams per plant. The values are the mean of three replications, where five plants were selected per replication.

#### 3.3.3.3 Root growth potential

Root growth potential for both the medicinal herbs, growing with and without hedgerows and organic manures was calculated as under:

$$\text{RGP} = \frac{\text{Crop root number under treatments} - \text{Root number in sole crops}}{\text{Crop root number in sole crop}} \times 100$$

Each value is the mean of three replications and expressed in per cent.

#### 3.3.3.4 Specific root length

This has been calculated by using the formula,

$$\text{SRL} = \frac{\text{Root length in cm}}{\text{Dry weight of roots in (g)}}$$

Where, root length was calculated by taking the average of the length of the tap roots and laterals. Each value is the mean of three replications.

### **3.3.4 Characteristics of hedgerow tree species**

#### **3.3.4.1 Height**

The height of hedgerow tree species i.e., *Morus alba* and *Leucaena leucocephala* at each spacing was measured in meters from the ground level to the top of the main shoot with the help of a rod. The measurements were made in July and October 2005 and 2006, respectively. Three trees per replication were used for the purpose.

#### **3.3.4.2 Collar diameter**

The collar diameter of selected hedgerow trees at each spacing was measured with the help of a digital caliper. The measurements for collar diameter were made in the month of October 2005 and October 2006, respectively. Each value is the mean of three replications.

#### **3.3.4.3 Leaf area index**

Leaf area index for hedgerow tree species under each spacing for both the hedgerow species was determined with the help of LAI 2000 Plant Canopy Analyzer. Each value was determined on the basis of one open reading and four beneath canopy readings. The open reading was taken away from the hedgerow trees. Each value is a mean of three replications.

#### **3.3.4.4 Crown spread**

The crown spread was measured from the tree trunk in East, West, North and South directions with the help of a properly graduated wooden rod. The measurements were made in the months of October 2005 and October 2006, respectively.

#### **3.3.4.5 Biomass**

The harvesting of hedgerow trees viz., *Morus alba* and *Leucaena leucocephala* for foliage and branch wood biomass was done in the second week

of October during the year 2005 and 2006, respectively. The braches other then the main stem were cut off from the tree. The leaves were separated from the branches and their fresh weight was recorded. Similarly, the fresh weight of the branches without leaves was also recorded in the field. Each value is the mean of three replications.

#### 3.3.4.6 Light transmission ratio/Interception of solar radiation

Photosynthetically active radiations (PAR) were measured both above canopy and below canopy of *Morus alba* and *Leucaena leucocephala*. The measurements were made with the help of PAR sensors in LCA4 portable photosynthesis system. The measurements were made on cloudless days. Three readings were taken per replication out of which one reading was taken in the open, away from any shade causing object and two readings were taken below the canopy of hedgerow trees. Light transmission ratio was calculated by using the following formula:

$$\text{LTR (\%)} = \frac{\text{Total solar radiation beneath canopy}}{\text{Total solar radiation in open}} \times 100$$

#### 3.3.4.7 Photosynthetic rate

The rate of photosynthesis for *Morus alba* and *Leucaena leucocephala* was measured in the same way as for *Ocimum basilicum* L. and *Tagetes minuta* L. by using LAC4 portable photosynthesis system. Each value is a mean of three replications and the photosynthetic rate is expressed as  $\mu \text{ mol m}^{-2}\text{s}^{-1}$ . Photosynthesis rate was recorded on five randomly selected fully expanded leaves from the different hedgerow trees.

#### 3.3.4.8 Transpiration rate

The transpiration rate of the hedgerow trees was also measured following the same procedure as in case of photosynthetic rate using the LAC4.ADC.UK portable photosynthesis system. Each value is the mean of three replications and expressed as  $\text{m mol m}^{-2}\text{s}^{-1}$ .

### 3.3.4.9 Water Use Efficiency

Water use efficiency of the hedgerow species was calculated on the basis of data recorded for photosynthesis and transpiration. It was calculated by using the following formula:

$$\text{WUE} = \frac{\text{Number of molecules of CO}_2 \text{ fixed}}{\text{Number of molecules of H}_2\text{O transpired}}$$

### 3.3.4.10 Difference in above and below canopy temperature

The difference in above and below canopy air temperature for the hedgerow trees was measured using the temperature sensor attached to the portable photosynthesis system (LAC4, ADC.UK). The temperature sensor attached to the leaf chamber was placed in the open, i.e., away from the tree canopy to record the above canopy air temperature. Thereafter, the sensor was placed below the tree canopy and the air temperature was recorded. The recorded data in the photosynthesis system was then downloaded into the computer. The difference between above canopy and below canopy air temperature was then calculated.

## 3.5 Statistical analysis

The entire data, generated from the present investigation were analyzed statistically using the technique of analysis of variance for factorial randomized block design in accordance with the procedure outlined by Gomez and Gomez (1984).

# **EXPERIMENTAL RESULTS**

## Chapter-4

# EXPERIMENTAL RESULTS

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The present investigation, "Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L." was conducted and completed at the experimental field of Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni - Solan (H.P.) during the years 2005 and 2006. The efforts were made to underline the impact of various tree spacing within the hedgerows as well as the application of three different organic manures on the performance and production ability of alley cropped medicinal and aromatic herbs namely, *Ocimum basilicum* and *Tagetes minuta*. The results obtained are presented in this chapter under the following heads:

- 4.1 Effect of tree spacing within the *Morus alba* hedgerows and organic manures on *Ocimum basilicum* and *Tagetes minuta*.
  - 4.1.1 Growth parameters
  - 4.1.2 Yield parameters
  - 4.1.3 Physiological attributes
  - 4.1.4 Root characteristics
- 4.2 Effect of tree spacing within the *Leucaena leucocephala* hedgerows and organic manures on *Ocimum basilicum* and *Tagetes minuta*.
  - 4.2.1 Growth parameters
  - 4.2.2 Yield parameters
  - 4.2.3 Physiological attributes
  - 4.2.4 Root characteristics
- 4.3 Growth and physiological status of *Morus* and *Leucaena* hedgerows
- 4.1. Effect of tree spacing within the *Morus alba* hedgerows and organic manures on *Ocimum basilicum* and *Tagetes minuta***

The influence of different tree spacing within hedgerows of *Morus* and organic manures on various growth characteristics of *Ocimum basilicum* and *Tagetes minuta* were studied for two successive years and the data so obtained is presented in the tables to follow.

#### 4.1.1. Growth parameters of *Ocimum basilicum* and *Tagetes minuta*

##### 4.1.1.1. Plant height

The data collected with regard to the impact of plant spacing within the *Morus* hedgerows and the application of different organic manures on the height of *Ocimum basilicum* and *Tagetes minuta* have been tabulated and presented in Table 4.

The data in table 4 reveal the influence of *Morus* hedgerows and organic manures on the height of *Ocimum basilicum* and *Tagetes minuta* during the experimental year 2005 and 2006, respectively. The height of *O. basilicum* was significantly affected by the different plant spacing within the hedgerows and three different types of organic manures applied. The maximum (58.83 cm) average height was recorded in treatment T<sub>6</sub> during the year 2005 whereas, the maximum (62.04 cm) height during the experimental year 2006 was again recorded in treatment T<sub>6</sub> (Table 4). The minimum (51.72 cm) average height was recorded in treatment T<sub>7</sub> during 2005. Similarly, the minimum (56.69 cm) average height of *O. basilicum* was recorded in the treatment T<sub>7</sub> during 2006. The critical differences were statistically significant between the treatments during both the experimental years. The pooling of data also followed the same trend whereby the maximum (60.61 cm) height and minimum (53.84 cm) height was observed in the treatments T<sub>6</sub> and T<sub>7</sub>, respectively (Table 4).

It is also clear from table 4, that the hedgerows suppressed the height of *O. basilicum*. The height of the intercrop increased as the distance of the crop from the hedgerows increased from D<sub>1</sub> (0-1m) to D<sub>3</sub> (2-3m). The effect of organic manure is also evident from the fact that despite the influence of hedgerow on the plant height, all the plots receiving organic manures recorded significantly higher average height as compared to the control (Table 4).

The interaction (T x D) between treatments x distance was found to be statistically significant during both the experimental years.

In case of *Tagetes minuta*, the plant height did not seem to be affected *Morus* hedgerows and organic manures. The difference in plant height among all

**Table 4** Effect of *Morus* hedgerows and organic manures on height (cm) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	38.97	56.00	63.27	52.74	41.30	63.53	71.03	58.62	40.12	60.63	67.15	55.97	106.93	131.50	145.13	127.86	101.83	131.87	142.90	125.53	104.40	131.70	144.00	126.70
T <sub>2</sub>	39.27	54.57	62.87	52.23	40.83	62.50	70.53	57.96	40.05	61.03	66.70	55.93	109.27	135.17	146.67	130.37	111.03	133.67	145.83	130.18	110.10	134.40	146.20	130.30
T <sub>3</sub>	40.63	61.07	65.10	55.60	44.73	67.80	71.80	61.44	42.68	62.02	68.45	57.72	113.70	144.83	143.67	134.07	109.83	140.20	134.03	128.02	111.80	142.50	138.80	131.00
T <sub>4</sub>	38.43	62.20	66.17	55.60	46.00	62.63	73.80	60.81	42.22	63.08	69.98	58.43	104.63	126.60	149.60	126.94	105.43	139.30	141.63	128.79	105.00	132.90	145.60	127.90
T <sub>5</sub>	40.67	61.90	64.07	55.54	46.27	67.13	70.47	61.29	43.47	63.52	67.27	58.08	111.40	138.80	143.03	131.08	110.50	135.00	147.73	131.08	110.90	136.90	145.40	131.10
T <sub>6</sub>	43.33	63.83	69.33	58.83	47.77	64.60	73.77	62.04	45.55	64.73	71.55	60.61	108.33	145.90	142.90	132.38	115.60	140.00	138.03	131.21	112.00	142.90	145.50	133.50
T <sub>7</sub>	35.20	56.17	63.80	51.72	41.87	60.40	67.80	56.69	38.53	57.20	65.80	53.84	97.33	124.47	152.13	124.64	97.23	125.90	148.63	123.92	97.28	125.20	150.40	124.30
T <sub>8</sub>	38.27	58.13	63.30	53.23	40.90	57.70	69.27	55.96	39.58	58.35	66.28	54.74	112.57	135.27	146.40	131.41	109.23	135.10	139.13	127.82	94.23	135.20	142.80	129.10
T <sub>9</sub>	38.30	57.30	64.07	53.22	41.40	63.70	70.03	58.38	39.85	60.27	67.55	55.89	109.87	133.63	144.27	129.26	111.57	137.27	140.07	129.63	110.70	135.40	142.20	129.40
T <sub>10</sub>	52.57	52.57	52.57	52.57	57.00	57.00	57.00	57.00	54.78	54.78	54.78	54.94	135.10	135.10	135.10	135.10	137.77	137.77	137.77	137.77	136.40	136.40	136.40	136.40
Mean	40.56	58.37	63.45		44.80	62.85	69.65		42.68	60.61	66.55		107.60	135.10	145.90		110.00	135.60	141.60		109.30	135.40	143.70	

CD<sub>0.05</sub>

T	4.20		3.67		3.13		NS		NS		7.52
D	2.30		2.01		1.71		7.08		4.22		4.12
T x D	7.28		6.36		5.42		NS		13.35		13.03

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

the treatments was statistically non-significant during both the experimental years (Table 4). However, the distance from the hedgerows affected the height of *T. minuta* significantly. It was observed that with the increase in distance away from the hedgerow, there was an increase in the plant height during the year 2005 and 2006, respectively (Table 4). The pooled data reveal that the maximum height (136.40 cm) was recorded in the control (T<sub>10</sub>), while the minimum height (124.30 cm) was recorded in treatment T<sub>7</sub>.

The interaction between treatments and distances (T x D) was also found to be significant (Table 4).

#### 4.1.1.2. Number of inflorescence/flower heads per plant

The observations with regard to the number of inflorescence per plant in *Ocimum basilicum* and *Tagetes minuta* are presented in table 5.

The number of inflorescence per plant of *O. basilicum* was significantly influenced by the tree spacing within the *Morus* hedgerows as well as by the application of three different organic manures. The maximum (73.89) number of inflorescence per plant was recorded in treatment T<sub>6</sub> during the year 2005, whereas the minimum number of inflorescence per plant (49.00) was recorded in treatment T<sub>10</sub> (Table 5). However, during 2006, maximum (78.89) number of inflorescence in *O. basilicum* was observed in treatment T<sub>3</sub> (*Morus* spacing of 2.50 m + vermicompost). The minimum (53.33) number of inflorescence per plant during 2006 was again recorded in treatment T<sub>10</sub> (without trees + without manures). The pooling of data revealed that overall, the maximum (75.89) number of inflorescence per plant was observed in treatment T<sub>3</sub>, while the minimum (51.17) number of inflorescence per plant was observed in T<sub>10</sub> (Table 5). The critical differences for number of inflorescence within the treatments were statistically significant during both the experimental years.

The number of inflorescence per plant decreased significantly due to the presence of hedgerows but only in the plants growing closer to the hedgerows. The average number of inflorescence per plant increased from 44.37 to 79.17 as

the distance from the hedgerow increased from 0-1 m ( $D_1$ ) to 2-3 m ( $D_3$ ) during the experimental year 2005. Almost similar effect was also observed for the year 2006 and the pooled data (Table 5). The impact of hedgerows was not evident at greater distance during both the experimental years. The findings in table 5 indicate that the application of organic manures have greatly influenced the number of inflorescence per plant.

The *Morus* tree spacing within the hedgerows and organic manures also affected the number of inflorescence in *T. minuta* significantly (Table 5). The maximum (174.89) number of inflorescence per plant was recorded at tree spacing of 2.50 m in the hedgerows where enriched manure had been applied to the crop ( $T_6$ ). A minimum (136.78) number of inflorescence per plant was recorded at a tree spacing of 1.50 m within the hedgerow, where FYM had been applied to the crop during the year 2005. Almost similar results were obtained during the year 2006, where the maximum (176.11) number of inflorescence per plant and minimum (150.11) number of inflorescence per plant were observed under treatments  $T_6$  and  $T_7$ , respectively (Table 5).

The effect of distance was also significant as far as the number of inflorescence per plant is concerned. An increase in the number of inflorescence per plant was observed with the increase in distance from the tree trunk. The pooling of data also showed almost similar trend for number of inflorescence per plant for different tree spacing within the hedgerow as well as for the distance away from the hedgerows (Table 5).

The interaction effect was statistically significant only for the year 2006.

#### 4.1.1.3. Length of inflorescence/flower heads

The length of inflorescence was measured in *Ocimum basilicum* and *Tagetes minuta* at the full bloom stage growing with and without *Morus* hedgerows and manures. The data so obtained is presented in table 6.

The hedgerows of *Morus* at three different plant spacing and organic manures affected the length of inflorescence of *O. basilicum* during the year 2005

**Table 5** Effect of *Morus* hedgerows and organic manures on number of inflorescence/flower heads per plant of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	46.00	61.00	75.67	60.89	46.00	50.33	83.67	60.00	46.00	55.67	79.67	60.44	81.67	139.67	239.33	153.56	76.67	140.00	247.00	152.33	79.17	136.50	243.20	152.90
T <sub>2</sub>	44.67	58.33	68.33	57.11	49.67	57.00	88.33	65.00	47.17	57.67	78.33	61.06	88.67	133.33	225.00	149.00	66.67	143.67	242.00	150.78	77.67	138.50	233.50	149.90
T <sub>3</sub>	46.67	83.00	89.00	72.89	50.00	83.67	103.00	78.89	48.33	83.33	96.00	75.89	87.67	161.67	239.33	162.89	91.67	147.33	258.33	165.78	89.67	154.50	248.80	164.30
T <sub>4</sub>	43.33	58.00	74.00	58.44	47.67	65.00	96.67	69.78	45.50	61.50	85.33	64.11	85.67	142.33	242.00	156.67	74.33	145.00	256.67	154.22	80.00	137.50	249.30	155.60
T <sub>5</sub>	40.00	55.00	81.33	58.78	41.00	62.00	96.33	66.44	40.50	58.50	88.83	62.61	86.00	147.00	242.33	158.44	80.33	138.67	241.00	154.44	83.17	144.50	241.70	156.40
T <sub>6</sub>	49.33	78.00	94.33	73.89	43.00	86.00	92.67	73.89	46.17	82.00	93.50	73.89	96.00	154.00	274.67	174.89	91.33	136.67	280.33	176.11	93.67	155.30	283.00	177.30
T <sub>7</sub>	37.00	46.00	72.33	51.78	46.67	57.00	75.67	59.78	41.83	51.50	74.00	55.78	83.33	129.67	197.33	136.78	80.00	141.67	228.67	150.11	82.17	135.70	213.00	143.60
T <sub>8</sub>	46.33	71.00	93.67	70.33	59.67	75.67	90.67	75.33	54.67	73.33	92.17	73.39	84.00	144.00	237.33	155.11	79.33	133.00	243.67	155.33	81.67	144.00	240.50	155.40
T <sub>9</sub>	41.33	70.00	94.00	68.44	49.33	84.00	99.33	77.56	45.33	77.00	96.67	73.00	86.67	157.00	238.67	160.78	90.33	130.33	252.67	157.78	88.50	133.70	245.70	155.90
T <sub>10</sub>	49.00	49.00	49.00	49.00	53.33	53.33	53.33	53.33	51.17	51.17	51.17	51.17	168.67	168.67	168.67	168.67	173.33	173.33	173.33	173.33	171.00	171.00	171.00	171.00
Mean	44.37	62.93	79.17		48.97	67.40	87.97		46.67	65.17	83.57		94.93	145.70	231.60		90.40	144.50	242.40		92.67	145.10	237.00	

CD<sub>0.05</sub>

T	9.78		10.80		7.21		18.05		13.96		11.07
D	5.35		5.91		3.95		9.89		7.64		6.06
T x D	16.95		18.71		12.50		31.27		24.18		19.17

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 6** Effect of *Morus* hedgerows and organic manures on the length (cm) of inflorescence/flower heads of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	14.20	16.03	16.67	15.63	16.37	17.40	18.80	17.52	15.28	16.72	17.73	16.58	2.40	2.30	2.50	2.40	2.77	2.77	2.30	2.61	2.58	2.53	2.40	2.50
T <sub>2</sub>	14.90	16.67	19.47	17.01	15.47	18.77	20.13	18.12	15.18	17.72	19.75	17.55	2.33	2.40	2.30	2.34	2.57	2.23	2.57	2.46	2.45	2.31	2.43	2.40
T <sub>3</sub>	15.83	16.43	20.47	17.58	17.03	16.10	20.30	17.81	16.43	16.27	20.38	17.69	2.63	2.23	2.53	2.47	2.83	2.57	2.30	2.57	2.73	2.40	2.41	2.51
T <sub>4</sub>	13.57	15.97	15.80	15.11	15.87	17.30	19.93	17.70	14.72	16.63	17.87	16.41	2.37	2.40	2.33	2.37	2.37	2.70	2.10	2.39	2.36	2.55	2.21	2.37
T <sub>5</sub>	13.60	15.73	17.93	15.76	15.87	17.03	20.47	17.79	14.73	16.38	19.20	16.77	2.30	2.57	2.37	2.41	2.47	2.33	2.30	2.37	2.38	2.45	2.33	2.38
T <sub>6</sub>	16.77	16.17	17.83	16.92	18.13	17.73	20.27	18.71	17.45	16.95	19.05	17.82	2.50	2.77	2.43	2.57	2.53	2.43	2.67	2.54	2.51	2.60	2.55	2.55
T <sub>7</sub>	11.00	14.47	16.80	14.09	12.67	15.40	19.60	15.89	11.83	14.93	18.20	14.99	2.60	2.60	2.47	2.56	2.53	2.27	2.50	2.43	2.56	2.43	2.48	2.49
T <sub>8</sub>	13.33	15.10	17.40	15.28	17.20	18.30	19.43	18.31	15.27	16.70	18.42	16.79	2.30	2.40	2.67	2.46	2.53	2.20	2.43	2.39	2.41	2.30	2.55	2.42
T <sub>9</sub>	15.00	14.87	16.90	15.59	16.73	16.03	18.03	16.93	15.87	15.43	17.47	16.26	2.63	2.50	2.43	2.52	2.40	2.33	2.70	2.48	2.51	2.41	2.56	2.50
T <sub>10</sub>	14.99	14.99	14.99	14.99	16.37	16.37	16.37	16.37	15.68	15.68	15.68	15.68	2.67	2.67	2.67	2.67	2.53	2.53	2.53	2.53	2.60	2.60	2.60	2.60
Mean	14.32	15.64	17.43		16.17	17.04	19.32		15.24	16.34	18.37		2.48	2.48	2.47		2.55	2.43	2.44		2.51	2.46	2.45	

CD<sub>0.05</sub>

T	1.98		NS		1.44		NS		NS		NS		NS		NS		NS		NS		NS		NS	
D	1.08		0.97		0.79		NS		NS		NS		NS		NS		NS		NS		NS		NS	
T x D	NS		NS		2.50		NS		NS		NS		NS		NS		NS		NS		NS		NS	

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

(Table 6). The maximum (17.58 cm) length of flower head was recorded at *Morus* hedgerow plant spacing of 2.50 m, where vermicompost had been applied to the crop (T<sub>3</sub>), while the minimum (14.09 cm) length of flower head was recorded at *Morus* spacing of 1.50 m along with application of FYM (T<sub>7</sub>). During the second year of experiment, the treatments were not significantly different with respect to the length of the flower head. However, the pooling of data revealed significant differences for this character (Table 6).

Once again, the distance from the hedgerows was found to be differentially and significantly affect the length of the flower head, irrespective of the plant spacing within the hedgerows and organic manure. The length of the flower head increased as the distance from the hedgerows increased from D<sub>1</sub> to D<sub>3</sub>, during the year 2005 and 2006, respectively. The pooled data also confirms this fact (Table 6). The application of all the three manures improved inflorescence length in comparison to control even in the presence of hedgerows, however, at greater distance from the hedgerows.

The interaction (T x D) was statistically significant for both the experimental years as well as for the pooled data.

Unlike *O. basilicum*, the length of the flower heads in *T. minuta* was unaffected by the plant spacing within the *Morus* hedgerows as well as the application of organic manures. The same holds true for both the experimental years as well as for the pooled data (Table 6).

#### 4.1.1.4. Leaf area index

Leaf area index (LAI) of *O. basilicum* and *T. minuta* growing in alleys of *Morus* was determined one week before harvesting. The data obtained for the leaf area index has been presented in table 7.

The leaf area index of *O. basilicum* was significantly influenced by the plant spacing in the *Morus* hedgerows and organic manures. A closer look at the table reveals the effect of distance on the leaf area index of *O. basilicum*. The crop growing closer to the hedgerows had lesser leaf area index as compared to

the crop plants growing away from the hedgerows (Table 7). During the year 2005, the maximum average value for leaf area index was 1.71 observed in T<sub>6</sub>, whereas the minimum leaf area index was 1.32 observed in T<sub>4</sub> (Table 7). In 2006, the maximum average leaf area index was again observed in T<sub>6</sub>, the value being 1.76. The minimum leaf area index was 1.27 during the same year, observed in T<sub>7</sub> (Table 7). The pooled data for the two years indicate an overall maximum (1.73) leaf area index in T<sub>6</sub> and a minimum (1.30) leaf area index in T<sub>4</sub> (Table 7). The critical differences within the treatments are statistically significant for both the experimental years.

The interaction effect was significant during the year 2005 and for the pooled data. However, it was non-significant during the second year of experiment i.e. 2006 (Table 7). Enriched manure application to the plots with wider within hedgerows plant spacing was more effective during both the years.

Like *O. basilicum*, the leaf area index of *T. minuta* was also influenced by the plant spacing within the *Morus* hedgerow as well as the application of organic manures. The maximum (1.22) average leaf area index was observed in crop growing adjacent to *Morus* hedgerow with a wider plant to plant spacing of 2.50 m (T<sub>6</sub>) during the year 2005 (Table 7). The minimum (0.75) leaf area index was observed in hedgerows with a narrow plant to plant spacing of 1.50 m (T<sub>1</sub>) during the same year. During the second year the maximum (1.18) leaf area index was observed in T<sub>3</sub> whereas, the minimum (0.80) Leaf area index was found in T<sub>2</sub> (Table 7). The pooled data revealed a maximum (1.15) Leaf area index in T<sub>6</sub> and a minimum (0.79) Leaf area index in T<sub>1</sub> and T<sub>2</sub>, respectively (Table 7). Enriched manure was comparatively more effective in comparison to vermicompost and FYM.

The interaction (TxD) was found to be significant only during the second year of experimentation.

#### 4.1.2. Yield parameters

The impact of plant spacing within the *Morus* hedgerows and organic manures on the yield of *O. basilicum* and *T. minuta* was recorded for two

**Table 7** Effect of *Morus* hedgerows and organic manures on LAI of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	1.34	1.33	1.34	1.34	1.25	1.30	1.30	1.28	1.29	1.32	1.32	1.31	0.68	0.73	0.84	0.75	0.80	0.90	0.84	0.85	0.74	0.81	0.83	0.79
T <sub>2</sub>	1.34	1.59	1.42	1.45	1.21	1.27	1.41	1.30	1.28	1.43	1.41	1.37	0.77	0.81	0.80	0.79	0.74	0.80	0.86	0.80	0.75	0.80	0.82	0.79
T <sub>3</sub>	1.51	1.63	1.83	1.66	1.48	1.82	1.92	1.74	1.50	1.72	1.87	1.70	0.70	0.86	1.46	1.01	1.02	1.21	1.30	1.18	0.86	1.03	1.38	1.09
T <sub>4</sub>	1.33	1.34	1.29	1.32	1.25	1.56	1.04	1.28	1.29	1.45	1.16	1.30	0.76	0.83	0.77	0.79	0.83	0.84	0.83	0.83	0.79	0.84	0.79	0.81
T <sub>5</sub>	1.47	1.54	1.53	1.51	1.40	1.38	1.23	1.33	1.43	1.46	1.38	1.42	0.77	1.08	1.18	1.01	0.89	1.20	1.17	1.09	0.83	1.14	1.17	1.04
T <sub>6</sub>	1.32	1.95	1.86	1.71	1.60	1.83	1.86	1.76	1.46	1.89	1.86	1.73	1.00	1.26	1.42	1.22	0.87	1.25	1.08	1.08	0.93	1.25	1.28	1.15
T <sub>7</sub>	1.32	1.41	1.86	1.53	1.21	1.30	1.32	1.27	1.26	1.36	1.59	1.40	0.73	0.83	0.79	0.78	0.79	0.82	0.85	0.82	0.75	0.82	0.82	0.80
T <sub>8</sub>	1.41	1.41	1.54	1.45	1.44	1.36	1.37	1.39	1.43	1.38	1.46	1.42	0.69	0.83	0.85	0.79	0.77	0.83	0.84	0.81	0.73	0.82	0.84	0.80
T <sub>9</sub>	1.37	1.19	1.43	1.33	1.31	1.35	1.69	1.45	1.34	1.27	1.56	1.39	0.87	0.89	0.80	0.85	0.77	0.81	0.90	0.83	0.82	0.85	0.85	0.84
T <sub>10</sub>	1.53	1.53	1.53	1.53	1.58	1.58	1.58	1.58	1.55	1.55	1.55	1.55	0.95	0.95	0.95	0.95	1.05	1.05	1.05	1.05	1.00	1.00	1.00	1.00
Mean	1.39	1.49	1.56		1.37	1.47	1.47		1.38	1.48	1.52		0.68	0.73	0.84		0.80	0.90	0.84		0.82	0.94	0.98	

CD<sub>0.05</sub>

T	0.17		0.18		0.13		0.21		0.17		0.12
D	0.09		NS		0.07		0.11		0.09		0.06
T x D	0.28		NS		0.22		NS		0.30		NS

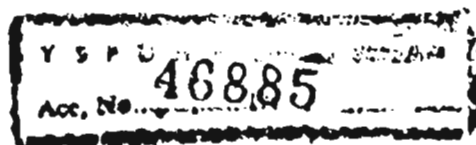
Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

consecutive years. The data was collected on the fresh weight basis and expressed in grams per plant and was then converted to  $q\ ha^{-1}$ . The findings have been described in ensuing pages.

#### 4.1.2.1. Fresh weight of inflorescence/flower heads (q/ha)

The fresh weight of inflorescence/flower heads was significantly influenced by the plant spacing within the *Morus* hedgerows. Hedgerows at narrow plant spacing (1.50 m) in treatments  $T_1$ ,  $T_4$  and  $T_7$  depressed the yield of flower head per plant as compared to wider plant spacing of 2.0 m and 2.50 m (Table 8). The yield was less when grown as intercrop in comparison to sole crop, especially at closer distance to the hedgerows. However, yield improved significantly as the distance increased from 1 m to 3 m from the hedgerows. All the three applied manures were effective and the presence of hedgerows had no adverse impact on the inflorescence/flower heads yield.

Moreover, among the organic manures, comparatively higher yield of inflorescence per plant was obtained where enriched manure was applied followed by vermicompost. Lowest yield of fresh weight of inflorescence per plant was obtained when FYM was applied. The maximum average fresh weight of inflorescence per plant was 38.18 q/ha recorded in  $T_6$  whereas, lowest fresh weight of inflorescence per plant was 26.01 q/ha, recorded in  $T_{10}$  during 2005 (Table 8). Similarly, in the year 2006, maximum (40.58 q/ha) fresh weight of inflorescence per plant was recorded in  $T_6$ , which was slightly higher than the previous year. The minimum (27.67 q/ha) fresh weight of inflorescence per plant was recorded in  $T_{10}$ . The pooling of data also revealed similar trend (Table 8). The effect of organic manures is evident from the fact that the lowest yield of inflorescence was recorded in  $T_{10}$  (control). The effect of *Morus* hedgerows was more prominent on the intercrop at distances closer to the hedgerow  $D_1$  (0-1 m) as compared to  $D_2$  (1-2 m) and  $D_3$  (2-3 m), respectively. The effect of distance on yield was similar during both the experimental years (Table 8). The critical differences for yield values between the treatments are statistically significant for both the experimental years.



The interaction (T x D) was also found to be statistically significant for all the treatments during the study period.

The herb *T. minuta* grown along with hedgerows of *Morus* was also affected by the plant spacing within the hedgerows and organic manures and was unable to counter the suppressing effect of hedgerows. The maximum average yield (16.97 q/ha) of flower heads was obtained in T<sub>6</sub> during the year 2005 (Table 8) whereas, the minimum (12.82 q/ha) fresh weight of flower head was recorded in T<sub>7</sub>, which was slightly lower than the control (T<sub>10</sub>) where value was 13.83 q ha<sup>-1</sup>. A similar trend was observed during the year 2006, where the maximum (17.61 q/ha) and minimum (13.46 q/ha) yield of inflorescence were obtained in treatments T<sub>6</sub> and T<sub>7</sub>, respectively. Higher yields were obtained with the application of enriched manure compared to vermicompost and FYM. The effect of *Morus* hedgerows was more prominent at closer distance on the intercrop for all the treatments except T<sub>10</sub> (control) where no hedgerows were present (Table 8). The pooled data also showed the similar effects. The interaction (T x D) was found to be statistically significant for all the treatments during both the experimental years as well as for the pooled data (Table 8). Differences for yield between the treatments were statistically significant.

#### 4.1.2.2. Fresh weight of shoot (q/ha)

The fresh weight of shoot was found to be significantly different among various treatments during this study. The data with regard to fresh weight of shoot implies that there was a conspicuous effect of plant spacing within the *Morus* hedgerow as well as organic manures. Fresh weight of shoot of *O. basilicum* was maximum at wider spacing of 2.50 m between the *Morus* trees followed by 2.0 m spacing whereas, the fresh weight was lowest at 1.50 m plant spacing within the *Morus* hedgerows. Like wise the effect of organic manures is also evident from the fact that all the plots receiving organic manures had higher fresh weight of shoot (T<sub>1</sub> to T<sub>9</sub>) as compared to the control (T<sub>10</sub>) where no manure was added. Out of all the treatments, T<sub>6</sub> recorded the maximum (82.63 q ha<sup>-1</sup>) fresh weight of shoot, while the minimum (57.27 q ha<sup>-1</sup>) fresh weight of shoot was recorded in T<sub>10</sub> during the year 2005 (Table 9). The pattern was similar

**Table 8** Effect of *Morus* hedgerows and organic manures on fresh weight of inflorescence/flower heads ( $q\ ha^{-1}$ ) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	17.98	27.11	47.31	30.80	19.09	28.22	49.52	32.28	18.54	27.67	48.42	31.54	9.68	13.56	17.71	13.65	10.51	15.22	17.71	14.48	10.10	14.39	17.71	14.06
T <sub>2</sub>	20.75	30.71	50.08	33.85	21.86	32.92	52.01	35.60	21.30	31.82	51.04	34.72	10.51	15.49	17.98	14.66	11.34	17.15	18.26	15.59	10.93	16.32	18.12	15.12
T <sub>3</sub>	22.41	32.92	52.29	35.87	23.79	35.41	53.40	37.53	23.10	34.17	52.84	36.70	11.34	16.32	19.09	15.59	11.62	17.71	17.98	15.77	11.48	17.07	18.54	15.68
T <sub>4</sub>	18.54	27.94	50.08	32.19	19.64	29.60	53.67	34.31	19.09	28.77	51.87	33.25	9.68	14.94	17.71	14.11	10.24	15.77	19.37	15.12	9.96	15.35	18.54	14.62
T <sub>5</sub>	21.58	33.48	51.74	35.60	22.13	34.31	55.61	37.35	21.86	33.89	53.67	36.47	11.07	16.60	19.09	15.59	12.17	16.32	20.47	16.32	11.62	16.46	19.78	15.95
T <sub>6</sub>	24.35	36.52	53.67	38.18	25.18	39.01	57.55	40.58	24.76	37.76	55.61	39.38	12.45	19.37	19.09	16.97	13.28	19.09	20.47	17.61	12.86	19.23	19.78	17.29
T <sub>7</sub>	17.15	25.73	45.93	29.60	17.71	26.84	50.08	31.54	17.43	26.28	48.00	30.57	8.85	13.28	16.32	12.82	9.68	14.39	16.32	13.46	9.27	13.83	16.32	13.14
T <sub>8</sub>	19.09	29.05	49.80	32.65	19.64	30.43	50.35	33.48	19.37	29.74	50.08	33.06	10.24	14.66	16.60	13.83	10.51	16.05	16.88	14.48	10.37	15.35	16.74	14.16
T <sub>9</sub>	20.47	30.99	51.18	34.21	21.86	33.20	52.01	35.69	21.16	32.09	51.60	34.95	11.62	15.22	17.15	14.66	11.07	14.94	17.71	14.57	11.34	15.08	17.44	14.62
T <sub>10</sub>	26.01	26.01	26.01	26.01	27.67	27.67	27.67	27.67	26.84	26.84	26.84	26.84	13.83	13.83	13.83	13.83	16.05	16.05	16.05	16.05	14.94	14.94	14.94	14.94
Mean	20.83	30.05	47.81		21.86	31.76	50.19		21.34	30.90	49.00		10.93	15.33	17.46		11.65	16.27	18.12		11.29	15.80	17.79	

CD<sub>0.05</sub>

T	3.85		1.47		3.30		1.13		1.40		1.11
D	2.11		1.61		1.81		0.62		0.76		0.60
T x D	6.74		5.08		5.62		1.96		2.42		1.92

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Free spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 9** Effect of *Morus* hedgerows and organic manures on fresh weight of shoot ( $q\ ha^{-1}$ ) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	41.78	59.48	97.66	66.31	44.54	65.02	106.50	72.03	43.16	62.25	102.10	69.17	62.25	92.68	116.2	90.38	71.93	96.83	117.6	95.45	67.09	94.76	116.9	92.91
T <sub>2</sub>	48.14	62.53	99.60	70.09	50.91	70.00	109.30	76.73	49.52	66.26	100.40	73.41	71.93	96.83	116.2	94.99	76.08	101.0	107.9	94.99	74.01	98.91	112.0	94.99
T <sub>3</sub>	53.95	69.44	111.20	78.20	54.23	73.87	113.70	80.60	54.09	71.66	112.50	79.40	74.70	105.1	119.0	99.60	80.23	106.5	120.3	102.4	77.47	105.8	119.7	101.0
T <sub>4</sub>	42.61	62.25	101.80	68.89	45.37	68.61	112.30	75.44	43.99	65.43	107.10	72.16	78.85	94.07	119.07	97.29	73.32	101.0	127.3	105.0	76.08	97.52	123.1	98.91
T <sub>5</sub>	48.97	69.17	107.30	75.16	54.23	77.74	112.60	81.52	51.60	73.45	110.00	78.34	73.32	94.07	121.7	96.37	81.62	96.83	131.4	103.3	77.47	95.45	126.6	99.83
T <sub>6</sub>	57.27	73.87	116.80	82.63	57.27	79.68	119.00	85.31	57.27	76.77	117.90	83.97	94.07	105.1	120.3	106.50	88.53	113.4	132.8	111.6	91.30	109.3	126.6	109.1
T <sub>7</sub>	39.29	58.93	92.96	63.73	40.67	63.08	102.40	68.71	39.98	61.00	97.66	66.22	71.93	88.53	106.5	88.98	77.47	87.15	113.4	92.68	74.70	87.84	110.0	90.84
T <sub>8</sub>	44.82	60.31	96.28	67.14	47.59	64.46	104.90	72.30	46.20	62.39	100.60	69.72	63.63	85.77	119.0	89.46	76.08	91.30	119.0	95.45	69.86	88.53	119.0	92.45
T <sub>9</sub>	49.52	66.95	107.10	74.52	50.08	68.06	108.50	75.53	49.80	67.51	107.80	75.02	66.40	99.60	110.7	92.22	73.32	98.22	113.4	94.99	69.86	98.91	112.0	93.61
T <sub>10</sub>	57.27	57.27	57.27	57.27	65.29	65.29	65.29	65.29	61.28	61.28	61.28	61.28	92.68	92.68	92.68	92.68	110.7	110.7	110.7	110.7	101.7	101.7	101.7	101.7
Mean	48.36	64.02	98.80		51.02	69.58	105.40		49.69	66.80	102.10		74.98	95.45	114.1		80.92	100.3	119.4		77.95	97.87	116.8	

CD<sub>0.05</sub>

T	5.61	6.08	5.31	8.25	8.97	6.83
D	3.07	3.33	2.91	4.52	4.91	3.74
T x D	5.61	10.53	9.20	14.29	15.53	11.83

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

during 2006 where the maximum (85.31 q ha<sup>-1</sup>) and minimum (65.29 q ha<sup>-1</sup>) fresh weight of shoot was recorded in treatments T<sub>6</sub> and T<sub>10</sub>, respectively. The pooling of data for the fresh weight of shoot also confirms this fact (Table 9). The effectiveness of organic manures is evident even in the presence of hedgerows of *Morus* during the present study.

The effect of distance of the crop from the hedgerows was also found to be significant. The data clearly envisage the fact that as the distance of the crop from the hedgerows increased, there was corresponding increase in the fresh weight of shoot. CDs for treatments (T) x distance (D) were statistically significant for both the experimental years as well as for the pooled data (Table 9).

In case of *T. minuta*, the highest fresh weight of shoot was found to be 106.50 q ha<sup>-1</sup> and 111.60 q ha<sup>-1</sup> in T<sub>6</sub> for the year 2005 and 2006, respectively. The fresh weight of shoot in *T. minuta* was also significantly affected by *Morus* hedgerows and organic manures. The maximum average (106.50 q ha<sup>-1</sup>) fresh weight of shoot was recorded in T<sub>6</sub> whereas, lowest (88.98 q ha<sup>-1</sup>) fresh weight of shoot was recorded in T<sub>7</sub>. Likewise in the next year (2006) and for the pooled data the behaviour was the same (Table 9). The effect of distance was also found statistically significant during both the years. It is clear from the data that the fresh weight of shoot was lower at distance D<sub>1</sub> (0-1 m) compared to D<sub>2</sub> (1-2m) and D<sub>3</sub> (2-3m) from the tree trunk. Almost similar effect was seen in the pooled data (Table 9).

The interaction effect was also found to be significant during both the years as well as for the pooled data.

#### 4.1.2.3. Economic/Herb Yield (q/ha)

The economic yield or the herb yield includes the yield of inflorescence/flower heads and leaves. The perusal of data from table 10 clearly explains the effect of *Morus* hedgerows, organic manures and respective distances on the herb species from the hedgerows on the economic yield. The

effect of organic manures is clear from the fact that the application of all the three organic manures enhanced herb yield in comparison to control despite the presence of hedgerows. This is important as well as desirable. For example, the minimum (36.80 qha<sup>-1</sup>) herb yield was recorded in T<sub>10</sub> during 2005 where no manure was added to *O. basilicum* plots whereas, all other organic manure treatments registered significantly higher yield as compared to T<sub>10</sub>. Similarly, the lowest (39.29 q ha<sup>-1</sup>) yield was recorded in T<sub>10</sub> during 2006 (Table 10). A maximum (51.00 q ha<sup>-1</sup>) herb yield was recorded in T<sub>6</sub> during 2005 at a plant spacing of 2.50 m within the hedgerows and including the application of enriched manure. The herb yield was also maximum (52.20 q ha<sup>-1</sup>) in the same treatment during 2006 (Table 10). A critical view of the data in table 10 reveal that at 2.5m plant spacing, the effectiveness of organic manures was in the order Enriched manure > vermicompost > FYM. The respective average herb yield were 51.00>48.60>46.57 q ha<sup>-1</sup> in the treatments T<sub>6</sub>, T<sub>3</sub>, and T<sub>9</sub> (Table 10). The values were significantly higher than the yield in control without manure and hedgerows.

The effect of distance of the herb species away from the hedgerow was also statistically significant whereby higher average herb yields were recorded at distance away from the hedgerows. The values are statistically significant.

The critical differences for treatments (T) and distances (D) were statistically significant during the two consecutive experimental years (Table 10).

In *T. minuta*, higher yield was observed in the sole crop (control) as compared to some of the treatments, indicating the suppressing effect of the hedgerows. Like *Ocimum*, the presence of *Morus* hedgerows significantly affected the herb yield of *T. minuta*. The maximum (24.62 q ha<sup>-1</sup>) herb yield was recorded in T<sub>6</sub> during 2005 whereas, the maximum (25.73 q ha<sup>-1</sup>) herb yield was again recorded in treatment T<sub>6</sub> during the year 2006 (Table 10). The minimum (18.17 q ha<sup>-1</sup>) herb yield was obtained in T<sub>7</sub> during 2005, while the minimum (19.46 q ha<sup>-1</sup>) herb yield during 2006 was recorded again in T<sub>7</sub>. It is evident from table 10 that high herb yield was obtained at wider spacing among trees as well as by the application of enriched manure.

**Table 10** Effect of *Morus* hedgerows and organic manures on economic yield (q ha<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	27.39	39.29	59.76	42.15	28.22	39.01	64.19	43.81	27.80	39.15	61.97	42.98	14.11	19.37	25.45	19.64	14.66	21.86	26.01	20.84	14.39	20.61	25.73	20.24
T <sub>2</sub>	30.16	43.44	62.80	45.47	31.26	44.27	65.85	47.13	30.71	43.85	64.32	46.30	14.66	21.86	26.56	21.03	16.05	25.18	27.67	22.96	15.35	23.52	27.11	21.99
T <sub>3</sub>	32.37	46.20	67.23	48.60	33.03	46.48	67.23	48.97	32.78	46.34	67.23	48.79	15.49	23.24	27.94	22.23	16.32	26.01	27.67	23.33	15.91	24.62	27.80	22.78
T <sub>4</sub>	28.50	40.39	64.19	44.36	29.33	38.46	67.51	45.10	28.91	39.42	65.85	44.73	13.83	20.47	25.73	20.01	14.66	22.69	28.50	21.95	14.25	21.58	27.11	20.98
T <sub>5</sub>	32.09	43.71	66.12	47.31	32.65	45.10	70.55	49.43	32.37	44.40	68.34	48.37	15.49	23.79	27.67	22.32	17.43	23.52	29.88	23.61	16.46	23.65	28.77	22.96
T <sub>6</sub>	35.69	49.25	68.06	51.00	35.69	50.35	70.55	52.20	35.69	49.80	69.30	51.60	17.15	27.94	28.77	24.62	18.81	28.22	30.16	25.73	17.98	28.08	29.46	25.18
T <sub>7</sub>	27.39	38.73	59.76	41.96	27.11	37.07	64.74	42.98	27.52	37.90	62.25	42.47	12.45	18.54	23.52	18.17	13.56	21.03	23.79	19.46	13.00	19.78	23.65	18.81
T <sub>8</sub>	28.77	40.95	63.08	44.27	29.33	40.39	64.19	44.64	29.05	40.67	63.63	44.45	14.39	21.03	24.62	20.01	14.66	23.52	24.35	20.84	14.52	22.27	24.48	20.43
T <sub>9</sub>	31.26	43.44	65.02	46.57	31.54	44.82	65.02	47.13	31.40	44.13	65.02	46.85	15.77	21.86	25.18	20.93	15.49	21.86	26.28	21.21	15.63	21.86	25.73	21.07
T <sub>10</sub>	36.80	36.80	36.80	36.80	39.29	39.29	39.29	39.29	38.04	38.04	38.04	38.04	21.30	21.30	21.30	21.30	22.96	22.96	22.96	22.96	22.13	22.13	22.13	22.13
Mean	31.04	42.22	61.28		31.76	42.52	63.91		31.40	42.37	62.60		15.47	21.94	25.67		16.46	23.68	26.73		15.96	22.81	26.20	

CD<sub>0.05</sub>

T	3.77		3.08		3.28		1.82		2.11		1.58
D	2.07		1.68		0.18		0.99		1.15		0.86
T x D	6.54		5.32		5.68		3.14		3.66		2.62

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The presence of hedgerows significantly reduced the herb yield in plants growing nearer to the hedgerows (Table 10). The critical differences between the treatments are statistically significant during both the experimental years. The pooling of data also reveals similar results both for the treatment combinations as well as for the distances.

The interaction (T x D) was significant during both the experimental years.

#### 4.1.2.4. Estimated oil yield (L ha<sup>-1</sup>)

Presence of *Morus* hedgerows and organic manures significantly affected the oil yield of *O. basilicum* during the present study. Plants grown closer to the hedgerows exhibited more reduction in oil yield; however, a significant increase in oil yield with increase in distance from hedgerow line was obvious (Table 11). The effect of organic manures, particularly enriched manure was eminent from the fact that the oil yield *per se* was less under control, where no manures were applied to the crop and the highest oil yield was recorded in treatments receiving enriched manure. The maximum (16.83 L ha<sup>-1</sup>) oil yield was observed in T<sub>6</sub> in comparison to a minimum of 12.14 L ha<sup>-1</sup> oil yield recorded in T<sub>10</sub> during 2005 (Table 11). Similarly in 2006, the maximum (17.23 L ha<sup>-1</sup>) oil yield was recorded in T<sub>6</sub> and the minimum (12.96 ha<sup>-1</sup>) in T<sub>10</sub>. The pooled data also showed the same variations (Table 11). It is clear from the data in table 11 that the applied organic manures significantly improve oil yield of *O. basilicum* over control even in the presence of hedgerows.

The interaction (TxD) between treatment (T) and distance (D) was statistically significant during both the experimental years.

The results obtained for the oil yield in *T. minuta* grown in association with *Morus* were similar to *O. basilicum* as far as the distance from the hedgerows is concerned (Table 11). The maximum (11.33 L ha<sup>-1</sup>) oil yield was observed in T<sub>6</sub> and the minimum (9.03 L ha<sup>-1</sup>) oil yield was recorded in T<sub>1</sub> during the first year of experiment. However, in the second year the maximum (11.84 L

ha<sup>-1</sup>) and minimum (8.95 L ha<sup>-1</sup>) oil yield was recorded in T<sub>6</sub> and T<sub>7</sub> (Table 11). The pooled data however showed maximum and minimum oil yield in T<sub>6</sub> and T<sub>7</sub>, respectively (Table 11). The oil yield was lesser at closer distance (upto 1 m) from the hedgerows, which increased thereafter with the increase in distance upto 3 m away from the hedgerows. The values were significantly higher in plots provided with organic manure in comparison to plots without the application of manure.

The interactions (TxD) effect was found to be significant for both the experimental years as well as for the pooled data (Table 11). The critical differences were statistically significant.

#### 4.1.2.5. Production Efficiency (kg/ha/day)

The data pertaining to production efficiency is presented in table 12. The production efficiency of *O. basilicum* grown under different spacing of *Morus* plants within the hedgerows showed significant variations. The application of organic manures also influenced the production efficiency of *O. basilicum*. The maximum production efficiency of 88.63kg/ha/day was recorded in T<sub>6</sub> during the first year of experiment. During the second year, a maximum production efficiency was 90.19 kg/ha/day recorded in T<sub>6</sub> (Table 12). The minimum production efficiency of 62.53 kg/ha/day and 67.69 kg/ha/day was observed in T<sub>10</sub> during the first year and second year, respectively (Table 12). The pooled data also showed the maximum and minimum production efficiency in treatments T<sub>6</sub> and T<sub>10</sub>, respectively (Table 12). As far as the role of organic manures is concerned, it is amply clear from the data that treatments receiving enriched manure showed higher production efficiency in comparison to vermicompost and FYM. Not only that, the data also revealed that all the treatments (T<sub>1</sub> to T<sub>9</sub>) receiving organic manures had higher levels of production efficiency despite competition from hedgerows as compared to control (T<sub>10</sub>), where no manure was added. hedgerows (Table 12).

The presence of hedgerows and the application of organic manures also affected the production efficiency of *T. minuta*. The results in table 12 indicate

**Table 11** Effect of *Morus* hedgerows and organic manures on estimated oil yield (L ha<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	9.03	12.96	19.72	13.91	9.13	12.87	21.18	14.46	9.17	12.92	20.45	14.18	6.49	8.90	11.71	9.03	6.74	10.05	11.96	9.58	6.61	9.48	11.84	9.31
T <sub>2</sub>	9.95	14.33	20.73	15.00	10.32	14.61	21.73	15.55	10.13	14.47	21.23	15.28	6.74	10.05	12.22	9.67	7.38	11.58	12.73	10.56	7.06	10.82	12.47	10.12
T <sub>3</sub>	10.68	15.25	22.19	16.04	10.96	15.34	22.19	16.16	10.82	15.29	22.19	16.10	7.12	10.69	12.85	10.22	7.50	11.96	12.73	10.73	7.31	11.33	12.79	10.48
T <sub>4</sub>	9.40	13.33	21.18	14.64	9.67	12.69	22.28	14.88	9.54	13.01	21.73	14.76	6.36	9.41	11.84	9.20	6.74	10.44	13.11	10.10	6.55	9.92	12.47	9.65
T <sub>5</sub>	10.59	14.43	21.82	15.61	10.77	14.88	23.28	16.31	10.68	14.65	22.55	15.96	7.12	10.94	12.73	10.27	8.08	10.82	13.74	10.86	7.57	10.88	13.24	10.56
T <sub>6</sub>	11.78	16.25	22.46	16.83	11.78	16.62	23.28	17.23	11.78	16.43	22.87	17.03	7.89	12.85	13.24	11.33	8.65	12.98	13.87	11.84	8.57	12.92	13.55	11.58
T <sub>7</sub>	9.03	12.78	19.72	13.85	8.94	12.23	21.36	14.18	8.99	12.51	20.54	14.01	5.72	8.52	10.82	8.35	6.23	9.67	10.94	8.95	5.98	9.10	10.88	8.65
T <sub>8</sub>	9.49	13.51	20.82	14.61	9.67	13.33	21.18	14.73	9.58	13.42	21.00	14.67	6.61	9.67	11.33	9.20	6.74	10.82	11.20	9.58	6.68	10.24	11.26	9.39
T <sub>9</sub>	10.32	14.33	21.46	15.37	10.41	14.79	21.46	15.55	10.36	14.56	21.46	15.46	7.25	10.05	11.58	9.63	7.12	10.05	12.09	9.57	7.19	10.05	11.84	9.69
T <sub>10</sub>	12.14	12.14	12.14	12.14	12.96	12.96	12.96	12.96	12.55	12.55	12.55	12.55	9.80	9.80	9.80	9.80	10.56	10.56	10.56	10.56	10.18	10.18	10.18	10.18
Mean	10.24	13.93	20.22		10.48	14.03	21.09		10.36	13.98	20.66		7.11	10.09	11.81		7.57	10.89	12.29		7.34	10.49	12.05	

CD<sub>0.05</sub>

T	1.24	1.01	1.08	0.83	0.97	0.72
D	0.68	0.55	0.59	0.45	0.53	0.39
T x D	2.14	1.76	1.86	1.44	1.68	1.26

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manur.

**Table 12** Effect of *Morus* hedgerows and organic manures on production efficiency (kg/ha/day) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	45.10	64.19	103.50	70.92	47.86	68.89	112.60	76.45	46.48	66.54	108.00	73.69	68.34	99.88	124.80	97.66	76.36	104.60	123.70	101.50	72.35	102.20	124.20	99.60
T <sub>2</sub>	52.29	68.06	106.80	75.71	53.95	73.59	115.60	81.06	53.12	70.83	111.20	78.39	78.85	105.10	124.20	102.70	82.45	110.10	117.30	103.30	80.65	107.60	120.80	103.00
T <sub>3</sub>	58.65	76.36	117.60	84.20	57.27	77.19	119.50	84.66	57.96	76.77	118.60	84.43	81.34	112.90	128.90	107.60	86.60	112.90	129.80	109.70	83.97	112.90	129.30	108.70
T <sub>4</sub>	46.48	68.8	108.70	74.70	48.42	74.15	118.40	80.33	47.45	71.52	113.60	77.51	85.77	102.40	123.90	104.00	80.23	109.80	136.40	108.80	83.00	106.10	130.20	106.40
T <sub>5</sub>	53.12	76.36	114.00	81.16	57.55	82.45	117.60	85.86	55.33	79.40	115.80	83.51	80.23	102.40	128.60	103.70	87.98	106.00	140.80	111.60	84.11	104.20	134.70	107.70
T <sub>6</sub>	62.25	80.51	123.10	88.63	60.31	85.21	125.10	90.19	61.28	82.86	124.10	89.41	102.10	112.30	129.50	114.60	96.00	119.50	145.80	120.40	99.05	115.90	137.60	117.50
T <sub>7</sub>	42.88	65.57	99.88	69.44	44.27	68.06	109.30	73.87	43.57	66.81	104.60	71.66	79.13	96.28	115.10	96.83	83.55	98.49	122.60	101.50	81.34	97.39	118.80	99.18
T <sub>8</sub>	48.97	65.57	103.20	72.58	50.35	69.17	110.70	76.73	49.66	67.37	106.90	74.65	70.27	92.96	127.50	96.93	82.72	99.60	127.80	103.40	76.50	96.28	127.70	100.20
T <sub>9</sub>	53.67	73.32	114.30	80.42	53.12	74.15	114.80	80.69	53.40	73.73	114.50	80.56	72.76	107.90	118.10	99.60	79.68	106.50	125.10	103.70	76.22	107.20	121.60	101.70
T <sub>10</sub>	62.53	62.53	62.53	62.53	67.69	67.69	67.69	67.69	65.11	65.11	65.11	65.11	101.80	101.80	101.80	101.80	113.00	113.00	113.00	113.10	107.40	107.40	107.40	107.40
Mean	52.59	70.13	105.40		54.17	74.15	110.90		53.38	72.14	108.10		82.06	103.40	122.30		87.34	107.80	128.00		84.70	105.60	125.10	

CD<sub>0.05</sub>

T	5.56		5.97		5.26		9.19		9.02		7.17
D	3.04		3.27		2.88		5.03		4.94		3.93
T x D	9.62		10.35		9.10		15.93		14.37		12.41

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompos:	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

that production efficiency was lesser than the control in plots closer (upto 2 m) from the hedgerows during both the experimental years. However, the values for production efficiency increased upto 3 m from the hedgerows, which were significantly higher in comparison to control. Organic manures were effective and significantly enhanced production efficiency than the control without manure, especially at a greater distance from the hedgerows. This was true during both the experimental years. Out of the three organic manures, enriched manure was most effective during both the experimental years. The critical difference within the treatments were statistically significant. This is also true for the pooled data.

The interaction effect (TxD) was also found to be statistically significant for both the experimental years.

#### 4.1.3. Physiological Attributes

It was also desired to understand the physiological behaviour of medicinal herbs grown with and without hedgerows and organic manures. The data obtained with regard to the impact of *Morus* hedgerows and organic manures on physiological attributes of *O. basilicum* and *T. minuta* is presented in Table 13-16.

##### 4.1.3.1. Photosynthetic rate ( $\mu \text{ mol m}^{-2} \text{ s}^{-1}$ )

The rate of photosynthesis in *O. basilicum* and *T. minuta* as affected by the *Morus* hedgerows as well as by the application of organic manures is shown in table 13. The critical differences among various treatments were statistically non-significant however, the application of organic manures was found to improve the rate of photosynthesis in *O. basilicum* and *T. minuta* during both the experimental years. The distance from the hedgerows did not seem to affect the photosynthetic rates. The data in table 13 reveal that photosynthetic rates irrespective of distance from the hedgerows were comparatively higher in plots  $T_1 - T_9$  in comparison to control ( $T_{10}$ ) without manures. This was true for both the experimental years. A similar pattern was observed for *T. minuta* where organic manure treated plants registered higher rate of photosynthesis than the plants without organic manure (Table 13). Response of both the herb species to

vermicompost, enriched manure and FYM with regard to photosynthetic rates were almost similar.

#### 4.1.3.2. Transpiration rate ( $\text{m mol m}^{-2}\text{s}^{-1}$ )

The amount of water transpired by *O. basilicum* and *T. minuta* grown in association with *Morus* hedgerows with and without organic manures is presented in table 14. During the present study, it was observed that the effect of hedgerows and organic manures was significantly different in case of *O. basilicum* during the year 2005 and 2006, respectively. The maximum ( $1.61 \text{ m mol m}^{-2}\text{s}^{-1}$ ) rate of transpiration was observed in T<sub>7</sub>, whereas the minimum ( $0.95 \text{ m mol m}^{-2}\text{s}^{-1}$ ) rate of transpiration was observed in T<sub>6</sub> during the first year of study. However, during the second year of study, the maximum ( $1.53 \text{ m mol m}^{-2}\text{s}^{-1}$ ) rate of transpiration was observed in T<sub>10</sub> whereas the minimum ( $0.94$ ) rate of transpiration was observed in T<sub>8</sub>. The pooled data also revealed significant differences among various treatments (Table 14).

The distance from the hedgerows seemed to affect the rate of transpiration in *O. basilicum* only during the first year of study. The effect of distance on the transpiration rate was statistically non-significant during the second year of study. The pooled data was also found to be non-significant (Table 14). The variation in transpiration rate did not exhibit any specific pattern during this and the use of organic manures was not found to regulate transpiration. The values in plants grown with manures were almost at par with those grown without organic manures.

The interaction (TxD) effect was non-significant during the entire study period.

An appraisal of the data regarding the effect of different tree spacing within the *Morus* hedgerows and the application of organic manures to *T. minuta* on transpiration rate showed non-significant differences. The distance of the crop from the hedgerows did not affect the transpiration rate significantly during the study period (Table 14).

The interaction effect among different treatments (T) and distance (D) was also non-significant.

**Table 13** Effect of *Morus* hedgerows and organic manures on the rate of photosynthesis ( $\mu\text{ mol m}^{-2}\text{ s}^{-1}$ ) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	3.94	4.15	3.28	3.79	3.25	3.11	3.51	3.29	3.59	3.63	3.39	3.54	5.21	4.68	4.89	4.93	4.02	4.48	4.25	4.25	4.61	4.58	4.57	4.58
T <sub>2</sub>	3.90	3.56	4.47	3.98	3.60	2.81	3.11	3.17	3.74	3.18	3.78	3.57	4.99	5.05	4.79	4.94	4.32	3.47	5.55	4.45	4.65	4.26	5.16	4.69
T <sub>3</sub>	3.76	4.63	3.87	4.09	3.35	4.28	2.98	3.54	3.55	4.45	3.42	3.81	5.79	4.41	4.81	5.00	4.70	4.86	4.17	4.58	5.24	4.63	4.49	4.78
T <sub>4</sub>	3.40	3.31	2.90	3.20	3.66	3.38	3.28	3.44	3.52	3.34	3.08	3.32	4.58	4.31	4.79	4.56	4.11	4.91	4.93	4.65	4.34	4.61	4.52	4.49
T <sub>5</sub>	3.08	3.46	3.51	3.35	4.46	3.45	2.39	3.43	3.76	3.45	2.95	3.39	4.61	5.42	4.48	4.84	4.17	3.54	5.07	4.26	4.39	4.47	4.77	4.54
T <sub>6</sub>	4.17	3.22	3.32	3.57	3.29	3.47	2.92	3.23	3.72	3.34	3.11	3.39	4.86	5.24	4.71	4.94	3.92	4.23	4.55	4.24	4.39	4.73	4.63	4.58
T <sub>7</sub>	3.14	3.57	4.51	3.74	3.21	2.82	4.43	3.49	3.17	3.19	4.47	3.61	4.24	4.47	4.45	4.39	4.29	3.58	4.90	4.26	4.26	4.02	4.67	4.32
T <sub>8</sub>	3.59	3.84	2.99	3.47	3.58	2.73	2.87	3.06	3.58	3.28	2.93	3.26	4.69	4.69	4.38	4.58	4.32	4.15	4.35	4.27	4.50	4.41	4.36	4.42
T <sub>9</sub>	3.55	3.38	3.17	3.36	3.38	3.36	3.02	3.25	3.46	3.37	3.09	3.30	4.38	4.13	4.40	4.30	4.37	3.85	4.26	4.16	4.37	3.99	4.32	4.23
T <sub>10</sub>	2.65	2.65	2.65	2.65	2.76	2.76	2.76	2.76	2.70	2.70	2.70	2.70	3.36	3.36	3.36	3.36	3.70	3.70	3.70	3.70	3.53	3.53	3.53	3.53
Mean	3.51	3.57	3.46		3.45	3.21	3.12		3.48	3.39	3.29		4.66	4.57	4.47		4.19	4.07	4.57		4.43	4.42	4.52	

CD<sub>0.05</sub>

T	NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS	
D	NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS	
T x D	NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS	

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 14** Effect of *Morus* hedgerows and organic manures on the rate of transpiration ( $\text{m mol m}^{-2}\text{s}^{-1}$ ) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	1.01	0.95	0.96	0.97	1.34	1.42	1.29	1.35	1.17	1.18	1.12	1.16	1.63	1.54	1.69	1.62	1.47	1.45	1.46	1.46	1.55	1.49	1.57	1.53
T <sub>2</sub>	1.42	1.32	1.09	1.28	1.49	1.32	1.62	1.48	1.45	1.32	1.35	1.37	1.58	1.62	1.34	1.51	1.69	1.50	1.68	1.62	1.63	1.56	1.50	1.56
T <sub>3</sub>	1.16	1.02	1.44	1.21	1.50	1.40	1.17	1.36	1.32	1.21	1.30	1.28	1.64	1.60	1.63	1.62	1.65	1.71	1.45	1.60	1.64	1.65	1.54	1.61
T <sub>4</sub>	1.40	0.90	1.30	1.20	1.12	1.20	1.35	1.23	1.26	1.05	1.32	1.21	1.52	1.53	1.49	1.51	1.49	1.60	1.61	1.56	1.50	1.56	1.54	1.53
T <sub>5</sub>	1.39	1.58	1.65	1.54	0.91	1.09	0.93	0.98	1.15	1.33	1.29	1.26	1.45	1.64	1.52	1.54	1.37	1.49	1.34	1.40	1.40	1.56	1.43	1.46
T <sub>6</sub>	0.93	0.84	1.07	0.95	1.43	1.25	1.45	1.38	1.18	1.04	1.26	1.16	1.76	1.52	1.34	1.54	1.41	1.36	1.46	1.41	1.58	1.44	1.39	1.47
T <sub>7</sub>	1.56	1.55	1.73	1.61	1.53	1.49	1.14	1.39	1.54	1.51	1.43	1.49	1.45	1.24	1.55	1.42	1.67	1.67	1.53	1.62	1.56	1.45	1.54	1.52
T <sub>8</sub>	1.44	1.27	1.66	1.46	0.96	0.84	1.04	0.94	1.19	1.05	1.35	1.20	1.32	1.59	1.78	1.56	1.73	1.41	1.67	1.60	1.52	1.50	1.72	1.58
T <sub>9</sub>	1.41	0.82	1.42	1.22	1.53	1.60	1.23	1.45	1.47	1.21	1.32	1.33	1.36	1.72	1.29	1.46	1.55	1.66	1.61	1.61	1.45	1.69	1.45	1.53
T <sub>10</sub>	1.45	1.45	1.45	1.45	1.53	1.53	1.53	1.53	1.49	1.49	1.49	1.49	1.35	1.35	1.35	1.35	1.58	1.58	1.58	1.58	1.46	1.46	1.46	1.46
Mean	1.31	1.17	1.37		1.33	1.31	1.27		1.32	1.24	1.32		1.50	1.53	1.49		1.56	1.54	1.53		1.53	1.53	1.51	

CD<sub>0.05</sub>

T	0.29		0.26		0.20		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS
D	0.16		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS
T x D	NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS
<b>Treatments</b>		T <sub>1</sub>		T <sub>2</sub>		T <sub>3</sub>		T <sub>4</sub>		T <sub>5</sub>		T <sub>6</sub>		T <sub>7</sub>		T <sub>8</sub>		T <sub>9</sub>		T <sub>10</sub> (Control)					
Tree spacing		1.50 m		2.00 m		2.50 m		1.50 m		2.00 m		2.50 m		1.50 m		2.00 m		2.50 m		2.50 m		- trees			
Organic manures (applied to crop)		Vermicompost		Vermicompost		Vermicompost		Enriched manure		Enriched manure		Enriched manure		FYM		FYM		FYM		FYM		- manure			

#### 4.1.3.3. Water efficiency (WUE)

The observations with regard to the impact of *Morus* hedgerows and organic manures on the water use efficiency of *O. basilicum* and *T. minuta* were recorded for two consecutive years and the data obtained is presented in Table 15.

The impact of *Morus* hedgerows and organic manures on *O. basilicum* was statistically significant only during the first year of experimentation. Significant differences in water use efficiency were observed between various treatments. The maximum (0.0040) water use efficiency was recorded in treatment T<sub>1</sub> whereas, a minimum (0.0019) water use efficiency was recorded in control (Table 15). The effect of distance on WUE was non-significant during the entire study period. It is clear from the data in table 15 that the water use efficiency was substantially higher in plants (T<sub>1</sub>-T<sub>9</sub>) in comparison to control (T<sub>10</sub>). All the three manures were equally effective even in the presence of hedgerows.

The interaction (TxD) was found to be non significant during the entire study period.

The influence of *Morus* hedgerows and organic manures on water use efficiency of *T. minuta* was non-significant during both the experimental years (Table 15). Distance from the hedgerows was not found to affect the water use efficiency in *T. minuta* however, organic manure treated plants registered slightly higher water use efficiency than the control plants.

#### 4.1.3.4. Light transmission ratio (LTR %)

This parameter reflects the general status of the canopy development in any crop and impact of other associated components. The plant spacing within the *Morus* hedgerows and organic manures applied to *O. basilicum* and *T. minuta* significantly affected the light transmission ratio. In general, the light transmission ratio was lower in treatments where the plant spacing within the hedgerows was wide i.e. 2.5m (Table 16). This shows better crop canopy development even in the presence of hedgerows.

It evinced from the data that light transmission ratio in *O. basilicum* was significantly affected by the plant spacing as well as organic manures. The maximum (66.33) LTR was observed in T<sub>7</sub> while the minimum (51.92) LTR was observed in T<sub>10</sub> (Table 16), during the year 2005. The maximum (64.02) LTR during 2006 was recorded in T<sub>8</sub>, whereas the minimum (53.92) LTR during the same year was recorded in T<sub>3</sub> (Table 16). The pooled data however, was non-significant (Table 16).

The effect of distance of *O. basilicum* grown along with hedgerows of *Morus* was significant during the study period. A decrease in light transmission ratio was observed as the distance from the hedgerows increased from D<sub>1</sub> to D<sub>3</sub> (Table 16). The use of organic manures maintained LTR almost at par with the plants without manures, which indicates that organic manures helped plants to develop canopy in spite of the presence of hedgerows.

The interaction (TxD) was found to be non-significant.

The data presented in table 16 also reveal the effect of *Morus* hedgerows and organic manures on light transmission ratio in *T. minuta*. Slightly higher values were obtained for LTR in *Tagetes* as compared to *Ocimum*. During the first year of study, the values obtained for LTR were non-significant. However, during the second year of study, the maximum (73.33) LTR was recorded in T<sub>7</sub>, whereas minimum (64.36) LTR was reported in T<sub>6</sub> (Table 16). The pooled data showed overall maximum (74.73) LTR in T<sub>7</sub>, while minimum (65.80) LTR was observed in T<sub>10</sub> (Table 16).

A similar effect of distance on LTR in *T. minuta* was observed as compared to *O. basilicum*. Here also, with the increase in distance from the hedgerows, there was a decrease in light transmission ratio (Table 16) showing better crop canopy at a greater distance from the hedgerows. This also hints at no adverse impact of hedgerows on crop development or positive of the organic manures.

**Table 15** Effect of *Morus* hedgerows and organic manures on water use efficiency of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	0.0038	0.0045	0.0035	0.0040	0.0032	0.0022	0.0030	0.0028	0.0035	0.0033	0.0032	0.0033	0.0033	0.0030	0.0030	0.0031	0.0029	0.0031	0.0030	0.0030	0.0030	0.0030	0.0029	0.0030
T <sub>2</sub>	0.0032	0.0031	0.0044	0.0036	0.0025	0.0021	0.0019	0.0022	0.0028	0.0026	0.0031	0.0028	0.0032	0.0032	0.0035	0.0033	0.0026	0.0023	0.0033	0.0027	0.0028	0.0027	0.0034	0.0030
T <sub>3</sub>	0.0034	0.0048	0.0031	0.0038	0.0023	0.0031	0.0027	0.0027	0.0028	0.0039	0.0029	0.0032	0.0036	0.0028	0.0031	0.0031	0.0029	0.0028	0.0029	0.0029	0.0032	0.0028	0.0029	0.0030
T <sub>4</sub>	0.0026	0.0040	0.0026	0.0031	0.0037	0.0029	0.0025	0.0030	0.0031	0.0034	0.0025	0.0030	0.0032	0.0029	0.0032	0.0031	0.0029	0.0029	0.0030	0.0029	0.0030	0.0029	0.0029	0.0029
T <sub>5</sub>	0.0023	0.0024	0.0021	0.0022	0.0050	0.0035	0.0026	0.0037	0.0036	0.0029	0.0023	0.0029	0.0031	0.0033	0.0029	0.0031	0.0031	0.0024	0.0039	0.0031	0.0031	0.0028	0.0033	0.0031
T <sub>6</sub>	0.0044	0.0039	0.0033	0.0039	0.0023	0.0033	0.0020	0.0025	0.0035	0.0036	0.0026	0.0032	0.0027	0.0035	0.0037	0.0033	0.0028	0.0032	0.0033	0.0031	0.0027	0.0033	0.0034	0.0031
T <sub>7</sub>	0.0020	0.0025	0.0026	0.0024	0.0021	0.0020	0.0043	0.0028	0.0020	0.0022	0.0034	0.0025	0.0032	0.0036	0.0029	0.0032	0.0026	0.0022	0.0033	0.0027	0.0028	0.0028	0.0030	0.0029
T <sub>8</sub>	0.0026	0.0030	0.0021	0.0026	0.0038	0.0032	0.0028	0.0033	0.0032	0.0031	0.0024	0.0029	0.0035	0.0029	0.0025	0.0030	0.0025	0.0029	0.0029	0.0028	0.0029	0.0028	0.0027	0.0028
T <sub>9</sub>	0.0027	0.0039	0.0022	0.0029	0.0023	0.0022	0.0026	0.0024	0.0024	0.0030	0.0023	0.0026	0.0034	0.0025	0.0035	0.0031	0.0028	0.0023	0.0026	0.0026	0.0030	0.0024	0.0030	0.0028
T <sub>10</sub>	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0018	0.0018	0.0018	0.0018	0.0025	0.0025	0.0025	0.0025	0.0023	0.0023	0.0023	0.0023	0.0024	0.0024	0.0024	0.0024
Mean	0.0028	0.0034	0.0027		0.0028	0.0026	0.0026		0.0028	0.0030	0.0026		0.0031	0.0030	0.0030		0.0027	0.0026	0.0030		0.0029	0.0028	0.0030	

CD<sub>0.05</sub>

T	0.0014		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS	
D	NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS	
T x D	NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS	

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 16** Effect of *Morus* hedgerows and organic manures on LTR (%) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	69.97	67.41	53.82	63.73	74.10	60.59	51.72	62.14	72.03	63.50	52.77	62.77	83.38	77.30	70.06	76.91	79.81	75.54	61.04	72.13	81.59	76.42	65.60	74.54
T <sub>2</sub>	72.44	62.97	52.32	62.58	69.95	57.13	54.13	60.40	71.19	60.05	53.22	61.49	80.01	75.97	64.60	73.53	84.19	75.21	58.28	72.56	82.10	75.59	61.44	73.04
T <sub>3</sub>	66.46	68.29	50.37	61.71	69.66	46.11	45.97	53.92	68.06	57.20	48.17	57.81	79.46	72.00	61.71	71.06	76.53	66.71	56.55	66.60	78.00	69.35	59.13	68.83
T <sub>4</sub>	70.74	56.45	49.76	58.99	76.33	56.46	50.63	61.14	73.04	56.46	50.20	59.90	77.77	72.48	66.61	72.29	80.44	74.49	62.18	72.37	79.10	73.48	64.39	72.33
T <sub>5</sub>	75.38	65.13	50.20	63.57	73.51	59.30	53.71	62.17	74.45	62.21	51.95	62.87	70.57	75.74	67.94	71.41	73.88	76.87	58.69	69.81	72.22	76.30	63.31	70.61
T <sub>6</sub>	58.33	57.73	50.45	55.50	66.84	50.59	47.82	55.08	62.58	54.16	49.14	55.29	69.67	73.02	67.45	70.05	73.09	67.17	52.81	64.36	71.38	70.10	60.63	67.37
T <sub>7</sub>	71.16	65.48	62.35	66.33	74.98	62.19	53.61	63.59	73.07	63.83	57.98	64.96	83.66	76.64	68.09	76.13	84.14	75.06	60.78	73.33	83.90	75.85	64.43	74.73
T <sub>8</sub>	70.85	61.41	56.61	62.96	70.86	64.07	57.14	64.02	70.85	62.74	56.87	63.49	79.83	77.71	62.22	73.25	81.59	71.37	59.66	70.88	80.71	74.54	60.94	72.06
T <sub>9</sub>	70.94	63.44	57.79	64.06	70.16	54.48	46.55	57.06	70.55	58.96	52.17	60.56	80.91	74.78	71.46	75.72	79.26	74.98	57.67	70.64	80.09	74.88	64.57	73.18
T <sub>10</sub>	51.92	51.92	51.92	51.92	57.85	57.85	57.85	57.85	54.88	54.88	54.88	54.88	65.26	65.26	65.26	65.26	66.34	66.34	66.34	66.34	65.80	65.80	65.80	65.80
Mean	67.82	61.92	53.36		70.32	56.88	51.91		69.07	59.40	52.74		77.05	74.09	66.54		77.93	72.37	59.51		77.49	73.23	63.02	

CD<sub>0.05</sub>

T	5.63		6.78		NS		NS		4.43		3.50
D	3.08		3.71		2.66		2.64		2.43		1.92
T x D	NS		NS		NS		NS		7.68		6.07

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The interaction (TxD) was significant during the year 2006 as well as for the pooled data.

#### 4.1.4. Root characteristics

##### 4.1.4.1 Number of Roots

The presence of *Morus* hedgerows and the incorporation of various organic manures to *O. basilicum* did not significantly affect the number of roots during both the experimental years. However, the effect of distance on the number of roots was significant (Table 17). The pooled data suggests that the maximum number of roots (20.72) were recorded in T<sub>3</sub> (*Morus* spacing 2.50m + vermicompost), while minimum number of roots (16.06) were found in T<sub>8</sub> (Table 17). The effect of distance is visible in the table, where an increase in the number of roots with the increase in distance away from the hedgerows during both the experimental years. The data reveal that the use of all the three organic manures could maintain significantly higher number of roots in *O. basilicum* even in the presence of hedgerows, where values were significantly higher than that in control plants. The critical differences between the treatments were statistically significant during both the experimental years.

The interaction between various treatments (T) and distance (D) was significant for both years as well as for the pooled data (Table 17).

In *T. minuta*, the data regarding the number of roots was found to be statistically non-significant (Table 17). Likewise, the interaction effect was also non-significant for the years 2005 and 2006, respectively. However, in this case, the effect of distance of the number of roots of *T. minuta* was significant for both the experimental years as well as for the pooled data (Table 17). The root number was reduced in plants grown between 0-1 m from the hedgerows which increased with the increase in distance upto 3 m. The use of organic manures maintained higher roots even in the presence of hedgerows (Table 17).

#### 4.1.4.2. Root dry weight

A significant effect of hedgerows and organic manures on the root dry weight of *O. basilicum* was observed. The reduction in root dry weight was more in crop growing adjacent to the hedgerows. Higher root dry weight, however, was observed in plants growing away from the hedgerows (Table 18). Maximum (3.93 g) root dry weight was recorded at a wider spacing of trees i.e. 2.50 m along with addition of vermicompost (T<sub>3</sub>), whereas the minimum (2.29 g) root dry weight was recorded at a narrow plant spacing 1.50 m, where FYM had been applied to the crop (T<sub>7</sub>) during the year 2005 (Table 18). However, in 2006, the maximum (4.21 g) root dry weight was recorded in treatment where the plant spacing within the hedgerow was 2.50 m and the manure added to the crop was enriched manure (T<sub>6</sub>), while minimum (2.76 g) root dry weight was again recorded in T<sub>7</sub>, but the difference was statistically non-significant (Table 18). The pooled data for both these years showed an overall maximum root dry weight of 3.93 g in T<sub>3</sub> and a minimum root dry weight of 2.52 g in T<sub>7</sub> (Table 18). It is clear from the data in the table that organic manures helped treated plants to register significantly higher root dry weight in comparison to plants without the application of manures.

The interaction (T x D) was statistically significant for the first year of experiment as well as for the pooled data. However, the interaction effect for the 2<sup>nd</sup> year was non-significant (Table 18).

The dry weight per plant in *T. minuta* was also affected by the presence of *Morus* hedgerows and different organic manures. There was a decrease in root dry weight of herb growing nearer to the tree trunk. The maximum (5.98 g) root dry weight was recorded in treatment T<sub>6</sub>, whereas the minimum (4.24 g) root dry weight was observed in T<sub>4</sub> during 2005. During 2006, statistically, the difference in root dry weight among various treatments was found to be non-significant (Table 18). The pooled data for root dry weight per plant in *T. minuta* reveals that the maximum root dry weight per plant was 5.93 g in T<sub>6</sub>, whereas the minimum root dry weight was 4.50 g in treatment T<sub>7</sub> (Table 18).

**Table 17** Effect of *Morus* hedgerows and organic manures on number of roots per plant of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	14.67	20.67	25.33	20.22	12.67	21.00	23.67	19.11	13.67	20.83	24.50	19.67	14.00	22.00	31.67	22.56	16.67	23.00	30.67	23.44	15.33	22.50	31.17	23.00
T <sub>2</sub>	14.33	20.67	23.33	19.44	13.67	22.67	25.67	20.67	14.00	21.67	24.50	20.06	15.00	24.67	31.67	23.78	17.00	24.00	31.00	24.00	16.00	24.33	31.33	23.89
T <sub>3</sub>	14.67	20.33	25.00	20.00	14.00	23.00	27.33	21.44	14.33	21.67	26.17	20.72	15.33	24.67	33.33	24.44	18.00	23.67	31.33	24.33	16.67	24.17	32.33	24.39
T <sub>4</sub>	14.00	23.67	22.00	19.89	14.00	24.00	25.67	21.22	14.00	23.83	23.83	20.56	14.67	22.00	33.67	23.44	17.00	20.33	31.00	22.78	15.83	21.17	32.33	23.11
T <sub>5</sub>	14.00	19.67	26.67	19.56	12.33	24.00	23.67	20.00	13.17	21.83	25.17	20.06	16.33	27.67	31.67	25.22	18.33	22.00	33.33	24.56	17.33	24.83	32.50	24.89
T <sub>6</sub>	11.67	22.33	26.67	20.22	13.33	24.67	24.00	20.67	12.50	23.50	25.33	20.44	18.67	27.33	31.67	25.89	20.33	24.67	31.00	25.33	19.50	26.00	31.33	25.61
T <sub>7</sub>	13.33	20.67	22.00	18.67	13.67	21.67	26.00	20.44	13.50	21.17	24.00	19.56	16.67	21.00	31.00	22.89	17.33	21.67	27.33	22.11	17.00	21.33	29.17	22.50
T <sub>8</sub>	13.00	18.67	24.67	18.78	13.00	22.33	22.67	19.33	13.00	20.50	23.67	16.06	16.33	21.33	32.33	23.33	17.67	20.00	31.33	23.00	17.00	20.67	31.83	23.17
T <sub>9</sub>	13.00	21.67	26.67	20.44	13.00	22.00	23.00	19.33	13.00	21.83	24.83	16.89	16.33	24.00	32.67	24.33	17.67	21.67	31.00	23.44	17.00	22.83	31.83	23.89
T <sub>10</sub>	15.67	15.67	15.67	15.67	17.33	17.33	17.33	17.33	16.50	16.50	16.50	16.50	22.33	22.33	22.33	22.33	21.33	21.33	21.33	21.33	21.83	21.83	21.83	21.83
Mean	13.83	20.40	23.80		13.70	22.27	23.90		13.77	21.33	23.85		16.57	23.70	31.20		18.13	22.23	18.13		17.35	22.97	30.57	

CD<sub>0.05</sub>

T	NS	NS	1.90	NS	NS	NS
D	1.56	1.53	1.04	0.20	2.11	1.67
T x D	4.93	NS	3.29	NS	NS	5.30

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 18** Effect of *Morus* hedgerows and organic manures on root dry weight (g) per plant of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	1.43	2.17	3.63	2.41	1.47	3.27	4.87	3.20	1.45	2.71	4.25	2.80	2.53	5.80	6.63	4.99	2.30	5.27	7.47	5.01	2.41	5.53	7.05	5.00
T <sub>2</sub>	1.60	2.23	4.67	2.83	1.50	2.83	4.80	3.04	1.55	2.53	4.73	2.93	2.50	5.10	6.17	4.59	3.47	4.77	7.50	5.24	2.98	4.93	6.83	4.91
T <sub>3</sub>	2.53	3.33	5.93	3.93	2.30	4.20	5.33	3.94	2.41	3.76	5.63	3.93	3.13	6.33	6.60	5.36	3.43	5.77	8.17	5.79	3.28	6.05	7.83	5.57
T <sub>4</sub>	1.90	2.67	4.93	3.17	1.40	3.23	4.23	2.96	1.65	2.95	4.58	3.06	2.40	4.77	5.57	4.24	2.30	6.07	6.77	5.04	2.35	5.41	6.16	4.64
T <sub>5</sub>	1.60	2.97	5.47	3.34	1.67	3.60	4.17	3.48	1.63	3.28	5.31	3.41	3.00	7.33	7.40	5.91	3.27	6.03	7.37	5.56	3.13	6.68	7.38	5.73
T <sub>6</sub>	2.33	3.47	4.77	3.52	2.23	4.27	6.13	4.21	2.28	3.90	5.45	3.87	3.07	6.13	8.73	5.98	3.23	7.10	7.37	5.90	3.15	6.61	8.05	5.93
T <sub>7</sub>	1.70	2.07	3.10	2.29	1.67	2.53	4.07	2.76	1.68	2.30	3.58	2.52	2.70	5.27	6.23	4.73	2.13	5.40	5.57	4.37	2.41	5.33	5.90	4.50
T <sub>8</sub>	1.33	2.00	5.07	2.80	1.97	3.70	4.80	3.49	1.65	2.85	4.93	3.14	2.53	5.40	5.60	4.51	2.17	6.63	7.33	5.38	2.35	6.01	6.46	4.94
T <sub>9</sub>	2.07	2.47	4.13	2.89	1.67	3.07	5.17	3.30	1.86	2.76	4.65	3.09	3.47	5.67	6.40	5.18	2.37	7.20	7.10	5.56	2.91	6.43	6.75	5.36
T <sub>10</sub>	2.97	2.97	2.97	2.97	3.57	3.57	3.57	3.57	3.26	3.26	3.26	3.26	5.07	5.07	5.07	5.07	6.50	6.50	6.50	6.50	5.78	5.78	5.78	5.78
Mean	1.94	2.64	4.46		1.94	3.42	4.81		1.94	3.03	4.64		3.04	5.68	6.44		3.11	6.07	7.11		3.07	5.88	6.77	

CD<sub>0.05</sub>

T	0.75		NS		0.59		0.83		NS		0.67
D	0.41		0.50		0.32		0.45		0.66		0.36
T x D	1.30		NS		1.02		1.45		NS		1.16

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The interaction among various treatments and distances was statistically significant during both the experimental years. The effectiveness of organic manures in maintaining higher root dry weight than the control is clearly evident from the data in table 18.

#### 4.1.4.3. Specific root length ( $\text{cm g}^{-1}$ ) per plant

The results obtained for specific root length per plant show a lot of variability (Table 19). For example, the maximum ( $4.20 \text{ cm g}^{-1}$ ) specific root length per plant was recorded in  $T_1$  and  $T_8$ , whereas the minimum ( $2.61 \text{ cm g}^{-1}$ ) specific root length per plant was observed in  $T_3$  during 2005 (Table 19). The specific root length per plant remained unaffected among different treatments during the year 2006. In the pooled data, the maximum ( $3.77 \text{ cm g}^{-1}$ ) specific root length was observed in  $T_7$ , whereas the minimum ( $2.58 \text{ cm g}^{-1}$ ) specific root length was observed in  $T_{10}$  (Table 19). All the three organic manures were equally effective.

The effect of distance on specific root length of *O. basilicum* did not follow any particular trend although manure treated plants registered substantially higher specific root length than the control plants during both the experimental years.

The interaction (T x D) was found to be non-significant for both the experimental years as well as for the pooled data.

The data with regard to the effect of *Morus* hedgerows and organic manures on specific root length of *T. minuta* was statistically non-significant for both the experimental years (Table 19). However, the pooled data showed significant differences among various treatments. Maximum specific root length of  $1.92 \text{ cm g}^{-1}$  was recorded in  $T_8$ , whereas the minimum specific root length of  $1.21 \text{ cm g}^{-1}$  was recorded in  $T_{10}$  (Table 19). The effect of distance on the specific root length of *T. minuta* however did not follow any particular trend (Table 19). Plants provided with organic manures helped to maintain significantly higher specific root length in comparison to control plants.

The interaction between treatment (T) and distance (D) was found to be statistically significant.

#### 4.1.4.4. Root growth potential (%)

Root growth potential gives an insight about the root characteristics of the alley crops. It is evident from table 20, that the distance from the hedgerows influenced the root growth potential of *O. basilicum*. During both the experimental years, it is observed that the root growth potential was very low for the herb growing at a closer distance ( $D_1$ ) to the hedgerow as compared to the distances ( $D_2$  and  $D_3$ ) away from the hedgerow (Table 20). During 2005, the maximum (41.38%) root growth potential was recorded in  $T_1$ . The minimum (23.39%) root growth potential was recorded in  $T_7$  during the same year (Table 20). In 2006, the critical differences between various treatments for this character were non-significant. The pooled data however showed significant difference with regards to root growth potential among various treatments. The maximum (32.80%) value for root growth potential was observed in  $T_3$ , whereas the minimum (19.67%) value was recorded in  $T_8$  (Table 20). The application of organic manures was useful even in the presence of hedgerows at various plant spacing, thus hinting at minimizing below ground competition.

The interaction between treatment (T) and distance (D) was found to non-significant during the study period.

The root growth potential in *T. minuta* did not seem to be affected by the presence of hedgerow as well as organic manures as all the treatments were statistically non-significant during 2005 and 2006, respectively (Table 20). However, the effect of distance from the hedgerow was significant on the root growth potential of *T. minuta* but it is impossible to draw any logical conclusion from the values obtained for this parameter as no specific trend was followed.

The interaction effect (T x D) was also non-significant during 2005 and 2006, respectively.

**Table 19** Effect of *Morus* hedgerows and organic manures on specific root length (cm g<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	4.95	4.90	2.72	4.20	5.14	2.78	2.07	3.33	5.06	3.84	2.40	3.76	2.53	1.71	1.21	1.63	2.90	1.40	1.07	1.79	2.72	1.28	1.14	1.71
T <sub>2</sub>	4.65	3.88	2.15	3.56	5.13	3.31	2.30	3.58	4.89	3.60	2.32	3.57	2.70	1.34	1.44	1.83	2.33	1.72	1.09	1.71	2.52	1.53	1.26	1.77
T <sub>3</sub>	3.33	2.82	1.68	2.61	3.72	2.30	2.02	2.68	3.52	2.56	1.85	2.65	2.58	1.21	1.26	1.65	2.29	1.49	1.07	1.62	2.44	1.30	1.71	1.64
T <sub>4</sub>	4.57	3.57	2.03	3.39	5.12	3.21	2.40	3.58	4.84	3.39	2.21	3.48	2.66	1.41	1.44	1.84	3.32	1.17	1.14	1.87	2.99	1.29	1.29	1.86
T <sub>5</sub>	5.27	3.28	1.78	3.44	5.44	2.95	1.90	3.43	5.36	3.11	1.84	3.44	2.37	1.05	1.10	1.51	2.58	1.34	1.14	1.69	2.48	1.19	1.26	1.60
T <sub>6</sub>	4.02	3.09	2.02	3.10	4.79	2.76	1.17	3.09	4.41	2.93	1.95	3.09	2.78	1.27	0.93	1.66	2.82	1.16	1.22	1.73	2.80	1.22	1.07	1.70
T <sub>7</sub>	4.80	4.66	2.64	4.03	4.14	3.66	2.44	3.50	4.61	4.16	2.54	3.77	2.47	1.35	1.18	1.66	3.29	1.38	1.34	2.00	2.88	1.36	1.26	1.83
T <sub>8</sub>	5.59	5.09	1.93	4.20	3.61	2.94	2.07	2.87	4.60	4.01	2.00	3.54	2.87	1.31	1.46	1.88	3.63	1.12	1.14	1.96	3.25	1.21	1.30	1.92
T <sub>9</sub>	4.92	4.67	2.53	4.04	4.84	2.74	2.01	3.07	4.70	3.71	2.27	3.56	2.13	1.34	1.35	1.61	3.53	1.07	1.25	1.95	2.83	1.21	1.30	1.78
T <sub>10</sub>	2.85	2.85	2.85	2.85	2.30	2.30	2.30	2.30	2.58	2.58	2.58	2.58	1.35	1.35	1.35	1.35	1.08	1.08	1.08	1.08	1.21	1.21	1.21	1.21
Mean	4.50	3.88	2.25		4.41	2.89	2.12		4.46	3.39	2.19		2.44	1.27	1.27		2.78	1.29	1.15		2.61	1.28	1.21	

CD<sub>0.05</sub>

T	1.12		NS		0.70		NS		NS		0.28
D	0.61		0.50		0.38		0.17		0.28		0.15
T x D	NS		NS		NS		0.56		0.90		0.48

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 20** Effect of *Morus* hedgerows and organic manures on root growth potential (%) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	0.57	45.36	78.21	41.38	-25.76	22.51	41.25	12.66	-12.60	33.93	59.73	27.02	-37.02	0.92	43.40	2.43	-19.77	8.83	43.77	10.94	-28.39	4.87	43.58	6.68
T <sub>2</sub>	-2.48	34.31	56.92	29.58	-19.05	37.02	54.76	24.24	-10.76	35.66	55.84	26.91	-33.02	12.96	45.27	8.41	-17.22	14.53	46.98	14.76	-25.12	13.75	46.13	11.58
T <sub>3</sub>	0.76	42.51	72.20	38.49	-15.24	33.80	62.78	27.11	-7.24	38.16	67.49	32.80	-32.18	13.78	52.24	11.28	-12.72	11.45	48.24	15.65	-22.45	12.61	50.24	13.47
T <sub>4</sub>	-1.56	68.95	48.13	38.51	-16.93	37.32	56.19	25.53	-9.24	53.13	52.16	32.02	-31.41	-0.11	54.68	7.72	-18.12	-3.77	44.76	7.62	-24.76	-1.94	49.72	7.62
T <sub>5</sub>	-7.58	38.23	79.49	36.71	-27.09	39.99	46.58	19.83	-17.33	39.11	63.04	28.27	-23.74	24.86	45.38	15.50	-12.03	3.51	56.34	15.94	-17.88	14.18	50.86	15.72
T <sub>6</sub>	-17.00	49.69	80.88	37.86	-19.13	43.61	42.21	22.23	-18.06	46.65	61.54	30.04	-15.55	24.44	45.00	17.96	-2.37	16.14	46.78	20.19	-8.96	20.29	45.89	19.07
T <sub>7</sub>	-10.90	31.35	49.71	23.39	-18.07	26.39	54.13	20.82	-9.48	28.87	51.92	23.77	-22.56	-3.27	41.72	5.30	-16.03	3.35	28.85	5.39	-19.29	0.004	35.29	5.34
T <sub>8</sub>	-14.42	22.50	67.10	25.06	-22.93	30.02	35.78	14.29	-18.68	26.25	51.43	19.67	-24.43	-1.56	48.55	7.52	-14.11	-4.35	46.88	9.47	-19.27	-2.95	47.71	8.49
T <sub>9</sub>	-14.33	48.95	82.36	38.99	-22.22	29.14	41.01	15.97	-18.27	39.04	61.68	27.48	-24.67	8.54	49.96	11.28	-15.17	2.21	47.71	11.58	-19.92	5.37	48.83	11.43
T <sub>10</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean	-5.69	38.18	61.50		-18.64	29.98	43.47		-12.17	34.08	52.48		-24.46	8.05	42.62		-12.75	5.19	41.03		-18.61	6.62	41.82	

CD<sub>0.05</sub>

T	24.46		NS		16.11		NS		NS		NS		NS
D	13.40		10.30		8.82		10.12		9.39		7.47		
T x D	NS		NS		NS		NS		NS		23.64		

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	1.50 m	2.00 m	2.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

## 4.2 Effect of tree spacing within the *Leucaena leucocephala* hedgerows and organic manures on *Ocimum basilicum* and *Tagetes minuta*.

### 4.2.1 Growth parameters of *Ocimum basilicum* and *Tagetes minuta*

Growth parameters of *O. basilicum* and *T. minuta* as influenced by *Leucaena* hedgerows are described below under the following heads.

#### 4.2.1.1. Plant height

Hedgerows of *Leucaena* at three different plant to plant spacing and the addition of three different organic manures during the present study have affected the height of *O. basilicum* significantly. The results of the findings have been reported in table 21. The distance from hedgerows was also observed to greatly influence the plant height in *O. basilicum*. The critical differences for plant height at three distances from the hedgerows were found to be statistically significant.

The plant height of *O. basilicum* receiving organic manures was observed to be comparatively more in comparison to the sole crop, growing without the addition of any organic manure. Moreover, plants growing closer to *Leucaena* hedgerows at a distance up to 1 m (D<sub>1</sub>) had comparatively lesser height (Table 21) than plants growing between 1-2 m (D<sub>2</sub>) and 2-3 m (D<sub>3</sub>) (Table 21). The effect of hedgerow and organic manures is clear from the Table 21. For example, the average value for maximum height was 59.28 cm in plants growing under hedge spacing of 1.50 m, whereas the average value for minimum height was 52.57 cm recorded in control during the year 2005. However, the maximum average plant height of 61.54 cm was observed in T<sub>5</sub> in the next year of experimentation. The minimum average plant height of 54.98 cm was again observed in T<sub>7</sub> (Table 21). An overall average for both the experimental years is shown in the form of pooled data where, the maximum and minimum average height has been observed in T<sub>6</sub> and T<sub>7</sub>, respectively (Table 21). The use of organic manures helped plants of *O. basilicum* to maintain significantly higher plant height in comparison to control without manure. The critical differences between the treatments were found to be statistically significant during both the experimental years.

The interaction effect (T x D) was found to be significant during the period of study.

The impact of *L. leucocephala* hedgerows and organic manures on the height of the herb *T. minuta* was not evident during both the experimental year. The data recorded for the plant height was found to be statistically non-significant for the entire study period. However, there was significant increase in plant height as the distance from the hedgerows increased from D<sub>1</sub> to D<sub>3</sub> (Table 21). The height was comparatively higher in plants treated with organic manures (Table 21), especially at greater distance from the hedgerows.

The interaction (T x D) between treatment and distances was found to be non-significant.

#### 4.2.1.2. Number of inflorescence/flower heads per plant

The data collected with regard to the impact of different *Leucaena* spacing and organic manures on the number of inflorescence per plant with respect to distance has been tabulated and shown in table 22. The number of inflorescence per plant in *O. basilicum* and *T. minuta* varied significantly with different plant spacing of trees within the hedgerows and the distances from the hedgerows. The critical differences for number of inflorescence per plant were found to be statistically significant (Table 22). Closer plant spacing (0.50 and 1.00 m) and distance (0-1 and 1-2 m) were not suitable for better growth of *O. basilicum* during the present study.

In case of *O. basilicum*, the maximum (66.56) number of inflorescence per plant during the first year of study was observed in *Leucaena* hedgerow at 1.0 m plant spacing where enriched manure was applied (T<sub>5</sub>). The *O. basilicum* plants grown without the application of any manure and without the presence of hedgerows had the minimum number of inflorescence per plant, where the value was 49.00 (T<sub>10</sub>) during the same year. In the year 2006, the maximum (65.11) numbers of inflorescence were found in *Leucaena* hedgerows at 1.50 m plant spacing, where the crop had been applied vermicompost (T<sub>3</sub>). The minimum

**Table 21** Effect of *Leucaena* hedgerows and organic manures on height (cm) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	39.97	58.80	62.13	53.63	40.87	61.83	70.93	57.88	40.42	60.32	66.53	55.76	107.43	132.90	145.83	128.72	111.73	120.43	142.67	124.90	109.60	126.70	144.20	126.80
T <sub>2</sub>	40.17	59.33	66.23	55.24	42.07	70.47	71.40	61.31	41.12	64.90	68.82	58.28	111.33	137.90	142.70	125.76	108.13	120.03	134.37	120.84	109.90	128.90	138.50	125.80
T <sub>3</sub>	40.60	57.97	63.17	53.91	45.03	68.57	69.93	61.18	42.82	63.27	66.55	57.54	117.17	136.17	146.23	133.19	113.47	133.33	145.83	130.88	115.30	134.70	146.00	132.00
T <sub>4</sub>	43.00	57.57	65.87	55.48	41.67	59.67	74.97	58.77	42.33	58.62	70.42	57.12	118.13	133.63	141.63	131.13	108.33	129.57	145.87	127.92	113.20	131.60	143.70	129.50
T <sub>5</sub>	41.97	62.77	69.83	58.19	45.97	66.83	71.83	61.54	43.97	64.80	70.83	59.87	121.23	138.83	142.27	134.11	107.93	137.07	145.83	130.28	114.60	137.90	144.00	132.20
T <sub>6</sub>	41.17	66.10	70.57	59.28	42.53	70.37	70.70	61.20	41.85	68.23	70.60	60.23	114.27	135.00	154.43	134.57	111.60	124.57	145.23	127.13	112.90	129.80	149.80	130.80
T <sub>7</sub>	38.63	55.30	67.33	53.76	38.37	57.43	69.13	54.98	38.50	56.37	68.23	54.37	112.53	129.90	137.53	126.66	106.40	123.10	131.37	120.29	109.50	126.50	134.40	123.50
T <sub>8</sub>	38.37	62.17	65.10	55.21	44.50	62.97	71.30	59.59	41.43	62.57	68.20	57.40	109.00	134.33	143.57	128.97	107.43	108.37	139.20	118.33	108.20	121.30	141.40	123.60
T <sub>9</sub>	39.20	56.53	65.63	53.79	45.20	67.23	69.30	60.58	42.20	61.88	67.47	57.18	113.57	134.77	144.70	131.01	110.00	119.63	136.50	122.04	111.80	127.20	140.60	126.50
T <sub>10</sub>	52.57	52.57	52.57	52.57	57.00	57.00	57.00	57.00	54.78	54.78	54.78	54.78	135.10	135.10	135.10	135.10	137.77	137.77	137.77	137.77	136.40	136.40	136.40	136.40
Mean	41.56	58.91	64.84		44.32	64.24	69.64		42.94	61.57	67.24		116.00	134.80	143.40		112.30	125.40	140.50		114.10	130.10	141.90	

CD<sub>0.05</sub>

T	4.13		4.10		3.16		NS		NS		NS
D	2.26		2.24		4.64		4.38		7.01		4.64
T x D	7.16		7.10		5.48		NS		NS		NS

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 22** Effect of *Leucaena* hedgerows and organic manures on number of inflorescence/flower heads per plant of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	35.33	56.33	87.00	59.56	37.33	53.67	75.00	55.33	36.33	55.00	81.00	57.44	69.67	147.33	251.67	156.22	83.33	143.67	209.67	145.56	76.50	145.50	230.70	150.90
T <sub>2</sub>	45.67	60.00	80.33	62.00	46.33	51.67	78.33	58.78	46.00	55.83	79.33	60.39	86.67	143.00	234.33	154.67	94.67	143.67	220.33	152.89	90.67	143.30	227.30	153.80
T <sub>3</sub>	43.33	55.33	91.00	63.22	51.00	62.67	81.67	65.11	47.17	59.00	86.33	64.17	86.33	140.00	275.00	167.11	77.67	144.00	237.67	153.11	82.00	142.00	256.30	160.10
T <sub>4</sub>	32.67	62.67	85.00	60.11	35.67	50.00	67.67	51.11	34.17	56.33	76.33	55.61	80.00	148.67	240.00	156.22	85.67	154.33	216.00	152.00	82.83	151.50	228.00	154.10
T <sub>5</sub>	44.00	71.00	84.67	66.56	47.33	58.33	76.33	60.67	45.67	64.67	80.50	63.61	78.00	153.67	260.33	164.00	77.00	162.67	228.00	155.89	77.50	158.20	244.20	159.90
T <sub>6</sub>	47.00	58.67	91.00	65.56	47.67	63.33	79.33	63.44	47.33	61.00	85.17	64.50	75.67	142.33	292.67	170.22	83.00	152.00	312.33	182.44	79.33	147.20	302.50	176.30
T <sub>7</sub>	31.00	55.00	92.33	59.44	34.33	61.00	76.00	57.11	32.67	58.00	84.17	58.28	84.00	125.67	213.00	140.89	89.33	123.67	209.00	140.67	86.67	124.70	211.00	140.80
T <sub>8</sub>	40.33	52.00	87.67	60.00	44.00	60.33	81.00	61.78	42.17	56.17	84.33	60.89	85.67	159.00	214.33	153.00	83.33	147.33	255.00	161.89	84.50	153.20	234.70	157.40
T <sub>9</sub>	42.67	65.00	86.67	64.78	45.00	58.00	80.00	61.00	43.83	61.50	83.33	62.89	80.67	126.67	254.67	154.00	85.33	166.00	254.67	168.67	83.00	146.30	254.70	161.30
T <sub>10</sub>	49.00	49.00	49.00	49.00	53.33	53.33	53.33	53.33	51.57	51.57	51.57	51.17	168.67	168.67	168.67	168.67	173.33	173.33	173.33	173.33	171.00	171.00	171.00	171.00
Mean	41.10	58.50	83.47		44.20	57.23	74.87		42.65	57.87	79.17		89.53	145.50	240.50		93.27	151.10	231.60		91.40	148.30	236.00	

CD<sub>0.05</sub>

T	8.30		8.13		4.96		NS		24.45		16.79
D	4.54		4.45		2.71		10.86		13.39		9.19
T x D	14.38		NS		8.59		34.35		42.36		29.08

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

(53.33) numbers of inflorescence per plant were again observed in treatment T<sub>10</sub> i.e. control. The pooled data however showed the maximum and minimum number of inflorescence in treatments T<sub>6</sub> and T<sub>10</sub>, respectively (Table 22). The reduced number of inflorescence was observed in plants growing near to the hedgerows, however, the number increased significantly up to 3 m from the hedgerows. The critical differences between the treatments were statistically significant, where organic manures maintained substantially higher number of inflorescence per plant than control.

The interaction (T x D) between treatment and distances was found to be significant during both the experimental years.

In case of *T. minuta*, the number of flower heads were reduced by the presence of *Leucaena* hedgerows especially at closer distances during the year 2005. However, during 2006, there was significant difference in the number of inflorescence among all the treatments (Table 22). The maximum number of inflorescence was 182.44 observed in T<sub>6</sub> and the minimum number of the number of inflorescence was 140.67 observed in T<sub>7</sub> (Table 22). The pooled data also showed maximum and minimum number of inflorescence in treatments T<sub>6</sub> and T<sub>7</sub>, respectively. The plants grown closer to the hedgerows of *Leucaena* with closer spacing decreased the number of inflorescence significantly (Table 22), however, the number increased with the increase in distance up to 3 m from the hedgerows. Closer plant spacing and distances were not found to be suitable for successful cultivation of *T. minuta*, however, plant spacing of 1.50 m and distance of 3 m from the hedgerows were suitable for better cultivation of this herb along with the use of organic manures.

The interaction between treatment and distance (T x D) was also found to be significant (Table 22).

#### **4.2.1.3. Length of flower head (cm)**

The observations with regard to the length of inflorescence per plant in *Ocimum basilicum* and *Tagetes minuta* grown under *Leucaena* hedgerows is presented in table 23.

The length of inflorescence of *O. basilicum* was not significantly influenced by the tree spacing within the hedgerow as well as by the application of three different organic manures during the first year of study, although the values were comparatively higher than the control, especially at D<sub>2</sub> (1-2 m) and D<sub>3</sub> (2-3 m) from the hedgerows. However, during the second year, the critical differences for the length of inflorescence were significant. The maximum (18.43) length of flower head was recorded in treatment T<sub>6</sub> during 2006. The minimum (16.37) length of flower head during the same year was recorded in control (Table 23). The pooling of data revealed that the maximum (17.71) length of inflorescence was observed in treatment T<sub>3</sub>, while the minimum (15.68) length of inflorescence was observed in T<sub>10</sub> (Table 23).

The length of inflorescence decreased significantly due to the presence of hedgerows. The average length of inflorescence increased as the distance from the hedgerow increased from 0-1 m (D<sub>1</sub>) to 2-3 m (D<sub>3</sub>) during the study period. Almost similar effect was also observed for pooled data (Table 23). Closer plant spacing within the hedgerows (0.50 and 1.00 m) and closer distance from the hedgerows had greater negative impact on the length of flower heads. Organic manures were more effective at greater distance and wider plant spacing within the hedgerows.

The interaction (T x D) between treatment (T) and distances (D) was found to be non-significant during the year 2005 and 2006, respectively.

The effect of *Leucaena* tree spacing within the hedgerow and organic manures did not seem to influence the length of inflorescence in *T. minuta*. The results obtained for this character was non significant. The pooling of data also showed non significant differences for the length of inflorescence per plant for different tree spacing within the hedgerows as well as for the distance away from the hedgerows (Table 23).

The interaction effect was non significant for both the experimental years.

#### **4.2.1.4. Leaf area index**

The recorded data with regard to the effect of organic manures and plant spacing within the hedgerows of *Leucaena* on leaf index of *O. basilicum* and *T.*

**Table 23** Effect of *Leucaena* hedgerows and organic manures on length (cm) of inflorescence/flower head of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	11.03	16.33	18.83	15.40	13.63	18.07	18.60	16.77	12.33	17.20	18.72	16.08	2.47	2.70	2.93	2.70	2.30	2.70	2.50	2.50	2.38	2.70	2.71	2.60
T <sub>2</sub>	13.83	16.03	17.30	15.72	15.27	18.97	19.97	18.07	14.55	17.50	18.63	16.89	2.90	2.73	2.73	2.79	2.57	2.57	2.50	2.54	2.73	2.65	2.61	2.66
T <sub>3</sub>	15.70	17.17	18.10	16.99	17.30	19.00	18.97	18.42	16.50	18.08	18.53	17.71	2.30	2.77	2.73	2.60	2.40	2.67	2.40	2.49	2.35	2.71	2.56	2.54
T <sub>4</sub>	12.17	16.67	17.13	15.32	14.53	18.27	19.57	17.46	13.35	17.47	18.33	16.38	2.47	2.50	2.67	2.54	2.80	2.30	2.60	2.57	2.63	2.40	2.63	2.55
T <sub>5</sub>	14.30	18.07	17.03	16.47	16.57	18.57	18.23	17.79	15.43	18.32	17.63	17.13	2.23	2.57	2.50	2.43	2.53	2.67	2.63	2.61	2.38	2.61	2.56	2.52
T <sub>6</sub>	15.10	16.23	18.00	16.44	16.30	18.27	20.73	18.43	15.70	17.25	19.37	17.44	2.47	2.47	2.63	2.52	2.37	2.67	2.33	2.46	2.41	2.56	2.48	2.48
T <sub>7</sub>	12.37	16.30	17.57	15.41	14.87	17.33	18.57	16.92	13.62	16.82	18.07	16.17	2.53	2.63	2.73	2.63	2.47	2.30	2.73	2.50	2.50	2.46	2.73	2.56
T <sub>8</sub>	14.17	16.23	16.40	15.60	15.50	17.47	18.83	17.27	14.83	16.85	17.62	16.43	2.60	2.13	3.07	2.60	2.57	2.67	2.43	2.56	2.58	2.40	2.75	2.57
T <sub>9</sub>	15.83	15.63	16.90	16.12	15.57	17.70	18.87	17.38	15.70	16.67	17.88	16.75	2.43	2.50	2.77	2.57	2.43	2.67	2.23	2.44	2.43	2.58	2.50	2.50
T <sub>10</sub>	14.99	14.99	14.99	14.99	16.37	16.37	16.37	16.37	15.68	15.68	15.68	15.68	2.67	2.67	2.67	2.67	2.53	2.53	2.53	2.53	2.60	2.60	2.60	2.60
Mean	13.95	16.37	17.22		15.59	18.00	18.87		14.77	17.18	18.05		2.50	2.56	2.74		2.49	2.57	2.49		2.50	2.57	2.61	

CD<sub>0.05</sub>

T	NS		1.30		1.10		NS		NS		NS	
D	0.92		0.71		0.60		0.13		NS		NS	
T x D	NS		NS		0.17		NS		NS		NS	

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

*minuta* is shown in table 24. The critical differences for leaf area index of *O. basilicum* and *T. minuta* were found to be statistically significant.

The medicinal and aromatic herb *O. basilicum* growing under *Leucaena* hedgerows revealed a distinct effect of distance on the leaf area index. The plants growing nearer to the hedgerows exhibited low values for LAI. However, a significant increase in LAI of *O. basilicum* was observed with an increase in distance from the hedgerows (Table 24). It was seen that higher leaf area index was observed in T<sub>6</sub> (*Leucaena* spacing of 1.50 m+ enriched manure) during both the experimental years, the corresponding value being 1.55 and 1.63, respectively (Table 24). The minimum leaf area index (1.31) was recorded in T<sub>4</sub> and T<sub>5</sub> during 2005, whereas the minimum (1.29) leaf area index during 2006 was observed in T<sub>2</sub> (Table 24). The pooling of data for both the experimental years revealed that maximum (1.59) leaf area index was observed in T<sub>6</sub> and a minimum (1.24) leaf area index was observed in T<sub>1</sub> (Table 24). The treatment effect did not follow any specific pattern during both the experimental years.

The interaction (TxD) between treatments (T) and distance (D) was significant during the entire study period.

The results obtained for leaf area index of *T. minuta* grown in association with *Leucaena* were similar to the results obtained for *O. basilicum* as for the distance effect. In *T. minuta* also, an increase in leaf area index was observed with an increase in distance from the hedgerows. The maximum (1.21) leaf area index was reported in T<sub>3</sub> while the minimum (0.74) leaf area index was observed in T<sub>1</sub> and T<sub>4</sub> during the year 2005. In 2006, the maximum (1.05) leaf area index was observed in T<sub>10</sub>, whereas the minimum (0.78) leaf area index was recorded in T<sub>7</sub> (Table 24). The pooled data showed that the maximum LAI of 1.18 was observed in T<sub>3</sub> and a minimum LAI of 0.77 was observed in T<sub>7</sub> (Table 24).

The interaction (TxD) was significant only during the year 2005.

## 4.2.2. Yield Parameters

### 4.2.2.1. Fresh weight of inflorescence ( $\text{q ha}^{-1}$ )

The data in table 25 reveal influence of *Leucaena* hedgerows and organic manures on the fresh weight of inflorescence of *O. basilicum* and *T. minuta* during the experimental years 2005 and 2006, respectively.

In *O. basilicum*, table 25 clearly indicates the suppressing effect of the hedgerows. It was observed that there is an increase in the fresh weight of inflorescence as the distance of the crop increases from  $D_1$  (0-1 m) to  $D_3$  (2-3 m) during the study period. In 2005, the maximum ( $40.67 \text{ q ha}^{-1}$ ) fresh weight of inflorescence was recorded at tree spacing of 1.50 m within the hedgerow along with the application of enriched manure ( $T_6$ ). During the same year, the minimum ( $26.01 \text{ q ha}^{-1}$ ) fresh weight of inflorescence was recorded in control (Table 25). Similarly, in 2006 the maximum ( $41.78 \text{ g ha}^{-1}$ ) yield of inflorescence was observed in  $T_6$ , whereas, the minimum ( $27.67 \text{ q ha}^{-1}$ ) yield was recorded in  $T_{10}$  (control). A similar trend was observed in the pooled data (Table 25). The reduction in yield was greater at closer plant spacing and distance from the hedgerows. The critical distances between the treatments were statistically significant during both the experimental years.

The interaction among various treatments (T) and distances (D) was significant for both the years under study as well as for the pooled data.

In the herb *T. minuta*, the effect of distance from the hedgerows as well as the effect of organic manures was found to be statistically significant during the study period. The data in table 25 reveal that there was an increase in the yield of inflorescence with the increase in distance away from the tree trunk. The maximum yield of inflorescence in the year 2005 was  $17.52 \text{ q ha}^{-1}$  and the minimum production during the same year was  $13.19 \text{ q ha}^{-1}$ , recorded in the treatments  $T_6$  and  $T_7$ , respectively (Table 25). Likewise, in the year 2006, the maximum ( $17.98 \text{ q ha}^{-1}$ ) yield of inflorescence was recorded in  $T_6$ , whereas the minimum ( $13.74 \text{ q ha}^{-1}$ ) yield was observed in  $T_7$  (Table 25). The pooled data also indicated the same trend.

**Table 24** Effect of *Leucaena* hedgerows and organic manures on LAI of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	1.25	1.42	1.33	1.33	1.32	1.43	1.31	1.35	1.28	1.42	1.32	1.24	0.64	0.80	0.78	0.74	0.89	0.88	0.85	0.87	0.76	0.84	0.81	0.80
T <sub>2</sub>	1.32	1.39	1.43	1.38	1.20	1.45	1.23	1.29	1.26	1.42	1.33	1.34	0.74	0.70	1.00	0.81	0.83	0.98	1.07	0.96	0.78	0.83	1.03	0.88
T <sub>3</sub>	1.21	1.32	1.70	1.41	1.29	1.53	1.90	1.57	1.25	1.42	1.80	1.49	1.02	1.61	1.01	1.21	0.86	0.90	1.30	1.02	0.94	1.23	1.16	1.18
T <sub>4</sub>	1.20	1.42	1.31	1.31	1.29	1.38	1.35	1.34	1.24	1.40	1.33	1.32	0.67	0.77	0.79	0.74	0.89	0.91	0.92	0.91	0.78	0.83	0.85	0.82
T <sub>5</sub>	1.27	1.37	1.29	1.31	1.33	1.63	1.87	1.61	1.30	1.50	1.58	1.46	0.79	0.78	1.08	0.88	0.74	0.84	1.15	0.91	0.76	0.80	1.11	0.89
T <sub>6</sub>	1.25	1.72	1.67	1.55	1.26	1.58	2.05	1.63	1.26	1.65	1.86	1.59	0.84	0.93	1.01	0.93	0.78	1.14	1.17	1.03	0.80	1.03	1.09	0.97
T <sub>7</sub>	1.23	1.35	1.40	1.33	1.28	1.39	1.38	1.35	1.25	1.37	1.39	1.34	0.67	0.76	0.89	0.77	0.62	0.79	0.92	0.78	0.64	0.77	0.90	0.77
T <sub>8</sub>	1.25	1.44	1.41	1.36	1.30	1.35	1.32	1.32	1.27	1.39	1.36	1.34	0.76	0.80	0.80	0.79	0.80	0.85	0.73	0.79	0.78	0.82	0.76	0.79
T <sub>9</sub>	1.30	1.40	1.71	1.37	1.28	1.43	1.34	1.35	1.29	1.42	1.52	1.41	0.74	0.80	0.95	0.83	0.69	0.93	1.13	0.92	0.71	0.87	1.03	0.87
T <sub>10</sub>	1.53	1.53	1.53	1.53	1.58	1.58	1.58	1.58	1.55	1.55	1.55	1.55	0.95	0.95	1.17	1.02	1.05	1.05	1.05	1.05	1.00	1.00	1.00	1.00
Mean	1.28	1.44	1.48		1.31	1.47	1.53		1.30	1.45	1.50		0.78	0.89	0.94		0.81	0.92	1.02		0.79	0.90	0.98	

CD<sub>0.05</sub>

T	0.11		0.13		0.09		0.15		0.15		0.01
D	0.06		0.07		0.04		0.08		0.08		0.05
T x D	0.18		0.24		0.15		0.27		NS		NS

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 25** Effect of *Leucaena* hedgerows and organic manures on fresh weight of inflorescence/flower heads (q ha<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	14.39	31.26	49.25	31.63	16.60	30.16	51.46	32.74	15.49	30.71	50.35	32.19	8.85	14.11	18.26	13.74	9.96	16.05	18.26	14.76	9.41	15.08	18.26	14.25
T <sub>2</sub>	18.81	33.75	52.01	34.86	19.37	36.24	55.33	36.98	19.09	35.00	53.67	35.92	9.96	16.32	18.81	15.03	11.07	17.98	18.81	15.95	10.51	17.15	18.81	15.49
T <sub>3</sub>	20.47	35.69	58.10	38.09	21.03	37.63	56.99	38.55	20.75	36.66	57.55	38.32	10.51	17.43	19.92	15.95	11.34	19.09	18.54	16.32	10.93	18.26	19.23	16.14
T <sub>4</sub>	16.32	33.48	54.50	34.77	18.26	36.80	55.33	36.80	17.29	35.14	54.92	35.78	9.13	16.05	18.54	14.57	9.96	16.60	19.37	15.31	9.54	16.32	18.95	14.94
T <sub>5</sub>	19.37	38.18	53.67	37.07	20.75	40.39	58.65	39.93	20.06	39.29	56.16	38.50	10.24	18.81	20.47	16.51	11.62	16.88	20.47	16.32	10.93	17.84	20.47	16.42
T <sub>6</sub>	22.96	40.95	58.10	40.67	23.24	43.71	58.38	41.78	23.10	42.33	58.24	41.22	11.34	20.75	20.47	17.52	12.73	20.75	20.47	17.98	12.03	20.75	20.47	17.75
T <sub>7</sub>	16.05	28.50	49.52	31.36	16.05	30.16	55.61	33.94	16.05	29.33	52.57	32.65	8.58	13.83	17.15	13.19	9.13	15.49	16.60	13.74	8.85	14.66	16.88	13.46
T <sub>8</sub>	17.43	32.37	50.08	33.29	17.71	30.71	52.29	33.57	17.57	31.54	51.18	33.43	9.68	15.49	17.43	14.20	10.24	16.88	17.15	14.76	9.96	16.18	17.29	14.48
T <sub>9</sub>	18.81	33.20	54.50	35.51	19.09	37.63	53.95	36.89	18.95	35.41	54.23	36.20	10.79	16.32	17.98	15.03	10.79	15.77	17.98	14.85	10.79	16.05	17.98	14.94
T <sub>10</sub>	26.01	26.01	26.01	26.01	26.27	26.27	26.27	27.67	26.84	26.84	26.84	26.84	13.28	13.28	13.28	13.28	16.05	16.05	16.05	16.05	14.94	14.94	14.94	14.94
Mean	19.06	33.34	50.57		19.98	35.11	52.57		19.52	34.22	51.57		10.29	16.24	18.23		11.29	17.15	18.37		10.79	16.70	18.30	

CD<sub>0.05</sub>

T	4.31		4.63		4.18		1.35		1.60		1.25
D	2.36		2.54		2.29		0.74		0.80		0.68
T x D	7.46		8.02		7.24		2.34		2.78		2.16

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The interaction (TxD) effect was also found to be statistically significant during the period of study.

#### 4.2.2.2. Fresh weight of shoot ( $\text{q ha}^{-1}$ )

The presence of *Leucaena* hedgerows and organic manures showed conspicuous effect on fresh weight of shoot of *O. basilicum* during the present study. Plants grown closer to the hedgerows exhibited more reduction in fresh weight of shoot; however, a significant increase in fresh weight of shoot with increase in distance from hedgerow line was obvious (Table 26). The effect of organic manures, particularly enriched manure was eminent from the fact that the fresh weight *per se* was less under control, where no manures were applied to the crop and the highest fresh weight yield of shoot was recorded in treatments receiving enriched manure. The maximum ( $85.65 \text{ q ha}^{-1}$ ) fresh weight yield of shoot was observed in  $T_6$ , whereas minimum ( $57.27 \text{ q ha}^{-1}$ ) yield of fresh weight of shoot was recorded in  $T_{10}$  during 2005 (Table 26). Similarly in 2006, the maximum ( $90.47 \text{ q ha}^{-1}$ ) fresh weight of shoot was recorded in  $T_6$  and the minimum ( $65.29 \text{ q ha}^{-1}$ ) fresh weight yield was recorded in  $T_{10}$ . The pooled data also showed similar variations (Table 26). Closer plant spacing within the hedgerows was not found suitable for cultivation even with the use of organic manures. The critical differences were also found to be statistically significant during both the experimental years.

The interaction (TxD) between treatment (T) and distance (D) was statistically significant during both the experimental years.

The results obtained for the yield of fresh weight of shoot in *T. minuta* grown in association with *L. leucocephala* were similar to *O. basilicum* as far as the distance from the hedgerows is concerned (Table 26). The maximum ( $107.9 \text{ q ha}^{-1}$ ) fresh weight yield of shoot was observed in  $T_6$  and the minimum average ( $90.84 \text{ q ha}^{-1}$ ) fresh weight yield was found in  $T_7$  during the first year of experiment. However, in second year the maximum ( $113.0 \text{ q ha}^{-1}$ ) and minimum ( $95.91 \text{ q ha}^{-1}$ ) yield was recorded in  $T_6$  and  $T_9$ , respectively (Table 26). The pooled data, however, showed maximum and minimum fresh weight yield of

shoot in T<sub>6</sub> and T<sub>7</sub>, respectively (Table 26). Use of organic manures improved yield over the control even in the presence of hedgerows.

The interactions (TxD) effect was found to be significant for both the experimental years as well as for the pooled data (Table 26).

#### 4.2.2.3. Economic yield (q ha<sup>-1</sup>)

The economic yield of herb species includes the combined yield of inflorescence and leaves. The economic yield of *O. basilicum* and *T. minuta* during the study period is presented in table 27. The effect of organic manures was more impressive in *O. basilicum* where all the treatments receiving organic manures maintained higher economic yield as compared to control, where no manure was applied (Table 27).

*O. basilicum* when grown along with *Leucaena*, the maximum (52.66 q ha<sup>-1</sup>) herb yield was observed in treatment having wider tree spacing (2.50 m) between the trees within the hedgerow (T<sub>6</sub>) along with the application of enriched manure during the year 2005. Similarly, during the year 2006, the maximum (54.69 q ha<sup>-1</sup>) herb yield was recorded in T<sub>6</sub> (Table 27). The minimum herb yield during both these years were 36.80 and 39.29 q ha<sup>-1</sup> in T<sub>10</sub> (control), respectively.

The effect of *Leucaena* hedgerows on the herb yield of alley cropped *O. basilicum* was significant during the entire period of study. The perusal of data from the Table 27 clearly suggests that the average herb yield increased from D<sub>1</sub> (0-1m) to D<sub>3</sub> (2-3m) away from the hedgerows. The increase in average herb yield was in the order D<sub>3</sub>>D<sub>2</sub>>D<sub>1</sub> (Table 27) during the study period. The data pooled for both the years also confirms the above mentioned results. The use of organic manures helped plants to register higher yield than the control plants. This was true for both the experimental years. The critical differences were statistically significant for both the experimental years.

The interaction effect (TxD) was significant for both the years as well as for the pooled data.

**Table 26** Effect of *Leucaena* hedgerows and organic manures on shoot yield (q ha<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	35.14	62.25	108.2	68.52	44.54	73.04	119.60	75.71	39.84	67.64	108.60	72.12	58.10	96.83	118.7	91.21	69.17	101.00	120.3	96.83	63.63	98.91	119.5	94.02
T <sub>2</sub>	41.78	61.70	115.1	72.86	50.91	75.22	112.3	79.68	46.34	68.75	113.7	76.27	67.78	102.4	119.0	96.37	73.32	105.1	110.7	96.37	70.55	103.7	114.8	96.37
T <sub>3</sub>	48.42	76.08	120.3	81.62	54.23	79.68	119.80	84.57	51.32	70.88	120.1	83.09	69.17	113.4	121.7	101.4	77.47	110.7	123.1	103.7	73.32	112.0	122.4	102.6
T <sub>4</sub>	38.46	72.76	109.0	73.41	45.37	78.57	118.40	80.79	41.91	75.67	113.7	77.10	70.55	99.60	121.70	97.29	70.55	105.1	130.0	101.9	70.55	102.4	125.9	99.60
T <sub>5</sub>	42.61	78.30	114.8	78.57	54.23	85.20	118.40	85.95	48.42	81.75	116.6	82.26	69.17	99.60	124.50	97.76	78.85	101.0	134.2	104.7	74.01	100.3	129.3	101.2
T <sub>6</sub>	49.52	83.55	124.8	85.65	57.27	88.53	125.60	90.47	53.40	86.04	125.20	88.21	89.92	110.7	123.1	107.9	85.77	117.6	135.6	113.0	87.84	114.1	129.3	110.4
T <sub>7</sub>	34.58	67.23	106	69.26	40.67	70.27	112.60	74.52	37.63	68.75	109.30	71.90	67.78	94.07	110.70	90.84	74.70	91.30	113.4	96.14	71.24	92.68	112.0	91.99
T <sub>8</sub>	37.35	67.51	104.6	69.81	47.59	73.59	117.3	76.18	42.47	70.55	106.00	72.99	59.48	91.30	123.1	91.30	73.32	95.45	121.7	96.83	66.46	93.37	122.4	94.07
T <sub>9</sub>	40.12	75.81	114.8	76.91	49.52	74.51	117.90	77.19	44.82	74.98	111.40	77.05	62.25	105.1	113.4	93.61	70.55	102.4	114.8	95.91	66.40	103.7	114.1	94.76
T <sub>10</sub>	57.27	57.27	57.27	57.27	65.29	65.29	65.29	65.29	61.28	61.28	61.28	61.28	92.68	92.68	92.68	92.68	110.7	110.7	110.7	110.7	101.7	101.7	101.7	101.7
Mean	42.52	70.25	107.5		50.96	76.42	119.70		46.74	73.33	108.60		70.69	100.6	116.9		78.43	104.00	121.5		74.56	102.3	119.2	

CD<sub>0.05</sub>

T	6.39	6.76	5.66	8.47	9.09	6.78
D	3.50	3.70	3.10	4.64	4.98	3.72
T x D	11.07	11.71	9.80	14.67	15.75	11.75

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 27** Effect of *Leucaena* hedgerows and organic manures on economic yield (q ha<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	24.35	42.61	61.97	42.98	25.73	42.88	66.40	45.00	25.04	42.74	64.19	43.99	12.45	20.47	26.84	19.92	14.11	23.24	26.84	21.40	13.28	21.86	26.84	20.66
T <sub>2</sub>	27.67	51.18	64.74	47.86	28.50	53.12	69.44	50.35	28.08	52.15	67.09	49.11	14.39	23.52	27.94	21.95	15.77	26.28	26.28	22.78	15.08	24.90	27.11	22.36
T <sub>3</sub>	29.60	52.57	71.38	51.18	30.43	51.18	70.55	50.72	30.32	51.87	70.96	50.95	15.22	25.45	29.33	23.33	16.05	27.94	26.56	23.52	15.63	26.70	27.94	23.42
T <sub>4</sub>	25.45	45.65	67.51	46.20	26.84	49.80	69.44	48.69	26.14	47.72	68.47	47.45	13.28	23.24	27.67	21.40	14.39	24.35	28.50	22.41	13.83	23.79	28.08	21.90
T <sub>5</sub>	29.05	55.33	65.85	50.08	30.16	52.57	71.38	51.37	29.60	53.95	68.61	50.72	14.66	27.39	29.88	23.98	16.32	24.94	29.88	23.70	15.49	26.14	29.88	23.84
T <sub>6</sub>	31.82	56.72	69.44	52.66	32.92	57.82	73.32	54.69	32.37	57.27	71.38	53.67	16.32	30.71	29.88	25.64	18.26	30.43	30.43	26.38	17.29	30.57	30.16	26.01
T <sub>7</sub>	24.62	39.84	62.53	42.33	25.73	45.65	68.89	46.76	25.18	42.74	65.71	44.54	12.17	19.92	25.18	19.09	13.00	22.69	24.07	19.92	12.59	21.30	24.62	19.50
T <sub>8</sub>	26.56	46.48	63.36	45.47	26.84	43.99	66.12	45.65	26.70	45.23	64.74	45.56	13.83	22.41	25.73	20.66	14.94	24.62	24.62	21.40	14.39	23.52	25.18	21.03
T <sub>9</sub>	27.94	48.42	68.61	48.32	28.77	50.91	67.51	49.06	28.36	49.66	68.06	48.69	15.22	23.79	26.84	21.95	15.49	22.96	26.56	21.67	15.35	23.38	26.70	21.81
T <sub>10</sub>	36.80	36.80	36.80	36.80	39.29	39.29	39.29	39.29	38.04	38.04	38.04	38.04	21.30	21.30	21.30	21.30	22.96	22.96	22.96	22.96	22.13	22.13	22.13	22.13
Mean	28.39	47.56	63.22		29.52	48.72	66.23		28.95	48.14	64.73		14.88	23.82	27.06		16.13	25.04	26.67		15.51	24.43	26.86	

CD<sub>0.05</sub>

T	4.62		4.58		4.28		2.05		2.47		1.78
D	2.53		2.51		2.34		1.12		1.35		0.97
T x D	8.00		7.92		7.42		3.54		4.26		3.08

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The aromatic herb *T. minuta* grown in alleys of *Leucaena* was also affected by the different plant spacing within the hedgerows as well as by the application of organic manure. The maximum (25.64 q ha<sup>-1</sup>) herb yield during 2005 was observed in the treatment receiving enriched manure and a plant spacing of 1.5m within the *Leucaena* hedgerow. However, *T. minuta* seemed to be more susceptible to competition from hedgerow as the minimum (19.09 q ha<sup>-1</sup>) herb yield was observed in treatment having a tree spacing of 0.5m within the hedgerow and the crop was applied FYM (Table 27). A similar effect of hedgerow was observed during 2006 where maximum (26.38 of ha<sup>-1</sup>) herb yield was observed in T<sub>6</sub> and the minimum (19.92 of ha<sup>-1</sup>) herb yield was observed in T<sub>7</sub> (Table 27). The pooled data also reveals the negative effect of hedgerows on *T. minuta*.

The interaction between different treatments (T) and distances (D) was significant during both the experimental years.

#### 4.2.2.4. Estimated oil yield

The oil yield of *O. basilicum* was significantly affected by the plant spacing in the hedgerows and the organic manures. The perusal of data from table 28 clearly explains the effect of the presence of *Leucaena* hedgerows, organic manures and respective distances of the herb species from the hedgerows on the oil yield. The effect of organic manures is clear from the fact that the minimum (12.14 L ha<sup>-1</sup>) oil yield was recorded in T<sub>10</sub> during 2005, where no manure was added to *O. basilicum*. All the other treatments (T<sub>1</sub>-T<sub>9</sub>) registered significantly higher oil yield as compared to T<sub>10</sub>. Similarly, the lowest (12.96 L ha<sup>-1</sup>) yield was again recorded in T<sub>10</sub> during 2006 (Table 28). The maximum (17.38 L ha<sup>-1</sup>) oil yield was recorded in T<sub>6</sub> during 2005 at a plant spacing of 1.50 m within the hedgerows and the application of enriched manure. The oil yield was also maximum (18.05 L ha<sup>-1</sup>) in the same treatment during 2006 (Table 28). The effect of distance on the oil yield was also statistically significant whereby lower oil yields were recorded at distance nearer to the hedgerows. The critical differences for treatments (T) and distance (D) were statistically significant during the two consecutive experimental years (Table 28). It is clear from the data that the

application of organic manures substantially improved oil yield and nullifies the negative impact of hedgerows during both the experimental years.

The pooled data for the oil yield also followed a similar trend.

The oil yield in the herb *T. minuta* was also significantly affected by the presence of *Leucaena* hedgerows and organic manures. The maximum (11.79 L ha<sup>-1</sup>) oil yield was recorded in T<sub>6</sub> during 2005, whereas minimum (8.78 L ha<sup>-1</sup>) oil yield was recorded in treatment T<sub>7</sub> during the same year (Table 28). The maximum oil yield obtained during 2006 was 12.13 L ha<sup>-1</sup> while the minimum oil yield during 2006 was 9.16 L ha<sup>-1</sup> recorded again in T<sub>7</sub> (Table 28). It is evident from the table 28 that more oil yield was obtained at wider spacing among trees as well as by the application of enriched manure. The presence of hedgerows significantly reduced the oil yield in the herbs growing near to the hedgerows (Table 28). The pooling of data also reveals similar impact both for the treatment combinations as well as for the distances. The critical differences were statistically significant for both the experimental years. Closer spacing, especially 0.50 m within the hedgerows and distance up to 1 m from the hedgerows negatively affected the oil yield.

The interaction (T x D) was significant during both the experimental years.

#### 4.2.2.5. Production efficiency

The persual of data (Table 29) shows that *Leucaena leucocephala* spacing in the hedgerow as well as organic manures impart significant influence on the production efficiency of *O. basilicum* and *T. minuta*. The maximum production efficiency in case of *O. basilicum* was observed in T<sub>6</sub> during the year 2005 and 2006, respectively. The maximum production efficiency of *O. basilicum* during these two years was 90.93 and 95.73 kg/ha/day (Table 29). The minimum production efficiency was observed in treatment receiving no organic manures as well as without trees during both the experimental year i.e. T<sub>10</sub>. The minimum value for production efficiency for the above mentioned treatment (T<sub>10</sub>) was 62.53 and 67.69 kg/ha/day for the period 2005 and 2006, respectively (Table 29). A similar trend was observed for the pooled data.

**Table 28** Effect of *Leucaena* hedgerows and organic manures on estimated oil yield (L ha<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	8.03	14.06	20.45	14.18	8.49	14.15	21.91	14.85	8.26	14.11	21.18	14.52	5.72	9.41	12.34	9.16	6.49	10.69	12.34	9.84	6.10	10.05	12.34	9.50
T <sub>2</sub>	9.13	16.89	21.36	15.79	9.40	17.53	22.92	16.62	9.26	17.21	22.14	16.21	6.61	10.82	12.85	10.10	7.25	12.09	12.09	10.48	6.93	11.45	12.47	10.29
T <sub>3</sub>	9.76	17.35	23.56	16.89	10.04	16.89	23.28	16.74	9.90	17.12	23.42	16.81	7.00	11.71	13.49	10.73	7.38	12.85	12.22	10.82	7.19	12.28	12.85	10.78
T <sub>4</sub>	8.40	15.06	22.28	15.25	8.85	16.43	22.92	16.07	8.62	15.75	22.60	15.66	6.10	10.69	12.73	9.84	6.61	11.20	13.11	10.31	6.36	10.94	12.92	10.08
T <sub>5</sub>	9.58	18.26	21.73	16.53	9.95	17.35	23.56	16.95	9.76	17.80	22.64	16.74	6.74	12.60	13.74	11.03	7.50	11.45	13.74	10.90	7.12	12.03	13.74	10.97
T <sub>6</sub>	10.50	18.72	22.92	17.38	10.86	19.08	24.19	18.05	10.68	18.90	23.56	17.71	7.50	14.13	13.74	11.79	8.40	14.00	14.00	12.13	7.95	14.06	13.87	11.96
T <sub>7</sub>	8.12	13.15	20.63	13.97	8.49	15.06	22.73	15.43	8.30	14.11	21.68	14.70	5.60	9.16	11.58	8.78	5.98	10.44	11.07	9.16	5.79	9.80	11.33	8.97
T <sub>8</sub>	8.76	15.34	20.91	15.00	8.85	14.52	21.82	15.06	8.81	14.93	21.36	15.03	6.36	10.31	11.84	9.50	6.87	11.33	11.33	9.84	6.61	10.82	11.58	9.67
T <sub>9</sub>	9.22	15.98	22.64	15.95	9.49	16.80	22.28	16.19	9.35	16.39	22.46	16.07	7.00	10.94	12.34	10.10	7.12	10.56	12.22	9.96	7.06	10.75	12.28	10.03
T <sub>10</sub>	12.14	12.14	12.14	12.14	12.96	12.96	12.96	12.96	12.55	12.55	12.55	12.55	9.80	9.80	9.80	9.80	10.56	10.56	10.56	10.56	10.18	10.18	10.18	10.18
Mean	9.36	15.69	20.86		9.74	16.08	21.86		9.55	15.89	21.36		6.84	10.96	12.45		7.42	11.52	12.27		7.13	11.24	12.36	

CD<sub>0.05</sub>

T	1.52		1.51		1.41		0.94		1.13		0.82
D	0.83		0.82		0.77		0.51		0.62		0.45
T x D	2.66		2.60		2.44		1.62		1.96		1.42

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompos:	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 29** Effect of *Leucaena* hedgerows and organic manures on production efficiency (kg/ha/day) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	37.90	66.46	114.80	72.39	47.03	78.85	115.90	80.60	42.47	71.66	115.40	76.50	63.91	105.40	127.50	98.95	74.15	108.50	129.50	104.00	69.03	106.90	128.50	101.50
T <sub>2</sub>	44.54	65.57	121.70	77.28	53.95	81.62	119.00	84.84	49.25	73.59	120.30	81.06	73.59	110.90	125.30	103.30	78.30	112.90	119.50	103.60	75.94	111.90	122.40	103.40
T <sub>3</sub>	52.01	80.23	126.20	86.14	56.99	85.21	126.70	89.64	54.50	82.72	126.40	87.89	74.70	122.60	130.90	109.40	83.28	120.60	131.70	111.90	78.99	121.60	131.30	110.60
T <sub>4</sub>	41.50	77.47	115.40	78.11	47.59	83.83	124.80	85.40	44.54	80.65	120.10	81.375	76.44	107.60	130.90	105.00	75.53	112.60	139.40	109.20	76.08	110.10	135.20	107.10
T <sub>5</sub>	45.65	82.72	120.90	83.09	57.27	90.47	124.50	90.75	51.46	86.60	122.70	86.92	77.47	106.20	133.90	105.90	84.66	108.70	143.00	112.10	81.06	107.50	138.50	109.00
T <sub>6</sub>	52.57	88.26	132.00	90.93	60.31	94.90	132.00	95.73	56.44	91.58	132.00	93.33	96.83	119.80	132.80	116.50	91.58	125.30	144.70	120.50	94.20	122.60	138.70	118.50
T <sub>7</sub>	37.63	72.49	112.00	74.05	43.44	76.08	118.40	79.31	40.53	74.28	115.20	76.68	73.87	99.60	119.50	97.66	80.51	98.77	122.60	100.60	77.19	99.18	121.00	99.14
T <sub>8</sub>	40.67	72.49	110.90	74.70	50.63	79.13	113.40	81.06	45.65	75.81	112.20	77.88	65.29	98.77	137.00	98.59	78.30	103.20	130.30	103.90	71.79	101.00	131.00	101.30
T <sub>9</sub>	43.16	81.06	121.70	81.99	52.84	82.72	114.50	83.37	48.00	81.89	118.10	82.68	68.61	113.40	122.80	101.60	75.81	109.60	123.90	103.10	72.21	111.50	123.40	102.40
T <sub>10</sub>	62.53	62.53	62.53	62.53	67.69	67.69	67.69	67.69	65.11	65.11	65.11	65.11	101.80	101.80	101.80	101.80	113.10	113.10	113.10	113.10	107.40	107.40	107.40	107.40
Mean	45.82	74.73	113.80		53.87	82.14	115.50		49.84	78.43	114.70		77.27	108.60	125.70		84.00	111.10	129.50		80.63	109.90	127.60	

CD<sub>0.05</sub>

T	6.58	6.87	5.87	9.32	9.14	7.06
D	3.60	3.76	3.21	5.10	5.00	3.87
T x D	11.35	11.89	10.17	16.13	15.83	12.23

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The effect of distance of the alley crop from the tree line on the production efficiency is also clear from table 29. There was an increase in production efficiency with the increase in distance away from the hedgerows. During both the experimental years, the distance closer to the hedgerows i.e. D<sub>1</sub>, (0-1m) had the lowest values for production efficiency as compared to D<sub>2</sub> (1-2m) and D<sub>3</sub> (2-3m). The usefulness of the applied organic manures in the regulation of production processes is evident from the results in table 29, where much higher production efficiency was maintained over the control without manures.

The interaction between treatment (T) and distance (D) was also found to be significant during both the years.

The observation with regard to the production efficiency of *T. minuta* grown along with the hedge rows of *L. leucocephala* is also presented in table 29. The maximum (116.50kg/ha/day) production efficiency of *T. minuta* during the year 2005 was observed in T<sub>6</sub>, whereas the minimum (97.66 kg/ha/day) production efficiency during the same year was observed in T<sub>7</sub> (Table 29). A similar trend was observed during the second year of experiment. The maximum (120.50 kg/ha/day) production efficiency was observed in T<sub>6</sub> and the minimum (100.60 kg/ha/day) production efficiency was observed in T<sub>7</sub>. The pooled data also followed a similar trend.

The effect of distance on the production efficiency of *T. minuta* was also significant. The crop growing closer to the hedgerows had lower production efficiency as compared to the crop growing away from the hedgerows during both the experimental years. This fact was also evident from the pooled data (Table 29). The closer spacing and distance were not suitable for better production efficiency as efficiency was adversely affected.

The interaction effect (TxD) was also significant during the study period.

#### **4.2.3. Physiological Attributes**

Efforts were made during the present investigation to quantify the effect of *Leucaena* hedgerows and organic manures on physiological attributes of *O.*

*basilicum* and *T. minuta*. The data exhibiting the effect of hedgerows and organic manures is presented in the form of tables (30-33).

#### 4.2.3.1. Photosynthetic Rate ( $\mu \text{ mol m}^{-2} \text{ S}^{-1}$ )

The rate of photosynthesis did not vary significantly among different treatments during the year 2005 and 2006, respectively (Table 30). However, there was quite variation in the data recorded for photosynthesis among all the treatments. The effect of distance on the rate of photosynthesis of *O. basilicum* was significantly different during the year 2005, but no concrete conclusions could be drawn from it (Table 30), since no specific trend was observed. Effect of organic manures was clear during 2005 but the same was not observed during the year 2006, where rate of photosynthesis was comparatively higher in manure treated plants.

The interaction (TxD) between treatments and distances was found to be significant only during the year 2006.

Significant differences in photosynthetic rates were observed during the year 2005 in *T. minuta*. The plant spacing within the hedgerows and organic manures caused significant differences in the rate of photosynthesis. The maximum photosynthetic rate was 5.81 observed in T<sub>3</sub>, whereas the minimum photosynthetic rate was 3.36 observed in T<sub>10</sub> (control) (Table 30). During 2006, there were non-significant differences in the photosynthetic rate among various treatments. The pooled data however showed significant differences in the rate of photosynthesis in *T. minuta*. The maximum (5.35) rate of photosynthesis was observed in T<sub>8</sub> while the minimum (3.53) rate of photosynthesis was observed in T<sub>10</sub> (control) (Table 30). Application of organic manures maintained higher rate of photosynthesis in comparison to control.

The effect of distance of the crop from *Leucaena* hedgerows was statistically non-significant during the experimental year 2005 and 2006 (Table 30). Spacing of plants within the hedgerows were also not found to influence the rate of photosynthesis during the study.

**Table 30** Effect of *Leucaena* hedgerows and organic manures on the rate of photosynthesis ( $\mu\text{ mol m}^{-2}\text{ s}^{-1}$ ) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	3.04	2.33	3.56	2.98	2.49	2.51	2.60	2.53	2.76	2.42	3.08	2.75	3.33	5.33	5.64	4.77	4.15	4.74	4.27	4.39	3.74	5.03	4.95	4.57
T <sub>2</sub>	3.51	2.40	3.47	3.13	2.66	2.51	2.36	2.51	3.08	2.45	2.91	2.81	4.39	4.06	4.81	4.42	5.30	4.81	4.33	4.81	4.84	4.43	4.56	4.61
T <sub>3</sub>	2.46	2.35	2.79	2.53	2.46	3.21	2.76	2.81	2.46	2.78	2.77	2.67	5.71	5.95	5.79	5.81	4.22	4.79	4.54	4.52	4.96	5.37	5.16	5.16
T <sub>4</sub>	2.98	2.35	4.19	3.17	2.48	2.69	2.78	2.65	2.72	2.52	3.48	2.91	5.23	4.68	5.52	5.14	4.48	4.91	5.12	4.84	4.85	4.79	5.32	4.98
T <sub>5</sub>	2.68	2.37	3.45	2.83	2.77	2.63	2.56	2.65	2.72	2.49	3.00	2.74	4.19	4.41	5.32	4.64	4.10	4.71	4.24	4.35	4.14	4.56	4.78	4.44
T <sub>6</sub>	3.13	3.85	4.53	3.84	2.75	2.39	3.51	2.89	2.94	3.12	4.02	3.36	4.78	4.92	5.21	4.97	5.48	4.50	4.75	4.91	5.13	4.71	5.15	4.99
T <sub>7</sub>	2.83	2.25	3.49	2.86	2.66	2.54	2.68	2.63	2.74	2.39	3.08	2.74	5.08	4.39	6.73	5.40	5.48	5.01	4.62	5.04	5.27	4.69	5.67	5.21
T <sub>8</sub>	3.47	2.36	3.17	3.00	2.68	2.55	2.77	2.67	3.07	2.45	3.02	2.85	6.21	5.46	4.78	5.48	5.38	5.54	4.77	5.23	7.46	5.50	4.77	5.35
T <sub>9</sub>	2.74	2.39	2.93	2.69	2.91	2.59	2.63	2.71	2.82	2.48	2.78	2.69	6.55	5.31	4.82	5.55	4.68	4.25	4.63	4.52	5.61	4.78	9.52	5.04
T <sub>10</sub>	2.65	2.65	2.65	2.65	2.76	2.76	2.76	2.76	2.70	2.70	2.70	2.70	3.36	3.36	3.36	3.36	3.70	3.70	3.70	3.70	3.53	3.53	3.53	3.53
Mean	2.94	2.53	3.42		2.66	2.63	2.75		2.80	2.54	3.08		4.88	4.78	5.19		4.69	4.69	4.49		4.79	4.74	4.84	

CD<sub>0.05</sub>

T	NS	NS	NS	1.23	NS	0.80
D	0.58	NS	0.29	NS	NS	NS
T x D	NS	0.42	NS	NS	NS	NS

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The interaction (TxD) between treatments and distances was found to be statistically non-significant during the entire study period.

#### 4.2.3.2. Transpiration Rate ( $\text{m mol m}^{-1}\text{s}^{-1}$ )

The rate of transpiration during the present study was recorded for two consecutive years. The plant spacing within the *Leucaena* hedgerows as well as the addition of organic manures significantly affected the rate of transpiration. The data so obtained have been presented in table 31.

The perusal of data shows that the maximum (1.61) transpiration rate was observed in T<sub>5</sub>, whereas the minimum (0.90) transpiration rate was observed in T<sub>3</sub> during the first year of study (Table 31). However, the rate of transpiration was found to be maximum (1.67) in treatment T<sub>7</sub> and the minimum (0.94) rate of transpiration was observed in T<sub>4</sub> during the second year of study (Table 31). The pooling of data showed maximum rate of transpiration in treatments T<sub>5</sub> and T<sub>10</sub>, while the minimum transpiration rate was observed in treatment T<sub>4</sub>. The effect of distance on the rate of transpiration in *O. basilicum* was significant only during the first year of study (Table 31). No specific pattern for transpiration rate was observed in relation to the application of organic manures.

The interaction between treatments (T) and distances (D) was significant only during the year of study.

The results obtained for the influence of *Leucaena* hedgerows and organic manures on the rate of transpiration in *T. minuta* were statistically non-significant during both the experimental years (Table 31). In this case also no particular trend was observed during the study period.

#### 4.2.3.3. Water use efficiency

The perusal of data (Table 32) shows that the effect of plant spacing within the hedgerows of *Leucaena* and organic manures did not affect water use efficiency of *O. basilicum* and *T. minuta* substantially, although values were comparatively higher in manure treated plants. The water use efficiency was not at all affected by the distance from the hedgerows in both the herb species during the entire study period (Table 32).

The effect of *Leucaena* hedgerows and organic manures on the water use efficiency of *O. basilicum* was statistically non-significant during the year 2005. However, during 2006 critical differences among the treatments were significant. The maximum water use efficiency was 0.0031 observed in T<sub>7</sub>. The minimum value for the water use efficiency during the same year was 0.0016 in T<sub>7</sub> (Table 32). The pooled data for water use efficiency in *O. basilicum* was non-significant.

The interaction (TxD) was significant only during the year 2006 (Table 32).

The effect of *Leucaena* hedgerows and organic manures on the water use efficiency of *T. minuta* was significant only during the second year of study. The maximum water use efficiency of 0.0039 was observed in T<sub>8</sub> and the minimum water use efficiency of 0.0023 was observed in T<sub>10</sub> (Table 32). The pooling of data showed significant variations in water use efficiency among different treatments. The maximum (0.0039) water use efficiency was observed in T<sub>2</sub> whereas, the minimum (0.0024) water use efficiency was observed in T<sub>10</sub> (Table 32). Values for water use efficiency were significantly higher for plants provided with organic manures. This was true for both the experimental years.

The interaction (TxD) was non-significant during both the experimental years as well as for the pooled data.

#### 4.2.3.4. Light transmission ratio (LTR %)

The observations regarding LTR were made in order to estimate the difference in amount of light utilization by plants under different treatments. The data in table 33 indicate that there is decrease in the LTR with the increase in distance from D<sub>1</sub> (0-1m) to D<sub>3</sub> (2-3m) during the year 2005. Almost same trend is observed for the year 2006 as well as for the pooled data. The decrease in LTR implies an increased utilization of light by the *O. basilicum*. The use of organic manures has improved crop canopy in comparison to plants without manure. However, there was no significant difference among various treatments with regards to LTR (%).

**Table 31** Effect of *Leucaena* hedgerows and organic manures on the rate of transpiration ( $\text{m mol m}^{-2}\text{s}^{-1}$ ) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	1.29	1.14	1.35	1.26	1.19	1.26	1.55	1.33	1.23	1.20	1.44	1.29	1.36	1.62	1.40	1.46	1.29	1.28	1.57	1.38	1.32	1.45	1.48	1.42
T <sub>2</sub>	1.05	1.41	1.36	1.27	1.44	1.37	1.61	1.47	1.24	1.38	1.48	1.37	1.45	1.36	1.33	1.38	1.23	1.46	1.42	1.37	1.33	1.41	1.37	1.37
T <sub>3</sub>	0.70	0.93	1.08	0.90	1.55	1.51	1.58	1.55	1.12	1.05	1.49	1.22	1.37	1.50	1.32	1.40	1.43	1.26	1.53	1.40	1.39	1.37	1.42	1.40
T <sub>4</sub>	1.22	1.13	1.49	1.28	0.93	0.79	1.09	0.94	1.07	0.96	1.29	1.10	1.55	1.25	1.61	1.47	1.44	1.44	1.35	1.41	1.49	1.34	1.48	1.44
T <sub>5</sub>	1.29	2.36	1.17	1.61	1.27	1.40	1.51	1.39	1.28	1.87	1.34	1.49	1.38	1.58	1.29	1.42	1.34	1.57	1.38	1.43	1.36	1.57	1.33	1.42
T <sub>6</sub>	1.26	1.13	1.09	1.16	1.44	1.41	1.32	1.39	1.34	1.27	1.20	1.27	1.34	1.54	1.67	1.52	1.36	1.34	1.82	1.51	1.35	1.44	1.74	1.51
T <sub>7</sub>	1.13	1.26	0.91	1.10	1.57	1.76	1.70	1.67	1.35	1.51	1.30	1.38	1.42	1.54	1.48	1.48	1.50	1.49	1.56	1.52	1.46	1.51	1.52	1.49
T <sub>8</sub>	1.01	1.02	1.09	1.04	1.36	1.76	1.40	1.51	1.18	1.39	1.24	1.27	1.30	1.61	1.62	1.51	1.42	1.20	1.48	1.37	1.19	1.40	1.54	1.38
T <sub>9</sub>	1.13	1.39	1.63	1.39	1.53	1.65	1.49	1.56	1.33	1.52	1.55	1.47	1.44	1.31	1.48	1.41	1.39	1.44	1.61	1.48	1.41	1.37	1.54	1.44
T <sub>10</sub>	1.45	1.45	1.45	1.45	1.53	1.53	1.53	1.53	1.49	1.49	1.49	1.49	1.35	1.35	1.35	1.35	1.58	1.58	1.58	1.58	1.46	1.46	1.46	1.46
Mean	1.15	1.32	1.29		1.38	1.41	1.47		1.26	1.36	1.38		1.39	1.46	1.45		1.39	1.40	1.53		1.39	1.43	1.49	

CD<sub>0.05</sub>

T	0.23		0.23		0.93		NS		NS		NS		NS		NS		NS		NS		NS		NS	
D	0.12		NS		NS		NS		NS		NS		NS		NS		NS		NS		0.07		NS	
T x D	0.40		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS		NS	

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 32** Effect of *Leucaena* hedgerows and organic manures on water use efficiency of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	0.0023	0.0021	0.0027	0.0024	0.0021	0.0020	0.0017	0.0019	0.0022	0.0020	0.0022	0.0021	0.0026	0.0034	0.0040	0.0034	0.0032	0.0038	0.0028	0.0033	0.0028	0.0036	0.0034	0.0031
T <sub>2</sub>	0.0033	0.0018	0.0026	0.0026	0.0019	0.0018	0.0015	0.0017	0.0026	0.0018	0.0020	0.0021	0.0030	0.0030	0.0036	0.0032	0.0043	0.0033	0.0031	0.0036	0.0036	0.0031	0.0033	0.0039
T <sub>3</sub>	0.0035	0.0026	0.0026	0.0029	0.0016	0.0022	0.0018	0.0018	0.0025	0.0031	0.0019	0.0025	0.0042	0.0040	0.0045	0.0042	0.0030	0.0039	0.0031	0.0033	0.0036	0.0039	0.0038	0.0079
T <sub>4</sub>	0.0024	0.0022	0.0028	0.0025	0.0030	0.0038	0.0026	0.0031	0.0027	0.0029	0.0026	0.0027	0.0034	0.0038	0.0036	0.0036	0.0031	0.0036	0.0039	0.0035	0.0023	0.0036	0.0037	0.0035
T <sub>5</sub>	0.0021	0.0010	0.0034	0.0022	0.0022	0.0019	0.0017	0.0019	0.0021	0.0014	0.0025	0.0020	0.0031	0.0028	0.0042	0.0034	0.0031	0.0029	0.0031	0.0030	0.0030	0.0029	0.0036	0.0032
T <sub>6</sub>	0.0025	0.0034	0.0041	0.0034	0.0020	0.0017	0.0027	0.0021	0.0022	0.0025	0.0033	0.0027	0.0036	0.0033	0.0033	0.0034	0.0040	0.0034	0.0026	0.0033	0.0038	0.0033	0.0029	0.0033
T <sub>7</sub>	0.0026	0.0021	0.0043	0.0030	0.0017	0.0014	0.0016	0.0016	0.0021	0.0017	0.0029	0.0022	0.0037	0.0028	0.0046	0.0037	0.0037	0.0034	0.0031	0.0034	0.0036	0.0031	0.0038	0.0035
T <sub>8</sub>	0.0035	0.0023	0.0029	0.0029	0.0020	0.0015	0.0020	0.0018	0.0027	0.0018	0.0025	0.0023	0.0048	0.0034	0.0030	0.0037	0.0039	0.0046	0.0033	0.0039	0.0029	0.0040	0.0031	0.0038
T <sub>9</sub>	0.0024	0.0018	0.0018	0.0020	0.0019	0.0016	0.0018	0.0018	0.0021	0.0016	0.0018	0.0018	0.0047	0.0041	0.0032	0.0040	0.0035	0.0030	0.0030	0.0032	0.0041	0.0035	0.0032	0.0036
T <sub>10</sub>	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0018	0.0018	0.0018	0.0018	0.0025	0.0025	0.0025	0.0025	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0024
Mean	0.0026	0.0021	0.0028		0.0020	0.0021	0.0019		0.0023	0.0021	0.0023		0.0035	0.0032	0.0036		0.0034	0.0034	0.0030		0.0034	0.0033	0.0037	

CD<sub>0.05</sub>

T	NS		0.00067		NS		NS		NS		0.00078		0.00064
D	NS		NS		NS		NS		NS		NS		NS
T x D	NS		0.42		NS		NS		NS		NS		NS

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 33** Effect of *Leucaena* hedgerows and organic manures on LTR (%) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	61.57	41.99	46.74	50.10	67.27	55.83	46.35	56.49	64.42	48.91	46.55	53.29	85.65	79.71	60.30	75.22	84.42	76.88	53.25	71.52	85.03	78.29	56.78	73.37
T <sub>2</sub>	59.13	52.36	46.22	52.57	58.56	62.29	48.75	56.53	58.84	57.32	47.50	54.55	82.02	72.68	61.52	72.07	87.21	75.84	50.31	71.12	84.61	74.26	55.91	71.60
T <sub>3</sub>	48.16	47.07	49.48	48.23	60.89	51.46	36.40	49.58	54.52	49.26	42.94	48.91	79.42	72.45	52.72	68.20	80.26	76.38	51.99	69.54	79.84	74.42	50.35	68.87
T <sub>4</sub>	64.38	45.47	44.58	51.48	58.91	59.87	46.06	54.95	61.64	52.67	45.32	53.21	79.53	73.97	59.77	71.09	82.09	75.29	60.77	72.72	80.81	74.63	60.27	71.90
T <sub>5</sub>	49.97	58.74	47.09	51.93	57.88	52.18	40.90	50.32	53.92	55.46	43.99	51.13	81.44	73.22	70.17	74.94	81.57	73.55	51.35	68.82	81.50	73.39	60.76	71.88
T <sub>6</sub>	50.20	47.72	58.87	52.27	50.74	49.72	41.45	47.31	50.47	48.72	50.16	49.79	76.78	75.31	61.35	71.15	79.84	66.99	50.13	65.65	78.31	71.15	55.74	68.40
T <sub>7</sub>	63.24	55.63	49.30	56.06	65.59	61.42	46.61	57.87	64.41	58.53	47.95	56.96	81.70	77.29	58.11	72.36	83.24	74.46	54.17	70.62	82.47	75.87	56.14	71.49
T <sub>8</sub>	64.20	55.12	56.99	58.77	61.73	62.90	45.26	56.63	62.97	59.01	51.13	57.70	80.45	72.68	59.10	70.74	84.63	73.12	57.89	71.88	82.54	72.90	58.49	71.31
T <sub>9</sub>	60.01	59.60	48.17	55.93	54.89	51.20	47.68	51.26	57.45	55.40	47.93	53.59	80.48	77.00	53.79	70.43	82.07	76.21	58.71	72.33	81.28	76.60	56.25	71.38
T <sub>10</sub>	51.92	51.92	51.92	51.92	57.85	57.85	57.85	57.85	54.88	54.88	54.88	54.84	65.26	65.26	65.26	65.26	66.34	66.34	66.34	66.34	65.80	65.80	65.80	65.80
Mean	57.25	51.56	49.94		59.43	56.47	45.73		58.34	54.02	47.84		79.27	73.96	60.21		81.17	73.50	55.49		80.22	73.73	57.85	

CD<sub>0.05</sub>

T	NS		NS		NS		4.37		4.00		2.64
D	NS		5.97		4.61		2.39		2.19		1.44
T x D	NS		NS		NS		7.57		6.94		4.57

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

The interaction (TxD) effect was also statistically non-significant.

Light transmission ratio was significantly different among various treatments in *T. minuta*. The maximum average LTR was 75.22 % in treatment T<sub>1</sub> whereas, the minimum average values for LTR (%) was 65.26 in the treatments T<sub>10</sub> during the first year of study (Table 33). During the second year of study, the maximum LTR was 72.72 % recorded in T<sub>4</sub>, while the minimum LTR was 65.65 % in T<sub>6</sub>. The pooling of data shows that the maximum LTR was 73.37 % in T<sub>1</sub> and the minimum value for LTR was 65.80 % in T<sub>10</sub> (Table 33). The data in table 33 also indicate a decrease in LTR with an increase in distance away from the hedgerows.

The interaction effect was found to be significant during the years 2005 and 2006, respectively.

#### **4.2.4. Root characteristics**

The root characters with and without the use of organic manures were determined for the medicinal and aromatic crops grown under *Leucaena* hedgerows. The results obtained for different root parameters are described in the tables 34-37.

##### **4.2.4.1. Number of roots**

The effect of *Leucaena* hedgerows on the number of roots is presented in table 34. During 2005, the variation in number of roots per plant in *O. basilicum* was statistically non-significant. In the year 2006, the maximum (22.22) number of roots were observed in T<sub>6</sub>. The minimum (17.33) number of roots per plant was observed in T<sub>10</sub> (Table 34). The most of the treatments were at par with each other. The pooled data however, showed the maximum (21.28) number of roots in T<sub>3</sub> whereas, the minimum (16.50) number of roots were observed in T<sub>10</sub> (Table 34).

The effect of distance on the number of roots was significant during both the experimental years. Comparatively higher number of roots were observed at D<sub>2</sub> (1-2 m) and D<sub>3</sub> (2-3 m) as compared to D<sub>1</sub> (0- 1 m) (Table 34). Except at

closer plant spacing within the hedgerows (0.50 m), organic manures were able to maintain higher root number at wider spacing and distances from the hedgerows.

The interaction (TxD) effect was significant during both the experimental years.

In the herb *T. minuta*, the differences in the number of roots among various treatments in 2005 were statistically non-significant (Table 34). However, during 2006, the maximum number of roots were 28.00 recorded in T<sub>6</sub>, whereas the minimum number of roots were 21.33 observed in T<sub>10</sub> (Table 34). The pooling of data also shows the maximum (27.39) and minimum (21.83) number of roots in T<sub>6</sub> and T<sub>10</sub>, respectively (Table 34).

The effect of distance was also significant during the entire study period. It was observed that the number of roots in *T. minuta* growing close to the hedgerows had lesser number of roots compared to the crop growing away from the hedgerows (Table 34). Benefit of organic manures was amply clear.

The interaction (TxD) was found to be significant for the second year of study as well as for the pooled data.

#### 4.2.4.2. Root dry weight (g)

The root dry weight of *O. basilicum* and *T. minuta* grown in association with *Leucaena* hedgerows and supplied with organic manures was determined after the crop was harvested and the data is expressed in table 35.

The data reveal that the average root dry weight of *O. basilicum* grown under different plant spacing within the hedgerows was significantly different among various treatments. The maximum (4.07 g) dry weight of root was recorded in T<sub>6</sub> whereas, the minimum (2.74) root dry weight was recorded during 2005 in T<sub>4</sub> (Table 35). A closer look at the table reveals that during the second year of study, the maximum (3.57 g) root dry weight per plant was observed in T<sub>10</sub> whereas, the minimum (2.68 g) root dry weight was recorded in T<sub>7</sub> (Table 35). The pooled data showed a maximum root dry weight of 3.75 g in T<sub>6</sub>

**Table 34** Effect of *Leucaena* hedgerows and organic manures on number of roots per plant of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	12.33	20.67	23.00	18.67	14.00	24.33	24.33	20.89	13.17	22.50	23.67	19.78	15.00	25.33	31.67	24.00	13.67	31.33	32.67	25.89	14.33	28.33	32.17	24.94
T <sub>2</sub>	13.00	18.33	24.67	18.67	12.67	24.33	25.00	20.67	12.83	21.33	24.83	19.67	12.33	27.33	28.67	22.78	14.67	30.67	35.67	27.00	13.50	29.00	32.17	24.89
T <sub>3</sub>	12.00	19.00	28.00	19.67	18.00	26.67	24.00	22.89	15.00	22.83	26.00	21.28	15.67	30.00	31.33	25.67	14.33	31.00	35.00	26.78	15.00	30.50	33.17	26.22
T <sub>4</sub>	12.00	19.00	24.33	18.44	12.33	24.33	25.33	20.67	12.17	21.67	24.83	19.56	14.67	27.00	31.00	24.22	15.33	31.67	31.67	26.22	15.00	29.33	31.33	25.22
T <sub>5</sub>	11.33	20.33	25.00	18.89	16.67	26.33	25.67	22.89	14.00	23.33	25.33	20.89	13.33	31.67	29.33	24.78	16.00	34.67	30.67	27.11	14.67	33.17	30.00	25.94
T <sub>6</sub>	13.67	21.33	24.67	19.89	16.33	26.33	24.00	22.22	15.00	23.83	24.33	21.06	17.67	31.33	31.33	26.78	16.67	32.67	34.67	28.00	17.17	32.00	33.00	27.39
T <sub>7</sub>	11.00	19.33	23.33	17.89	13.33	24.33	25.00	20.89	12.17	21.83	24.17	19.39	14.67	26.67	25.33	22.22	15.00	29.33	34.67	26.33	14.83	28.00	30.00	24.28
T <sub>8</sub>	12.00	18.67	27.00	19.22	14.67	23.00	24.67	20.78	13.33	20.83	25.83	20.00	13.33	27.00	25.33	21.89	13.33	28.00	36.00	25.78	13.33	27.50	30.67	23.83
T <sub>9</sub>	11.00	20.00	25.67	18.89	12.00	24.33	24.33	20.22	11.50	22.17	25.00	19.56	15.00	29.33	28.33	24.22	13.00	28.33	33.00	24.78	14.00	28.83	30.67	24.50
T <sub>10</sub>	15.67	15.67	15.67	15.67	17.33	17.33	17.33	17.33	16.50	16.50	16.50	16.50	22.33	22.33	22.33	22.33	21.33	21.33	21.33	21.33	21.83	21.83	21.83	21.83
Mean	12.40	19.23	24.13		14.73	24.13	23.97		13.57	21.68	24.05		15.40	27.80	28.47		15.33	29.90	32.53		15.37	28.85	30.50	

CD<sub>0.05</sub>

T	NS		2.50		2.45		NS		2.83		2.96
D	2.08		1.37		1.34		2.17		1.55		1.62
T x D	NS		4.33		4.25		NS		4.91		5.13

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 35** Effect of *Leucaena* hedgerows and organic manures on root dry weight (g) per plant of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	1.43	2.33	4.70	2.82	1.77	2.60	4.30	2.89	1.60	2.46	4.50	2.85	2.47	4.17	7.07	4.57	2.47	5.80	6.93	5.07	2.46	4.98	7.00	4.81
T <sub>2</sub>	1.87	2.87	4.77	3.17	1.50	2.33	4.70	2.84	1.68	2.60	4.73	3.00	2.70	4.47	6.47	4.54	2.57	5.47	6.17	4.73	2.63	4.96	6.31	4.63
T <sub>3</sub>	2.00	3.03	5.47	3.50	1.63	2.40	5.27	3.10	1.81	2.71	5.36	3.30	2.87	6.17	8.30	5.78	3.67	6.63	7.73	6.01	3.26	6.40	8.01	5.89
T <sub>4</sub>	1.33	2.60	4.30	2.74	1.37	2.93	4.23	2.84	1.35	2.76	4.26	2.79	2.70	4.37	6.97	4.68	2.60	4.77	8.53	5.30	2.65	4.56	7.75	4.98
T <sub>5</sub>	2.13	4.37	4.93	3.81	1.83	2.90	4.37	3.03	1.98	3.63	4.65	3.42	2.53	3.93	7.00	4.49	3.00	5.13	8.73	5.62	2.76	4.53	7.86	5.05
T <sub>6</sub>	2.37	4.07	5.77	4.07	2.27	3.23	4.83	3.44	2.31	3.65	5.30	3.75	3.53	4.93	7.27	5.24	3.23	6.20	8.73	5.72	3.83	5.56	8.00	5.65
T <sub>7</sub>	1.80	2.87	3.83	2.83	1.33	2.50	4.20	2.68	1.56	2.68	4.01	2.75	3.10	5.03	7.47	5.20	2.90	4.90	6.50	4.77	3.00	4.96	6.98	4.98
T <sub>8</sub>	1.70	4.07	4.60	3.46	1.43	2.53	4.67	2.88	1.56	3.30	4.63	3.16	2.53	4.70	6.30	4.51	2.87	5.50	7.13	5.17	2.70	5.10	6.71	4.83
T <sub>9</sub>	1.93	4.03	4.90	3.62	1.77	2.50	4.40	2.89	1.85	3.26	4.65	3.25	2.77	4.53	6.50	4.60	3.30	5.27	7.87	5.48	3.03	4.90	7.18	5.03
T <sub>10</sub>	2.97	2.97	2.97	2.97	3.57	3.57	3.57	3.57	3.26	3.26	3.26	3.26	5.07	5.07	5.07	5.07	6.50	6.50	6.50	6.50	5.78	5.78	5.78	5.78
Mean	1.95	3.32	4.62		1.84	2.75	4.45		1.90	3.03	4.53		3.02	4.73	6.84		3.31	5.61	7.48		3.16	5.17	7.16	

CD<sub>0.05</sub>

T	0.79		0.27		0.43		NS		1.01		0.76
D	0.43		0.56		0.23		0.56		0.55		0.41
T x D	NS		0.87		0.75		NS		1.23		1.31

<b>Treatments</b>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

whereas, the minimum root dry weight was 2.75 g, recorded in T<sub>7</sub> (Table 35). Organic manures could maintain significantly higher root dry weight even in the presence of hedgerows in comparison to control without manures. The critical differences between the treatments were statistically significant during both the experimental years.

The interaction (TxD) was significant during the second year of study as well as for the pooled data.

The effect of *Leucaena* hedgerows and organic manures was non-significant during the first year of experiment in *T. minuta*. However, during the second year of study, significant differences were observed among different treatments. The maximum root dry weight in *T. minuta* was 6.50 g in T<sub>10</sub> (control), while the minimum root dry weight was 4.73 g in T<sub>2</sub> (Table 35). The pooling of data for both the years revealed that overall maximum (5.89 g) root dry weight was found in T<sub>3</sub>, whereas overall minimum (4.63 g) root dry weight was found in T<sub>2</sub> (Table 35). Root dry weight was lesser at closer plant spacing and distances from the hedgerows.

The interaction (TxD) was significant only during the second year of study.

#### 4.2.4.3. Specific root length (cm<sup>-1</sup> g)

Specific root length is an important parameter to study the influence of plant to plant spacing in the *Leucaena* hedgerows on root characteristics of medicinal and aromatic herbs grown as alley crop. It was observed that the specific root length in *Ocimum* was non-significant during the first year of study. However, during the second year of study, the specific root length was maximum (3.43 cm<sup>-1</sup> g) in T<sub>4</sub> whereas, the minimum (2.30 cm<sup>-1</sup> g) specific root length was observed in T<sub>10</sub> (Table 36). The pooling of data also showed maximum specific root length of 3.47 cm<sup>-1</sup> g in T<sub>4</sub> and a minimum specific root length of 2.58 cm<sup>-1</sup> g in T<sub>10</sub> (Table 36).

The effect of distance on specific root length was significantly different for different distances away from the tree line. A decrease in specific root length was observed as the distance from the hedgerow increased (Table 36).

The interaction (TxD) was non-significant during both the experimental years. However, in the pooled data, the interaction was significant.

The results for specific root length of *T. minuta* grown along with *Leucaena* hedgerows and organic manures were significantly different among various treatments. During the year 2005, the maximum ( $1.81 \text{ cm}^{-1} \text{ g}$ ) specific root length was observed in T<sub>5</sub> whereas, the minimum ( $1.35 \text{ cm}^{-1} \text{ g}$ ) specific root length was found in T<sub>10</sub> (Table 36). The maximum ( $1.71 \text{ cm}^{-1} \text{ g}$ ) specific root length in the year 2006 was observed in T<sub>1</sub> whereas, the minimum  $1.08 \text{ cm}^{-1} \text{ g}$  specific root length was again observed in T<sub>10</sub>. The pooled data in table 36 for the specific root length indicate a maximum ( $1.74 \text{ cm}^{-1} \text{ g}$ ) specific root length in T<sub>1</sub> whereas, the minimum ( $1.21 \text{ cm}^{-1} \text{ g}$ ) specific root length was observed in T<sub>10</sub> (Table 36).

Like *O. basilicum*, the effect of distances on the specific root length of *T. minuta* was also found to decrease as the distance from the *Leucaena* hedgerow increased (Table 36).

The interaction effect between treatments (T) and distance (D) was non-significant for both the years.

#### 4.2.4.4. Root growth potential (%)

Different spacing, different distances from the hedgerows and different organic manures applied to *O. basilicum* grown in association with *Leucaena* hedgerows influenced root growth potential of *O. basilicum*. Besides a greater variation in the values obtained for root growth potential in the year 2005, the differences among various treatments were statistically non-significant. However, during 2006, significant differences among various treatments were observed. The maximum root growth potential of 36.66 % was recorded in T<sub>6</sub> whereas, the minimum root growth potential of 22.43 % was recorded in T<sub>7</sub> (Table 37). The pooled data showed significant differences among different treatments. The

**Table 36** Effect of *Leucaena* hedgerows and organic manures on specific root length (cm g<sup>-1</sup>) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	4.77	3.49	2.05	3.44	4.04	2.88	2.24	3.04	4.41	3.16	2.14	3.24	2.69	1.58	1.07	1.78	2.62	1.42	1.09	1.71	2.66	1.50	1.08	1.74
T <sub>2</sub>	3.99	2.54	1.98	2.84	4.59	3.15	2.22	3.32	4.29	2.85	2.10	3.08	2.41	1.46	1.16	1.67	2.59	1.28	1.23	1.70	2.50	1.37	1.19	1.69
T <sub>3</sub>	3.99	2.68	1.82	2.83	4.55	3.14	2.10	3.27	4.27	2.91	1.96	3.05	2.35	1.02	0.90	1.42	1.83	1.04	0.98	1.28	2.09	1.03	0.94	1.35
T <sub>4</sub>	5.27	3.00	2.28	3.51	5.17	2.62	2.51	3.43	5.21	2.81	2.39	3.47	2.31	1.47	1.12	1.63	2.51	1.43	0.87	1.61	2.41	1.45	1.00	1.62
T <sub>5</sub>	3.56	1.88	2.04	2.49	3.75	2.61	2.38	2.91	3.65	2.25	2.21	2.70	2.53	1.82	1.80	1.81	2.09	1.45	0.86	1.47	2.31	1.63	0.97	1.64
T <sub>6</sub>	3.43	2.33	1.91	2.56	3.08	2.52	2.35	2.65	3.26	2.43	2.13	2.60	2.05	1.47	1.08	1.53	2.06	1.12	0.88	1.36	2.06	1.30	0.98	1.44
T <sub>7</sub>	3.68	2.95	2.74	3.12	4.77	2.90	2.43	3.37	4.32	2.92	2.58	3.24	1.80	1.24	1.09	1.38	2.13	1.39	1.06	1.53	1.97	1.31	1.07	1.45
T <sub>8</sub>	4.13	1.96	2.08	2.72	4.84	3.04	2.17	3.35	4.48	2.50	2.12	3.04	2.48	1.52	1.19	1.73	2.23	1.31	1.03	1.52	2.36	1.42	1.11	1.63
T <sub>9</sub>	3.99	1.96	1.95	2.63	4.07	3.09	2.39	3.18	4.03	2.52	2.17	2.91	2.29	1.53	1.25	1.69	2.02	1.51	0.98	1.50	2.16	1.52	1.11	1.60
T <sub>10</sub>	2.85	2.85	2.85	2.85	2.30	2.30	2.30	2.30	2.58	2.58	2.58	2.58	1.35	1.35	1.35	1.35	1.08	1.08	1.08	1.08	1.21	1.21	1.21	1.21
Mean	3.96	2.56	2.17		4.12	2.82	2.31		4.04	2.69	2.24		2.22	1.44	1.13		2.12	1.30	1.01		2.17	1.37	1.07	

CD<sub>0.05</sub>

T	NS		0.60		0.48		0.32		0.33		0.26
D	0.43		0.32		0.26		0.17		0.18		0.14
T x D	NS		NS		0.84		NS		NS		0.46

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompost	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

**Table 37** Effect of *Leucaena* hedgerows and organic manures on root growth potential (%) of *Ocimum basilicum* and *Tagetes minuta* with respect to distance from the tree trunk

Treatments	<i>Ocimum basilicum</i>												<i>Tagetes minuta</i>											
	Year 2005				Year 2006				Pooled				Year 2005				Year 2006				Pooled			
	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean	D <sub>1</sub> (0-1m)	D <sub>2</sub> (1-2m)	D <sub>3</sub> (2-3m)	Mean
T <sub>1</sub>	-14.78	38.65	61.29	28.39	-16.22	48.07	44.69	25.51	-15.50	43.36	52.99	26.95	-32.79	16.33	42.98	8.84	-35.03	48.37	55.02	22.79	-33.91	32.35	49.00	15.81
T <sub>2</sub>	-12.55	24.60	67.39	26.48	-22.12	46.46	47.23	23.86	-17.34	35.53	57.31	25.17	-44.22	23.11	29.56	2.81	-30.83	46.72	68.88	28.26	-37.52	34.91	49.22	15.54
T <sub>3</sub>	-19.49	20.12	95.98	32.20	9.30	59.08	41.60	36.66	-5.09	39.60	68.79	34.43	-27.83	36.65	41.60	16.81	-32.05	47.88	65.14	26.99	-29.94	42.26	53.37	21.90
T <sub>4</sub>	-13.66	25.05	67.02	26.13	-26.64	43.45	52.12	22.98	-20.15	34.25	59.57	24.55	-34.12	25.26	40.08	10.41	-26.39	50.26	49.53	24.47	-30.25	37.76	44.80	17.44
T <sub>5</sub>	-23.39	35.52	73.29	28.47	-0.06	53.58	52.10	35.21	-11.73	44.55	62.70	31.84	-39.76	45.42	32.11	12.59	-24.37	64.85	44.86	28.45	-32.06	55.13	38.48	20.52
T <sub>6</sub>	-6.08	47.29	68.77	36.66	-4.31	59.18	43.18	32.68	-5.19	53.24	55.98	34.67	-20.63	44.58	40.34	21.43	-21.17	55.92	63.45	32.73	-20.90	50.25	51.89	27.08
T <sub>7</sub>	-23.66	30.06	66.00	24.13	-21.79	44.87	48.66	23.91	-22.73	37.46	57.33	24.02	-33.82	24.03	13.77	1.33	-29.41	40.90	64.15	25.22	-31.61	32.47	38.96	13.27
T <sub>8</sub>	-19.88	34.25	88.75	34.37	-11.09	39.76	46.01	24.89	-15.49	37.01	67.38	29.63	-40.30	26.17	14.50	0.12	-36.41	32.76	70.04	22.13	-38.35	29.46	42.27	11.13
T <sub>9</sub>	-23.66	35.34	78.67	30.12	-29.39	47.88	48.78	22.43	-26.53	41.61	63.73	26.27	-32.90	35.13	27.22	9.82	-37.77	31.45	56.14	16.61	-35.34	33.29	41.68	13.21
T <sub>10</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean	-15.72	29.09	66.72		-12.23	44.23	42.44		-13.98	36.66	54.58		-30.64	27.67	28.21		-27.34	41.91	53.72		-28.99	34.79	40.97	

CD<sub>0.05</sub>

T	NS		17.11		19.38		NS		14.60		14.84
D	16.07		9.37		10.61		10.89		7.99		8.13
T x D	NS		NS		NS		NS		25.30		25.72

Treatments	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>	T <sub>9</sub>	T <sub>10</sub> (Control)
Tree spacing	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	0.50 m	0.75 m	1.50 m	- trees
Organic manures (applied to crop)	Vermicompost	Vermicompos.	Vermicompost	Enriched manure	Enriched manure	Enriched manure	FYM	FYM	FYM	- manure

maximum and minimum pooled values for root growth potential were 34.67 % and 24.02 % found in T<sub>6</sub> and T<sub>7</sub>, respectively (Table 37).

The effect of distance on the root growth potential was significantly different for D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub> during both the experimental years. The root growth potential seems to increase with the increase in distance from the tree trunk (Table 37).

The interaction (TxD) was non-significant for the entire period of study for this character.

The root growth potential of *T. minuta* was found to be non-significant among different treatments during the year 2005. During 2006, however, the critical differences between different treatments were statistically significant. The maximum and minimum values for root growth potential were 32.73 % and 16.61 % obtained in treatment T<sub>6</sub> and T<sub>9</sub>, respectively (Table 37). The pooled values for the two years indicated a maximum and minimum root growth potential in treatments T<sub>6</sub> and T<sub>8</sub> with corresponding values of 27.08 % and 11.13 %, respectively (Table 37).

The effect of distance on root growth potential was significant during the study period. The herb *T. minuta* showed negative values for root growth potential while growing at a distance of 0-1 m (D<sub>1</sub>) to the tree trunk. However, positive values were obtained as the distance increased to 1-2 m (D<sub>2</sub>) and 2-3 m (D<sub>3</sub>) from the hedgerows, respectively (Table 37).

The interaction (TxD) effect was significant during the year 2006 as well as for the pooled data.

#### **4.3. Growth and physiological status of *Morus* and *Leucaena* hedgerows**

The influence of different spacing and the associated medicinal and aromatic herbs as intercrops on the growth of *Morus* and *Leucaena* was studied during the present investigation. Various parameters such as height, collar diameter, leaf area index were studied.

#### 4.3.1. Hedgerow height (m)

The height of both *Morus* and *Leucaena* was recorded and the data so obtained is presented in figures 1 and 11. The maximum average height for *Morus* (3.43 m) was recorded in T<sub>9</sub> (2.50 m spacing). The average height of *Morus* remained at par at the spacing of 2.50 m i.e. 3.42 m and 3.41m in T<sub>3</sub> and T<sub>6</sub>, respectively (Fig. 1). The minimum average height was 2.48 m recorded in T<sub>7</sub> (1.50 m spacing), closely followed by T<sub>1</sub> and T<sub>4</sub>, which were at par with T<sub>7</sub> with corresponding values of 2.74 m and 2.66 m (Fig. 1).

The height of *Leucaena* hedgerows in different treatments is presented in Fig. 11. The maximum average height of 2.26 m was observed in T<sub>3</sub> (1.50 m spacing). The hedgerows with 1.50 m spacing i.e. T<sub>3</sub>, T<sub>6</sub> and T<sub>9</sub> were at par with each other. The minimum average height was recorded in T<sub>4</sub>, with plant to plant spacing of 0.50 m within the hedgerow. The other two treatments with 0.50 m spacing (T<sub>1</sub> and T<sub>7</sub>) were at par with T<sub>4</sub> (Fig. 11).

#### 4.3.2. Collar diameter (mm)

The data recorded for collar diameter showed significant variation for different plant spacing within the hedgerows both for *Morus* as well as *Leucaena*, (Figs. 2 and 12). In case of *Morus*, the maximum collar diameter was 76.86 mm observed in T<sub>9</sub> (2.50 m), while the minimum value was 59.78 mm in treatment T<sub>1</sub> (Fig. 2). Like *Morus*, the maximum collar diameter in *Leucaena* was recorded in treatments with wider plant to plant spacing within the hedgerows i.e., 0.75 and 1.50 m (Fig. 12). The maximum collar diameter in *Leucaena* was 24.51 mm recorded in treatment T<sub>6</sub> (1.50 m) and the minimum value for collar diameter was 16.48 mm is treatment T<sub>7</sub> with plant spacing of 0.50 m (Fig. 12).

#### 4.3.3. Leaf area index (LAI)

The critical differences in leaf area index (Fig. 3) in different treatments were statistically significant for both the hedgerow species. In case of *Morus* hedgerows, the maximum (1.84) leaf area index was recorded in treatment T<sub>3</sub> (2.50 m) whereas, a minimum (1.22) leaf area index was recorded in T<sub>1</sub> (1.50 m).

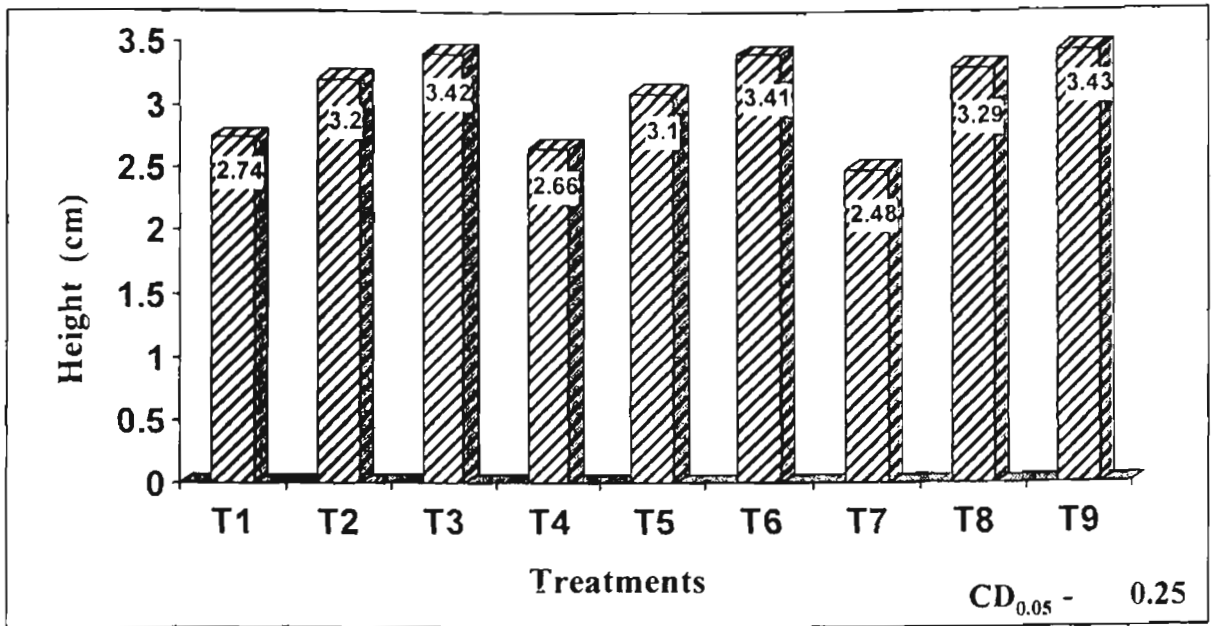


Fig. 1 Effect of different treatments on height (m) of *Morus* under alley cropping

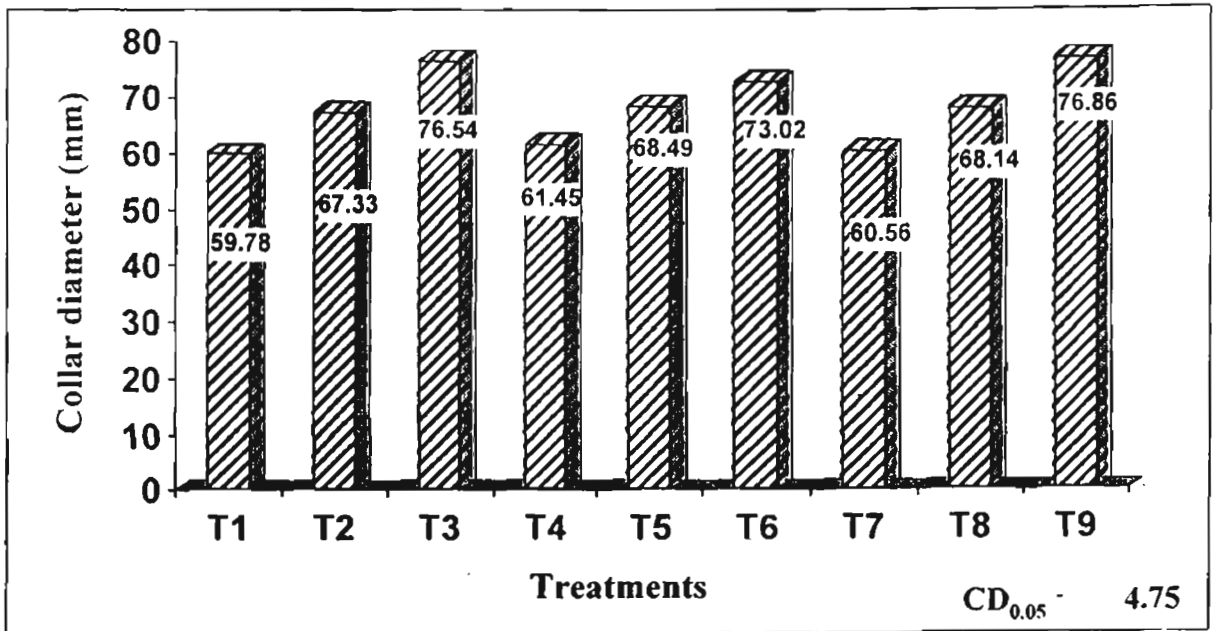


Fig 2. Effect of different treatments on collar diameter (mm) of *Morus* under alley cropping

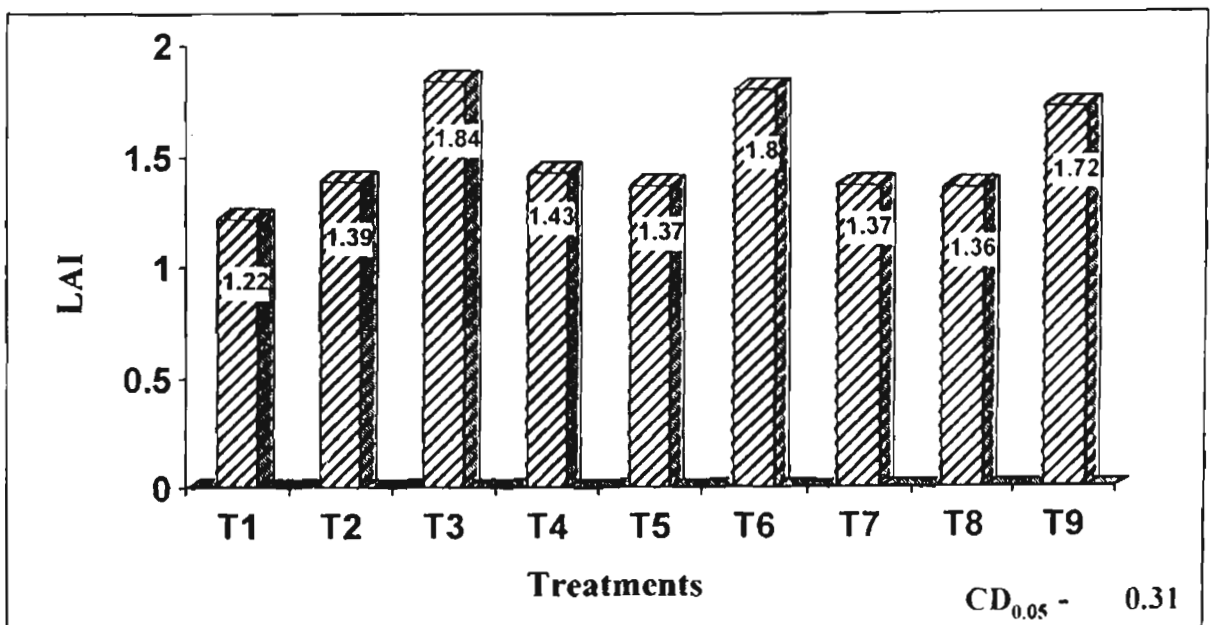


Fig. 3 Effect of different treatments on LAI of *Morus* under alley cropping

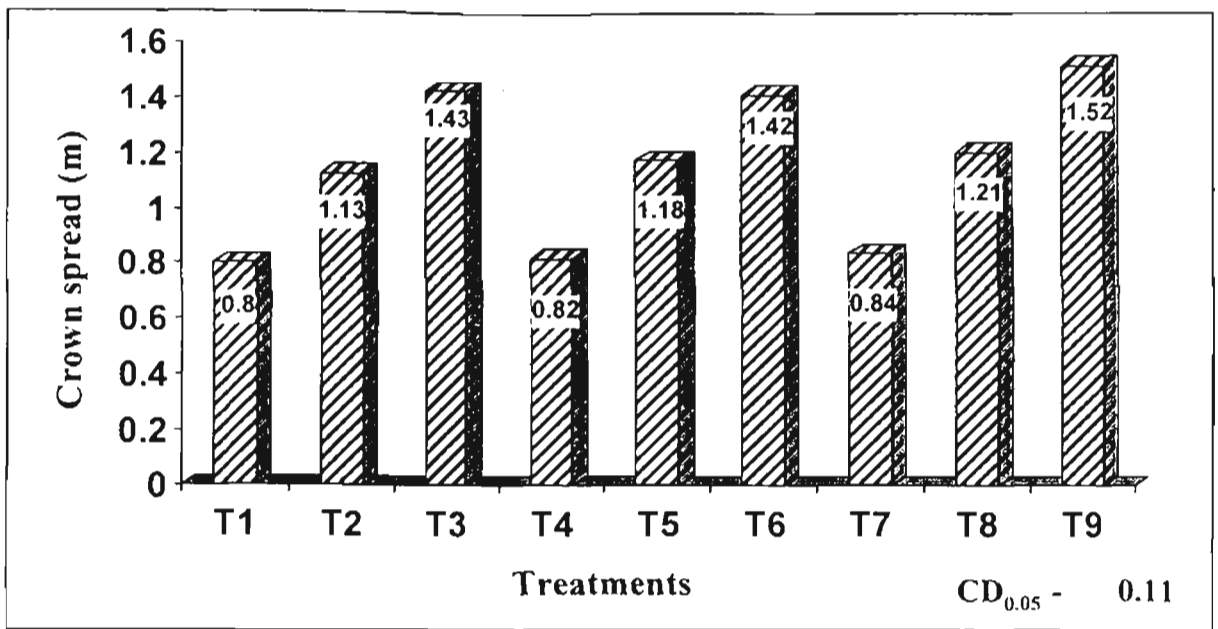


Fig. 4 Effect of different treatments on crown spread (m) of *Morus* under alley cropping

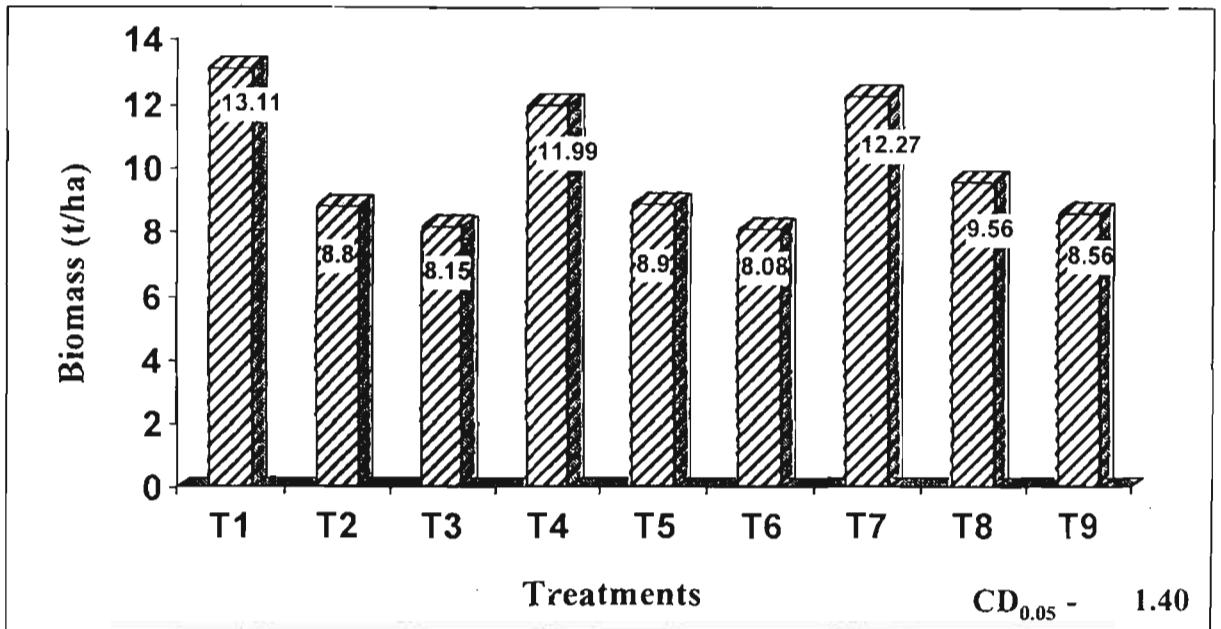


Fig. 5 Effect of different treatments on biomass (t/ha) of *Morus* under alley cropping

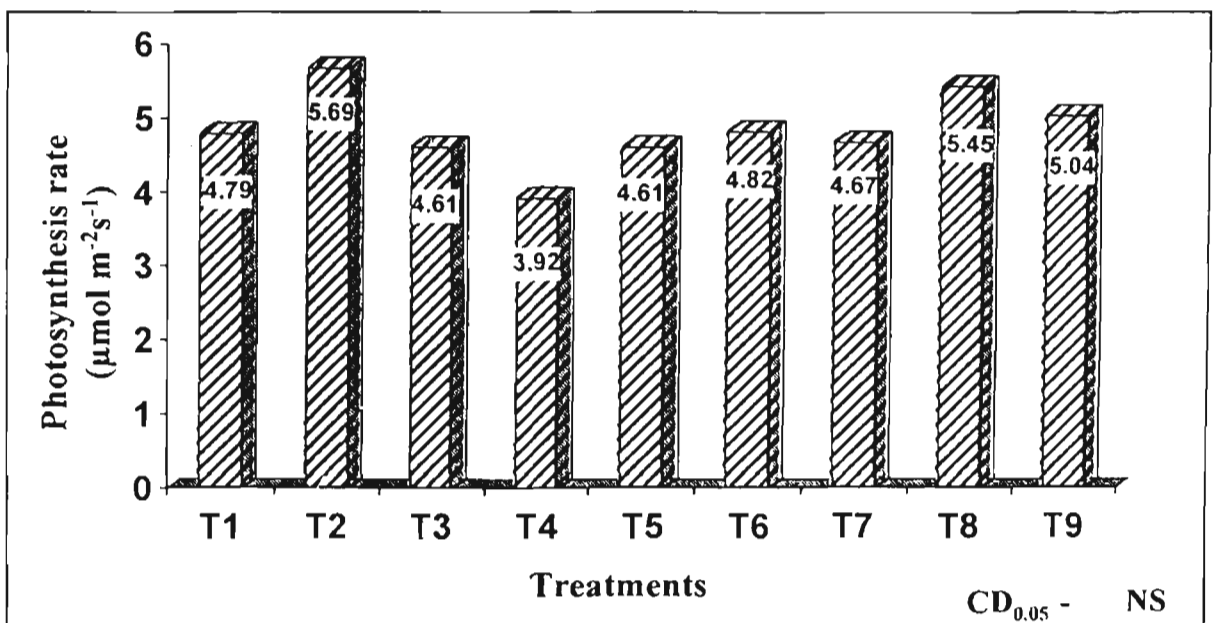


Fig. 6 Effect of different treatments on rate of Photosynthesis (µmol m<sup>-2</sup>s<sup>-1</sup>) of *Morus* under alley cropping

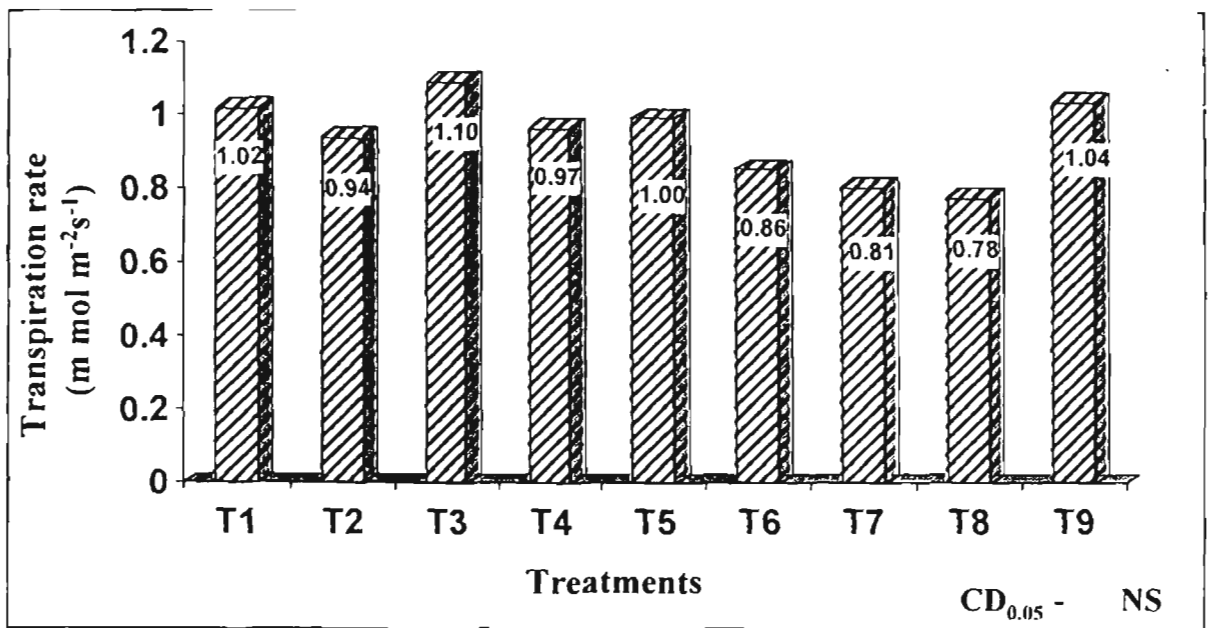


Fig. 7 Effect of different treatments on rate of Transpiration (m mol m<sup>-2</sup>s<sup>-1</sup>) in *Morus* under alley cropping

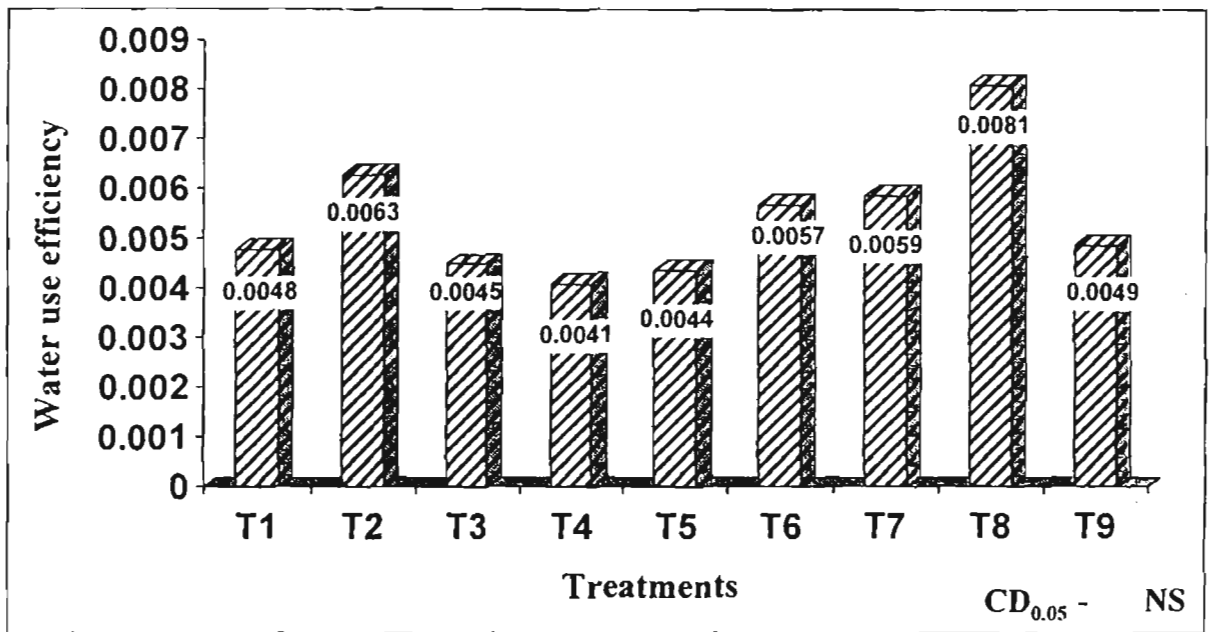


Fig. 8 Effect of different treatments on Water Use Efficiency of *Morus* under alley cropping

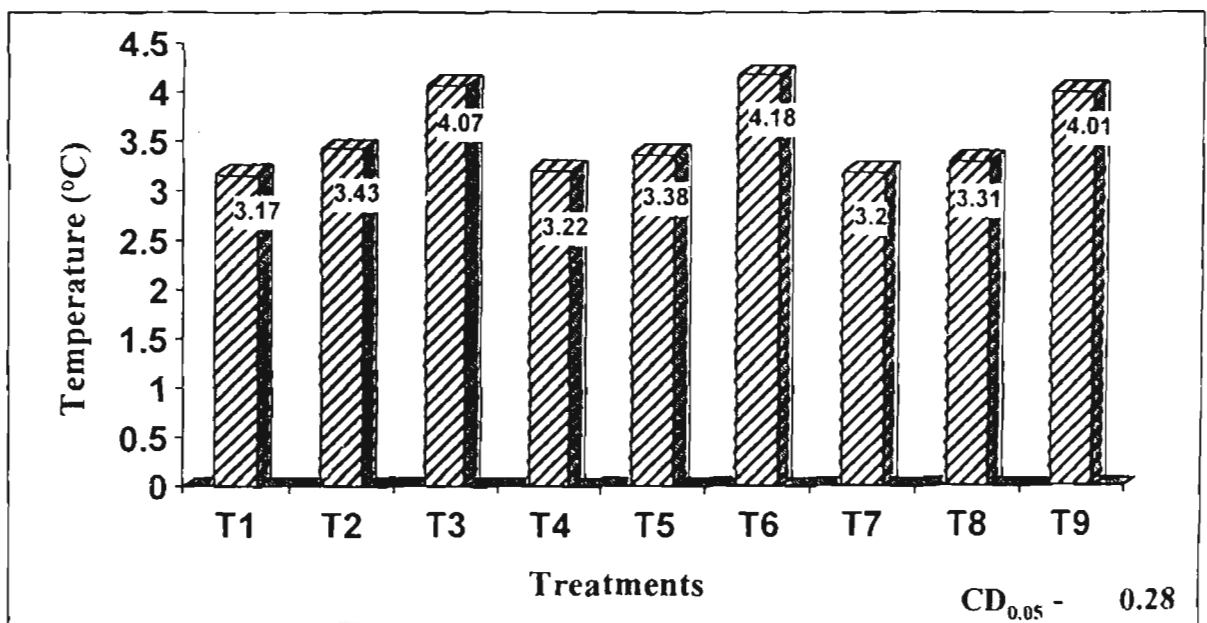


Fig. 9 Effect of different treatments on temperature (°C) of *Morus* under alley cropping

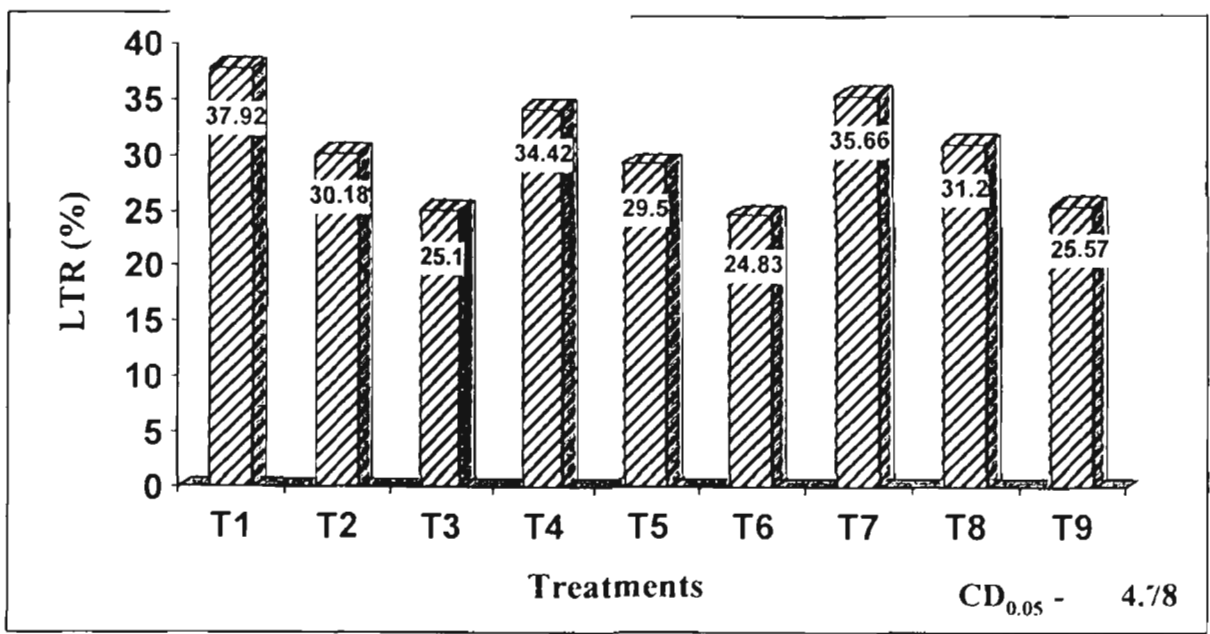


Fig. 10 Effect of different treatments on LTR (%) of *Morus* under alley cropping

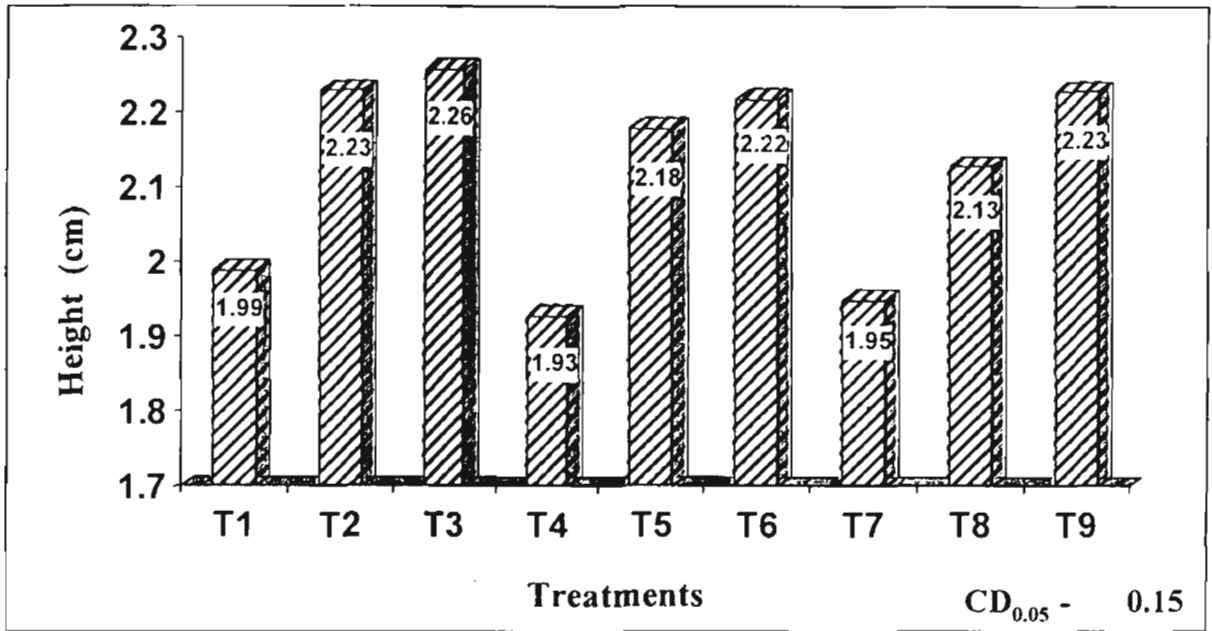


Fig. 11 Effect of different treatments on height (m) of *Leucaena* under alley cropping

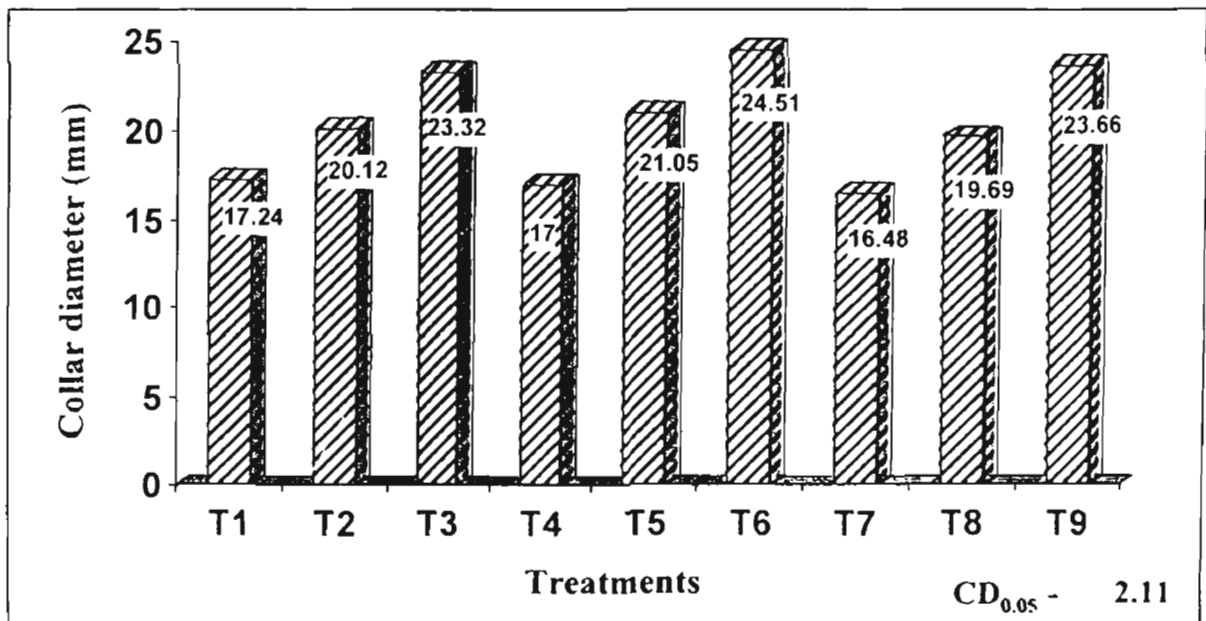


Fig. 12 Effect of different treatments on collar diameter (mm) of *Leucaena* under alley cropping

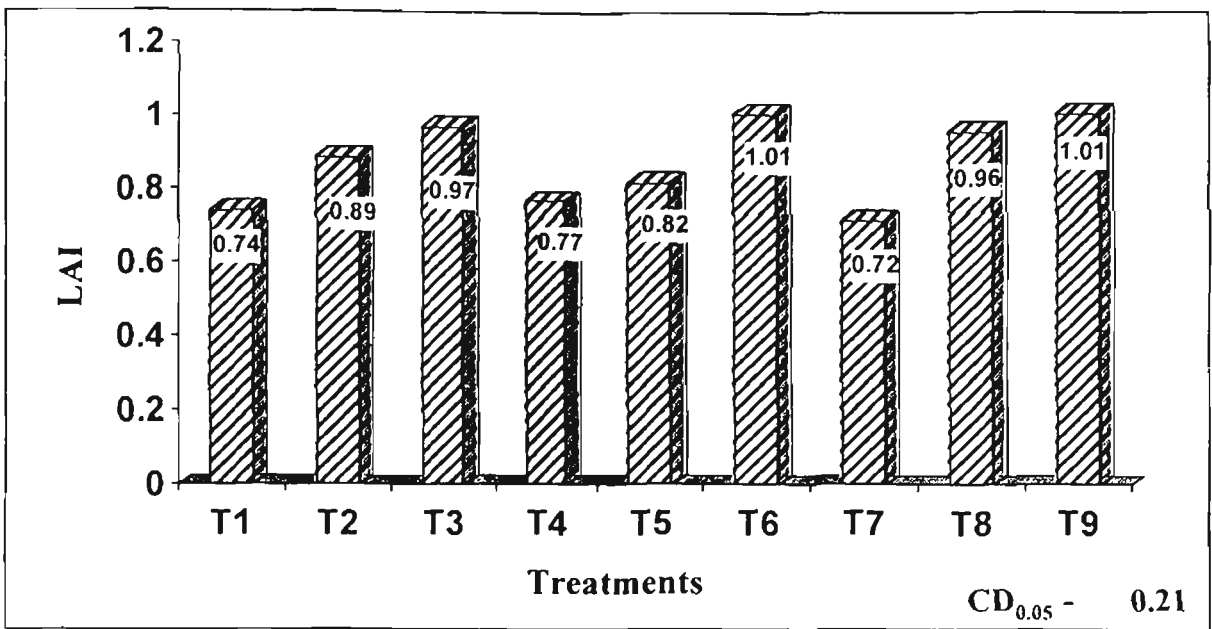


Fig. 13 Effect of different treatments on LAI of *Leucaena* under alley cropping

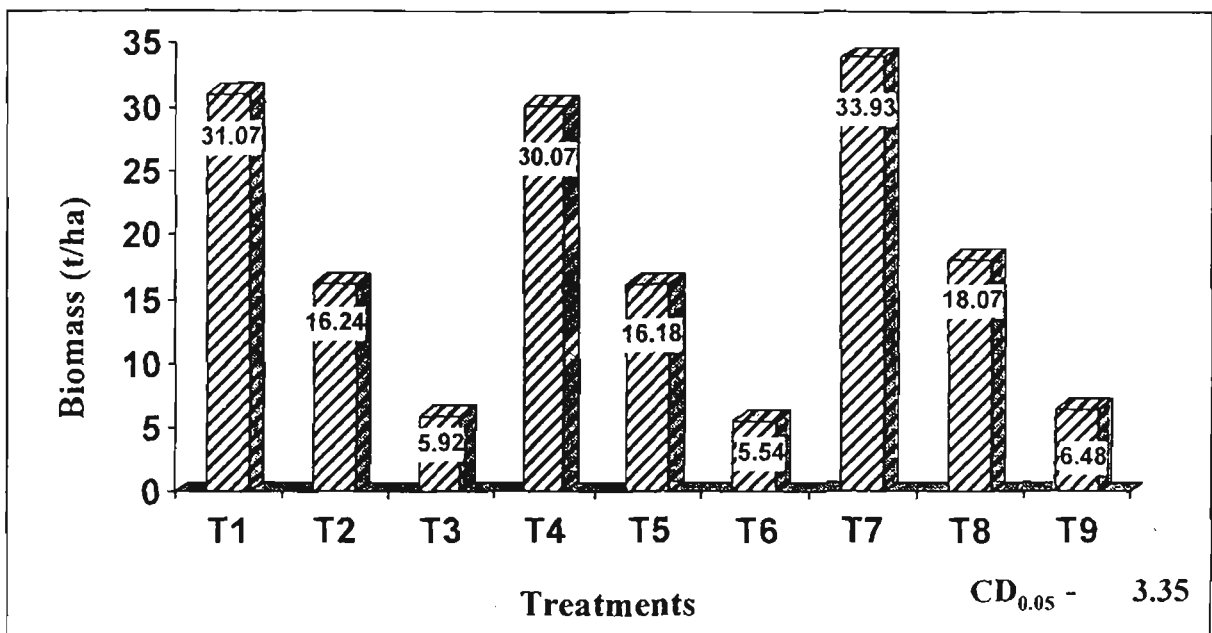


Fig. 14 Effect of different treatments on biomass (t/ha) of *Leucaena* under alley cropping

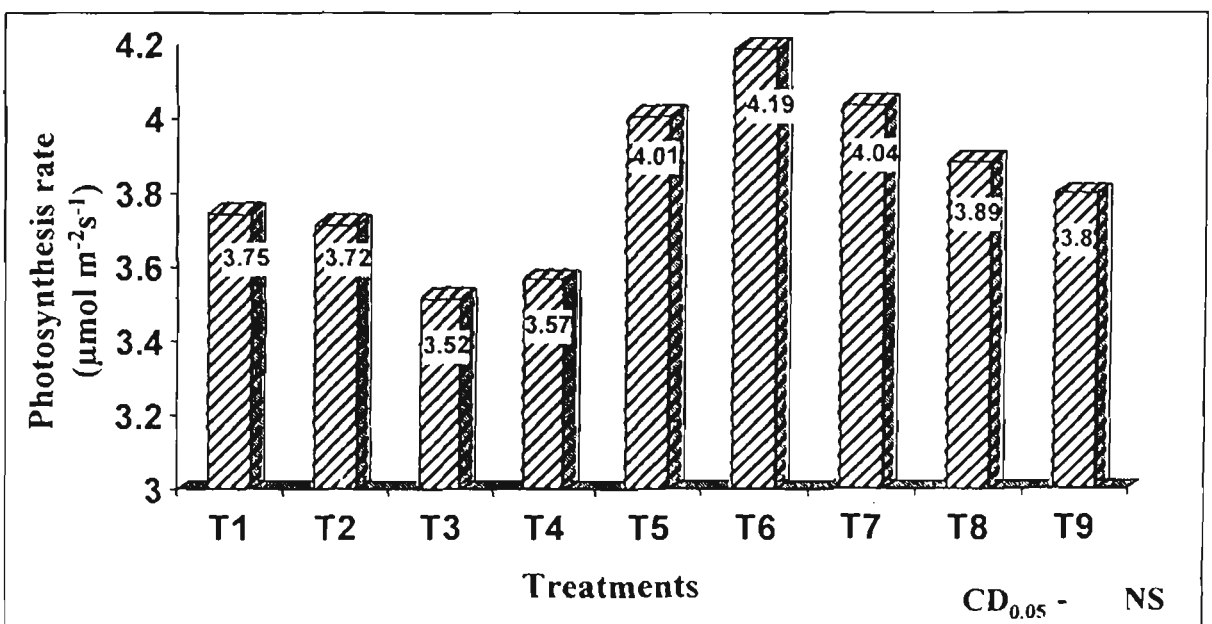


Fig. 15 Effect of different treatments on rate of Photosynthesis (µmol m<sup>-2</sup>s<sup>-1</sup>) of *Leucaena* under alley cropping

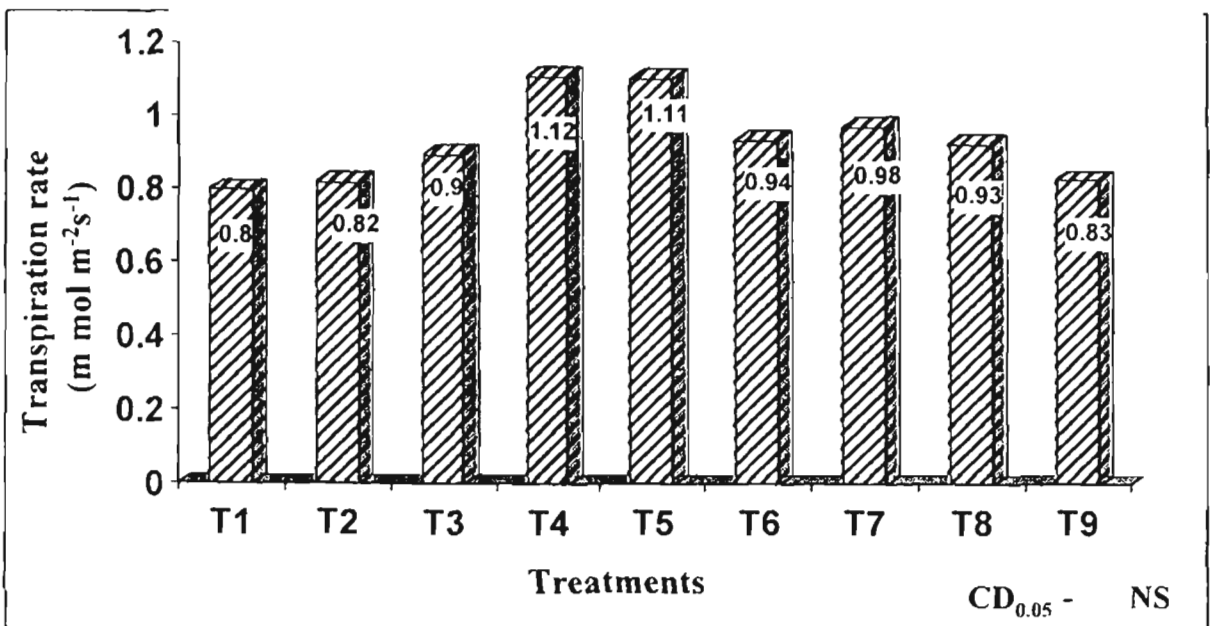


Fig. 16 Effect of different treatments on rate of Transpiration (m mol m<sup>-2</sup>s<sup>-1</sup>) in *Leucaena* under alley cropping

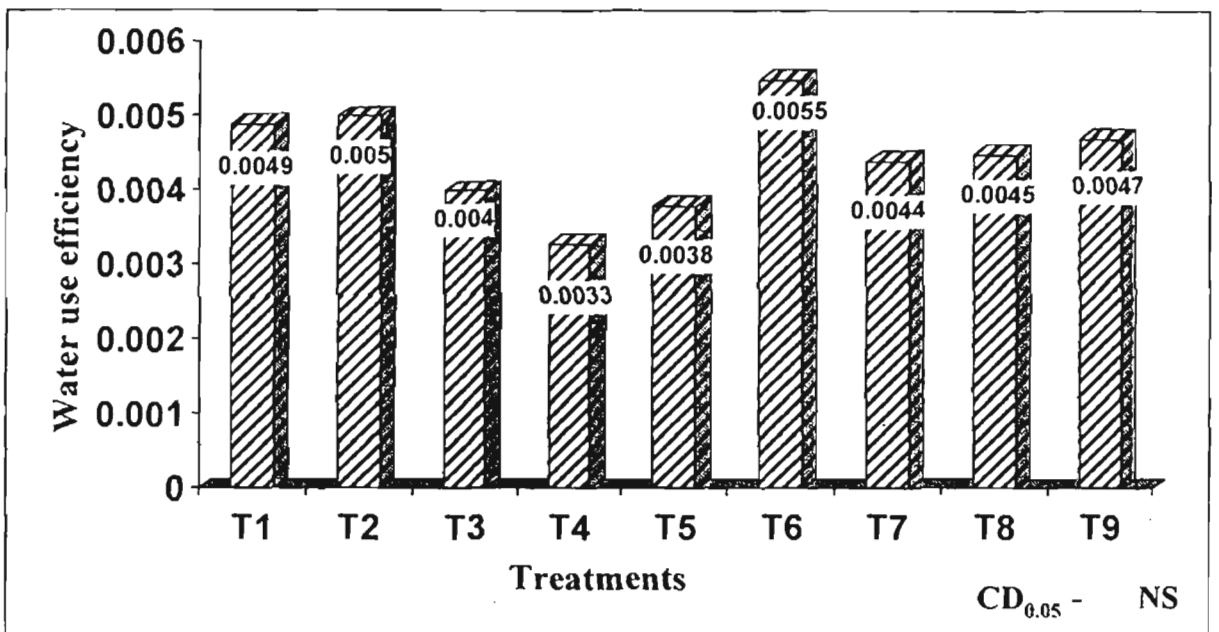


Fig. 17 Effect of different treatments on Water Use Efficiency of *Leucaena* under alley cropping

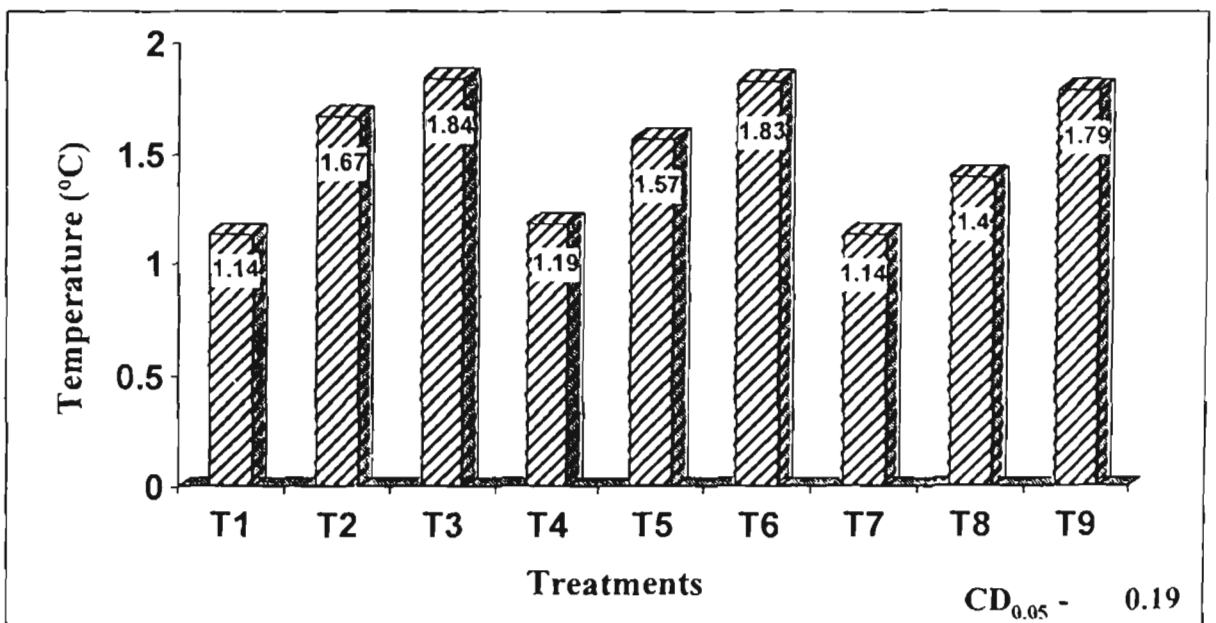
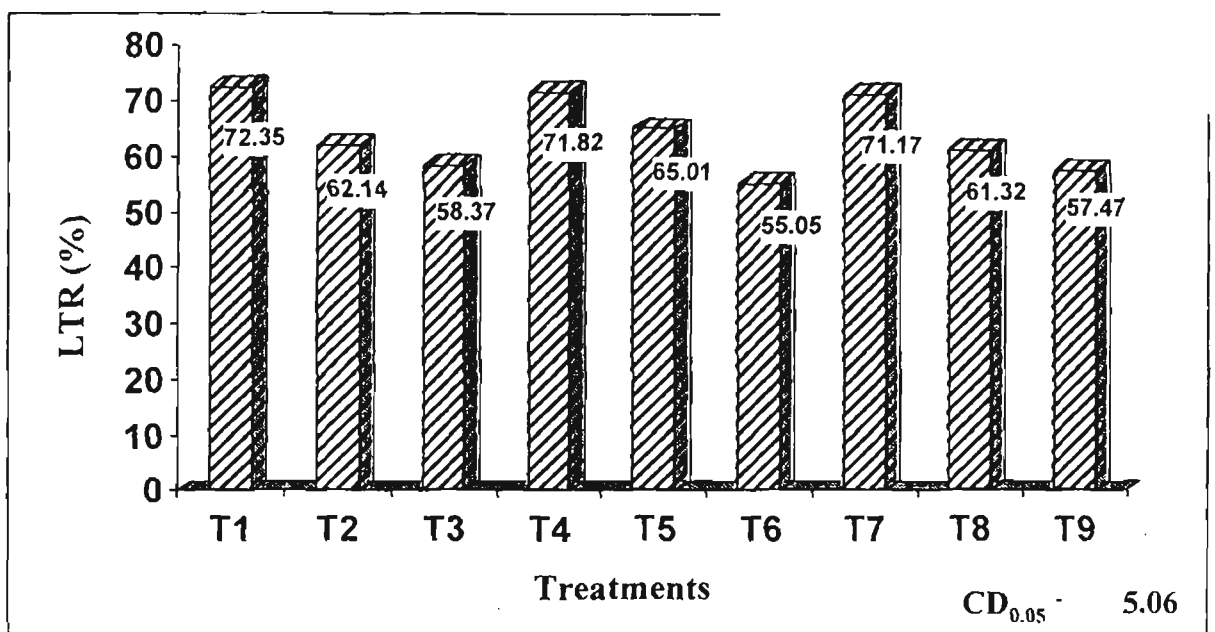


Fig. 18 Effect of different treatments on temperature (°C) of *Leucaena* under alley cropping



**Fig. 19. Effect of different treatments on Light Transmission Ratio (LTR %) of *Leucaena* under alley cropping**

A similar trend was observed in *Leucaena* hedgerows, where maximum (1.01) leaf area index was recorded in treatments T<sub>6</sub> and T<sub>9</sub> (1.50 m) at wider plant spacing within the hedgerows. The minimum (0.72) leaf area index was observed in treatment T<sub>7</sub> with plant spacing of 0.50 m (Fig. 13).

#### 4.3.4. Crown spread (m)

The crown spread of *Morus* was found to be significantly different in different treatments (Fig. 4). The maximum crown spread was 1.52 m in T<sub>9</sub> whereas, the minimum crown spread was 0.80 m in T<sub>2</sub> (Fig. 4). However the treatments with similar plant spacing within the hedgerows i.e., 1.50 m, 2.00 m and 2.50 m were at par with each other. *Leucaena* hedgerows grow in a vertical fashion, with less horizontal spread, so the data collection for this parameter was abandoned.

#### 4.3.5. Biomass (t/ha)

The data for biomass was recorded by measuring the fresh weight of foliage and branch wood per tree. Due to different tree spacing within the hedgerows, significant differences in biomass (t/ha) were obtained for *Morus* and *Leucaena* (Fig. 5 and 14). A maximum of 13.11 t ha<sup>-1</sup> of fresh biomass was recorded in treatment T<sub>1</sub> (1.50 m) while a minimum biomass of 8.08 t ha<sup>-1</sup> was recorded in T<sub>6</sub> (2.50 m) in *Morus* hedgerows (Fig. 5). Similarly, in *Leucaena* hedgerows a maximum (33.93 t ha<sup>-1</sup>) biomass was obtained at closer spacing in treatment T<sub>7</sub> (0.50 m) whereas the minimum (5.54 t ha<sup>-1</sup>) biomass was recorded at wider tree spacing within the *Leucaena* hedgerows in treatment T<sub>6</sub> with spacing of 1.50 m (Fig. 14).

#### 4.3.6. Photosynthetic rate ( $\mu\text{ mol m}^{-2}\text{s}^{-1}$ )

It was also intended to study the physiological status of the hedgerow tree species. The rate of photosynthesis in different treatments in both the hedgerow species was statistically non-significant (Fig. 6 and 15). This shows that the plant spacing within the hedgerows do not have any influence on the rate of photosynthesis.

#### 4.3.7. Transpiration rate ( $\text{m mol m}^{-2}\text{s}^{-1}$ )

The rate of transpiration was also found to be non-significant for all the treatments in case of *Morus* and *Leucaena* hedgerows (Fig. 7 and 16). As expected, plant spacing during the early phenological phases of any tree species do not influence loss of water from the tree canopy.

#### 4.3.8. Water use efficiency (WUE)

The data for water use efficiency of *Morus* and *Leucaena* was collected during the present study and is presented in figure 8 and 17, respectively. Despite differences in the values obtained for water use efficiency in different treatments, the results for this parameter were statistically non significant for both the species.

#### 4.3.9. Difference in above and below canopy air temperature ( $^{\circ}\text{C}$ )

The present study reveals that the difference in above and below canopy air temperature was significantly affected by different plant spacing within the hedgerows of both *Morus* and *Leucaena* (Fig. 9 and 18). In *Morus*, the maximum difference in above and below canopy air temperature was  $4.18^{\circ}\text{C}$ , recorded in treatment  $T_6$  (2.50 m), while the minimum difference was  $3.17^{\circ}\text{C}$  recorded in treatment  $T_1$  with plant spacing of 1.50 m (Fig. 9). In case of *Leucaena*, the difference in above and below canopy air temperature was less as compared to *Morus*. The maximum difference was  $1.84^{\circ}\text{C}$  observed in  $T_3$  (1.50 m), whereas the minimum difference was  $1.14^{\circ}\text{C}$  observed in treatments  $T_1$  and  $T_7$  (Fig. 18).

#### 4.3.10. Light transmission rate (LTR %)

The light transmission ratio varied significantly among various treatments both in *Morus* as well as in *Leucaena* (Fig. 10 and 19). The data recorded for LTR reveals that in *Morus* hedgerows, LTR was higher at closer spacing. The maximum (37.92%) LTR was recorded in  $T_1$  (1.50 m) while minimum (24.83%) LTR was observed in  $T_6$  with plant spacing of 2.50 m (Fig. 10). Similarly, in *Leucaena*, the maximum (72.35%) LTR was found in  $T_1$  (0.50 m) and the minimum (55.05%) LTR was recorded in  $T_6$  having spacing of 1.50 m (Fig. 19). This indicator indeed represents status of canopy architecture in general.

# **DISCUSSION**

## Chapter-5

# DISCUSSION

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The findings of the present investigation entitled “Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.” are discussed as under. Efforts were made during the present investigation to explore the possibility of successful integration of *O. basilicum* and *T. minuta*, important medicinal and aromatic plant species, as alley crops between the hedgerows of *Morus* and *Leucaena*. In addition, the aim of the present study, which was conducted for two consecutive years, was to understand the influence of three plant spacing within the hedgerows and the application of three different organic manures on the performance and production ability of alley cropped medicinal and aromatic plants. This information was essential to prepare suitable tree-crop combinations in order to achieve diversification and obtain the maximum benefit from the cultivable land. The interacting behaviour of intercropped components, which vary in size, structure and nature but growing together on the farmland and their response to the presence of hedgerows and applied doses of organic manures are discussed in the following pages.

- 5.1 Performance of medicinal and aromatic plants grown with and without hedgerows and organic manures
  - 5.1.1 Growth parameters
  - 5.1.2 Yield parameters
  - 5.1.3 Physiological attributes
  - 5.1.4 Root characteristics
- 5.2 Growth and physiological status of *Morus* and *Leucaena* hedgerows
- 5.1 Performance of medicinal and aromatic plants grown with and without hedgerows and organic manures**

The ecological interactions between trees and crops in alley cropping systems have been the subject of numerous experiments, wherever the layout of

such an experiment is physically possible. The above and below ground interactions define the resource sharing patterns between the integrating components and thus control compatibility of the components as well as decide and derive production processes. The inclusion of medicinal and aromatic crops as alley crops in the present study is basically attributed to two reasons, i) because of immense interest generated all over the world, especially in the South East Asian region over the rapid depletion of medicinal and aromatic plants owing to their increased demand and ruthless exploitation and ii) to achieve diversification by combining high value cash crops in place of conventional food crops, at least during one cropping season. The medicinal and aromatic crops when cultivated with woody perennials may experience competition for critical resources, so in the present study the use of organic manures was done; other reasons being increase in the demand for the organically grown herbal products and the quality of farm soil. Moreover in alley cropping systems, the competition for resources is bound to decrease yields, so the use of organic manures was two fold, one, to improve crop yields and second to ease the competition from tree hedgerows. Thus, different competition situations were created viz., three different plant spacing within the *Morus* and *Leucaena* hedgerows, three different types of organic manures, two different medicinal and aromatic crops and sole crop. The results indicate that the presence of hedgerows and the application of organic manures did influence the growth, herb, oil yield and physiological behaviour and root parameters of both the medicinal and aromatic herbs. The use of organic manures during the present study was found to improve performance and production ability of both the herb species even in the presence of hedgerows. This is important and desirable. The results are discussed together for *Morus* and *Leucaena* hedgerows.

### 5.1.1 Growth parameters

*Morus* and *Leucaena* with different plant spacing within the hedgerows affected various growth parameters like plant height, number of flower heads per plant, leaf area index of *O. basilicum* and *T. minuta* (Tables 4-7 and 21-24). The presence of *Morus* hedgerows with plant spacing of 1.50, 2.00 and 2.50 m and

*Leucaena* having within hedgerows plant spacing of 0.50, 0.75 and 1.50 m were found to influence growth parameters differentially, where growth of both the herb species was influenced adversely only at closer plant spacing within the hedgerows as well as closer distance to the hedgerows. The wider plant spacing within the hedgerows and greater distances from the hedgerows did not have any impact on growth parameters. A marked reduction was observed in the growth parameters at closer plant spacing of 1.50 and 0.50 in *Morus* and *Leucaena* hedgerows, respectively. At wider spacing of 2.00m and 2.50 m in *Morus* and 0.75 and 1.50 m in *Leucaena*, there was comparatively less reduction in the growth parameters. The effect of distance from the hedgerows was similar in *O. basilicum* and *T. minuta*. There was a marked reduction in the growth of crops growing very close (0-1 m) from the hedgerows as compared to the crops growing at a greater distance (1-2 m and 2-3 m) from *Morus* and *Leucaena* hedgerows. Reduction in plant height, number of flower heads per plant, leaf area index of *O. basilicum* and *T. minuta* was observed, while growing in association with *Morus* and *Leucaena* hedgerows. This probably indicates intense competition for critical resources like water, nutrients, photosynthetically active radiation (PAR) etc, especially at TCI (Tree-crop interface). The hedgerows being stronger and dominant component of the system, certainly has greater and easy access to the available resources. This deprives the associated crops of their share of resources, resulting in resource crunch at the tree crop interface. Possible reasons for this could be that closer plant to plant spacing resulted in more competition for above ground as well as below ground resources thereby causing reduction in growth parameters of herb species at closer spacing. The crop growing adjacent to the hedgerows would suffer from the shading caused by the hedgerows. It is true that the growing of hedgerows with medicinal and aromatic herbs paves the way for diversification but nevertheless creates complex biological interactions, which may not be desirable. The results of the present study also hint at the stronger competition between the system components but only at closer plant spacing and distance to the hedgerows. During the present investigation it was found that *Morus* hedgerows with plant spacing of 1.50 m and *Leucaena* hedgerows with 0.5 and 0.75 m within plant spacing were not

suitable for successful cultivation of *O. basilicum* and *T. minuta* under rainfed conditions. Adverse effects of the competition have also been reported earlier by Gillespie *et al.* (2000), Puri and Sharma (2002), Thakur and Dutt (2004), Thakur and Kumar (2006), Thakur *et al.*, (2007).

As mentioned earlier that the application of organic manures namely vermicompost, enriched manure and farm yard manure was found very useful because the applied doses substantially bettered growth and performance of both *O. basilicum* and *T. minuta* even when growing as intercrop with hedgerows of *Morus* and *Leucaena*. The impact of organic manures was some what different in the two aromatic herbs under study. In *O. basilicum* significantly higher values for growth parameters were observed in all the treatments receiving organic manures as compared to the sole crop (control), however, in *T. minuta*, the response was not so prominent. The growth was almost at par with the sole crop. This behaviour in *T. minuta* where lesser response to the applied organic manure was observed, remains unexplained. Out of the three organic manures applied, the effectiveness of enriched manure was more than vermicompost and FYM. The applied organic manures, probably improves growth of herb species by meeting the requirement for organic carbon and nitrogen. This is useful. The use of organic manures improved height, leaf area index etc., of herb species. The increase in LAI for example, helps plants to intercept more solar radiation, which helps in greater fixation of carbon dioxide. Comparatively higher rates of photosynthesis in plants provided with organic manures in comparison to control plants without manure seem to facilitate and maintain higher growth of plants when grown with the application of organic manures. Lower LAI results in lesser interception of photosynthetically active radiation thereby causing lower rate of photosynthesis. The lesser rates of photosynthesis in herbal plants beneath hedgerows supports above argument. The reduction in growth parameters of four medicinal and aromatic plants namely *O. sanctum*, *Spilanthus acmella*, *T. minuta* and *Withania somnifera* at closer spacing of popular has been recently reported by Thakur and Dutt (2004).

### 5.1.2 Yield parameters

Looking at the data collected for the economic yield of *O. basilicum* and *T. minuta*, it becomes clear that economic yields were almost similar to the results obtained for the yield of flower heads and shoot yield for both the crops grown under the *Morus* and *Leucaena* hedgerows. As discussed earlier, the closer tree spacing in *Morus* and *Leucaena* viz., 1.50 m and 0.50 m adversely affected the yield parameters as compared to the other two spacing of which the widest spacing of 2.50 m and 1.50 m performed the best in *Morus* and *Leucaena*, respectively. The reason for this could be the availability of adequate resources for utilization due to better root growth of medicinal herbs on account of the application of organic manures. Tree crop interface area was more in closer plant spacing in the hedgerows. Closer tree spacing means more number of trees resulting in more competition for light, moisture and nutrients. The adverse effects of hedgerows on production, especially at closer plant spacing (dense canopies) suggest that above ground shading was also an important factor, limiting crop production.

The effect of distance on the yield parameters was significant and absolutely clear. Irrespective of the tree spacing within *Morus* and *Leucaena* hedgerows, the yield parameters like fresh weight of inflorescence, fresh weight of shoot and herb and oil yield of *O. basilicum* and *T. minuta* were suppressed to a greater extent at a distance closer to the hedgerows. The maximum reduction was observed at 0-1 m distance ( $D_1$ ) as compared to 1-2 m ( $D_2$ ) and 2-3 m ( $D_3$ ) distance from the hedgerows. Almost similar effect of distance was observed in the alley crops, irrespective of *Morus* and *Leucaena* hedgerows. Thus, the adverse effect of hedgerows immediately beneath canopies reflects the cumulative effect of shading and below ground competition. It was very interesting to note that the use of organic manures namely vermicompost, enriched manure and FYM reversed the inhibiting nature of the hedgerows to a great extent, where herb and oil yield as well as production efficiency of herb species was significantly higher than the control without organic manures.

The effectiveness of fertilizer was different in *O. basilicum* and *T. minuta*. *O. basilicum* grown along with *Morus* and *Leucaena* hedgerows registered higher yields when incorporated with organic manures as compared to the sole crop without manures. This implies that the addition of organic manures helped the crop to overcome the competition from the hedgerows to some extent. On the other hand, in case of *T. minuta*, even after the addition of organic manures, the yields were low as compared to the sole crop, indicating higher sensitivity of *T. minuta* to hedgerows.

The application of different organic manures have resulted in higher yields in *O. basilicum* and *T. minuta*, particularly at D<sub>2</sub> (1-2 m) and D<sub>3</sub> (2-3 m) as compared to control. An increase in yield of *O. basilicum* and *T. minuta* due to the application of organic manures has also been reported by Haripriya and Sriramchandrasekhran (2002), Singh *et. al* (2003), Blank *et. al.* (2003), Senthilkumar *et. al.* (2003). Out of the three organic manures used during the present study, comparatively higher yields were obtained in treatments receiving enriched manure in both the aromatic herbs. This is attributed to the higher nutrient content in the enriched manure as compared to Vermicompost and FYM. Similar results have been reported by Okon (2003).

The data for the estimated oil yield was different for all the treatments, depending upon the economic yield obtained. However, the application of organic manures did not cause any difference in the per cent oil content neither in *O. basilicum* nor in *T. minuta*. The possible reason may be the low nutrient present in organic manures in comparison to inorganic fertilizers to initiate changes at the metabolic levels in order to result significant increase in the oil content of the alley cropped medicinal and aromatic plants. Most of the literature, where an increase in oil per cent is reported, the use of inorganic fertilizers was made or in some cases combination of both organic and inorganic sources (Singh and Singh, 2002). The results in the present study are in agreement with the findings of Singh *et al.* (2004).

Comparatively higher yields and production efficiency were recorded in the year 2006 as compared to the year 2005. The possible reasons for this could

be the improvement in the soil quality as a result of manure application during the previous year, the second reason could be the higher number of rainy days during the critical growth period of the alley cropped medicinal and aromatic crops. Comparatively more rainfall was recorded in the year 2006, than in 2005. In addition, there was an even distribution of rainfall during the experimental year 2006.

The integration of trees with field crops results into a number of above and below ground biological interactions, where woody and non-woody components of the system compete with each other for the critical resources. Numerous previous reports describe positive and/or negative impacts of the tree canopies on the performance of associated crops (Kang *et al.*, 1981; Rao *et al.*, 1998; Chauhan, 2000; Thakur and Dutt, 2003, Thakur *et al.*, 2007). In this study the presence of hedgerows of *Morus* and *Leucaena* at different spacing caused reduction in total herb yield (yield of economic organs viz. leaf and inflorescence) and production efficiency during both the consecutive experimental years only at closer within hedgerows spacing and distances. The herb and oil yield was greater in intercrops grown with organic manures even in the presence of tree-crop competition. The role of organic manures appears to minimize intra as well as inter specific competition for critical resources, thus favoring better growth and production of herb species. The impact of tree spacing on medicinal and aromatic herbs was more pronounced up to 1 m distance from the hedgerows than at 1-2 or 2-3 m from the hedgerows. Closer within hedgerow spacing reduced total herb yield and production efficiency to a greater extent relative to wider row spacing. Greater adverse effects of hedgerow trees at closer spacing on growth and production behaviour of two medicinal and aromatic herbs during both the experimental years show that shade is the key factor, limiting productivity of crops in agroforestry systems. The radiation availability was lower in all the agroforestry treatments relative to sole crops during the present investigation. Besides the competition for solar radiation, the competition for below ground critical resources, especially up to 1 m distance from the hedgerows is also important under tree crop combination. The experimental design of this study was inadequate to segregate effects of below ground and

above ground competition, the former is not likely to be as severe as the latter because of extensive damage of tree roots in the top 30 cm soil profile due to conventional ploughing, where major portion of crop roots mainly concentrate. Tree-crop competition for resources is often believed to be responsible for decline in crop yields at the hedgerow-crop interface. This has been commonly observed in many alley cropping trials (Singh *et al.*, 1990; Thakur and Dutt, 2003, Thakur and Kumar, 2006). However the possibility of latter being remote because traditional ploughing, two times every year right up to the tree trunk before growing medicinal and aromatic herbs may damage tree roots in the crop root zone (0-25 cm). The medicinal herbs during the present investigation spread their entire roots in the top soil between 0-25 cm. The addition of organic manures to the herb species, however, minimized tree-crop competition, which helped plants to maintain significantly higher production in comparison to control growing without organic manures. The findings of this investigation are also in agreement with the findings of researchers (Singh *et al.*, 1990; Chauhan *et al.*, 1997) who have reported greater production of dry matter in the open field than in intercropped field. Many previous reports describe dominance of tree components under agroforestry systems (Lawson and Kang, 1990; Ong *et al.*, 1991; Williams and Gordon, 1995; Jose *et al.*, 2000; Kohli and Saini, 2003; Thakur and Dutt, 2003; Rao *et al.*, 2004). The above and below ground interactions reflect the resource sharing pattern of the associated crops and trees and thus, control productivity. The findings of the present investigation suggest that high herb and oil yields farther away from the tree trunk relative to that immediately beneath canopies as well as with the use of organic manures are the result of adequate availability of photosynthetically active radiation beneath tree canopies. This is further supported by the data obtained for photosynthesis during the present investigation, where significantly greater photosynthesis was obtained for medicinal and aromatic plants growing away from the hedgerows with organic manures. The possibility that herbal crops may benefit from microclimate improvement due to the presence of hedgerow canopies was not apparent in the present study, except that beneath canopy temperature declined under the hedgerows. Out of the two medicinal and aromatic crops, *O. basilicum* performed

comparatively better than *T. minuta*, especially under agroforestry systems when provided with organic manures. This suggests that this herb species is better equipped than *T. minuta* to efficiently utilize the available resources, probably by avoiding and/or tolerating competition from the hedgerows. This is important and desirable *per se*, since crops with greater intrinsic abilities to undergo quick adjustments always performs better.

### 5.1.3 Physiological attributes

Physiological processes like photosynthesis, respiration and transpiration are important determinants of plant productivity. Most of these processes are dependent on the intercepted solar radiation, which plays an important role in the plant productivity. It is, therefore not surprising that most management decisions e.g. sowing date, planting density, in the shape and extent of canopies are made keeping in view the interception of solar radiation. The productivity of a plant system can be defined in terms of the efficiencies with which the solar resource is captured and converted into biomass (Monteith, 1972; Azam Ali *et al.*, 1994). Similar is the case with agroforestry systems. In the present study, the different plant spacing within *Morus* and *Leucaena* hedgerows and the addition of organic manures have differentially affected the important physiological processes viz., photosynthesis, transpiration and water use efficiency of *O. basilicum* and *T. minuta* to some extent (Tables 13-15, 30-33).

During the present investigation, no marked difference in the photosynthetic rates due to different plant spacing within the hedgerows as well as distances from the hedgerows were evident, although photosynthetic rates in plants, especially of *O. basilicum*, grown with organic manures maintained higher rates in comparison to control without manures. Use of organic manures seemed to improve photosynthetic efficiency.

Transpiration is another significant physiological process. A difference in the transpiration behaviour was observed in *O. basilicum* and *T. minuta*. In *O. basilicum*, the rate of transpiration was different in different treatments, but in case of *T. minuta*, the rate of transpiration was not affected by the presence of

hedgerows and organic manures. Similarly, a very little change in water use efficiency was observed for different treatments, but the values were comparatively higher in plants provided with organic manures. This indicates that the use of organic manures also improves water use efficiency. This is a welcome step toward the improved production potential.

It is true that performance and aggressiveness of the crop components in any agroforestry system depend on physiological status and efficient use of resources. Thus, any alteration in the normal functioning of the physiological processes, especially anabolic will have direct bearing on the productivity of the crops. Shade caused by the hedgerow canopies seems to play a significant role. Photosynthesis is the most important physiological process, which decides biological yield of the crops. During the present investigation, photosynthesis was greatest in the plots provided with organic manures.

#### 5.1.4 Root characteristics

The root parameters viz., number of roots, root dry weight, specific root length and root growth potential was significantly affected by the presence of *Morus* and *Leucaena* hedgerows and the organic manures applied to *O. basilicum* and *T. minuta* (Tables 17-20, 34-37). The number of roots per plant was found to be less near the hedgerows, immediately beneath canopies. It gives an idea about the below ground competition existing between the hedgerows and herb species. The use of organic manures, however, was found to minimize competition, thus producing higher number of better roots in intercropped herbs in comparison to control without manures. It was observed that in *O. basilicum*, growing along with *Morus* and *Leucaena* hedgerows, the treatments receiving organic manures had higher number of roots as compared to the control. A similar observation was made for *T. minuta* also. The effect of distance was also clear in case of root dry weight, irrespective of *Morus* and *Leucaena* hedgerows. The plants growing nearer to the tree trunk had less root dry weight in comparison to plants growing away from the hedgerows. The root growth potential is an indication of the growing ability of roots. The negative values obtained for both *O. basilicum* and *T. minuta* growing along with the hedgerows of *Morus* and *Leucaena* show the

negative effect of the hedgerows on the associated crop growing adjacent to hedgerows. As the distance from the hedgerows increased from D<sub>1</sub> (0-1 m) to D<sub>3</sub> (2-3 m), the root growth potential increased.

The positive effect of organic manures on maintaining good root networking was evident during the present study. The critical analysis of values obtained for all the root characters, it seems that slightly higher values for root growth potential and number of roots were observed in treatments receiving enriched manure as compared to FYM and vermicompost. Similarly, higher values are obtained for wider plant spacing in *Morus* (2.50 m) and *Leucaena* (1.50 m) as compared to narrower spacing.

Overall, it can be concluded that the roots of plants growing nearer to the hedgerows appear to face competition from the hedgerows, however, the level of competition is reduced with the use of organic manures. Similar findings have been reported by Newaj *et al.* (2001), Thakur and Singh (2002), Thakur and Kumar (2006).

## 5.2 Growth and physiological status of hedgerows

Growth parameters of *Morus* and *Leucaena* hedgerows like height, collar diameter, LAI, crown spread were studied during the present investigations. Significant differences were observed for growth parameters of different treatments. Hedgerows at different plant spacing were found to be different with regards to growth characters. Higher collar diameter, height, leaf area index was observed in treatments at wider plant spacing. The difference in growth parameters of the hedgerows can be attributed to the differences in the plant spacing within the hedgerow and not possibly due to the effect of alley crops. However, the growth parameters of the hedgerows having the same plant spacing were mostly at par with each other. So, at this stage of establishment, the trees in the hedgerows do not seem to experience neither inter specific nor intra specific competition for available resources.

The physiological parameters like photosynthesis, transpiration and water use efficiency were non-significant for *Morus* and *Leucaena* hedgerows at different plant spacing within the hedgerows. However, there was a significant difference in above and below ground canopy temperature in *Morus* and *Leucaena* hedgerows. Significant differences in the light transmission ratio (LTR) were also observed. It may be due to difference in the canopy thickness and difference in the crown spread.

Highest biomass (t/ha) was obtained at closer spacing compared to wider hedgerow spacing both in *Morus* and *Leucaena* as the number of trees per hectare increase drastically as the spacing between the tree decreases. The closer spacing accommodating higher number of plants in the hedgerows contributed towards more production of foliage and branchwood biomass in both *Morus* and *Leucaena*. So the growing of hedgerows with medicinal and aromatic herbs provides extra benefit in the form of foliage and branch wood biomass from the system for longer duration.

# **SUMMARY AND CONCLUSIONS**

## Chapter-6

# SUMMARY AND CONCLUSIONS

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The present investigation entitled “Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.” was conducted at the experimental field of Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.) during the year 2005 and 2006.

The present study, which was conducted for two consecutive years, aimed at exploring the possibilities of growing medicinal and aromatic herbs as intercrops with hedgerows under alley cropping system for diversification and to understand the influence of three plant spacing within the hedgerows and the application of three different organic manures on the performance and production ability. The experiment was laid out in Factorial Randomized Block Design with three replications using two species i.e. *Ocimum basilicum* and *Tagetes minuta* grown in association with different plant spacing of *Morus* and *Leucaena* hedges having separate control plots without hedgerows and without the application of manures. The findings of the present study are summarized as under:

- 6.1 Performance of medicinal and aromatic plants grown with and without hedgerows and organic manures
    - 6.1.1 Growth parameters
    - 6.1.2 Yield parameters
    - 6.1.3 Physiological parameters
    - 6.1.4 Root parameters
  - 6.2 Growth and physiological status of hedgerows
- 
- 6.1 Performance of medicinal and aromatic plants grown with and without hedgerows and organic manures**
    - 6.1.1 Growth parameters**

The results obtained for various growth parameters of the alley cropped medicinal and aromatic plants indicate that different tree spacing of *Morus* and

*Leucaena* significantly affected the various growth parameters. The growth parameters like plant height, number of inflorescence/flower heads per plant, inflorescence length and leaf area index were found to be higher at wider plant spacing within hedgerows. Out of the three plant spacing studied, the adverse effect of *Morus* and *Leucaena* hedgerows was more at closer spacing of 1.50 m and 0.5 m, respectively. There was comparatively lesser impact of hedgerows on medicinal and aromatic crops at wider plant spacing. The effect of distance of the herb from the hedgerow was more pronounced. Irrespective of the hedgerow species, the growth of *O. basilicum* and *T. minuta* was markedly reduced at a distance of 0-1 m from the tree line, while little or no adverse effect was visible upto 3 m distance from the hedgerows. The addition of organic manures to the alley crop resulted in higher growth, especially in *O. basilicum*. Manure treated plants registered more growth compared to the control. However, the effect of organic manures was more visible at distances 1-2 and 2-3 m from the hedgerows. The use of all the three organic manures namely vermicompost, enriched manure and FYM benefited both the herb species, although enriched manure was found more effective.

### 6.1.2 Yield parameters

All the yield related parameters namely fresh weight of inflorescence/flower heads, fresh weight of shoot and the economic/herb yield were significantly influenced by the plant spacing within *Morus* and *Leucaena* hedgerows as well as by the addition of organic manures to the alley crops. Like growth parameters, the yield of the medicinal and aromatic crops was significantly higher at wider spacing of 2.50 m and 1.50 m in *Morus* and *Leucaena*. There was a decrease in yield at closer spacing of 1.50 and 2.00 m in *Morus* and 0.50 and 0.75 m in *Leucaena*. The effect of organic manures was significant in the present study. The applied organic manures considerably improved the yields including oil yield of both the herb species, higher yields were obtained in treatments receiving organic manures over control. Enriched manure was found to be most effective as compared to vermicompost and FYM. The negative impact of the hedgerows was visible at closer distance to the

hedgerows in the present study. The crop growing upto 1 m distance from the hedgerow was severely affected by the hedgerows. However, as the distance of the crop increased more than 1 m, there was improvement in the yield. Higher yields were obtained at D<sub>2</sub> (1-2 m) and D<sub>3</sub> (2-3 m) as compared to the control. The application of organic manures helped plants of both the herb species to maintain significantly higher yields than the plants without manures even in the presence of hedgerows.

### 6.1.3 Physiological attributes

Physiological attributes like photosynthesis, transpiration and water use efficiency of the herbs, *O. basilicum* and *T. minuta* showed variation in different treatments. However, the differences were mostly non-significant, statistically. Moreover, no specific trend was observed in the data recorded for the physiological attributes. The use of organic manures, however improved the rate of photosynthesis in comparison to plants not provided with manures.

### 6.1.4 Root characteristics

The results obtained for the root characteristics were significantly different in different treatments. Root characters like number of roots per plant, root dry weight, specific root length and root growth potential, which give an insight to the below ground behaviour of the crop were significantly affected due to the presence of hedgerows and organic manures. The adverse effect of hedgerows on root characteristics was also observed, especially at closer distances and closer plant spacing. The effect of distance was more severe as compared to the spacing of plants within the hedgerows. The addition of organic manures to the crops resulted in higher values for root characteristics, especially at 1-2 and 2-3 m away from the hedgerows. Use of organic manures improved the root characteristics of intercropped herb species.

## 6.2 Growth and physical status of hedgerows

The growth parameters of hedgerows like height, collar diameter and leaf area index were studied for *Morus* and *Leucaena* hedgerows. Out of the three plant spacing, higher growth was registered at wider plant spacing. In *Morus*,

higher growth parameters were observed at a spacing of 2.50 m, followed by 2.0 m, whereas lowest growth was observed at a narrow spacing of 1.5 m. Similarly, the wider plant spacing in *Leucaena* viz., 1.50 m had higher growth as compared to 0.75 and 0.50 m. The physiological characteristics like photosynthesis, transpiration, water use efficiency remained mostly unaffected. However, significant difference in above and below canopy temperature and light transmission ratio were observed. Higher difference in above and below canopy temperature was observed in *Morus* at wider plant spacing as compared to *Leucaena*. Light transmission ratio was higher at narrow plant spacing in the hedgerows, whereas the hedgerows at wider plant spacing utilized the light more efficiently resulting in lower values of LTR.

## CONCLUSIONS

The findings of the present investigation revealed that *O. basilicum* and *T. minuta* can be grown successfully as intercrops under *Morus* and *Leucaena* hedgerows. The plant spacing of 2.00 m and 2.50 m in case of *Morus* and 1.50 m in *Leucaena* did not influence the growth, yield and root parameters of the alley crops at 2 m and 3 m distance although some adverse effect was evident near the hedgerows. Thus, closer spacing and distance were not found suitable for the cultivation of these herbal crops along with the hedgerows. The use of three organic manures greatly benefited plants and helped to minimize below ground competition for resources. The usefulness of the applied organic manures was observed during the present study, which was in the order of enriched manure > vermicompost > FYM. The use of organic manures improved growth, total herb and oil yield of both the herb species over control without manures even in the presence of hedgerows. Based on the findings of the present investigation it can be concluded that the growth and production ability of *O. basilicum* and *T. minuta*, important medicinal and aromatic plants, can be improved substantially by the use of organic manures even when grown as intercrops with hedgerows of *Morus* and *Leucaena* under agroforestry systems. The standing hedgerow biomass ensures additional benefit from the system (medicinal herbs + hedgerows).

# REFERENCES

## Chapter-7

# REFERENCES

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# **ABSTRACT**

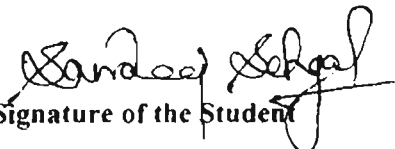
**Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP)**  
**Department of Silviculture & Agroforestry**

**Title of Thesis** : Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L.  
**Name of the Student** : Sandeep Sehgal  
**Admission Number** : F-2003-9-D  
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**Major Field** : Agroforestry  
**Minor Field(s)** : i) Minor Forest Products  
ii) Soil Science and Water Management  
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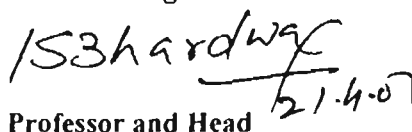
**ABSTRACT**

The present investigation, "Effect of tree hedgerows and manures on growth and production behaviour of *Ocimum basilicum* L. and *Tagetes minuta* L." was conducted for two consecutive years and completed at the experimental field of Department of Silviculture and Agroforestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni - Solan (H.P.) during the years 2005 and 2006. The study was aimed to explore the possibilities of successfully cultivating medicinal and aromatic herbs namely, *Ocimum basilicum* and *Tagetes minuta* under alley cropping. The impact of hedgerows of *Morus* with three plant spacing of 1.50 m, 2.00 m and 2.50 m and *Leucaena* hedgerows with a plant spacing of 0.50 m, 0.75 m and 1.50 m ; three organic manures viz., FYM, vermicompost and enriched manure on the performance and production ability of alley cropped medicinal and aromatic plants has been studied. The findings indicate that the effect of different plant spacing within the hedgerows, distances from the hedgerows and application of organic manures on growth, yield, physiological and root characteristics of both the herb species was significant. The growth parameters namely plant height, number of inflorescence/flower heads, leaf area index were negatively influenced at closer plant spacing. At wider spacing there was no or little impact on growth parameters. A similar effect was observed for the yield parameters like yield of inflorescence/flower heads, shoot yield and yield of economic parts (herb yield). The closer tree spacing in *Morus* and *Leucaena* viz., 1.50 m and 0.50 m adversely affected the yield as compared to other two spacing. The distance of the crop from the *Morus* and *Leucaena* hedgerows also affected the growth and yield of the intercrops. Irrespective of the tree spacing, the growth and yield of the associated herbs were suppressed to a greater extent at a distance closer to the hedgerows (0-1 m). However, the yield increased with the increase in distance from the hedgerows (1-2 and 2-3 m), which was significantly higher than the control (without hedgerows and without manures). Out of the three organic manures, comparatively higher yields including oil yield were obtained in treatments receiving enriched manure than vermicompost and FYM. The physiological parameters like photosynthesis, transpiration and water use efficiency were not affected much due to different plant spacing within the hedgerows and organic manures. The findings of the present investigation indicated that medicinal and aromatic plants can be grown successfully as intercrops between the *Morus* and *Leucaena* hedgerows. Out of the three different spacing and distances, only closer plant spacing and distances were not found suitable for successful cultivation of *O. basilicum* and *T. minuta*, however wider plant spacing within the hedgerows may be adopted for satisfactory cultivation of herb species. The important findings were that the use of manures maintained significantly higher production efficiency even when grown in association with hedgerows of *Morus* and *Leucaena*. This is important as well as desirable.

  
Signature of Major Advisor

  
Signature of the Student

Countersigned

  
21.4.07

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# APPENDIX

**Appendix -I**

**Effect of tree spacing within the *Morus alba* and *Leucaena leucocephala* hedgerows and organic manures on *Ocimum basilicum* and *Tagetes minuta*.**

Sources of Variation	Degree of freedom	Plant height											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	43.83	40.02	38.03	210.31	126.47	135.79	40.68	44.02	33.53	70.56	320.24	158.00
Distance	2	4334.80	4946.00	4631.80	11695.00	7878.50	9673.50	4390.30	5535.90	4849.30	5890.30	5967.00	5833.80
Replication	2	4.10	7.51	0.13	233.85	139.41	176.97	114.17	37.88	69.42	333.60	194.69	229.41
T × D	18	59.45	69.62	58.37	295.51	173.61	190.06	66.43	89.18	70.45	108.40	136.18	92.86

Sources of Variation	Degree of freedom	Number of inflorescence per plant											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	692.30	677.04	651.00	1119.30	788.27	899.82	222.12	182.46	166.61	730.90	1503.20	901.62
Distance	2	9096.40	11419.00	10212.00	14308.00	17799.00	16005.00	13605.00	7106.20	10094.00	17466.00	14481.00	15927.00
Replication	2	222.68	250.48	232.16	2775.9	255.74	337.11	94.57	42.10	4.50	1413.4	381.91	705.67
T × D	18	212.87	315.99	220.06	2121.80	2385.20	2185.50	247.70	115.23	155.86	2981.00	2840.60	2674.60

Sources of Variation	Degree of freedom	Inflorescence length											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	10.29	6.90	7.22	0.10	0.06	0.053	3.61	4.35	3.65	0.08	0.02	0.02
Distance	2	72.91	79.57	75.67	0.001	0.13	0.035	86.44	86.61	86.53	0.45	0.06	0.10
Replication	2	1.01	30.68	10.17	0.003	0.31	0.079	4.52	15.75	9.14	0.02	0.06	0.03
T × D	18	3.38	3.90	3.18	0.089	0.11	0.032	4.77	2.56	3.04	0.09	0.08	0.04

Sources of Variation	Degree of freedom	LAI											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	0.161	0.320	0.207	0.21	0.19	0.18	0.072	0.172	0.088	0.20	0.08	0.11
Distance	2	0.217	0.099	0.145	0.27	0.15	0.20	0.321	0.388	0.354	0.21	0.34	0.27
Replication	2	0.008	0.075	0.026	0.13	0.01	0.05	0.042	0.106	0.069	0.01	0.01	0.007
T × D	18	0.064	0.058	0.026	0.05	0.01	0.02	0.037	0.077	0.038	0.05	0.04	0.02

Sources of Variation	Degree of freedom	Inflorescence yield											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	109.99	118.27	113.73	13.04	12.52	11.95	150.18	147.82	147.36	17.53	12.58	13.69
Distance	2	5640.10	6201.20	5917.20	332.61	333.48	332.88	7469.60	7980.00	7722.40	512.00	430.24	469.44
Replication	2	1499.1	1290.3	1392.6	147.46	202.93	174.00	1847.2	1448.1	1628.0	97.21	122.65	109.56
T × D	18	71.53	80.76	75.43	5.51	5.53	5.07	98.04	107.48	100.04	9.33	6.97	7.53

Sources of Variation	Degree of freedom	Shoot yield											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	496.83	332.39	403.44	261.97	409.53	282.79	578.45	444.55	498.14	264.56	401.45	278.22
Distance	2	19992.20	22959.00	21444.00	11503.00	11092.00	11295.00	31876.00	26053.00	28891.00	16453.00	14048.00	15213.00
Replication	2	4368.3	4938.6	4649.1	5243.9	6889.2	6038.4	4031.8	3835.1	3926.7	4492.2	6700.9	5536.0
T × D	18	256.59	292.43	271.43	227.53	207.01	191.59	422.23	342.23	371.22	293.48	246.20	246.03

Sources of Variation	Degree of freedom	Economic yield											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	142.37	123.21	131.55	28.27	29.05	28.09	202.84	162.34	178.21	34.31	27.45	29.92
Distance	2	7013.70	8033.70	7512.20	800.43	833.81	815.82	9130.60	10116.00	9614.70	1192.60	965.71	1072.60
Replication	2	1839.7	1542.9	1687.8	395.64	479.71	431.98	2184.5	1721.0	1939.0	196.48	261.15	225.44
T × D	18	88.67	106.89	96.24	12.51	13.35	12.04	128.21	133.43	127.59	19.43	16.26	16.34

Sources of Variation	Degree of freedom	Oil yield											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	15.50	13.41	14.32	5.98	6.14	5.94	22.09	17.69	19.40	7.25	5.80	6.33
Distance	2	763.79	874.87	818.08	169.37	176.43	172.63	994.32	1101.70	1047.00	252.36	204.34	226.97
Replication	2	200.35	168.02	183.81	83.71	101.51	91.40	237.89	187.41	211.16	41.57	55.25	47.70
T × D	18	9.65	11.64	10.48	2.64	2.82	2.54	13.96	14.53	13.89	4.11	3.44	3.45

Sources of Variation	Degree of freedom	Production Efficiency											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	536.53	373.43	444.88	273.75	341.39	287.47	572.90	525.78	539.02	294.82	346.36	299.78
Distance	2	21659.00	24880.00	23239.00	12135.00	12389	12259.00	34944.00	28562.00	31661.00	18109.00	15740.00	16889.00
Replication	2	4982.6	5241.9	5111.0	5616.8	7308.2	6434.7	4403.2	4171.3	4274.3	5268.7	7092.2	6145.2
T × D	18	277.08	350.62	310.10	242.44	274.93	226.76	467.33	408.24	425.58	324.45	343.17	312.36

Sources of Variation	Degree of freedom	Photosynthesis											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	1.55	0.48	0.77	2.03	0.60	1.03	1.22	0.12	0.36	4.59	1.69	2.52
Distance	2	0.08	0.84	0.26	2.91	2.01	0.28	5.97	0.11	1.91	1.39	0.40	0.084
Replication	2	3.54	2.81	2.65	23.44	19.64	21.30	8.13	0.10	1.66	2.37	0.38	0.316
T × D	18	0.57	0.83	0.45	0.32	0.67	0.17	0.43	0.18	0.18	1.53	0.38	0.527

Sources of Variation	Degree of freedom	Transpiration											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	0.45	0.36	0.14	0.06	0.07	0.022	0.31	0.35	0.14	0.029	0.04	0.016
Distance	2	0.33	0.02	0.07	0.01	0.004	0.003	0.24	0.07	0.12	0.042	0.16	0.070
Replication	2	0.20	0.007	0.04	0.12	0.14	0.055	0.0009	0.0356	0.010	0.055	0.001	0.018
T × D	18	0.07	0.05	0.02	0.07	0.02	0.021	0.21	0.06	0.075	0.048	0.04	0.023

Sources of Variation	Degree of freedom	Water Use Efficiency											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	0.0000050	0.0000025	0.000016	0.00000041	0.00000057	0.00000038	0.0000018	0.0000017	0.0000009	0.0000021	0.0000015	0.0000014
Distance	2	0.0000034	0.00000069	0.0000008	0.00000018	0.0000013	0.00000037	0.0000044	0.00000036	0.0000005	0.0000008	0.0000016	0.00000017
Replication	2	0.00000035	0.00000030	0.0000007	0.000011	0.000011	0.000011	0.0000067	0.00000074	0.0000007	0.0000006	0.0000011	0.00000044
T × D	18	0.00000086	0.0000015	0.00000065	0.00000040	0.00000030	0.00000015	0.0000012	0.00000075	0.0000005	0.0000011	0.00000056	0.00000046

Sources of Variation	Degree of freedom	LTR (%)											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	173.51	112.76	106.74	106.30	82.28	82.71	87.85	135.46	73.13	77.38	54.17	44.79
Distance	2	1540.00	2722.60	2024.00	881.33	2677.40	1657.60	442.83	1558.70	836.63	2903.90	5212.20	3973.80
Replication	2	137.21	53.56	75.25	133.21	195.30	140.59	536.53	1406.2	688.50	165.38	0.92	36.06
T × D	18	55.81	53.24	35.26	41.63	48.38	36.28	104.28	53.79	41.47	66.66	84.85	60.33

Sources of Variation	Degree of freedom	Number of roots											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	18.38	13.43	13.27	11.95	12.77	11.60	12.49	22.94	16.17	22.96	30.27	20.22
Distance	2	770.08	900.48	826.31	1606.30	1076.70	1319.90	1041.90	868.21	906.91	1624.70	2574.80	2067.70
Replication	2	111.14	74.74	89.40	76.84	61.43	65.58	96.21	25.54	38.93	30.47	111.08	51.35
T × D	18	16.74	13.99	12.08	26.86	17.61	20.10	17.23	15.06	13.10	28.04	40.87	29.13

Sources of Variation	Degree of freedom	Root dry weight											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	2.24	1.78	1.77	2.96	3.01	2.23	1.90	0.71	0.87	1.69	3.04	1.74
Distance	2	50.83	61.80	55.14	95.66	128.98	111.66	53.47	52.56	52.54	109.45	131.11	119.60
Replication	2	5.27	3.96	4.50	5.65	4.93	4.57	1.24	3.01	0.45	0.27	4.56	1.54
T × D	18	1.19	0.98	0.87	1.93	2.76	1.72	1.13	8.52	0.85	1.74	2.62	1.88

Sources of Variation	Degree of freedom	Specific root length											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	2.92	1.62	1.65	0.23	0.63	0.35	1.10	1.19	0.77	0.25	0.33	0.24
Distance	2	40.39	40.78	38.65	13.75	24.31	18.63	26.71	26.07	26.36	9.53	9.95	9.74
Replication	2	9.44	5.61	6.53	0.48	1.38	0.43	0.57	1.68	0.84	0.015	0.37	0.066
T × D	18	1.05	0.92	0.77	0.23	0.63	0.30	0.73	0.71	0.58	0.19	0.19	0.17

Sources of Variation	Degree of freedom	Root Growth Potential											
		<i>Morus alba</i>						<i>Leucaena leucocephala</i>					
		<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>			<i>Ocimum Basilicum</i>			<i>Tagetes minuta</i>		
		Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares			Mean Sum of Squares		
		2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled	2005	2006	Pooled
Treatments	9	1379.20	577.52	814.64	274.34	310.88	271.94	925.90	937.20	876.64	484.54	745.14	473.61
Distance	2	34919.00	32018.00	33287.00	33755.00	22496.00	27637.00	51096.00	30901.00	37922.00	34314.00	57535.00	44999.00
Replication	2	40346.00	12273.00	23352.00	16002.00	9795.90	12218.00	46036.00	19945.00	31472.00	7886.90	10742.00	8455.10
T × D	18	836.55	483.79	508.43	562.35	369.09	422.30	883.73	561.89	553.35	592.59	918.55	635.00

Appendix –II

Effect of different treatments on growth and physiological parameters

<i>Morus alba</i>											
Source of variation	Degree of freedom	Height	Collar diameter	LAI	Crown Spread	Biomass	Photosynthesis	Transpiration	Water use efficiency	Difference in Temp.	Light transmission ratio
		MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS
Treatments	8	0.398	128.64	0.149	0.235	11.533	0.799	0.035	0.0000046	0.502	69.113
Replication	2	0.009	16.17	0.215	0.014	15.21	0.95	0.44	0.0000075	0.002	

<i>Leucaena leucocephala</i>											
Source of variation	Degree of freedom	Height	Collar diameter	LAI	Biomass	Photosynthesis	Transpiration	Water use efficiency	Difference in Temp.	Light transmission ratio	
		MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS	MSS	
Treatments	8	0.0525	30.41	0.040	378.73	0.146	0.040	0.0000014	0.264	130.52	
Replication	2	0.0090	1.63	0.048	13.76	0.463	1.03	0.0000137	0.0028	33.04	

**CURRICULUM VITAE**

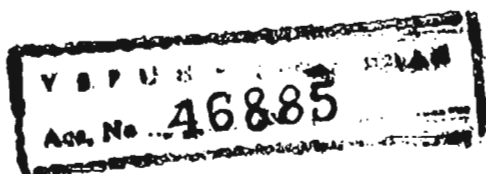
Name : Sandeep Sehgal  
Father's Name : Mr. Gulshan Sehgal  
Date of Birth : 10 January, 1972  
Sex : Male  
Marital Status : Married  
Nationality : Indian

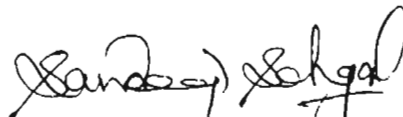
**Educational Qualifications :**

Certificate/ degree	Class grade	Board/ University	Year
Matric	First	J&K Board	1988
10+2	First	J&K Board	1990
B.Sc. (Forestry)	First	Dr. Y.S.P. UHF, Nauni-Solan	1996
M.Sc. (Agroforestry)	First	Dr. Y.S.P. UHF, Nauni-Solan	1999

Whether sponsored by some state/  
Central Govt./Univ./SAARC : No

Scholarship/ Stipend/ Fellowship, any  
other financial assistance received  
during the study period : B.Sc. (ICAR) – Merit Scholarship  
M.Sc. (UNDP) Fellowship



  
( Sandeep Sehgal )