ESSENTIALITY OF PACKAGE OF PRACTICES (POPS) OF TOMATO CULTIVATION IN SEMI-ARID REGION OF KARNATAKA – A BIRD'S EYE VIEW

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Abstract

The present study, conducted in a semi-arid region of Karnataka, was meant to understand the various practices of cultivation of tomato in the region. This research has helped in evaluating the socio-economic and ecological impacts of various practices of tomato cultivation in the semi-arid region and provided insights on the best practice for sustainable production of tomato along with livelihood development of the farmers. A set of 7 treatments (T1-T7) were superimposed to different plots in the experimental site where T1 was considered as the control sampling plot. Based on the detailed study on POPs of tomato cultivation and their socio-economic and ecological outcomes the treatment 7 (T7: FYM + RDF + VC + MN + Trichoderma (TD) + Mulching) is considered as the best practice for cultivation of tomato in the study region. It is also suggested that there is a need to organise farmers to go through training progammes for awareness generation for sustainable land use development along with their socio-economic development.

Introduction

Tomato (*Lycopersicon esculentum* L) plays very prominent role in the human diet since it has an affluent composition of minerals like calcium, sodium and trace elements copper and vitamins like vitamin A, B and C. The attractive red and yellow colour of the tomato is mainly due the presence of the elements lycopene and carotene respectively. Tomato is a highly nutritive and expensive crop with India contributing about 11.2 per cent to the world production (Shalini *et al* 2016). Its cultivation is expanding year after year in India and the world. The expansion of the area in India is mainly due to its demand and the existence of an ideal climate for intensive crop cultivation. In addition, there is theavailability of high yielding tomato varieties from both private and public sectors. Also, the availability of synthetic fertilizers, credit facility, free electricity, local transportation and market facility. Another prime reason for the continuous expansion of tomato crop cultivation is provision for re-usability of drip mains, laterals, inlets, plastic threads and wooden poles in the subsequent crop production programme serially and also local transportation which reduces the cost of cultivation.

In India, the area under tomato was 478.80 thousand hectares in 2002-03 and it was increased to 797.00 hectares in 2016-17, (60.07 %); similarly, the production was increased from 7616.16 thousand metric tons in 2002-03 to 20708.00 thousand metric tons in 2016-17. The increase in area and production of tomato crop was at 3.46 per cent and 6.90 per cent as Compounded Annual Growth Rate respectively. Tomato production has continuously increased during the last 15 years because of higher demand, increase in consumption and high rate of return. The all-India average tomato production is about 18.00 to 18.5 million metric tonnes every year. The four highest tomato yielding states in India are Himachal Pradesh, Uttar Pradesh, Andhra Pradesh and Karnataka with 43.98, 39.49, 37.86 and 33.55 tons per hectare respectively.

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In Karnataka, the total cultivable area is 123.85 lakh ha which is 65% of the total geographical area. The total number of operational holdings is 70.79 lakh and 1.74 ha is the average size of the operational holdings. Small and marginal farmers account for 75% of the total holdings, but cultivate only 36% of the total cultivable area. The number of holdings is increasing substantially and in the last five years approximately 9 lakh holdings were added. There is increase in fallow land and absentee landlordism. The state receives normal annual rainfall of 1139 mm mainly through the South West monsoon and North East monsoon. Only 30 % of the area is irrigated and the state has 10 agro-climatic zones with rich crop diversity. Area under horticulture is expanding. The productivity of the fruit crop is 16.73 ton/ha, vegetable crop 17.23 on/ha, spice crop 2.51 ton/ha, commercial flowers 7.85 ton/ha, medicinal plant 3.0 ton/ha, and aromatic plants 10 ton/ha. The total earnings from the horticulture exports are increasing every year.

The enhancement in area and production of all the arable crops is essentially need based and it should not be at the cost of a deterioration and depletion of the prime crop production..For the sustainable crop production with the limited use of natural entities (like soil and water) has proved successful with the development of scientifically standardized, economically viable and naturally feasible cultivation practices.These were evolved based on the type and nature of crops being cultivated in that particular agro-climatic region and these sets of cultivation practices are called a ***Package of Practices***. These practices are also called as prime cultivation or cultural practices. Each practice was tested for its performance in terms of its viability, efficacy, efficiency, feasibility and sustainability in that particular agro-climatic zone. The non practice or excess of any practice could influence its impacts both in crop production and also in the environment in which it is practised, Several studies have proved that non soil test based application of excess synthetic-chemical fertilizers application has had a significant reduction anddestruction of soil beneficial microbes, organic carbon percentage and the earthworm population in the soil. Hence, it isthe need of the hour to practice and adopt ecologically sustainable production practices in all the crop production programmes.

At the eastern dry zone, year-round and intensive cultivation of tomato was developed in a congenial climate, with the availability of high yielding seed varieties, provision of re-usability of drip system equipment, local transportation, high fertility of the soil, high water holding capacity, optimum soil reaction, availability of crop production inputs including farmyard manure, weed biomass etc. The sequential and serial system of tomato crop production has caused the farming community to adopt the view that it was the only crop that is easy to cultivate and they could get more money or profit with it than from any other crop. The cultivation of the crop is ever increasing in the region due to the presence of the second largest tomato market in Asia at Kolar. As per the spatial-temporal integration of tomato markets, Kolar and Chintamani have secured highest rate (52%) compared to Kolar and Mysore (40%). (Vasanthi *et al* 2017). Hence, intensity and extent of cultivation was increased at a geometric rate in comparison with the cost of prime production entities viz, soil and water.

With the aid of group discussion and primary study data, it was found that the practice of crop specific advocated Package of Practices by a majority of the farmers are excessive with a high dosage of fertilizers being used and very basic practices (soil testing) are not being practised. This intensive cultivation of tomato and non-practice of prime cultivation practices resulted in no curative measure

against the leaf curl, disease and depletion of the ground water table because tomato is a water-intensive crop (Nagaraja-2009). In fact, in 2012 itself the Central Ground Water Board declared the district as a red and over-exploited zone, with a decrease in the number and intensity of earth worms per unit area. The present study conducted a focus group discussion among chosen farmers to make them see and understand the importance of a Package of Practices (variety, time or season of planting or transplanting, spacing, dosage and type of inputs required for the crop, irrigation methods, quantity of irrigation, frequency of irrigation, type and number of plant protection practices, time and dosage of synthetic fertilizers application, planting time and methods, plant population per unit area, staking material usage, integrated nutrient management practice, integrated pest and disease management etc) in the crop with the conducting of field demonstrations. The following were its prime objectives of the field demonstration/experiment.

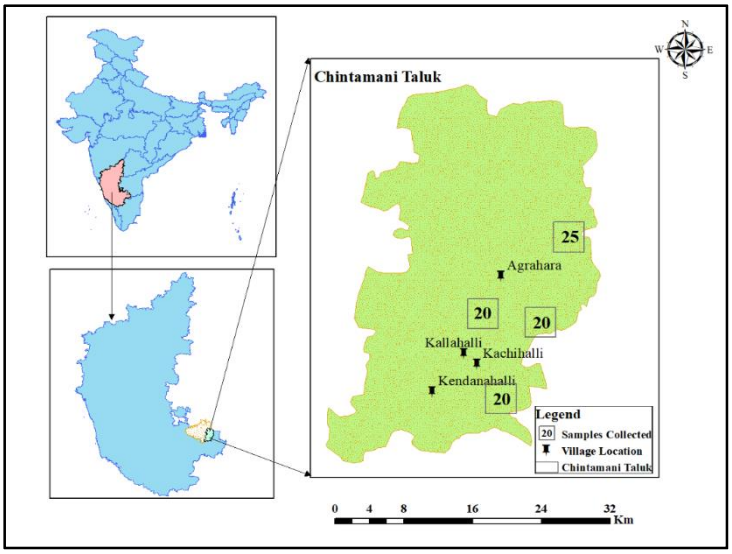
1. To study the socio-economic characteristics of the selected households in the study area;
2. To study the technical and economic aspects of the existing tomato cultivation practices and its implications on farmers' income and ecosystem;
3. To experiment with the technical and economic feasibility of the scientifically recommended cultivation practices;
4. Comparative analysis of existing cultivation practices and scientific cultivation practices in relation with its sustainability and adoptability in the study area.

Methodology

Study Area

Chintamani taluk is the second largest taluk after Bagepalli in Chikkaballapura district. The total geographical area of the taluk is 867 sq km and it is situated at an elevation of 865 meters above the mean sea level (MSL). Geographically, it lies between 78^{O} 12′ N, 13^{o} 16′ E, and 77^{O} 51′ N 13^{O} 42′ E. The area under forests is 3,243 ha, while the area not available for cultivation is 18,263 ha, fallow land is 4,043 ha, net area sown is 45,366 ha, and area sown more than once is 6,264 ha. The taluk consists of six hoblies viz., Ambajidurga, Chintamani Casaba, Kaiwara, Muragamalla, Munganahalli, and Chilakalanerpu. Among these hoblies, four villages, two from Chintamani Kasaba, one village from Muragamalla, and one from Kaiwara hobli were randomly selected and also the key factors considered during selection were the market accessibility, number of tomato crops year round and also intensive cultivation practices for research study, while in one village belonging to Murgamalla hobli, a field experiment was conducted with the adoption of Package of Practices (PoP). *(Chikkaballapura -2016-17).*

Figure 1: Study Area Location Map of Chintamani Taluk with Samples Collected in Each Village



Sampling Procedure Followed During the Investigation

The sample villages were randomly selected based on the area under tomato, especially from the three hoblies belonging to Chintamani. They are Agrahara (25). Kachahalli, Kallahalli and Kendanahalli. Generally, a total of 20 respondents from each villagewere selected. However, a total of 25 respondents were selected from Agrahara village to make a provision for more participation in the field experiment with the adoption of Package of Practices (PoP) A total of 85 respondents from four villages were selected from among four villages coming under three hoblies viz., Kaiwara, Muragamalla and Chintamani kasaba.

Experimental Details

Keeping the technological complexity of the adoption and to prove the importance of Package of Practices (PoP). a field experiment was conducted at Agrahara village located under Muragamalla Panchayat of Chintamani taluk. The details of treatments, layout of the field experiment, crop husbandry, biometric observations and yield components recorded in the crop are described below.

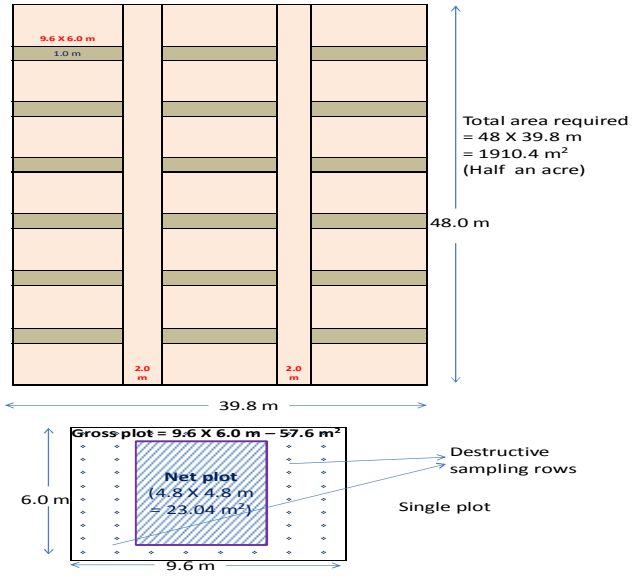
Layout of the experiment: The experiment was laid out in an area measuring 1910.4 m^2 (half an acre). The length and width of the experimental site was 48.0 m X 39.8 m and the net plot size was 4.8mX4.8m

Total Number of treatments: 7

Number of replications: 3

Design: Randomized Complete Block Design (RCBD)

Figure 2: Experimental Layout for Tomato Cultivation with PACKAGE of Practices



Statistical analysis

The farmer-wise data of tomato crop yield and 15 independent variables collected in the 4 villages were analyzed using different statistical methods as described below.

Descriptive statistics

Descriptive statistics viz., minimum, maximum, mean, standard deviation, standard error of mean, coefficient of variation, skewness and kurtosis were derived for each variable observed in each village. An assessment was made about the variability of yield and different independent variables and their distribution based on the data collected from different farmers. The descriptive statistics were derived for each variable in each village and also when pooled over villages.

Grouping of farmers

A statistical grouping of farmers was made based on mean and standard deviation in order to assess the input resources of farmers and the tomato yield attained by them. The groups were made for yield and each of the 15 independent variables. For a given variable, the three groups made were farmers with a value (i) less than (Mean – SD); (ii) between (Mean – SD) to (Mean + SD); and (iii) more than (Mean + SD). The grouping of farmers was made for each village and also when pooled over villages for assessing the number of farmers under each group.

Correlation analysis

Estimates of correlation were determined between different pairs of variables to assess the magnitude of relationship which could be either positive or negative and would range from -1 to +1. The correlations between variables were derived for each village and also when pooled over all villages. The correlations were tested for significance based on t-test as described by Gomez and Gomez (1984).

Regression analysis

Regression analysis was carried out in order to predict the tomato yield through different combinations of independent variables. Six different regression models were calibrated for predicting the tomato yield through different combinations of independent variables.

Findings and Analysis

Socio-economic Characteristics of the Selected Households in the Study Area

The features pertain to the socio-economic variables viz. age, education, family size and landholding of the selected households in the study area of 4 villages were as follows:

Age: With respect to age, the head was considered based on the experience in tomato cultivation, his involvement and innovativeness. The study of all the 85 respondents in the 4 villages revealed that 21.17 percent of the respondents were in the young (youth) age group, while 50.59 percent of the respondents were in the category of middle age group, and 28.24 percent of the respondents were in the slab of old age group.

Education: Regarding the education of the respondents, it is observed that 14.11 percent of them were illiterate, while 18.82 percent had primary education, 23.53 percent had higher primary education, 38.82 percent studied up to high school level, and 4.72 percent of the respondents studied up to the pre-university and college level.

Size of the family: The family structure of the respondents shows that a majority (69.42 percent) of them were of medium size consisting of 5 to 7 persons per household, while 14.11 percent and 16.47 percent of respondents (farmers) were small and large families respectively consisting of less than 4 members in a small family and more than 7 members in a large family.

Type of the family: Among the selected respondents, it is observed that a majority were in a joint family system and they constituted up to 61.18 percent, while the remaining 38.82 percent of respondents belonged to the nuclear family type.

Land area operating size: The distribution of land holdings and its operation among respondents indicated that a majority was in the medium-size category, i.e. 55.30 percent, while 31.76 percent were in the category of large farmers, and only 12.94 percent of respondents were in the category of small farmers. About 87.06 percent of the respondents belonged to the medium and large category of farmers who were cultivating tomato as a major crop. It is observed that tomato crop occupied about 1/3rd and 2/3rd of the cultivated area of the respondents in these two categories of farmers. The frequency and percentage of farmers in different categories based on the socio-economic variables are given in Table 1 and Figure 3 and 4.

Table 1: Socio-economic Characteristics of the Selected Households in the Study Area Pooled Over Villages (N = 85)

Variable	Category	Frequency	Percent
Age	Up to 30 years	18	21.17
	31 to 50 years	43	50.59
	Above 51 years	24	28.24
Education	Illiterate	12	14.11
	Primary Education	16	18.82
	Higher Primary Education	20	23.52
	High School	33	38.82
	Pre-University College	4	4.70
Size of the family	Small family (Up to 4)	12	14.11
	Medium size (5-7)	59	69.42
	Large family (>7)	14	16.47
Type of family	Nuclear family	33	38.82
	Joint family	52	61.18
Land holdings distribution	Small farmers (< 2.5 acres)	11	12.94
	Medium farmers (2.5 - 5.0 acres)	47	55.30
	Large farmers (> 5 acres)	27	31.76

Source: Field study-2016

Experience in tomato cultivation

Since the intensive cultivation of tomato has influenced both the socio-economic features and also on the farm ecosystem, besides the microclimate of the farm. It is observed that only 20 percent of the respondents were engaged in tomato cultivation since the last five years (< 5 years). About 27.06 percent were having experience in tomato cultivation which ranged from more than five years and less than 10 years (5-10 years). and a majority of 51.76 percent were having experience of more than 10 years (>10 years).

Tomato cultivation experience

Among the selected respondents, nearly 16.47 percent of them were having experience of less than 3 years, while 45.89 percent had experience between 4 to 10 years and 37.45 percent were having experience of more than 10 years.

Adoption of package of practices

Similarly, the respondents preferred the means to understand the implementation of the Package of Practice in their field. About 15.29 percent preferred an exposure visit, while 22.35 percent preferred the Krishimela, 11.76 percent preferred Farmers Field School, and the maximum number of respondents i.e. 37.67 percent preferred field demonstration. Hence, the adoption of a major Package of Practice through field experiment was conducted. With the adoption of PoP, via., minimum crop required cultural practices, we could attain a sustainable yield of tomato crop.

Figure 3: Distribution of Farmers into Different Categories Based on Age, Education, Family Size and Type of Family Using Pooled Data of 4 Villages

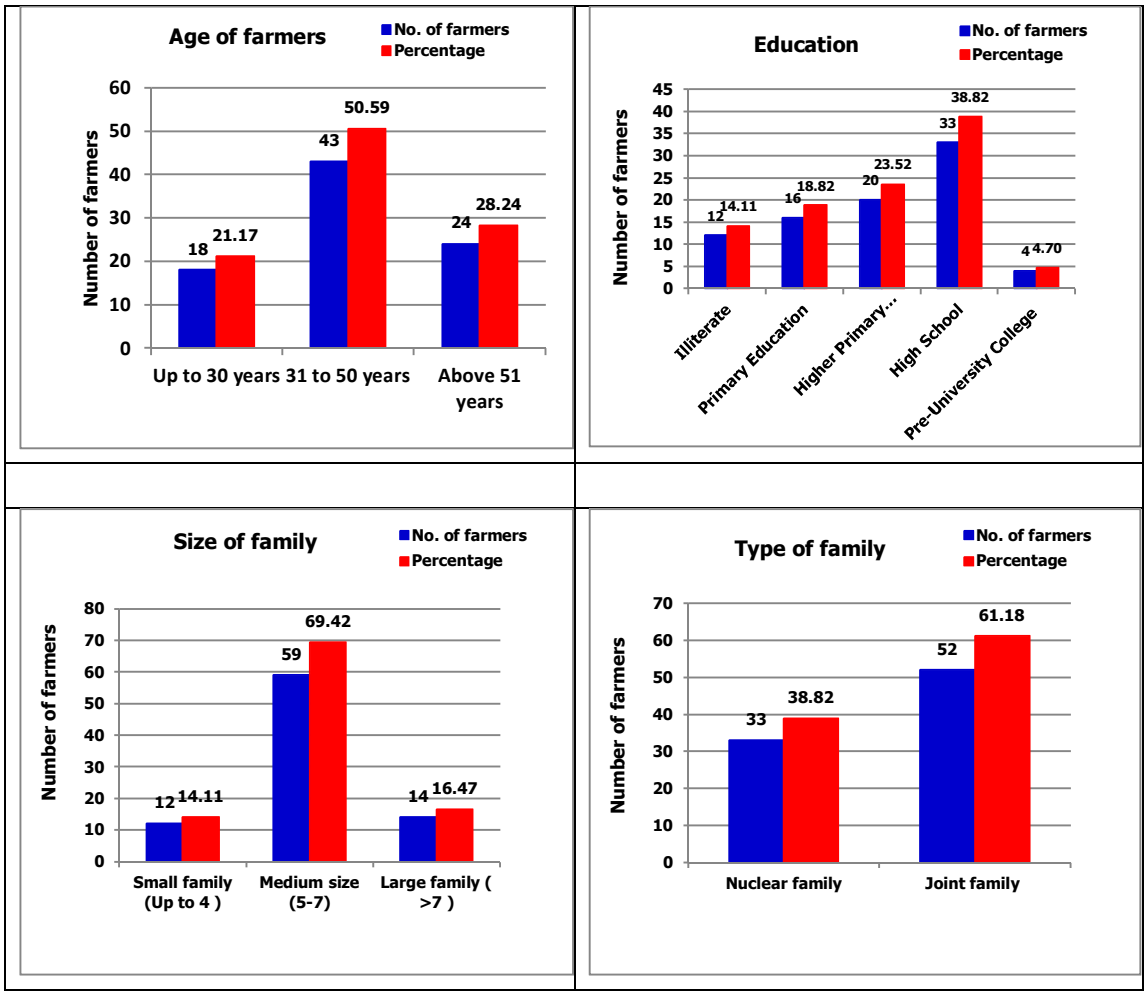
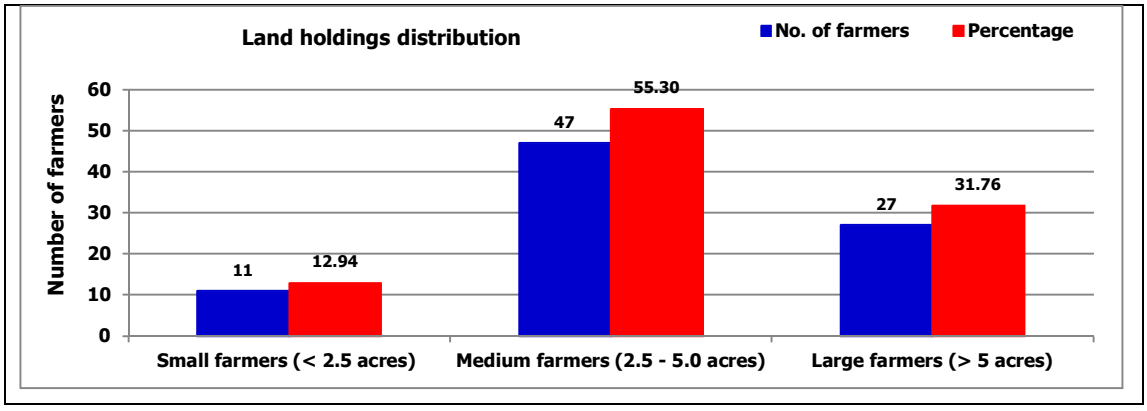


Figure 4: Distribution of Farmers into Different Categories Based on Their Land Holdings Using Pooled Data of 4 Villages



Technical and Economic Aspects of the Existing Tomato Cultivation Practices and Its Implications on Farmer's Income and Ecosystem

The technical and economic aspects of the selected major Package of Practices (PoP) in tomato cultivation made by the respondents were assessed, and the details are described as follows.

Knowledge of the recommended Package of Practices

The responses pertain to the availability of the recommended Package of Practices for tomato cultivation for that particular region indicated that only 10.58 percent of the respondents were knowing about the Package of Practices, while the remaining 89.42 percent of the farmers were not knowing about the availability of any recommended Package of Practices for the region.

Percent of soil test-based farming in tomato

The first step to begin any suitable cultivation is soil testing. It is a pre-requisite to operate on-farm with farming practices based on the soil test results for efficient nutrient management. In the study area, it was observed that among the selected respondents, only 11.76 percent were testing their soils every year, while 22.35 percent were testing their soils at least once in three years and a majority of 65.88 percent were not testing their soils at all. This indicated that the farmers who were doing tomato cultivation were on the one side disturbing the soil health by the application of excess chemical fertilizers, apart from destroying the earthworm population in the soil drastically.

Type of seed and planting material usage

Among the respondents, only 7.05 percent were using the zonal recommended planting material but a majority of 81.17 percent were using the recommended material of private companies. About 11.76 percent were practising both as and when the materials were available from either zonal or private company sources.

Age of the transplanting seedlings

With respect to the age of the seedlings for transplanting, it was recommended that they should be 22 to 24 days old. The seedlings should be stout and disease free and must be highly viable. The investigation in this regard revealed that a bulk of the respondents i.e. 68.23 percent had adopted 25-30 days old seedlings, while 18.82 percent of the farmers were using more than 35-days old seedlings. Only 12.95 percent of them were using 22-24 days old seedlings which are the optimum age for transplanting to the main field.

Application of bio-fertilizers

The study revealed that 28.23 percent of the respondents were using bio-fertilizers either for seed treatment or application to the soil along with farmyard manure (FYM) every year, while 63.52 percent of the farmers were practising it once in three years and 8.23 percent were not using this practice at all.

Application of essential micronutrients

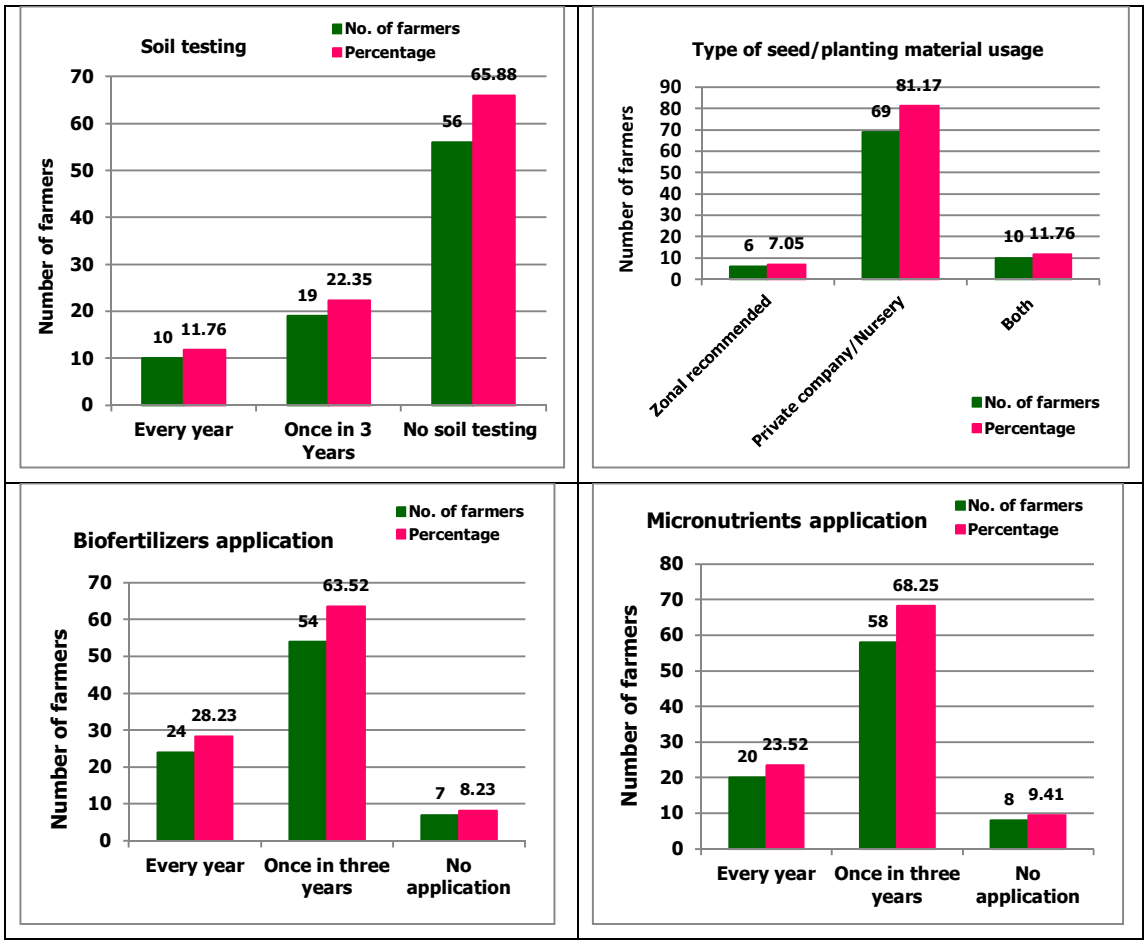
It was observed that 23.52 percent of the respondents were applying essential micronutrients every year, while 68.23 percent of farmers were applying it once in three years and 9.41 percent were not using this practice at all. The frequency and percentage of farmers using different practices of soil testing, type of seed/plant material, bio-fertilizers and micro-nutrients are given in Table 2 and are described in Figure 5

Table 2: Particulars of Type of Seed/Planting Material Usage, Bio Fertilizers Application, and Essential Micronutrients Application (N= 85)

Variable	Particulars	Frequency	Percent
Soil testing practice	Every year	10	11.76
	Once in three years	19	22.35
	No soil testing	56	65.88
Type of seed/ planting material usage	Zonal recommended	6	7.05
	Private company/ Nursery	69	81.17
	Both	10	11.76
Application of bio-fertilizers	Every year	24	28.23
	Once in three years	54	63.52
	No application	7	8.23
Application of micronutrients	Every year	20	23.52
	Once in three years	58	68.25
	No application	8	9.41

Source: Field study-2016

Figure 5: Distribution of Farmers into Different Categories Based on Soil Testing, Type of Seed/Plant Material used, Application of Bio-fertilizers and Micronutrients using Pooled Data of 4 Villages



Maintenance of optimum plant population

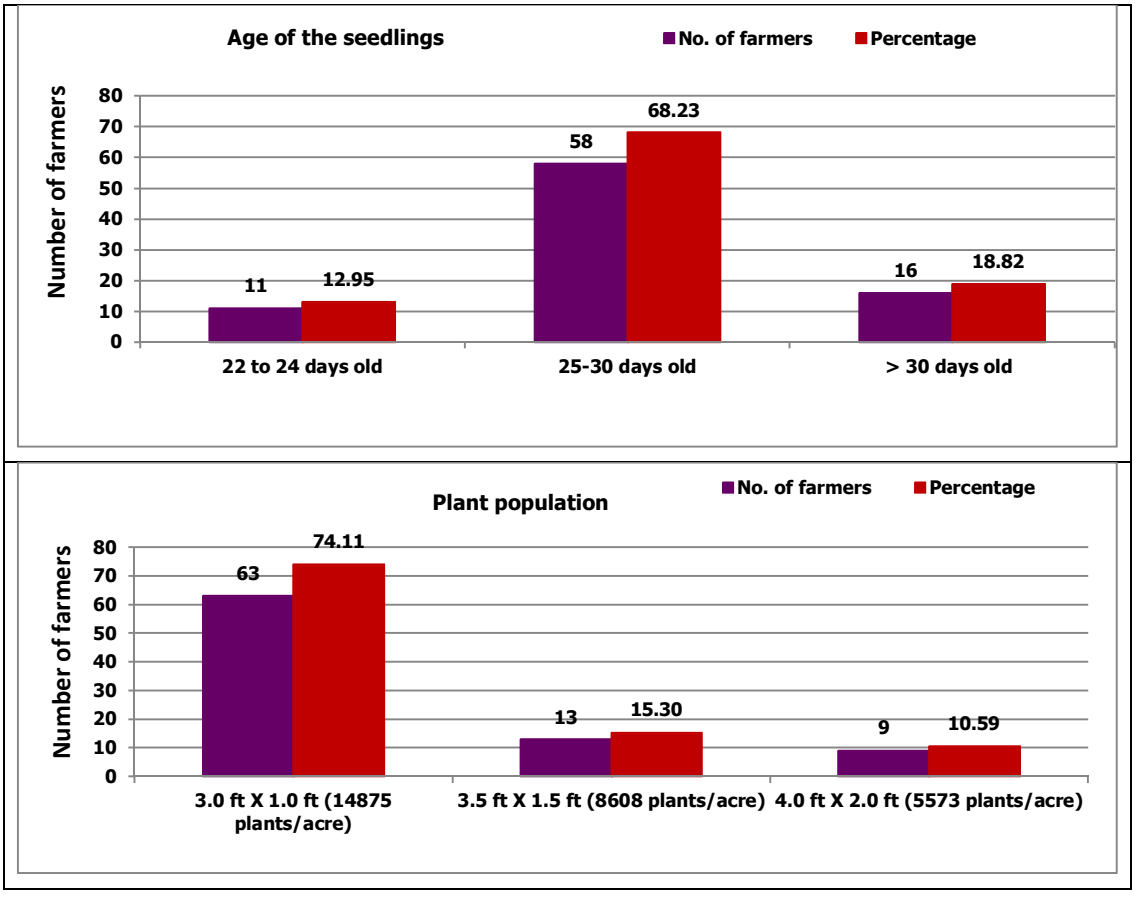
The recommended Package of Practices regarding optimum plant population per unit area is based on both intra and inter-row spacing. Among the selected respondents, it is observed that a majority of respondents (74.11 percent) were practising below the recommended spacing (3.0 ft X 1.0 ft). while 15.30 percent were practising a little more spacing than the recommended practice (3.5 ft X 1.5ft) and the remaining 10.59 percent were practising wider spacing (4.0 ft X 2.0 ft) than the recommended practice. As per the recommended spacing, the optimum plant population per unit area was 9990 plants per acre, whereas 74.11 percent of the respondents maintained 14875 plants per acre in 3.0 ft X 1.0 ft spacing, 15.30 percent of farmers have maintained 8608 plants per acre and 10.59 percent of the respondents maintained 5573 plants per acre. The details of the number of farmers and the percentage of farmers adopting the age of seedlings and plant population are given in Table 3 and are described in Figure 6.

Table 3: Age of the Seedlings for Transplanting and Maintenance of Optimum Plant Population in Tomato Crop (N = 85)

Recommended practice	Existing practice	Frequency	Percent
Transplanting age of seedlings (22 to 24 day old)	Age of seedlings at usage in the field		
	22 – 24 days old	11	12.95
	25 – 30 days old	58	68.23
	30 days old	16	18.82
Maintenance of optimum plant population per unit area As per 3.0 ft X 1.5 ft (9990 plants/acre)	Existing practice in the field		
	3.0 ft X 1.0 ft (14875 plants/acre)	63	74.11
	3.5 ft X 1.5 ft (8608 plants/acre)	13	15.30
	4.0 ft X 2.0 ft (5573 plants/acre)	9	10.59

Source: Field study-2016

Figure 6: Distribution of Farmers into Different Categories Based on Age of the Seedlings Used and Plant Population Maintained in their Fields Using Pooled Data of 4 Villages



Transplanting bed preparation

Regarding the preparation of transplanting bed, a maximum of 65.88 percent of the selected respondents were practising more than the recommended (i.e. two times ploughing and one time harrowing). while 24.70 percent were over-practising (three times ploughing and two times harrowing) and only 9.42 percent were on-par (two times ploughing and one time harrowing).

Farmyard manure (FYM) application

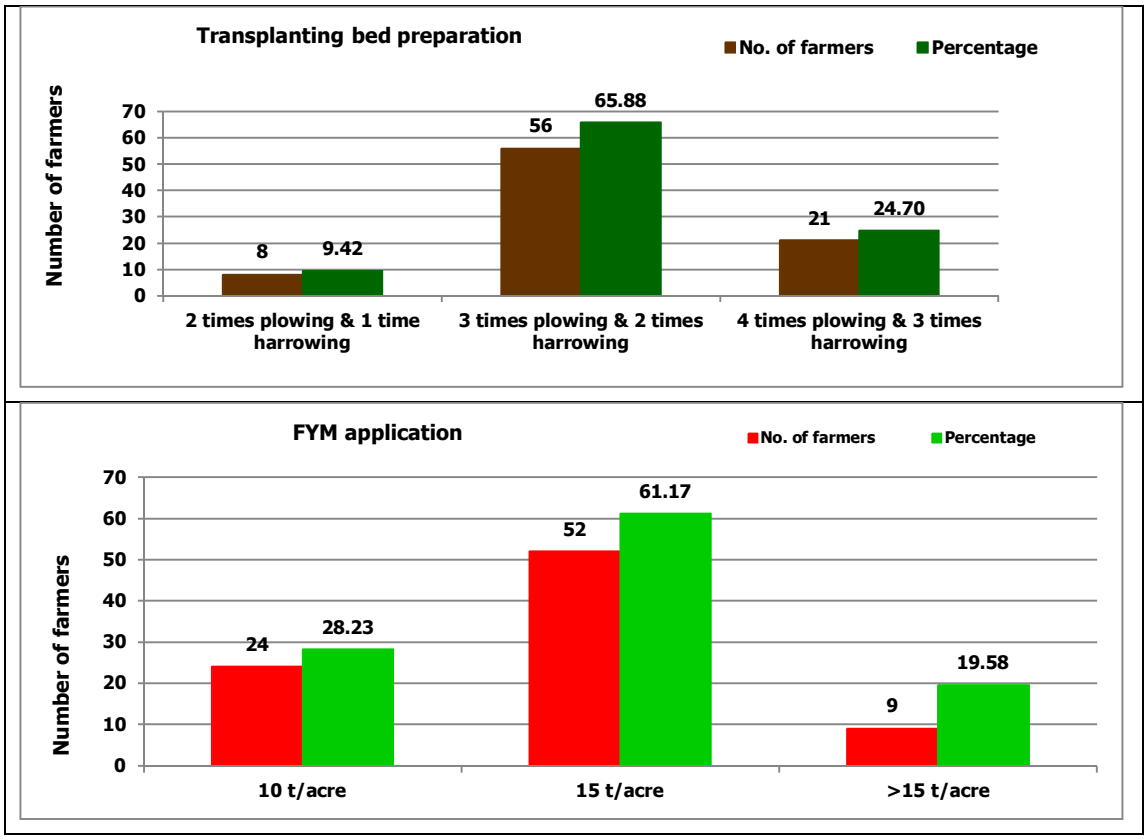
About 61.17 percent of the respondents were practising the application of FYM on par (12 tons per acre) with the recommended dosage, whereas 28.24 percent were practising less than (5 tons per acre) the recommended dosage, and 10.58 percent were practising more than (15 tons per acre) the recommended dosage. The details of the number and percentage of farmers using the transplanting bed preparation and FYM applications are given in Table 4 and are described in Figure 7.

Table 4: Transplanting bed preparation and Farmyard manure application

Recommended practice	Existing practice	Frequency	Percent
Transplanting bed preparation			
2 times plowing and 1 time harrowing	2 times plowing & 1 time harrowing	8	9.42
	3 times plowing & 2 times harrowing	56	65.88
	4 times plowing & 3 times harrowing	21	24.70
Application of FYM	**Application of FYM**		
15 t/acre	10 t/acre	24	28.23
	15 t/acre	52	61.17
	>15 t/acre	9	19.58

Source: Field study-2016

Figure 7: Distribution of Farmers into Different Categories Based on Transplanting Bed Preparation and FYM Using Pooled Data of 4 Villages



The practice of on-farm application of oiled neem cake, green manure and chemical fertilizers

The on-farm practice of application of oiled neem cake was observed in 32.95 percent of the selected respondents. They were adopting on-par with the Package of Practices, while 42.35 percent of the farmers were using less than the recommended level, and 24.70 percent of the respondents were using more than the recommended neem cake level.

Similarly, only 8.23 percent of the farmers practised application of green manures as per the recommendation, while 3.52 percent of the farmers were practising less than the recommended level, and few (2.35 percent) were practising more than the recommended level. Hence, the total percent of the respondents who were practising use of green manure was 14.1 percent, while 85.9 percent of the farmers were not practising green manure application at all in the study area.

With regard to the application of chemical fertilizers, it is observed that among the selected respondents, only 28.23 percent were applying lower dose than the recommended level. About 37.65 percent of the farmers were applying on-par dose with the recommendation, compared to 34.11 percent of respondents who were applying more than the recommended level. About 91.76 percent of the respondents were using water-soluble fertilizers through drip irrigation, while the remaining 8.24 percent were applying it as basal and top dressing to the soil as a soil application. In addition, about 49.41 percent of the respondents were using micronutrients, while the remaining 50.58 percent were not applying any type of micronutrients.

Application of weedicides in tomato

The application of weedicides revealed that a majority (72.95 percent) of the respondents have followed the practice of applying more dose of weedicide, while 21.17 percent of the farmers used less than the recommended level and only 5.88 percent of the farmers practiced on-par with the recommended Package of Practices with regard to weedicide application.

The practice of planting African marigold as a trap crop in tomato

The survey findings with respect to the practice of planting African marigold crop indicated that about 22.35 percent of the respondents did not know about the trap crop, while a majority of 60.0 percent of the respondents was growing fodder maize along the border of the tomato crop. Only 17.65 percent of the respondents were found to raise marigold as a trap crop that may be a costly practice. The details of number and percentage of respondents who were practising the application of oiled neem cake, green manures, chemical fertilizers, and weedicides are given in Table 5 and are described in Figure 8 and for the practice of growing a trap crop Figure 9.

Table 5: The practice of application of oiled neem cake, green manures, and application of chemical fertilizers

Recommended practice	Existing practice	Frequency	Percent
Application of oiled neem cake	**Application of oiled neem cake**		
100 kg per acre	As per Package of Practices (PoP)	28	32.95
	Less than PoP	36	42.35
	More than PoP	21	24.70
Application of green manures	**Application of green manures**		
2 tons per acre	As per PoP	7	8.23
	Less than PoP	3	3.52
	More than PoP	2	2.35
Application of chemical fertilizers	**Application of chemical fertilizers**		
100:100:100 kg NPK per acre	As per PoP	32	37.65
	Less than PoP	24	28.23
	More than PoP	29	34.12
Application of weedicides (PE = Pre-emergent)	**Application of weedicides**		
Alachlor 0.6 g/liter PE	Metrubuzine 1.0 g/liter		
Butachlor 0.6 g/liter PE	(It acts as both Pre-emergent & Post-emergent)		
	As per PoP	5	5.88
	Less than PoP	18	21.17
	More than PoP	62	72.95
The practice of planting African marigold as a trap crop	**The practice of planting African marigold as a trap crop**		
For every 16 rows of tomato one row trap crop and as border crop	As per PoP	19	22.35
	Less than PoP	51	60.00
	More than PoP	15	17.64

Source: Field study-2016

NKTC-No Knowledge on Trap Crop

Figure 8: Distribution of Farmers into Different Categories Based on Application of Neem Cake, Green Manure, Chemical Fertilizers and Weedicides in their Fields using Pooled Data of 4 Villages

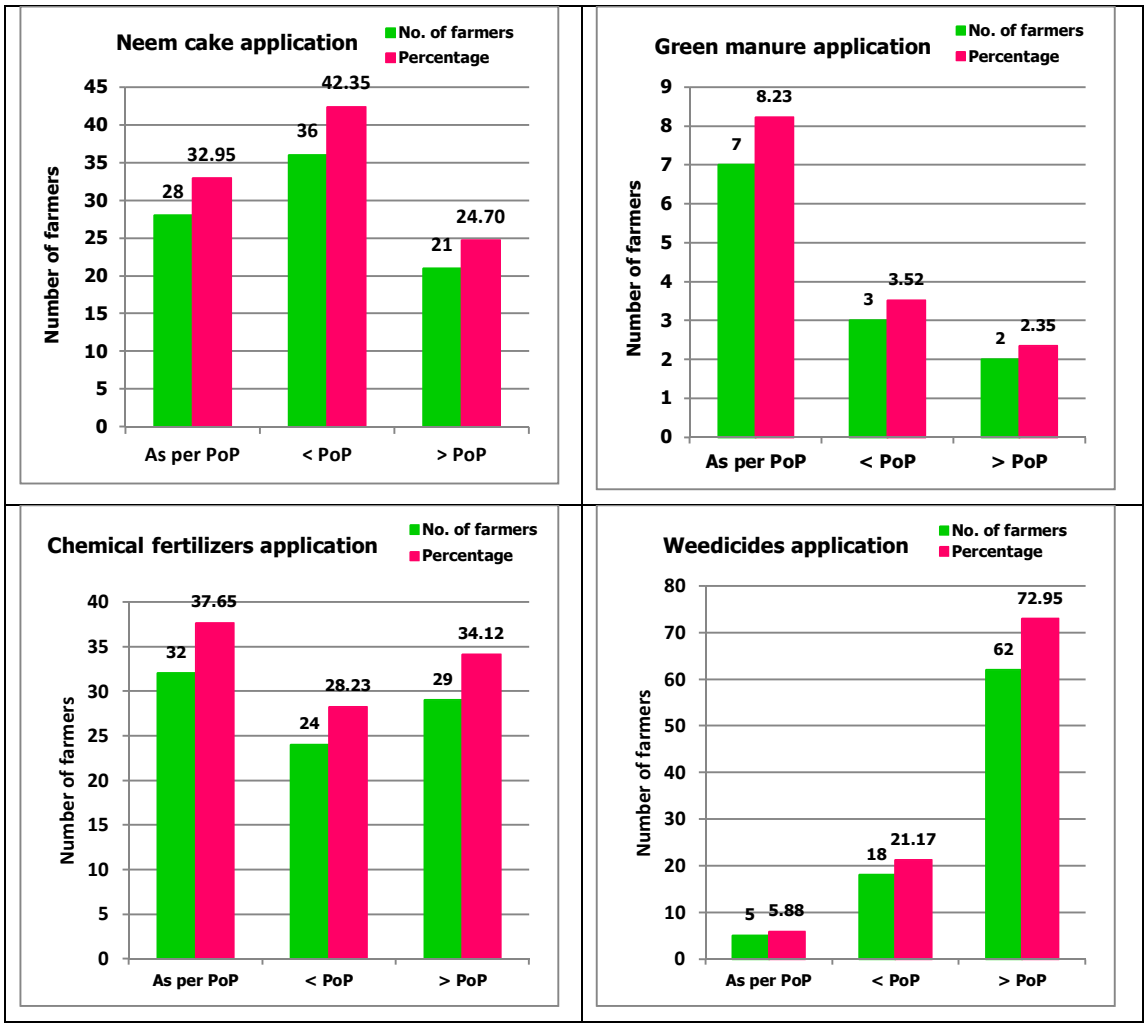
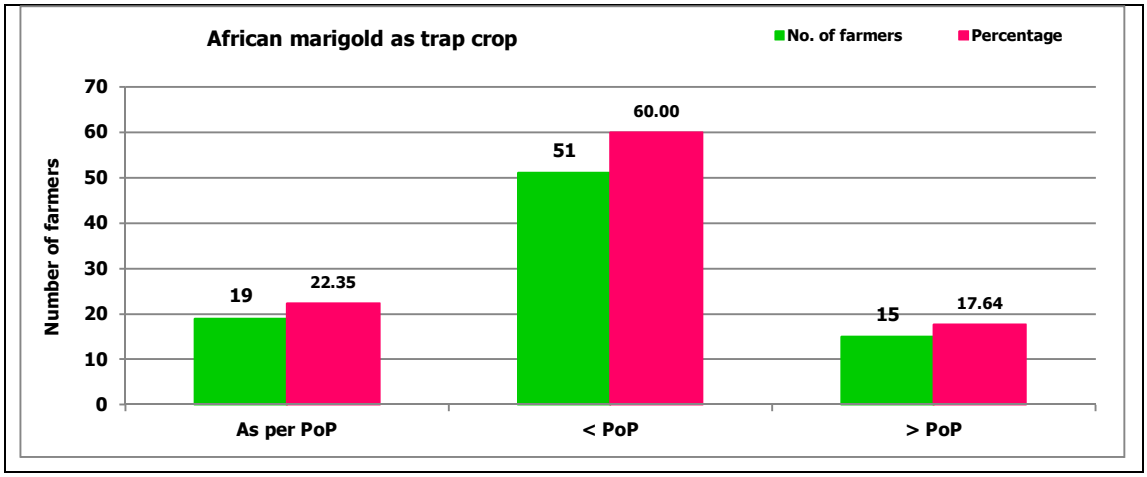


Figure 9: Distribution of Farmers into Different Categories Based on Planting of African Marigold as Trap Crop in their Fields using Pooled Data of 4 Villages



Application of plant protection chemicals

The practice of application of plant protection chemicals includes insecticides and fungicides. It is observed that about 54.11 percent of the respondents were spraying insecticide more than the recommended level, while 16.89 percent of the respondents were spraying less than the recommended level and only 27.05 percent of the respondents were following the recommended level. Similarly, regarding spraying of fungicides, it is observed that 40.0 percent of the farmers were practising on-par with the recommended package, while 25.88 percent of the farmers were using less than the recommended level and 34.12 percent were practising more than the recommended level.

Regarding the number of sprays and total spraying solution used on-farm per crop in one acre, 48.23 percent of the respondents were spraying 15 times, while 27.05 percent were spraying 10 times and 24.20 percent of the farmers were spraying 20 times. Similarly, 45.88 percent were spraying 4000 litres of spray solution, while 32.94 percent of the farmers were spraying 4500 litres of spray solution and 21.17 percent were spraying 3500 litres of spray solution.

The practice of irrigation

Number of irrigations per crop

The study indicated that about 67.05 percent of the respondents were giving 60 irrigations per crop, while 23.52 percent of the respondents were giving 50 irrigations and only 9.41 percent of respondents were giving 40 irrigations per crop in different villages.

Quantity of water provided per irrigation

The study indicated that a majority of 71.76 percent of the farmers used about 0.5 to 4.0 litres of water per plant per irrigation, while 17.64 percent of the respondents were found to use 0.5 to 5.0 litres of water and 10.58 percent of farmers used water in the range of 0.5 to 3.0 litres per plant per irrigation.

Frequency of irrigation

The study revealed that a majority of the farmers, i.e., about 61.17 percent, were providing irrigation to the crop on every alternate day, while 24.98 percent of farmers were providing irrigation to the crop every day and 14.11 percent of the farmers were providing irrigation to the crop once in four days.

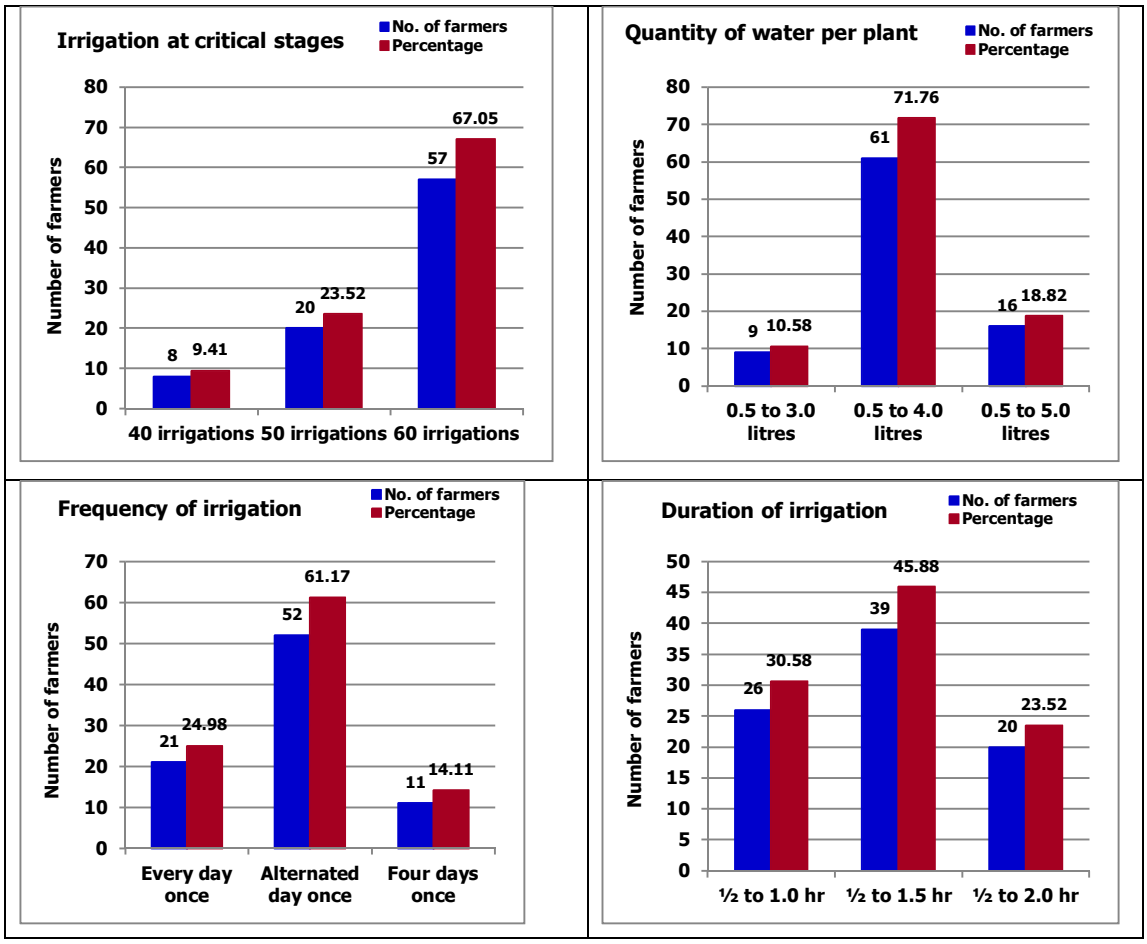
Duration of the irrigation

The results indicated that about 45.88 percent of the farmers were providing irrigation to the crop for a duration of 1.5 to 2.0 hours, while 30.58 percent of the farmers were providing irrigation for 0.5 to 1.0 hours and 23.32 percent of farmers were providing irrigation for more than 2.0 hours. The details of recommended practice and existing practice of irrigation in farmers' fields adopted by farmers regarding number of irrigations, quantity, frequency and duration are given in Table 6 and are described in Figure 9.

Table 6: Irrigation Practice in Tomato Crop (N = 85)

Recommended practice	Existing practice	Frequency	Percent
Irrigation at critical stages			
Planting stage	40 irrigations	8	9.41
Flowering stage	50 irrigations	20	23.52
Fruiting stage	60 irrigations	57	67.05
Weekly once (24 lakh liters water)			
	Quantity of water provided/plant		
	0.5 to 3.0 litres	9	10.58
	0.5 to 4.0 litres	61	71.76
	0.5 to 5.0 litres	16	18.82
	Frequency of irrigation		
	Every day once	21	24.98
	Alternated day once	52	61.17
	Four days once	11	14.11
	Duration of irrigation		
	½ to 1.0 hour	26	30.58
	½ to 1.5 hours	39	45.88
	½ to 2.0 hours	20	23.52

Figure 9: Distribution of farmers into different categories based on irrigation at critical stages, quantity of water per plant, frequency of irrigation and duration of irrigation using pooled data of 4 villages



Conduct of field experiment with the adoption of Package of Practices (PoP)

A field experiment was conducted with 7 treatments in Agrahara by adoptinga different Package of Practices with 3 replications. Four vegetative and reproductive growth parameters viz., plant height (cm). number of leaves, stem girth (cm) and number of branches were recorded at different stages on 30, 60, 90 and 120 days after transplanting (DATP) under each treatment and were statistically analyzed. The details are described below.

Treatment details

Based on the approval of the doctoral committee, a set of 7 treatments viz., T1, T2, T3, T4, T5, T6 and T7 were superimposed to different plots in the experiment. The treatment T1 is control which would serve as the check, i.e., all the tomato cultivation practices in that particular locality were followed. The 7 treatments tested are as follows:

T1: Control (625:625:625 kg NPK + 35 tons FYM + 450 kg PC + EADI + NAVC + NABF & MN)

T2: Farm Yard Manure (FYM) + Recommended Dose of Fertilizer (RDF) + Mulching

T3: FYM + RDF + Vermi-Compost (VC) + Mulching

T4: FYM + RDF + VC + Micro Nutrient (MN) + Mulching

T5: FYM + Mulching

T6: RDF + Mulching

T7: FYM + RDF + VC + MN + Trichoderma (TD) + Mulching

Transplanting of seedlings

The transplanting of seedlings was taken up on July 6, 2015. As many as 5555 plants per acre were planted. It has been taken up in three replications. Accordingly, a total of 16665 plants were planted in the experimental site.

Vegetative growth parameters

Plant height (cm)

At 30 DATP, the plant height ranged from 18.5 cm in T3 to 20.6 cm in T7 with mean of 19.6 cm (CV of 3.6%) over different treatments. At 60 DATP, the plant height ranged from 43.9 cm in T5 to 49.2 cm in T1 (Farmer's practice) with mean of 45.8 cm (CV of 4.9%) over different treatments. At 90 DATP, the plant height ranged from 108.0 cm in T6 to 170.0 cm in T7 with mean of 141.2 cm (CV of 15.5%) over different treatments. At 120 DATP, the plant height ranged from 112.3 cm in T6 to 175.5 cm in T7 with mean of 141.4 cm (CV of 18.1%) over different treatments. Based on Analysis of Variance (ANOVA) of treatments, there was no significant difference among treatments for the plant height measured on 30 and 60 DATP, while there was a significant different among treatments on 90 and 120 DATP. The observations of plant height (cm) recorded on different days after planting, along with the descriptive statistics viz., minimum, maximum, mean, standard deviation, coefficient of variation, standard error of mean and critical difference at 5% level of significance are given in Table 7.

Number of leaves

At 30 DATP, the number of leaves ranged from 4.3 in T5 to 6.3 in T4 with mean of 5.2 (CV of 12.5%) over different treatments. At 60 DATP, the number of leaves ranged from 19.6 in T4 to 28.4 in T2 with mean of 23.3 (CV of 14.9%) over different treatments. At 90 DATP, the number of leaves ranged from 24.0 in T6 to 39.1 in T7 with mean of 29.9 (CV of 17.8%) over different treatments. At 120 DATP, the number of leaves ranged from 27.9 in T6 to 36.0 in T4 with mean of 31.2 (CV of 9.0%) over different treatments. Based on ANOVA of treatments, there was no significant difference among treatments for the number of leaves observed on 30, 60 and 120 DATP, while there was a significant difference among treatments on 90 DATP. The observations of number of leaves recorded on different days after planting, along with the descriptive statistics and critical difference at 5% level of significance are given in Table 7.

Stem girth (cm)

At 30 DATP, the stem girth ranged from 1.0 cm in T2 and T3 to 1.9 cm in T7 with mean of 1.3 cm (CV of 26.5%) over different treatments. At 60 DATP, the stem girth ranged from 1.8 cm in T6 to 3.8 cm in T7 with mean of 2.4 cm (CV of 29.6%) over different treatments. At 90 DATP, the stem girth ranged

from 4.6 cm in T6 to 7.2 cm in T7 with mean of 5.7 cm (CV of 15.4%) over different treatments. At 120 DATP, the stem girth ranged from 6.2 cm in T1 to 8.7 cm in T7 with mean of 6.9 cm (CV of 12.2%) over different treatments. Based on ANOVA of treatments, there was no significant difference among treatments for the stem girth observed on 30 and 120 DATP, while there was a significant difference among treatments on 60 and 90 DATP. The observations of stem girth (cm) recorded on different days after planting, along with descriptive statistics and critical differences at 5% level of significance are given in Table 7.

Number of branches

At 30 DATP, the number of branches ranged from 2.0 in T5 to 3.4 in T7 with mean of 2.5 (CV of 18.9%) over different treatments. At 60 DATP, the number of branches ranged from 3.9 in T6 to 7.9 in T7 with mean of 5.7 (CV of 23.2%) over different treatments. At 90 DATP, the number of branches ranged from 13.1 in T6 to 27.0 in T7 with mean of 18.8 (CV of 27.7%) over different treatments. At 120 DATP, the number of branches ranged from 14.3 in T6 to 28.1 in T7 with mean of 20.4 (CV of 25.4%) over different treatments. Based on ANOVA of treatments, there was no significant difference among treatments for the number of branches observed on 30 and 120 DATP, while there was a significant difference among treatments on 60 and 90 DATP. The observations of number of branches recorded on different days after planting, along with the descriptive statistics and critical difference at 5% level of significance for comparing the differences between treatments are given in Table 7.

Table 7: Analysis of variance of growth parameters observed at 30, 60, 90, and 120 days after transplanting (DATP) in tomato crop at Agrahara

Treatments	Plant height (cm)				Number of leaves				Stem girth (cm)				Number of branches			
DATP	30	60	90	120	30	60	90	120	30	60	90	120	30	60	90	120
T1	19.0	49.2	122.7	127.5	4.6	20.2	26.0	29.3	1.1	2.1	4.9	6.2	2.1	6.0	14.3	15.8
T2	20.2	44.4	147.3	149.5	5.6	28.4	29.2	32.8	1.0	2.0	6.3	6.6	2.2	5.1	16.0	18.6
T3	18.5	48.5	132.0	137.3	5.3	20.9	27.5	29.6	1.0	2.2	5.4	6.4	2.6	5.5	20.7	21.9
T4	19.8	46.3	162.4	172.6	6.3	19.6	35.0	36.0	1.2	2.9	6.0	6.7	2.8	6.8	24.1	26.0
T5	19.6	43.9	146.3	115.2	4.3	22.4	28.2	30.0	1.2	2.0	5.6	6.6	2.0	4.8	16.7	17.9
T6	19.7	44.1	108.0	112.3	5.3	24.2	24.0	27.9	1.5	1.8	4.6	7.1	2.5	3.9	13.1	14.3
T7	20.6	44.1	170.0	175.5	5.1	27.2	39.1	32.9	1.9	3.8	7.2	8.7	3.4	7.9	27.0	28.1
Minimum	18.5	43.9	108.0	112.3	4.3	19.6	24.0	27.9	1.0	1.8	4.6	6.2	2.0	3.9	13.1	14.3
Maximum	20.6	49.2	170.0	175.5	6.3	28.4	39.1	36.0	1.9	3.8	7.2	8.7	3.4	7.9	27.0	28.1
Mean	19.6	45.8	141.2	141.4	5.2	23.3	29.9	31.2	1.3	2.4	5.7	6.9	2.5	5.7	18.8	20.4
SD	0.7	2.3	21.9	25.6	0.7	3.5	5.3	2.8	0.3	0.7	0.9	0.8	0.5	1.3	5.2	5.2
CV (%)	3.6	4.9	15.5	18.1	12.5	14.9	17.8	9.0	26.5	29.6	15.4	12.2	18.9	23.2	27.7	25.4
Sem (+)	0.99	35.1	8	3.28	0.69	1.63	1.9	24	1.01	0.19	0.3	5.37	1.97	0.39	1.27	16
CD (5%)	NS	NS	24	10.11	NS	NS	5.8	NS	NS	0.58	1	NS	NS	1.2	3.9	NS

SD: Standard deviation CV: Coefficient of variation SEM: Standard error of mean

CD: Critical difference DATP: Days after transplanting NS: Not significant

Assessment of changes in growth parameters over a period of time

The changes in effects of treatments on plant height, number of leaves, stem girth and number of branches were assessed based on the regression model of each variable over a period of time using the observations recorded on different days after planting. The results are described in Figure 9 for plant height and number of leaves and Figure 10 for stem girth and number of branches. The rate of change (cm/day) in plant height was found to be maximum in T7 (1.968 cm/day). while it was minimum in T6 (1.139 cm/day). The coefficient of determination (R2) for assessing the changes in plant height based on regression models of different treatments ranged from 0.715 for T5 to 0.909 for T1. The rate of change (number of leaves/day) in number of leaves was found to be maximum in T4 (0.348/day). while it was minimum in T6 (0.225/day). The coefficient of determination (R2) for assessing the changes in plant height based on regression models of different treatments ranged from 0.690 for T7 to 0.913 for T4.

The rate of change (cm/day) in stem girth was found to be maximum in T7 (0.078 cm/day). while it was minimum in T1 (0.06 cm/day). The coefficient of determination (R2) for assessing the changes in stem girth based on regression models of different treatments ranged from 0.889 for T2 to 0.978 for T7. The rate of change (cm/day) in number of branches was found to be maximum in T7 (0.311/day). while it was minimum in T6 (0.148/day). The coefficient of determination (R2) for assessing the changes in number of branches based on regression models of different treatments ranged from 0.883 for T3 to 0.94 for T1.

Figure 10: Effect of Treatments on Plant Height and Number of Leaves in Tomato Crop in Agrahara

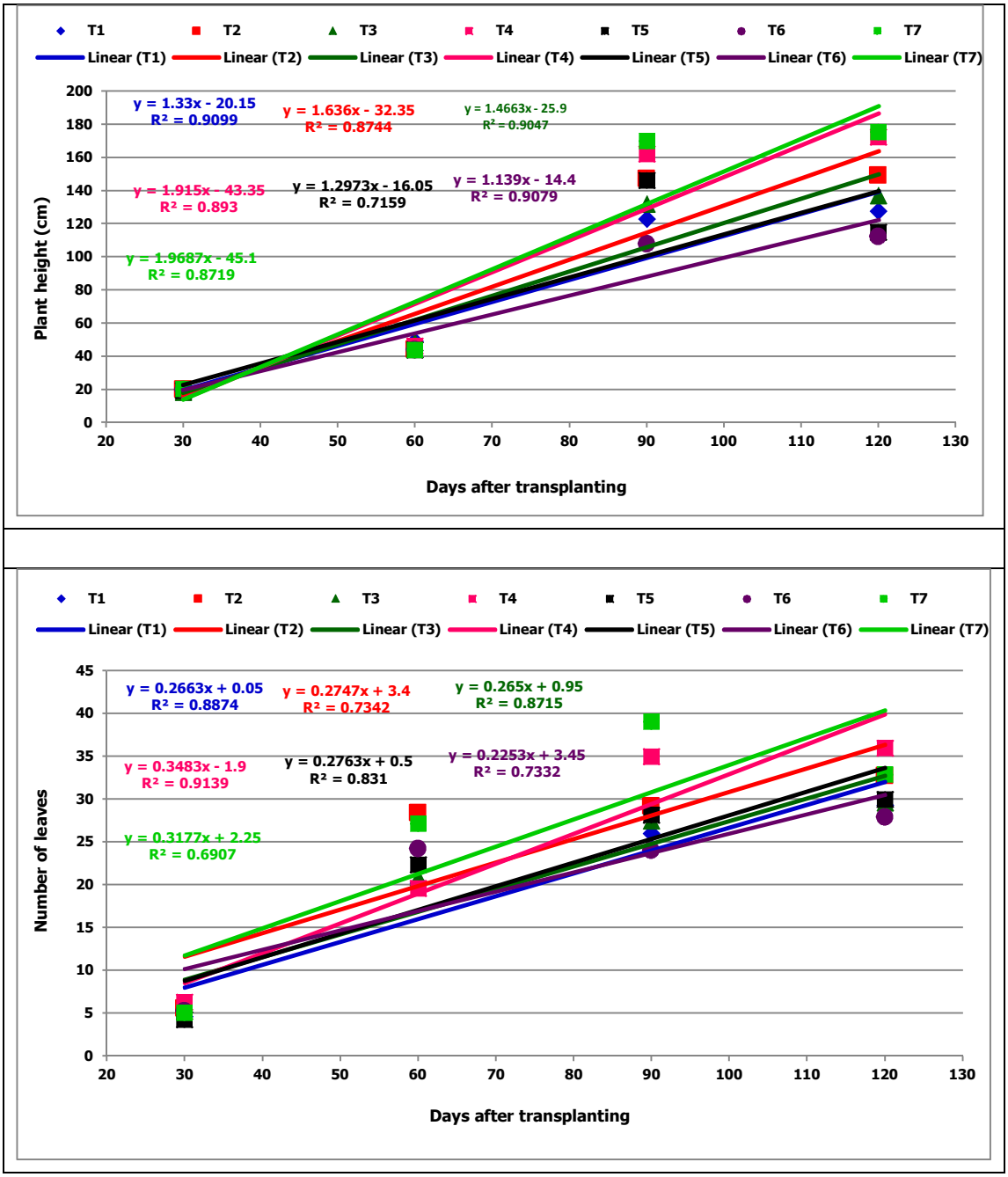
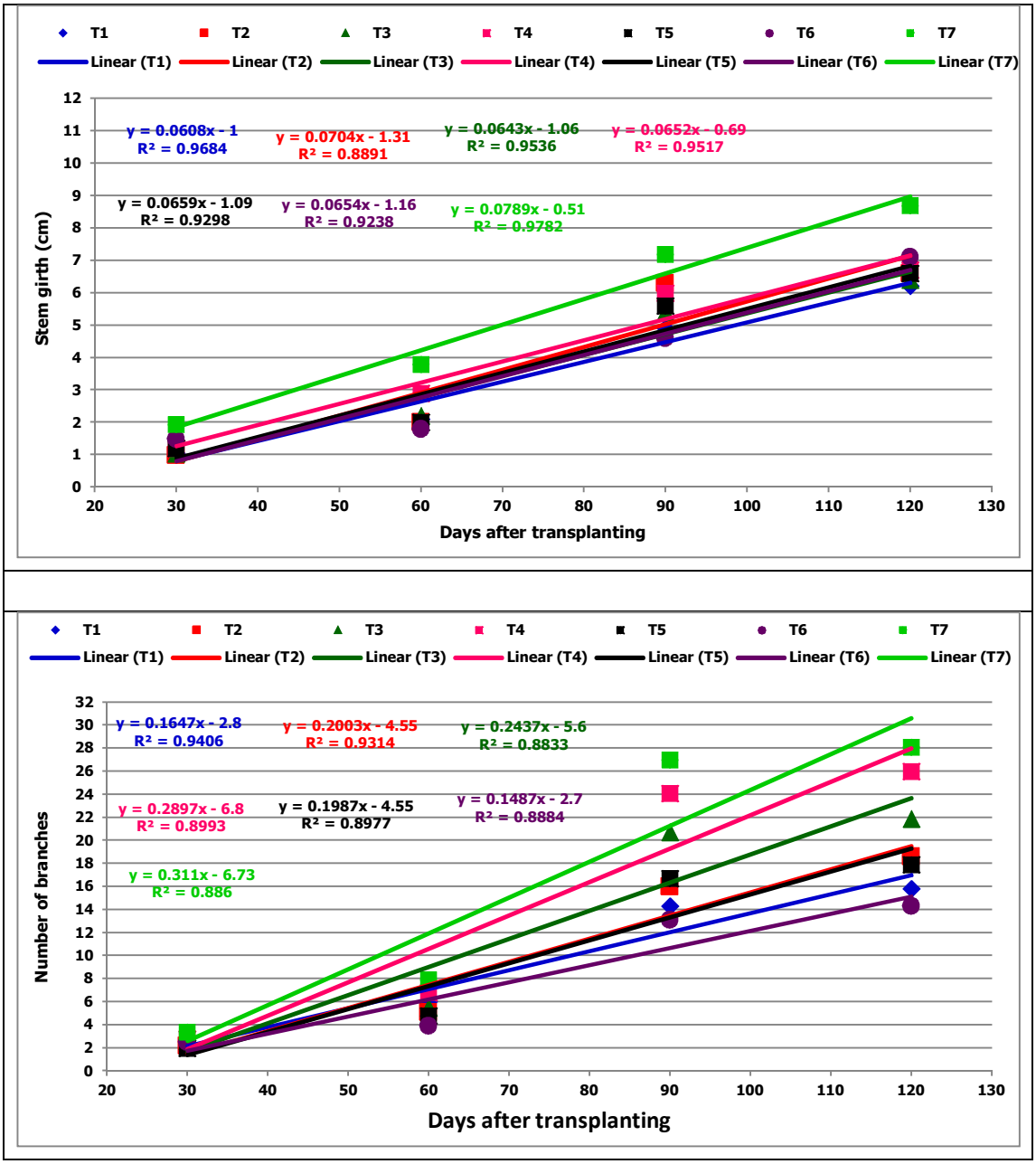


Figure 11: Effect of Treatments on Stem Girth and Number of Branches in Tomato Crop in Agrahara



It is observed that there is a significant increase in the vegetative growth of all the four parameters viz., plant height, number of leaves, stem girth, and number of branches in the tomato crop based on the field experiment conducted with different Package of Practices in Agrahara. The observations on the growth of vegetative growth parameters in the tomato crop indicated that they would greatly contribute for attaining maximum tomato productivity and monetary returns over years. In a study by Jain et al. (2000). the authors have observed that the drip irrigation has created a lot of interest because of the decreased water requirement and a significant increase in the production of crops.

Reproductive Growth Parameters

Number of fruits and fruit yield

The growth and development of reproductive parameters like the number of flower buds, number of fruits and weight of fruits were observed in the study. It was observed that there was an increasing trend in the growth and development and the number of fruits weighed per kilogram in the farmer's practice and also the different treatments compared. The fruit yield (kg/plant) ranged from 6 kg/plant in T2 and T6 to 8 kg/plant in T7 with mean of 6.86 kg/plant (CV of 10.1%). The fruit yield (t/ha) ranged from 77.25 t/ha in T6 to 112.50 t/ha in T7 with mean yield of 92.38 t/ha (CV of 12.7%). The number of fruits/kg ranged from 11.0 fruits/kg in T7 to 13.7 fruits/kg in T1 and T4 with mean of 12.6 fruits/kg (CV of 8.2%) over different treatments.

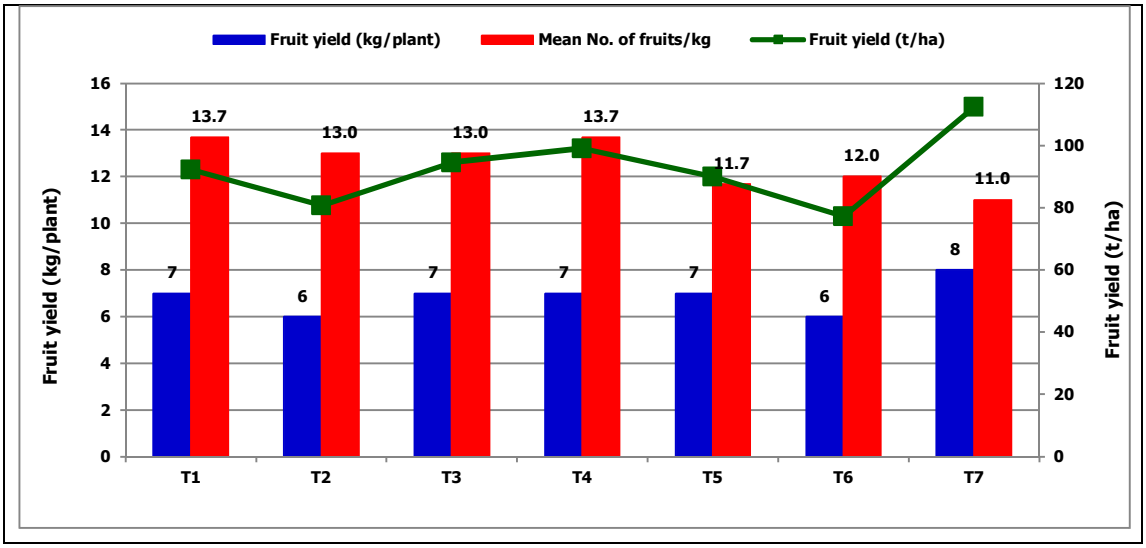
Based on ANOVA, the treatments were found to significantly differ for fruit yield (kg/plant) and fruit yield (t/ha). while there was no significant difference among the treatments for number of fruits/kg based on the study. The observations on fruit yield harvested (kg/plant). fruit yield per hectare (tons/ha) and mean number of fruits/kg attained under 7 treatments of Package of Practices of tomato along with the descriptive statistics and critical difference at 5% level of significance for comparing the difference between treatments are given in Table 4.63. The effects of treatments on fruit yield harvested (kg/plant). fruit yield per hectare (tons/ha) and mean number of fruits/kg attained under T1 to T7 are depicted in Figure 11.

Table 8: Fruit Yield (kg/plant). Fruit Yield Per Hectare (t/ha) and Number of Fruits/kg in Different Treatments Tomato Crop at Agrahara

Treatments	Fruit yield (kg/plant)	Fruit yield (t/ha)	Mean number of fruits/kg
T1	7	92.29	13.7
T2	6	80.82	13.0
T3	7	94.59	13.0
T4	7	99.19	13.7
T5	7	90.00	11.7
T6	6	77.25	12.0
T7	8	112.50	11.0
Minimum	6	77.25	11.0
Maximum	8	112.50	13.7
Mean	6.86	92.38	12.6
SD	0.69	11.72	1.0
CV (%)	10.1	12.7	8.2
SEM (+)	0.081	1.376	0.859
CD (5%)	0.251	4.24	NS

SEM: Standard error of mean CD: Critical difference CV: Coefficient of variation NS: Not significant

Figure 12: Effect of Treatments on Fruit Yield in Tomato Crop in Agrahara



An increasing trend was observed at both vegetative and reproductive stages of tomato crop in Agrahara village based on the study. This trend was mainly due to the presence of sufficient moisture and plant nutrients in the available ionic form under the mulched condition along with the drip irrigation.

Discussion

Comparative analysis of existing cultivation practices and scientific cultivation practices with sustainability and adaptability in the study area

Practice of soil testing

The basis of scientific cultivation would be testing the soils before taking up cropping. In the study area, it is observed that a majority (85.89 percent) of the farmers were not practising soil testing. The soil test would serve as a road map to check the soil suitability, its physical, chemical and biological properties, soil pH, organic carbon percentage, soil residual nutrients status, electrical conductivity, and many other parameters.

The tomato crop yields of 35-40 t/ha would remove almost 147.8 kg/ha of N, 19.8 kg/ha of P and 186.2 kg/ha of K (White, 1964). Hence, application of N and K would be very much important, and this should be done on a soil test basis. All these parameters would play an important role during the crop growing period in the field. Any cropping systems without soil testing would lead to soil fertility and soil health problems. Accordingly, nutrient management is one of the most cost-intensive cultural practices, which would constitute about 46 percent of the total cost of cultivation. There is a need to take care of the following issues:

Imbalance in the soil nutritional status

Poor soil fertility

Poor soil hygiene

Accumulation of heavy metals

Water logging

Low crop yields

Crop loss

Practice of transplanting bed preparation

The study indicated that 65.88 percent of the respondents were practising bed preparation for transplanting more than the recommended level, while 24.70 percent were doing it as over-practice. Excess and repeated ploughing of the soil would lead to the development of a powdery soil. The clay particles would settle at the bottom of the soil, and these would clog the drainage pore space and lead to the development of water clogging in the soil. It would also cause the formation of a hardpan and lead to a susceptibility of the top layer for erosion. It was evident that repeated ploughings could lead to the destruction of various species of earthworms and beneficial microbes and their count in the soil.

Maintaining optimum plant population per unit area

Based on the recommended spacing of 3.0 ft X 1.5 ft, the optimum plant population per unit area was 9990 plants/acre. It was observed that 74.11 percent of the respondents maintained a population of 14875 plants/acre. Due to more number of plants, a depletion for nutrients and moisture in the plant rhizosphere region would be created. The micro-climate within a row may cause infestation and spread of the leaf spot and leaf curl disease leading to a significantly higher management cost. Slowly, the insect-pest resistance build-up would occur. Alternatively, lower or insufficient number of plants per unit area would lead to lower yields, which would be highly uneconomical. About 10.59 percent of the respondents were found to maintain 5573 plants per acre based on the survey.

Practice of on-farm application of oiled neem cake, green manure, and chemical fertilizers

The effect of application of oiled neem cake in tomato crop was assessed. About 32.95 percent of the selected respondents were using it on par with the recommended package. This is a good sign for protecting the soil infestation. It has been scientifically proven that application of neem cake would significantly control the infestation in the soil and help in dissolving and slowing the release of soil nutrients. Often, the application of neem cake would act as a soil antiseptic. However, about 42.35 percent of the farmers were using less than the recommended level of oiled neem cake in their fields.

With regard to the application of green manure, it was observed that only 8.23 percent of the farmers were practising as per the recommendation, while 3.52 percent of the farmers were practising less than the recommended level, compared to 2.35 percent who were practising more than the recommended level. Hence, the total percent of respondents who were practising the green manure crops were only 14.1 percent, while 85.9 percent were not practising the green manure application. This is surely a threatening aspect of tomato cultivation. The practice of green manure application would improve both soil structure and the soil fertility of nutrients. It is a practice that would detoxify the soil to a great extent. Scientific evidence indicates that the practice of green manure application would help to build-up soil-beneficial microbial load, apart from improving the atmospheric nitrogen fixation. The

continuous practice of green manuring would significantly add organic matter to the soil, especially by improving the organic carbon in the top soil. This practice is essential for enhancing the soil quality, soil fertility and soil health, apart from providing sustainable crop yields for many years.

With regard to the application of chemical fertilizers, it was observed that among different respondents, about 28.23 percent were applying a lower dosage compared to the recommended level, while 37.65 percent of farmers were applying it on par with the recommendation and 34.11 percent were applying more than the recommended level. This indicated that 34.11 percent of the farmers require proper knowledge/training about need-based nutrition management, apart from the fact that an excess application would be a wastage of nutrients and also uneconomical.

The continuous use of water-soluble fertilizers (91.76 percent) in the soil could leach the non-dissolved ions into the soil parent material and would develop into a problematic soil. Based on the study, it is evident that a majority of the farmers were using a lower dosage of FYM and a few farmers followed the practice of green manuring. Hence, the possibility of accumulation of indissoluble ions and formation of problematic soils was observed to be very high. The percolation and seepage of these ions would exist, if the region receives a high rainfall. But the Eastern Dry Zone is not a high rainfall receiving zone and it has a mean number of 43 rainy days per annum. Immediate training and sensitization with respect to the soil management and its amelioration for sustaining the soils and crop productivity are very important.

Application of weedicides in tomato

The recommended practice is the application of pre-emergent weedicides, especially alachlor or butachlor and the dosage was 0.6 grams per litre but a majority of the farmers were using metribuzin which acts as both contact and systemic; in turn, these farmers were using this herbicide at higher dosage i.e. 1.0 ml per litre. The continuous use of this could also favour the accumulation of herbicide residues in the soil and it may contaminate the water bodies and cause irreparable damage to the aquatic ecosystem. Hence, serious sensitization about the higher dosage usage of herbicides needed to be done at the earliest.

Application of plant protection chemicals

The practice of application of plant protection chemicals includes insecticides and fungicides. It is observed that with regard to spray of insecticides, about 54.11 percent of the respondents were spraying more than the recommended level. It led to more crop resistance to pests. In the long-run, natural toughness would be developed. The continuous drift of these plant protection chemicals would also cause damage to the topsoil due to an easy detachment of the soil particles.

With regard to the spray of fungicides, it was observed that 40.0 percent of the farmers were applying fungicides on par with the recommended package, while 25.88 percent of the farmers were practising less than the recommended level and 34.12 percent were practising more than the recommended level. With higher dosage, the pest resistance and survivability may be faster in nature, but it would lead to many uneconomical benefits.

It was observed that 48.23 percent of the respondents were spraying 15 times, while 27.05 percent of the farmers were spraying 10 times and 24.20 percent of the farmers were spraying 20 times. Similarly, 45.88 percent of the farmers were spraying 4000 litres of spray solution, while 32.94 percent of the farmers were spraying 4500 litres of spray solution, and only 21.17 percent were spraying 3500 litres of spray solution in tomato crop.

The Practice of Irrigation

Number of irrigations per crop

The results indicated that 67.05 percent of the respondents were practising 60 irrigations per crop, while 23.52 percent of the respondents were using 50 irrigations, and 9.41 percent were using 40 irrigations per crop.

Quantity of water provided per irrigation

The results indicated that a majority of 71.76 percent of the farmers' usage of water varied from 0.5 to 4.0 litres per plant per irrigation, while 17.64 percent of the respondents were using 0.5 to 5.0 litres of water per plant, and 10.58 farmers were using 0.5 to 3.0 litres of water per plant in each irrigation.

Frequency of irrigation

It was observed that most of the farmers, i.e., about 61.17 percent were providing irrigation every alternate day, while 24.98 percent of the farmers were providing irrigation every day, and 14.11 percent of the farmers were providing irrigation once in four days.

Duration of the irrigation

The results indicated that 45.88 percent of the farmers were providing irrigation for 1.5 to 2.0 hours, while 30.58 percent were providing irrigation for 0.5 to 1.0 hours, and 23.32 percent of farmers were providing irrigation for more than 2.0 hours. Thus continuous cultivation of tomato crop in the region was causing a serious threat to the groundwater. In fact, the region was already declared as an over-exploited zone by the Central Ground Water Board. There was an urgent need to alert the farming community in this regard so that further exploitation of the groundwater was avoided.

The total cost incurred in drilling a borewell, installing a pump with high horsepower, installation of a full-fledged drip system, extraction of water from the borewell and its application cost were estimated. The cost per acre, in both experimental plot and farmers practice, were worked out and are described in Table 4.64.

Table 9: Estimates of Cost of Borewell, Drip Micro-irrigation System, Water Extraction and Application to the Crop in the Field in the Study Area

S no	Particulars	Unit/ cost worked out (Rupees)
1	Borewell depth range in feet- 475 ft to 1250 ft	Rs.1.40, 450
2	Pump set capacity	Rs.65790
3	Casing depth and cost – 300 ft to 500 ft	Rs.47550
4	Water yield in per hour	1586 gallons per hour i.e. 7137 liters per hour
5	Pump set running per day -	6 hours
6	Electricity charges for borewell HP Pump	NA-Nil
7	Average quantity of water extracted from each borewell per day	42822 litres
8	Cost of drip irrigation set installation per acre	Rs.55275
9	Cost incurred for collecting irrigation water	Total cost/ total quantity of water extracted = 309065/ 42822 = 7.21
10	Average quantity of water required per plant from transplanting to harvest & total frequencies of irrigations required per acre	4 litres and 60 frequencies per crop
11	Cost incurred for irrigation water application in control plot per acre	4 x 60 x 7.21= 1730.60 (M.G.Chandrakanth & Kirankumar 2014) #
12	Cost incurred for irrigation water application in experimental plot per acre	4 x 24 x 7.21= 692.16 (40.05 percent lower than farmers practice)

Irrigation cost per acre inch for individual owned wells is (Rs.629)

Analysis of cost of cultivation and benefit-cost ratio (B:C Ratio)

The details of agri-inputs used and monetary returns attained in the experimental field of tomato crop at Agrahara village are given in Table 4.68. An amount of Rs.82390/- was incurred as cost of cultivation for different inputs and agricultural operations during the crop cultivation period. An amount of Rs.306000/- was attained as a gross returns based on tomato yield of 45000 kg from the experimental site with a market price of Rs. 6.80 per kg of tomatoes. Thus from the experimental plot the net returns was calculated to be Rs.223610/-. The study gave a benefit-cost ratio of 3.71 from the tomato cultivation in Agrahara village. It was found to be significantly higher and economically viable with the adoption of Package of Practices in tomato crop cultivation. Further two relay crops viz., cowpea and ridge gourd were cultivated in the study.

With a limited number of 4 irrigations to cowpea and 8 irrigations for ridge gourd, an additional income of Rs.4845 and Rs.29910 was attained with benefit:cost ratios of 2.31 and 4.55 with cowpea and ridge gourd crops respectively. The study has clearly indicated that by adopting the recommended Package of Practices (PoP). the farmers could grow tomato crop along with two relay crops of cowpea and ridge gourd with the minimum number of irrigations and attain maximum yield and monetary returns with a high benefit-cost ratio in the region. Adoption of this model in the cultivation of tomato crop would lead to a change in the cropping patterns. The change in the cropping pattern would lead to crop rotation. Crop rotation with cereals, pulses and legumes would buildup soil fertility and soil health. The change in the cropping sequence would decrease the dependence on the groundwater table. The adoption and practice of integrated cropping practices would add the natural nitrogen fixation through green manuring. This in turn would ensure the inclusion of animal husbandry in the cropping systems. Both plant and animal components would ensure better livelihoods and ensure natural sustainability in the agro ecosystems.

Table 10: Details of Agri-inputs Used and Monetary Returns Attained in the Experiment in Agrahara

Sno	Type of inputs	Quantity	Unit cost (Rs)	Cost (Rs/acre)
1	Ploughing charges for 4 hours (Tractor cultivation)	1 acre	Rs.750/hour	3000
2	Tomato seedlings (Abinava variety)	5555	Rs.1/seedling	5555
3	Farmyard manure (t/acre)	12.5	700	8750
4	Pangamia & neem cake (kg/acre)	250	18	4500
5	Synthetic fertilizers (kg/ha)	375	21	7875
6	Plant protection chemicals (litres)	28	550	15400
7	Staking sticks/stumps (No.)	1750	6	10500
8	Steel wires (kg)	20	80	1600
9	Gunny twine/rope (kg)	32	30	960
10	Vermicompost (kg/acre)	3000	3	9000
11	ZnSo4 & MgSo4 (kg)	5 each	40	400
12	Bio-fertilizers (kg)	2.5	42	75
13	Irrigations (No.)	30	140	4200
14	Black polythene sheet (kg)	25	90	2500
15	Drip mains, laterals & inlets (meters)	350	2.5	875
16	Labour (No.)	32 (24 women & 8 men)	Rs.200 (woman) Rs.300 (man)	7200
17	Total cost (Rs.)			82390
18	Total harvested fruit yield (kg)	45000 kg	6.8	306000
19	Total cost of cultivation (Rs.)			82390
20	Net returns (Rs.)			223610
21	Benefit : Cost ratio			1 : 3.71

Source: Data from field experiment conducted in Agrahara

Post-experimental studies in the field

Before final harvesting of the main crop in the field, two relay crops were taken up without any land preparation and no basal dosage application of synthetic fertilizers.

A. Relay cropping

The practice of sowing or raising a second crop before harvesting the main is called relay cropping. The two short duration crops namely cowpea and ridge guard were raised and the substantial yields were harvested as additional crops and income with minimum investment.

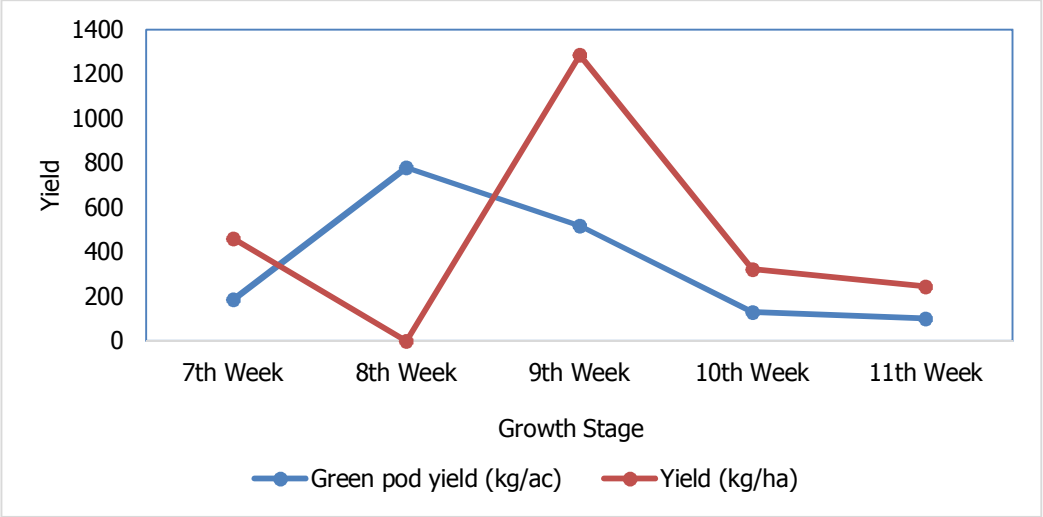
Cowpea (*Vigna unguiculata*) was taken upfor sowing 120 days after tomato planting the seeds of cowpea S-411 in between the tomato plants at 2.0 ft X 2.0 ft spacing. After germination of the seeds only liquid fertilizers and irrigation along with tying of veins to fixed wooden poles was carried out. And 45 days after sowing, the runners had initiated the flowering and pod formation. In the 7^{th} week, a sample of the green pods produce was harvested. The harvesting was continued for a few more weeks and the total green pods harvested in different weeks were recorded and the same are presented in the following table.

Table 11: Green Pod Yield of Cowpea Grown as Relay Crop in Tomato

S. No	Growth stage	Green pod yield (kg/ac)	Yield (kg/ha)	Total CoC/Ac (Per Acre)
1	7th Week	185.4	459.79	Seed - 350-00
2	8th Week	778.60	1930-92	Irrigations (4)- 560-00
3	9th Week	519.00	1287.12	Labour- 1800-00
4	10th Week	129.60	321.40	Top dressing-1000-00
5	11th Week	98.50	244.28	Total cost (Rs) 3710-00
Total		1711.1	4243.51	Avg. Price per kilogram (Greens)- Rs.5.0
Total crop yield (Kg) 1711.00 x5.0 =				8555-00
Gross cost of cultivation (Rs).				3710-00
Net Profit (Rs)				8555-3710= **4845-00**
B:C ratio				**1:1.3**

Source: Data from field experiment conducted in Agrahara

Figure 13: Green Pod Yield (kg/ac) in Cowpea (*Vigna anguculata)* in Different Growth Stages



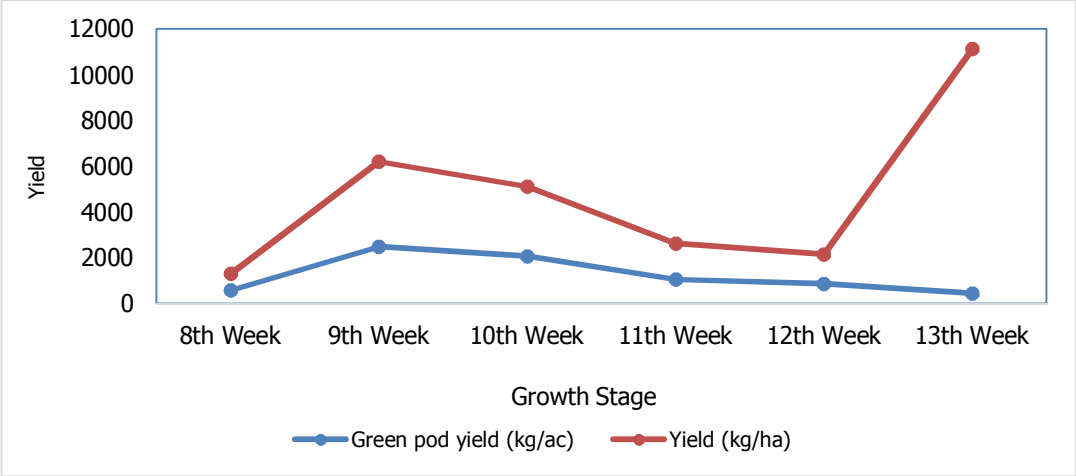
Ridge gourd (*Luffa acutangula*) was taken up for sowing 120 days after tomato planting, with the seeds of cowpea S-411 in between the tomato plants at 2.5 ft X 2.5 ft spacing. After germination of the seeds, only liquid fertilizers and irrigation along with tying of veins to the fixed wooden pole was carried out. And 55 days after sowing, the runners initiated the flowering and pod formation. In the 8th week, a sample of the green fingerlings produce was harvested. The harvesting was continued for a few more weeks and the total of green fingerlings harvested in different weeks was recorded and the same are presented in the following table 11.

Table 11: Green fingerlings yield in ridge gourd grown as relay crop in tomato

S. NO	Growth stage (Weeks)	Green pod yield (kg/ac)	Yield (kg/ha)	Total CoC/Ac (Per Acre)
1	8th Week	572-00	1318-00	Seed - 650-00
2	9th Week	2488-00	6220-00	Irrigations (8)- 1120-00
3	10th Week	2052-00	5130-00	Labour- 2400-00
4	11th Week	1050.00	2625-00	Top dressing-4000-00
5	12th Week	865-00	2163-00	Total cost (Rs) – **8170-00**
6	13th Week	454-00	11135-00	Avg. Price per kilogram (Greens) - Rs.5.0
	Total	7436-00	18590-00	
	Total crop yield (Kg) 7436 x5.0 = **37180-00**			
	Gross cost of cultivation (Rs). **8170-00**			
	Net Profit (Rs) = 37180-00 – 8170 = **29010-00**			
	B:C ratio **1;3.5**			

Source: Data from field experiment conducted in Agrahara

Figure 14: Green Fingerlings Yield (kg) in Ridge Gourd as Relay Crop in Different Growth Stage



Soil microbial biomass: The most practicable and general procedures of the natural status of soil is the microbial biomass. (Jenkinson, 1988), it theater a key role in soil nutrient transformation and largely controls the rate of C:N ratio in addition to other nutrient cycles. Microbial activity was found to be influenced by the type of vegetation, substrate availability and abiotic factors in the ecosystem.

Soil microbial biomass varied significantly among the treatments at different stages of crop growth. Increased soil microbial biomass (3669 micrograms) was noticed in the treatment which received the more organics along with vermi compost and recommended dose of fertilizers. The biomass in the treatments which received farmyard manure and vermi compost and no recommended dose of fertilizers T6 was on-par (3565 micrograms) with the T7 and lower microbial biomass was noticed in the treatment which received no organic manures but the control T1 (1355 micrograms) has registered 38 percent of the best treatment.

Analysis of cost of cultivation and benefit cost ratio

Table 12: Details of Agri-inputs Used in the Experiment and the Cost Incurred in Rupees (Rs)

S. No	Type of In-puts procured	Quantity (No/Ac)	Unit cost (Rs)	Cost (Rs/Ac)
1	Ploughing charges (Tractor cultivation)	1.0 Acre	@Rs.750 x4 hr	3000.00
1	Tomato seedlings–Abinava variety (No.)	5555-00	@ Rs.1.0 per seedling	5555-00
2	Farm Yard Manure (t/Ac)	12.50	@Rs.700-00	8750-00
3	Pongamia & neem cake (kg/Ac)	250 -00	@ Rs.18-00	4500-00
4	Synthetic fertilizers (kg/ha)	375-00	@ Rs.21-00	7875-00
5	Plant protection chemicals (lit)	28.00	@ Rs.550-00	15400-00
6	Staking sticks/stumps (No)	1750-00	@ Rs.6.0	10500-00
7	Steel wires (kg)	20.00	@80.00	1600-00
8	Gunny twine/rope (kg)	32.00	@ Rs.30-00	960-00
9	Vermi compost (Kg/Ac)	3000-00	@Rs.3.0	9000-00
10	Zn So4 & MgSo4(kg)	5.0 each	@ Rs.40-00	400-00
11	Bio fertilizers (kg)	2.5	@ Rs.42-00	75-00
12	Irrigation charges (No)	30.00	@Rs.140-00	4200-00
12	Black polythene sheet (kg)	25 .00	@ Rs.90-00	2500-00
13	Drip mains, laterals & inlets (mts)	350	@ Rs.2.5-00	875-00
14	Labour costs (Rs.)	32 no (24 women+8 men)	@Rs.200 per women & Rs.300 per Men	7200-00
	Total cost (Rs.)			**82,390-00**
17	Total fruit yield (Harvested) (kg)	**45,000 -00 kg**	**Rs.6.80**	**3,06,000-00**
18	Total cost of cultivation (Rs)	**82,390-00**		
19	Net Profit (Rs)	**2,23,610**		
20	B:C ratio	**1:2.7**		

(Source: Data from field experiment conducted in Agrahara)

Conclusion

In Agrahara, farmers aged between 25-65 years (CV of 32.9%) & had family size of 3-15 persons (45.9%). Their land holding ranged from 2.1-7.2 acres (36.3%) & had 1-4 borewells (32.3%). Groundwater depth was 480-1200 feet (24.2%). Farmers had experience of 2.5-10 years (31.9%). Tomato was grown 3-5 times/year (15.2%) with yield of 57.5-92.5 t/acre (13.5%). Tomato seedlings used were aged 22.5-30 days (6.4%). Farmers applied FYM @ 10-15 t/ha (16.7%). Crop was irrigated once in 2-7 years (54.7%), with duration of 0.75-1.25 hours (18.5%); irrigation quantity of 1.75-2.75 liters (10.8%). Crop susceptibility ranged from 20-50% (27.8%). Farmers invested Rs.25000 to Rs.50000 (14.2%) & used 3000-4000 wooden poles (9.4%).

In Kachihalli, farmers aged between 28-63 years (CV of 27.1%). Family size ranged from 3-9 persons (28.6%). Land holding ranged from 1.7-6.9 acres (34.1%). They had 2-5 borewells (30.6%), while groundwater depth was 600-1200 feet (21%). Farmers had experience of 2.5-10 years (31.9%). Farmers have grown tomato for 3-5 times/year (19.4%) & attained yield of 57.5-87.5 t/acre (12.8%). Tomato seedlings had age of 22.5-30 days (9.7%). Farmers applied FYM @ 10-15 t/ha (17.5%). Crop

was irrigated once in 2-4 years (27.7%), while irrigation duration was 0.75-1.25 hours (20.4%). Irrigation quantity ranged from 1.75-2.75 liters (13.1%). Crop had susceptibility of 25-50% (29%). Farmers invested Rs.25000/- to Rs.50000/- (16.6%). Wooden poles used were 3000 to 4000 (10.2%).

In Kendanahalli, farmers were aged 27-61 years (CV of 26%). Family size ranged from 4-7 persons (16.7%). Land holding ranged from 1.5-6.5 acres (31.6%). Farmers have 2-5 borewells (28.6%), while groundwater depth was 600-1420 feet (26%). Farmers had experience of 2.5-10 years (40.9%). They have grown tomato for 3-5 times/year (16.2%) & attained yield of 65-87.5 t/acre (10.8%). Tomato seedlings were aged 22.5-30 days (9%). Farmers applied FYM @ 10-15 t/ha (14.7%). Crop was irrigated once in 2-7 years (32.4%), while duration was 0.75-1.25 hours (18%). Irrigation quantity applied was 1.75-2.75 liters (12.5%). Crop had susceptibility of 25-50% (29.8%). Farmers invested Rs.25000/- to Rs.50000/- (14.4%). Wooden poles used were 3000-4000 (9.2%).

In Kallahalli, farmers were aged 27-68 years (CV of 26%). Family size ranged from 4-10 (25.7%) with land holding of 2.1-7.2 acres (33.9%). Farmers had 1-4 borewells (26.9%), while groundwater depth was 480-1350 feet (25.6%). Farmers had experience of 2.5-10 years (32%). Farmers have grown tomato for 3-5 times/year (13.8%) & attained yield of 57.5-87.5 t/acre (10.6%). Tomato seedlings were aged 22.5-30 days (7.2%). Farmers applied FYM @ 10-15 t/ha (16.2%). Crop was irrigated once in 2-7 years (33%), while irrigation duration was 0.75-1.25 hours (17.4%). Irrigation quantity was 1.75-2.75 liters (11.2%). Crop susceptibility was 25-50% (28.7%). Farmers invested Rs.25000/- to Rs.50000/- (12.6%). Wooden poles used were 3000-4000 (9.1%).

Pooled analysis indicated that farmers were aged 25-68 years (CV of 28.7%). Family size ranged from 3-15 persons (35.4%). Land holding ranged from1.5-7.2 acres (33.7%). Tomato was irrigated once in 2-7 days (46.5%). Quantity of water ranged from 1.75-2.75 liters/irrigation/plant (11.8%). Irrigation duration ranged from 0.75-1.25 hours (18.7%). Farmers had experience of 2.5-10 years (35.3%). **Tomato seedlings were aged 22.5-30 days (7.9%). Farmers applied FYM @ 10-15 t/ha (15.1%). Farmers had 1-5 borewells (34.2%), while groundwater depth was 480-1420 feet (25.9%). Farmers cultivated tomato for 3-5 times/year (16.1%) & attained yield of 57.5-92.5 t/acre (12%). Crop susceptibility was 0-50% (93.9%).** Farmers invested 0 to Rs.50000/- (46.9%). Wooden poles used were 3000-4000 (9.4%).

Experience was cashless input for cultivation. Innovativeness & motivation for livelihood improvement was maximum. As head of family & with responsibilities, farmer continued farming profession. **About 43 farmers (50.59%) were in middle age group,** while 18 farmers (21.17%) were in young age group & 24 farmers (28.24%) were in old age group. **Old age farmers are not strong to do hard work, but their experience/innovativeness serves as milestone for youth & middle aged farmers**.

Family size indicated that **59 farmers (69.42%) had medium-size family with 5-7 people**. Being labour intensive crop, medium-sized families are actively involved in tomato cultivation. About 14 farmers (16.47%) belonged to large-size family who cultivated large areas. **Higher the number of family members, more intensive farming is carried out.** This group acts as source of implementation of new innovations/technology. About 12 farmers (14.11%) had small-size family (<4 members).

Participation of people with higher education in farming was low. Education of respondents indicated that 12 farmers (14.11%) were illiterate, while 16 farmers (18.82%) completed primary education, 20 farmers (23.52%) studied upto higher primary & 33 farmers (38.82%) studied upto high school**. Use of pesticides & number of irrigations was more in primary education group.** Only 4 farmers (4.72%) studied up to pre-university/college level.

Majority were in joint family system i.e., 52 respondents (61.18%). Findings confirmed that rural country is predominantly agriculture-based. It needs more labour & family has >7 people. Presence of more family members is an asset & help in agricultural operations. Involvement of family members reduces cost of cultivation. Remaining 33 respondents (38.82%) belonged to nuclear family type.

Distribution of land holdings indicated that 47 respondents (55.3%) were medium, while 27 respondents (31.76%) were large & 11 respondents (12.94%) were small farmers. Thus 74 respondents (87.06%) belonged to medium & large group of farmers who were cultivating tomato. Size of operating area depended on size of family & number of working members. Bigger the family size, larger was operating area. Agriculture requires sufficient labour for efficiently taking up operations with timeliness & precision. This ensures farmers to attain sustainable & profitable yield.

About 10 farmers (11.76%) were testing soils every year, while 19 farmers (22.35%) were testing once in 3 years & 56 farmers (65.88%) were not testing soils. ***Farmers who cultivated tomatos are disturbing soil health by applying excess fertilizers & destroying earthworm population. Efficient cultivation is done by testing soil before taking up cropping. Soil testing serves as road map for assessing soil suitability & physical/chemical/biological properties, pH, OC, soil nutrients, EC etc. NPK application should be based on soil test values. Growing crops without soil testing leads to problems of imbalance in soil nutrients; soil hygiene; heavy metals; low yield & water logging.***

Recommended practice of transplanting bed preparation is 2 times ploughing+1 time harrowing. About ***56 farmers (65.88%) adopted 3 times ploughing+2 times harrowing, while 21 farmers (24.7%) adopted 4 times ploughing+3 times harrowing*** & only 8 farmers (9.42%) were on-par with recommended practice. **If the practice is not adopted, it leads to destruction of soil**. Textural soil class is red clay & clay loam soils which cause compactness in root rhizosphere region since clay particles are heavier & lead to waterlogging due to low infiltration. **Excess/repeated ploughing makes soil powdery & lead to movement of clay particles. This movement incepts the soil erosion during monsoon season. Repeated ploughing also aids in the blocking of natural drainage Repeated ploughing also leads to destruction of beneficial microbes in soil.**

Recommended plant population is 9990 plants/acre & spacing is 3 ft X 1.5 ft. **About 63 respondents (74.11%) adopted spacing of 3 ft X 1 ft & maintained population was 14,875 plants/acre. Due to non-practice/adopting narrow spacing, maximum plants were accommodated. This created competition for light, water & nutrients. Dense population gave scope for change in micro-climate of plant canopy, apart from developing pest/diseases. To efficiently manage pest/diseases, spray of plant protection chemicals is**

important. Cost of cultivation increases due to increase of pest/diseases. Hence, the tomato leaf curl disease prevails throughout the growing season and it has become one of the noncurative diseases in tomato in the region. About 13 respondents (15.3%) adopted spacing of 3.5 ft X 1.5 ft with population of 8608 plants/acre, while 9 respondents (10.59%) adopted 4 ft X 2 ft with population of 5573 plants/acre. Gaps in rows promote growth of weeds, management of which would add to cultivation cost.

Neem cake application to vegetable fields is recommended since it contains *azaradictin* plant hormone which inhibits the growth of disease causing fungal & bacterial colony, root–knot and root gall disease causing nematodes in soil. This enhances sustainability of yield & soil fertility. Neem cake acts as antagonistic and antiseptic. It controls soil infestation, replenishes soil & acts as soil antiseptic**. On-farm practice of oiled neem cake @ 100 kg/acre was adopted by only 28 farmers (32.95%), while 36 farmers (42.35%) used less & 21 farmers (24.7%) used more than recommended level.**

Green manures detoxify soil & buildup soil-beneficial microbial load & atmospheric $\mathbf{N_2}$ fixation. They add organic matter & increase soil organic carbon (SOC). It is important for attaining sustainable yield & maintenance of fertility. **Only11 farmers (12.94%) were applying, while 74 farmers (87.06%) were not** applying green manures. **Recommended dose of green manures is 2 t/acre. Seven farmers (8.23%) applied green manures as per recommendation, while 2 farmers (2.35%) each applied less & more than recommended level. It is threatening aspects in tomato cultivation with respect to loss of SOC. Lower the SOC, higher the rate of soil susceptibility in terms of soil erosion & fertility**. Low fertile soils require external feeding with fertilizers. With fertilizer application, soil loses its native fauna/flora &not supports plant population. To overcome these issues, green manures are recommended to buildup soil physical/chemical/ biological properties.

With regard to of chemical fertilizers, recommended dose is 100 kg/acre each of NPK. About 24 farmers (28.23%) were applying less than recommended dose, while 32 farmers (37.65%) were applying on-par &**29 farmers (34.11%) were applying more than recommended dose**. Farmers need thorough knowledge/training on nutrition management. They should be trained about implications with excess application/wastage when crop exhausted all nutrients. Excess application leads to fertilizer wastage & destroys soil properties & enhances cultivation cost.

About 78 farmers (91.76%) were using water-soluble fertilizers through drip, while 7 farmers (8.24%) were applying as basal/top-dressing. About 42 farmers (49.41%) were applying micronutrients, **while 43 farmers (50.58%) were not applying any micronutrients**. **Continuous use of water-soluble fertilizers by 78 farmers (91.76%) through drip caused whitish top soil due to release of non-dissolvable anions & cations into soil & causing soil degradation and No single earthworm was notice in this top soil (0.5 ft depth).** Majority of farmers were using low FYM, while 12 farmers (14.1%) were applying green manures. Formation of white patches near edge of each tomato row was due to excess water soluble fertilizer application. Farmers should be trained/sensitized regarding soil management practices to obtain sustained yield levels.

Recommended dose of **weedicide** is alachlor @ 0.6 g/liter & butachlor @ 0.6 g/liter water as pre-emergent dose. **About 62 farmers (72.95%) applied more,** while 18 farmers (21.17%) applied less & 5 farmers (5.88%) applied as per recommended dose. Farmers used metribuzin @ 1 ml/litre to control pre-emergent & post-emergent weeds. Continuous use leads to accumulation of herbicide residues in soil and destroy soil living biota. Weedicide residues contaminates water bodies & cause irreparable damage to aquatic ecosystem. Training of farmers on ill-effects of use of higher herbicide dose should be done immediately.

About 47 farmers (55.29%) sprayed higher insecticide dose, while 14 farmers (16.47%) sprayed less than recommended level & 24 farmers (28.24%) adopted recommended level. Regarding fungicides, 34 farmers (40%) adopted recommended dose, while 22 farmers (25.88%) used less & 29 farmers (34.12%) used more than recommended dose. With higher fungicide dose, pest resistance/survival is faster & application will be uneconomical.

Plants become highly susceptible to pests/diseases. Repeated/consistent spray would cause accumulation of residuals in plant/soil/water/human ecosystem. Tomato leaf curl viruses are also spreading through irrigation water, while infected fields are contaminating non-infected fields. **Cultivation of trap crop was recommended and it aids in the prevention of pest infestation by 35-40%**& minimize spray frequency. Need to educate farmers about implications arising due to excess use of plant protection chemicals.

Regarding number of sprays & spray solution, **41 farmers (48.23%) sprayed 15 times, while 23 farmers (27.06%) sprayed 10 times & 21 farmers (24.71%) sprayed 20 times**. Regarding spray solution, 39 farmers (45.88%) sprayed **4000 liters**; while 28 farmers (32.94%) sprayed **4500** litres & 18 farmers (21.18%) sprayed 3500 liters per acre/cycle. Regarding No. of irrigations, **24-26 irrigations are optimum.** Farmers were irrigating continuously on every alternate day. **About 57 respondents (67.05%) gave 60 irrigations, while 20 respondents (23.52%) gave 50 irrigations & 8 respondents (9.41%) gave 40 irrigations.** After each picking, irrigation once in a week is enough when crop moved from reproductive to senescence stage. Post-reproductive stage contains maximum K which supports resistance to moisture stress. Water is extracted through borewells & there is heavy pressure on groundwater. **Water requirement/plant depends on crop stage & season. About 61 respondents (71.76%) used 0.5-4 litres/plant, while 16 respondents (18.82%) used 0.5-5 litres/plant & 9 respondents (10.58%) used 0.5-3 litres/plant per irrigation.** During 2-4 weeks after transplanting, quantity of water/plant varies from 0.5-1 litre in summer & 0.5-0.75 litre in winter & rainy seasons. **Water requirement is about 3.5-4 litres/plant during flowering & fruiting stages.**

As per recommendation, frequency of irrigation is *weekly once under ridge & furrow method*. About 52 farmers (61.17%) were providing irrigation on alternate day, while 21 farmers (24.98%) provided irrigation daily. About 11 farmers (14.11%) provided irrigation once in 4 days due to water scarcity. Stage of crop & moisture in root rhyzosphere region is important for irrigation. About 82 farmers (97%) cultivated tomato with black polythene mulch & trickle/drip irrigation. Farmers do not understand field capacity, crop water requirement & available soil moisture. Mindset of farmers that irrigations should be provided daily even if moistness is there in soil should change. Irrigation duration

with drip depends on soil type/water flow rate. Finer soil type with higher water reduces irrigation duration. About 39 farmers (45.88%) provided irrigation for 0.5-1.5 hours, while 26 farmers (30.58%) provided for 0.5-1 hour & 20 farmers (23.32%) provided for 0.5-2 hours. Tomato cultivation is a threat to groundwater. Need to educate farmers on groundwater use/irrigation. Intensive tomato cultivation affected socio-economic features, ecosystem & farm micro-climate. About 17 farmers (20%) were engaged in tomato cultivation for <5 years, while 32 farmers (37.65%) had 5-10 years experience. 36 farmers (42.35%) had >10 years experience. Responses pertain to package of practices for tomato indicated that 9 farmers (10.59%) had knowledge, while 76 farmers (89.41%) had no knowledge of package of practices. Regarding adoption of package of practices, 13 farmers (15.29%) preferred exposure visit, while 11 farmers (12.94%) preferred Krishimela, 9 farmers (10.59%) preferred Farmers Field School & 52 farmers (61.18%) preferred field demonstration. 6 farmers (7.06%) used Zonal recommended planting material, while 69 farmers (81.18%) used recommended material of private companies. About 10 farmers (11.76%) used from both sources.

Recommended age of seedlings for transplanting is 22-24 days old. Seedlings should be stout, disease-free & highly-viable. About 58 respondents (68.23%) adopted 25-30 days old seedlings, while 16 respondents (18.82%) adopted >30-days old seedlings & only 11 respondents (12.95%) adopted 22-24 days old seedlings.52 respondents (61.18%) used recommended FYM@ 15 t/acre, while 24 respondents (28.23%) used FYM@ 10 t/acre & 9 respondents (10.59%) used >15 t/acre. 24 respondents (28.24%) used biofertilizers for seed treatment/application each year, while 54 respondents (63.53%) applied once in 3 years & 7 respondents (8.23%) did not use bio-fertilizers. Regarding planting African Marigold as trap crop for every 16 tomato rows, it was planted by 19 respondents (22.35%). 51 respondents (60%) did not adopt this & have grown fodder maize as border crop. 15 respondents (17.65%) adopted more than recommended practice which is costly practice.

Postfield experimentation study indicated that in Aggrhara 21 farmers (85%), in Kallahalli 16 farmers (80%), in Kachahalli 18 farmers (90 %) and in Kendhanahalli 15 famers (75%) are adopted the field demonstrated cultural practices (package of practices) and it is was observed that it has influenced nearly 60-70 per cent of the surrounding tomato cultivators and are practicing these practices in the study region.

Recommendations:

1. Provision should be made the availability of new HYV at the public research institutes.
2. Season and demand based cropping systems has to be introduced in the region
3. Permissions and strict rules must be framed pertains to drilling of new bore wells and ground water extraction
4. Strengthening of argil extension system to update the modern agricultural technologies to the farming community.
5. Soil test based fertilizers recommendations and conservation of soil fauna & flora needs to be educated among all the farming community.

References

Achutaraju, K and Radhakrishnamurthy (2001). Knowledge Level of Betel Vine Growers. *Journal of Extension Education*, 13 (1): 3271-76.

Anilkumar, P (2001). Irrigation and Nitrogen Management through Drip Fertigation in Chilli. *M.Sc (Agri.) Thesis.* Submitted to Acharya N.G.Ranga Agricultural University, Hyderabad.

Ara, N, M K Bashar, S Begam and S S Kakon (2007). Effect of Spacing and Stem Pruning on the Growth and Yield of Tomato. *Int.J.Sustain.Crop.prod.*, 2: 35-39.

Aujla, M S, H S Thind and G S Butter (2005). Cotton Yield and Water use Efficiency at Various Levels of Water and Nitrogen through Drip Irrigation under Two Methods of Planting. *Agricultural Water Management*, 71: 167-79.

Branthome, X, Y Ple, J R Machado and B J Bieche (1994). Influence of Drip Irrigation on the Technological Characteristics of Processing Tomatoes. *Acte Horticulture*, 376: 285-90.

Chandrashakara, S K (2007). Analysis of Onion Production and Marketing Behaviour of Farmers in Gadag District of Karnataka. *M.Sc. (Agri.) Thesis. Univ.Agric. Sci.*Dharawad, Karnataka (India).

FAO (2006). Fertiliser Use by Crop in Sudan. United Nations, Rome: Land and Plant Nutrition Management Service, Land Water Development Division, Food and Agriculture Organization.

Gulshan, M and K G Singh (2006). Response of Greenhouse Tomato to Irrigation and Fertigation. *Agricultural Water Management*, 84: 202-206.

Hamid Reza Rajablariani, Farzad Hassankhana and Ramin Rafezi (2012). Effect of Coloured Plastic Mulches on Yield of Tomato and Weed Biomass. *International Journal of Environmental Sciences and* Development, 3 (5): 590-93.

ICRISAT (1988). International Crops Research Institute for Semi-Arid Tropics, Annual Report. Patancheru Hyderabad, Andhra Pradesh (India): ICRISAT.

Jayakrishnakumar, V and G P Pillai (1991). Water Use Efficiency of Bhendi as Affected by Irrigation and Split Application of Nitrogen. *Agricultural Research Journal of Kerala*, 29: 75-78

Kadam, J R and J S Sahane (2001). Studies on Water Use Efficiency and Yield of Tomato, As Influenced by NPK Fertilizers Briquette. *Journal of Maharashtra Agriculture* University, 26 (3): 231-33.

Laksmisha (2000). Impact of Cashew Demonstration on Knowledge and Adoption and Yield Levels of Farmers in Dakshina Kannada District. *M.Sc. (Agri.) Thesis.* Bangaluru, Karnataka: Univ. Agric. Sci.

M Shalini, Devaraja and Manjunatha Gowda (2016). Impact of Frontline Demonstration on Yield and Economics of Tomato in Chikkaballapura District of Karnataka. *International Journal of Applied and Pure Science and Agriculture*, 2 (7): 4-8.

Mahamad, A P, I Mahammad, S Khuran and Anwar-UL-Hassam (2009). Effect of Mulch on Soil Physical Properties and NPK Concentrations in MAIZE (*Zea mays*) Shoots Under Two Tillage Systems. *International Journal of Agriculture and Biology*, 11: 120-24.

Mukherji, A, M Kundu and S Sarkar (2010). Role of Irrigation and Mulch on Yield, Evapotranspiration Rate and Water Use Pattern in Tomato. (*Lycopersicon sculentum L*) *Agricultural Water Management*, 98: 182-89.

Nagaraja, N N (2009). Kare Acchukattu Pradeshakke Adhunika Krishi Thantrikathegalu. Bangalore: UAS, GKVK.

Narendra Agrawal, H K Panigrahi, D Sharma and R Agrawal (2010). Effect of Different Colour Mulches on Growth and Yield of Tomato under Chhattisgarh Region. *Indian Journal of Horticulture*, 67: 295-300.

Panigrahi, B, D P Roy and S N Panda (2010). Water Use and Yield Response of Tomato as Influenced by Drip and Furrow Irrigation. *International Agricultural Engineering Journal*, 19: 1-19.

Patil, N (2005). A Study on Knowledge Extent of Participation and Benefits Derived by Participant Farmers of the Watershed Programme. *M.Sc. (Agri.) Thesis.* Dharwad, Karnataka: Univ.Agric.Sci.

Reddy, V S V (2006). Knowledge and Adoption of Integrated Pest Management Practices among Vegetable Growers of Gadag District in Northern Karnataka. *M.Sc. (Agri.) Thesis.* Dharwad, Karnataka: Univ.Agric.Sci.

Shashidhara, D N (2004). A Study on Influencing Factors and Constrains in Drip Irrigation of Horticulture Farmers of Bijapur District. M.Sc. *(Agri.) Thesis.* Dharwad, Karnataka: Univ.Agric.Sci.

Singh, P N, B P Joshi and G Singh (1987). Effect of Mulch on Moisture Conservation, Irrigation Requirement and Yield of Potato. *Indian Journal of Agronomy*, 32 (4): 451-52.

Sunilkumar, G M (2004). A Study on Farmer's Knowledge and Adoption of Production and Postharvest Technology in Tomato Crop of Belgaum District in Karnataka. M.Sc. *(Agri.) Thesis.* Dharwad, Karnataka: Univ.Agric.Sci.

Suresh Kumar (2009). A Study on Technological Gap in Recommended Soybean Cultivation Practices. M.Sc. *(Agri.) Thesis.* Dharwad, Karnataka: Univ.Agric.Sci.

Tiwari, K N, P K Mal, R M Singh and A Chattopadhya (1998). Response of Okra (*Abelomaschus esculentus* (L) Monech) to Drip Irrigation Under Mulch and Nonmulch Conditions. *Agriculture Water Management*, 38 (2): 91-102.

Vani, C H S (2002). Awareness of Farmers, Scientists and Extension Personnel about Pesticide Pollution in Guntur District of Andhra Pradesh.

Veeranna, H K (2000). Effect of Fertigation, Irrigation and Potassium Levels on the Productivity of Chilli (*Capsicum annuam*,). *South Indian Horticulture*, 49 (Special): 101-103.

Venkatesha, Gandhi (2002). Knowledge Levels and Behaviour of Vegetable Growers with Respect to IPM of Tomato Crop in Kolar District of Karnataka, Unpublished M.Sc. *(Agri.) Thesis.* Dharwad, Karnataka: Univ.Agric.Sci.

Viswanatha, G B, B K Ramachandrappa and H V Nanjappa (2000). Effect of Drip Irrigation and Methods of Planting on Root and Shoot Biomass Tasseling, Silking Interval Yield and Economics of Sweet Corn Maize, (*Zea mays L cv sacharata*). *Mysore Journal of Agricultural Sciences*, 34: 134-141.