“EFFECT OF MULCHING ON VEGETABLES AS INTERCROP IN THE KINNOW ORCHARD UNDER AGRO-CLIMATIC CONDITION OF BASTAR PLATEAU OF CHHATTISGARH”

M.Sc. (Hort.) Thesis

By

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INDIRA GANDHI KRISHI VISHWAVIDYALAYA
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“EFFECT OF MULCHING ON VEGETABLES AS INTERCROP IN THE KINNOW ORCHARD UNDER AGRO-CLIMATIC CONDITION OF BASTAR PLATEAU OF CHHATTISGARH”

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

by

BHUPENDRA KUMAR

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Master of Science
In
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CERTIFICATE – I

This is to certify that the thesis **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh"** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Horticulture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Bhupendra Kumar** under my guidance and supervision. The subject of the thesis has been approved by student's advisory committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been duly acknowledged by him.

Date : 11-12-2017

Chairman

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member :	**Shri G.P. Ayam**
Member :	**Dr. R.R. Saxena**

CERTIFICATE - II

This is to certify that the thesis entitled thesis **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh"** submitted by **Bhupendra Kumar** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Science (Horticulture)** in the **Department Vegetable Science** has been approved by the External Examiner and Student's Advisory Committee after oral examination.

16/1/18

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Head of the Department/Section _____

Dean/ Dean Faculty _____

Approved/Not approved _____

Director of Instructions _____

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LIST OF ABBREVIATIONS

Abbreviations	Description
%	Per cent
@	At the rate
^{0}C	Degree Celsius
Cm	Centimeter
Df	Degree of freedom
et al.	And others/ Co- workers
Fig.	Figure
G	Gram
Ha	Hectare
Hrs	Hours
i.e.	That is
Kg	Kilogram
m^2	Square meter
MT	Million tonne
NPK	Nitrogen, Phosphorus and Potassium
Q	Quintal
var.	variety
via.	Through
viz.	For example
µl	Micro liter
bp	Base pair
L	Ladder

THESIS ABSTRACT

a) Title of the Thesis: **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh"**

b) Full Name of the Student: Bhupendra Kumar

c) Major Subject: Vegetable Science

d) Name and Address of the major advisor: Dr. K.P. Singh, Scientist, Department of Vegetable Science, Collage of horticulture and research station Jagdalpur,

e) Degree to be Awarded: M.Sc. (Hort.) Vegetable Science

Signature of the student

Signature of Major Advisor

Date: 11-12-2017

Signature of Head of the Department

ABSTRACT

A field experiment entitled **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh"** was conducted during the *Rabi* season of 2016-17 at the Instructional farm, College of Horticulture and Research Station, Jagdalpur (C.G.). The experiment was laid out in T-test with three replications. The treatment consisted of mulched and non mulched plots in four different crops *viz*., tomato, chilli, brinjal and bitter gourd. Observations on 13 important characters *viz*., plant height, number of branches plant^{-1}, number of fruits plant^{-1}, days taken to 1st flowering, days taken to 50 per cent flowering, leaf area, nutrient uptake (N,P and

K), maximum days taken to 1st harvesting, protein per cent, total soluble solids, vitamin C, yield plant^{-1} and yield ha^{-1} were recorded during the experimentation. The data regarding growth studies and its components, correlation and B: C ratio has also been summarized below:

Perusal of data in the mulched tomato plots revealed the maximum plant height (59.85cm), number of branches plant^{-1} (26.53), numbers of fruits plant^{-1} (43.93), days taken to 1st flowering (42), days taken to 50 per cent flowering (61%), leaf area (16.69cm), nutrient uptake (123.27,14.21 and 110.81 kg ha^{-1} N, P and K respectively), days taken to 1st harvesting (78.00), protein percent (7.75%), TSS per cent (4.56%), vitamin C (25.08 mg/100g), yield plant^{-1} (13000g) and a total yield ha^{-1} (130.33q). preformed of mulch chilli plots the maximum plant height was recorded to be (60.64cm), number of branches plant^{-1} (37.47), numbers of fruits plant^{-1} (58.73), days taken to 1st flowering (35.67), days taken to 50 per cent flowering (55.67), leaf area (62.46 cm), nutrient uptake (74.65, 13.04 and 77.44 kg ha^{-1} N, P and K respectively), days taken to 1st harvesting (76.67), protein per cent (2.80%), TSS per cent (4.37%), vitamin C (120.04 mg/100g), yield plant^{-1} (3000g) and the total yield ha^{-1} (30q). The mulched plots of brinjal recorded the following maximum datas *viz*., plant height (52.61cm), number of branches plant^{-1} (21.53), numbers of fruits plant^{-1} (11.73), days taken to 1st flowering (42.33), days taken to 50 per cent flowering (61.0), leaf area (57.66cm), nutrient uptake (222.22,33.34 and 107.99 kg ha^{-1} N, P and K respectively), days taken to 1st harvesting (77.33), protein per cent (15.00%), TSS per cent (5.27%), vitamin C (15.41 mg/100g), yield plant^{-1} (20000g) and the total yield ha^{-1} (200q). While the mulched plots of bitter gourd recorded the maximum plant height of (191.51cm), number of branches plant^{-1} (29.67), numbers of fruits plant^{-1} (42.27), days taken to 1st flowering (66.33), days taken to 50 per cent flowering (86.67), leaf area (43.15cm), nutrient uptake (47.67,7.63 and 41.20 kg ha^{-1} N, P and K respectively), days taken to 1st harvesting (95.67), protein per cent (1.62%), TSS per cent (1.34%), vitamin C (46.21 mg/100 g), yield plant^{-1} (10666.67g) and the total yield ha^{-1} (101.66q). However in the non mulched plots the datas were comparatively low for all the four crops *viz*., tomato, chilli, brinjal and bitter gourd than the mulched plots.

The present investigation revealed that among the mulched and non mulched treatments, plastic mulch recorded comparatively higher yield attributes and higher economic returns in tomato (2.66), chilli (1.25), brinjal (2.55) and bitter gourd (4.85) when raised as intercrops in the kinnow orchard.

शोध सारांश

(अ.)	शोध शीर्षक	"छत्तीसगढ़ के बस्तर का पठार कृषि जलवायु परिस्थिति में किन्नो फलो उद्यान में अन्तवर्ती सब्जीयों पर पलवार का प्रभाव"
(ब.)	विद्यार्थी का पूरा नाम	भूपेन्द्र कुमार
(स.)	प्रमुख विषय	सब्जी विज्ञान
(द.)	मुख्य सलाहकार का नाम और पता	डॉ के.पी. सिंह, (वैज्ञानिक) सब्जी विज्ञान , उद्यानिकी महाविद्यालय एवं अनुसंधान केन्द्र जगदलपुर, (छत्तीसगढ़)
(इ.)	सम्मानित किये जाने वाली उपाधि	एम.एस.सी.उद्यानिकी (सब्जी विज्ञान)

मुख्य सलाहकार के हस्ताक्षर

विद्यार्थी के हस्ताक्षर

विभागाध्यक्ष के हस्ताक्षर

दिनॉक : 11 - 12 - 2017

सारांश

वर्तमान प्रक्षेत्र शोध जॉच "छत्तीसगढ़ के बस्तर का पठार कृषि जलवायु परिस्थिति में किन्नो फलो उद्यान में अन्तवर्ती सब्जीयों पर पलवार का प्रभाव" उद्यानिकी महाविद्यालय एवं अनुसंधान केन्द्र जगदलपुर छत्तीसगढ़ के प्रक्षेत्र अनुक्षेत्र पर 2016–2017 के रबी ऋतु के दौरान संचालित किया गया था। यह प्रयोग टी. टेस्ट में तीन उपचार संयोजन में किया गया था। यह उपचार पलवार और बिना पलवार मे चार विभिन्न फसल अर्थात टमाटर , मिर्च , बैंगन , और करेला से युक्त था। शोध के दौरान 13 महात्वपूर्ण विशेषता अर्थात पौधे की ऊँचाई प्रति पौधे

शाखाओ की संख्या ,प्रति पौधे फलो की संख्या प्रथम पुष्पन की दिवस की 50 प्रतिशत पुष्पन के लिए लगे दिवस की संख्या , पत्ती क्षेत्र पोषक तत्व उदग्रहरण नत्रजन : स्फुर और पोटाश प्रथम फसल की कटाई के लिए अधिकतम दिवस प्रोटीन प्रतिशत , कुल ठोस विलय विटामिन सी. , प्रति पौधे पैदावार और प्रति हेक्टेयर पैदावार पर दुसरे घटको सह सम्बंध बी. : सी. अनुपात के भी सम्बंधित आंकड़ो के सार प्रस्तुत किया जा रहा है। आकड़ो के अवलोकन में पलवारित टमाटर भूखण्ड अधिकतम पौधे की ऊॅचाई (59.85 से.मी.) प्रति पौधे शाखाओ की संख्या (26.53) प्रति पौधे फलो की संख्या (43.93), प्रथम पुष्पन में लगे दिवस की संख्या (61), पत्ती क्षेत्र (16.69 से.मी.) पोषक तत्वों का ग्रहण (123.26 : 14.21 और 110.81 किलो ग्राम प्रति हेक्टेयर नत्रजन : स्फुर और पोटाश के क्रमश) प्रथम फसल कटाई दिवस (7.75 प्रतिशत), कुल ठोस विलय (4.56) विटामिन –सी (25.08 मि.ग्रा. प्रति 100 ग्राम) , प्रति पौध पैदावार (130.33 क्विंटल), प्रकट करता है। पलवारित मिर्च भूखण्ड में अधिकतम पौधे की ऊॅचाई (60.64 से.मी.) प्रति पौध शाखाओ की संख्या (37.47), प्रति पौधे फलों की संख्या (58.73 से.मी.), प्रथम पुष्पन लगे दिवस की संख्या (35. 67) 50 प्रतिशत पुष्पन में लगे दिवस की संख्या संख्या (55.67 से.मी.), पत्ती क्षेत्र (62.46 से.मी.), पोषक तत्व की ग्रहण (74.65 : 13.04 और 74.44 किलो ग्राम प्रति हेक्टेयर नत्रजन : स्फुर और पोटाश के क्रमश) प्रथम फसल कटाई दिवस (76.67) प्रोटीन प्रतिशत (2.80 प्रतिशत), कुल ठोस विलेय (4.37 प्रतिशत), विटामिन – सी (120.04 मि.ग्रा. प्रति ग्राम), प्रति पौध पैदावार (3000 ग्राम), और पैदावार के महायोग प्रति हेक्टेयर (30 क्विंटल) अभिलेखबद्ध किया गया था। पलवारित बैंगन के भूखण्ड पर निम्नलिखित अभिलेखबद्ध किया गया था। अर्थात पौधो की ऊॅचाई (52.61 से. मी.), प्रति पौध शाखाओ की संख्या (21.53), प्रति पौधे फलों की संख्या (11.73 से.मी.), प्रथम पुष्पन लगे दिवस की संख्या (42.33), 50 प्रतिशत पुष्पन में लगे दिवस की संख्या (61.0 से.मी.), पत्ती क्षेत्र (57.66 से.मी.), पोषक तत्व की ग्रहण (222.22 : 33.34 और 107.99 किलो ग्राम प्रति हेक्टेयर नत्रजन : स्फुर और पोटाश के क्रमश) प्रथम फसल कटाई दिवस (77.33) प्रोटीन प्रतिशत (15 प्रतिशत), कुल ठोस विलेय (5.27 प्रतिशत), विटामिन –सी (15.41 मि.ग्रा. प्रति ग्राम), प्रति पौध पैदावार (20000 ग्राम), और पैदावार का महायोग प्रति हेक्टेयर (200 क्विंटल) जबकि पलवारित करेला के भूखण्ड में अधिक पौध की की ऊॅचाई (191.51 से.मी.) प्रति पौध शाखाओ की संख्या (29.67), प्रति पौधे फलों की संख्या (42.27 से.मी.), प्रथम पुष्पन लगे दिवस की संख्या (66. 33), 50 प्रतिशत पुष्पन में लगे दिवस की संख्या संख्या (86.67 से.मी.), पत्ती क्षेत्र (43.15 से.मी.),

पोषक तत्व की ग्रहण (47.67 : 7.63 और 41.20 किलो ग्राम प्रति हेक्टेयर नत्रजन : स्फुर और पोटाश के क्रमश) प्रथम फसल कटाई दिवस (95.67) प्रोटीन प्रतिशत (1.62 प्रतिशत), कुल ठोस विलेय (1.34 प्रतिशत), विटामिन –सी (46.21 मि. ग्रा. प्रति ग्राम), प्रति पौध पैदावार (10666.67 ग्राम), और पैदावार का महायोग प्रति हेक्टेयर (101.66 क्विंटल) अभिलेखबद्ध किया गया था। फिर भी बिना पलवारित भूखण्ड के आकड़े तुलात्मक रूप से चारों फसल अर्थात टमाटर, मिर्च, बैंगन और करेला में निम्न प्रदर्शित हो रहे थे।

वर्तमान अनुसंधान यह खुलासा करता है कि यदि किन्नो फलो उद्यान में अन्तवर्तीय फसल उगााते है तो पलवार और बिना पलवार उपचार के मध्य में तुलनात्मक रूप से अधिकतम पैदावार और अधिकतम अर्थिक मुनाफा टमाटर (2.66), मिर्च (1.25), बैंगन (2.55), और करेला (4. 85) प्लास्टिक पलवार में अभिलेखबद्ध किया गया था।

CHAPTER -1
INTRODUCTION

Vegetables are the fresh and edible portions of herbaceous plants. They are important food and highly beneficial for the maintenance of health and prevention of diseases. They contain valuable food ingredients which can be successfully utilized to build up and repair the body. They are valued mainly for their high carbohydrates, vitamin and mineral contents. India produces 168.300 million tonnes of vegetables from an area of 95.41 million hactare (Horticulture Statistics Division, 2015).

Kinnow is a high yield mandarin hybrid cultivated extensively in the wider Punjab region of Pakistan and India. It is a hybrid of two citrus cultivars King (*Citrus nobilis*) × Willow Leaf (*Citrus* × *deliciosa*) first developed by Howard B. Frost at the University of California Citrus Experiment Station. After evaluation, the kinnow was released as a new citrus hybrid for commercial cultivation in 1935. In a hot climate, plants can grow up to 35 feet high Kinnow trees are highly productive. It is not uncommon to find 1000 fruits per tree in usual (Rattanpal *et al*., 2008). In India, Kinnow is being grown in Punjab, Rajasthan, Haryana, Himachal Pradesh, Jammu & Kashmir and Uttar Pradesh.

Intercropping refers to growing two or more dissimilar crops simultaneously on the same piece of land, crop intensification is in both time and space dimensions. It also helps the farmers for having a stable production and maintaining the soil fertility level. Intercropping between high and low canopy crops is a common practice in tropical agriculture and to improve light interception and hence yields of the shorter crops requires that they be planted between sufficiently wider rows of the taller once. Intercropping is advantageous when intercrop combinations make better use of growth factors and thus produces more yield than monocultures. According to Timbilla and Nyako (2001) intercropping increased the grain yield by 70% over sole crop due to (i) better utilization of natural resources (ii) less incidence of pest, disease and weeds (iii) improved nitrogen economy where legume crop is present.

Mulching is the process or practice of covering the soil surface to make it more favourable for plant growth, development and efficient crop production.

Natural mulches such as leaf, straw, dead leaves and compost have been used for centuries, during the last 60 years advent of synthetic materials has altered the methods and benefits of mulching. The research as well as field data available on the effect of synthetic mulches make a vast volume of useful literatures. When compared to other mulches plastic mulches are completely impermeable to water; it therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface. In this manner it plays a positive role in water conservation. Plastic mulching suppresses completely the growth of weeds and hence increases the nutrient use efficiency considerably especially for net economic return. Plastic mulch is often used in conjunction with drip irrigation. In drip system, irrigation water is placed just near the crop root zone and if mulch material is placed on soil surface, upward flux of soil water is restricted and optimum supply of moisture to crop is maintained for longer period. The beneficial effects of plastic mulch for enhanced water and fertilizer utilization and weed control have been reported by Fortnum *et al*. (2000). Mulching minimizes the evaporation loss from soil surface and thus utilizes the conserved moisture for higher transpiration and improves yield and WUE of tomato (Agele *et al*., 2002).

Black plastic mulch is the most popular colour used in commercial vegetable production, especially for weed control. As a blackbody absorber, this plastic absorbs most incident solar radiation, including visible, infrared and ultraviolet light. Much of the thermal energy, however, is lost to the atmosphere through convection and re-radiation. Transferring of thermal energy to the soil can be optimized by maximizing mulch contact with the soil. Soil temperatures under black plastic during the daytime can be as much as 5ºF higher at a 2-inch depth and 3ºF higher at a 4-inch depth than bare soil at the same depths.

Tomato (*Solanum lycopersicon* L.) is one of the most popular and versatile cash earning vegetable crop and plays a vital role in culinary purposes for its nutrients, delicious taste and various modes of consumption *i.e.* fresh as salads, cooked vegetables and its utilization in preparation of range of processed products such as puree, paste, powder, ketchup, sauce, soup and canned whole fruits. It is universally treated as ‘protective food’ and is being extensively grown as an annual

plant all over the world. It is a very good source of income to small and marginal farmers and contributes to the nutrition of the consumers. It is the second most important vegetable crop next to potato in the world in terms of acreage and production. In India, tomato is cultivated in about 791 thousand hectares area with the production of 173.98 t ha^{-1} (Horticulture Statistics Division, 2015). In Chhattisgarh also, tomato is one of the top ranking vegetable and is estimated to be grown on about 414.440 hectares area comprising three leading districts of the state *viz*. Bilaspur 74.05 ha, Jashpur 51.43 ha and Durg 44.10 ha (Directorate of Horticulture, 2015).

Brinjal (*Solanum melongena* L.*)* is a common vegetable crop grown in the sub-tropics and tropics. It is called eggplant in USA and aubergine in Europe. It is adapted to a wide range of climatic conditions. Dry fruit is reported to contain goitrogenic principles. Brinjal fruits are good source of vitamin-B. It is essentially a warm weather crop which is grown extensively in India, Bangladesh, Pakistan, China, Japan, and the Philippines. It is also grown in Egypt, France, Italy, and the United States. The early inhibitions to its consumption by certain population groups could be because of the suspicion of the presence of anti-nutritional/poisonous substances. It is being produced in 14.76 million tons from an area of 23.63 million hectare (Horticulture Statistics Division, 2015). Chhattisgarh produces nearly 606.711 metric tonnes of brinjal from an area of 334.21 hectares whereas; Jagdalpur region of Bastar produces 124.00 metric tons from an area of 77.5 hectares (Directorate of Horticulture, 2015).

Chilli (*Capsicum annuum* L.*)* is an important spice crop belonging to the family Solanaceae. Chilli is widely cultivated throughout the warm temperature of tropical and sub-tropical countries and is a native to Mexico. It was introduced to India during 17th century by Portuguese. Chilli used in every Indian cuisine due to its pungency, spicy taste, appealing odour and flavours. Its fruits are rich source of vitamin C, A and E. Nearly 19.83 million tons of it is being produced from an area of 17.0 million hectare (Horticulture Statistics Division, 2015). Chhattisgarh produces 640.027 metric tonnes of chilli from an area of 911.15 hectares. The region in Bastar produced 119.07 metric tons of chilli from an area of 10.85 hectares

(Directorate of Horticulture, 2015). Vegetables could be a good proposition for growing in combination with chilli grown for green fruits under irrigated conditions.

Bitter gourd (*Momordica charantia* L.) is grown for its bitter tender fruits. It is a rich source iron. It can be canned and pickled. As well the bitter gourd slices can be dried and used as a vegetable as and when required. India produces 12.40 million tons of bitter gourd from an area of 12.2 million hectares (Horticulture Statistics Division, 2015). Chhattisgarh produces 130.772 metric tons from an area of 103.85 hectares whereas Jagdalpur region of Bastar produces 31.00 metric tons from an area of 31.0 hectares (Directorate of Horticulture, 2015).

Yield advantage occurs in intercropping system because component crops differ in their use of growth resources in such a way that when they are grown in combination they are able to complement each other and so make better overall use of resources than when grown separately. The main reasons for higher yields in intercropping is that the component crops are able to use natural resources differently and make better overall use of natural resources than grown separately. Whereas with mulching the suppression of evaporation also has a supplementary effect; it prevents the rise of water containing salt, which is important in countries with high salt content water resources.

Keeping the above points in view **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh."** has been undertaken with the following objectives:

1) To study the effect of mulching on yield & yield attributing characters of intercrop.
2) To identify the best suited intercrop for Kinnow orchard.
3) To study the economics (C: B) of the treatments.

CHAPTER-II
REVIEW OF LITERATURE

Intercropping is as system of growing two or more crops in the same piece of land which aim at reducing the risk of crop failures in agriculture. There are different kinds of intercropping followed in different parts of the country since a long period. The crop yield is the function of various production technologies and intercropping is known to influence it up to a good extent. In this chapter an attempt has been made to review the available literature on effect of different intercrops and their impact on production of tomato, brinjal, chilli and bitter gourd in India and abroad under following heads:

2.1 To study the effect of mulching on yield & yield attributing characters of intercrop.

2.2 To identify the best suited intercrop for Kinnow orchard.

2.3 To study economics (C: B) of the treatments.

2.1 Effect of mulching on yield & yield attributing characters of intercrop.

Hundal *et al.* (2000) reported that concentration of nitrogen and phosphorus and nutrient uptake was significantly higher in mulched plots over unmulched plot which was attributed to the stimulating effect of mulches on above ground growth of tomato plants.

Singh *et al.* (2001) evaluated the effect on crop yield and economic potential of intercropping potato cv. Kufri Badshah, cauliflower, cabbage, knol-khol, turnip, carrot or radish with autumn- planted sugarcane were determined in a field experiment. Intercropping of potato with sugarcane improved cane yield by 6.12 percent and resulted highest net returns (Rs. 72.808/ha).

Kannan *et al.* (2001) observed that, when intercrops of vegetable cowpea (*Vigna unguiculata*), cluster bean (*Cyamopsis tetragonoloba*) *cv*. Pusa Navbahar, okra (*Abelmoschus esculentus*) *cv*. Parbhani Kranti, aggregatum onion (*Allium cepa var*. *aggregatum*) *cv*. CO-4 and amaranthus (*amaranthus viridis*) *cv*. CO-3 were

tested in Elephant Foot Yam based intercropping during the first season, the highest tuber yield was recorded from the elephant foot yam intercropped with vegetable cowpea, although the yield of the sole crop was at par with this result. However, during the second season, intercropping Elephant Foot Yam with vegetable cowpea recorded statistically superior yields than sole cropping.

Prasad *et al*. (2001) reported that cultivation of Fenugreek as an intercrop in 1:1 or 2:1 ratio increased the potato yield by about 2.5 t ha^{-1} when no cut of fenugreek as a fresh vegetable was made. Taking a cut of fenugreek as a fresh vegetable reduced the potato tuber yield compared to no cut but potato equitant values were obtained closely for the 1:1 ratio intercrop followed by the 2:1 intercrop system.

Awasthi *et al.* (2006) showed that the significant variation in soil moisture percentage (30 cm below the mulch) in September- November was recorded under black polyethylene and conserved 46-50% more moisture. Fruit yield/plant was 84 and 77% more under black and white polyethylene mulches. Among the organic mulches, fruit yield/plant as compared to control was 66 and 58% more under mulches of lasoda leaf and kheep clippings respectively. Fruit quality parameters were significantly influenced by mulch treatments. Fruit size and moisture content was maximum under black and white polyethylene mulches. Ascorbic acid, acidity, β-carotene and vitamin-content were higher under lasoda leaf mulch.

Suresha *et al.* (2007) observed the effect of different intercrops *viz*., radish, carrot, onion, garlic, cluster bean and dolichos bean on chilli. Significantly the highest (75.16 q ha^{-1}) yields were obtained in sole chilli. Yield of chilli varied with different intercropping systems. Radish + chilli intercropping system results in realization of significantly the highest (72.05 q ha^{-1}) yield in chilli followed by chilli + carrot (70.77 q ha^{-1}). On the contrary 'chilli + cluster bean' resulted in lower yield of 64.43 q ha^{-1}.

Firoz *et al*. (2009) reported the highest yield (21.43 t ha^{-1}) was obtained from plant where mulch was given one month before planting. Among three planting times, the highest yield (15.27 t ha^{-1}) was obtained from 01 October planting. In case

of combined effect, mulching one month before planting with 01 October planting produced the highest yield (28.06 t ha^{-1}) of tomato in hill slope.

Khambal *et al*. (2009) revealed that the treatment transparent polythene recorded significantly superior total uptake of N, P and K by okra plant over no mulch, straw mulch and black mulch.

Ashrafuzzaman *et al.* (2011) observed that the different mulches generated higher soil temperature and soil moisture under mulch over the control. Transparent and blue plastic mulches encouraged weed population which were suppressed under black plastic. Plant height, number of primary branches, stem base diameter, number of leaves and yield were better for the plants on plastic. At the mature green stage, fruits had the highest vitamin-C content on the black plastic. Mulching produced the fruits with the highest chlorophyll-a, chlorophyll-b and total chlorophyll contents and also increased the number of fruits per plant and yield. However, mulching did not affect the length and diameter of the fruits and number of seeds per fruit. Plants on black plastic mulch had the maximum number of fruits and highest yield. Thus, mulching appears to be a viable tool to increase the chilli production under tropical conditions.

Madhumathi *et al.* (2013) observed that the significantly higher number of fruits per plant (33.31), yield per plant (1.25kg), fruit size (length, diameter and volume), fruit weight (42.63 g), pulp content (54.01%), ascorbic acid (20.81 mg/100 g pulp) and number of seeds per fruit (192.21) over other dates of planting. Among the treatment combinations Pusa Ruby planted on October 15th emerged as the best combination with regard to fruit quality and seed characters.

Singh *et al.* **(**2013*)* reported the different synthetic and organic mulches in brinjal grown as ground storey crop with aonla was studied with respect to soil-hydrothermal regimes, growth, fruit yield and quality parameters**.** A significant variation in soil moisture percentage (30 cm below the mulch) in September-November was recorded under black polyethylene and conserved 46-50% more moisture. Fruit yield/plant was 84 and 77% more under black and white polyethylene mulches. Fruit quality parameters were significantly influenced by

mulch treatments. Fruit size and moisture content was maximum under black and white polyethylene mulches.

Ali *et al.* (2014) results obtained indicated that growth and yield of tomato was lowest in control treatments which showed that the organic manure and sowing date used in the study especially poultry manure and sowing date of 5th February, 2013 promoted the yield of tomato. Poultry manure and sowing date 5th February, 2013 enhanced tomato vine length, number of leaves plant^{-1}, number of branches plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1}, fruit weight plant^{-1}, fruit yield plot^{-1} and fruit yield hectare^{-1} compared to control treatments. There was no significant effect with respect to leaf area plant^{-1}, number of fruits plant^{-1} and fruit weight plant^{-1}.

Tipu *et al.* (2014) observed that rice husk mulch was found superior to sawdust, garden leaves and black polyethylene mulch in producing higher yield of tomato. Higher number of fruits per plant and maximum yield was recorded with rice husk which was 17.93% higher than the control (without mulch). BARI Tomato 14 in combination with rice husk produced highest yield (79.74 t ha^{-1}) highest TSS (6.67).

Singh *et al.* (2014) reported the effect of organics on growth yield and biochemical parameters in chilli having different 7 treatment of FYM, Vermicompost and Biofertilizers (Azospirillum + PSB) ware applied. The results show that better plant height , number of leaves, number of branches, number of flower, number of fruit, fresh weight and dry weight per plant consisting of treatment FYM (12.5t/ha) + Vermicompost (2.5t ha^{-1}) + Biofertilizer (@2.5kg/ha Azospirillum + PSB) The biochemical parameters like the Chlorophyll a, and b, carotenoid, protein and abscorbic acid were recorded maximum in with organics FYM (12.5t ha^{-1}) + Vermicompost (2.5t ha^{-1}) + Biofertilizer (@2.5kg ha^{-1} Azospirillum + PSB.

Bhujbal *et al.* (2015) observed that the growth and yield of tomato were significantly higher in black colour on silver polythene mulch followed by silver colour on black polythene mulch and transparent polythene mulch.

Banjara *et al.* (2015) reported the effect of three mulch treatments [namely black plastic mulch, paddy straw mulch and without mulch] with two days irrigation interval. The result showed that the amount of water significantly affected the number of fruits per plant, average weight of fruits and total fruit yield ha^{-1}. Significant difference was also observed between black plastic mulch and without mulch treatments on number of fruits and total fruit yield/ha.

Singh *et al.* (2015) the result revealed that the growth parameters and yield attributing traits were significantly influenced by different planting dates and sources of nutrients. Planting on September 15 (D1) recorded the highest plant height (254.95 cm), number of leaves per plant (33.47), fruits per plant (80.39), fruit length (6.75 cm), fruit girth (5.53 cm), mean fruit weight (124.26 g), yield per plant (10.39 kg), yield per plot (42.44 kg) and TSS (5.55 ºB) content over later date of planting. The plants treated with 50% RDF +10 t ha FYM + 5 t ha poultry manure + bio fertilizer showed maximum number of leaves per plant (36.88), fruits per plant (74.69), fruit length (6.85 cm), mean fruit weight (134.33 g), yield per plant (10.77 kg), yield per plot (38.90 kg) and ascorbic acid content (40.02 mg/100g) over treatment having 100% RDF alone. Among interaction the plants planted on 15th September along with 50% RDF +10 t haFYM + 5 t ha Poultry manure +bio fertilizer resulted better yield and quality traits.

Varghese *et al.* (2015) observed that tomato and brinjal are the two major crops having significant scope for increasing the production by using these technologies. Nitrogen and potassium are important to the plants and at the same time these fertilizers are very costly. Application of these fertilizers through drip ensures proper utilization and results in better yield. Plastic mulching when used along with drip and fertigation controls weeds and further increases the efficiency of the system.

Chaurasiya *et al.* (2016) observed that the black polyethylene mulch was significantly superior, covers high yielding and good quality of fruits followed by paddy straw mulch and without mulch. The fertilizer 80% RD through fertigation gave maximum fruit yield followed by 100% RD through fertigation with maximum plant height and number of leaves.

Prajapati *et al.* (2016) reported that the treatment T2 (hand weeding at the interval of 15 days) recorded maximum growth and yield *viz*., plant height, number of branches per plant, days of first flowering, number of flowers per plant and fruiting span, number of fruits per plant, fruit length, fruit weight, fruit yield per plant and fruit yield per plot followed by treatment T_9 (three hand weeding at 15,30 and 45 days after transplanting + back polythene mulch (50 μ) and T_{10} three hand weeding at 15, 30 and 45 days after transplanting + white polythene mulch (50 μ) over control T_1.

Singh *et al.* (2017) observed that the significantly highest fruit yield of 10.9 kg m^2 was obtained in M_7 i.e. double shaded plastic mulch and was statistically at par with M_6 i.e. black colour plastic mulch (10.2 kg m^2). Mulch showed significant variation in a number of fruits/plant. M_7 i.e. double shaded plastic mulch (40.4) remained statistically at par with M_6 (39.5) and M_1 (38.6) produced significantly more number of fruits $plant^{-1}$. Significantly highest net returns (Rs.147.6 m^{-2}) were observed in M_7, as compared to other mulches.

2.2 To identify the best suited intercrop for Kinnow orchard.

Varghese (2000) studied the sustainability of cabbage based intercropping system on the basis of response on indices of sustainability such as growth, yield, quality, crop nutrient uptake, soil fertility changes, with cabbage + radish followed by cabbage + spinach in comparison to monoculture cabbage, indicating the superiority of intercropped cabbage over a sole crop. These observations warrant a strong potential of improving vegetable production through intercropping on a sustained basis using a compatible cropping strategy.

Yildirim and Guvenc (2003) studied the effect of different intercropping systems on growth, some mineral contents and yield of cauliflower under field conditions in 2000–2002. In addition, land equivalent ratio (LER) as an index of intercropping advantage was determined to assess the efficiency of different cropping systems. LER values were always more than 1 in intercropping systems. The study showed that cauliflower based intercrop treatments might provide the highest total yield as well as profitability.

Hussain (2003) conducted a research work at Horticultural Research Farm, Mackinder, NWFP Agricultural University, Peshawar (Pakistan) during 1998-2000 to study the effect of intercropping on growth, yield and economic dynamics of vegetables in summer and winter vegetables. In summer, tomato was intercropped with okra, potato, com, chilli and eggplant whereas among winter vegetables, pea was tested in combination with cauliflower, potato, lettuce, radish, turnip, coriander and spinach. This combination gave significantly highest land equivalent ratio (1.54), followed by yield of pea and potato (1.45). The pea + lettuce combination recorded lowest value of LER (1.16).

Patil *et al.* (2004) conducted a field study at Regional Fruit Research Station, Ganeshkhind, Pune during the *kharif* seasons of 1993-94,1994-95 and 1995-96 on a cabbage based intercropping system and observed that cabbage + radish recorded highest LER (1.57) value followed by cabbage + methi (1.38). Cabbage + coriander system recorded lowest value (1.28) for LER.

Tiwari *et al.* (2013) reported that the intercrops were grown with different intercropping systems like mono, companion and sequential are pigeon pea, tomato, cluster bean, okra, black gram, soybean, cowpea, maize, mustard, coriander and bengal gram. The results of two years of investigation indicated that number of fruits was maximum in mango with companion intercropping system of pigeonpea + soybean followed by sequential intercropping system of cowpea - bengal gram did not differ significantly. Fruit length, fruit diameter and fruit weight was also highest with companion intercropping system of pigeon pea + soybean closely followed by sequential intercropping system of cowpea-bengal gram. Fruit quality of mango did not significantly differ among the intercrops treatment. Nitrogen concentration in the orchard soil was improved due to growing of leguminous crops while phosphorus and potassium were depleted in all the cases.

2.3 To study economics (C: B) of the treatments.

Singh *et al*. (2000) obtained the highest gross and net returns in potato + wheat intercropping compared to sole cropping of either crop. The lowest gross and net returns were obtained with wheat sole crop. The higher cost- benefit ratio was

with wheat sole crop (3.64) followed by wheat + potato (2.68) and potato sole crop (2.47). Potato sole crop had 7.3 percent more yield that the intercrop of potato + wheat. A mean reduction of 44.89 percent in wheat yield was obtained when wheat was intercropped with potato after ear thing up.

Adeniyi (2001) reported that an intercropping of tomato + okra produced a favourable 8:1 benefit cost ratio and increased net returns of between 8.9 and 85.1 percent ha^{-1} above other treatment hence its recommendation as a modest cultural practice.

Singh *et al.* (2002) suggested that intercropping of potato with maize resulted in the highest gross return of Rs. 73019 ha^{-1} and net return of Rs. 46119 ha^{-1}. Potatoes were planted on top of the ridge and maize on the slope of the ridge at a row to row distance of 0.80 m row distance and maize in furrows.

Nemagouda (2004) reported that intercropping of vegetables *viz*., cluster bean, onion and chilli in cotton increased the gross as well as net returns compared to sole cotton.

Koli *et al.* (2003) observed that the intercropping system of red gram + cluster bean recorded significantly higher monetary returns (Rs.19, 419 ha^{-1}) as compared to standard check with sole red gram (Rs.10, 820 ha^{-1})

Koli *et al.* (2004) conducted at dry farming research station, Sholapur revealed that intercropping of castor + cluster bean in 1:2 row proportion and castor + ridge gourd intercropping were remunerative on inceptisols under dry land conditions.

Kumar *et al.* (2005) revealed that intercropping of maize and cowpea in the row proportion of 2:2 recorded significantly higher net returns (Rs.8346/ha) over other treatments. However, B: C ratio of sole maize was higher (1.78) but it was at par with maize + cowpea planted in the row ratio of 2:1 and 2:2.

Singh *et al.* (2009) reported that drip irrigation to tomato at 80% ET resulted in higher net return (Rs 34431 ha^{-1}) and B: C ratio (1.76) compared to 100 and 60% ET. However, net return (51386 ha^{-1}) and benefit cost ratio (2.03) were further

increased when drip irrigation in tomato was given at 80% ET was coupled with polyethylene mulch compared to other treatments.

Aladakatti *et al.* (2010) revealed that cotton + sunflower intercropping system in 2:1 row proportion resulted in significantly higher net income of 16,582 ha^{-1} with a benefit cost ratio of 2.09, compared to other intercropping systems and sole cotton (8620 ha^{-1} and 1.65 respectively). Intercropping of sunflower in cotton in 2:1 row proportion found remunerative over sole cotton and intercropping of castor or sesamum in cotton with different row proportions.

Tiwari *et al.* (2013) observed that the economic analysis was also carried out. Highest net return was calculated from mango + (pigeonpea + tomato) combination (Rs. 81077.50) followed by mango + cowpea-bengal gram (Rs. 71,677.13) and mango + tomato (Rs. 67,034.38).

Prajapati *et al.* (2016) reported that the maximum gross return was obtained from treatment T_2 167080. The maximum net profit of 1,16,080 per ha was obtained under treatment combination T_2 (hand weeding at the interval of 15 days) which was closely followed by treatment combination T_8 (three hand weeding at 15, 30 and 45 days after transplanting + soybean straw mulch) with net profit of 82,500 per ha. The minimum net profit was found in treatment T_{12} (paddy straw mulch + black polythene mulch (50 μ) with net profit of 9,980 per ha and the economics of various treatment combinations with 3.28 BC ratio over control.

Singh *et al.* (2017) observed that the significantly highest fruit yield of 10.9 kg m^{-2} was obtained in M_7 i.e. double shaded plastic mulch and was statistically at par with M_6 i.e. black colour plastic mulch (10.2 kg m^{-2}). Mulch showed significant variation in a number of fruits $plant^{-1}$. M_7 i.e. double shaded plastic mulch (40.4) remained statistically at par with M_6 (39.5) and M_1 (38.6) produced significantly more number of fruits $plant^{-1}$. Significantly highest net returns (Rs.147.6 m^{-2}) were observed in M_7, as compared to other mulches.

CHAPTER- III
MATERIALS AND METHODS

The investigation entitled **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh."** was conducted during the year 2016-17 at Instructional farm College of Horticulture and Research Station, Jagdalpur (C.G.).This chapter deals with brief descriptions of the materials adopted and methods used during the course of investigation.

3.1 Experimental Site

The experiment was conducted in the year 2016-17 at Instructional farm College of Horticulture and Research Station, Jagdalpur (C.G.).

3.2 Geographical Situation

Chhattisgarh state is located between $17^0$30' and $24^0$45' N latitude and $70^0$30' and $84^0$15' E longitude. Whereas, Bastar lies at $19^0$10' N latitude and $81^0$95 E longitude with an altitude of 552 meter above the mean sea level. Kumhrawand is located at Bastar district that lies at $19^0$05'N latitude and $81^0$57'E longitude. It has an average elevation of 552 meters.

3.3 Climate and weather conditions

The region comes under sub-humid climate. The average annual rainfall of the area is 1544 mm. Weekly temperature (maximum and minimum), open pan evaporation and rainfall of 2016- 2017 were recorded from the meteorological observatory of Agro-meteorology Department, S.G.C.A.R.S. Jagdalpur. The investigation period received rainfall of 194.5 mm. The weather condition prevailed during the field experiment are given in the appendix A and presented in figure 3.1.

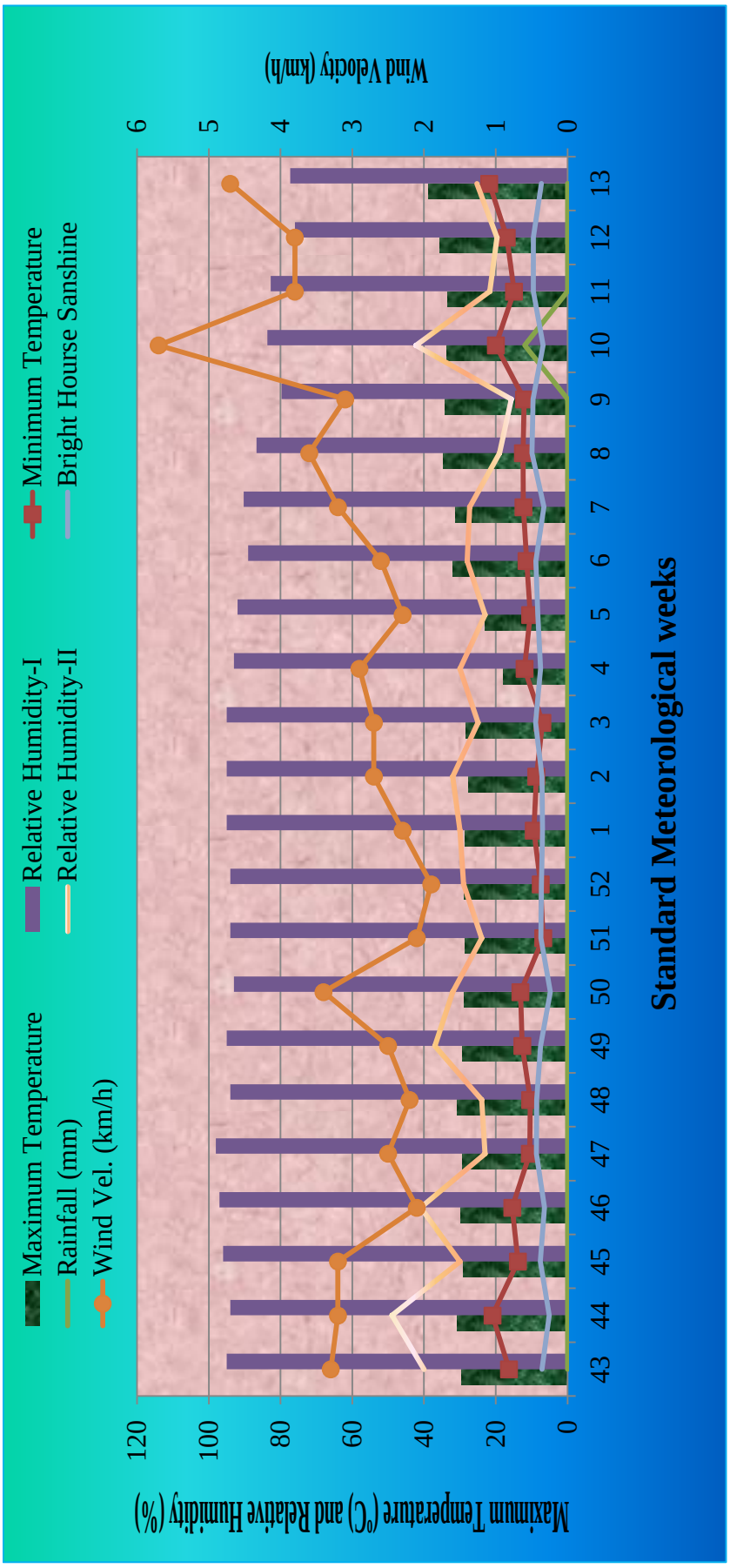

Fig. 3.1: Weekly meteorological observations during crop growth period (Oct. 1 to April 1, 2017)

3.4 Soil Characteristic

For the assessment of various physico-chemical properties of the experiment site, surface soil sample (0-15cm) were collected randomly with the help of auger and a respective composite sample was prepared. The soil was analyzed for its initial characteristics as per the methods mentioned below and some important physico-chemical properties of the soil are given in Table 3.1

Table 3.1 Physico-chemical properties of soil

S.N.	SOIL PROPERTIES	VALUES	CLASSIFICATION
1	**Mechanical composition**		
	Sand %	52	
	Silt %	26	International pipette method (Jackson, 1979).
	Clay %	22	
	Texture classes	Sandy loam	
2	Soil pH (1:2:5)	5.75	(Glass electrode pH meter; Piper, 1967).
3	EC (dSm^{-1})	0.10	(Solubridge method; Black, 1965).
4	Organic carbon (%)	0.23	(Walkley and Black's rapid titration method; Black, 1965).
5	Available N (kg ha^1**)**	181.56	(Alkaline potassium permanganate method; Subbiah and Asija, 1956).
6	Available P (kg ha^1)	11.55	(Olsen 'modified method; Jackson, 1967).
7	Available K (kg ha^1)	176.04	(Flame photometric method; Jackson 1967).
8	Available S (kg ha^1)	35.1	(Turbiditimetric or Colorimetric method).
9	Available Fe (kg ha^1)	7.95	(DTPA extraction method using AAS; Lindsay and Norvell, 1978).
10	Available Zn (kg ha^1)	20.52	(DTPA extraction method using AAS; Lindsay and Norvell, 1978).

3.5 Experimental details

Crop	:	Tomato, Chilli, Brinjal, Bitter gourd.
Treatment	:	With mulch and without mulch.
Spacing	:	90×50 cm (row x plant)

Comparison of treatment has been done using T- test. Correlation & Regression has also been undertaken.

3.6 Field preparation

The preparation of field was done by tractor-drawn M.B. plough followed by one cultivator, two cross-harrowing to pulverize the soil and finally the field was levelled with planter. Field was divided into plots according to treatments and replications.

3.7 Crop and variety

Tomato	:	Pusa Ruby
Chilli	:	NS.1701 DG
Brinjal	:	VNR-212
Bitter gourd	:	VNR-28

3.8 Observation procedure

The observations of different growth parameters and yield parameters were recorded on five randomly selected competitive plants from each plot in each replication. Percent emergence was recorded by counting the emerged plant up to 30 days after planting. The method adapted to record different observations on growth as well as yield attributing traits. The characters under study were as follows:

3.8.1. Plant height (cm)

From each plot, five plants were randomly selected and stakes were fixed nearly each selected plant for recording observation. The height of the plant was measured with meter scale from ground level to top of main stem of the five tagged plants in cm at different stages of crop growth and averaged.

3.8.2. Number of branches plant^{-1}

The number of branches per plant was recorded from five randomly selected plant of each plot at the time of last picking and mean was presented as number of branches per plant.

3.8.3. Leaf area (cm^2)

Numbers of leaves were also recorded on randomly selected five tagged plants in each plot at 45, 60 and 75 DAT.

3.8.4. Number of fruits plant^{-1}

The number of fruits per plant was recorded in each plot from five randomly selected plants at marketable stage of fruits and mean value was calculated and averaged over replications.

3.8.5. Days taken to 1st flowering

This was recorded as number of days from transplanting date to the date when 1st plants of the plot bloomed and the mean value was calculated and averaged over replications.

3.8.6. Days taken to 50% flowering

This was recorded as number of days from transplanting date to the date when 50% plants of the plot bloomed and the mean value was calculated and averaged over replications.

3.8.7. Days taken to 1st harvesting

Days to first fruit harvest was recorded as number of days taken from the date of transplanting to the date of first picking of edible fruits from randomly selected plants of each plot and mean value was calculated and averaged over replications.

3.8.8. Yield plant^{-1} (g)

Average weight of fruits was recorded on five fruits in gram from five randomly selected plants of each plot in each replication and then average fruit weight and mean value was calculated and averaged over replications.

3.8.9. Yield (q/ha)

The fruit yield in q/ha was worked out with the help of the following formula:

$$\text{Fruit Yield (q/ha)} = \frac{\text{Weight of fruit (kg per plot)}}{\text{Net plot area (sq. m2.) } 100} \; X \; 10000$$

3.8.10. Biochemical analysis

3.8.11. Protein

Protein has been estimated by Lowry's Method (Lowry *et al*., 1951). Plant material was cut into small pieces (8-10 mm). After thorough mixing, representative sample weighing 0.5-1.0 g was extracted with 5 ml of 0.1 M phosphate buffer, pH 7.5 using pestle mortar at 0-4o C (Extraction is generally carried out with same buffer used for the enzyme assay). Extracted material was transferred to centrifuge tube. Homogenate was centrifuged for 15 min. at 10,000 rpm at 4 0 C. Supernatant was decanted and residues were discarded. Equal volume of 15% TCA was added to the supernatant which precipitated the protein and solution was kept overnight at room temperature. The above solution was centrifuged at 3,000 rpm for 10 min. The supernatant was decanted and discarded. The precipitate was then dissolved in 0.1 N NaOH and its volume was made upto 10 ml with 0. 1N NaOH. This solution was used further for protein estimation.

3.8.12. Vitamin C

The ascorbic acid content was estimated by using the procedure given in A.O.A.C (1990) by using 2, 6-dichlorophenol indophenol sodium salt using the titration method (A.O.A.C., 1975) and expressed in mg per 100 g of fruit weight.

Reagents

Metaphosphoric acid solution (3%)

Metaphosphoric acid (HPO3)	15 g
Glacial acetic acid	40 ml
Volume	500 ml

2, 6-dichlorophenol indophenol dye

2, 6-dichlorophenol indophenols dye	50 mg
Sodium bicarbonate	42 mg
Volume	200 ml

Preparation of standard ascorbic acid solution

A quantity of 50 mg ascorbic acid was dissolved in metaphosphoric acid solution (3%) and the final volume was made to 50 ml by adding metaphosphoric acid. One ml of standard ascorbic acid solution was used to standardize the dye with appearance of pink colour as the endpoint.

Estimation

In a conical flask, 5 ml tomato juice was taken and diluted with 15 ml and a pinch of activated charcoal was added for the disappearance of red colour. It was then filtered through rough filter paper. The filtrate was further diluted with 3% metaphosphoric acid and final volume was made to 50 ml. In conical flask, 5 ml aliquot was taken and it was titrated against 2, 6- dichlorophenol indophenol dye. The endpoint was the appearance of pink colour persistent up to one minute. The ascorbic acid content was calculated using the following formula and results were expressed in mg of ascorbic acid per 100 g of fresh pulp weight.

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titer value (Y) x total volume made up}}{\text{Standard reading x ml of sample taken for titration x weight of fruit taken}} \times 100$$

Where,

Y is ml of 2, 6-dichlorophenol indophenol dye used.

3.8.13. TSS (Brix ˚B)

The firmly ripe fruits taken from five randomly selected plants from each treatment in middle of the total pickings per plot were cut into two pieces, their juice was directly dropped on the glass of hand refractometer and the reading on scale was recorded as percent total soluble solids.

3.8.14 N, P and K uptake at final harvest (kg ha^{-1}):

Plant samples collected for dry matter estimation at final harvest were used for analysis after grinding into fine powder. Nutrient uptake (N, P & K) of fruit was analyzed from the samples drawn from 6^{th} harvest.

3.8.15. Nitrogen Content:

Nitrogen content of plant samples was determined using method as described by Chapman and Pratt (1961). 0. 5 g uniform prepared plant sample was taken in digestion tube. Salt mixture (K_2SO_4 and $CuSO_4$.5H2O in the ratio of 10:1) was added in the tube 10ml. of concentrated H_2SO_4 acid was added and material was digested at 350 0C in digestion block till the material becomes colourless. Then the nitrogen in digested material was distilled by automatic KEL plus system.

3.8.16. Phosphorus Content:

Phosphorus content was determined by vanadomolybdo-phosphoric acid yellow colour complex method as described by Jackson (1973). An aliquot of 10 ml. was taken, 10 ml. of vanado-molebdate yellow reagent was added and volume was made up to 50 ml. After half an hour colour intensity was measured by spectrophotometer.

3.8.17. Potassium Content:

Potassium content was determined by flame photometer as described by Chapman and Pratt (1961). An aliquot of 5 ml. was taken and made up to volume of 25 ml. In volumetric flask and potassium content was determined by flame photometer.

3.8.18. Uptake of nutrients:

The uptake of N, P and K nutrients was calculated using the following formula and expressed in kg ha^{-1}

$$\text{Uptake (kg ha}^{-1}) = \frac{\text{Per cent Nutrient concentration} \times \text{Dry matter}}{100}$$

3.8.19. Economics

Cost of production for all treatment was worked out on the basis of the inputs used and market price existing for the produce. The net return ha^{-1} was calculated by deducting the cost of production ha^{-1} from the gross return ha^{-1}. Ultimately, net return per rupees (Benefit: Cost ratio) was calculated treatment wise to assess the economic impact of the treatment by dividing the net return ha^{-1} by the cost of production.

$$\text{Benefit-Cost ratio} = \frac{\text{Gross returns } (ha^{-1})}{\text{Cost of cultivation } (ha^{-1})}$$

3.8.20. Statistical analysis

The data collected from field observation and recorded in laboratory were subjected to statistical analysis of variance technique as described in "Statistical procedure for Agriculture Research" by Gomez and Gomez (1985) for significant treatment effects.

3.8.20.1 Mean: It was calculated by using following formula.

$$\text{Mean } (\bar{X}) = \frac{\sum x}{n}$$

Where,

$\sum x$ = the sum of all the observation
N = Number of observation

3.8.20.2 Correlation coefficients

Correlation coefficients were calculated in all possible combinations taking all the characters in to consideration by using the formula as proposed by Panse and Sukhatme (1961).

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

Where,

r = Correlation coefficient

n = Number of treatments

X and Y = Character under study

Testing of correlations

The correlations are tested for their significance by following formula based on "t" test:

$$tc = r\sqrt{\frac{n-2}{(1-R2)}} \quad \text{at (n-2) d.f.}$$

Where,

N= Number of treatments

r= correlations coefficient

The calculated value of "t" is compared with table of "t" at (n-2) d.f. If the calculated value is equal to or greater than table value, it is significant at given probability level. If $t_c < t_T$, it is non -significant.

3.8.20.3 T test: It was calculated by using following formula.

$$t = \frac{\bar{x_1} - \bar{x_2}}{\sqrt{s^2[\frac{1}{n_1} + \frac{1}{n_2}]}}$$

Where,

$\bar{x_1}$= mean of sample 1

$\bar{x_2}$ = mean of sample 2

n_1= number of subjects in sample 1

n_2= number of subjects in sample 2

s^2 = variance of sample

However, the degree of freedom is altered to compensate the heterogeneity of variances. The of freedom associated with this t is ½ $(n_{1+} n_2) - 1$.

CHAPTER- IV
RESULT AND DISCUSSION

A field experiment entitled **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh"** was conducted during the *Rabi* season of 2016-17 at the Instructional farm, College of Horticulture and Research Station, Jagdalpur (C.G.). The data has been recorded and analyzed on various parameters of crop growth, yield attributing characters, biochemical and economic parameters. The results and discussion of the experiment are briefly described in this chapter under the following heads:

4.1 T- test analysis
4.2 Mean performance
4.3 Correlation analysis
4.4 Economics

4.1 T- test analysis

Table 4.1 Effect of mulch and no mulch on the morphological characters of tomato in the kinnow orchard

Character treatment (mean)	With mulch	Without mulch	T -value	P- value
P.H. at 30 DAT	41.7	32.31	4.94*	0.003
P.H. at 60 DAT	49.55	43.7	2.03^{NS}	0.055
P. H. at 90 DAT	55.38	52.98	1.12^{NS}	0.162
P.H. at 120 DAT	59.85	55.17	2.72*	0.264
No. of branches plant^{-1}	26.53	18.2	5.03*	0.003
No. of fruits plant^{-1}	43.93	24.8	3.005*	0.019
Days taken to 1st flowering	42	46.66	-3.21*	0.016
Days taken to 50% flowering	61	67	-5.19*	0.003
Leaf area (cm)^2	16.69	11.34	5.00*	0.003
Nutrient Uptake N (kg ha^{-1})	123.27	113.70	5.82*	0.00
Nutrient Uptake P (kg ha^{-1})	14.21	12.09	4.66*	0.00
Nutrient Uptake K (kg ha^{-1})	110.81	97.76	3.03*	0.02
Days taken to 1st harvesting	78.00	83.00	-5.00*	0.00
Yield plant^{-1} (g)	13000	10000	3.67*	0.010
Yield ha^{-1} (q)	130.33	100	20.87*	0.001

*Significant at 5% level of probability, NS=Non-Significant

Table 4.2 Effect of mulch and no mulch on the morphological characters of chilli in the kinnow orchard

Character treatment (mean)	With mulch	Without mulch	T-value	P- value
P.H. at 30 DAT	20.21	13.87	2.91*	0.022
P.H. at 60 DAT	42.27	24.73	7.44*	0.001
P.H at 90 DAT	54.73	42.54	5.49*	0.003
P.H. at 120 DAT	60.64	53.71	3.02*	0.020
No. of branches plant^{-1}	37.47	25.60	2.65*	0.029
No. of fruits plant^{-1}	58.73	16.65	11.93*	0.000
Days taken to 1st flowering	35.67	43.67	-5.37*	0.003
Days taken to 50% flowering	55.67	64.00	-5.00*	0.004
Leaf area (cm)^2	62.46	51.39	4.99*	0.003
Nutrient Uptake N (kg ha^{-1})	74.65	72.50	22.37*	0.000
Nutrient Uptake P (kg ha^{-1})	13.04	12.24	7.82*	0.001
Nutrient Uptake K (kg ha^{-1})	77.44	74.69	13.41*	0.001
Days taken to 1st harvesting	76.67	80.67	-3.62*	0.011
Yield plant^{-1} (g)	3000	1966.66	7.11*	0.001
Yield ha^{-1} (q)	30	19.66	7.11*	0.001

*Significant at 5% level of probability, NS=Non-Significant

Table 4.3 Effect of mulch and no mulch on the morphological characters of brinjal in the kinnow orchard

Character treatment (mean)	With mulch	Without mulch	T -value	P- value
P.H. at 30 DAT	13.65	9.42	3.54*	0.012
P. H. at 60 DAT	34.84	18.54	3.83*	0.009
P.H. at 90 DAT	47.41	35.17	2.18^{NS}	0.051
P.H. at 120 DAT	52.61	41.22	2.14*	0.050
No. of branches plant^{-1}	21.53	16.33	2.18*	0.047
No. of fruits plant^{-1}	11.73	5.97	2.58*	0.031
Days taken to 1st flowering	42.33	45.67	-2.24*	0.045
Days taken to 50% flowering	61.00	65.33	-6.50*	0.001
Leaf area (cm)^2	57.66	47.66	4.37*	0.005
Nutrient Uptake N (kg ha^{-1})	222.22	225.59	-3.39*	0.014
Nutrient Uptake P (kg ha^{-1})	33.34	34.27	-2.98*	0.020
Nutrient Uptake K (kg ha^{-1})	107.99	114.23	-3.92*	0.009
Days taken to1st harvesting	77.33	83.33	-8.05*	0.001
Yield plant^{-1} (g)	20000	10000	5.11*	0.003
Yield ha^{-1} (q)	200	100	5.69*	0.002

*Significant at 5% level of probability, NS=Non-Significant

Table 4.4 Effect of mulch and no mulch on the morphological characters of bitter gourd in the kinnow orchard

Character treatment (mean)	With mulch	Without mulch	T -value	P- value
P.H. at 30 DAT	30.18	22.59	2.41*	0.037
P.H. at 60 DAT	76.43	65.72	3.46*	0.013
P.H. at 90 DAT	126.51	106.60	2.82*	0.024
P.H. at 120 DAT	191.51	150.99	4.89*	0.004
No. of branches plant^{-1}	29.67	17.93	4.89*	0.004
No. of fruits plant^{-1}	42.27	32.07	2.48*	0.034
Days taken to 1st flowering	66.33	71.33	-4.52*	0.005
Days taken to 50% flowering	86.67	91.33	-2.60*	0.030
Leaf area (cm)^2	43.15	36.91	4.24*	0.006
Nutrient Uptake N (kg ha^{-1})	47.67	31.83	13.57*	0.000
Nutrient Uptake P (kg ha^{-1})	7.63	6.85	4.83*	0.004
Nutrient Uptake K (kg ha^{-1})	41.20	35.13	11.47*	0.000
Days taken to 1st harvesting	95.67	106.00	-9.80*	0.000
Yield plant^{-1} (g)	10666.66	8000	3.94*	0.008
Yield ha^{-1} (q)	101.66	80	9.28*	0.003

*Significant at 5% level of probability, NS=Non-Significant

4.2 Mean performance

4.2.1 Plant parameter

4.2.1.1 Plant height at 30 DAT

The data on plant height at 30 days for tomato, chilli, brinjal and bitter gourd has been depicted in Table 4.5. The results revealed that the plant height at 30 days (cm) under mulching plots was 41.70, 20.21, 13.64, and 30.18 for tomato, chilli, brinjal and bitter gourd respectively. While without mulch it was observed to be 32.31, 13.87, 9.42 and 22.58 for tomato, chilli, brinjal and bitter gourd. Plant height at 30 DAT for tomato, chilli, brinjal and bitter gourd varied significantly in plastic mulch. It had a positive effect on initial germination of crop growth and development of crop. Plastic mulch discouraged the weed growth while in the non mulched plots, weeds occurrence was observed to be more. Quite similar results have been corroborated by Singh et *al*. (2017).

Table 4.5 Plant height of the mulched and non mulched intercrops in the kinnow orchard at 30 DAT

S.No.	Crop	With mulch	Without mulch	t-value	P – value	Test of significance
1.	Tomato	41.7	32.31	4.94	0.003	Significant
2.	Chilli	20.21	13.87	2.91	0.021	Significant
3.	Brinjal	13.64	9.42	3.54	0.011	Significant
4.	Bitter gourd	30.18	22.58	2.41	0.036	Significant

4.2.1.2 Plant height at 60 DAT

The data on plant height at 60 days (cm) is depicted in Table 4.6. The results showed that the plant height at 60 days under mulched plots was 49.55, 42.26, 34.84 and 76.43 while it was 43.70, 24.73, 18.54 and 65.72 respectively for tomato, chilli, brinjal and bitter gourd in the non mulched plots. The remarkable higher plant height under mulched crop might be attributed to the availability of longer and favourable growing period for plant growth and utilization of sufficient nutrients from the soil,

which resulted in quick and vigorous growth of the plants. The results of the present investigation are in conformity with the findings of Islam *et al*. (2010), Ali *et al*. (2014) and Singh *et al*. (2017).

4.2.1.3 Plant height at 90 DAT

Table 4.7 depicted the datas on plant height at 90 days (cm). The results revealed that the plant height at 90 days under the mulched plots was 55.38, 54.72, 47.40 and 126.50 whereas it was 52.98, 42.54, 35.16 and 106.6 respectively in the non mulched plots in tomato, chilli, brinjal and bitter gourd. Application of plastic mulch significantly increased the plant height over other treatments however the non mulched plots were at par among themselves. Improvement in micro climate with respect to moisture and nutrient availability might be responsible for increase in shoot height. Similar results were reported by Awasthi *et al*. (2006) and Ashrafuzzaman *et al.* (2011).

Table 4.6 Plant height of the mulched and non mulched intercrops in the kinnow orchard at 60 DAT

S.No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	49.55	43.70	2.03	0.055	Non significant
2.	Chilli	42.26	24.73	7.44	0.001	Significant
3.	Brinjal	34.84	18.54	3.82	0.001	Significant
4.	Bitter gourd	76.43	65.72	3.45	0.012	Significant

Table 4.7 Plant height of the mulched and non mulched intercrops in the kinnow orchard at 90 DAT

S. No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	55.38	52.98	1.12	0.162	Non significant
2.	Chilli	54.72	42.54	5.48	0.002	Significant
3.	Brinjal	47.40	35.16	2.18	0.051	Non significant
4.	Bitter gourd	126.50	106.6	2.82	0.023	Significant

4.2.1.4 Plant height at 120 DAT

Plant height of tomato, chilli, brinjal and bitter gourd at 120 DAT (cm) has been depicted in Table 4.8. The results of the present investigation revealed that the plant height varied from 59.85, 60.64, 52.61 and 191.51 in mulched plots to 55.17, 53.70, 41.22 and 150.98 for the plots without mulch. Application of plastic mulch significantly increased the plant height over the other treatments. Improvement in micro climate with respect to moisture and nutrient availability might be responsible for increase in shoot height. Similar results were reported by Awasthi *et al*. (2006) and Ashrafuzzaman *et al.* (2011).

Table 4.8 Plant height of the mulched and non mulched intercrops in the kinnow orchard at 120 DAT

S.No.	Crop	With mulch	Without mulch	t-value	P - value	Test of significance
1.	Tomato	59.85	55.17	2.72	0.264	Significant
2.	Chilli	60.64	53.70	3.02	0.019	Significant
3.	Brinjal	52.61	41.22	2.13	0.049	Significant
4.	Bitter gourd	191.51	150.98	4.88	0.004	Significant

4.2.2 Number of branches plant $^{-1}$

The datas pertaining to number of branches plant^{-1} is presented in Table 4.9. It was recorded to be significantly higher in mulched plots *viz*. 26.53, 37.47, 21.53 and 29.67. However the plots without mulch recorded 18.2, 25.60, 16.33 and 17.93 for tomato, chilli, brinjal and bitter gourd. Perusal of data clearly indicated that the mulched plots had a significant effect on the number of branches plant^{-1} in all the four crops where it significantly increased with the plant age. The mulch gave a positive effect on increasing and retaining higher number of branches plant^{-1}. Control recorded the least number of branches plant^{-1}. Favourable weather conditions and moisture of the soil are the important parameters affecting the branches plant^{-1}. The results of present investigation are in conformity with the findings of Ali *et al*. (2014) and Singh *et al*. (2015).

Table 4.9 Number of branches plant $^{-1}$ in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	26.53	18.2	5.03	0.003	Significant
2.	Chilli	37.47	25.60	2.65	0.029	Significant
3.	Brinjal	21.53	16.33	2.18	0.047	Significant
4.	Bitter gourd	29.67	17.93	4.89	0.004	Significant

4.2.3 Leaf area (cm^2)

The data on leaf area (cm^2) has been given in Table 4.10. It was observed to be significantly higher in the mulched plots *viz*., 16.69, 101.19, 57.66 and 43.15 however, the plots without mulch recorded 11.34, 68.26, 47.66 and 36.91 for tomato, chilli, brinjal and bitter gourd respectively. Leaf area components were observed to be comparatively higher in the mulched treatments than the control due to improved soil moisture conservation, reduced soil temperature, reduced weed infestation and nutrient availability as a result of reduced leaching of nutrients. The finding of present investigation is in agreement with the results of Ali *et al.* (2014).

Table 4.10 Leaf area (cm^2) of the mulched and non mulched intercrops in the kinnow orchard

S. No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	16.69	11.34	5.00	0.003	Significant
2.	Chilli	62.46	51.39	4.99	0.003	Significant
3.	Brinjal	57.66	47.66	4.37	0.005	Significant
4.	Bitter gourd	43.15	36.91	4.24	0.006	Significant

4.2.4 Number of fruits plant $^{-1}$

Table 4.11 displays the data on number of fruits plant^{-1}. It was recorded significantly higher in the mulched plots with a mean variable of 43.93, 58.73,

11.73 and 42.27 whereas in the plots without mulch it was recorded to be 24.8, 16.65, 5.97 and 32.07 for tomato, chilli, brinjal and bitter gourd. Mulching produced significantly more number of fruits plant^{-1} as compared to the non mulched plots. It can be attributed to the fact that mulching had a positive influence on fruit setting in tomato, chilli, brinjal and bitter gourd. This might be due to increased growth of plant under favourable soil micro climate both beneath and above the soil surface. The suitable conditions enhanced the plant growth and development and produced fruit bearing nodes as compared to the control. The results are in close harmony with the results of Singh *et al.* (2017).

Table 4.11 Number of fruits plant^{-1} in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P - value	Test of significance
1.	Tomato	43.93	24.8	3.005	0.019	Significant
2.	Chilli	58.73	16.65	11.93	0.001	Significant
3.	Brinjal	11.73	5.97	2.58	0.031	Significant
4.	Bitter gourd	42.27	32.07	2.48	0.034	Significant

4.2.5 Days taken to 1st flowering

The data on days taken to 1st flowering is presented in Table 4.12 for tomato, chilli, brinjal and bitter gourd. The datas revealed that the days taken to 1st flowering was recorded to be 42.00, 35.67, 42.33, 66.33 in the mulched plots while non mulched plots recorded 46.66, 43.67, 45.67, 71.33 days respectively. The data pertaining to days taken to 1st flowering also indicated that the different transplanting dates and mulching had significant effect on these traits. It is apparent from the data for tomato, chilli, brinjal and bitter gourd that there was a gradual decrease in days taken to 1st flowering, with the advancement in date of transplanting. It might be due to a marked influence of day and night temperature on the initiation of flowering. The results of present study are supported by the findings of Ahammad *et al*. (2009), Islam *et al*. (2010) and Hossain *et al*. (2013, 2014), Singh *et al*. (2017).

Table 4.12 Days taken to 1st flowering in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P - value	Test of significance
1.	Tomato	42.00	46.66	-3.21	0.016	Significant
2.	Chilli	35.67	43.67	-5.37	0.003	Significant
3.	Brinjal	42.33	45.67	-2.24	0.045	Significant
4.	Bitter gourd	66.33	71.33	-4.52	0.005	Significant

4.2.5 Days taken to 50% flowering

Table 4.13 depicts the datas on days taken to 50% flowering for tomato, chilli, brinjal and bitter gourd. The datas revealed that the mulched plots recorded 61.00, 55.67, 61.00, 86.67 days for 50% flowering whereas it was comparatively high in the non mulched plots that recorded 67.00, 64.00, 65.33, 91.33 days for the same. High soil temperature under plastic mulch improves the plant micro climate leading to early growth and development which advanced the flowering. Similar kind of observation with respect to plant growth was also reported by Ahammad *et al*. (2009), Islam *et al*. (2010) and Hossain *et al*. (2013 & 2014), Singh *et al*. (2017).

Table 4.13 Days taken to 50% flowering in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	61.00	67.00	-3.21	0.016	Significant
2.	Chilli	55.67	64.00	-5.00	0.004	Significant
3.	Brinjal	61.00	65.33	-6.50	0.001	Significant
4.	Bitter gourd	86.67	91.33	-2.60	0.030	Significant

4.2.6 Nutrient uptake (N, P and K)

4.2.6.1 Nutrient uptake N (kg ha^{-1})

The data on the effect of mulches on nutrient uptake (kg ha^{-1}) has been presented in Table 4.14 for tomato, chilli, brinjal and bitter gourd. The mulched plots recorded significantly higher values for Nitrogen i.e. 123.27, 74.65, 222.22 and 47.67 kg ha^{-1} while the non mulched plots recorded 113.70, 72.50, 225.59 and 31.83 kg ha^{-1}. Similar results were reported by Shedeed *et al*. (2009) and Hundal *et al.* (2000).

4.2.6.2 Nutrient uptake P (kg ha^{-1})

The data on the effect of mulches on nutrient uptake (kg ha^{-1}) has been depicted in Table 4.15 for tomato, chilli, brinjal and bitter gourd. The mulched plots recorded significantly higher phosphorus uptake of 14.21, 13.04, 33.34, and 7.63 kg ha^{-1} than the non mulched plots that recorded 12.09, 12.24, 34.27 and 6.85 kg ha^{-1} respectively for tomato, chilli, brinjal and bitter gourd respectively. The results of present study are supported by the findings of Khambal *et al*. (2009).

4.2.6.3 Nutrient uptake K (kg ha^{-1})

The data on the effect of mulches on potassium uptake (kg ha^{-1}) has been presented in Table 4.16. Significantly higher potassium uptake was recorded in the mulched plots *viz*., 110.81, 77.44, 107.99, 41.20 kg ha^{-1} however in the non mulched plots the uptake was 97.76, 74.69, 114.23 and 35.13 kg ha^{-1} for tomato, chilli, brinjal and bitter gourd respectively. Similar results were reported by Shedeed *et al*. (2009), Hundal *et al.* (2000) and Khambal *et al*. (2009).

4.2.7 Days taken to 1st harvesting

The data on days taken to 1st harvesting is presented in Table 4.2.7 for tomato, chilli, brinjal and bitter gourd. The mulched plots recorded an average of 78.00, 76.67, 77.33 and 95.67 days whereas the non mulched plots recorded 83.00, 80.67, 83.33, 106.00 days for 1st harvesting respectively. The data pertaining to days taken to 1st harvesting for tomato, chilli, brinjal and bitter gourd clearly indicated the significance of mulched plots. A gradual increase in temperature coupled with short growth period resulted in early flowering in plant and 1st harvesting, which are the

major components for the enhanced number of fruits. The results of present study are supported by the findings of Ahammad *et al*. (2009), Islam *et al*. (2010) Hossain *et al*. (2013, 2014) and Singh *et al*. (2017).

4.2.8 Yield plant^{-1} (g)

The data on the effect of mulches on the fruit yield plant^{-1} (g) is given in Table 4.18 for tomato, chilli, brinjal and bitter gourd. The yield data obtained in the mulched plots were 13000, 3000, 20000, 10666.67g plant^{-1} while the non mulched plots recorded 10000, 1966.66, 10000, 8000g plant^{-1} for tomato, chilli, brinjal and bitter gourd respectively. The effect of mulch on fruit yield was significant for different crops *viz*., tomato, chilli, brinjal and bitter gourd. The increase in number of harvesting, number of fruits plant^{-1} and higher early and total yield plastic mulch might be attributed to increased growth of plants under warmer and favourable soil microclimate. Similar kind of observation was also reported by Awasthi *et al*. (2006), Ashrafuzzaman *et al*. (2011) and Singh *et al*. (2017).

4.2.9 Yield ha^{-1} (q)

The data on the effect of fruit yield (q ha^{-1}) with and without mulches has been presented in Table 4.19 for tomato, chilli, brinjal and bitter gourd. The mean yields of the mulched plot were 130.33, 30.00, 200.00, 101.66 while that of the non mulched plots were 100.00, 19.66, 100.00, 80.00 q ha^{-1} for tomato, chilli, brinjal and bitter gourd respectively. The effect of the mulched plots on fruit yield was significant for all the crops under study. Similar kind of observations was also reported by Awasthi *et al*. (2006), Ashrafuzzaman *et al*. (2011) and Singh *et al*. (2017).

Table 4.14 Comparative study of Nutrient uptake of N (kg ha^{-1}) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P - value	Test of significance
1.	Tomato	123.27	113.70	5.82	0.001	Significant
2.	Chilli	74.65	72.50	22.37	0.001	Significant
3.	Brinjal	222.22	225.59	-3.39	0.014	Significant
4.	Bitter gourd	47.67	31.83	13.57	0.001	Significant

Table 4.15 Comparative study of Nutrient uptake of P (kg ha^{-1}) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	14.21	12.09	4.66	0.001	Significant
2.	Chilli	13.04	12.24	7.82	0.001	Significant
3.	Brinjal	33.34	34.27	-2.98	0.020	Significant
4.	Bitter gourd	7.63	6.85	4.83	0.004	Significant

Table 4.16 Comparative study of Nutrient uptake of K (kg ha^{-1}) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P - value	Test of significance
1.	Tomato	110.81	97.76	3.03	0.020	Significant
2.	Chilli	77.44	74.69	13.41	0.001	Significant
3.	Brinjal	107.99	114.23	-3.92	0.009	Significant
4.	Bitter gourd	41.20	35.13	11.47	0.001	Significant

Table 4.17 Days taken to 1st harvesting in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P - value	Test of significance
1.	Tomato	78.00	83.00	-5.00	0.001	Significant
2.	Chilli	76.67	80.67	-3.62	0.011	Significant
3.	Brinjal	77.33	83.33	-8.05	0.001	Significant
4.	Bitter gourd	95.67	106.00	-9.80	0.001	Significant

Table 4.18 Yield plant^{-1} (g) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	13000	10000	3.67	0.106	Significant
2.	Chilli	3000	1966.66	7.11	0.001	Significant
3.	Brinjal	20000	10000	5.22	0.003	Significant
4.	Bitter gourd	10666.67	8000	3.94	0.008	Significant

Table 4.19 Yield ha^{-1} (q) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P – value	Test of significance
1.	Tomato	130.33	100.00	20.87	0.001	Significant
2.	Chilli	30.00	19.66	7.11	0.001	Significant
3.	Brinjal	200.00	100.00	5.69	0.002	Significant
4.	Bitter gourd	101.66	80.00	9.28	0.003	Significant

4.2.10 Biochemical analysis

4.2.10.1 Protein (%)

The data on the effect of mulches on protein content (Table 4.20) recorded significant mean of 7.75, 2.8, 15.00 and 1.62% with mulch while without mulch the protein content (%) was observed to be 6.71, 1.83, 11.00 and 1.17 for tomato, chilli, brinjal and bitter gourd respectively. The increase in protein content of fruits in these treatments could be attributed to application of mulches. The findings are supported by the work of Singh *et al.* (2014).

4.2.10.2 Vitamin C (mg/100g)

The data on the effect of mulches (Table 4.21) recorded significantly higher Vitamin C content (mg/100g) in the mulched plots than the plots without mulch. The mulched plots recorded an average of 25.08, 120.04, 15.41, 46.21 mg/100g Vitamin C whereas the non mulched plots recorded 23.61, 112.14, 11.57, 24.64 mg/100g Vitamin C for tomato, chilli, brinjal and bitter gourd respectively. The data revealed that the different crops under study *viz*., tomato, chilli, brinjal and bitter gourd in the mulched plots recorded significant results. Similar findings were reported by Madhumathi and Sadarunnisa (2013) and Ashrafuzzaman *et al*. (2011).

4.2.10.3 TSS (^{0}Brix)

The total soluble solids (TSS ^{0}brix) were significantly affected by mulch (Table 4.22) for tomato, chilli, brinjal, bitter gourd. It recorded a mean value of 4.56, 4.37, 5.27 and 1.34^{0}brix. However the plots without mulch recorded 3.60, 3.33, 4.17, and 1.76^{0}brix for tomato, chilli, brinjal and bitter gourd respectively. Increase in the quality parameters might be due to increased availability of total soluble solids in the mulched plots. Quite similar findings were reported by Tipu *et al*. (2014) and Singh *et al*. (2015).

Table 4.20 Protein (%) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P -value	Test of significance
1.	Tomato	7.75	6.71	2.67	0.027	Significant
2.	Chilli	2.8	1.83	13.30	0.001	Significant
3.	Brinjal	15	11	4.89	0.004	Significant
4.	Bitter gourd	1.62	1.17	8.26	0.005	Significant

Table 4.21 Vitamin C (mg/100g) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P –value	Test of significance
1.	Tomato	25.08	23.61	2.82	0.023	Significant
2.	Chilli	120.04	112.14	3.64	0.010	Significant
3.	Brinjal	15.41	11.57	5.08	0.003	Significant
4.	Bitter gourd	46.21	24.64	12.87	0.001	Significant

Table 4.22 TSS (^{0}Brix) in the mulched and non mulched intercrops in the kinnow orchard

S.No.	Crop	With mulch	Without mulch	t-value	P –value	Test of significance
1.	Tomato	4.56	3.60	2.76	0.025	Significant
2.	Chilli	4.37	3.33	7.24	0.001	Significant
3.	Brinjal	5.27	4.17	4.97	0.003	Significant
4.	Bitter gourd	1.34	1.76	-2.79	0.024	Significant

4.3 Correlation analysis

The correlation analysis in tomato with mulch revealed (Table 4.23) that the total fruit yield had a significant positive correlation with days taken to 1st flowering (0.981) whereas it exhibited a negative correlation (-0.912) with the number of fruits plant^{-1} and leaf area (-0.944). Plant height showed a significant negative correlation with the number of fruits plant^{-1} (- 0.957). Number of branches plant^{-1} expressed a significant positive correlation with days taken to first flowering (0.940) however; days taken to 1st harvesting (-0.933) and leaf area (-0.979) expressed a significant negative correlation with it. Days taken to first flowering expressed a significant negative correlation with leaf area (-0.989) while, days taken to 50% flowering expressed a significant negative correlation with days taken to 1st harvesting (-0.944) in plots with mulch.

The data given in Table 4.24 depicted that the total fruit yield showed significant positive correlation without mulch number of branches plant^{-1}(0.998). Plant height showed a significant positive correlation with number of fruits plant^{-1} (0.995), days taken to 1st flowering (0.979) and days taken to 50% flowering (0.991) whereas leaf area (-0.941) expressed a significant negative correlation without mulch. Number of fruits plant^{-1} had expressed significant positive correlation with days taken to first flowering (0.994) and days taken to 50% flowering (0.974). However leaf area (-0.969) expressed a significant negative correlation without mulch. Days taken to 1st flowering and days taken to 50% flowering expressed significant negative correlation with leaf area (-0.990 and -0.890 respectively) in tomato. Similar results were reported by Tiwari and Upadhyay (2011).

Table 4.23 Correlation analysis in the mulched tomato plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
yield	1							
P.H.	0.075	1						
N.B.	0.859	0.316	1					
N.F.	-0.912*	-0.957*	-0.575	1				
1st F.	0.981*	0.619	0.940*	-0.818	1			
50%F.	0.327	-0.370	0.764	0.088	0.5	1		
1st H.	-0.618	0.045	0.933*	0.242	-0.755	-0.944*	1	
L A	-0.944*	-0.500	-0.979*	0.727	-0.989*	-0.619	0.842	1

R value = 0.878 *Significant at 5% level of probability

Table 4.24 Correlation analysis in the non mulched tomato plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
Yield	1							
P.H.	0.794	1						
N.B.	0.997*	0.746	1					
N.F.	0.731	0.995*	0.678	1				
1st F.	0.654	0.979*	0.596	0.994*	1			
50%F.	0.866	0.991*	0.826	0.974*	0.944*	1		
1st H.	0	0.607	-0.075	0.682	0.755	0.5	1	
L A	-0.542	-0.941*	-0.478	-0.969*	-0.990*	-0.890*	-0.839	1

R value = 0.878 *Significant at 5% level of probability

In chilli the correlation analysis in the mulched plots is depicted in Table 4.25. The total fruit yield showed that a significant positive correlation with number of branches plant^{-1} (0.959), number of fruits plant^{-1} (0.957), days taken to 1st flowering (0.960) and days taken to 50% flowering (0.960). While a significant negative correlation with days taken to 1st harvesting (-0.981). Number of branches plant^{-1} had a significant negative correlation with days taken to 1st harvesting (-0.889). The number of fruits plant^{-1} had a significant positive correlation with days taken to first flowering (0.999) and days taken to 50% flowering (0.999) however; days taken to 1st harvesting (-0.994) and leaf area (-0.909) expressed a significant negative correlation with number of fruits plant^{-1}. Days taken to 1st flowering and days taken to 50% flowering expressed a significant negative correlation with days taken to 1st harvesting (-0.995 and -0.995 respectively) and leaf area (-0.904 and -0.904

respectively).

Table 4.26 depicts the correlation in the non mulched plots. The total fruit yield showed a significant positive correlation with number of branches plant^{-1} (0.933) and days taken to 50% flowering (0.981). Plant height had a significant positive correlation with number of branches plant^{-1} (0.970) while, days taken to 1st flowering (0.905) recorded a significant negative correlation. Number of fruits plant plant^{-1} had a significant positive correlation with leaf area (0.884) while, days taken to 1st harvesting (-0.996) a significant negative correlation. Similar findings were reported by Ojeniyi *et al.* (2007) and Tiwari and Upadhyay (2011).

Table 4.25 Correlation analysis in the mulched chilli plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
yield	1							
P.H.	0.636	1						
N.B.	0.959*	0.827	1					
N.F.	0.957*	0.388	0.838	1				
1st F.	0.960*	0.397	0.844	0.999*	1			
50%F.	0.960*	0.397	0.844	0.999*	1	1		
1st H.	-0.981*	-0.479	-0.889*	-0.994*	-0.995*	-0.995*	1	
L A	-0.750	-0.030	-0.535	-0.909*	-0.904*	-0.904*	0.862	1

R value = 0.878 *Significant at 5% level of probability

Table 4.26 Correlation analysis in the non mulched chilli plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
yield	1							
P.H.	0.819	1						
N.B.	0.933*	0.970*	1					
N.F.	-0.696	-0.159	-0.392	1				
1st F.	-0.5	-0.905*	-0.777	-0.273	1			
50%F.	0.981*	0.696	0.848	-0.819	-0.327	1		
1st H.	0.755	0.244	0.470	-0.996*	0.188	0.866	1	
L A	-0.281	0.318	0.081	0.884*	-0.690	-0.457	-0.841	1

R value = 0.878 *Significant at 5% level of probability

Table 4.27 depicted the correlation values among various traits in brinjal grown under the mulched plots. Plant height had a significant positive correlation with days

taken to 50% flowering (0.900). Number of branches plant^{-1} also expressed a significant positive correlation with days taken to first flowering (0.999) however leaf area (-0.999) recorded a significant negative correlation. The number of fruits plant^{-1} had a significant positive correlation with days taken to 50% flowering (0.957) whereas, days taken to 1st harvesting (-0.973) had a significant negative correlation with it.

The correlation analysis in the non mulched plots has been depicted in the Table 4.28. Plant height recorded a significant positive correlation with number of branches plant^{-1} (0.957), number of fruits plant^{-1} (0.999) and days taken to 1st flowering (0.947) however, days taken to 50% flowering (-0.947) and days taken to 1st harvesting (-0.947) expressed a significant negative correlation. Number of branches plant^{-1} had a significant positive correlation with number of fruits plant^{-1} (0.965). The number of fruits plant^{-1} had a significant positive correlation with days taken to 1st flowering (0.938) whereas, days taken to 50% flowering (-0.938) and days taken to 1st harvesting (-0.938) expressed a significant negative correlation. Days taken to 1st flowering had a significant negative correlation with leaf area (-0.944). Days taken to 50% flowering and days taken to 1st harvesting recorded a significant positive correlation with leaf area (0.944). The results are in conformity with Moniruzzaman (2006), Awodoyin (2007), Ojeniyi *et al.* (2007), Dauda (2011), Norman *et al.* (2011) and Tiwari and Upadhyay (2011).

Table 4.27 Correlation analysis in the mulched brinjal plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
yield	1							
P.H.	0.073	1						
N.B.	-0.574	0.774	1					
N.F.	0.729	0.735	0.140	1				
1st F.	-0.596	0.757	0.999*	0.114	1			
50%F.	0.5	0.900*	0.421	0.957*	0.397	1		
1st H.	0.596	-0.562	0.088	-0.973*	0.114	-0.866	1	
L A	-0.397	-0.757	-0.999*	-0.114	-1	-0.397	-0.114	1

R value = 0.878 *Significant at 5% level of probability

Table 4.28 Correlation analysis in the non mulched brinjal plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
yield	1							
P.H.	0.379	1						
N.B.	0.097	0.957*	1					
N.F.	0.354	0.999*	0.965*	1				
1st F.	0.654	0.947*	0.815	0.938*	1			
50%F.	-0.654	-0.947*	-0.815	-0.938*	-1	1		
1st H.	-0.654	-0.947*	-0.815	-0.938*	-1	1	1	
L A	-0.866	-0.791	-0.581	-0.774	-0.944*	0.944*	0.944*	1

R value = 0.878 *Significant at 5% level of probability

Perusal of data in Table 4.29 depicts the correlation in the mulched plots in bitter gourd. The total fruit yield showed a significant negative correlation with leaf area (-0.907). Plant height expressed a significant positive correlation with number of branches (0.991) whereas, it was negative with the leaf area (-0.993). Number of branches had a negative correlation with leaf area (-0.971). Number of fruits plant^{-1} had shown significant positive correlation with days taken to 1st harvesting (0.960) whereas, days taken to 50% flowering (-0.960) expressed a significant negative correlation. Days taken to 1st flowering had a significant positive correlation with days taken to 50% flowering (0.944) whereas it was negatively correlated with days taken to 1st harvesting (-0.944).

Table 4.30 shows the correlation results in bitter gourd under non mulched plots. The total fruit yield had a significant positive correlation with number of fruits plant^{-1} (0.960), whereas, it was negatively correlated with number of branches plant^{-1} (-0.922). Plant height had a significant positive correlation with days taken to 1st flowering (0.892) and days taken to 50% flowering (0.892) whereas it had a negative correlation with the leaf area (-0.974). Number of branches had expressed significant positive correlation with days taken to 1st harvesting (0.991) however, it had a significant negative correlation with leaf area (-0.886). With regard to the days taken to 1st harvesting it had a significant negative correlation with leaf area (-0.938). The results are in conformity with Moniruzzaman (2006), Awodoyin (2007), Ojeniyi *et al.* (2007), Dauda (2011), and Norman *et al.* (2011).

Table 4.29 Correlation analysis in the mulched bitter gourd plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
Yield	1							
P.H.	-0.853	1						
N.B.	-0.780	0.991*	1					
N.F.	-0.355	-0.183	-0.306	1				
1st F.	-0.248	0.716	0.799	-0.817	1			
50%F.	0.082	0.449	0.558	-0.960*	0.944*	1		
1st H.	-0.082	-0.449	-0.558	0.960*	-0.944*	-1	1	
L A	-0.907*	-0.993*	-0.971*	0.070	-0.632	-0.344	0.344	1

R value = 0.878 *Significant at 5% level of probability

Table 4.30 Correlation analysis in the non mulched bitter gourd plots

	Yield	P.H.	N.B.	N.F.	1st F.	50%F.	1st H.	L A
yield	1							
P.H.	-0.451	1						
N.B.	-0.922*	0.760	1					
N.F.	0.960*	-0.186	-0.780	1				
1st F.	0.00	0.892*	0.384	0.277	1			
50%F.	0.00	0.892*	0.384	0.277	1	1		
1st H.	-0.866	0.837	0.991*	-0.693	0.5	0.5	1	
L A	0.640	-0.974*	-0.886*	0.402	-0.768	-0.768	-0.938*	1

R value = 0.878 *Significant at 5% level of probability

4.3 Economics

Economics of the mulched and non mulched plots for tomato, chilli, brinjal and bitter gourd

The data pertaining to gross income (ha^{-1}), net returns (ha^{-1}) and benefit cost ratio of the four vegetables under study during the *Rabi* seasons of 2016 and 2017 is presented in Tables 4.31, 4.32, 4.33 and 4.34.

Gross returns (Rs ha^{-1})

The gross income (Rs ha^{-1}) with the mulched and non mulched plots has been given in Table 4.31. In the mulched plots the gross income was observed to be 104264.00, 45000.00 and 100000.00 and 202000.00 whereas in the non mulched plots it was recorded to be 80000.00, 28599.00, 50000.00 and 160000.00 respectively for tomato, chilli, brinjal and bitter gourd. The highest gross return in

the mulched plots and non mulched plots was recorded in bitter gourd followed by tomato. The mulched plots recorded an amount of Rs 202000.00 ha^{-1} in bitter gourd followed by Rs 104264.00 ha^{-1} tomato while that in the non mulched plots it was observed to be bitter gourd Rs 160000.00 ha^{-1} followed by Rs 80000.00 ha^{-1} tomato. Similar results were reported by Singh (2017).

Net returns (Rs ha^{-1})

The net returns (Rs ha^{-1}) were the highest in the treatments having mulch. Bitter gourd (160419.00) followed by tomato (65083.00) recorded the maximum net returns in the mulched plots while in the non mulched plots bitter gourd and tomato recorded a net return of Rs 126419.00 and Rs 48819.00 ha^{-1} respectively. The lowest net return was obtained in chilli in the mulched (9099.00) and non mulched plots chilli Rs 698.00 ha^{-1} respectively. The highest net returns with the drip and plastic mulch treatment may be attributed to the higher yield of fruits. Similar results were reported by Singh (2017) and Suresha *et al.* (2007).

Benefit-cost ratio

The benefit-cost ratio was higher in bitter gourd and tomato both in the mulched (4.85 and 2.66) and non mulched plots (4.76 and 2.56 respectively). Similar results were reported by Prajapati *et al.* (2016) and Singh (2017).

Table 4.31 Cost of cultivation in tomato

Sl. No.	Operation/inputs	Requirement/ha	Rate(Rs)	Total cost (Rs)
A.	**Fixed cost**			
1.	**Seed**	200 g	25	5000.00
A	**Main field preparation**			
b.	**Tractor ploughing**	3 hours	750/hrs	2250.00
c.	**Layout of the field**	10 man days	207/ man days	2070.00
d.	**Planting**	10 man days	207/ man days	2070.00
e.	**Drip Irrigation**	15 hours	300/hours	4500.00
2.	**Plant protection chemicals**			
a.	**Cost of chemicals**	1500ml	20	3000.00
b.	**Application cost of chemicals**	3 man days	207/ man days	621.00
3.	**Cost of mulching**	8000	-	8000.00
4.	**Application cost of mulching**	By mulching machine	1000	1000.00
5.	**Harvesting**	10 man days	207/ man days	2070.00
6.	**Loading and carrying for Market**	6 times	750/hours	4500.00
	Total A			**35081.00**
B.	**Variable cost**			
A.	**Inorganic fertilizers**			
1.	**N:P:K**	3 kg	700/kg	2100.00
2.	**Growth hormones**	10 g	200rs/ g	2000.00
	Total B			**4100.00**
	Total cost (A+B)			**39181.00**

Table 4.32 Cost of cultivation in chilli

Sl. No.	Operation/inputs	Requirement/ha	Rate (Rs)	Total cost (Rs)
A.	**Fixed cost**			
1.	**Seed**	1.5 k g	980/kg	1470.00
A	**Main field preparation**			
b.	**Tractor ploughing**	3 hours	750/hrs	2500.00
c.	**Layout of the field**	10 man days	207/ man days	2070.00
d.	**Planting**	10 man days	207/ man days	2070.00
e.	**Drip Irrigation**	15 hours	300/hours	4500.00
2.	**Plant protection chemicals**			
a.	**Cost of chemicals**	1500ml	20	3000.00
b.	**Application cost of chemicals**	3 man days	207/ man days	621.00
3.	**Cost of mulching**	8000	-	8000.00
4.	**Application cost of mulching**	By mulching machine	1000	1000.00
5.	**Harvesting**	10 man days	207/ man days	2070.00
6.	**Loading and carrying for Market**	6 times	750/hours	4500.00
	Total A			**31801.00**
B.	**Variable cost**			
A.	**Inorganic fertilizers**			
1.	**N:P:K**	3 kg	700/kg	2100.00
2.	**Growth hormones**	10 g	200rs/g	2000.00
	Total B			**4100.00**
	Total cost (A+B)			**35901.00**

Table 4.33 Cost of cultivation in brinjal

Sl. No.	Operation/inputs	Requirement/ha	Rate (Rs)	Total cost (Rs)
A.	**Fixed cost**			
1.	**Seed**	200 g	25	5000.00
A	**Main field preparation**			
b.	**Tractor ploughing**	3hours	750/hrs	2250.00
c.	**Layout of the field**	10 man days	207/ man days	2070.00
d.	**Planting**	10 man days	207/ man days	2070.00
e.	**Drip Irrigation**	15 hours	300/hours	4500.00
2.	**Plant protection chemicals**			
a.	**Cost of chemicals**	1500ml	20	3000.00
b.	**Application cost of chemicals**	3 man days	207/ man days	621.00
3.	**Cost of mulching**	8000	-	8000.00
4.	**Application cost of mulching**	By mulching machine	1000	1000.00
5.	**Harvesting**	10 man days	207/ man days	2070.00
6.	**Loading and carrying for Market**	6 times	750/hours	4500.00
	Total A			**35081.00**
B.	**Variable cost**			
A.	**Inorganic fertilizers**			
1.	**N:P:K**	3 kg	700/kg	2100.00
2.	**Growth hormones**	10 g	200rs/g	2000.00
	Total B			**4100.00**
	Total cost (A+ B)			**39181.00**

Table 4.34 Cost of cultivation in bitter gourd

Sl. No.	Operation/inputs	Requirement /ha	Rate (Rs)	Total cost (Rs)
A.	**Fixed cost**			
1.	**Seed**	4 kg	1000/kg	4000.00
A	**Main field preparation**			
b.	**Tractor ploughing**	3 hours	750/hrs	2250.00
c.	**Layout of the field**	10 man days	207/ man days	2070.00
d.	**Planting**	10 man days	207/ man days	2070.00
e.	**Drip Irrigation**	15 hours	300/hours	4500.00
2.	**Plant protection chemicals**			
a.	**Cost of chemicals**	1000ml	20	2000.00
b.	**Application cost of chemicals**	3 man days	207/ man days	621.00
3.	**Cost of mulching**	8000	-	8000.00
4.	**Application cost of mulching and staking cost**	By mulching machine	-	5400.00
5.	**Harvesting**	10 man days	207/ man days	2070.00
6.	**Loading and carrying for Market**	6 times	750/hours	4500.00
	Total A			**37481.00**
B.	**Variable cost**			
A.	**Inorganic fertilizers**			
1.	**N:P:K**	3 kg	700/kg	2100.00
2.	**Growth hormones**	2 g	200rs/g	2000.00
	Total B			**4100.00**
	Total cost (A+B)			**41581.00**

Table 4.35 Economics of kinnow based intercropping with mulch

Treatments	Yield (q/ha)	Gross income (Rs)	Treatment Cost (Rs.)			Net return (Rs)	Benefit: Cost Ratio (BCR)
			Fixed Cost	Variable Cost	Total cost		
Tomato	130.33	104264.00	35081.00	4100.00	39181.00	65083.00	2.66
Chilli	30.00	45000.00	31801.00	4100.00	35901.00	9099.00	1.25
Brinjal	200.00	100000.00	35081.00	4100.00	39181.00	60819.00	2.55
Bitter gourd	101.66	202000.00	37481.00	4100.00	41581.00	160419.00	4.85

Sale price of tomato @ Rs. 8/kg; chilli @ Rs 15/kg; brinjal @ Rs 5/kg; bitter gourd @ Rs 20/kg.

Table 4.36 Economics of kinnow based intercropping without mulch

Treatments	Yield (q/ha)	Gross income (Rs)	Treatment Cost (Rs.)			Net return (Rs)	Benefit :Cost Ratio (BCR)
			Fixed Cost	Variable Cost	Total Cost		
Tomato	100.00	80000.00	27081.00	4100.00	31181.00	48819.00	2.56
Chilli	19.66	28599.00	23801.00	4100.00	27901.00	698.00	1.02
Brinjal	100.00	50000.00	27081.00	4100.00	31181.00	18819.00	1.60
Bitter gourd	80.00	160000.00	29481.00	4100.00	33581.00	126419.00	4.76

Sale price of tomato @ Rs. 8/kg; chilli @ Rs 15/kg; brinjal @ Rs 5/kg; bitter gourd @ Rs 20/kg.

FIG. 1. GENERAL VIEW OF EXPERIMENTAL FIELD WITH MULCH

FIG. 2. GENERAL VIEW OF EXPERIMENTAL FIELD WITH MULCH

FIG. 1. GENERAL VIEW OF EXPERIMENTAL FIELD WITHOUT MULCH

FIG.2. GENERAL VIEW OF EXPERIMENTAL FIELD WITHOUT MULCH

CHAPTER-V
SUMMARY AND CONCLUSIONS

A field experiment entitled **"Effect of mulching on vegetables as intercrop in the Kinnow orchard under agro-climatic condition of Bastar plateau of Chhattisgarh"** was conducted during the *Rabi* season of 2016-17 at the Instructional farm, College of Horticulture and Research Station, Jagdalpur (C.G.).

The experiment was laid out in T-test with three replications. The treatment consisted of mulched and non mulched plots in four different crops *viz*., tomato, chilli, brinjal and bitter gourd. Observations on 13 important characters *viz*., plant height, number of branches plant^{-1}, number of fruits plant^{-1}, days taken to 1st flowering, days taken to 50% flowering, leaf area, nutrient uptake (N, P and K), days taken to 1st harvesting, protein, total soluble solids, vitamin C, yield plant^{-1} and yield ha^{-1}. The growth studies, correlation and B: C ratio its components have also been summarized below:

A. Tomato

The mulched plots of tomato recorded the maximum plant height (59.85cm), number of branches plant^{-1} (26.53), numbers of fruits plant^{-1} (43.93), days taken to 1st flowering (42.00), days taken to 50% flowering (61.00), leaf area (16.69cm), nutrient uptake (123.27, 14.21 and 110.81 NPK respectively), days taken to 1st harvesting (78.00), protein percent (7.75%), TSS percent (4.56), vitamin C (25.08), yield plant^{-1} (13000g), yield ha^{-1} (130.33q) and benefit cost: ratio of (2.66). However, the non mulched plots recorded the maximum plant height (55.17cm), number of branches plant^{-1} (18.20), numbers of fruits plant^{-1} (24.80), days taken to 1st flowering (46.66), days taken to 50% flowering (67.00), leaf area (11.34cm), nutrient uptake (113.70, 12.09 and 97.76 NPK respectively), days taken to 1st harvesting (83.00), protein percent (6.71%), TSS percent (3.60), vitamin C (23.61), yield plant^{-1} (10000g), yield ha^{-1} (100q) and benefit cost: ratio of (2.56).

(B) Chilli

Perusal of data on the mulched and non mulched plots revealed the following results. The mulched plots recorded the maximum plant height (60.64cm), number of branches plant^{-1} (37.47), numbers of fruits plant^{-1} (58.73), days taken to 1st flowering (35.67), days taken to 50% flowering (55.67), leaf area (62.46cm), nutrient uptake (74.65, 13.04 and 77.44 NPK respectively), days taken to 1st harvesting (76.67), protein percent (2.80%), TSS percent (4.37), vitamin C (120.04), yield plant^{-1} (3000g), yield ha^{-1} (30q) and benefit cost: ratio (1.25). However, the non mulched plots recorded the maximum plant height (53.71cm), number of branches plant^{-1} (25.60), numbers of fruits plant^{-1} (16.65), days taken to 1st flowering (43.67), days taken to 50% flowering (64.00), leaf area (51.39cm), Nutrient uptake (72.50, 12.24 and 74.69 NPK respectively), days taken to 1st harvesting (80.67), protein percent (1.83%), TSS percent (3.33), vitamin C (112.14), yield plant^{-1} (1966.66g), yield ha^{-1} (19.66q) and benefit cost: ratio (1.02).

(C) Brinjal

The mulched plots of brinjal recorded the maximum plant height (52.61cm), number of branches plant^{-1} (21.53), numbers of fruits plant^{-1} (11.73), days taken to 1st flowering (42.33), days taken to 50% flowering (61.00), leaf area (57.66cm), nutrient uptake (222.22, 33.34 and 107.99 NPK respectively), days taken to 1st harvesting (77.33), protein percent (15.00%), TSS percent (5.27), vitamin C (15.41), yield plant^{-1} (20000g), yield ha^{-1} (200q) and benefit cost: ratio (2.55). However, the maximum plant height (41.22cm), number of branches plant^{-1} (16.33), numbers of fruits plant^{-1} (5.97), days taken to 1st flowering (45.67), days taken to 50% flowering (65.33), leaf area (47.66cm), Nutrient uptake (225.59, 34.27 and 114.23 NPK respectively), days taken to 1st harvesting (83.33), protein percent (11.00%), TSS percent (4.17), vitamin C (11.57), yield plant^{-1} (10000g), yield ha^{-1} (100q) and benefit cost: ratio of (1.60) was observed in the non mulched plots of brinjal.

(D) Bitter gourd

The mulched plots of bitter gourd recorded the maximum plant height (191.51cm), number of branches plant^{-1} (29.67), numbers of fruits plant^{-1} (42.27), days taken to 1st flowering (63.33), days taken to 50% flowering (86.67), leaf area (43.15cm), nutrient uptake (47.67, 7.63 and 41.20 NPK respectively), days taken to 1st harvesting (95.67), protein percent (1.62%), TSS percent (1.34), vitamin C (46.21), yield plant^{-1} (10666.67g), yield ha^{-1} (101.66q) and benefit cost: ratio of (4.85). However, the maximum plant height (150.99cm), number of branches plant^{-1} (17.93), numbers of fruits plant^{-1} (32.07), days taken to 1st flowering (71.33), days taken to 50% flowering (91.33), leaf area (36.91cm), Nutrient uptake (31.83, 6.85 and 34.13 NPK respectively), days taken to 1st harvesting (106.00), protein percent (1.17%), TSS percent (1.76), vitamin C (24.64), yield plant^{-1} (8000g), yield ha^{-1} (80q) and benefit cost: ratio of (4.76) was recorded in the non mulched plots of bitter gourd.

CONCLUSIONS

1. The present investigation revealed that among the mulched and non mulched treatments, plastic mulch recorded comparatively higher yield attributes of tomato, chilli, brinjal and bitter gourd as intercrops in the kinnow orchard.
2. Higher economic returns were obtained with mulch under tomato, chilli, brinjal and bitter gourd intercropping system.

SUGGESTIONS FOR FUTURE RESEARCH WORK

On the basis of experience gained and results obtained after completion of present investigation, following suggestions are being made for further research work:

- There is a need to conduct long-term investigation to ascertain the combined benefits of drip irrigation with mulches on crop yield under different intercropping systems.
- Effect of mulching on other aspects like temperature modulation, pest and disease incidence, soil microbial flora and fauna and nutrient mineralization must be studied.

REFERENCES

A.O.A.C. 1975. Official methods of analysis. 2nd Edn. Association of Official Agricultural Chemist, Washington, D.C. 832 pp.

A.O.A.C. 1990. Official methods of analysis. 15th Edn. Association of Official Agricultural Chemist, Washington, D.C.

Adeniyi, O.R. 2001. An economic evaluation of intercropping with tomato and okra in a rain forest zone of Nigeria. Agricultural University, Coimbatore, Indian Journal of Horticultural Science and Biotechnology, 76(3):347-34

Agele, S.O., Olufayo, A. and Iremiren, G.O. 2002. Effects of season of sowing on water use and yield of tomato in the humid south of Nigeria. African Crop Science Journal, 10(3), 231-237.

Ahammad, K.U., Siddiky, M.A., Ali, Z. and Ahmed, R. 2009. Effect of planting time on the growth and yield of tomato varieties in late season. Progressive Agriculture, 20(1&2): 73-78.

Aladakatti, Y.R., Hallikeri, S.S., Nandagavi, R.A., Hugar, A.Y. and Naveen, N.E. 2010. Effect of Inter cropping of oilseed crops on growth, yield and economics of cotton (*Gossypium hirsutum*) under rainfed conditions Karnataka J. Agric. Sci., 24 (3) : (280 - 282).

Ali, M.B., Lakun, H.I., Abubakar, W. and Mohammed, Y.S. 2014. Performance of tomato as influenced by organic manure and sowing date in Samaru, Zaria. International Journal of Agronomy and Agricultural Research, 5(5): 104-110.

Ashrafuzzaman, M., Hamid, A.M., Ismail, M.R and Sahidullah, S.M. 2011. Effect of Plastic Mulch on Growth and Yield of Chilli (*Capsicum annuum* L.). Brazilian Archives of Biology and Technology, 54(2): 321-330.

Awasthi, O.P., Singh, I.S. and Sharma, B.D. 2006. Effect of mulch on soil-hydrothermal regimes, growth and fruit yield of brinjal under arid conditions. Indian Journal of Horticulture, 63(2):192-194.

Awodoyin, R.O., Ogbeide, F.I. and Oluwole, O. 2007. Effects of three mulch types on the growth and yield of tomato (*Lycopersicon esculentum* Mill.) and weed

suppression in Ibadan, Rainforest-savanna Transi-tion Zone of Nigeria. Tropical Agricultural Research and Extension.

Banjara, N.C., Sahu, G.D., Singh, P. and Chandrakar, O. 2015. Effect of Mulching and Amount of Water on the Growth and Yield of Chilli (*Capsicum frutescens* L.) Under drip Irrigation Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya Raipur, (C.G.) Trends in Biosciences, 8(8): 1982-1985.

Bhujbal, P.D.**,** Tambe, T.B.and Ulemale, P.H. 2015. Effects of different types of mulches on growth and yield of tomato. (*Lycopersicon esculentum* Mill.) Var. Dhanashree. Bioinfolet, 12 (2): 64 - 466.

Black, C.A. (Ed.) 1965. Methods of soil analysis, part 1 and part 2. American society of agronomy, Inc. Madison, Wisconsin, USA.

Chapman, H.D. and Pratt, P.F.1961. Methods of analysis for soils, plants, and waters. Univ. of Calif., Div. Agri. Sci., Berkeley, Calif. 309 p.

Chaurasiya, P.C. and Sahu, G.D. 2016. Effect of Different Type of Mulch, Fertigation and Drip Irrigation in Chilli on Open Field Condition. Int. J. Multidisciplinary Research and Advanced, 1 (1): 1-6.

Dauda belel, M. 2012. Effects of grassed and synthetic mulching materials on growth and yield of sweet pepper (*Capsicum annum*) in Mubi, Nigeria Journal of Agriculture and Social Sciences, 8: 97-99.

Directorate of Horticulture, 2015. Area and Production of Vegetable crops, Raipur (Chhattisgarh), 12(8): 56-58.

Firoz, Z.A., Zaman, M.M., Uddin, M.S. and Akand, M.H. 2009. Effect of mulching method and planting time on the yield and yield attributes of tomato in hill slope ISSN 0258-7122 Bangladesh J. Agril. Res., 34(2): 227-232.

Fortnum, R.A., Kasperauer, M.J. and Decoteau, D.R. 2000. Effect of Mulch Surface colour on root-knot nematode of Tomato grown in simulated planting beds. Journal of Nematology, 32(1): 101- 109.

Gomez, K.A. and Gomez, A. 1985. Statistical procedure for agriculture research. wibey- International Science Publication John and Sons. Newyork. Indian Fd. Pack., 68-72.

Horticulture Statistics Division, 2015. FAC &FW.

Hossain, M.F., Ara, N., Islam, M.R., Hossain, J. and Akhter, B. 2013. Effect of different sowing dates on yield of tomato genotypes. International Journal Agricultural Research Innovation and Technology, 4(1): 40-43.

Hossain, M.F., Ara, N., Uddin, M.S., Islam, M.R. and Kaisar, M.O. 2014. Effect of sowing dates on fruit setting and yield of tomato genotypes. Journal of Agricultural Research, 52(4): 547-553.

Hundal, I.S., Sandhu, K.S., Singh, D and Sandhu, M.S. 2000. Effect of different types of mulching and herbicidal treatments on nutrient uptake in tomato (*Lycopersicon esculentum* L.). *Haryana Journal of Horticulture Science*, 29(3&4): 242-244.

Hussain Syed Asghar. 2003. Growth, yield and economic impacts of intercropping in Vegetables. Ph.D.Thesis Pakistan.pp., 26-90.

Islam, M., Saha, S., Akand, H. and Rahim, A. 2010. Effect of sowing date on the growth and yield of sweet pepper (*Capsicum annuum* L.). Agronomski Glasnik, 1(3): 3-14.

Jackson, M.L. 1967. Soil Chemical Analysis. Asia Publishing House, New Delhi.

Jackson, M.L. 1973. Soil Chemical Analysis, prentice hall, New Delhi.

Jackson, M.L. 1979. Soil Chemical Analysis, Advanced Course. 2nd edn. University of Wisconsin, Madison, WI, USA, 11th Printing, Published by the author. 895 p.

Kannan, M., Jaansirani, P., Sathiyamurthy, V.A. Veeraragavathatham, D. and Sanker, V. 2001. Standardization of vegetable intercropping system in

Amorphophallus Yam (*Amorphophallus paeoniifolius*). South Indian Horticulture. 49: 370-372.

Khambal, P.D., Shinde, P.P., Pawar, P.P. and Dahiphale, A.V. 2009. Scheduling of drip irrigation to okra (*Abelmoschus esculentus* L. Moench) under polythene mulches. Journal of Maharashtra Agricultural University, 34(1): 99-101.

Koli, B.D., Deshpande, A.N., Kate, R.N. and Bangar, A.R. 2004. Inter and intra cropping of vegetables in castor on inceptisols of dry land conditions. Indian Journal of Agronomy, 49 (2): 154-159.

Koli, B.D., Kate, R.N., Deshpande, A.N. and Bangar, A.R. 2003. Intercropping of vegetables in redgram based cropping system on inceptisols under dry land conditions. Indian Journal of Dry land Agricultural Research and Development, 18 (2): 27-34.

Kumar, S., Rawat, C.R. and Melkania, N. P. 2005. Forage production potential and economics of maize and cowpea intercropping under rainfed conditions. Indian Journal of Agronomy, 50(3): 184-186.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J., 42: 421-428.

Lowry, O.H., Rosebrough, N.J., Farr, A.L., and Randall, R.J. 1951. J. Biol. Chem., 193: 265 (The original method).

Madhumathi, C. and Sadarunnisa, S. 2013. Effect of different transplanting dates and varieties on fruit quality and seed yield of tomato (*Lycopersicon esculentum* Mill.). Asian Journal of Horticulture, 8(1): 8-11.

Maria, Z.D.N., Francisco, B.N., Vânia, C.N.P. and Ricardo, H.S.S. 2000. Performance of lettuce cultivars with and without intercropping with carrot. Mossoro Horticulture Brasileira, 20 (2):625-690.

Moniruzzaman, M. 2006. Effects of Plant Spacing and Mulching on Yield and Profitability of mulch in arid region of India. Agrochemical, 31: 183-202.

Nemagouda, S.V. 2004. Production potential of hybrid cotton (*Gossypium hirsutum* L.) based vegetable intercropping systems under irrigated condition. M.Sc. (Ag) Thesis submitted to University of Agricultural Sciences, Dharwad.

Norman, J.C., Opata, J. and Ofori, E. 2011. Growth and yield of okra and hot pepper as affected by mulching. Ghana Journal of Horticulture, 9: 35-42.

Ojeniyi, S. O., Awodun, M. A. and Odedina, S. A. 2007. Effect of Animal Manure, Amended Spent Grain and Cocoa Husk on Nutrient Status, Growth and Yield of Tomato. Middle –East Journal of Sciencetific Research, 2 (1):33-36.

Panse, V.G. and Sukhatme.P.V. 1961. Statistical methods for Agricultural Research Workers, lCAR, New Delhi.

Patil, J.D., Ranpise, S. A. and Kakade, D.S. 2004. Intercropping studies in cabbage during kharif season. Journal of Maharashtra Agricultural University, 29(1):39-41.

Piper, C.S. 1967. Soil and plant analysis. The University of Adelaide, Australia pp: 286.

Prajapati Om Prakash, Gupta Prashant Kumar, Lekhi Rajesh, Patidar Jairam and Jatav Rajesh. 2016. Effect of different mulches on growth, yield and its attributing characters of chilli (*Capsicum annuum* L.) CV. Kalipeeth, ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 8, Issue 64, pp.-3599-3602.

Prasad, R., Singh, R., Singh, S. and Pal, M. 2001. Studies on intercropping potato with fenugreek. Acta Agronomical Hungarian, 49 (2):189-19.

Rattanpal, H.S., Singh Sandeep, Arora Anita and Sangwan, A.K. 2008. Citrus Cultivation in Punjab Harvest and Post-harvest handling of citrus fruits.

Selvakumar, T. 2006. Performance evaluation of drip fertigation on growth, yield and water use in hybrid chilli (*Capsicum annuum* L.). PhD Thesis. Tamil Nadu Agricultural University, Coimbatore, India.

Shedeed, S.I., Zaghloul, S.M. and Yassen, A.A. 2009. Effect of method and rate of fertilizer application under drip application on yield and nutrient uptake by tomato. Ozean Journal of Applied Sciences, 2: 139-147.

Singh, A., Gulati, I.J., Sharma, S and Prasad, M. 2013. Studies on NPK drip fertigation with organic manures for tomato (*Lycopersicon esculentum* Mill.) under arid condition. Annals of Agri. Bio Research, 18 (2):182-185.

Singh, A., Jain, P.K., Sharma, H.L. and Singh, Y. 2015. Effect of planting date, and integrated nutrient management on the production potential of tomato (*Solanum lycopersicum* Mill.) under polyhouse conditions. Journal of Crop and Weed, 11(Special Issue): 28-33.

Singh, B., Kumar, M. and Singh, G.C. 2005. Effects of different plastic mulches on growth and yield of winter tomato. Indian Journal of Horticulture, 62(2): 200-202.

Singh, C.K., John, S.A. and Jaiswal, D. 2014. Effect of organics on growth, yield and biochemical parameters of chilli (*Capsicum annum* L.). IOSR Journal of Agriculture and Veterinary Science, (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 7, Issue 7 Ver. II, PP 27-32.

Singh, D.P., Mandal, S.S., Kumar, and Akhtar, S.A. 2002. Production and profitability of potato and maize intercropping system. Potato global research and development proceeding of the Global conference on potato**.** 2:968-969.

Singh, H., Sharma, P., Kumar, P., Dhillon, N.S. and Sekhon, B.H. 2017. Influence of Mulching on Growth and Yield of Tomato (*Solanum lycopersicum* L.) under Protected Environment. Biotechnology Journal International, 19(2): 1-6, 2017; Article no.BJI.35410 ISSN: 2456-7051

Singh, I.S., Awasthi, O.P. and Nagaraja A. 2013. Effect of manuring and mulches on irrigated arid brinjal in Western India. Indian Journal of Horticulture, 70(2): 248-254.

Singh, M.V., Singh, A.P. and Verma, S.K. 2000. Yield and economics of intercropping of wheat with potato. Haryana Journal of horticulture Science, 29 (1/2):130.

Singh, R., Kumar, S., Nangare, D.D and Meena, M.S. 2009. Drip irrigation and black polyethylene mulch influence on growth, yield and water-use efficiency of tomato. African Journal of Agricultural Research, 4(12): 1427-1430.

Singh, S.N., Malic, J.P.S. and Sharma, M.L. 2001. Intercropping of potato and other vegetable with autumn- planted sugarcane. Journal of the Potato Association, 28 (1):48-49.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 25, 259–260.

Suresha, B.A., Alloli, T.B., Patil, M.G., Desai, B.K. and Hussain, S.A. 2007. Yield and economics of chilli based intercropping system. Karnataka Journal of Agricultural Science, 20 (4): 807-809.

Timbilla, J.A. and Nyako, K.O. 2001. Efficacy of intercropping as a management tool for the control on insect pests of cabbage in Ghana. Tropicultural, 19 (2): 49-52.

Tipu, M.M.H., Amin, M., Dhar, M., & Alam, M.A. 2014. Effects of Mulching on Yield and Quality of Tomato Varieties. Research & Reviews: Journal of Agricultural Science and Technology, 3(3), 12-14.

Tiwari, J.K. and Upadhyay, D. 2011. Correlation and path-coefficient studies in tomato (*Lycopersicon esculentum* Mill.). *Res. J. of Agric. Sci.,* 2 (1): 63-68.

Tiwari, R. and Baghel, B.S. 2013. Effect of intercropping on plant and soil of Dashehari mango orchard under low productive environments. The Asian Journal of Horticulture, Volume 9 DOI: 10.15740/HAS/TAJH/9.2/439-442.

Varghese, L.L. 2000. Indicators of production sustainability in intercropped vegetable farming in montmorillonite soils of Indian journal of Sustainable Agriculture, 16:5-17.

Varghese, A. and Habeeburrahman, P.V. 2015. Fertigation and plastic mulching in tomato and brinjal - A review. Agricultural Reviews, 36(3): 246-249.

Walkley, A. 1965. An examination of methods for determining organic carbon and nitrogen in soil. J. Agric Sci., 25: 598-609.

Wolf, B. 1971. Determination of boron in soil extract, plant materials, composts, manures, water and nutrient solutions. Commun. Soil Sci. Plant Anal., 2: 363-374.

Yildirim, E. and Ismail, G. 2003. Intercropping based on cauliflower: more productive, profitable and highly sustainable. Indian journal of Agricultural Science, 79 (2):135-137.

APPENDICES

Appenx-I.Weekly meteorological data recorded during crop growth period.

Week No	Week	Max. Temp 0C	Min. Temp 0C	Rainfall mms	Relative Humidity I	Relative Humidity II	Wind Vel. Kmph	Bright hours Sunshine	Rainy Days
1.	1 Oct -7 Oct	30.8	22.7	47.9	95	68	3.5	5.7	4
2	8 Oct -14 Oct	29.5	20.8	134.7	96	66	3.0	3.9	4
3	15 Oct -21 Oct	29.7	17.0	0.0	97	37	2.8	9.1	0
4	22 Oct -28 Oct	29.6	16.3	0.0	95	40	3.3	7.1	0
5	29 Oct-4 Nov	30.7	20.9	0.0	94	49	3.2	5.1	0
6	5 Nov -11 Nov	29.0	13.8	0.0	96	30	3.2	7.6	0
7	12 Nov -18 Nov	29.7	15.4	0.0	97	41	2.1	6.4	0
8	19 Nov -25 Nov	29.3	10.5	0.0	98	23	2.5	8.7	0
9	26 Nov-2 Dec	30.7	10.4	0.0	94	24	2.2	8.6	0
10	3 Dec -9 Dec	29.3	12.6	0.0	95	37	2.5	7.5	0
11	10 Dec -16 Dec	28.8	13.1	0.0	93	32	3.4	4.8	0
12	17 Dec -23 Dec	28.7	6.8	0.0	94	24	2.1	7.4	0
13	24 Dec -31 Dec	28.8	7.5	0.0	94	29	1.9	7.3	0
14	1Jan-7Jan	28.7	9.4	0.0	95	30	2.3	7.0	0
15	8Jan-14 Jan	27.6	8.7	0.0	95	32	2.7	7.1	0
16	15 Jan-21 Jan	28.4	7.0	0.0	95	25	2.7	8.9	0
17	22 Jan-28 Jan	18.0	12.0	0.0	93	30	2.9	7.5	0
18	29 Jan-4 Feb	23.0	10.4	0.0	92	23	2.3	8.3	0
19	5 Feb - 11 Feb	32.1	11.4	0.0	89	28	2.6	8.8	0
20	12 Feb - 18 Feb	31.3	12.3	0.0	90.3	27.3	3.2	6.6	0
21	19 Feb - 25 Feb	34.6	12.4	0.0	86.7	19.0	3.6	9.9	0
22	26 Feb - 4 March	34.2	12.1	0.0	79.7	15.7	3.1	9.6	0
23	5 Mar - 11 Mar	33.7	20.0	11.9	83.7	42.3	5.7	6.8	1
24	12 Mar - 18 Mar	33.4	14.9	0.0	82.7	21.7	3.8	9.5	0
25	19 Mar - 25 Mar	35.6	16.9	0.0	76.0	19.7	3.8	9.5	0
26	26 Mar - 1 April	38.8	21.8	0.0	77.3	25.3	4.7	7.3	0

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Degree	Year	University/Institute
10th	2007	CGBSE, Raipur
12th	2009	CGBSE, Raipur
B.Sc. (Ag.)	2015	IGKV, Raipur
M.Sc. (Hort.) Vegetable science	2017	IGKV, Raipur

Professional Experience (If any): Rural Agricultural Work Experience Programme

Membership of Professional Societies (If any): No

Awards / Recognitions (If any): No

Publications (If any): No

Signature