

**EFFECT OF HYBRID MAIZE (*Zea mays*) + SOYBEAN (*Glycine max*  
L. Merrill)/COWPEA (*Vigna sinensis*) INTERCROPPING WITH  
DIFFERENT CROP CONFIGURATION ON PRODUCTIVITY AND  
ECONOMICS OF HYBRID MAIZE BASED INTERCROPPING  
SYSTEM**

**M.Sc. (Ag.) Thesis**

**by**

**Mukesh Kumar Sahu**

**DEPARTMENT OF AGRONOMY  
COLLEGE OF AGRICULTURE  
FACULTY OF AGRICULTURE  
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SYSTEM**

**Thesis**

**Submitted to the**

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**by**

**Mukesh Kumar Sahu**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR  
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**In**

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## CERTIFICATE - I

This is to certify that the thesis entitled “Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system” submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Mukesh Kumar Sahu** 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 or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Date: 25/06/16



Chairman

### THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman (Dr. S. N. Khajanji)



Member (Dr. (Major) G. K. Shrivastava)



Member (Dr. Sunil Nag)



Member (Dr. Ravi R. Saxena)




Member (Dr. Rajendra Lakpale)



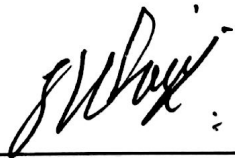
## CERTIFICATE - II

This is to certify that the thesis entitled “Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system” submitted by **Mukesh Kumar Sahu** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the Department of Agronomy has been approved by the external examiner and Student's Advisory Committee after oral examination.


Date: 13/08/16

  
Signature External Examiner  
(Name Dr. S.K. Choudhary)

Major Advisor

  
\_\_\_\_\_

Head of the Department /Section

  
\_\_\_\_\_ 13/8/16

Dean Faculty

\_\_\_\_\_

Approved/Not approved

Director of Instructions

\_\_\_\_\_

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---

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*(Mukesh Kumar Sahu)*

*Department of Agronomy*

*College of Agriculture, IGKV, Raipur (CG)*

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## LIST OF ABBREVIATIONS AND NOTATION

Abbreviation	Description
°C	Degree Celsius
%	Per cent
@	At the rate
B:C	Benefit: Cost ratio
CD	Critical Difference
CGR	Crop growth rate
cm	Centimeter
CV	Coefficient of variance
d.f.	Degree of freedom
DAS	Days after planting
Day <sup>-1</sup>	Per day
E	East
<i>et al.</i>	And others/ co - worker
Fig.	Figure
g	Gram
ha	Hectare
HI	Harvest index
hr	Hours
<i>i.e.</i>	That is
Kg	Kilogram
LA	Leaf area
LAI	Leaf area index
Leaf <sup>-1</sup>	Per leaf
m	Meter
MEY	Maize equivalent yield
MJ	Mega joule
mm	Millimeter
N	North
no.	Number
NS	Non significant
OC	Organic carbon
PE	Production efficiency
Plant <sup>-1</sup>	Per plant
Rs	Rupees
S	Significant
SE±	Standard error of mean
t	Tonne

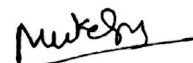
## THESIS ABSTRACT

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- (a) Title of the Thesis : “Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system”
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- (c) Major Subject : Agronomy
- (d) Name and Address of the Major Advisor : Dr. S. N. Khajanji ( Professor)  
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- (e) Degree to be awarded : M. Sc. (Ag.) in Agronomy



Signature of Major Advisor



Signature of the Student

Date: 25/06/16



Signature of Head of the Department

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### ABSTRACT

The present investigation entitled “Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system” was carried out at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *Kharif* season of 2015. The soil of experimental field was clayey (*Vertisols*) in texture, locally known as “*Kanhar*” which was low, medium and high in available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O respectively. The experiment was laid out in randomized block design with three replication. The experiment comprised eleven treatments. The crop configurations were T<sub>1</sub>-Hybrid maize + soybean (2:4) – line sown, T<sub>2</sub> Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize), T<sub>3</sub>-Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize), T<sub>4</sub>-Hybrid maize + cowpea (1:2) – line sown, T<sub>5</sub>-Hybrid maize + cowpea (broadcasting of cowpea after alternate


row of hybrid maize), T<sub>6</sub>-Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), T<sub>7</sub>-Sole hybrid maize (60 cm apart), T<sub>8</sub>-Sole soybean (30 cm apart), T<sub>9</sub>-Sole cowpea (30 cm apart), T<sub>10</sub>-Sole soybean(broadcasted) and T<sub>11</sub>-Sole cowpea (broadcasted). The treatments were replicated three times. The crop was supplied with the recommended dose of fertilizer @ 25 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 30 K<sub>2</sub>O in sole soybean/cowpea and 150 kg N, 75 kg P<sub>2</sub>O<sub>5</sub> and 40 K<sub>2</sub>O in sole maize and maize + intercrops.

The result revealed that various growth parameters *viz.* branches plant<sup>-1</sup>, dry matter accumulation, plant height (except plant height of soybean and cowpea); yield attributing characters *viz.* pods plant<sup>-1</sup>, seeds pod<sup>-1</sup>, grains row<sup>-1</sup>, row cob<sup>-1</sup>, seeds plant<sup>-1</sup>, grains plant<sup>-1</sup> and seeds/grain yield were recorded maximum under sole crops so grain yield and stover yield was also maximum in sole crops but maximum system yield (7450 kg ha<sup>-1</sup>) and energy output was recorded under treatment of T<sub>6</sub>- hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) which was found *at par* with T<sub>3</sub>- hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).

The highest gross realization (Rs. 130040 ha<sup>-1</sup>) and net realization (Rs. 95370 ha<sup>-1</sup>) was noted under T<sub>6</sub>- hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) which was found *at par* with T<sub>3</sub>- hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) and T<sub>2</sub>- hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize). The maximum B:C ratio (4.3) was obtained under T<sub>3</sub>- hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) which was *at par* with T<sub>2</sub>- hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize).


## शोध सारांश

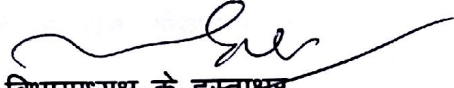
- अ) शोध का शीर्षक - : "संकरित मक्का आधारित अंतर्वर्ती खेती में संकरित मक्का + सोयाबीन/बरबटी अंतर्वर्ती का विभिन्न विन्यास में उत्पादकता एवं अर्थतन्त्र पर प्रभाव"
- ब) विद्यार्थी का पूरा नाम : मुकेश कुमार साहू
- स) मुख्य विषय : सस्य विज्ञान
- द) मुख्य सलाहकार का नाम व पता : डॉ. एस. एन. खजांजी (प्राध्यापक)  
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- इ) सम्मानित की जाने वाली उपाधि : एम.एस.सी. (कृषि) सस्य विज्ञान

  
मुख्य सलाहकार के हस्ताक्षर

दिनांक

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विद्यार्थी के हस्ताक्षर

  
विभागाध्यक्ष के हस्ताक्षर

## सारांश

यह वर्तमान परीक्षण खरीफ मौसम में इंदिरा गांधी विश्वविद्यालय, रायपुर छ.ग. के अनुदेशक प्रक्षेत्र पर वर्ष 2015 के दौरान परीक्षण किया गया। जिसका शोध शीर्षक "संकरित मक्का आधारित अंतर्वर्ती खेती में संकरित मक्का, सोयाबीन/बरबटी अंतर्वर्ती का विभिन्न विन्यास में उत्पादकता एवं अर्थतन्त्र पर प्रभाव" था। इस अनुसंधान कार्य का मुख्य उद्देश्य आर्थिक रूप से उपयुक्त अंतर्वर्ती फसल विन्यास ज्ञात करना था। प्रयोग प्रक्षेत्र की मृदा "कन्हार मृदा" है तथा भूमि का पी एच मान उदासीन, नत्रजन न्यूनतम, स्फुर मध्यम, और पोटाश की मात्रा अधिक उपलब्ध थी। प्रयोग में 11 फसल विन्यास अर्थात् टी-1 संकरित मक्का + सोयाबीन (2:4) पंक्ति में बुवाई, टी-2 संकरित मक्का + सोयाबीन (संकरित मक्का की एकान्तर पंक्तियों के बीच सोयाबीन का छिड़काव), टी-3 संकरित मक्का + सोयाबीन (संकरित मक्का की पंक्तियों के बीच सोयाबीन का छिड़काव), टी-4 संकरित मक्का + बरबटी (1:2) पंक्ति में बुवाई, टी-5 संकरित मक्का + बरबटी (संकरित मक्का की एकान्तर पंक्तियों के बीच बरबटी का छिड़काव), टी-6 संकरित मक्का + बरबटी (संकरित मक्का की पंक्तियों के बीच बरबटी का छिड़काव), टी-7 संकरित मक्का (60 सेमी दूरी पर पंक्तियों में बुवाई), टी-8 सोयाबीन (30 सेमी दूरी पर पंक्तियों में बुवाई), टी-9 बरबटी (30 सेमी दूरी पर पंक्तियों में बुवाई), टी-10 सोयाबीन (छिड़काव

विधि से बुवाई) और टी-11 बरबटी (छिड़काव विधि से बुवाई) का अध्ययन किया गया। उपरोक्त उपचारों की उपयोगिता के मूल्यांकन के लिए बेतरतीब खण्ड अभिकल्पना में तीन पुनरावृत्तियों के साथ प्रयोग किया गया।

एकफसली बुवाई में सार्थक रूप से सर्वाधिक शाखाएँ/पौधा, शुष्क भार/पौधा, उपज वृद्धि कारक जैसे फलियाँ/पौधा, दानों की पंक्तियाँ/भुट्टा, दानों की संख्या/पंक्ति, दाने/फली, एवं दाने/पौधा पाये गये। इसके कारण अधिक दाना उपज और भूसा उपज प्राप्त हुआ। परन्तु टी-6 संकरित मक्का + बरबटी (संकरित मक्का की पंक्तियों के बीच बरबटी का छिड़काव) से अधिकतम निकाय उपज (7450 किग्रा/हेक्टेयर) एवं ऊर्जा उत्पादन प्राप्त हुआ, जोकि टी-3 संकरित मक्का + सोयाबीन (संकरित मक्का की पंक्तियों के बीच सोयाबीन का छिड़काव) के समान था।

अधिकतम सकल लाभ (130040 रुपये/हेक्टेयर) और शुद्ध लाभ (95370 रुपये/हेक्टेयर) टी-6 संकरित मक्का + बरबटी (संकरित मक्का की पंक्तियों के बीच बरबटी का छिड़काव) से प्राप्त हुआ जोकि टी-3 संकरित मक्का + सोयाबीन (संकरित मक्का की पंक्तियों के बीच सोयाबीन का छिड़काव) एवं टी-2 संकरित मक्का + सोयाबीन (संकरित मक्का की एकान्तर पंक्तियों के बीच सोयाबीन का छिड़काव) के समान था। जबकि अधिकतम लाभ-लागत अनुपात (4:3) टी-3 संकरित मक्का + सोयाबीन (संकरित मक्का की पंक्तियों के बीच सोयाबीन का छिड़काव) से प्राप्त हुआ, जोकि टी-2 संकरित मक्का + सोयाबीन (संकरित मक्का की एकान्तर पंक्तियों के बीच सोयाबीन का छिड़काव) के समान था।

## CHAPTER I

### INTRODUCTION

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Intercropping is the practice of growing two or more crops together in a single field. The main purpose of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop efficiently. Legume intercropping systems play a significant role in the efficient utilization of resources. Cereal-legume intercropping is a more productive and profitable cropping system in comparison with solitary cropping (Evans *et al.*, 2001). The main subject of intercropping is to augment total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs including labours (Marer *et al.*, 2007). Maize + legume intercropping was found more productive and remunerative compared to sole cropping (Li *et al.*, 2003). Maize-legume intercropping systems are able to lessen amount of nutrients taken from the soil in comparison to a maize mono crop (Tsubo *et al.*, 2003). Kamanga *et al.* (2010) reported that maize-legume intercropping was a more productive system and a less risky technology. Higher crop productivity and efficiency in resource use was observed in maize-bean intercropping systems than in the respective sole cropping (Tsubo and Walker, 2002).

Intercropping which is the practice of growing more than one crop simultaneously in alternating rows of the same field (Ahmad *et al.*, 2013; Arif *et al.*, 2012; Bilalis *et al.*, 2010; Ennin *et al.*, 2002) is an effective practice in maize production which not only helps reduce the available space for weed growth but also increase the production per unit area. Moreover, in case of a severe disease or insect attack there are least chances of 100% crop loss, as the same disease or insect can't attack two different crops at the same time in the same field.

The availability of land for agriculture is shrinking day by day as it is being utilized for many non agricultural purposes. In India nearly 65 per cent of cultivated area is under rainfed condition, where the production is very low. Under

this situation one of the important strategies to increase agricultural production by harvesting more and more solar radiation and the development of new high intensive cropping systems including intercropping system involving stress resistant, soil fertility build up with high protein containing and oil producing grain legumes. Intercropping is more productive per unit time and also per unit area and remunerative. Cereals mainly supply the energy requirement by having high carbohydrates, while pulses supply vegetarian protein for vast Indian population.

Maize (*Zea mays* L.) is one of the world leading crop cultivated over an area of 140 M ha with a production of about 600 M t of grains. USA leads to largest area, followed by Brazil, China, Mexico and India. It is grown in states of India occupying an area of 9.07 M ha with the production and productivity of 24.2 M t and 2665 kg ha<sup>-1</sup>, respectively (www.indiastat.com). It is one of the important cereal crops in the world agricultural economy both as food grains for human and fodder and feed for cattle and poultry. Its grain contains about 10 per cent protein, 4 per cent fats, 70 per cent carbohydrates, 2.3 per cent crude fiber, 10.4 per cent albuminoides and 1.4 per cent ash. The crop also contains the vitamins A, B, C and E, including mineral salts and essential trace elements such as carotene, thiamine and tocopherol (Groote, 2002). In the industry, it is used in the production of starch, oil and alcohol (Kling and Edmeades, 1997). In Chhattisgarh it is grown in almost all the three agro-climatic zones viz, Northern hills, Chhattisgarh plains and Bastar plateau comprising the maize area of 288.10 thousand ha and contribute the grain production of 509.93 thousand tonne with the productivity of 1770 kg ha<sup>-1</sup> (Anonymous, 2016).

Maize is a heavy feeder of plant nutrients, growing of this crop alone over the years will barren the land and cause for decline in productivity. Inclusion of legumes in rotation or raising them in association with maize crop has been advocated by various workers to sustain the soil health and due importance was given for achieving higher productivity. Intercropping of legume with cereals has been recognized as very common practice in India. In Chhattisgarh area under maize crop is increasing day by day. For the intercropping with maize, soybean and cowpea may be used.

Soybean (*Glycine max* L. Merrill) belongs to the legume family and is a native to East Asia. It grows on a variety of soil and a wide range of climates (Ijoyah and Fanen, 2012). It is known as the **Golden Bean** of the 21<sup>st</sup> century. It is a legume but widely grown for oil purpose. It is one of the important oilseed crop and ranked second among oilseed crops of India. It is the only crop which has been included both in the categories of oilseed and pulses. It is the cheapest, richest and easiest source of best quality protein. Owing to multiplicity of uses as food and industrial products, soybean is called as **wonder crop**. Soybean seed contains about 20.5% carbohydrates, 20% oil with poly unsaturated fatty acids specially Omega 6 and Omega 3 fatty acid (Chauhan *et al.*, 1988), 4.5% minerals, 3.7% fibre, 8.1% water and 43.2% protein, its protein is complete and contains all the essential amino acids therefore from nutritional point of view it is known as **miracle bean**. It also contains a good amount of salts, vitamins and health promoting phyto-chemicals for human and livestock. Soybean is an environment friendly grain legume and its cultivation improves soil health because of its atmospheric nitrogen fixing ability and deep root system.

Soybean is a World's first rank crop as a source of vegetable oil. In oilseed scenario of India, it occupies number one place. In India, soybean occupies an area of 12.2 M ha, with production potential of 11.95 million tonnes and average productivity of 979.3 kg ha<sup>-1</sup> (www.faostat.org). The productivity of soybean is less in India as compared to world average (2484.1 kg ha<sup>-1</sup>). Global area and production of soybean is 111.27 M ha and 276.4 M t, respectively (www.faostat.org.). Due to the combined efforts of the agricultural scientists and the ingenuity of Indian farmers, significant strides have been made in increasing soybean area and production over the period from 1983 to 2004 by 490% and 715%, respectively. It is unique example of expansion of area under any single crop. Lack of adoption, sowing optimum crop geometry and varieties of soybean crop under real farm condition form a major factor for lower yield realization in the country. The major soybean producing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh and Karnataka (www.sopa.org).

In Chhattisgarh, agriculture is mainly based on rainwater, therefore most of

the crops are grown as rainfed in *kharif* season. Soybean occupies 121.42 thousand ha area with a yield of 1050 kg ha<sup>-1</sup> (Anonymous, 2016). In Chhattisgarh, maximum area and production of soybean comes under Rajnandgaon followed by Durg, Bemetara, Mungeli and Kabirdham districts.

Crop configuration plays an important role in contributing the higher yield. If plant density is above the optimum, the plant growth may be poor due to competition for nutrients, light and space. On the other hand, if it is below optimum then the nutrients, space and light will not be utilized to their fullest, thus resulting in poor yield. For exploiting the potential of high yielding varieties the optimum plant stand is very important non-monetary input

In soybean, narrow row spacing reduces the amount of light that reaches the soil surface and the amount of time to full canopy closure. As a result, late-season weed emergence and/or resurgence are reduced, resulting in greater late-season weed control in narrow-row systems. Farmers of Chhattisgarh not adopting line sowing of soybean due to weed problems. They have the concept that in case of broadcast soybean weed problem is less as compared to line sown soybean because the space in between the rows allow more weeds whereas in case of broadcast method has more suppression of weeds.

Cowpea or Lobia (*Vigna unguiculata* L. Walp) belongs to the family leguminosae, sub family fabaceae and genus *Vigna*. The annual area cropped under cowpea and their total productions in India are difficult to estimate, since it is rarely grown as single crop. However, the total production and yield per unit area has increased over the past decade. The area under cowpea is about 1.5 million hectare. Cowpea is grown throughout India in both summer and rainy season. It is grown for green pods, dry seeds and fodder. Dry seeds are rich in protein (23-28%) therefore, it is called as vegetable meat. When it is cultivated for dry seeds, it is called 'black eye pea' or 'Kaffir pea' or Southern bean'.

Cowpea is a nutritive vegetable which supplies protein 3.5 g, calcium 72.0 mg, phosphorus 59.0 mg, iron 2.5 mg, carotene 564.0 mg, thiamine 0.07 mg, riboflavin 0.09 mg and vitamin C 24.0 mg per 100 g in edible pods (Gopalan *et al.*,

1982). Amino acid profile reveals that lysine, leucine and phenylalanine content were relatively higher in cowpea (Bressani and Elias,1980). Cowpea, which is a high protein vegetable, suffers from alarmingly low yield, especially in south-east Asia.

In Chhattisgarh, although large amount of variability is available for almost all the traits, even then productivity for green pod yield *i.e.*, 14.15 t ha<sup>-1</sup> with an area of 14421 ha and production of 204075 M t had been recorded (Anonymous, 2016). The yield level, of cowpea in Chhattisgarh is low, which is mainly due to the non-availability of desirable high yielding, disease and insect resistant varieties and poor management practices. It is also used as green manuring crop.

Weed competition results from the use of widely spaced maize rows, which allow a high portion of ambient light to penetrate. It is possible that maize could be intercropped with a short-duration legume such as cowpea and soybean, however, to fill the uncovered spaces between the rows and thus act as a living mulch. Living mulches are cover crops that are planted between the rows of a main crop and are maintained as a living ground cover throughout the growing season of the main crop (Monaco *et al.*, 2002), suppressing weed establishment and growth, and thereby reducing the number of weeds. De Haan *et al.* (1993) reported that spring-seeded living mulches can reduce weed density by 80% with little effect on maize yield. Living mulches suppress weeds by competing for the use of growth resources, and changing environmental factors that affect weed germination and establishment, and can ultimately result in reduced herbicide application (Liebman and Davis, 2000).

In maize based intercropping system, selection of an appropriate intercrop having desirable plant type and growth pattern assumes greater importance. Crop maturation well before the peak growth period of maize is ideal. Research on intercropping has indicated how niche differences in crop species can lead to resource capture and conversion leading to increased biological efficiency and yield advantage (Willey, 1979). Intercropping suppresses weeds better than sole cropping and provides an opportunity to utilize crop themselves as tools of weed

management (Rao and Shetty, 1976). Very less work in this aspects have been done in agro-climatic condition of Chhattisgarh.

Keeping in view the aforesaid points as well as importance of planting system and nutrient management the present investigation entitled “**Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system**” was conducted at *kharif* season of 2015 with the following specific objectives:

1. To find out the effect of different configuration of intercropping system of hybrid maize + soybean/cowpea on growth of hybrid maize, soybean and cowpea.
2. To find out the effect of different configuration of intercropping system of hybrid maize + soybean/cowpea on yield/productivity of hybrid maize, soybean and cowpea.
3. To find out the economic feasibility of different configuration of intercropping system of hybrid maize + soybean/cowpea.

### REVIEW OF LITERATURE

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Intercropping, an important feature of crop production is mostly considered as an insurance against vagaries of weather or natural calamities in India. Recently intercropping has been recognized as a potentially beneficial system of crop production and research evidence also suggests that intercropping can provides substantial yield advantages compared to sole cropping by simple expedient of growing crops together.

There is ample scope of maize cultivation in Chhattisgarh state, but to explore its possibility there is a need to work out the agronomy of maize, especially hybrid maize intercropping system. The research works on such aspects have already been done in many parts of India and abroad. The literature on maize indicated that some work has been done in other parts of the country and very limited work highlighting the appropriate agro-techniques of maize has been done in Chhattisgarh.

The present investigation **“Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system”** was conducted at Instructional cum Research Farm, IGKV, Raipur during *kharif* 2015. Attempts are, therefore, made here to present a brief summary of research work done in India and abroad on this aspect under following heads.

#### **2.1 Intercropping systems**

#### **2.2 Advantages of intercropping**

#### **2.3 Maize- legume intercropping**

#### **2.4 Effect of intercropping on growth and yield components**

#### **2.5 Intercropping row configurations**

#### **2.6 Economics of intercropping system**

#### **2.7 Effect of intercropping on land equivalent ratio (LER)**

## 2.1 Intercropping systems

Andrews and Kassam (1976) stated that intercropping is an age - old practice of growing simultaneously two or more crops in the same piece of land. It is a technique of crop intensification in both time and space wherein the competition between crops may occur during a part or whole of crop growth period. It has been a common practice followed by the farmers of India, Africa, Srilanka , West Indies and Bangladesh.

Lakhani (1976) and Sivakumar and Virmani (1980) reported that higher yield in terms of total biomass and grain production per unit area in a given season without the use of costly inputs under intercropping system is attributed to better use of growth resources namely, light, moisture and nutrients.

Rao and Willey (1980) stated that the crop mixtures would also stabilize returns over seasons as they provide more than one commodity and can act as buffer against frequent price changes in any one of the component crops. Price fluctuations are quite common in countries like India, where 65 % of agricultural produce comes from rainfed agriculture

Tsubo and Walker (2002) measured photosynthetically active radiation above and beneath a maize-bean intercrop canopy in both north-south and east-west rows. They observed that the intercropping was equivalent in growth efficiency of maize to the sole cropping whereas, beans had greater radiation use efficiency in intercropping than in sole cropping. This might explain the intercrop yield advantage.

## 2.2 Advantages of intercropping

The main advantage of intercropping is the more efficient utilization of the available resources and the increased productivity compared with each sole crop of the mixture (Hauggaard and Jensen, 2001; Hauggaard *et al.*, 2001b; Zhang and Li, 2003; Szumigalski and Van Acker, 2005; Andersen *et al.*, 2007; Dhima *et al.*, 2007; Oforu and Limbani, 2007; Muoneke *et al.*, 2007; Agegnehu *et al.*, 2008; Carrubba *et al.*, 2008; Launay *et al.*, 2009; Mucheru- Muna *et al.*, 2010).

Intercropping is one way of introducing more biodiversity into agro ecosystems and results from intercropping studies indicate that increased crop diversity may increase the number of ecosystem services provided. Higher species richness may be associated with nutrient cycling characteristics that often can regulate soil fertility (Russell, 2002), limit nutrient leaching losses (Hauggaard *et al.*, 2003), and significantly reduce the negative impacts of pests (Bannon and Cooke, 1998; Fininsa, 1996) also including that of weeds (Hauggaard *et al.*, 2001a; Liebman and Dyck, 1993).

Barik *et al.* (1998) reported that the intercropping serves as an insurance against total crop failure in uncertain weather condition, increasing total productivity, equitable and judicious use of land resources and farming inputs including labour.

Assefa and Ledin (2001) revealed that the intercropping can provide better lodging resistance for some crops highly susceptible to lodging.

Kariaga (2004) found that intercropping controls soil erosion by preventing rain drops from hitting the bare soil where they tend to seal surface pores, prevent water from entering the soil and increase surface erosion. In maize-cowpea intercropping, cowpea acts as the best cover crop and reduces soil erosion.

Mashingaidze (2004) found that by intercropping land was effectively utilized and yield was improved.

Reddy and Reddi (2007) mentioned that taller crops act as wind barrier for short crops.

### **2.3 Maize- legume intercropping**

Mongi *et al.* (1976) revealed that maize-cowpea intercropping suppresses weeds and insures against total crop failure when one crop fails.

West and Griffith (1992) observed that the yield of maize was increased by 26% in maize-soybean strip intercropping.

Pal and Shehu (2001) found that all legume crops contributed to yield and N uptake of maize either intercropped with legume or grown after legume as a sole crop.

Tsubo *et al.* (2003) observed the higher crop productivity and resource use efficiency in maize-bean intercropping systems than respective sole cropping.

Tsubo *et al.* (2005) found that the maize-legume intercropping systems are able to lessen amount of nutrients taken from the soil in comparison to a maize monocrops.

Ghosh (2007) observed that among legume-cereal intercropping system, the combination of maize + pigeonpea was considered to be highly suitable with a minimum competition for nutrients, while legume + legume intercropping system, pigeonpea + groundnut system was the most efficient one in terms of resource use-efficiency.

Ghosh (2007) revealed that regularly intercropped pigeon pea or cowpea can help to maintain maize yield to some extent when maize is grown without mineral fertilizer on sandy soils.

Hugar and Palled (2008b) found that the maize-french bean intercropping gave high maize equivalent yield over sole maize yield.

Ghanbari *et al.* (2010) reported that intercropping maize with cowpea has been increase light interception in the intercrops, reduce water evaporation, and improve conservation of the soil moisture compared with maize alone.

Bilalis *et al.* (2010) reported that intercropping maize with legumes considerably reduced weed density in the intercrop compared with maize pure stand due to decrease in the available light for weeds in the maize-legume intercrops, which led to a reduction of weed density and weed dry matter as compare to the sole crops.

Dahmardeh *et al.* (2010) observed that maize-cowpea intercropping increases the amount of nitrogen, phosphorous and potassium contents compared to mono crop of maize.

Jamshidi (2013) revealed that increasing the maize density from 7.5 to 9 plants/m<sup>2</sup> reduced the weed biomass by 21.5%. Furthermore, cowpea acted as a living mulch, reducing weed biomass by up to 45.5% and 39.6% when intercropped with maize at a density of 7.5 and 9 plants/m<sup>2</sup>, respectively. Under weed-free conditions, an increase in maize density from 7.5 to 9 plants/m<sup>2</sup> resulted in maize grain yield

increasing from 8.92 to 9.40 t ha<sup>-1</sup>; however, the addition of cowpea only increased the maize grain yield by about 4.2%, on average, under these conditions. By contrast, under weed-infested conditions, there was a large decrease in maize grain yield (up to 32%), but intercropping with cowpea reduced this to only a 16% decrease.

#### **2.4 Effect of intercropping on growth and yield components**

Reddy and Reddi (1981) observed higher grain yield of maize when intercropped with groundnut and greengram but the grain yield of maize was significantly reduced by the intercrop of cowpea in all the three spacings (60 × 30, 75 × 24, 90 × 20 cm) because of its quick early vegetative growth.

Fawusi and Wanki (1982) revealed that maize and cowpea mixture grown for fodder purpose recorded higher leaf area index and light interception for maize in mixture over sole.

Singh and Kaushik (1987) found that the intercropping of maize with black gram, soybean, pigeon pea and cluster bean at 50 kg N ha<sup>-1</sup> increased the maize grain yield by 0.34 to 0.56 t ha<sup>-1</sup> compared with maize grain yield in pure stand at 50 kg N ha<sup>-1</sup>.

Chui (1988) observed that dry matter yields at maturity in intercrops were reduced by 24.4 per cent and 11.6 per cent when maize and beans were in same row and beans between two maize rows, respectively over sole maize. Maize grain yield was not significantly affected while bean yield was significantly reduced by intercropping system. However, intercropping systems increased total grain yield significantly over pure stand.

Arya and Saini (1989) observed the highest yield of maize (22 q ha<sup>-1</sup>) was recorded in maize + soybean at 45 cm/30 cm in 2:2 row ratio followed by 16.7 q ha<sup>-1</sup> in an additional row of soybean in between two rows of normal sown maize.

Kanakeri (1991) recorded observations on maize intercropped with legumes (green gram, black gram, soybean and cowpea) in 1:1 and 1:2 row ratios at Dharwad. No significant differences in maize growth, yield parameters and yield were obtained compared to sole maize.

Gangwar and Sharma (1994) observed the decreased yield of maize due to intercropping of legumes namely cowpea, clusterbean, sunhemp and dhiancha.

Cardoso *et al.* (1994) revealed that intercropping of maize with cowpea significantly affected the yield of cowpea, which decreased from an average of 0.48 tonnes to 0.23 tonnes ha<sup>-1</sup> as maize population increased from 20,000 to 80,000 plants ha<sup>-1</sup>.

Raposo *et al.* (1995) observed that maize grain yields were comparable in the monocrop and intercropping systems in 2:2 row proportion with Frenchbean, but the yields decreased significantly when intercropped with other crops and yields were the lowest under 2:3 row proportion.

Barik and Tiwari (1996) noticed that, in intercropping of maize with cowpea, the height of maize plant did not differ significantly at different growth stages compared to sole cropping.

Gollar and Patil (1997) in maize based cropping system observed that maize grain yields with cowpea, French bean, soybean and sunflower were 3421, 4544, 4024 and 2260 kg ha<sup>-1</sup>, respectively, under staggered sowing and 4181, 4935, 4539 and 3019 kg ha<sup>-1</sup>, respectively, under simultaneous sowing. Intercropping of maize with French bean recorded significantly higher maize yield than the sole crop (4491 kg ha<sup>-1</sup>).

Marin *et al.* (1998) revealed that there was no adverse effect of intercropping on the leaf area development or biomass accumulation in maize. Whereas, these characteristics were reduced in intercropped *Phaseolus vulgaris*, which behaves as a poor competitor.

Singh *et al.* (2000) observed that intercropping of maize with vegetable pea and lentil increased the dry matter accumulation and yield attributes *viz.*, length and girth of cob. number and weight of grains per cob and 1000 grain weight and also improved yield of maize over sole maize.

Rana *et al.* (2001) observed that the grain yield of maize increased to the extent of 2.32 to 7.5 per cent over sole cropping when it was intercropped with

legumes (soybean, urdbean, cowpea and groundnut). In addition, there was bonus yield from legume component.

Shivay *et al.* (2001) revealed that intercropping of maize with urd bean significantly increased the grain yield of maize compared to sole maize grown both in normal row planting and paired row planting.

Randhawa *et al.* (2005) studied maize-legume intercropping to see effect of legume on maize productivity grown in different geometrical patterns. The treatments comprised: Sole maize, maize + blackgram, maize + mungbean and maize + cowpea at different planting patterns, i.e. P<sub>1</sub>=90 cm apart double row strips (80/90 cm) and P<sub>2</sub>=120 cm apart triple row strips (80/120 cm). Maize grain yield was significantly greater in sole maize compared to other treatment combinations; while maize + cowpea intercropping gave minimum yield. Maize grown under P<sub>1</sub> provided the maximum yield of 39.38 q ha<sup>-1</sup>.

Hugar and Palled (2008b) revealed that vegetables viz., cowpea (*Vigna unguiculata* L.), frenchbean (*Phaseolus vulgaris* L.) and coriander (*Coriandrum sativum* L.) were included as intercrops in maize at 1:1, 1:2 and 1:5 row proportion. Vegetables did not influenced leaf area index, kernel yield, stover yield and harvest index of maize in 1:1 and 1:2 row proportion. Intercropping systems recorded higher MEY and productivity (kg ha<sup>-1</sup> day<sup>-1</sup>). Among the intercropping systems, maize + cowpea and maize + frenchbean recorded the lowest weed population and weed dry weight and highest weed control efficiency. The lowest WCE was found with maize + coriander intercropping system.

Thobatsi (2009) observed that intercropping reduced maize LAI and plant height while time to physiological maturity was also reduced by weed infestation, especially under drier and warmer environments. Glanda and Agrinawa intercrops produced more nodules per plant under cooler and wetter conditions. Agrinawa produced the highest leaf and total dry matter yield under sole crop conditions and this was significantly reduced by weed infestation. Different growth duration cultivar did not differ in their N<sub>2</sub>-binding abilities. Maize intercropping, especially with Glanda and Agrinawa, significantly reduced weed biomass. Maize sole crop under zero weeds had high grain yield compared to intercropping. PAN311 and Glenda sole crops under zero weeds produced higher yield under dry and warmer conditions, and

cooler and wetter conditions, respectively, compared to intercropping. High cowpea grain yield were strongly correlated to more seeds per pod and larger pod lengths and number of pods per plant especially for Glenda. No intercropping advantage compared to sole cropping was observed. This implies that maize and cowpea must rather be planted as sole crops for better yield under wetter and cooler, and warmer & drier conditions.

Adeleke *et al.* (2012) reported that crop arrangement of maize and cowpea are significantly affected the rate of growth of the two component crops. The Relative Growth Rate (RGR) and Crop Growth Rate (CGR) measured at 6-8 and 8-10 week after sowing (WAS) were higher under the inter-row crop arrangement in maize by 23 and 22.6 % respectively on the average relative to those under the intra-row crop arrangement. The 3:1 and 2:2 (Cowpea: Maize) crop proportion had higher RGR and CGR values. The 3:1 (Cowpea: Maize) crop proportion in the single row arrangement produced higher growth rates of cowpea than under any of the arrangements.

Legwiala *et al.* (2012) Botswana observed that only maize dry matter was significantly reduced by intercropping. Intercropping reduced the numbers of cowpea flower per plant but had no significant effect in the number of seeds per pod and weight of seeds. Cowpea dry matter weight was significantly reduced by intercropping. Planting pattern significantly affected the number of cowpea flower, number of pods and dry matter weight.

## **2.5 Intercropping row configurations**

In an intercrop system, row configurations (arrangements) alter the amount of light transmission to lower layers of the crops and affect the competition of species for light, water, and nutrients.

The results of a field experiment conducted by Kanakeri (1991) under rainfed conditions in black soils, revealed that when maize was intercropped with legumes (in 1:1 and 1:2 ratios) namely horsegram, black gram, soybean and cowpea, no significant differences in maize growth and yield were noticed compared to sole maize.

Raposo *et al.* (1995) observed that maize grain yields were comparable in the monocrop and intercropping systems in 2:2 row proportion with French bean, but the

yields decreased significantly when intercropped with other crops and yields were the lowest under 2:3 row proportion.

Ramaswamy *et al.* (1996) reported that when maize was intercropped with pigeon pea, black gram, green gram and cowpea in 1:1, 2:1 or 2:2 row ratio, maize grain yield was highest when intercropped with pigeon pea in 2:1 row ratio.

Pereirafilho *et al.* (2000) revealed that maize (cv. BR201, Cargil 606 and CMS-350) grown in double rows at density of 40,000 or 60,000 plants ha<sup>-1</sup>, with a single row of beans at a density of 40,000 plants ha<sup>-1</sup> or with beans sown in the maize rows at 1,20,000 plants ha<sup>-1</sup> did not indicate any significant variation. Bean yield decreased when intercropped with double row of Cargil 606 or CMS 350, while single row of Cargil 606 increased bean yield. BR 201 was the most efficient cultivar for intercropping as it had higher grain yield than the other two cultivars and in association with bean, yields were also higher.

Padhi (2001) observed that in maize based cropping system, the maize grain yields with Runner bean, cowpea and clusterbean were 2461, 2571 and 2474 kg ha<sup>-1</sup> respectively under 1:1 ratio and 2633, 2495 and 2439 kg ha<sup>-1</sup>, respectively under 2:2 ratios, compared to sole maize 2928 kg ha<sup>-1</sup>. Further, intercropping of maize with runnerbean at 2:2 row ratio realized the maximum production efficiency followed by maize with cowpea at 1:1 row ratio.

Flesch (2002) confirmed that in the intercropping of maize and French bean, sowing dates and spatial arrangement influenced the yield of French bean. The most efficient spatial arrangements for french bean were 1:2 and 2:3. Early sowing of French bean (15 days before maize) increased its yield by 35 per cent. While, maize yield was reduced by 75 percent and agronomic as well as economic efficiency of row intercropping over sole cropping increased with early French bean sowing.

Kumar *et al.* (2004) conducted experiment at Indian Agricultural Research Institute, New Delhi revealed that maize and groundnut accumulated significantly more dry matter when grown in 1:1 row ratio.

Kumar *et al.* (2005) indicated that intercropping of maize and cowpea in 2:2 row proportion recorded significantly higher green fodder, dry matter and crude protein yield compared to 1:1, 1:2, 1:3, 1:4, 2:1, 3:1, 3:3 and 4:1 row proportion.

Meena *et al.* (2006) recorded highest grain yield of maize with soybean intercropping at 1:1 row ratio and was on par with 2:2 row ratio. The highest mean maize equivalent yield was recorded under 2:2 row ratio.

Padhi and Panigrahi (2006) reported that maize + blackgram and maize + soybean at 1:1 row ratio and maize + groundnut at 2:2 row ratio recorded significantly higher total maize grain equivalent yield than respective sole component crops.

Mandal *et al.* (2014) observed that the grain yield and stover yield of maize were significantly higher in case of pure stand of maize than either of its intercropping systems with legumes while the cob yield was highest in the maize with soybean (1:2) intercropping system and it was statistically at par with the yield obtained in sole maize. The grain yield of legume was highest in maize with groundnut intercropping (1:2) and it had highest yield followed by sole groundnut. The maize equivalent yield was highest in maize with soybean intercropping (1:2) followed by maize with groundnut (1:2), maize with groundnut (2:4) and maize with soybean (2:4) intercropping. Thus, under the red and lateritic soil condition where cultivation is practiced with limited water, legume crops like groundnut can be grown as intercrops with maize to get higher monetary returns.

## **2.6 Economics of intercropping system**

Economic returns obtained from the systems such as intercropping or sole cropping depend mainly on the component crops, their yield and price prevailing during the period of study.

Singh and Pritamchand (1980) observed that the net returns were maximum when maize + soybean was grown with 120 kg N ha<sup>-1</sup> followed by pure maize.

Gangwar and Kalra (1982) stated that growing of maize with legumes like black gram, ground nut, green gram and cowpea was remunerative. Higher net returns were obtained (Rs.9507 ha<sup>-1</sup>) with intercropping treatment than with pure maize (Rs.6695 ha<sup>-1</sup>).

Balyan and Seth (1985) reported the maximum mean net returns Rs. 5147 ha<sup>-1</sup> were obtained with maize intercropped with cowpea fodder-wheat cropping system

followed by Rs. 5081 ha<sup>-1</sup> in maize intercropped with grain cowpea-wheat cropping sequence. The minimum net returns of Rs. 2957 ha<sup>-1</sup> accrued from maize-wheat cropping sequence.

Gil-Munoz *et al.* (2000) found that the existing diversity of maize and *Phaseolus vulgaris* varieties enabled the farmer to profit from the whole growing season taking advantage of periods with moisture availability resulting from rainy season. Further, they also observed that growth dynamics and grain yield of species involved depend on multi factors.

Padhi (2001) observed that intercropping maize with runner bean recorded higher net returns (Rs.12667 ha<sup>-1</sup>) at 2:2 row ratio followed by maize + cowpea (Rs.7800 ha<sup>-1</sup>) at 1:1 row ratio.

Patel and Rajgopal (2001) observed that the highest monetary returns (Rs.11,781 ha<sup>-1</sup>) can be obtained when maize + cowpea was sown in planting pattern of 5:2 compared to sole maize.

Singh *et al.* (2002) observed that the maximum net returns (Rs. 35, 226 ha<sup>-1</sup>) were obtained in the maize + cowpea cauliflower cluster bean cropping system.

Estheskekinah (2004) reported that both net returns and benefit : cost ratio were highest in the maize + cowpea – wheat + coriander sequence with the application of composted buffalo manure at 100 and 75 per cent production levels.

Kumar *et al.* (2005) reported higher benefit:cost ratio (2.21) under maize-cowpea association in 2:2 row ratio over sole maize (1.78).

Sahu (2006) concluded that maize + soybean grown either in 1:1 or 2:2 row ratio recorded significantly higher net return (Rs. 10,934 and 10,711 ha<sup>-1</sup>, respectively) over other intercropping systems and sole crops (Rs. 5,993 – 9,745 ha<sup>-1</sup>).

Meena *et al.* (2006) recorded the highest net returns and benefit-cost ratio under maize + soybean at 2:2 row ratio.

Hugar and Palled (2008a) observed that vegetables did not influence yield and yield parameters of maize significantly in 1:1 and 1:2 row proportions. Land equivalent ratio in maize + frenchbean (1:2 row proportion) and area time equivalent

ratio in maize + cowpea (1:2 row proportion) were significantly higher over 1:5 row proportion and sole crop systems. Maize + frenchbean at 1:2 row proportion resulted in maximum maize equivalent yield (9894 kg ha<sup>-1</sup>) and net returns (Rs.38773 ha<sup>-1</sup>).

## 2.7 Effect of intercropping on land equivalent ratio (LER)

Singh *et al.* (1986) reported that the intercropping of cereals with cowpea and horsegram, maize + horsegram recorded higher land equivalent ratio (1.44) followed by maize + cowpea (1.35) intercropping systems.

Bhatnagar and Chaplot (1991) revealed that intercropping maize cv. Ganga-5 with peas cv. Arkel (intra row) + rajma cv. PDR-14 (inter-row) recorded higher land equivalent ratios (1.54-1.55).

Shah *et al.* (1991) observed that among the intercropping of maize with cowpea, rajmash and soybean in 4:1, 2:1 and 1:1 row proportion, maize + rajmash recorded the highest LER (1.81) followed by maize + cowpea (1.74) and maize + soybean (1.59) all sown in the ratio of 2:1.

Raposo *et al.* (1995) also reported higher LER in the intercrops than in the monocrops with 2:2 row proportions recording the highest value.

Krishna and Raikhelkar (1997) observed that when maize was grown with pigeonpea, greengram, blackgram, groundnut and soybean the higher land equivalent ratio was recorded by maize + blackgram (1.84) and maize + pigeonpea (1.83) when compared with others. It indicated that there was yield advantage of 84% with maize + blackgram and 83% with maize+ pigeonpea when compared with sole crop of maize.

Anonymous (1998) reported that intercropping of maize + soybean at 1:2 row proportion with 100 per cent maize population and 75 per cent soybean population recorded significantly higher land equivalent ratio.

Halikatti (1998) observed that strip intercropping of maize with legumes significantly decreased grain yield of both crops compared to their sole crops but increased maize HI and test weight. As compared to sole maize, intercropping 1 or 2 rows of urd or soybean between maize paired rows increased LER and maize equivalent yield in both years, while ATER (area time equivalent ratio) increased in

the high rainfall first year with both legumes but only with urd in the low rainfall second year.

Pandey *et al.* (1999) reported higher LER value (pooled 1.41) in paired rows of maize (30/90 cm) + 2 rows of soybean, which implied that this intercropping system was biologically most efficient in utilizing land area compared to other intercropping patterns.

Pandita *et al.* (2000) reported that maize and *Phaseolus vulgaris* intercropping at 1:2 ratio gave the maximum land equivalent ratio (1.61) and maize equivalent yield (78 q ha<sup>-1</sup>).

Singh and Singh (2001) reported that the paired row of maize (30 x 90 cm) + soybean in 2:2 row ratio recorded higher land equivalent ratio (1.36) and it was on par with paired row of maize (45 cm x 90 cm) + soybean in 2:2 row ratio.

Gangaiah (2004) reported that the paired row of maize (30 x 90 cm) + soybean in 2:2 row ratio recorded higher land equivalent ratio (1.36) and it was on par with paired row of maize (45 cm x 90 cm) + soybean in 2:2 row ratio.

Ijoyah *et al.* (2013) observed that intercropping soybean with maize significantly reduced soybean yield by 43.8 % and 55.6 % respectively. Maize yield was not significantly affected when intercropped with soybean. Total intercrop yield was greater than the sole crop yields. Intercropping soybean and maize gave land equivalent ratio (LER) values of 1.40 and 1.29 respectively. Indicating that higher productivity per unit area was achieved by growing the two crops together than by growing them separately. With these LER values, 28.6 % and 22.5% of lands were saved respectively, which could be used for other agricultural purposes. Land equivalent coefficient values exceeded 0.25, indicating yield advantage of the intercropping system. Competitive pressure of component crops was low, indicating that both crops are complementary and suitable in mixture.

From the review of literature, it is observed that cereal-legumes, intercropping system is generally productive and economical than the sole cropping. The extent of benefit from cereal legume intercropping system depends on the selection of suitable component crops that intercept maximum amount of growth resources for better yield improvement. Intercropped productivity is further influenced by duration of

component crops and differential demand of growth resources. Differences in maturation of component crops facilitate each other in better resources use. Low competition for light or availability of more light to shorter intercropped legumes may be ensured by defoliation of taller maize without affecting the yield.

### MATERIALS AND METHODS

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A field experiment was carried out at Research cum Instructional Farm to study the “**Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system**” during *kharif* season of 2015. Details of the materials used and the experimental techniques adopted during the course of study are described in this chapter.

#### **3.1 Location and experimental site**

The field experiment was conducted at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *kharif* 2015.

#### **3.2 Geographical situation**

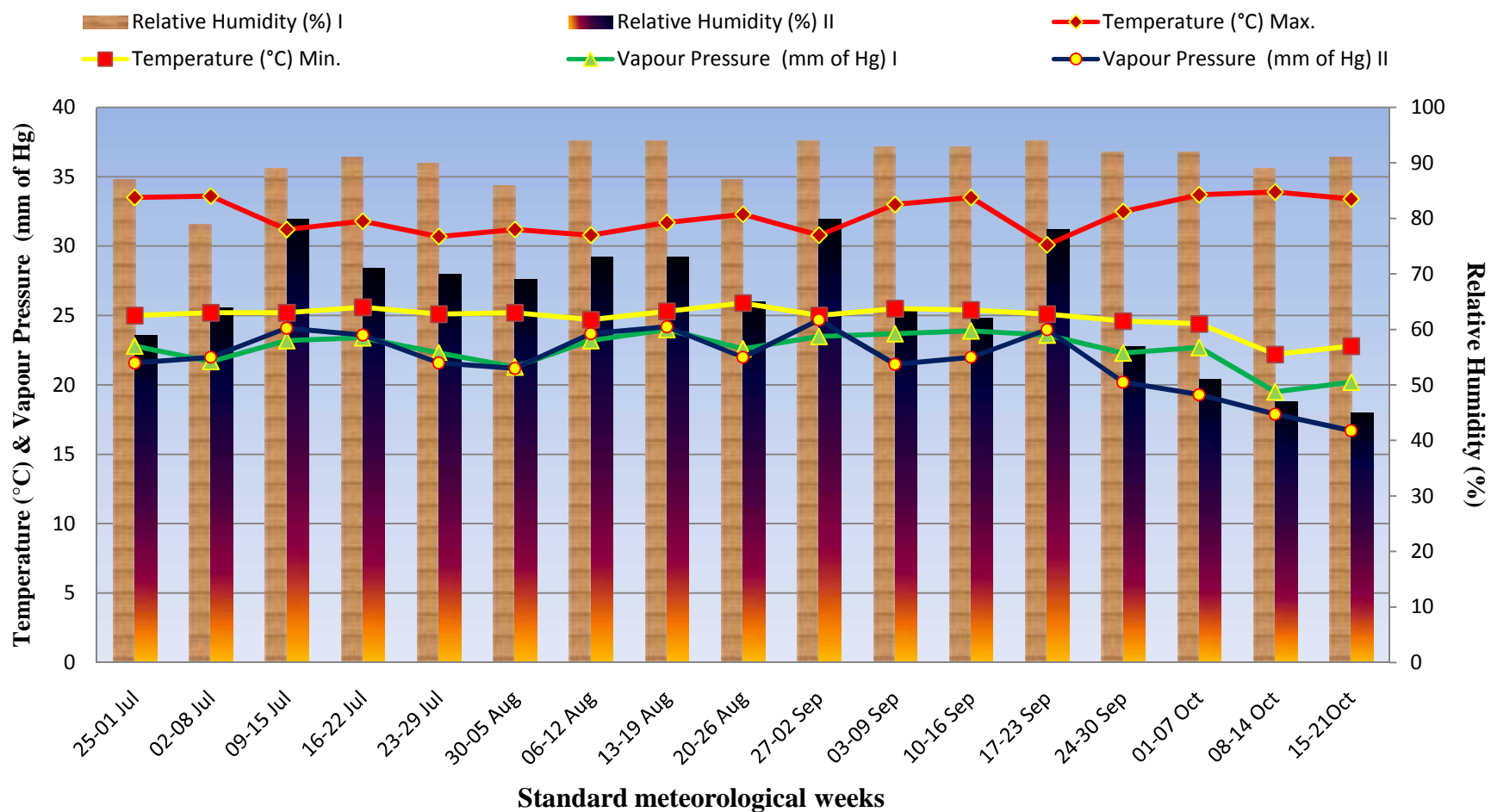
Raipur is situated in south eastern part of Chhattisgarh at 21°4' N latitude and 81°35' E longitude at the height of 290.20 m above the mean sea level (MSL).

#### **3.3 Climatic condition**

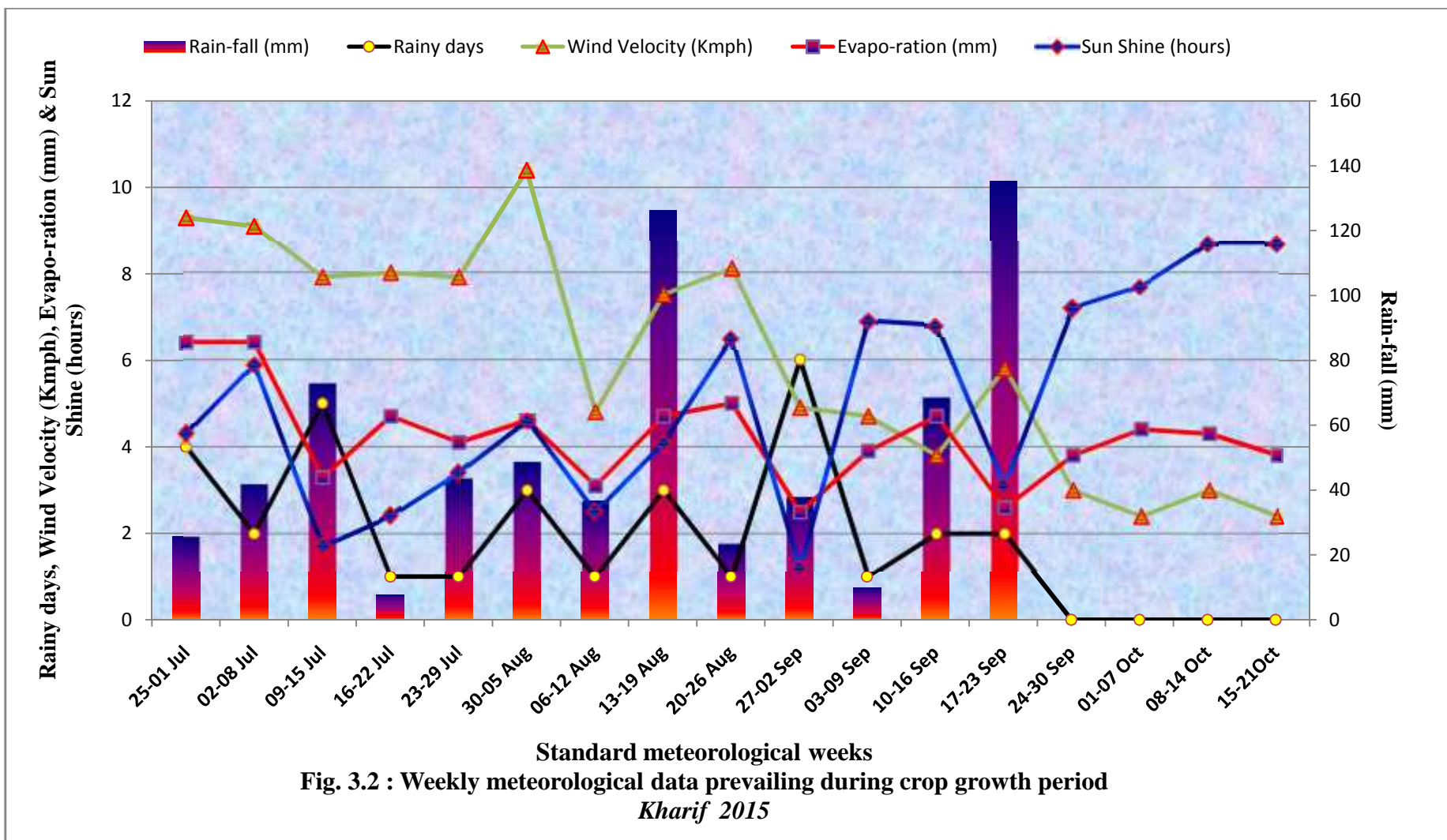
The general climatic condition of Raipur is sub-humid to semi-arid. The mean annual precipitation of the region is 1326 mm (based on 80 years mean), about 85% of rainfall is received during rainy season that is middle of June to September with occasional showers in winter and summer months. The weekly maximum temperature raises upto 46°C during summer and minimum temperature drop down as low as 6°C during winter season. The relative humidity is high from June to October and wind velocity is high from May to August with its peak in June-July months.

#### **3.4 Weather conditions during crop period**

The weather data recorded at meteorological observatory, IGKV, Raipur



**Fig. 3.1: Weekly meteorological data prevailing during crop growth period  
Kharif 2015**



during the life span of crop is given in Appendix-A and depicted through fig. 3.1 and 3.2. The crop received 678.8 mm rainfall. The weekly maximum temperature during crop period was 33.9°C in the second week of October and the minimum temperature of 22.2°C during the second week of October. Relative humidity throughout the crop season varied between 79.0 to 94.0 per cent at morning and 45 to 80 per cent in evening hours. The bright sunshine varied from 1.2 to 8.7 hours day<sup>-1</sup>. The monthly wind velocity ranged between 2.4 to 10.4 kmph.

### **3.5 Physico-chemical properties of the soil**

In order to determine the mechanical and chemical composition of experimental plot, soil samples were collected randomly from the experimental site up to 20 cm depth with the help of soil auger. A composite sample was drawn from mixed representative samples by dividing repeatedly till the amount of representative samples remain about 250 gm and then it was used for analysis. The detailed physico-chemical properties of the soil are presented in Table 3.1

### **3.6 Cropping history of the field**

Year wise cropping history of the experimental field for the past five year has been presented in Table 3.2.

### **3.7 Test crop**

“RMH- 4212 (Hybrid)” cultivar of maize, “JS-335 (Jawahar Soybean – 335)” cultivar of soybean, “and “VU – 89 (Ankur Gomti)” Cultivar of cowpea were taken as test crops.

### **3.8 Experimental details**

The treatment consisted of eleven crop configuration. The experiment was laid out in Randomized Block Design (RBD) with three replications. The details of treatments are given in Table 3.3 and layout plan in Figure 3.3.

Table 3.1: Physico-chemical analysis of the experimental soil

Properties	Analysis Values	Group/ Class	Method used
<b>A. Physical properties</b>			
1. Mechanical composition			
Sand (%)	20.45		International Pipette method (Black and Evans, 1965)
Silt (%)	35.36		
Clay (%)	44.19		
Textural classes		Clay ( <i>Vertisols</i> )	
2. Bulk density ( $\text{Mg m}^{-3}$ )	1.40		Soil Core method (Black, 1965)
<b>B. Chemical properties</b>			
1. Organic carbon (%)	0.64	Medium	Walkley and Blacks (Piper, 1967)
2. Available N ( $\text{kg ha}^{-1}$ )	235.83	Low	Alkaline permanganate method (Subbiah and Asija, 1956)
3. Available $\text{P}_2\text{O}_5$ ( $\text{kg ha}^{-1}$ )	18.35	Medium	Olsen's method (Olsen <i>et al.</i> , 1954)
4. Available $\text{K}_2\text{O}$ ( $\text{kg ha}^{-1}$ )	384.26	High	Flame photometric method (Hanwy and Heiddle, 1952)
5. pH (1: 2.5, soil: water)	7.2	Neutral	Glass electrode pH meter (Piper, 1967)
6. EC ( $\text{dsm}^{-1}$ at $25^\circ\text{C}$ )	0.18	Normal	Solubridg conductivity method (Black and Evans, 1965)

Table 3.2: Cropping history of the experimental field

Year	Crop grown	
	<i>kharif</i>	<i>Rabi</i>
2010-11	Soybean	Wheat
2011-12	Soybean	Wheat
2012-13	Soybean	Safflower
2013-14	Soybean	Safflower
2014-15	Soybean	Wheat

Table 3.3: Detail of treatment

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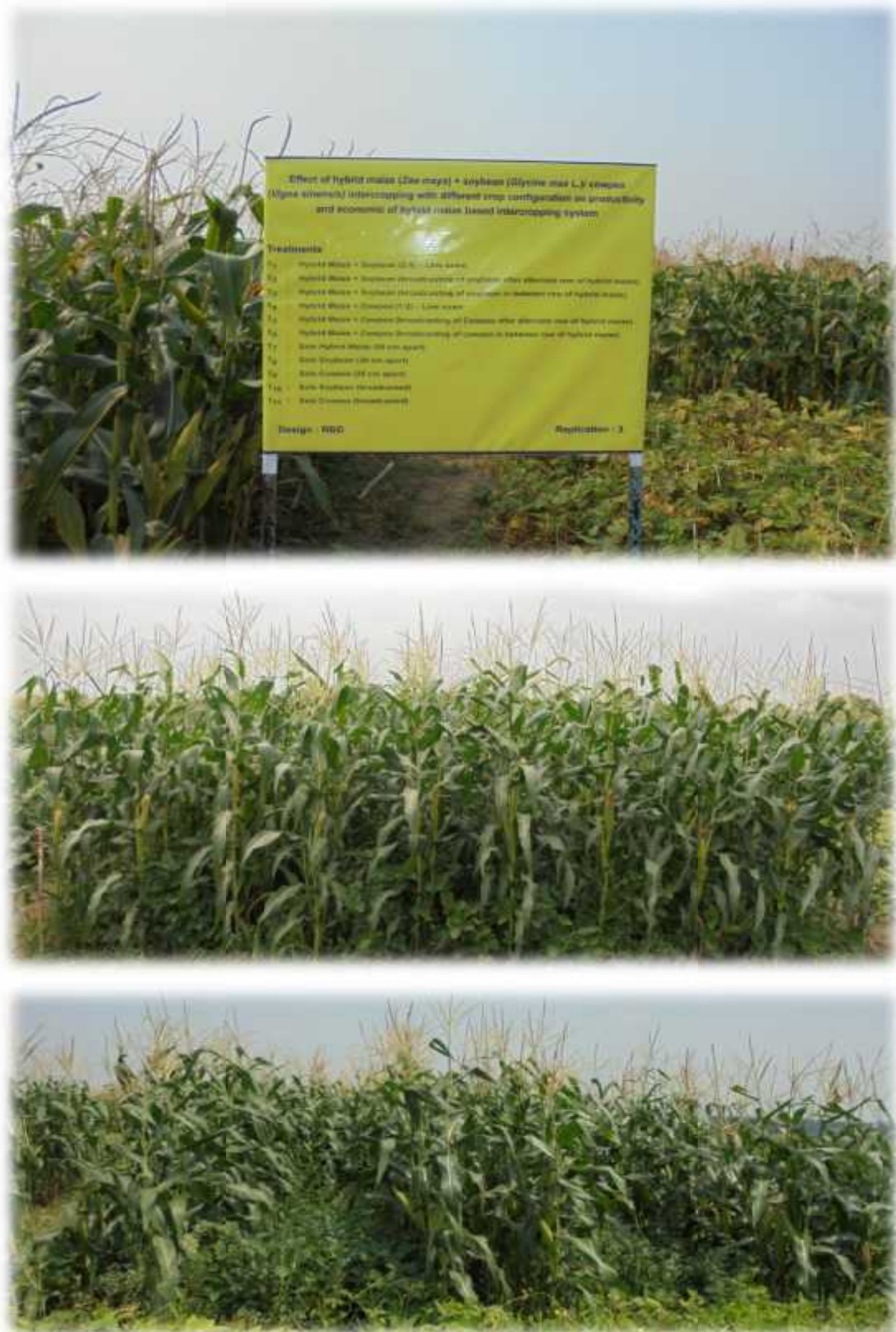
Treatment details:

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<b>T<sub>1</sub></b>	: Hybrid maize + soybean (2:4) – line sown
<b>T<sub>2</sub></b>	: Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)
<b>T<sub>3</sub></b>	: Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)
<b>T<sub>4</sub></b>	: Hybrid maize + cowpea (1:2) – line sown
<b>T<sub>5</sub></b>	: Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize)
<b>T<sub>6</sub></b>	: Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)
<b>T<sub>7</sub></b>	: Sole hybrid maize (60 cm apart)
<b>T<sub>8</sub></b>	: Sole soybean (30 cm apart)
<b>T<sub>9</sub></b>	: Sole cowpea (30 cm apart)
<b>T<sub>10</sub></b>	: Sole soybean(broadcasted)
<b>T<sub>11</sub></b>	: Sole cowpea (broadcasted)

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**Fig. 3.4: View of Experimental Field**

### **3.9 Field preparation**

The preparation of field was done when the soil reached to the working condition. The field was prepared with tractor drawn plough followed by harrowing to obtain a well pulverized seed bed. The weed and crop residues removed to get weed and stubble free seed bed. Finally, it was leveled with the help of tractor driven leveler.

### **3.10 Seed treatment and sowing**

In order to prevent the crop from seed and soil borne diseases, the seeds were treated with carbendazim @ 3 g kg<sup>-1</sup> of seed followed by *Rhizobium* culture @ 5 g kg<sup>-1</sup> of seed. Then treated seeds were dried in shade for 3-4 hours before sowing the seeds were sown as per crop configuration by manually.

### **3.11 Fertilizer**

Recommended dose of fertilizer *i.e.* 150:75:40 kg N, P, and K through Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) for maize and 25:60:30 kg N, P, and K through Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) for soybean and cowpea were applied. In soybean and cowpea full dose of N, P and K given at the time of sowing. Whereas, in maize 1/3<sup>rd</sup> nitrogen, full P and K was applied at the time of sowing. Top dressing of 1/3<sup>rd</sup> N was done at knee height stage and remaining 1/3<sup>rd</sup> was applied at the time of tasseling.

### **3.12 Weed management**

In intercropping system Intercropping suppresses weeds better than sole cropping and provides an opportunity to utilize crop themselves so weeds were managed by one manual hand weeding at 25 days after sowing (DAS).

### **3.13 Plant protection**

Plant protection measures were adopted as and when needed during crop

growth period. Quinolphos @ 1.0 liters ha<sup>-1</sup> was applied at 30 DAS to reduce the infestation of leaf defoliator insects.

### **3.14 Harvesting**

Harvesting was done manually from net plot area when the seed became hard and leaves turned yellow in colour in soybean and cowpea and harvest maize crop when husk has turned yellow and grains are hard enough having less than 30 % moisture. The plants were left in plot for five days to sun dry and thereafter bundles were made and the bundle weight plot<sup>-1</sup> was recorded.

### **3.15 Threshing and winnowing**

Threshing of produce of each net plot was done manually by beating with wooden stick in soybean and cowpea and in maize grains are removed by maize shellers. After manual winnowing seed yield plot<sup>-1</sup> was noted. Stover yield was worked out after subtracting the seed yield from bundle weight.

### **3.16 Observation**

The experimental observations on crops are presented under the following heads.

#### **3.16.1 Studies on crop**

For study of effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system, several observations were recorded on the growth parameters and yield attributing characters of crop. For recording pre-harvest and post-harvest observations, five plants were randomly selected from each plot and tagged.

##### **3.16.1.1 Pre-harvest studies**

###### **3.16.1.1.1 Plant population (No. m<sup>-2</sup>)**

Plant population per square metre area was recorded at 30 DAS and at

harvest stage from three randomly selected spot in each plot and averaged is worked out.

#### **3.16.1.1.2 Plant height (cm)**

Height of five tagged plants in each plot was recorded in cm at an interval of 30, 60, 90 DAS and at harvest and then average was worked out and used for statistical analysis. Height was measured in centimetre from ground surface to the tip of main stem.

#### **3.16.1.1.3 Number of branches plant<sup>-1</sup>**

Number of branches were counted from five tagged plants of each plot at 30 and 60 DAS. The mean number of branches plant<sup>-1</sup> was obtained by dividing the summation with five and used for statistical analysis.

#### **3.16.1.1.4 Number of leaves plant<sup>-1</sup>**

Number of leaves plant<sup>-1</sup> were counted from the five tagged plants in each plot, periodically at 30, 60, and 90 DAS.

#### **3.16.1.1.5 Leaf area (cm<sup>2</sup> plant<sup>-1</sup>)**

Leaf area plant<sup>-1</sup> was recorded from the five tagged plants in each plot, periodically at 30 and 60 DAS. The leaf area in cm<sup>2</sup> measured with the help of following formula-

$$\text{Leaf area} = L \times B \times F \times N$$

Where,

L = Maximum length of leaves

B = Maximum breath of leaves

F = Correction factor (0.75)

N = Number of leaves

#### **3.16.1.1.6 Dry matter accumulation (g plant<sup>-1</sup>)**

Dry matter accumulation (g plant<sup>-1</sup>) was observed at 30, 60, 90 DAS and at harvest. Five randomly selected plants were uprooted carefully along with the roots. Root portion was detached and shoot portion of the plant was sun dried followed by drying in hot air oven at 60°C for 48 hours to record constant dry

weight. The samples were weighed on an electronic digital balance and then average was worked out by dividing the summation by five to get dry matter accumulation plant<sup>-1</sup>.

### **3.16.1.2 Post-harvest studies**

#### **3.16.1.2.1 Number of pods plant<sup>-1</sup>**

To study the influence of different treatment on pod formation in soybean/cowpea crop, total number of pods was recorded from five randomly tagged plants and mean was worked out by dividing the total number of pods by five and used for statistical analysis.

#### **3.16.1.2.2 Number of seeds pod<sup>-1</sup>**

Randomly selected matured pods of five tagged plants from each plot were picked up and their seeds were counted and it was averaged by pods of five tagged plants to get mean number of seeds pod<sup>-1</sup>.

#### **3.16.1.2.3 Number of seeds row<sup>-1</sup>**

Randomly selected matured cobs of five tagged plants from each plot were picked up and their seeds were counted per row and it was averaged by cobs of five tagged plants to get mean number of seeds row<sup>-1</sup>.

#### **3.16.1.2.4 Number of rows cob<sup>-1</sup>**

Randomly selected matured cobs of five tagged plants from each plot were picked up and their rows were counted and it was averaged by cobs of five tagged plants to get mean number of rows cob<sup>-1</sup>.

#### **3.16.1.2.5 Number of seeds plant<sup>-1</sup>**

All matured pods or cobs of five tagged plants from each plot were picked up and their seeds were counted and it was averaged by seeds of five tagged plants to get mean number of seeds plant<sup>-1</sup>.

### 3.16.1.2.6 100-seed weight (g)

Randomly seed samples were taken from each net plot. 100 healthy seeds from the produce of each plot were counted and same were oven dried till constant weight and then weight was recorded in gram accurately by using an electronic digital balance.

### 3.16.1.2.7 Seed yield (kg ha<sup>-1</sup>)

Seed yield of the net plot was noted down, after threshing, winnowing and drying then calculated in kg ha<sup>-1</sup> with appropriate multiplication factor.

### 3.16.1.2.8 Stover yield (kg ha<sup>-1</sup>)

The harvested produce from each net plot was tied in bundles separately. Stover yield of plot was calculated after subtraction of seed yield from bundle weight. Bundle weight was recorded with the help of spring balance and converted into kg ha<sup>-1</sup>.

## 3.17 Computation

### 3.17.1 Leaf area index

Leaf area index was calculated with the help of following formula (Watson, 1947).

$$\text{Leaf area index (LAI)} = \frac{\text{Total leaf area of plant (cm}^2\text{)}}{\text{Total ground area of plant (cm}^2\text{)}}$$

### 3.17.2 Crop growth rate (g plant<sup>-1</sup> day<sup>-1</sup>)

Crop growth rate was observed at 0-30, 30-60, 60-90 DAS and 90 DAS to harvest. Crop growth rate was calculated from the dry weight taken at different time intervals. It denotes overall growth rate of the crop plant and it is measured after fix period of the time, irrespective of the previous growth rate. The value was calculated by using the following formula suggested by Leopold and Kridemann (1975).

### 3.17.3 Land equivalent ratio (LER)

Land equivalent ratio (LER) was used for comparison among the treatments. LER values were computed from the grain yield data of the crops according to the following formula.

$$\text{LER} = \frac{\text{Intercrop yield of soybean/cowpea}}{\text{Sole crop yield of soybean/cowpea}} + \frac{\text{Intercrop yield of maize}}{\text{Sole crop yield of maize}}$$

### 3.17.4 Area Time Equivalent Ratio (ATER)

It measures duration of land occupancy in the intercrop monoculture comparisons (Hiebsch and McCollum, 1987).

$$\text{ATER} = \frac{(L_a \times D_a) + (L_b \times D_b)}{T}$$

Where,

$L_a$  and  $L_b$  = Partial land equivalent ratio of crop a and in intercropping system

$T$  = Total duration of intercropping

$D_a$  and  $D_b$  = duration of intercrop a and intercrop b in intercropping system

### 3.17.5 Maize equivalent yield (MEY)

Crop (maize) equivalent yield was calculated by the following formula.

$$\text{MEY} = \frac{\text{Grain yield of intercrop (q ha}^{-1}\text{)} \times \text{Market price of intercrop (Rs. q}^{-1}\text{)}}{\text{Market price of maize (Rs. q}^{-1}\text{)}}$$

### 3.17.6 Harvest Index (HI)

The harvest index was determined by using the formula given by Donald (1962).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where,

Economic yield = Seed yield

Biological yield = Seed yield + Stover yield

### 3.17.7 Production efficiency (PE)

Production efficiency of soybean was calculated by using the formula given by Tomar and Tiwari (1990).

$$\text{Production efficiency (kg ha}^{-1} \text{ day}^{-1}) = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Duration of the crop (days)}}$$

## 3.18 Chemical analysis

### 3.18.1 Soil analysis

Five soil samples were collected from 20 cm depth from each plot. Composite soil samples were dried under shade and grinded and passed through 2 mm sieve. The analysis for available N, P and K were done, following the analysis procedure indicated in Table 3.1. Soil samples were collected from each plot after harvest of soybean. The available N, P and K content in soil was determined at harvest.

## 3.19 Economics

The cost of cultivation was calculated on the basis of prevailing prices for different inputs. The production was converted into gross return (Rs ha<sup>-1</sup>) on the basis of prevailing prices of market. Net return was calculated by deducting the cost of cultivation from the gross return. Benefit: cost ratio was computed by dividing gross return with cost of cultivation.

## 3.20 Energetics

Energy input and output was calculated from sowing to harvest of all the treatments. It was estimated in Mega Joules (MJ) ha<sup>-1</sup> with reference to the standard

values. Energy use efficiency and output/input ratio were calculated by using the following formula; given by (Mittal *et al.*, 1985)

$$\text{Energy use efficiency} = \frac{\text{Total produce (kg)}}{\text{Energy input (MJ} \times 10^{-3}\text{)}}$$

$$\text{Energy output-input ratio) = } \frac{\text{Energy output}}{\text{Energy input}}$$

### 3.20 Statistical analysis

The experiment was laid out in randomized block design. The data obtained on various characters under study were analyzed statistically by using the method of analysis of variance for randomized block design and significance was tested by (Gomez and Gomez, 1984).

Table 3.3: The skeleton of the analysis of variance

Source of variation	DF	SS	MSS	F Cal	F Tab
Replication (r)	(r-1)	RSS	RMA	RMS/EMS	-
Treatment (t)	(t-1)	TSS	TMS	TMS/EMS	-
Error (E)	(r-1) (t-1)	ESS	EMS	-	-
Total					

The following formula was used for standard error, critical difference and coefficient of variance estimations:

$$(a) \quad \text{S.Em} \pm = \sqrt{\frac{\text{EMS}}{r}}$$

$$(b) \quad \text{SEd} = \sqrt{\frac{2\text{EMS}}{r}}$$

$$(c) \quad \text{C.D.} = t_{\text{at error d.f.}} \times \text{SEd}$$

$$(d) \quad \text{C.V. (\%)} = \sqrt{\frac{\text{EMS}}{x}} \times 100$$

### RESULTS AND DISCUSSION

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Proper crop configuration is suitable for higher yield of crops. Obtaining higher yield of intercrop there should be optimum plant population to cater maximum sunlight, nutrients from soil and to suppress weed growth. Present investigation entitled “**Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system**” was conducted in *Kharif* season of 2015 at the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur Chhattisgarh. In this chapter, experimental results are presented with the help of tables and figures related to the observations recorded during course of investigation on various aspects.

#### 4.1 Pre-harvest observations

##### 4.1.1 Plant population (No. m<sup>-2</sup>)

The data pertaining to plant population of maize, soybean and cowpea are presented in Table 4.1. Plant population was recorded at 30 DAS and at harvest. Irrespective of the treatments, the plant population decreased slightly with the advancement in the crop age.

Maize did not show significant difference in plant population due to different crop configurations of maize based intercropping system.

In soybean, T<sub>8</sub>- sole soybean (30 cm apart) shows significantly higher plant population which was *at par* with T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown. The lowest plant population was observed under T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) at all time intervals of observations.

Table 4.1: Plant population of maize and intercrops as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Plant population (No. m <sup>-2</sup> )					
	Maize		Soybean		Cowpea	
	30DAS	At harvest	30DAS	At harvest	30DAS	At harvest
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	10.7	10.0	34.52	32.67	–	–
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	10.3	9.67	28.45	26.25	–	–
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	10.3	9.67	28.24	25.56	–	–
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	10.7	10.0	–	–	38.03	35.97
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	10.3	9.67	–	–	33.16	30.71
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	10.0	9.33	–	–	32.45	30.35
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	11.0	10.33	–	–	–	–
T <sub>8</sub> -Sole soybean (30 cm apart)	–	–	36.23	33.48	–	–
T <sub>9</sub> -Sole cowpea (30 cm apart)	–	–	–	–	40.06	37.95
T <sub>10</sub> -Sole soybean (broadcasted)	–	–	28.58	26.67	–	–
T <sub>11</sub> -Sole cowpea (broadcasted)	–	–	–	–	33.32	32.05
SEm±	0.36	0.31	0.48	0.46	0.40	0.43
CD (P=0.05)	NS	NS	1.50	1.58	1.33	1.38

In cowpea, T<sub>9</sub>-sole cowpea (30 cm apart) shows significantly higher plant population which was *at par* with T<sub>4</sub>-hybrid maize + cowpea (1:2) –line sown. The lowest plant population was observed under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) at all time intervals of observations.

Lower plant population under these treatments may be due to sowing methods of crops. In broadcasting method of sowing the seeds did not germinate properly.

#### **4.1.2 Plant height (cm)**

The data pertaining to plant height of maize and intercrops as influenced by different crop configuration of hybrid maize based intercropping system presented in Table 4.2. In general, plant height of maize and intercrops were increased with the advancement in the crop age up to harvest stage.

The data reveal that plant height of maize increased from 30 to 60 rapidly and increased at slower pace up to at harvest stage. At 30 DAS, significantly maximum plant height was recorded under T<sub>7</sub>-sole hybrid maize (60 cm apart) which was found comparable to plant height of T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown. At 60 DAS and at harvest, significantly maximum plant height was recorded under T<sub>7</sub>-sole hybrid maize (60 cm apart). Irrespective of period of observation, significantly minimum plant height was recorded under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). The highest plant height was recorded under above mentioned treatments are mainly due to lower competition *i.e.* plant attained height and properly utilized light, solar radiation and nutrient. Similar findings were reported by Nyasasi and Kisetu (2014).

Plant height of soybean was recorded at 30, 60, 90 DAS and at harvest stage. The data reveal that plant height increased rapidly from 30 to 60 and

Table 4.2: Plant height of maize and intercrops as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Plant height (cm)									
	Maize			Soybean				Cowpea		
	30DAS	60DAS	At harvest	30DAS	60DAS	90DAS	At harvest	30DAS	60DAS	At harvest
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	38.0	170.0	172.1	20.9	48.2	50.7	51.2	–	–	–
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	37.3	169.0	171.3	26.2	68.7	70.3	70.8	–	–	–
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	36.0	168.9	170.7	23.2	63.0	64.2	65.3	–	–	–
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	36.0	169.4	172.1	–	–	–	–	42.6	189.3	208.4
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	35.4	167.6	170.0	–	–	–	–	46.1	194.8	212.4
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	35.1	167.1	169.6	–	–	–	–	47.5	195.6	213.8
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	40.9	174.4	176.8	–	–	–	–	–	–	–
T <sub>8</sub> -Sole soybean (30 cm apart)	–	–	–	19.5	45.3	47.3	47.7	–	–	–
T <sub>9</sub> -Sole cowpea (30 cm apart)	–	–	–	–	–	–	–	38.0	183.4	201.8
T <sub>10</sub> -Sole soybean (broadcasted)	–	–	–	19.3	41.0	47.4	47.8	–	–	–
T <sub>11</sub> -Sole cowpea (broadcasted)	–	–	–	–	–	–	–	34.0	182.4	201.0
SEm±	1.1	1.4	1.2	1.3	3.3	3.3	3.5	2.5	2.4	2.3
CD (P=0.05)	3.4	4.3	3.7	4.1	10.9	10.9	11.5	8.0	7.7	7.5

after that the increase was at slower pace up to harvest. Significantly maximum plant height was recorded under T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize) which was found comparable to plant height of T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) at all the time intervals of observations. Irrespective of period of observation, significantly minimum plant height recorded under T<sub>10</sub>-sole soybean (broadcasted) which was *at par* with T<sub>8</sub>-sole soybean (line sowing).

The maximum plant height was recorded under above mentioned treatments are mainly due to higher crop-intercrop competition *i.e.* plant attained height owing to less utilization of light and solar radiation. Similar findings were reported by Khatri *et al.* (2014)

Plant height of cowpea was recorded at 30, 60 DAS and harvest. The data reveal that plant height increased rapidly from 30 to 60 DAS and after that the increase was at slower pace up to at harvest. At all the time intervals of observations significantly maximum plant height was recorded under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) which was found comparable to plant height of T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize ) and T<sub>4</sub>-hybrid maize + cowpea (1:2) – line sown. Irrespective of period of observation, significantly minimum plant height recorded under T<sub>11</sub>-sole cowpea (broadcasted) which was *at par* with T<sub>8</sub>-sole cowpea (line sowing).

The maximum plant height was recorded under above mentioned treatments are mainly due to higher crop-intercrop competition *i.e.* plant attained height owing to less utilization of light and solar radiation. Similar findings were reported by Hamdalla *et al.* (2014).

#### **4.1.3 Dry matter accumulation plant<sup>-1</sup> (g)**

Dry matter accumulation plant<sup>-1</sup> of maize and intercrops was observed at 30, 60, 90 DAS and at harvest and data are presented in Table 4.3. It was observed that dry matter plant<sup>-1</sup> increased up to the time of harvest.

At 30 and 60 DAS, maize did not show significant difference in dry matter accumulation  $\text{plant}^{-1}$  in different crop configuration of hybrid maize based intercropping system. At harvest, significantly maximum dry matter accumulation  $\text{plant}^{-1}$  was recorded under T<sub>7</sub>-sole hybrid maize (60 cm apart), whereas, the lowest dry matter accumulation was recorded under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). It may be due to adverse effect of excessive crop-intercrop competition as evident from maximum dry matter production of intercrops, which resulted in reduction of nutrient uptake and dry matter accumulation by crop. Similar findings were reported by Nyasasi and Kisetu (2014).

In soybean, significantly maximum dry matter accumulation  $\text{plant}^{-1}$  was recorded under T<sub>8</sub>-sole soybean (30 cm apart) which was found comparable to T<sub>10</sub>-sole soybean (broadcasted) at all stages of observations. The lowest dry matter accumulation was recorded under T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) which was found comparable to T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize) at all the time intervals of observations. It may be due to competition of associated crops for lights, solar radiation and nutrients. Similar findings were reported by Khatri *et al.* (2014).

In cowpea, significantly maximum dry matter accumulation  $\text{plant}^{-1}$  was recorded under T<sub>9</sub>-sole cowpea (30 cm apart) which was found comparable to T<sub>11</sub>-sole cowpea (broadcasted) at all stages of observations. The lowest dry matter accumulation was recorded under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) which was found comparable to T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize) at all the time intervals of observations. It may be due to competition of associated crops for light, solar radiation and nutrients. Similar findings were reported by Legwiala (2012).

Table 4.3: Dry matter accumulation in maize and intercrops as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Dry matter accumulation (g plant <sup>-1</sup> )									
	Maize			Soybean				Cowpea		
	30DAS	60DAS	At harvest	30DAS	60DAS	90DAS	At harvest	30DAS	60DAS	At harvest
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	24.7	142.3	249.7	2.5	13.4	21.4	28.2	–	–	–
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	24.0	141.7	246.7	2.3	7.2	10.6	12.4	–	–	–
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	23.6	140.1	245.0	2.3	7.0	9.9	11.3	–	–	–
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	24.1	142.5	245.3	–	–	–	–	4.3	13.5	16.1
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	23.7	141.7	243.9	–	–	–	–	4.3	13.0	15.2
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	23.6	140.7	242.8	–	–	–	–	4.2	12.6	14.5
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	26.0	144.5	257.9	–	–	–	–	–	–	–
T <sub>8</sub> -Sole soybean (30 cm apart)	–	–	–	3.2	15.2	23.1	30.8	–	–	–
T <sub>9</sub> -Sole cowpea (30 cm apart)	–	–	–	–	–	–	–	4.6	16.3	19.3
T <sub>10</sub> -Sole soybean (broadcasted)	–	–	–	2.7	14.3	21.6	29.7	–	–	–
T <sub>11</sub> -Sole cowpea (broadcasted)	–	–	–	–	–	–	–	4.5	15.7	17.4
SEm±	1.3	3.8	2.0	0.2	0.5	0.6	1.0	0.1	0.5	0.6
CD (P=0.05)	NS	NS	6.3	0.6	1.6	1.8	3.1	0.4	1.4	1.7

#### 4.1.4 Number of leaves plant<sup>-1</sup>

The data presented in Table 4.4 reveal that the number of leaves plant<sup>-1</sup> in maize increased with the advancement in crop age up to 60 DAS. Maize show significant difference in number of leaves plant<sup>-1</sup> at 60 DAS and at harvest stage. In maize, significantly maximum number of leaves plant<sup>-1</sup> was recorded under T<sub>7</sub>-sole maize (60 cm apart) at 60 DAS and harvest stage of observation, whereas, the lowest number of leaves plant<sup>-1</sup> was recorded under T<sub>6</sub>- hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) at 60 DAS and at harvest stage of observations. It may be due to adverse effect of excessive competition of associated crop for moisture, light and solar radiation. Similar findings were reported by Alhaji (2008).

#### 4.1.5 Leaf area plant<sup>-1</sup> and leaf area index

The data presented in Table 4.4 reveal that the leaf area and leaf area index in maize increased with the advancement in crop age up to 60 DAS. Maize show significant difference in leaf area plant<sup>-1</sup> and leaf area index at all the time intervals of observations in different crop configuration of hybrid maize based intercropping system. In maize, significantly maximum leaf area plant<sup>-1</sup> and leaf area index was recorded under T<sub>7</sub>-sole maize (60 cm apart) at 30 and 60 DAS of observation, whereas, the lowest leaf area plant<sup>-1</sup> and leaf area index was recorded under T<sub>6</sub>- hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) at 30 and 60 DAS of observations. It may be due to adverse effect of excessive competition of associated crops for moisture, light and solar radiation. Similar findings were reported by Venkatachalam (1990) and Thobatsi (2009).

#### 4.1.6 Number of branches plant<sup>-1</sup>

Number of branches of soybean and cowpea was observed at 60 DAS and data are presented in Table 4.5. In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced significantly maximum number of branches plant<sup>-1</sup> which was found comparable to T<sub>8</sub>-sole soybean (30 cm apart), whereas, the lowest number of branches was recorded under T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).

Table 4.4: Number of leaves, leaf area and leaf area index of maize as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Leaves plant <sup>-1</sup> (No.)			Leaf area (cm <sup>2</sup> )		Leaf area index	
	30DAS	60DAS	At harvest	30DAS	60DAS	30DAS	60DAS
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	4.6	11.6	7.9	1170	4373	1.3	4.9
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	4.4	11.4	7.8	1132	4376	1.3	4.9
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	4.4	11.3	7.7	1137	4287	1.3	4.8
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	4.5	11.4	7.7	1153	4338	1.2	4.8
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	4.5	11.3	7.6	1101	4340	1.2	4.8
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	4.3	11.2	7.6	1030	4096	1.1	4.6
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	4.7	12.3	8.9	1315	4896	1.5	5.4
SEm±	0.10	0.18	0.22	44	115	0.05	0.13
CD (P=0.05)	NS	0.58	0.69	137	354	0.14	0.39

Table 4.5: Branches of intercrops as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Number of Branches plant <sup>-1</sup>	
	Soybean	Cowpea
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	3.8	–
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	3.3	–
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	3.0	–
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	–	4.3
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	–	4.1
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	–	4.0
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	–	–
T <sub>8</sub> -Sole soybean (30 cm apart)	5.1	–
T <sub>9</sub> -Sole cowpea (30 cm apart)	–	5.0
T <sub>10</sub> -Sole soybean (broadcasted)	5.7	–
T <sub>11</sub> -Sole cowpea (broadcasted)	–	5.1
SEm±	0.59	0.20
CD (P=0.05)	1.42	0.64

In cowpea, T<sub>11</sub>-sole cowpea (broadcasted) produced significantly maximum number of branches plant<sup>-1</sup> which was found comparable to T<sub>9</sub>-sole cowpea (30 cm apart), whereas, the lowest number of branches was recorded under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize).

The maximum number of branches plant<sup>-1</sup> was recorded under T<sub>10</sub>-sole soybean (broadcasted) T<sub>11</sub>-sole cowpea (broadcasted). It may be due to lack of crop-intercrop competition, which facilitates more space; nutrient and light ultimately resulted in more number of branches plant<sup>-1</sup>. Similar findings were reported by Hamdalla *et al.* (2014).

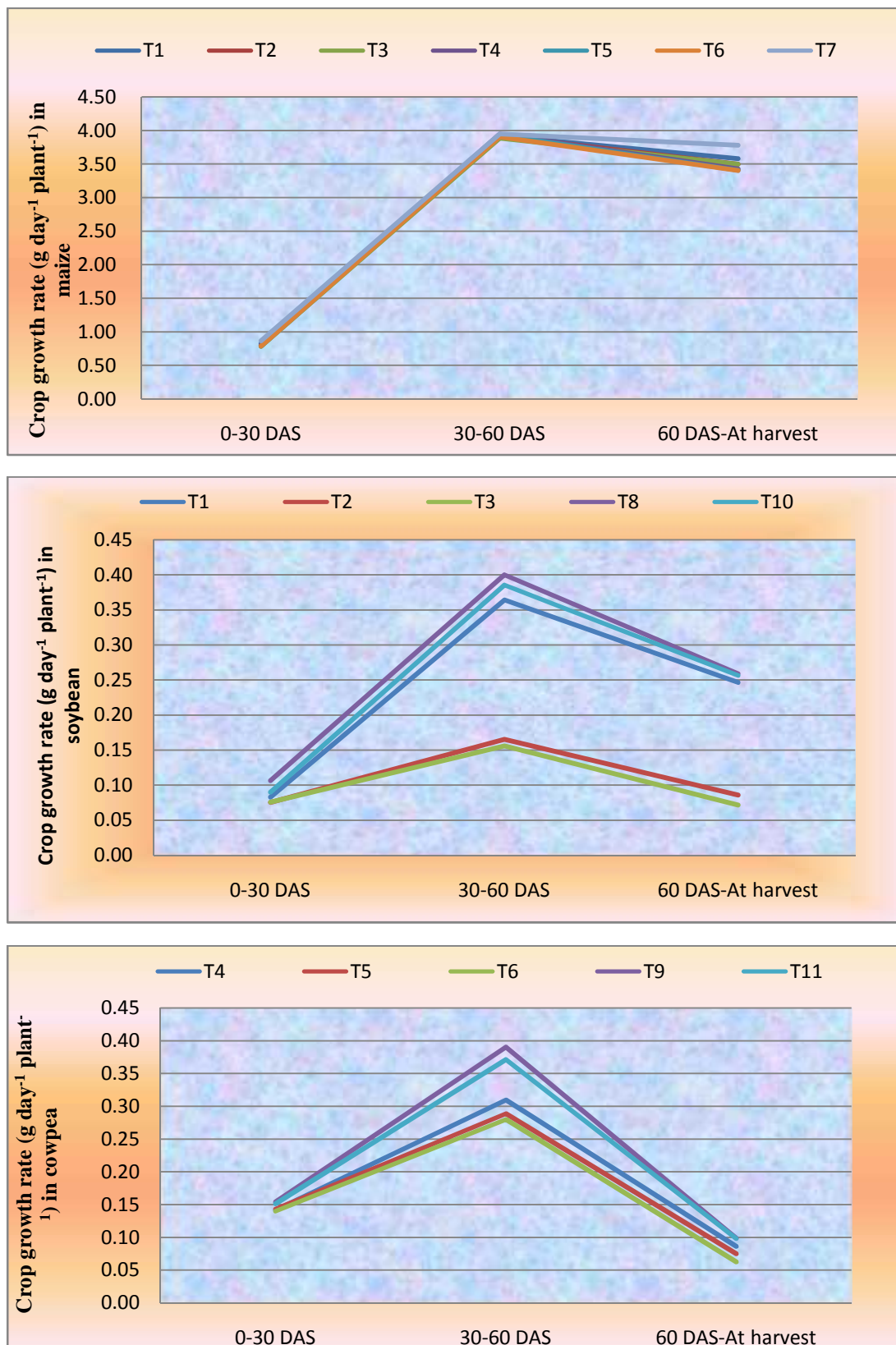
#### **4.1.7 Crop Growth Rate (g day<sup>-1</sup> plant<sup>-1</sup>)**

Crop growth rate of maize, soybean and cowpea was observed at 0-30, 30-60 DAS and 60 DAS-at harvest and data are presented in fig. 4.1. Irrespective of different duration of observations crop growth rate during 30-60 DAS was quite higher. In maize, maximum CGR was obtained under T<sub>7</sub>-sole hybrid maize (60 cm apart) at harvest stage. On the other hand, T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) showed minimum CGR.

In soybean, the maximum CGR was obtained under T<sub>8</sub>-sole soybean (30 cm apart) which was found comparable to T<sub>10</sub>-sole soybean (broadcasted) at all stages of observations. On the other hand, T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) showed minimum CGR at all stages of observation.

In cowpea, the maximum CGR was obtained under T<sub>9</sub>-sole cowpea (30 cm apart) at all stages of observation. On the other hand, T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) showed minimum CGR at 30-60 DAS.

The crop growth rate increased sharply up to 60 DAS, irrespective of the treatment and declined thereafter. This might be due to the fact that the dry matter accumulation was also higher during this period, which resulted in higher crop growth rate values.



**Fig 4.1: Crop growth rate of maize, soybean and cowpea as influenced by different crop configuration of maize based intercropping system.**

## 4.2 Post harvest observations

### 4.2.1 Number of rows cob<sup>-1</sup> and number of pods plant<sup>-1</sup>

The data on number of rows cob<sup>-1</sup> and number of pods plant<sup>-1</sup> under various treatments have been presented in Table 4.6, which reveal that maize did not show significance difference in number of rows cob<sup>-1</sup> as influenced by different crop configuration of hybrid maize based intercropping system. Similar findings were reported by Francies (1978).

In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced maximum number of pods plant<sup>-1</sup>, however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart). Whereas, the lowest number of pods plant<sup>-1</sup> was recorded under treatment T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).

In cowpea, T<sub>9</sub>- sole cowpea (30 cm apart) produced maximum number of pods plant<sup>-1</sup>, however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted). Whereas, the lowest number of pods plant<sup>-1</sup> was recorded under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)

The possible reason for lower number of rows cob<sup>-1</sup> and pods plant<sup>-1</sup> is due to higher competition of associate crop for light, solar radiation, space, soil moisture and nutrient during entire crop season as compared to the plots of sole crop. Similar findings were reported by Sonam *et al.* (2014).

### 4.2.2 Number of grains row<sup>-1</sup> and numbers of seeds pod<sup>-1</sup>

The data on number of grains row<sup>-1</sup> and number of seeds pod<sup>-1</sup> under various treatments have been presented in Table 4.6, which reveal that in maize, T<sub>7</sub>-sole hybrid maize (60 cm apart) gave significantly higher number of grains row<sup>-1</sup>, however, it was found statistically similar to T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown. On the other hand, the lowest number of grains row<sup>-1</sup> was recorded under treatment of T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize).

Table 4.6: Yield attributes of maize and intercrops as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Maize				Soybean				Cowpea			
	No. of row cob <sup>-1</sup>	No. of grain row <sup>-1</sup>	No. of grain cob <sup>-1</sup>	100 seed weight (g)	No. of pods plant <sup>-1</sup>	No. of seeds pod <sup>-1</sup>	No. of seeds plant <sup>-1</sup>	100 seed weight (g)	No. of pods plant <sup>-1</sup>	No. of seeds pod <sup>-1</sup>	No. of seeds plant <sup>-1</sup>	100 seed weight (g)
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	13.3	32.5	433	26.4	33.3	2.5	83.3	9.7	–	–	–	–
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	13.2	31.3	411	25.3	17.1	2.0	34.2	9.7	–	–	–	–
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	12.8	33.5	430	26.2	15.0	2.0	30.0	9.8	–	–	–	–
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	13.2	30.7	404	27.3	–	–	–	–	10.9	13.1	143	8.7
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	13.3	28.9	382	26.6	–	–	–	–	10.3	12.7	130	8.7
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	12.8	28.7	371	26.2	–	–	–	–	10.2	12.2	124	8.8
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	13.2	34.5	455	29.0	–	–	–	–	–	–	–	–
T <sub>8</sub> -Sole soybean (30 cm apart)	–	–	–	–	52.8	2.6	131.9	9.6	–	–	–	–
T <sub>9</sub> -Sole cowpea (30 cm apart)	–	–	–	–	–	–	–	–	11.7	14.3	167	8.6
T <sub>10</sub> -Sole soybean (broadcasted)	–	–	–	–	63.3	2.5	157.5	9.5	–	–	–	–
T <sub>11</sub> -Sole cowpea (broadcasted)	–	–	–	–	–	–	–	–	11.3	13.7	155	8.5
SEm±	0.2	0.7	9.4	1.0	3.8	0.1	8.2	0.1	0.2	0.1	3.3	0.1
CD (P=0.05)	NS	2.3	29.0	NS	12.3	0.4	27.0	NS	0.8	0.3	10.7	NS

In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced maximum number of seeds plant<sup>-1</sup>, however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart). Whereas, the lowest number of seeds plant<sup>-1</sup> was recorded under treatment T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).

In cowpea, T<sub>9</sub>-sole cowpea (30 cm apart) produce maximum number of seeds plant<sup>-1</sup>, however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted). Whereas, the lowest number of seeds plant<sup>-1</sup> was recorded under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize).

The possible reason for lower number of grains row<sup>-1</sup> and seeds pod<sup>-1</sup> is due to higher competition of associate crop for light, solar radiation, soil moisture and nutrient during entire crop season as compared to the plots of sole crop. Similar findings were reported by Patel and Rajgopal (2003) and Sonam *et al.* (2014)

#### **4.2.3 Number of grains plant<sup>-1</sup> and seeds plant<sup>-1</sup>**

The data on number of grains plant<sup>-1</sup> and number of seeds plant<sup>-1</sup> under various treatments have been presented in Table 4.6, which reveal that in maize, T<sub>7</sub>-sole hybrid maize (60 cm apart) gave significantly higher number of grains plant<sup>-1</sup> than others, however, it was found statistically similar to T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown. On the other hand, the lowest number of grains row<sup>-1</sup> was recorded under treatment of T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize).

In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced maximum number of seeds plant<sup>-1</sup>, however, it was found similar to T<sub>8</sub>-sole soybean (30 cm apart). Whereas, the lowest number of seeds plant<sup>-1</sup> was recorded under treatment T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) and T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize).

In cowpea, T<sub>9</sub>-sole cowpea (30 cm apart) produced maximum number of seeds plant<sup>-1</sup>. Whereas, the lowest number of seeds plant<sup>-1</sup> was recorded under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)

The possible reason for lower number of grains plant<sup>-1</sup> and seeds plant<sup>-1</sup> is due to higher competition of associate crop for light, solar radiation, and nutrient during entire crop season as compared to the plots of sole crop. Similar findings were reported by Aziz *et al.* (2012).

#### **4.2.4 100 seed weight (g)**

The weight of 100-seed is also an important attribute of yield. The effect of different crop configuration of hybrid maize based intercropping system on 100-seed weight is presented in Table 4.6. The data clearly reveal that crops did not show a significant effect of different crop configuration of hybrid maize based intercropping system on the 100-seed weight. Similar findings were reported by Francies (1978).

#### **4.2.5 Grain and seed yield (kg ha<sup>-1</sup>)**

The data on grain and seed yield as affected by crop configuration are presented in Table 4.7. In maize, significantly maximum grain yield was obtained under T<sub>7</sub>-sole hybrid maize (60 cm apart), however, it was found statistically similar to T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize), T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize), T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize ) and T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). Whereas, the lowest grain yield was recorded under T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown.

In soybean, maximum seed yield was obtained under T<sub>8</sub>-sole soybean (30 cm apart), however, it was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted). Whereas, the lowest seed yield was recorded under treatment T<sub>2</sub>-

Table 4.7: Grain/Seed yield, stover yield and harvest index of maize and intercrops as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Maize			Soybean			Cowpea		
	Grain yield (kg ha <sup>-1</sup> )	Stover yield (kg ha <sup>-1</sup> )	Harvest index (%)	Seed yield (kg ha <sup>-1</sup> )	Stover yield (kg ha <sup>-1</sup> )	Harvest index (%)	Seed yield (kg ha <sup>-1</sup> )	Stover yield (kg ha <sup>-1</sup> )	Harvest index (%)
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	3919.4	5110.9	43.4	780.6	1169.8	40.0	–	–	–
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	5569.4	7263.3	43.4	574.0	941.6	37.9	–	–	–
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	5363.9	7159.7	42.8	808.3	1330.1	37.8	–	–	–
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	4483.3	5894.7	43.2	–	–	–	533.3	1395.8	27.6
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	5375.0	7241.0	42.6	–	–	–	346.7	968.1	26.4
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	5291.6	7247.8	42.2	–	–	–	684.4	1918.0	26.3
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	5805.5	7503.8	43.6	–	–	–	–	–	–
T <sub>8</sub> -Sole soybean (30 cm apart)	–	–	–	1830.5	2400.0	43.3	–	–	–
T <sub>9</sub> -Sole cowpea (30 cm apart)	–	–	–	–	–	–	969.4	2339.0	29.3
T <sub>10</sub> -Sole soybean (broadcasted)	–	–	–	1741.7	2343.4	42.6	–	–	–
T <sub>11</sub> -Sole cowpea (broadcasted)	–	–	–	–	–	–	845.6	2081.2	28.9
SEm±	199.6	241	0.7	238.2	70.8	0.3	53.6	71.0	0.3
CD (P=0.05)	615.1	742.6	NS	380.0	230.9	1.0	174.0	231.4	0.8

hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize).

In cowpea, maximum seed yield was obtained under T<sub>9</sub>-sole cowpea (30 cm apart), however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted). Whereas, the lowest seed yield was recorded under treatment T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize).

The increase in grain or seed yield under treatments of sole crop was due to lack of competition during entire crop season as compared to the other plots. Similar results were also noted by Thobatsi (2009); sonam *et al.* (2014); Silwana and Lucas (2002).

#### **4.2.6 Stover yield (kg ha<sup>-1</sup>)**

The data on stover yield (kg ha<sup>-1</sup>) as influenced by different crop configuration of hybrid maize based intercropping system have been presented in Table 4.7. The data clearly reveal that crop configuration of maize based intercropping system had a significant effect on the stover yield of crop and intercrops.

In maize, maximum stover yield was obtained under treatment T<sub>7</sub>-sole hybrid maize (60 cm apart), however, it was found statistically similar to T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize), T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize), T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize) and T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). Whereas, the lowest stover yield was recorded under T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown.

In soybean, maximum stover yield was obtained under T<sub>8</sub>-sole soybean (30 cm apart), however, it was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted). Whereas, the lowest stover yield was recorded under treatment T<sub>2</sub>-

hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize).

In cowpea, maximum stover yield was obtained under T<sub>9</sub>-sole cowpea (30 cm apart), however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted). Whereas, the lowest stover yield was recorded under treatment T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize).

The higher stover yield in above treatments might be due to lesser competition between the crop and intercrops during crop growth period which leads to higher stover yield. Similar results were also noted by Matusso *et al.* (2013) and Sonam *et al.* (2014).

#### **4.2.7 Harvest index (%)**

The data on harvest index as influenced by different crop configuration of hybrid maize based intercropping system have been presented in Table 4.7. The harvest index of maize was not affected by different crop configuration of hybrid maize based intercropping system.

In soybean, the maximum harvest index was obtained under treatment T<sub>8</sub>-sole soybean (30 cm apart), however, it was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted). Whereas, the lowest harvest index was recorded under treatment T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).

In cowpea, the statistically highest harvest index was obtained under treatment T<sub>9</sub>-sole cowpea (30 cm apart), however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted). Whereas, the lowest harvest index was recorded under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize).

The minimum harvest index in above treatments might be due to more competition of associate crop for light, solar radiation, soil moisture and nutrient during crop growth period.

### **4.3 Efficiency of intercropping system**

#### **4.3.1 Land equivalent ratio (LER)**

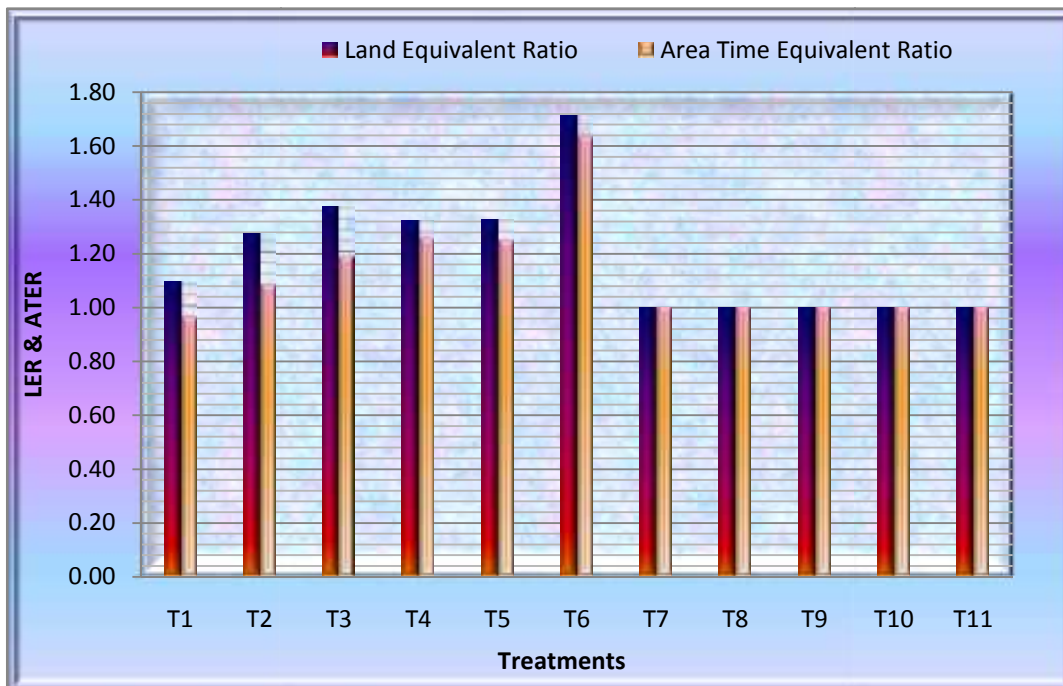
The data on land equivalent ratio as influenced by different crop configuration of hybrid maize based intercropping system have been presented in Table 4.8. The maximum land equivalent ratio was obtained under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). On the other hand, the lowest land equivalent ratio was recorded under treatments of sole crop. If grow maize, soybean and cowpea separately, it takes more land but intercropping treatments land utilization could be saved, which is advantages while cultivable land decreasing day by day. Rao and Willey (1983) reported that intercropping increased land equivalent ratio (LER). Sarno (1998) stated that land equivalent ratio (LER) values were found to be greater with intercropping than sole cropping.

#### **4.3.2 Area time equivalent ratio (ATER)**

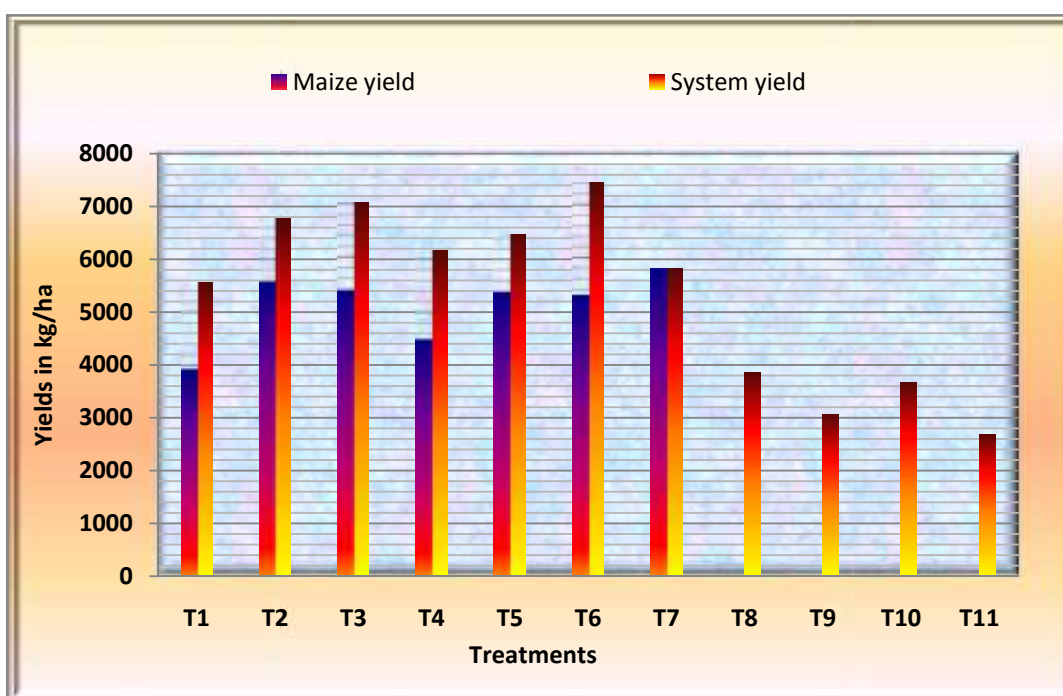
The data on area time equivalent ratio as influenced by different crop configuration of hybrid maize based intercropping system have been presented in Table 4.8. The maximum area time equivalent ratio was obtained under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). Whereas, the lowest area time equivalent ratio was recorded under T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown.

#### **4.3.3 System yield (kg ha<sup>-1</sup>)**

System yield have been presented in Table 4.9. The results showed that different intercropping treatments have significant impact on yield. The significantly highest system yield was recorded under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), however, it was



**Fig4.2: Land equivalent ratio and area time equivalent ratio as influenced by different crop configuration of maize based intercropping system**



**Fig4.3: Maize yield and system yield as influenced by different crop configuration of maize based intercropping system**

Table 4.8: Land equivalent ratio and area time equivalent ratio in maize and intercrops as influenced by different crop configuration of hybrid maize based inter cropping system

Treatment	Land Equivalent Ratio	Area Time Equivalent Ratio
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	1.10	0.96
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	1.28	1.08
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	1.37	1.18
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	1.32	1.26
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	1.32	1.25
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	1.71	1.63
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	1.00	1.00
T <sub>8</sub> -Sole soybean (30 cm apart)	1.00	1.00
T <sub>9</sub> -Sole cowpea (30 cm apart)	1.00	1.00
T <sub>10</sub> -Sole soybean (broadcasted)	1.00	1.00
T <sub>11</sub> -Sole cowpea (broadcasted)	1.00	1.00
SEm±	0.05	0.05
CD (P=0.05)	0.15	0.14

Table 4.9: Maize yield, intercrops yield, maize equivalent yield and system yield as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Maize yield (kg ha <sup>-1</sup> )	Soybean yield (kg ha <sup>-1</sup> )	Cowpea yield (kg ha <sup>-1</sup> )	Maize equivalent yield (kg ha <sup>-1</sup> )	System yield (kg ha <sup>-1</sup> )
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	3919	781	–	1638	5557
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	5569	574	–	1204	6773
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	5364	808	–	1695	7059
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	4483	–	533	1681	6164
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	5375	–	347	1095	6470
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	5292	–	684	2158	7450
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	5806	–	–	5806	5806
T <sub>8</sub> -Sole soybean (30 cm apart)	–	1831	–	3842	3847
T <sub>9</sub> -Sole cowpea (30 cm apart)	–	–	969	3057	3057
T <sub>10</sub> -Sole soybean (broadcasted)	–	1742	–	3655	3655
T <sub>11</sub> -Sole cowpea (broadcasted)	–	–	846	2669	2669
SEm±	199.6	114	54	84.6	191.3
CD (P=0.05)	615.1	372	175	249.6	564.4

Maize-1525 Rs q<sup>-1</sup>, Soybean - 3200 Rs q<sup>-1</sup>, Cowpea - 4811 Rs q<sup>-1</sup>

found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize). Whereas, the lowest system yield was recorded under T<sub>11</sub>-sole cowpea (broadcasted), might be due to low productivity of cowpea.

#### **4.3.4 Production efficiency (kg ha<sup>-1</sup> day<sup>-1</sup>)**

The data on Production efficiency under maize based intercropping system have been presented in Table 4.10. The data clearly reveal that the crop configuration of maize based intercropping system had a significantly effect on the production efficiency. The maximum production efficiency was obtained under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). On the other hand, the lowest production efficiency obtained under T<sub>11</sub>-sole cowpea (broadcasted) might be due to low productivity of cowpea.

### **4.4. Soil analysis**

#### **4.4.1 Available N, P and K content in soil (kg ha<sup>-1</sup>)**

The data pertaining to NPK content in soil have been presented in Table 4.11. Data reveal that the NPK content in soil was significantly affected due to different treatments. Among all crop configuration, significantly highest N, content in the soil was recorded under T<sub>8</sub>-sole soybean (30 cm apart), however, it was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted). On the other hand, the lowest N content in soil was observed under T<sub>7</sub>-sole hybrid maize (60 cm apart).

Among all crop configuration, significantly highest P content in the soil was recorded under T<sub>10</sub>-sole soybean (broadcasted), however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart) and T<sub>11</sub>-sole cowpea (broadcasted). On the other hand lowest P content in soil was observed under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize).

Among all crop configuration, significantly highest K content in the soil was recorded under T<sub>10</sub>-sole soybean (broadcasted), however, it was found statistically

Table 4.10: Production efficiency as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Production efficiency (kg ha <sup>-1</sup> day <sup>-1</sup> )
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	50.5
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	61.6
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	64.2
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	64.9
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	68.1
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	78.4
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	66.7
T <sub>8</sub> -Sole soybean (30 cm apart)	34.9
T <sub>9</sub> -Sole cowpea (30 cm apart)	32.2
T <sub>10</sub> -Sole soybean (broadcasted)	33.2
T <sub>11</sub> -Sole cowpea (broadcasted)	28.1
SEm±	1.9
CD (P=0.05)	5.6

Table 4.11: Nutrient content in soil as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Nutrient content in soil		
	Available Nitrogen (kg ha <sup>-1</sup> )	Available Phosphorus (kg ha <sup>-1</sup> )	Available Potassium (kg ha <sup>-1</sup> )
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	224.8	12.4	339.2
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	217.7	13.07	329.0
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	216.6	12.0	326.1
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	217.4	12.3	334.8
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	215.8	11.8	328.0
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	214.3	11.0	320.2
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	212.6	13.0	334.0
T <sub>8</sub> -Sole soybean (30 cm apart)	228.6	15.2	371.2
T <sub>9</sub> -Sole cowpea (30 cm apart)	225.5	14.1	366.2
T <sub>10</sub> -Sole soybean (broadcasted)	227.8	15.7	373.8
T <sub>11</sub> -Sole cowpea (broadcasted)	224.2	14.8	368.8
SEm ±	0.94	0.4	6.13
CD (P=0.05)	2.78	1.29	18.10

similar to T<sub>8</sub>-sole soybean (30 cm apart), T<sub>11</sub>-sole cowpea (broadcasted) and T<sub>9</sub>-sole cowpea (30 cm apart). On the other hand lowest K content in soil was observed under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize).

#### 4.6 Economics

To examine the economic feasibility and viability of different treatment under investigation, economics of maize soybean and cowpea production in terms of gross return, net return and benefit:cost ratio were calculated for different crop configuration and the outcome is presented in Table 4.12. The data clearly reveal that significantly maximum gross return was obtained under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), however, it was found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize). Whereas, the minimum gross return was obtained under treatment T<sub>11</sub>-sole cowpea (broadcasted).

The data clearly reveal that significantly maximum net return was obtained under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), however, it was found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) and T<sub>2</sub>-hybrid, maize + soybean (broadcasting of soybean after alternate row of hybrid maize). Whereas, the minimum net return was obtained under treatment T<sub>11</sub>-sole cowpea (broadcasted).

The data clearly reveal that significantly maximum B:C ratio was obtained under treatment T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize), however, it was found statistically similar to T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize). Whereas, the minimum B:C ratio was obtained under treatment T<sub>11</sub>-sole cowpea (broadcasted).

All intercropping treatments resulted in more profit in term of monetary returns as compared to sole crops. Similar results were also reported by Singh and Singh (1995). The higher economic returns were obviously due to higher seed and

Table 4.12: Economics of various treatments of maize based intercropping system

Treatment	Cost of cultivation (Rs ha <sup>-1</sup> )	Gross return (Rs ha <sup>-1</sup> )	Net return (Rs ha <sup>-1</sup> )	Benefit : Cost ratio
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	26764	96141	69377	3.6
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	27740	118770	91030	4.3
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	28860	123315	94455	4.3
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	30580	107214	76634	3.5
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize )	30920	114097	83177	3.7
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	34670	130040	95370	3.8
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	26620	103541	76921	3.9
T <sub>8</sub> -Sole soybean (30 cm apart)	25257	60978	35721	2.4
T <sub>9</sub> -Sole cowpea (30 cm apart)	30817	48979	18162	1.6
T <sub>10</sub> -Sole soybean (Broadcasted)	25257	58077	32820	2.3
T <sub>11</sub> -Sole cowpea (Broadcasted)	30817	42761	11944	1.4
SEm±	–	2392.7	2392.7	0.11
CD ( P=0.05)	–	7058.49	7058.49	0.33

Marketable price: Seed of maize = Rs 1525 q<sup>-1</sup> and Stover yield = Rs 200 q<sup>-1</sup>

Seed of soybean = Rs 3200 q<sup>-1</sup> and Stover yield = Rs 100 q<sup>-1</sup>

Seed of cowpea = Rs 4811 q<sup>-1</sup> and Stover yield = Rs 100 q<sup>-1</sup>

stover yield production of component crops. This could be attributed to higher yield advantage under intercropping of maize with soybean and cowpea. In agreement with these results, higher net monetary return was also reported by Gangwar and Kalra (1982); Padhi (2001); Patil and Joshi (2002); Kumar *et al.* (2005); Sahu (2006); Meena (2006); Sonam *et al.* (2014). Hence, it was concluded that intercrop of maize with soybean/cowpea is biological and economically sustainable intercropping system.

#### **4.6 Energetics**

Data calculated on energetic parameters at harvest have been presented in Table 4.13. The treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) gave the maximum energy output which was *at par* with T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) and T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize). The lowest value was recorded under T<sub>11</sub>-sole cowpea (broadcasted). Almost similar trend was noted for energy output-input ratio and energy use efficiency for total biomass in respect to crop configuration of hybrid maize based intercropping system. The higher energy gain in aforesaid treatment may be due to higher energy use efficiency.

Table 4.13: Energetics of maize and intercrops as influenced by different crop configuration of hybrid maize based intercropping system

Treatment	Energy input (MJ× 10 <sup>-3</sup> ha <sup>-1</sup> )	Energy output (MJ× 10 <sup>-3</sup> ha <sup>-1</sup> )			Energy output: input ratio	Energy use efficiency (kg MJ× 10 <sup>-3</sup> ha <sup>-1</sup> )		
		Seed	Stover	Total		Seed	Stover	Total
T <sub>1</sub> -Hybrid maize + soybean (2:4) – line sown	13.5	67.7	76.9	144.6	10.7	0.35	0.46	0.81
T <sub>2</sub> -Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize)	13.6	88.5	100.5	189.0	13.9	0.45	0.60	1.06
T <sub>3</sub> -Hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize)	14.1	89.0	104.0	193.0	13.7	0.44	0.60	1.04
T <sub>4</sub> -Hybrid maize + cowpea (1:2) – line sown	13.2	72.2	89.2	161.4	12.2	0.38	0.55	0.93
T <sub>5</sub> -Hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize)	13.3	82.4	100.5	182.9	13.8	0.43	0.62	1.05
T <sub>6</sub> -Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize)	13.5	86.1	112.2	198.3	14.7	0.44	0.68	1.12
T <sub>7</sub> -Sole hybrid maize (60 cm apart)	13.1	83.5	91.8	175.4	13.4	0.44	0.57	1.02
T <sub>8</sub> -Sole soybean (30 cm apart)	6.4	24.4	27.2	51.6	8.1	0.29	0.38	0.66
T <sub>9</sub> -Sole cowpea (30 cm apart)	5.8	12.8	26.2	39.0	6.7	0.17	0.40	0.57
T <sub>10</sub> -Sole soybean (broadcasted)	6.4	23.2	26.5	49.7	7.8	0.27	0.37	0.64
T <sub>11</sub> -Sole cowpea (broadcasted)	5.8	11.1	23.3	34.5	5.9	0.15	0.36	0.50
SEm±	-	2.3	2.7	5.0	0.4	0.01	0.02	0.03
CD (P=0.05)	-	6.74	8.07	14.80	1.15	0.04	0.05	0.09

## CHAPTER- V

### SUMMARY AND CONCLUSIONS

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The present experiment entitled “**Effect of hybrid maize (*Zea mays*) + soybean (*Glycine max* L. Merrill)/cowpea (*Vigna sinensis*) intercropping with different crop configuration on productivity and economics of hybrid maize based intercropping system**” was carried out during *kharif* season of 2015 at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, with the objective to find out the best combination of crop configuration of intercropping system of hybrid maize + soybean/cowpea. The experiment was laid out in randomized block design with eleven treatments and three replications. The crop configurations were T<sub>1</sub>-hybrid maize + soybean (2:4) – line sown, T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize), T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize), T<sub>4</sub>-hybrid maize + cowpea (1:2) – line sown, T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize), T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), T<sub>7</sub>-sole hybrid maize (60 cm apart), T<sub>8</sub>-sole soybean (30 cm apart), T<sub>9</sub>-sole cowpea (30 cm apart), T<sub>10</sub>-sole soybean(broadcasted) and T<sub>11</sub>-sole cowpea (broadcasted). The soil of the experimental field was clayey in texture (*Vertisols*) with low available N, medium P and high K content. Climate of the region was dry moist, sub humid with an average rainfall of 1326 mm. Maize variety “RMH-4212” soybean variety “JS 335” and cowpea variety “VU-89” was sown on June 26, 2015. Sowing was done with a seed rate of 25 kg, 70 kg and 30 kg ha<sup>-1</sup> of maize, soybean and cowpea respectively. The harvesting of crops completed on October 14, 2015.

The observations on plant height, number of leaves plant<sup>-1</sup>, Leaf area plant<sup>-1</sup>, number of branches, dry matter accumulation, number of rows cob<sup>-1</sup> and number of pods plant<sup>-1</sup>, number of grains row<sup>-1</sup> and number of seeds pod<sup>-1</sup>, number of grains plant<sup>-1</sup> and number of seeds plant<sup>-1</sup>, 100-seed weight, seed and stover yield of maize, soybean and cowpea were recorded and statistical analyzed, crop growth

rate, land equivalent ratio, area time equivalent ratio, system yield, production efficiency, energetics and harvest index were worked out.

**The results are summarized as below:**

- In maize, T<sub>7</sub>-sole maize shows significantly maximum plant population which was *at par* with T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) and T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize). In soybean, T<sub>8</sub>-sole soybean (30 cm apart) showed significantly higher plant population than other which was *at par* with T<sub>1</sub>-hybrid maize + soybean (2:4) –line sown. In cowpea, T<sub>9</sub>-sole cowpea (30 cm apart) showed significantly higher plant population than other which was *at par* with T<sub>4</sub>-hybrid maize + cowpea (1:2) –line sown.
- In maize at 30 DAS, significantly maximum plant height was recorded under T<sub>7</sub>-sole hybrid maize (60 cm apart) which was found statistically similar to plant height of T<sub>1</sub>-hybrid maize + soybean (2:4) –line sown. At 60 DAS and at harvest stage significantly maximum plant height was recorded under T<sub>7</sub>-sole hybrid maize (60 cm apart). In soybean, significantly maximum plant height was recorded under T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize) which was found statistically similar to plant height of T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) at all the time intervals of observations. In cowpea, significantly maximum plant height was recorded under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) which was found statistically similar to plant height of T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize) and T<sub>4</sub>-hybrid maize + cowpea (1:2) –line sown at all the time intervals of observations.
- In maize, at harvest maximum dry matter accumulation plant<sup>-1</sup> was recorded under T<sub>7</sub>-sole hybrid maize (60 cm apart). In soybean, significantly maximum dry matter accumulation plant<sup>-1</sup> was recorded under T<sub>8</sub>-sole soybean (30 cm apart) which was found statistically similar to T<sub>10</sub>-

sole soybean (broadcasted) at all stages of observations. In cowpea, significantly maximum dry matter accumulation plant<sup>-1</sup> was recorded under T<sub>9</sub>-sole cowpea (30 cm apart) which was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted) at all stages of observations.

- Maximum number of leaves plant<sup>-1</sup> was recorded under T<sub>7</sub>-sole maize (60 cm apart) at 60 DAS of observation.
- Maximum leaf area plant<sup>-1</sup> and leaf area index was recorded under T<sub>7</sub>-sole maize (60 cm apart) at 30 and 60 DAS of observation.
- In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced significantly maximum number of branches plant<sup>-1</sup> which was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart). In cowpea, T<sub>11</sub>-sole cowpea (broadcasted) produced significantly maximum number of branches plant<sup>-1</sup> which was found statistically similar to T<sub>9</sub>-sole cowpea (30 cm apart).
- In maize, maximum crop growth rate was obtained under T<sub>7</sub>-sole hybrid maize (60 cm apart) at all stages of observations. In soybean, maximum CGR was obtained under T<sub>8</sub>-sole soybean (30 cm apart) which was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted) at all stages of observations. In cowpea, maximum CGR was obtained under T<sub>9</sub>-sole cowpea (30 cm apart) at all stages of observation.
- Maize did not showed significance difference in number of rows cob<sup>-1</sup>. In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced maximum number of pods plant<sup>-1</sup>, however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart). In cowpea, T<sub>9</sub>-sole cowpea (30 cm apart) produced maximum number of pods plant<sup>-1</sup>, however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted).
- In maize, T<sub>7</sub>-sole hybrid maize (60 cm apart) gave significantly higher number of grains row<sup>-1</sup> than others, however, it was found statistically similar to T<sub>1</sub>-hybrid maize + soybean (2:4) –line sown. In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced maximum number of pods plant<sup>-1</sup>, however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart). In cowpea, T<sub>9</sub>-sole cowpea (30 cm apart) produced maximum number of

pods plant<sup>-1</sup>, however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted).

- In maize, T<sub>7</sub>-sole hybrid maize (60 cm apart) gave significantly maximum number of grains plant<sup>-1</sup>, however, it was found statistically similar to T<sub>1</sub>-hybrid maize + soybean (2:4) –line sown. In soybean, T<sub>10</sub>-sole soybean (broadcasted) produced maximum number of seeds plant<sup>-1</sup>, however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart). In cowpea, T<sub>9</sub>-sole cowpea (30 cm apart) produce maximum number of seeds plant<sup>-1</sup>.
- In maize, maximum grain yield was obtained under T<sub>7</sub>-sole hybrid maize (60 cm apart), however, it was found statistically similar to T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize), T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize), T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize) and T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). In soybean, maximum grain yield was obtained under T<sub>8</sub>-sole soybean (30 cm apart) however, it was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted). In cowpea, maximum grain yield was obtained under T<sub>9</sub>-sole cowpea (30 cm apart), however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted).
- In maize, maximum stover yield was obtained under treatment T<sub>7</sub>-sole hybrid maize (60 cm apart), however, it was found statistically similar to T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize), T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize), T<sub>5</sub>-hybrid maize + cowpea (broadcasting of cowpea after alternate row of hybrid maize) and T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize). In soybean, maximum stover yield was obtained under T<sub>8</sub>-sole soybean (30 cm apart) however, it was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted). In cowpea, maximum stover yield was obtained under T<sub>9</sub>-sole cowpea (30 cm apart), however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted).

- The highest land equivalent ratio was obtained under T<sub>6</sub>-Hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) than others.
- The highest area time equivalent ratio was obtained under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) than others.
- The significantly highest system yield was recorded under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) than others, however, it was found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).
- The maximum production efficiency was obtained under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), although these treatment was significantly superior over others.
- The harvest index of maize was not affected due to different crop configuration of hybrid maize based intercropping system. In soybean, maximum harvest index obtained under treatment T<sub>8</sub>-sole soybean (30 cm apart), however, it was found statistically similar to T<sub>10</sub>-sole soybean (broadcasted). In cowpea, maximum harvest index obtained under treatment T<sub>9</sub>-sole cowpea (30 cm apart), however, it was found statistically similar to T<sub>11</sub>-sole cowpea (broadcasted).
- Among all crop configurations, significantly maximum N content in the soil was recorded under T<sub>8</sub>-sole soybean (30 cm apart), however, it was found statistically similar to T<sub>10</sub>- sole soybean (broadcasted). Maximum P content in the soil was recorded under T<sub>10</sub>-sole soybean (broadcasted), however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart) and T<sub>11</sub>-sole cowpea (broadcasted). Maximum K content in the soil was recorded under T<sub>10</sub>-sole soybean (broadcasted), however, it was found statistically similar to T<sub>8</sub>-sole soybean (30 cm apart), T<sub>11</sub>-sole cowpea (broadcasted) and T<sub>9</sub>-sole cowpea (30 cm apart).
- Maximum gross return was obtained under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize),

however, it was found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize). Maximum net return was obtained under treatment T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), however, it was found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) and T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize).

- Maximum B:C ratio was obtained under treatment T<sub>2</sub>-hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize, however, it was found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).
- Energy output:input ratio and energy use efficiency were maximum under, T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize), however, it was found statistically similar to T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) and T<sub>2</sub>-Hybrid maize + soybean (broadcasting of soybean after alternate row of hybrid maize).

## CONCLUSION

The result reveals that the growth parameters (except plant height of soybean and cowpea) and yield attributing characters were recorded higher in sole crops so that the grain yield and stover yield was also higher in sole crop but maximum system yield was recorded under T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) which was *at par* with T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize).

Considering economics and energetics under different treatments, T<sub>6</sub>-hybrid maize + cowpea (broadcasting of cowpea in between row of hybrid maize) and T<sub>3</sub>-hybrid maize + soybean (broadcasting of soybean in between row of hybrid maize) found to be the superior to gave highest gross return, net return and energy output.

### **SUGGESTIONS FOR FUTURE RESEARCH WORK**

1. Some more crop configuration like 45 cm for maize sowing should be studied for more production.
2. Combination of pre and post-emergence herbicide should be studied for effective weed control throughout the crop season.
3. Nutrient uptake study by weeds under different crop configuration and weed control measures should be investigated.
4. Some organic and inorganic fertilizer combinations for maize should be studied for effective nutrient management.

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## Appendix-B: Fixed cost of cultivation for sole maize and maize + intercrops

SN.	Particular	Requirement	Price (Rs ha <sup>-1</sup> )	Total cost (Rs ha <sup>-1</sup> )
1.	Land preparation			
a.	Ploughing	1 Tractor (2 hrs) ha <sup>-1</sup>	500 Rs hrs <sup>-1</sup>	1000
b.	Harrowing	1 Tractor (2 hrs) ha <sup>-1</sup>	500 Rs hrs <sup>-1</sup>	1000
c.	Planking	1 Tractor (1 hrs) ha <sup>-1</sup>	500 Rs hrs <sup>-1</sup>	500
2.	Seed Treatment			
a.	Carbendazim	100 g ha <sup>-1</sup>	500 Rs kg <sup>-1</sup>	50
b.	Seed treatment and sowing	15 man days	200 Rs day <sup>-1</sup>	3000
4.	Fertilizer			
a.	N (Urea)	260 kg ha <sup>-1</sup>	7 Rs kg <sup>-1</sup>	1820
b.	P <sub>2</sub> O <sub>5</sub> (SSP)	375 kg ha <sup>-1</sup>	6.5 Rs kg <sup>-1</sup>	2437
c.	K <sub>2</sub> O(MOP)	67 kg ha <sup>-1</sup>	18 Rs kg <sup>-1</sup>	1206
d.	Fertilizer application	4 man days	200 Rs day <sup>-1</sup>	800
5.	Weeding			
	Hand weeding	20 man days	200 Rs day <sup>-1</sup>	4000
5.	Plant Protection			
a.	Cost of chemical	Quinolphos 1 litre ha <sup>-1</sup>	460 Rs litre <sup>-1</sup>	460
b.	Application cost	1 man days	150 Rs man days	200
6.	Harvesting(manual)	15 man days	200 Rs day <sup>-1</sup>	3000
7.	Threshing & winnowing	10 man days	200 Rs day <sup>-1</sup>	2000
A.	Common cost			21473.00
B.	Miscellaneous cost	10 % of common cost		2147.30
	Grand Total (A+B)			23620.30

Rs = Rupees, ha<sup>-1</sup> = Per hectare, hrs<sup>-1</sup> = Per hour, g = Gram, kg<sup>-1</sup> = Per kilogram,  
% = Per cent

Appendix-C: Fixed cost of cultivation for sole soybean and cowpea

SN.	Particular	Requirement	Price (Rs ha <sup>-1</sup> )	Total cost (Rs ha <sup>-1</sup> )
1.	Land preparation			
a.	Ploughing	1 Tractor (2 hrs) ha <sup>-1</sup>	500 Rs hrs <sup>-1</sup>	1000
b.	Harrowing	1 Tractor 2 hrs ha <sup>-1</sup>	500 Rs hrs <sup>-1</sup>	1000
c.	Planking	1 Tractor (1 hrs) ha <sup>-1</sup>	500 Rs hrs <sup>-1</sup>	500
2.	Seed Treatment			
a.	Carbendazim	100 g ha <sup>-1</sup>	500 kg <sup>-1</sup>	50
3.	Sowing operation	15 man days	200 Rs day <sup>-1</sup>	3000
4.	Fertilizer			
a.	N (Urea)	54 kg ha <sup>-1</sup>	7 Rs kg <sup>-1</sup>	378
b.	P <sub>2</sub> O <sub>5</sub> (SSP)	375 kg ha <sup>-1</sup>	6.5 Rs kg <sup>-1</sup>	2437
c.	K <sub>2</sub> O(MOP)	50 kg ha <sup>-1</sup>	18 Rs kg <sup>-1</sup>	900
d.	Fertilizer application	4 man days	200 Rs day <sup>-1</sup>	800
5.	Weeding			
	Hand weeding	26 man days	200 Rs day <sup>-1</sup>	5200
5.	Plant Protection			
a.	Cost of chemical	Quinolphos 1 l ha <sup>-1</sup>	460 Rs l <sup>-1</sup>	460
b.	Application cost	1 man days	200 Rs man days	200
6.	Harvesting(manual)	15 man days	200 Rs day <sup>-1</sup>	3000
7.	Threshing &winnowing	10 man days	200 Rs day <sup>-1</sup>	2000
A.	Common cost			20925.00
B.	Miscellaneous cost	10 % of common cost		2092.50
Grand Total ( A+B)				23,017.50

Rs = Rupees, ha<sup>-1</sup> = Per hectare, hrs<sup>-1</sup> = Per hour, g = Gram, kg<sup>-1</sup> = Per kilogram, % = Per cent, l = Litre

Appendix- D: Variable cost of maize and intercrops cultivation

Treatment	Seeds	Requirements (kg ha <sup>-1</sup> )	Cost (Rs kg <sup>-1</sup> )	Total Cost (Rs ha <sup>-1</sup> )
T <sub>1</sub>	Maize	15	120	3144
	Soybean	42	32	
T <sub>2</sub>	Maize	25	120	4120
	Soybean	35	32	
T <sub>3</sub>	Maize	25	120	5240
	Soybean	70	32	
T <sub>4</sub>	Maize	17	120	6960
	Cowpea	18	260	
T <sub>5</sub>	Maize	25	120	7300
	Cowpea	15	260	
T <sub>6</sub>	Maize	25	120	11050
	Cowpea	30	260	
T <sub>7</sub>	Maize	25	120	3000
T <sub>8</sub>	Soybean	70	32	2240
T <sub>9</sub>	Cowpea	30	260	7800
T <sub>10</sub>	Soybean	70	32	2240
T <sub>11</sub>	Cowpea	30	260	7800

Appendix-E: Total cost of cultivation as per treatment combination (Rs ha<sup>-1</sup>)

Treatment	Fixed Cost (X)	Variable Cost (Y)	Total Cost (X+Y)
T <sub>1</sub>	23620	3144	26764
T <sub>2</sub>	23620	4120	27740
T <sub>3</sub>	23620	5240	28860
T <sub>4</sub>	23620	6960	30580
T <sub>5</sub>	23620	7300	30920
T <sub>6</sub>	23620	11050	34670
T <sub>7</sub>	23620	3000	26620
T <sub>8</sub>	23017	2240	25257
T <sub>9</sub>	23017	7800	30817
T <sub>10</sub>	23017	2240	25257
T <sub>11</sub>	23017	7800	30817

Appendix-F: Energy input through different sources (fixed), MJ ha<sup>-1</sup> for sole maize and maize + intercrops

SN.	Particular	Requirement	Rate of energy input, (MJ)	Total energy (MJ ha <sup>-1</sup> )
1.	Land preparation			
a.	Ploughing	1 Tractor (2 hrs) ha <sup>-1</sup>	Rs 56.31 l <sup>-1</sup>	563.1
b.	Harrowing	1 Tractor (2 hrs) ha <sup>-1</sup>	Rs 56.31 l <sup>-1</sup>	563.1
c.	Planking	1 Tractor (1 hrs) ha <sup>-1</sup>	Rs 56.31 l <sup>-1</sup>	281.5
2.	Seed Treatment			
a.	Carbendazim	0.24 kg ha <sup>-1</sup>	10 kg ha <sup>-1</sup>	2.4
b.	Sowing and application cost	15 man days	1.96 hr <sup>-1</sup>	235.2
3.	Fertilizer			
a.	N	150 kg ha <sup>-1</sup>	60.0 kg <sup>-1</sup>	9000
b.	P <sub>2</sub> O <sub>5</sub>	75 kg ha <sup>-1</sup>	11.3 kg <sup>-1</sup>	847.5
c.	K <sub>2</sub> O	40 kg ha <sup>-1</sup>	6.7 kg <sup>-1</sup>	268
d.	Fertilizer application	4 man days	1.96 hr <sup>-1</sup>	62.7
4.	Weeding			
	Hand weeding	20 man days	1.96 hr <sup>-1</sup>	313.6
5.	Plant protection			
	Cost of chemical (Quinolphos)	1 l ha <sup>-1</sup>	120 l <sup>-1</sup>	120
	Application cost	1 man day	1.96 hr <sup>-1</sup>	15.7
6.	Harvesting(manual)	15 man days	1.96 hr <sup>-1</sup>	235.2
7.	Threshing & winnowing	12 man days	1.96 hr <sup>-1</sup>	188.2
	Total			12696.2

Rs = Rupees, ha<sup>-1</sup> = Per hectare, hrs<sup>-1</sup> = Per hour, g = Gram, kg<sup>-1</sup> = Per kilogram, % = Per cent, l = Litre

Appendix-G: Energy input through different sources (fixed), MJ ha<sup>-1</sup> sole soybean and cowpea

SN.	Particular	Requirement	Rate of energy input, (MJ)	Total energy (MJ ha <sup>-1</sup> )
1.	Land preparation			
a.	Ploughing	1 Tractor (2 hrs) ha <sup>-1</sup>	Rs 56.31 l <sup>-1</sup>	563.1
b.	Harrowing	1 Tractor 2 hrs ha <sup>-1</sup>	Rs 56.31 l <sup>-1</sup>	563.1
c.	Planking	1 Tractor (1 hrs) ha <sup>-1</sup>	Rs 56.31 l <sup>-1</sup>	281.5
2.	Seed Treatment			
a.	Carbendazim	0.24 kg ha <sup>-1</sup>	10 kg ha <sup>-1</sup>	2.4
b.	Sowing and application cost	15 man days	1.96 hr <sup>-1</sup>	235.2
3.	Fertilizer			
a.	N	25 kg ha <sup>-1</sup>	60.0 kg <sup>-1</sup>	1560
b.	P <sub>2</sub> O <sub>5</sub>	60 kg ha <sup>-1</sup>	11.3 kg <sup>-1</sup>	678
c.	K <sub>2</sub> O	30 kg ha <sup>-1</sup>	6.7 kg <sup>-1</sup>	201
d.	Fertilizer application	4 man days	1.96 hr <sup>-1</sup>	62.7
4.	Weeding			
	Hand weeding	26 man days	1.96 hr <sup>-1</sup>	407.7
5.	Plant protection			
	Cost of chemical (Quinolphos)	1 l ha <sup>-1</sup>	120 l <sup>-1</sup>	120
	Application cost	1 man day	1.96 hr <sup>-1</sup>	15.7
5.	Harvesting(manual)	15 man days	1.96 hr <sup>-1</sup>	235.2
6.	Threshing &winnowing	10 man days	1.96 hr <sup>-1</sup>	156.8
	Total			5356.9

Rs = Rupees, ha<sup>-1</sup> = Per hectare, hrs<sup>-1</sup> = Per hour, g = Gram, kg<sup>-1</sup> = Per kilogram, % = Per cent, l = litre

Appendix- H: Energy input through seeds of maize and intercrops (variable),  
MJ ha<sup>-1</sup>

Treatment	Seeds	Requirements (kg ha <sup>-1</sup> )	Rate of energy input, (MJ)	Total energy, (MJ ha <sup>-1</sup> )
T <sub>1</sub>	Maize	15	14.7	837.9
	Soybean	42	14.7	
T <sub>2</sub>	Maize	25	14.7	882.0
	Soybean	35	14.7	
T <sub>3</sub>	Maize	25	14.7	1396.5
	Soybean	70	14.7	
T <sub>4</sub>	Maize	17	14.7	521.9
	Cowpea	18	14.7	
T <sub>5</sub>	Maize	25	14.7	588.0
	Cowpea	15	14.7	
T <sub>6</sub>	Maize	25	14.7	808.5
	Cowpea	30	14.7	
T <sub>7</sub>	Maize	25	14.7	367.5
T <sub>8</sub>	Soybean	70	14.7	1029.0
T <sub>9</sub>	Cowpea	30	14.7	441.0
T <sub>10</sub>	Soybean	70	14.7	1029.0
T <sub>11</sub>	Cowpea	30	14.7	441.0

Appendix-I: Total energy input of treatment combination through different source (MJ ha<sup>-1</sup>)

Treatment	Energy input (MJ ha <sup>-1</sup> )		
	Fixed input (X)	Variable input (Y)	Total input (X+Y)
T <sub>1</sub>	12696	838	13534
T <sub>2</sub>	12696	882	13578
T <sub>3</sub>	12696	1397	14093
T <sub>4</sub>	12696	522	13218
T <sub>5</sub>	12696	588	13284
T <sub>6</sub>	12696	809	13505
T <sub>7</sub>	12696	367	13064
T <sub>8</sub>	5357	1029	6386
T <sub>9</sub>	5357	441	5798
T <sub>10</sub>	5357	1029	6386
T <sub>11</sub>	5357	441	5798

Appendix-J: Standard value for energy relationship during the course of investigation

S.No.	Input/Output form	Units	Energy coefficient, (MJ)
1.	Labour	Man hour <sup>-1</sup>	1.96
2.	Diesel	Litre <sup>-1</sup>	56.31
3.	Chemical fertilizer		
	N	kg <sup>-1</sup>	60
	P <sub>2</sub> O <sub>5</sub>	kg <sup>-1</sup>	11.1
	K <sub>2</sub> O	kg <sup>-1</sup>	6.7
4.	Superior Chemicals		
	Carbendazim	kg <sup>-1</sup>	10
	Quinalphos	Litre <sup>-1</sup>	120
5.	Seed	kg <sup>-1</sup>	14.7
6.	Stover	kg <sup>-1</sup>	12.5

## Appendix-K: The details of the cultural operations adopted in the experimental field

S. No.	Cultural operation	Implement / method used	Date
1.	Ploughing and harrowing	Tractor drawn cultivator and disc harrow	12-06-2016
2.	Planking	Tractor drawn planking	15-06-2016
3.	Layout preparation	Manually	25-06-2016
4.	Soil sampling	Soil auger	25-06-2016
5.	Seed treatment, fertilizer application and sowing	Manually	26-06-2016
6.	Gap filling	Manually	14-07-2016
7.	Hand weeding	Manually	22-07-2016
8.	Application of second dose of urea in maize	Manually	20-07-2016
9.	Application of third dose of urea in maize	Manually	12-08-2016
10.	Insecticide application	Knapsack sprayer	19-08-2016
11.	Harvesting of maize	Manually	21-09-2016
12.	Harvesting of cowpea	Manually	29-09-2016
13.	Harvesting of soybean	Manually	14-10-2016
14.	Threshing and winnowing	Manually	20-10-2016

Appendix-L: Analysis of variance (ANOVA) table of system yield

Source of variation	DF	SS	MSS	Fcal	Ftab (5%)	Result
Replication (r)	2	603	301	0.003	3.49	NS
Treatment (t)	10	87312152	8731215	79.5	2.35	S
Error (E)	20	2196562	109828			
Total	32	89509317				

$SE_{m\pm} = 191.33$

$SE_d = 270.58$

$CV (\%) = 6.23$

$CD = 564.44$

**RESUME**

Name : Mukesh Kumar Sahu  
 Date of birth : 02-01-1990  
 Present Address : Sundaram Boys Hostel, College of  
 Agriculture, Raipur (C. G.)  
 Phones : 7879955023  
 Fax :  
 E. mail : mukeshsahu791@gmail.com  
 Permanent address : Vikas Nagar Gudhiyari  
 Raipur (C.G.)

**Academic Qualification:**

Degree	Year	University/Institute
10 <sup>th</sup>	2006	CGBSE, Raipur
12 <sup>th</sup>	2008	CGBSE, Raipur
B.Sc. (Ag)	2014	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

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**Dr. S.S. Kolhe**

Professor, Agronomy & Editor In Chief

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Date : 25/06/2016

Dear

Mukesh Kumar Sahu  
Department of Agronomy  
CoA, IGKV, Raipur

Your research article entitled “Effect of different configuration of intercropping system of hybrid maize+soybean/ cowpea on growth of hybrid maize, soybean and cowpea” authored by Mukesh Kumar Sahu, S.N. Khajanji, G.K. Shrivastava and RajendraLakpale has been received for publication in the Journal of Agricultural Issues (JAI) and has allotted the reference No. MS JAI 799 Dated 25.06.2016.

In all future correspondence, please quote the reference number of your research article

Thanks for the interest shown in the research article publication in the JAI.

*SS Kolhe*  
25/6/16  
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