

**EVALUATION OF BIO-EFFICACY OF MACARENA (BIO-STIMULANT) ALONG WITH HERBICIDES ON SOYBEAN [*Glycine max* (L.) Merrill]**

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

**by**

**Harendra Kumar**

**DEPARTMENT OF AGRONOMY  
COLLEGE OF AGRICULTURE  
FACULTY OF AGRICULTURE  
INDIRA GANDHI KRISHI VISHWAVIDYALAYA  
RAIPUR (C.G.)  
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**EVALUATION OF BIO-EFFICACY OF MACARENA (BIO-STIMULANT) ALONG WITH HERBICIDES ON SOYBEAN [*Glycine max* (L.) Merrill]**

**Thesis**

**Submitted to the**

**Indira Gandhi Krishi Vishwavidyalaya, Raipur**

**by**

**Harendra Kumar**

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF**

**Master of Science  
In Agriculture  
(Agronomy)**

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**September, 2020**

## CERTIFICATE – I

This is to certify that the thesis entitled “**Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on soybean [*Glycine max* (L.) Merrill]**” 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 **Harendra Kumar** under our guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.

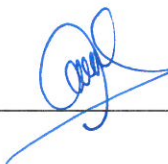
No part of the thesis has been submitted for any other degree or diploma or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by her.

  
Chairman

Date: 8/7/2020

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**CERTIFICATE – II**

This is to certify that the thesis entitled “**Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on soybean [*Glycine max* (L.) Merrill]**” submitted by **Harendra Kumar** to Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) 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, under the chairmanship of head of the Department.

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(Name :.....)

**Date:** 21/9/2020

**Major Advisor**

  
\_\_\_\_\_

**Faculty Dean**

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**Approved/Not approved**

**Director of the Instructions**

\_\_\_\_\_

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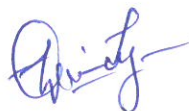
*I am highly obliged to **Dr. M. Pandey** (Librarian, Nehru Library, Raipur) for his support during my study and I express my sincere thanks to **Chandra Sekhar Chandra**,**Sandip**, **Sidharthpatre** , **Chandrakala**, **Dhanraj**, **Yamuna**, **Kajal** for their kind help without any hesitation as and when required during my research work period.*

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Dept. of Agronomy, I.G.K.V.,  
Raipur (C.G)*

*Date:*

*Place:*

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## LIST OF ABBREVIATIONS

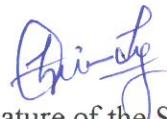
Abbreviations	Description	Abbreviations	Description
<b>AGR</b>	Absolute Growth Rate	<b>mM</b>	Milimolar
<i>et al.</i>	And others/ co-workers	<b>min.</b>	Minimum
@	At the rate of	<b>M</b>	Molarity
<b>B:C</b>	Benefit Cost Ratio	<b>NAA</b>	$\alpha$ -Naphthyl Acetic Acid
<b>°C</b>	Degree Celcius	<b>NAR</b>	Net Assimilation Rate
<b>cm</b>	Centimeter	<b>N</b>	Nitrogen
<b>CD</b>	Critical difference	<b>NS</b>	Non-significant
<b>CGR</b>	Crop growth rate	<b>No</b>	Number
<b>d</b>	Day	<b>ppm</b>	Parts Per Millions
<b>DAS</b>	Days after sowing	<b>%</b>	Percentage
<b>EC</b>	Emulsifiable concentrate	<b>P<sub>2</sub>O<sub>5</sub></b>	Phosphorus pentaoxide
<b>Fig.</b>	Figure	<b>PGR</b>	Plant growth regulators
<b>GA<sub>3</sub></b>	Gibberellic Acid	<b>K<sub>2</sub>O</b>	Potassium oxide
<b>G</b>	Gram	<b>q</b>	Quintal
<b>HI</b>	Harvest index	<b>RGR</b>	Relative growth rate
<b>ha</b>	Hectare	<b>RH</b>	Relative humidity
<b>Hrs</b>	Hours	<b>r</b>	Replication
<b>IAA</b>	Indole Acetic Acid	<b>SA</b>	Salicylic Acid
<b>kg</b>	Kilogram	<b>S.No.</b>	Serial number
<b>kmph</b>	Kilometre per hour	<b>S</b>	Significant
<b>LAI</b>	Leaf Area Index	<b>SL</b>	Soluble liquid
<b>L.</b>	Linneaus	<b>SP</b>	Soluble Powder
<b>L</b>	Litre	<b>SC</b>	Suspension concentrates
<b>max.</b>	Maximun	<b>i.e.</b>	That is
<b>m</b>	Meter	<b>t</b>	Ton
<b>mg</b>	Milligram	<b>T</b>	Treatment
<b>ml</b>	Milliliter	<b>var.</b>	Variety
<b>mm</b>	Millimeter	<b>w/w</b>	Weight by weight

## THESIS ABSTRACT

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- a) Title of the Thesis: **“Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on soybean [*Glycine max* (L.) Merrill]”**
- b) Full Name of the Student: Harendra Kumar
- c) Major Subject: Agronomy
- d) Name and Address of the : Dr. Rama Mohan Savu  
Major Advisor Department of Agronomy  
College of Agriculture, IGKV, Raipur (C.G.)
- e) Degree to be Awarded: Master of Science in Agriculture (Agronomy)

  
Signature of Major Advisor

  
Signature of the Student

Signature of Head of the Department

Date: \_\_\_\_\_

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### ABSTRACT

The present experiment entitled **“Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on soybean [*Glycine max* (L.) Merrill]”** was carried out during *kharif* season of 2019 at Instructional cum Research Farm of IGKV, Raipur CG. The soil of the experimental field was ‘*Vertisols*’ locally known as ‘*Kanhar*’ with sandy clay loam in texture and pH 7.10. It was low in available nitrogen (220 kg ha<sup>-1</sup>), medium in available phosphorus (12.54 kg ha<sup>-1</sup>), and high in potassium (288 kg ha<sup>-1</sup>). The climate of this region is sub-humid. The experiment was laid out in Randomized block design (RBD) with 7 treatments and 3 replications. The treatments comprised of seven weed management practices viz, Sodium Acifluorfen (16.5%) + Clodinafoppropargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>), Imazethapyr 10 SL @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>2</sub>), Fluazifop-p-butyl 13.4 EC @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>3</sub>), Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), MACARENA @ 625 ml/ha (T<sub>5</sub>), Two hand weeding at 20 and 40 DAS (T<sub>6</sub>) and

Weedy check (T<sub>7</sub>). The crop was sown manually on 02 July 2019 after the onset of monsoon and harvested on 22 October 2019. Soybean variety JS 97-52 (Jawahar Soybean 97-52) was grown as a test crop with the row and plant spacing 30 × 10 cm and seed rate of 75 kg ha<sup>-1</sup>. Recommended dose of nutrients was 20:60:40 kg ha<sup>-1</sup> N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O applied through Urea, Single Super Phosphate and Muriate of potash.

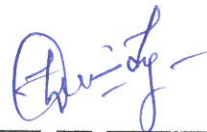
The result of present experiment conclude that growth attributes *viz*, plant height, number of branch, dry matter accumulation, crop growth rate, relative growth rate as well as yield attributes *viz*, number of podplant<sup>-1</sup>, number of seed pod<sup>-1</sup>, Seed index (100 seed), Seed yield, Stover yield, harvest index were found maximum under Sodium Acifluarfan (16.5%) + Clodinafoppropargyl (8% EC) @ 1000 MI/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) which was at par with Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>) in case of plant height, dry matter accumulation, leaf area index, crop growth rate, relative growth rate, number of seed pod<sup>-1</sup>, Seed yield, Stover yield while in case of number of branch, number of pod plant<sup>-1</sup>, Seed index (100 seed) it was at par with Imazethapyr 10 SL@ 1000 ml/+ MACARENA @ 625 ml/ha (T<sub>2</sub>), Fluazifop-p-butyl 13.4 EC @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>3</sub>), Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), MACARENA @ 625 ml/ha (T<sub>5</sub>), and two hand weeding at 20 and 40 DAS (T<sub>6</sub>). Minimum values of above characters were observed in Weedy check (T<sub>7</sub>).

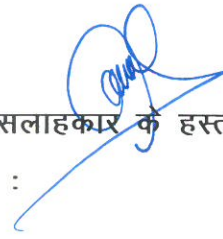
In the experimental field, *Echinochloa colonum*, *Cyperus rotundus*, *Parthenium hysterophorus* L., *Digera arvensis*, *Celosia argentea*, and *Alternanthera spp.* and some other weeds were dominant and observed throughout the crop growth period. Under two hand weeding at 20 and 40 DAS (T<sub>6</sub>) followed by Sodium Acifluarfan (16.5%) + Clodinafoppropargyl (8% EC) @ 1000 MI/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) recorded minimum weed density, weed dry matter production and weed index whereas maximum was observed in weedy check (T<sub>7</sub>). Weed control efficiency was found highest in two hand weeding at 20 and 40 DAS (T<sub>6</sub>) and lowest in weedy check (T<sub>7</sub>).

In terms of economics, maximum gross return (₹88195 ha<sup>-1</sup>), net return (₹71410) with B: C ratio (5.2) were detected under Sodium Acifluarfan (16.5%) + Clodinafoppropargyl (8% EC) @ 1000 MI/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) which was followed by Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>) and two hand weeding at 20 and 40 DAS (T<sub>6</sub>). Minimum gross return weedy check (T<sub>7</sub>).

## शोध सारांश

- अ) शोध शीर्षक - "सोयाबीन [ग्लाइसिन मैक्स (L.) मेरिल] पर मेकारेना (जैव-उत्तेजक) के साथ शाकनाशी के जैव-प्रभाव का मूल्यांकन"
- ब) छात्र का नाम - हरेन्द्र कुमार
- स) मुख्य विषय - शस्य विज्ञान विभाग
- द) मुख्य सलाहकार का नाम और पता - डॉ. रामा मोहन सावु  
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छात्र का हस्ताक्षर

  
प्रमुख सलाहकार के हस्ताक्षर  
दिनांक :

विभागाध्यक्ष के हस्ताक्षर

## सारांश

वर्तमान प्रयोग "सोयाबीन [ग्लाइसिन मैक्स (L.) मेरिल] पर मेकारेना (जैव-उत्तेजक) के साथ शाकनाशी के जैव-प्रभाव का मूल्यांकन" का आयोजन इं.गां.कृ.वि.वि., रायपुर (छ.ग.) के अनुदेशात्मक सहअनुसंधान फार्म में 2019 के खरीफ के दौरान किया गया था। प्रायोगिक क्षेत्र की मिट्टी 'वर्टिसोल' स्थानीय रूप से 'कन्हार' के रूप में जानी जाती है, जिसकी बनावट और पीएच 7.10 में रेतीले मिट्टी वाले दोमट होती है। यह उपलब्ध नत्रजन में कम था (220 किलोग्राम हे<sup>-1</sup>), उपलब्ध मध्यमस्फुर (12.54 किलोग्राम हे<sup>-1</sup>), और उच्चपोटाश (288 किलोग्राम हे<sup>-1</sup>)। इस क्षेत्र की जलवायु उप-आर्द्र है। प्रयोगको 7 उपचार और 3 प्रतिकृति के साथ रैंडोमाइज्ड ब्लॉक डिज़ाइन में रखा गया था। उपचार में सात खरपतवार प्रबंधन शामिल हैं, सोडियमएसिफ्लुअर्फ़न (16.5%) + क्लोडिनाफोप्रोपार्गील (8% ई.सी.) @ 1000 एमआईप्रतिहे + मेकारेना @ 625 मिली प्रति हेक्टेयर (T<sub>1</sub>), इमेजाथापाइर10 एसएल @ 1000 मिली प्रतिहेक्टेयर + मेकारेना @ 625 मिली प्रति हेक्टेयर (T<sub>2</sub>), फ्लुज़ाफ़ॉप-पी-ब्यूटाइल 13.4 ई.सी. @ 2000 मिली प्रति हेक्टेयर + मेकारेना @ 625 मिली प्रतिहेक्टेयर (T<sub>3</sub>), प्रोपेक्ज़िफ़ॉप 2.5% ई.सी. + इमेजाथापाइर 3.7% एमई @ 2000 मिली प्रति हेक्टेयर + मेकारेना @ 625 मिली प्रति हेक्टेयर (T<sub>4</sub>), मेकारेना @ 625 मिली प्रति हेक्टेयर (T<sub>5</sub>), दो हाथ से निराई 20 और 40 दिन (T<sub>6</sub>) और वीडो चेक (T<sub>7</sub>)। मानसून की शुरुआत के बाद और 22 अक्टूबर 2019 को कटाई के बाद फसल को मैन्युअल रूप

थी। और बीज की दर 75 किग्रा। पोषक तत्वों की अनुशंसित खुराक 20:60:40 किलो ग्राम प्रति हेक्टेयर कम नत्रजन, मध्यम स्फुर और उच्च पोटाश माध्यम से लागू किया गया था।

वर्तमान प्रयोग के परिणाम से यह निष्कर्ष निकलता है कि विकास गुण, अर्थात् पौधे की ऊँचाई, शाखा की संख्या, शुष्क पदार्थ का संचय, फसल की वृद्धि दर, सापेक्षिक वृद्धि दर के साथ-साथ उपज के गुण, फली की संख्या<sup>-1</sup>, बीज की संख्या फली<sup>-1</sup>, बीज की संख्या सूचकांक (100बीज), बीज की उपज, स्टोवर की उपज, फसल का सूचकांक अधिकतम सोडियमएसिफ्लुअर्फन (16.5%) + क्लोडिनाफॉप्रोपार्गल (8% ईसी) @ 1000 एम. आई. प्रति हेक्टेयर + मेकारेना (625 मिली लीटर प्रति हेक्टेयर (T<sub>1</sub>)) के तहत अधिकतम पाया गया जो बराबर था। पौधे की ऊँचाई के मामले में, प्रोपेक्विजाफॉप 2.5% ई.सी. + इमेजाथापाइर 3.7% एम ई @ 2000 मली प्रति हेक्टेयर + मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>4</sub>) के साथ, शुष्क पदार्थ का संचय, पत्ती क्षेत्र सूचकांक, फसल विकास दर, सापेक्षिक विकास दर, बीजफली-1 की संख्या, बीज की उपज, स्टोवर की उपज जब क शाखा की संख्या के मामले में, फली संयंत्र<sup>-1</sup> की संख्या, बीज सूचकांक (100 बीज) यह इमेजाथापाइर 10 SL @ 1000 मली प्रति हेक्टेयर + मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>2</sub>), फ्लुजाफॉप-पी-ब्यूटाइल 13.4 ई.सी. @ 2000 मली प्रति हेक्टेयर + मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>3</sub>), प्रोपेक्विजाफॉप 2.5% ई.सी. के बराबर था। + इमेजाथापाइर 3.7% एम ई @ 2000 मली प्रति हेक्टेयर + मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>4</sub>), मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>5</sub>), और दो हाथ से निराई 20 और 40 दिन (T<sub>6</sub>) पर। उपरोक्त पात्रों के न्यूनतम मूल्यों को वीडि चेक (T<sub>7</sub>) में देखा गया था।

प्रायोगिक क्षेत्र में, इकाइनो क्लोनम, साइप्रस रोटंडस, पार्थेनियम हिस्टेरोफोरस एल।, डाइया अरवें संस, सेलो शया अरेंजिया और अल्टरनेथेरा स्पीसीस। और कुछ अन्य खरपतवार प्रमुख थे और पूरे फसल विकास काल में देखे गए। 20 और 40 डीएस (T<sub>6</sub>) पर दो हाथ से निराई के तहत सो डियमएसिफ्लुअर्फन (16.5%) + क्लो डनाफोप्रोपार्गी (8% ईसी) @ 1000 एम.आई. प्रति हेक्टेयर + मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>1</sub>) न्यूनतम खरपतवार घनत्व, खरपतवार शुष्क पदार्थ दर्ज किया गया। उत्पादन और खरपतवार सूचकांक जब क अधिकतम वीडि चेक (T<sub>7</sub>) में देखा गया था। खरपतवार नियंत्रण दक्षता 20 वें और 40 दिन (T<sub>6</sub>) में दो गुना निराई में सबसे ज्यादा पाई गई और सब से कम वजन की जाँच (T<sub>7</sub>) में हुई।

अर्थशास्त्र के संदर्भ में, लाभ: लागत अनुपात (5.2) के साथ अधिकतम सकल आय (88195 हे<sup>1</sup>), शुद्ध वापसी (71410) सो डियमएसिफ्लुअर्फन (16.5%) + क्लो डनाफोप्रोपार्गी (8% ईसी) @ 1000 एम.आई. प्रति हेक्टेयर के तहत पाया गया। हेक्टेयर + मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>1</sub>) जिसके बाद प्रोपेक्विजाफॉप 2.5% ई.सी. + इमेजाथापाइर 3.7% एम ई @ 2000 मली प्रति हेक्टेयर + मेकारेना @ 625 मली प्रति हेक्टेयर (T<sub>4</sub>) और 20 और 40 दिन (T<sub>6</sub>) पर दो हाथ की निराई की गई। सबसे कम शुद्ध लाभ, लाभ लागत अनुपात अनियंत्रित जांच में पाया गया। (T<sub>7</sub>)

## CHAPTER-I INTRODUCTION

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Soybean [*Glycine max* (L.) Merrill] is one of the most important oilseed crop in the world and it is also known as wonder crop of the 20<sup>th</sup> century. It is a cheapest source of vegetable oil and protein. It contains about 40 percent protein, well balanced in essential amino acids, 18-20 per cent oil rich with poly unsaturated fatty acids specially Omega 6 and Omega 3 fatty acids, 6-7 percent total mineral, 5-6 percent crude fiber and 17-19 percent carbohydrates. The protein quality of soybean is equivalent to that of meat, milk products and eggs and at the same time rich in iron and vitamin C. Hence, it is well established fact that soybean is a cheap source of protein and edible oil. Soybean builds up the soil fertility by fixing atmospheric nitrogen through the root nodules, and also through leaf fall on the ground on maturity. It is able to leave residual nitrogen effect for succeeding crop equivalent to 35-40 kg N ha<sup>-1</sup>. Soybean can tolerate mild drought as well as floods. This characteristic has made soybean to fit well in sustainable agriculture. Soybean due to its various uses is rightly called “**Golden Gift**” of nature to mankind.

Globally soybean is cultivated over an area of 118.3 million hectares with a production of 318.25 million metric tonnes and having a productivity of 2.69 metric tones ha<sup>-1</sup> (Anonymous, 2015). In India, during 2000, soybean occupied an area of 6.22 million hectares which is now increased to 12.2 million hectares in 2013-14, while the production was 7.08 million tonnes in 2000 and now it has been recorded to 11.95 million tonnes and the mean national productivity of the crop has decreased from 1138 kg ha<sup>-1</sup> in 2000 to 979 kg ha<sup>-1</sup> in 2013-14. In Chhattisgarh, during 2015-16, soybean occupies an area of 137.53 thousand hectares with productivity of 995 kg ha<sup>-1</sup> (Anonymous, 2017). In Chhattisgarh, major soybean growing districts are Rajnandgaon, Durg, Mungeli, Bemetara and Kabirdham.

Soybean is mainly grown during *kharif* season in sandy loam to clay loam soils in Chhattisgarh. In these soils, by virtue of their water holding capacity, do not turn up in working condition, hindering timely weeding and interculture

operation. Weed flush come at same time in almost all the *kharif* crops, which also restrict the availability of manpower for weeding operation in this crop. The untimely and poor weed management adversely affects proper growth and yield of soybean. The critical period of crop weed competition in soybean is reported to be first 45 DAS (Panneerselvam and Lourduraj, 2000). There are several constraints in the soybean one of the them is weeds which often pose serious problem. Weed can compete with crop plants for moisture, nutrients, light and space. In addition, they also serve as an alternate host for several insect pests and disease. Weed infestation during early stages in soybean is one of the major factors for loss in yield. The yield loss due to weed infestation in soybean was to the tune of 20-77 per cent (Kurchania *et al.*, 2001).

At Raipur (C.G) most prominent weeds observed in soybean are *Echinochloa*, *Cyperus rotundus*, *Euphorbia spp.*, *Commelina benghalensis*, *Phyllanthus niruri*, (Kolhe *et al.*, 1998). In soybean the weed flora as observed from the unweeded control plots consist of 58 per cent sedges, 32 per cent broad-leaved weeds and 10 per cent grasses. Among the sedges, *Cyperus rotundus*, the broad-leaved weeds like *Trianthema portulacastrum*, *Digera arvensis*, *Amaranthus viridis* and *Phyllanthus niruri* and the grasses like *Acrachne racemosa*, *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Eragrostis pilosa* and *Commelina benghalensis* were mostly found in soybean (Kumar and Das, 2008).

Wide spectrum new herbicides are required to control the majority of weed flora in soybean crop. Mostly the farmers are using pre-plant incorporated and pre-emergence herbicides for weed control in soybean, but their efficacy are reduced by various climatic and edaphic factors. Hand weeding is a traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour at peak time are main limitations of manual weeding. The only alternative that needs to be explored is the use of post-emergence herbicides. The screening of such herbicides in soybean reveals their efficiency against either monocotyledonous or dicotyledonous weeds. Hence, their mixtures may broaden the window of weed management by broad-spectrum weed control (Bineet *et al.*, 2001).

Now a days a few herbicides like imazethapyr, quizalofop and fenoxaprop are available, which can be used safely in soybean (Sharma *et al.*, 2009). Recent investigations have revealed that Imidazolinones group of herbicide is very effective in controlling the weeds in soybean (e.g. Imazethapyr). These herbicides are active against broad leaf and grassy weeds, but their effects are variable at different places depending on the soil type, intensity and type of weed flora, rainfall etc (Yadav *et al.*, 2009).

Alleviating weed competition through weed management practices especially involving new herbicides have been found to be effective in enhancing crop yield of soybean. The use of selective herbicide in soybean seems to be effective and economical. Although several post and pre-emergence herbicides have been used by the farmers of the state to maximize the crop-weed competition, but there is always scope to work on newer herbicides for effective, timely and economical control of weeds for efficient utilization of applied inputs. Therefore, it is of paramount importance to evaluate new herbicides for controlling weeds in agro-ecological situation of Chhattisgarh plains.

The traditional method of weed control *i.e.* hand weeding is expensive, tedious and time consuming (Yadav *et al.*, 2009). Moreover, hand-weeding and mechanical weeding are difficult due to continuous rainfall and less availability of labourers at the critical stage of crop-weed competition. Use of herbicides not only improves crop yield but also makes available labour for other productive activities. Herbicides in isolation, however, are unable to obtain complete weed control because of their selective killing. Wide spectrum new herbicides are required to control majority of weed flora in soybean crop. Mostly the farmer's use pre-plant incorporated and pre-emergence herbicides for weed control in soybean, but their efficacy are reduced by various climatic and edaphic factors. Hand weeding is a traditional and effective method of weed control, but untimely and continuous rains as well as unavailability of labour at peak time are main limitations of manual weeding. The only alternative that needs to be explored is the use of post-emergence herbicides. The screening of such herbicides in soybean reveals their efficiency against either monocotyledonous or dicotyledonous weeds. Hence, their mixtures may broaden the window of weed management by broad-spectrum weed

control (Bineet *et al.*,2001).

Keeping the above fact in view, the present investigation entitled **“Evaluation of bio-efficacy of MACARENA (Bio-stimulant) along with herbicides on Soybean”** was carried out during *kharif* season of 2019 at the Instructional Cum Research Farm, I.G.K.V., Raipur (C.G.) with the following, objectives:

Therefore the present study will be undertaken with the following specific objectives:

1. To study the effect of weed management practices on growth of soybean.
2. To study the effect of MACARENA (bio-stimulant) along with weed management practices on yield and yield attributes of soybean.
3. To identify the associated weed flora in *kharif* soybean.
4. To work out the economics of soybean under different weed management practices.

## **CHAPTER –II**

# **REVIEW OF LITERATURE**

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Chemical weed control in various crops has received adequate attention by scientists engaged in the research of weed science in India and during the recent past soybean crop is not the exception. In this chapter, an attempt has been made to present in brief the review of literature on associated weeds and effect of weed management practices on soybean growth, yield attributes and yield of soybean under following heading:

### **2.1 Effect of herbicides on soybean**

2.1.1 Growth and development

2.1.2 Yield and yield attributes

### **2.2 Effect of weed management practices on weeds**

2.2.1 Weed flora

2.2.2 Weeds density

2.2.4 Weed dry weight

2.2.4 Weed control efficiency

### **2.3 Economics**

## **2.1 Effect of herbicides on soybean**

### **2.1.1 Growth and development**

Singh *et al.* (2003) at Sehore (M.P.) recorded maximum plant height, branches plant<sup>-1</sup> and pods plant<sup>-1</sup> with weed free condition, followed by one hand weeding at 30 DAS and Pendimethalin 1 kg *a.i.* ha<sup>-1</sup> as pre-emergence.

Behera *et al.* (2005) from Indore (M.P.) recorded the maximum dry matter per plant with weed free plots, followed by post emergence application of Imazethapyr.

Kushwah and Vyas (2005) at Sehore (M.P.) recorded maximum height and branches plant<sup>-1</sup> with 2 HW than rest of the treatments. The treatment of 2 HW recorded higher values for growth followed by post-emergence application of imazethapyr 10 SL @ 75 g ha<sup>-1</sup>.

Kothawade *et al.* (2006) reported that the plant height was significantly less at harvest in weed free treatment (49.28 cm) followed by pursuit @ 100 g ha<sup>-1</sup> at 21 DAS (55.33 cm). The maximum height was recorded in weedy check (58.33 cm). The highest dry matter plant<sup>-1</sup> was found in the weed free treatment (50.50 g) followed by pursuit @ 100 g ha<sup>-1</sup> at 21 DAS (47.96 g) and significantly lowest dry matter was recorded in weedy check.

Deore *et al.* (2008) at Rahuri (Maharashtra) observed that application of imazethapyr @ 200 g ha<sup>-1</sup> resulted the greatest plant spread, number of branches plant<sup>-1</sup>, number of functional leaf area, mean leaf area and dry matter accumulation plant<sup>-1</sup>.

Amaregouda *et al.* (2013) in Karnataka noticed that herbicides pendimethalin (1350.5 g a.i ha<sup>-1</sup>) and imazethapyr (87.50 g a.i ha<sup>-1</sup>) increased important physiological characters like leaf area, LAD, RGR, CGR and NAR. Whereas, weed competition reduced all these parameters.

Habimana *et al.* (2013) found that intercultivation followed by hand weeding at 20 and 40 DAS recorded significantly higher plant height and dry matter production of crop and thus resulted in higher uptake of nutrients (N, P and K) by the soybean as well as higher grain yield over other herbicide treatments and unweeded check except pre-emergence application of metribuzin 70 WP followed by imazethapyr and metribuzin 70 WP followed by intercultivation at 30 DAS which remained at par to each other.

Prachand *et al.* (2014) found that application of Imazethapyr @ 0.100 kg a.i.ha<sup>-1</sup> + Quizalofop ethyl @ 0.075 kg a.i ha<sup>-1</sup> as PoE to be superior in respect of various growth and yield attributes (*viz.* plant height, dry matter, number of pods plant<sup>-1</sup>, 100 seed weight and seed yield plant<sup>-1</sup>).

Thakare *et al.* (2015) found that application of Imazethapyr @ 0.100 kg a.i.ha<sup>-1</sup> + Quizalofop ethyl @ 0.075 kg a.i.ha<sup>-1</sup> was effective in improving most of the growth parameters..

### 2.1.2 Yield and yield attributes

Kumar *et al.* (2001) revealed that hand weeding at 20 and 40 DAS resulted in the highest number of pods plant<sup>-1</sup>, 1000-grain weight, average grain yield and weed control efficiency (63.07%).

Vyas and Jain (2003) found that the highest value of yield and yield attributes like branches plant<sup>-1</sup>, pods plant<sup>-1</sup>, seeds pod<sup>-1</sup> were higher in two hand weeding (30 and 45 DAS) treatment and this treatment significantly enhanced the seed yield (73.66 and 20.97%) over weedy check.

Pramila *et al.* (2004) at Guntur (Andhra Pradesh) observed significantly higher seed yield under 2 HW treatments. Post-emergence application of Imazethapyr 75 g ha<sup>-1</sup> were found promising alternative to HW practices and recorded 23% higher yield over weedy check.

Kushwah and Vyas (2005) in Madhya Pradesh noted that the treatment of 2 HW recorded higher values for growth, yield attributes, harvest index and yield followed by post-emergence application of Imazethapyr 10% @ 75 g ha<sup>-1</sup>.

Singh (2005) in Punjab studied that Pendimethalin (0.45 kg a.i. ha<sup>-1</sup>) + HW give significantly higher yield, number of pod plant<sup>-1</sup> and 100 seed weight this was followed by Alachlor (2.0 kg a.i. ha<sup>-1</sup>) and Quizalofop ethyl (0.05 kg a.i. ha<sup>-1</sup>), lowest was noted in weedy check.

Kothawade *et al.* (2006) at Rahuri revealed that the yield attributing characters *viz.*, number of pods plant<sup>-1</sup>, number of seeds pod<sup>-1</sup>, thousand seed weight, straw yield, biological yield and seed yield were significantly highest in the weed free treatment at harvest. The decrease in seed yield and biological yield was noted in weedy check.

Pandya *et al.* (2006) stated that the 2 HW (20 and 40 DAS) resulted in significantly higher seed yield (17.18 q ha<sup>-1</sup>) than rest of the treatments.

Deore *et al.* (2008) from Maharashtra observed that the grain yield was significantly highest in imazethapyr @ 200 g ha<sup>-1</sup>. This was followed by imazethapyr @ 100 g ha<sup>-1</sup>, chlorimuron ethyl 9.37 g ha<sup>-1</sup> and the lowest seed yield was recorded in weedy check.

Vyas and Kushwah (2008) recorded the highest value of yield attributes viz., branches plant<sup>-1</sup>, pods plant<sup>-1</sup>, yield plant<sup>-1</sup> and seed index (100-seed weight) were recorded in 2 hand weedings at 20 and 40 DAS.

Meena and Jadon (2009) at Rajasthan recorded that hand weeding twice at 20 and 40 DAS gave highest number of seeds pod<sup>-1</sup> which was significantly higher over weedy check.

## 2.2 Effect of weed management practices on weeds

### 2.2.1 Weed flora

Kolhe *et al.* (1998) from Raipur observed that the most dominant weeds in soybean were *Echinochloa colona*, *Commelina benghalensis*, *Euphorbia heterophylla*, *Euphorbia hirta*, *Phyllanthus niruri* and *Cyperus rotundus*.

Kewat *et al.* (2000) at New Delhi reported that among the broad leaved weeds, *Trianthema portulacastrum* (42.17%) and *Digera arvensis* (13.08%) were more dominant, while *Digitaria sanguinalis* (19.53%) and *Echinochloa colonum* (12.64%) were among the dominant grassy weeds. Beside these *Phyllanthus niruri* (5.22%), *Dactyloctenium aegyptium* (3.01%), *Cyperus rotundus* (2.90%), *Commelina benghalensis* (0.87%) and *Convolvulus arvensis* (0.58%) also showed their presence in low numbers.

Pramila *et al.* (2004) at Andhra Pradesh observed that the weed flora found in *kharif* soybean was mainly *Phyllanthus niruri*, *Abutilon indicum*, *Celosia argentea*, *Trianthema portulacastrum*, *Digera arvensis*, *Amaranthus tricolor*, *Cenchrus ciliaris* and *Cynotis cucullate*.

Idapuganti *et al.* (2005) at Junagadh (Gujarat) reported that the soybean experimental field was mainly infested with *Echinochloa colona* (58%), *Cyperus rotundus* (17.9), *Trianthema portulacastrum* (4.8%) and *Digera arvensis* (17.3%). In addition to these, *Digitaria sanguinalis*, *Commelina benghalensis*, *Dactyloctenium aegyptium* and *Phyllanthus niruri* were also recorded in small numbers.

Pandya *et al.* (2006) at Udaipur (Rajasthan) found that the major species infesting soybean crop included *Trianthema portulacastrum*, *Commelina*

*benghalensis*, *Parthenium hysterophorus*, *Amaranthus spinosus* and *Digera arvensis* among broadleaf weeds, and *Echinochloa colonum*, *Cynodon dactylon* and *Cyperus rotundus* among grassy weeds, *Echinochloa colonum* and *Trianthema portulacastrum* were the most dominant ones.

Tiwari *et al.* (2006) from Jabalpur (M.P.) reported that the predominant weed species observed in the experimental field were *Commelina* spp., *Cynodon dactylon*, *Cyperus rotundus*, *Digitaria sanguinalis*, *Echinochloa crus-galli* and *Panicum ischmi* among monocots and *Acalypha indica*, *Convolvulus arvensis*, *Digera arvensis*, *Phyllanthus niruri* and *Phaseolus tribulus* among the dicot weeds.

Vyas and Kushwah (2008) at Sehore (M.P.) found that the experimental field of soybean was severely infested with about 23 weed species, consisting of both monocots and dicot in weedy check plots. Among monocot weeds, *Cyperus rotundus*, *Digitaria sanguinalis*, *Echinochloa colonum*, *Commelina benghalensis*, *Cynotis axillaries* and *Dinebra arabica* were dominant, whereas *Caesulia axillaries*, *Acalypha indica*, *Anotis mothulani*, *Digera arvensis*, *Xanthium strumarium*, *Phyllanthus niruri* and *Euphorbia hirta* were among dicot weeds.

Mishra and Singh (2009) at Jabalpur (M.P.) reported that the major weeds observed at 30 DAS were *Echinochloa colonum*, *Commelina communis*, *Phyllanthus niruri* and *Cyperus iria* during rainy season.

Tomar *et al.* (2009) at Madhaya Pradesh reported that *Celosia argentea* was most dominant weed in Gwalior district on *kharif* soybean.

Singh *et al.* (2013) at Jabalpur found that *Echinochloa colonum*, was the most dominant weed followed by *Dinebra retroflexa* and *Cyperus iria* among the monocot weed at 40 DAS and harvest, respectively. Dicot weeds like *Eclipta alba* and *Alternanthera philoxeroides* were less dominant at 40 DAS and harvest. The highest weed infestations were recorded in weedy check plot.

Khedkar *et al.* (2009) from Gujarat found that interculturing *fb* hand weeding at 20 and 40 DAS registered higher seed yield, straw yield and harvest index followed by quizalofop ethyl 75 g ha<sup>-1</sup> as PoE *fb* hand weeding at 30 DAS.

Pradhan *et al.* (2010) noted that post-emergence application of lactofen

120g ha<sup>-1</sup> + propaquizafop 60 g ha<sup>-1</sup> had higher weed control efficiency with higher grain yield. All the recorded weed flora was found with reduce dry matter accumulation by combined application of herbicides rather than alone application.

Meena *et al.* (2011) at Kota (Rajasthan) reported that application of Imazethapyr XL 10 % SL at 150 g ha<sup>-1</sup> as post emergence significantly reduced the density of all grassy, broad leaf weeds, sedges and their dry weight.

Wadafale *et al.* (2011) the effect of some new post- emergence herbicides on weed and plant growth parameters of soybean (*Glycine max L.*) Highest grain yield and straw yield were obtained under two hoeings and two hand weedings at 20 DAS and 35 DAS which were at par with the application of imazethapyr@ 75g a.i. ha<sup>-1</sup> at 15 DAS+ 1 hoeing and 1 hand weeding at 35 DAS and chlorimuron ethyl @ 10 g a.i. ha<sup>-1</sup> at 15 DAS + 1 hoeing and 1 hand weeding at 35 DAS.

Upadhyay *et al.* (2012) at Research Farm, JNKVV, Jabalpur to study the bio- efficacy of post-emergence herbicides on weeds in soybean. Early post-emergence applications of imazethapyr with adjuvant and ammonium sulphate (100 g + 750 ml + 1 kg/ha) was most effective in paralyzing the weed growth and producing significantly higher yield attributing characters and seed yield (2.6 t/ha).

Younesabadi *et al.* (2013) at New Delhi observed that tank-mix pre-emergence application of pendimethalin 0.5 kg ha<sup>-1</sup> + imazethapyr 0.075 kg ha<sup>-1</sup> resulted in considerably higher seed yield over others treatments.

Amaregouda *et al.* (2013) at Karnataka studied the effect of weedicides on physiological parameters, growth, yield and yield components of Soybean (*Glycine max. L.*) and noticed that all herbicide treatments significantly improved yield and yield components like number of pods per plant, number of seeds per plant, 100 seed weight, pod weight and harvest index compared to control and increase was more in pendimethalin (1350.5 g a.i ha<sup>-1</sup>) and imazethepyr (87.50 g a.i ha<sup>-1</sup>) treatments.

Habimana *et al.* (2013) at Bengaluru reported that intercultivation fb. Hand weeding at 20 and 40 DAS recorded significantly higher grain and haulm yield, However, pre-emergence application of metribuzin 70 WP fb. imazethapyr 10 SC

and metribuzin 70 WP *fb.* intercultivation at 30 DAS gave lower weed population, dry weight and higher grain, haulm yield, no. of pods per plant, pod weight per plant, no. of grains per pod and 100 grains weight as compared to other herbicide treatments and unweeded check.

### 2.2.2 Weed density

Kushwah and Vyas (2005) working at Sehore (M.P.) recorded that among various weed control measures, hand weeding twice at 20 and 40 days resulted in significantly lower weed population compared with rest of the treatments. Among post emergence herbicide application of Imazethapyr 10 % @ 75 g ha<sup>-1</sup> gave significantly less weed biomass and higher WCE except Quizalofop ethyl.

Idapuganti *et al.* (2005) reported that the lowest weed density was recorded with 2 HW (39.2 m<sup>-2</sup>) or two hoeings (52.7 m<sup>-2</sup>) at 20 and 40 DAS which may be ascribed to effectiveness of these methods to control all sort of weeds during critical period of crop-weed competition.

Sharma (2005) at Raipur proposed that minimum weed density was recorded under metribuzin @ 300 g ha<sup>-1</sup> *fb* quizalofop @ 50 g ha<sup>-1</sup>.

Kushwah and Vyas (2006) working at Sehore (M.P.) observed that the lowest weed biomass was recorded with two hand weedings 20 and 40 DAS followed by imazethapyr at 75 g ha<sup>-1</sup> and quizalofop-ethyl 5 EC at 50 g ha<sup>-1</sup>. Two hand weedings (at 20 and 40 DAS) and imazethapyr at 75 g ha<sup>-1</sup> were most appropriate treatments in terms of reduction in total weed density and increase in soybean yield.

Pandya *et al.* (2006) at Udaipur (Rajasthan) recorded the lowest weed density of broad-leaf weeds with 2 HW treatments at 20 and 40 DAS compared to rest of the treatments.

Meena *et al.* (2011) at Kota (Rajasthan) reported that application of Imazethapyr XL 10 % SL at 150 g ha<sup>-1</sup> as post emergence significantly reduced the density of all grassy, broad leaf weeds, sedges and their dry weight.

Amaregouda *et al.* (2013) found that among herbicides pendimethalin 1350.5 (g *a.i* ha<sup>-1</sup>) and imazethapyr 87.50 (g *a.i* ha<sup>-1</sup>) gave season long weed

control and effectively checked the weed density. All herbicides increased leaf dry matter, stem dry matter and total dry matter. The herbicides also increased important physiological characters like leaf area, LAD, RGR, CGR and NAR. Nitrate reductase activity and total chlorophyll content were higher in pendimethalin 1350.50 (g *a.i* ha<sup>-1</sup>) and imazethapyr 87.50 (g *a.i* ha<sup>-1</sup>). tepraloxym 100.(g *a.i* ha<sup>-1</sup>).

Prachand *et al.* (2015) found that application of Imazethapyr @ 0.100 kg *a.i.*ha<sup>-1</sup> + Quizalofop ethyl @ 0.075 kg *a.i* ha<sup>-1</sup> as PoE was found to be more efficient to control monocot and dicot weed in soybean which recorded lowest weed density, dry matter and weed index.

Singh *et al* (2016) found that the losses caused by weeds and their control measure to enhance the productivity of soybean. Lowest weed density and dry matter were observed in twice hand weeding (20 & 40 DAS) however it was found at par with tank mix herbicides *i.e.*, Chlorimuron Ethyl @ 09gm ha<sup>-1</sup> + Quizalofop-p-ethyl @ 50 g ha<sup>-1</sup> and Imazethapyr @ 35 g ha<sup>-1</sup> + Imazamox @ 35 g ha<sup>-1</sup>. As per economics, combined application of Chlorimuron Ethyl (POE) @ 09gm ha<sup>-1</sup> Quizalofop-p-ethyl @ 50 g ha<sup>-1</sup>.

### 2.2.3 Weed dry weight

Vyas and Jain (2003) found the lowest weed dry matter in two hand weedings (30 and 45 DAS) because of weed removal.

Halvankar *et al.* (2005) at Maharashtra reported that the maximum reduction in weed biomass was observed due to HW followed by post emergence application of Imazamox + Imazethapyr. However, the latter weedicide produced phytotoxic effects.

Singh (2005) from Ludhiana (Punjab) revealed that application of quizalofop ethyl @ 50 g ha<sup>-1</sup> + chlorimuron ethyl @ 9 g ha<sup>-1</sup> as post emergence application significantly reduced weed dry matter production as compared to weedy check.

Idapuganti *et al.* (2005) at New Delhi observed that the quizalofop ethyl was the most effective against *E. colona* and *Cyprus rotundus* among the weed control treatments.

Tiwari *et al.* (2006) at Rahuri (Maharashtra) observed that the dry matter of weeds and weed index were significantly the lowest under weed free treatment with 2 HW at 20 and 40 DAS indicating superiority of this treatment for efficient weed control which was at par with those of Imazethapyr @ 100 g ha<sup>-1</sup>. The dry matter of weeds was significantly the highest under weedy check.

Singh *et al.* (2006) found that 2 HW at 30 and 45 DAS resulted in complete absence of weeds at 50 DAS. It also gave the lowest weed dry biomass and highest weed control efficiency.

Deore *et al.* (2008) at Maharashtra observed that the Imazethapyr @ 200 g ha<sup>-1</sup> resulted in the lowest dry weight of weed.

Singh *et al.* (2012) at Kota evaluated the weed control efficiencies of herbicides quizalofop ethyl (50g ha<sup>-1</sup>), fenoxaprop-p-ethyl (70g ha<sup>-1</sup>) and chlorimuron ethyl (9 g ha<sup>-1</sup>) and their mixtures along with different fertility levels and reported that herbicides quizalofop ethyl (50 g ha<sup>-1</sup>) and fenoxaprop-p-ethyl (70 g ha<sup>-1</sup>) were effective against graminaceous weeds whereas chlorimuron ethyl (9 g ha<sup>-1</sup>) reduced the density and biomass of broad leaved weeds effectively.

Singh *et al.* (2013) at Jabalpur (M.P) observed that two hand weeding (20 and 40 DAS) reduced the density and dry weight of weeds to the maximum extent over herbicidal treatments.

#### **2.2.4 Weed control efficiency**

Chandel and Saxena (2001) at Pantnagar reported that the effect of post emergence herbicide imazethapyr @ 100.0 g ha<sup>-1</sup> was found effective in soybean in controlling weeds and increasing weed control efficiency.

Vyas and Jain (2003) at Sehore (M.P.) reported that highest weed control efficiency with 2 HW at 30 and 45 DAS. Post emergence application of quizalofop ethyl 50 g ha<sup>-1</sup> and quizalofop ethyl 50 g ha<sup>-1</sup> + chlormuron ethyl 9 g ha<sup>-1</sup> was not effective in controlling weeds.

Pramila *et al.* (2004) from A.P. noted that the 2 HW and farmers practice showed higher WCE. Among the weedicides, Imazethapyr @ both 75 g ha<sup>-1</sup> and 100 g ha<sup>-1</sup> gave WCE upto 50%.

Kushwah and Vyas (2005) at Sehore (M.P.) revealed that hand weeding twice at 20 and 40 DAS resulted in WCE of 95.6 and 95.3 % during 2001 and 2002, respectively. Among the post emergence herbicides, application of imazethpyr (10 SL) @75 g ha<sup>-1</sup> gave significantly higher WCE (90.2 %) than quizalofop ethyl (5 EC) @ 50 g ha<sup>-1</sup>.

Pradhan *et al.* (2010) noted that post-emergence application of lactofen 120g ha<sup>-1</sup> + propaquizafop 60 g ha<sup>-1</sup> had higher weed control efficiency with higher grain yield. All the recorded weed flora was found with reduce dry matter accumulation by combined application of herbicides rather than alone application.

Meena *et al.* (2011) at Kota (Rajasthan) revealed that maximum weed control efficiency of grasses (86.9 %), broad leaf (88.4 %) and sedges (73.0 %) was obtained with 2 HW at 20 and 40 DAS closely followed by Imazethapyr XL 10 % at 150 g ha<sup>-1</sup>.

Kundu *et al.* (2011) noted that the bio-efficacy of imazethapyr against predominant weeds in soybean and the crop safety at different doses of imazethapyr. The predominant weed species in experimental field were *Echinochloa colona* L. Link, *Echinochloa crusgalli* L., *Beauv.*, *Cyperus difformis* L., *Euphorbia hirta* L., *Croton sparsiflorus* Morang and *Digera an,ensis* Forsk. The maximum suppression of all the weed density, weed biomass, and highest weed control efficiency vis-à-vis crop yield were obtained where twice hand weeding done at 20 and 40 days after sowing, and closely followed by the treatment with imazethapyr 150 g ha<sup>-1</sup> and imazethapyr 125 g ha<sup>-1</sup> respectively.

Benke *et al.* (2012) at Nagpur found that the highest weed control efficiency (96.8%) and the lowest weed biomass were recorded with two hoeings and two hand weedings at 20 and 40 DAS followed by Quizalofop ethyl @ 62.5 g ha<sup>-1</sup> at 20 DAS+1 hoeing at 20 days after spraying and one hoeing at 15 DAS+ Quizalofop ethyl @ 62.5 g ha<sup>-1</sup> at 30 DAS.

Thakare *et al.* (2015) observed that the tank mix application of Imazethapyr @ 0.100 kg *a.i.* ha<sup>-1</sup> + Quizalofop ethyl @ 0.075 kg *a.i.* ha<sup>-1</sup> recorded significantly lower weed dry weight, maximum weed control efficiency and lowest

weed index and significantly improved the growth characters, yield and yield contributing characters. Herbicides Imazethapyr @ 0.1 kg *a.i.* ha<sup>-1</sup> and Quizalofop ethyl @ 0.075 kg *a.i.* ha<sup>-1</sup> applied separately were less effective in controlling weeds.

Harithavardhini *et al.* (2016) reported that post emergence herbicides *viz.*, imazethapyr 10% EC @ 50 g *a.i.* ha<sup>-1</sup> and acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24% EC) @ 180, 240 and 300 g *a.i.* ha<sup>-1</sup> were sprayed at 15 and 25 DAS. Hand weeding and weedy check were also included for comparison. Statistical analysis of the data showed that all the parameters were affected by herbicides. Weed free check was found best by recording highest weed control efficiency, plant dry weight, yield parameters and yield of blackgram.

Billore (2014) to evaluate the bio-efficacy of quizalofop ethyl 10 per cent EC against grassy weeds in soybean. The existence of weeds throughout the crop season led to maximum reduction (49.94 %) in seed yield. Significantly higher soybean yield (99.76 %) was recorded when weeds were managed by manual weeding (at 30 and 45 days after sowing) over control. Among different levels of quizalofop – p-ethyl tried, its application either @ 45 or 37.50 g *a.i.* ha<sup>-1</sup> as post-emergence yielded maximum and out-yielded over its lower level (30 g *a.i.* ha<sup>-1</sup>). Both the higher levels of quizalofop ethyl were found to be as effective as check herbicides *viz.*, quizalofop- p-tefuryl and fenoxaprop-p-ethyl. The physical maximum dose of quizalofop-p-ethyl worked out to be 50.11 g ha<sup>-1</sup> with corresponding yield of 1,599 kg ha<sup>-1</sup>. Manual weeding maintained its supremacy over chemical weed control in limiting the weed load (weed density as well as their dry biomass) in soybean crop.

### 2.3 Economics

Tiwari *et al.* (2006) at Jabalpur (M.P) found that the weed free treatment gave the highest additional income over control (Rs. 5606 ha<sup>-1</sup>) and benefit cost ratio (1.44), while Imazethapyr @ 100 g *a.i.* ha<sup>-1</sup> gave the net return and benefit cost ratio of Rs. 4056 ha<sup>-1</sup> and 1.18, respectively.

Tiwari *et al.* (2007) at Jabalpur (M.P) reported that the higher cost of weed control (Rs. 3,500 ha<sup>-1</sup>) is the reason for lower values of net monetary return (Rs.

1,460 ha<sup>-1</sup>) and benefit cost ratio (1.13) under 2 HW (20 and 40 DAS) treatment in spite of maximum seed (10.25 q ha<sup>-1</sup>) and straw yield (34.20 q ha<sup>-1</sup>). 2.5 Energetics

Dhane *et al.* (2009) at Maharashtra revealed that 2 HW (30 and 45 DAS) registered the highest gross income (Rs. 62,500 ha<sup>-1</sup>) and net monetary return (Rs. 25635 ha<sup>-1</sup>) indicating superiority of this treatment over rest of the treatments. The B:C ratio was the highest (5.10) under 2 HW (30 and 45 DAS) followed by Imazethapyr (Early post emergence) @ 100 g ha<sup>-1</sup> (4.64) and Imazethapyr (Early post emergence) @ 100 g ha<sup>-1</sup> + one HW at 30 DAS (4.55) would be the most economical proposition in soybean.

Yadav *et al.* (2009) working in Maharashtra noticed the highest gross income (Rs. 41,822 ha<sup>-1</sup>), net monetary return (Rs. 21971.50 ha<sup>-1</sup>) and B:C ratio (2.11) under weed free check condition which was followed by 2 HW at 15 and 30 DAS (Rs. 39,198, Rs. 20,543 ha<sup>-1</sup> and 2.10, respectively).

Kundu *et al.* (2009) at West Bengal to find out the effect of different weed management practices in mungbean. The maximum reduction of weed population, weed dry weight and the highest weed control efficiency vis-a-vis crop yield, and maximum benefit: cost ratio were obtained in the treatment receiving quizalofop-p-ethyl 50 g a.i. ha<sup>-1</sup> at 21 day after emergence (DAE) + hand weeding (HW) at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl 50 g a.i. ha<sup>-1</sup> at 14 DAE + HW at 21 DAE. Weedy check treatment produced lowest yield of mungbean.

Meena *et al.* (2011) at Kota (Rajasthan) reported that application of Imazethapyr 10 % SL at 100 g ha<sup>-1</sup> recorded significantly higher net return (Rs.14,237 ha<sup>-1</sup>) and B:C ratio (1.68) followed by Imazethapyr 10 % SL at 150 g ha<sup>-1</sup> over weedy check and Imazethapyr 10 % SL at 50 g ha<sup>-1</sup>.

Sangeetha *et al.* (2013) in Tamil Nadu found that application of early post emergence imazathapyr at 100 g ha<sup>-1</sup> recorded the highest gross return (Rs 34,654 ha<sup>-1</sup>), net return (Rs 19029ha<sup>-1</sup>) and B: C ratio (2.21).

## CHAPTER-III

### MATERIALS AND METHODS

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The experiment entitled “**Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on soybean [*Glycine max* (L.) Merrill].” was carried out during *khariif* season (02 July to 22 October) of 2019. The details regarding experimental soil, weather condition, materials used, techniques adopted and various aspect of experiment during the course of investigation are briefly presented in this chapter.**

#### **3.1 Location of experimentalsite**

The experiment was carried out at Instructional cum Research Farm of IGKV, Raipur situated at latitude of 21°4' N, longitude of 81°35' E and altitude of 290.2 m above mean sea level.

##### **3.1.1 Climate**

The climate of Raipur region is sub-humid to semi arid. The source of rainfall is south-west monsoon. The average annual rainfall is 1326 mm (based on 80 years mean), of which mostly concentrated during the period from June to September and very little during October to February. May is the hottest and December is the coolest month of the year. The pattern of rainfall particularly during June to September months has great variations from year to year. The weekly maximum temperature raises up to 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.

##### **3.1.3 Weather conditions during crop period**

The weather data recorded at meteorological observatory, IGKV, Raipur during the life span of crop is given in Appendix I and depicted through 1086.8 mm rainfall during the growth period, Maximum rainfall received in crop period during third week of July and maximum temperature varied from 32.2 °C in third week of September to 28.6 °C in first week of August, whereas, minimum temperature varies from 15.6 °C in second week of November to 25.5 °C in third week of

August. Relative humidity throughout the crop season varied between 86.5 to 95.0 percent at morning and 28.5 to 88.5 per cent in evening hours, whereas, the bright sunshine varied from

#### **3.1.4 Temperature ( $^{\circ}\text{C}$ )**

Temperature controls seed germination, tillering, and other plant practices. Through experiments, the weekly mean maximum and minimum temperature varied from 28.01 to 35.67 and 15.23 to 26.22 during the experiments, respectively. The maximum temperature recorded was 35.67 on 02 to 05 July whereas the minimum temperature was 15.23  $^{\circ}\text{C}$  from 20 to 22 October.

#### **3.1.5 Rainfall (mm)**

The cumulative rainfall in the cropping season of 2019*khari*f (02/7/19 to 22/10/19) during the investigation period was 1320 mm. During the experimental era, the pattern of rainfall distribution was satisfactory. The majority of which has been received during the meteorological month and period between 2 September to 8 September and the highest rainfall recorded was (33.94 mm)

#### **3.1.6 Relative humidity (%)**

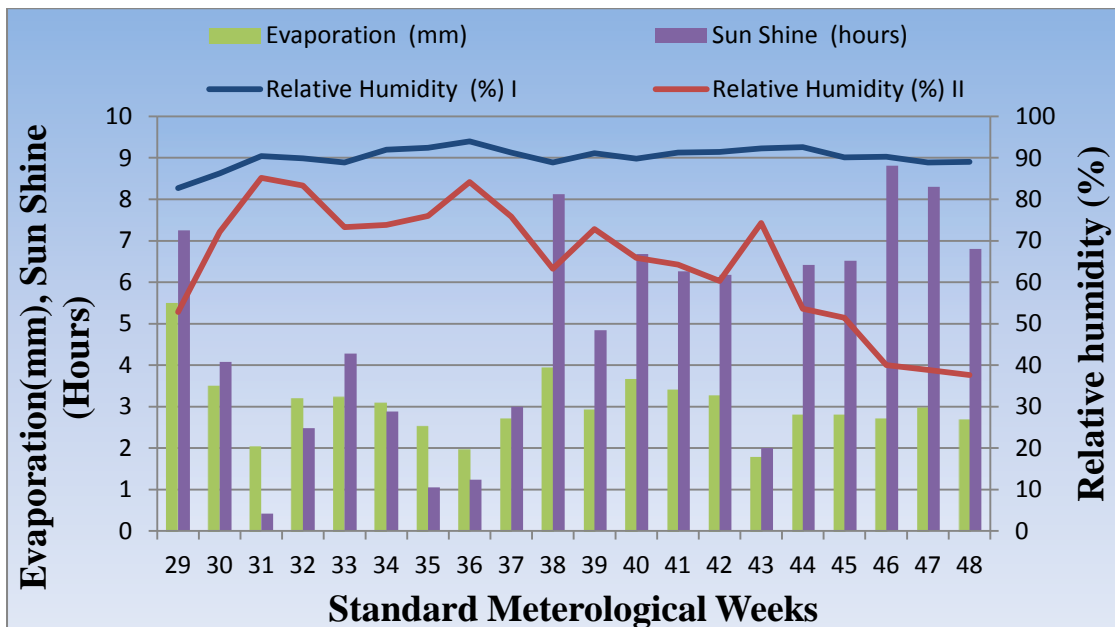
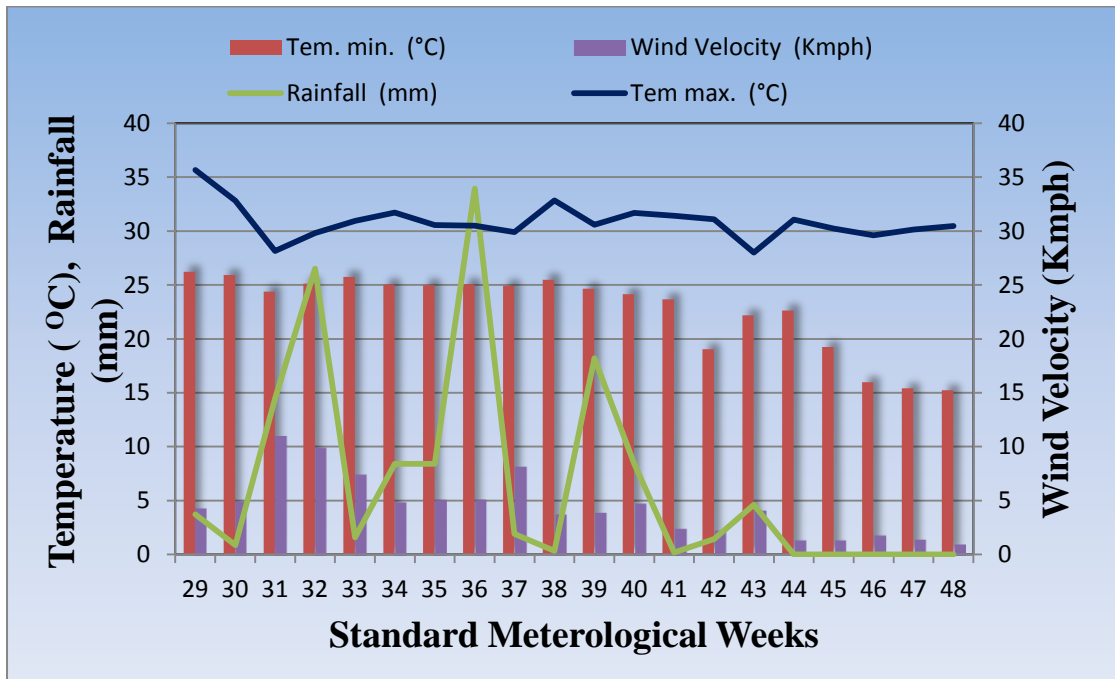
During the soybean-growing season, the weekly average relative humidity varied from 6 to 10% and the total relative humidity ranged from 82.71 to 92.57 %.

#### **3.1.7 Sunshine duration (hours)**

The average duration of bright sunshine was 6 to 8 hours. The maximum and minimum weekly dazzling sunshine duration ranged between 8.81 to 2 hours, respectively during the period of investigation.

#### **3.1.8 Evaporation (mm)**

Evaporation data obtained from Meteorological Office IGKV, Raipur from Open Pan evaporimeter shows that average evaporation ranged from 1.8 to 5.48 mm per hour during the crop period.



**Fig:3.1 Standard weekly meteorological data during the crop growth (02 July to 22 October 2019)**

### 3.2 Physico-chemical properties of soil

In order to determine the mechanical and chemical composition of experimental plot, soil samples were collected randomly from the experimental site from 0 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 samples remain about 250 g and then it was used for analysis. The detailed physico-chemical properties of the soil are presented in Table 3.1.

**Table 3.1: Physico-chemical properties of the experimental soil**

S. No.	Particulars	Values	Rating	Method used
<b>A. Physical- Mechanical composition</b>				
1.	Sand (%)	21.10	-	International pipette method (Black & Evans, 1965)
2.	Silt (%)	35.41	-	
3.	Clay (%)	43.33		
4.	Texture	class	<i>Vertisols</i>	
<b>B. Chemical composition</b>				
1.	Available N (kg ha <sup>-1</sup> )	220	Low	Alkaline permanganate method (Subbiah & Asija, 1956)
2.	Available P (kg ha <sup>-1</sup> )	12.54	Medium	Olsen's method (Olsen <i>et al.</i> , 1954)
3.	Available K (kg ha <sup>-1</sup> )	288	High	Flame photometric method (Hanwy and Heiddle, 1952)
4.	pH (1:2.5)	7.10	Neutral	Glass electrode pH meter (Piper, 1967)
5.	EC (d Sm)	0.17	Normal	Solubridge method (Black & Evans, 1965)

### 3.3 Cropping history of the experimental field

The cropping history of the experimental field of the preceding five years and during the year of experimentation is given in Table 3.2.

**Table 3.2 Cropping history of the experimental field**

Year	Kharif	Rabi
2011-12	Soybean	Linseed
2012-13	Soybean	Chickpea
2013-14	Soybean	Chickpea
2014-15	Soybean	Chickpea
2015-16	Soybean	Chickpea
2016-17	Soybean	Chickpea
2017-18	Soybean	Linseed
2018-19	Soybean	-

### 3.4 Test crop

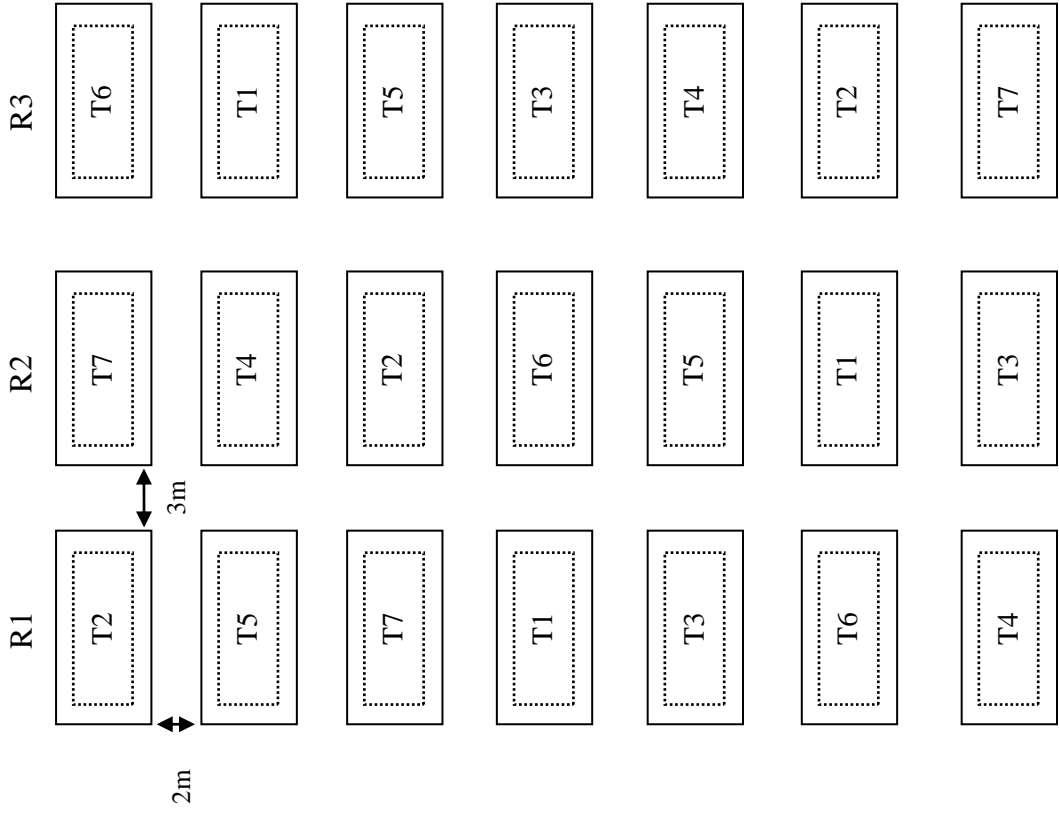
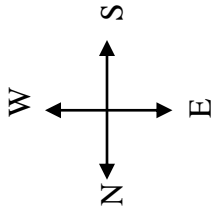
Soybean variety ‘JS 97-52’ (Jawahar Soybean 97-52) was grown as a test crop. It is released from JNKVV, Jabalpur. This variety has potential to provide high yield in varied eco-edaphic situation. It is multiple resistant against major diseases including yellow mosaic virus and root rot, moderately resistant to stem borer and defoliator and tolerant to excessive moisture stress. Excellent regarding germinability, field emergence and longevity. Duration of crop is 98-102 days.

**Table 3.3 Experimental details:**

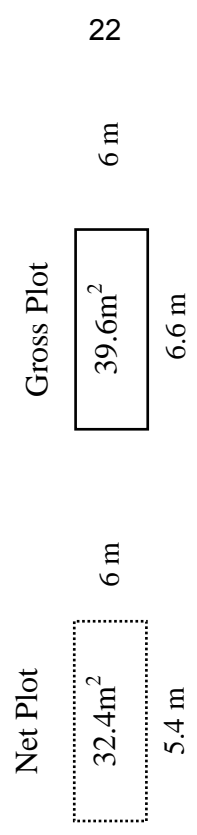
Crop and Season	: Soybean, <i>Kharif</i>
Number of Treatments	: 7
Number of Replications	: 3
Design of Experiment	: Randomized Block Design
Variety	: J.S. 97-52
Recommended dose of fertilizer	: 20:60:40:(N:P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)
Planting distance	: 30 cm X 10 cm (Row to Plant)
PLOT SIZE	: 3.6×6 m

**Table 3.4 Treatment details:**

T <sub>1</sub>	Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 MI/ha + MACARENA @ 625 ml/ha
T <sub>2</sub>	Imazethapyr 10 SL@ 1000 ml/+ MACARENA @ 625 ml/ha
T <sub>3</sub>	Fluazifop-p-butyl 13.4 EC @ 2000 ml/ha + MACARENA @ 625 ml/ha
T <sub>4</sub>	Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha
T <sub>5</sub>	MACARENA @ 625 ml/ha
T <sub>6</sub>	Two hand weeding at 20 and 40 DAS
T <sub>7</sub>	Weedy check



**Crop** : Soybean (*Glycine max* (L.)Merrill)  
**Season** : *khanf 2019*  
**Variety** : J.S. 97-52  
**Design of Experiment** : Randomized Block Design  
**Number of Treatments** : 7  
**Number of Replications** : 3  
**Gross plot size** : 6 x 6.6 = 39.6 m<sup>2</sup>  
**Net plot Size** : 5.4 x 6 = 32.4 m<sup>2</sup>  
**Recommended dose of fertilizer** : 20:60:40: (N:P205:K20) kg ha<sup>-1</sup>  
**Flaming distance** : 30 cm row to row X 10 cm plant to plant  
**Date of sowing** : 02 July 2019  
**Date of harvesting** : 22. October 2019



**Fig. 3.2: Layout and treatment detail of experiment field**



## **3.5 Cultural operations**

### **3.5.1 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 two cross harrowings 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.

### **3.5.2 Herbicide application**

All chemical were applied as post-emergence at 20 DAS. The required quantity of herbicide (Sodium Aciflorfan + Clodinofof (Kover), Imazethapyr (Pursuit 10 SL ) Fluazifop-p-butyl (Fusilade), Propaquizafop .MACARENA were applied. The quantity of water used as carrier was 1.2 litre plot<sup>-1</sup>. The calculated above mentioned quantity of herbicide, as per treatment, was mixed in 1.2 litre of water and sprayed over the gross plot by knapsack sprayer using flat fan nozzle as blind application.

### **3.5.3 Fertilizer application**

Recommended dose of fertilizer i.e. 20:60:40 kg N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O ha<sup>-1</sup> was applied through urea, single super phosphate and muriate of potash as basal in rows uniformly to each plot.

### **3.5.4 Irrigation**

The crop was grown under rain-fed condition, so no irrigation was applied.

### **3.5.5 Seed rate, treatment and sowing**

The crop was sown manually on 02 July 2019. The row and plant spacing was 30 cm × 10 cm using a seed rate of 75 kg ha<sup>-1</sup>. To prevent the crop from soil and seed borne diseases, the seeds were treated with bavistin @ 2 g kg<sup>-1</sup> of seeds followed by seed inoculation seeds with *Rhizobium japonicum* @ 4 g kg<sup>-1</sup> seeds before sowing. The furrows were opened, seeds were drilled manually and covered immediately.

### 3.5.6 Thinning

The population of the plants with 30 cm row spacing and 10 cm plant spacing was maintained by thinning manually after emergence of seedlings (10 DAS) in all the experimental plots.

### 3.5.7 Weed management practices

Weed management practices were adopted as per the treatments.

#### i Manual weeding

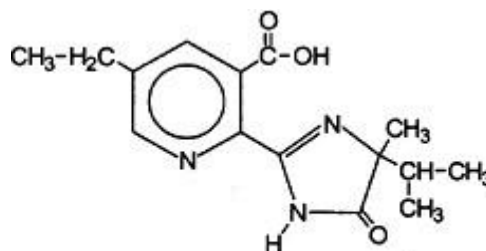
Hand weeding was performed as per the treatments. Hand weeding once at 25 DAS was done in treatments . While two hand weeding was done in treatment T<sub>6</sub> *i.e.* farmer's practice at 20 DAS and 40 DAS.

#### ii Herbicide application

The doses of different herbicides were determined as per treatment according to their active ingredient present in the commercial products.

#### (A) Imazethapyr

Group	: Imidazolinones.
Trade name	: Pursuit.
Common name	: Imazethapyr
Chemical name	: 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid.
Empirical formula	: C <sub>15</sub> H <sub>19</sub> N <sub>3</sub> O <sub>3</sub> Structural formula:



**imazethapyr acid**

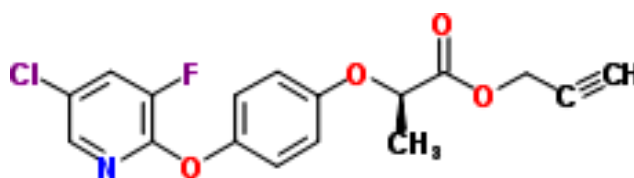
Molecular weight	: 289.335 g mol <sup>-1</sup> Melting point : 173 °C
Recommended dose	: 100 g a.i. ha <sup>-1</sup>

**(B) Clodinafop**

Group	: Phenoxypropionic
Trade name	: Kover
Common name	: Clodinafop propargyl
Chemical name	: prop-2-ynyl-(-2-R)-2-[4-(5-chloro-3-fluoropyridin-2-yl)oxyphenoxy] propanoate

Empirical formula :  $C_{17}H_{13}ClFNO_4$

Structural formula :



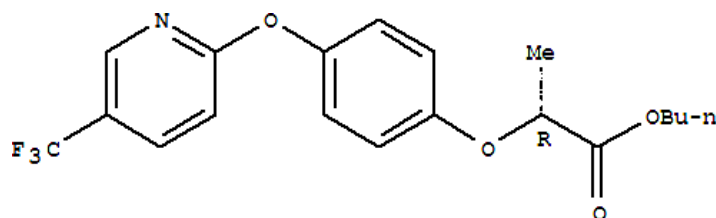
Molecular weight	: 349.742 g mol <sup>-1</sup>	Melting point	
Recommended dose	: 125 g a.i. ha <sup>-1</sup>	Application time	: post emergence
Type of weed control	: grassy weeds	Selectivity	: Selective
Nature of crop in which it is recommended	: Wheat		

**Mode of action:**

Clodinafop propargyl is absorbed by the leaves and rapidly translocated to the growing points of leaves and stems. It interferes with the production of fatty acids needed for plant growth in susceptible grassy weeds. Depending on the species, growing conditions and crop competition, leaves and growing points turn yellow within one to three weeks after application. Further colour changes and loss of vigour will be observed, followed by a browning and complete control three to five weeks after application.

**(C) Fluazifop-p-butyl**

Group	: Aryloxyphenoxypropionate
Trade name	: Fusilade®, Tornado®. Common name : Fluazifop-p-butyl
Chemical name	: R-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoate
Empirical formula	: $C_{19}H_{20}F_3NO_4$
Structural formula	:



Molecular weight : 383.37 g mol<sup>-1</sup>

recommended : forage legumes, soybeans.

### Mode of action:

Fluazifop-p-butyl is a post-emergence phenoxy herbicide. It is absorbed rapidly through leaf surfaces and quickly hydrolyzes to fluazifop acid. The acid is transported primarily in the phloem and accumulates in the meristems where it disrupts the synthesis of lipids in susceptible species. Fluazifop-p-butyl inhibits acetyl CoA carboxylase, an enzyme that catalyzes an early step in fatty acid synthesis. Lipids are important components of cellular membranes, and when they cannot be produced in sufficient quantities, cell membrane integrity fails, especially in regions of active growth such as meristems. The cells then burst, or leak and die. Fluazifop-p-butyl affects susceptible grasses, but does not affect most other monocots or dicots weeds.

### 3.5.8 Harvesting

Harvesting was done manually from net plot area when the seed became hard and leaves turned yellow in color. The plants were left in plot for five days for sun drying and thereafter bundles were made and the bundle weight plot<sup>-1</sup> was recorded.

### 3.5.9 Threshing and winnowing

Threshing of produce for each net plot was done manually by beating with wooden stick and after manual winnowing seed yield plot<sup>-1</sup> was noted.

### 3.5.10 Details of cultural schedule

The details of the cultural operation adopted in the experimental plot from preparatory tillage to harvesting are given in Table 3.4.

**Table 3.5: Cultural schedule of experiment**

<b>S.No.</b>	<b>Cultural operation</b>	<b>Implement /method used</b>	<b>Date</b>
<b>1</b>	Ploughing and harrowing	Power tiller	16-06-2019
<b>2</b>	Soil sampling	Soil auger	26-06-2019
<b>3</b>	Planking	Tractor drawn planker	27-06-2019
<b>4</b>	Layout preparation	Manual	28-06-2019
<b>5</b>	Seed treatment, basal fertilizer application and sowing	Manual	02-07-2019
<b>6</b>	Application of herbicides		
<b>7</b>	Post-emergence herbicide	Knapsack sprayer	24-07-2019
<b>8</b>	Hand weeding	Manual	22-07-2019
<b>9</b>	Harvesting	Manual	22-10-2019
<b>10</b>	Threshing and winnowing	Manual	22-10-2019

### **3.6 Observations :**

The experimental observations on crop are presented under the following heads. For studying the effect of fertigation on growth, yield and nutrient uptake of soybean, 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.

#### **3.6.1:Pre-harvest observations**

For taking observations, five plants plot<sup>-1</sup>were randomly selected and tagged in each plot in order to get representative samples for recording the various growth parameters. The details of techniques adopted in taking observations are given below.

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

Plant population was counted per meter row length at initial and at harvest of crop. The average plant population was worked out. Crop stand was counted randomly from five places by using scale of one meter in each plot.

##### **3.6.1.2 Plant height (cm)**

Height of five tagged plants in each plot was recorded in cm at an interval of 30, 60, DAS and at harvest and then average was worked out and used for statistical analysis. Plant height was measured in cm from ground surface to upper most leaf top.



**Fig soybean harvesting**



**Fig observation.**

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

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

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

Dry matter accumulation was observed at 30, 60, 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>.

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

Five plants from each plot were collected and then leaf area plant<sup>-1</sup> was measured with the help of leaf area meter. The leaf area was worked out at 30, 60 DAS.

## **3.6.2 Post-harvest observations**

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

To study the influence of different treatment on pod formation in soybean 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.

### **3.6.2.2 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>.

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

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

### **3.6.2.4 100 - seed weight (g)**

Randomly seed samples were taken from each net plot. Hundred healthy seeds from the produce of each plot were counted and same were oven dried at 60 °C to get constant weight. The weight of seeds were recorded in gram by using an electronic digital balance.

#### **3.6.2.5 Seed yield (q ha<sup>-1</sup>)**

The weighed bundles were threshed, winnowed and cleaned separately. Treatment wise moisture content of threshed seed samples was recorded and then seed yield was recorded and presented in q ha<sup>-1</sup>.

#### **3.6.2.6 Stover yield (q 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 q ha<sup>-1</sup>.

### **3.7 Computation**

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

The CGR denotes overall growth rate of the crop plants and calculated after the fixed period of time, irrespective of the previous growth rate. The unit of CGR is g plant<sup>-1</sup>day<sup>-1</sup>. The values were calculated by using following formula as suggested by Leopold and Kridemann (1975) Crop growth rate was calculated from the dry matter accumulation obtained between 0-30, 30-60, 60-90 and 90 DAS to harvest.

$$\text{Crop growth rate (CGR) (g plant}^{-1}\text{day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W<sub>2</sub> – W<sub>1</sub> = Difference in oven dry biomass at the time interval t<sub>2</sub> – t<sub>1</sub> = Time interval in days

#### **3.7.2 Relative growth rate (g g<sup>-1</sup>day<sup>-1</sup>)**

Relative growth rate was observed at 30-60, 60 at harvest. The relative growth rate indicates the increase in dry weight per unit of original dry weight over any specific time interval. The values were computed by using the following formula suggested by Leopold and Kridemann (1975)

$$\text{Relative growth rate (RGR) (g g}^{-1}\text{plant}^{-1}\text{day}^{-1}) = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where,  $\ln$  = Logarithm at base (natural log)

$W_2 - W_1$  = Difference in oven dry biomass at the time interval

$t_2 - t_1$  = Time interval in days

### 3.7.3 Harvest index (%)

The harvest index was determined by using the formula given by Donald (1962). Harvest index (%) =  $\frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$  Where, Economic yield = Seed yield (kg ha<sup>-1</sup>) Biological yield = Seed yield + Stover yield (kg ha<sup>-1</sup>)

## 3.8 Economics

The economics of soybean crop production pertaining to each of the treatments has been worked out in terms of cost of cultivation. Gross return (Rs ha<sup>-1</sup>) was obtained by converting the harvested produce into monetary terms at the prevailing market rate during the course of studies for every treatment. Net return was obtained by deducting cost of cultivation from the gross return, gross realization, net realization (Rs ha<sup>-1</sup>) based on the current market prices of the fertilizers, prevailing wages of labours and market price of the produce.

### 3.8.1 Cost of cultivation (Rs ha<sup>-1</sup>)

The different variable expenses of items were considered when calculating the economics. The cost includes spending on seeds, manures, fertilizers, and labor costs, and was considered at the prevailing market price and reported in Rs ha<sup>-1</sup>.

Cost of cultivation = Fixed cost + variable cost

### 3.8.2 Gross return (Rs ha<sup>-1</sup>)

Gross returns are calculated by multiplying the yield of grain and straw with the respective prevailing market prices (Perin *et al.* 1979). Gross returns are given as Rs ha<sup>-1</sup>.

Gross return = Seed yield (q ha<sup>-1</sup>) x Price of seed (Rs q<sup>-1</sup>)

### 3.8.3 Net return (Rs ha<sup>-1</sup>)

The net returns hectare<sup>-1</sup> was determined by subtracting production costs from the gross returns and reported as Rs ha<sup>-1</sup>.

Net return (Rs ha<sup>-1</sup>) = Gross return (Rs ha<sup>-1</sup>) – Cost of cultivation (Rs ha<sup>-1</sup>)

### 3.8.4 Benefit: Cost ratio

Benefit-cost ratio (BCR) was expanded using the following formula:

$$B: C \text{ ratio} = \frac{\text{Gross return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

### 3.9 Statistical analysis

The data collected from field observation and that recorded in laboratory subjected to statistical analysis of variance technique as described in “Statistical Procedures for Agriculture Research” by Gomez and Gomez (1984). For significant treatment effects, standard error of mean (SEm±) and critical differences were calculated at 5% level of significance.

#### The skeleton of the analysis of variance

#### Source of Variation DF SS MSS F Calculated F Tabulated (5%)

Replication (r) (r-1) RSS RMS RMS/EMS

Treatment (t) (t-1) TrSS TrMS TrMS/EMS

Error (r-1)(t-1) ESS EMS Total rt-1TSS

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

(a)  $SEm\pm = \sqrt{EMS/r}$

(b)  $CD = SE (d) \times t \text{ value at } 5\% \text{ error (df)}$

(c)  $CV (\%) = \sqrt{EMS/GM}$

Where r = Number of replication MSS = Mean sum of square

t = Number of treatment SEm± = Standard error of mean

DF = Degree of freedom EMS = Error mean square

SS = Sum of square CD = Critical difference

## CHAPTER -IV RESULTS AND DISCUSSION

A field experiment entitled “**Evaluation of bio-efficacy of MACARENA (Bio-stimulant) along with herbicides on Soybean**” was conducted during *kharif* 2019 at Instructional-cum-Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The results obtained during the course of investigation were analyzed and data are presented in this chapter with the help of tables as well as figures. The evaluation of results suggests certain explanations based on the available evidences. The observed variations in the various characteristics of soybean are considered to infer some cause and effect relationships that may be further evaluated for improvement in our understanding and production of soybean.

### 4.1: Pre-harvest observation

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

The data on plant population of soybean observed at 30 DAS and at harvest are presented in Table 4.1 The data on plant population remained unaffected due to application of different herbicides at 30 DAS and at harvest.

**Table 4.1: Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on plant population of soybean.**

Treatment	Plant population (cm <sup>2</sup> ) 30 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	22.45
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	20.83
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	20.67
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	22.33
T <sub>5</sub> - MACARENA @ 625ml/ha	20.50
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	21.83
T <sub>7</sub> - Weedy check	20.76
<b>SE m±</b>	<b>0.60</b>
<b>CD (P=0.05)</b>	<b>NS</b>

#### 4.1.2 Plant height

At 30 DAS , there was no significant effect of herbicides on the height of crop growth. At 60 DAS T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha produced significantly taller plants than rest of the treatment, but it was *at par* with T<sub>4</sub>-Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha and T<sub>6</sub>- Two hand weeding at 20 and 40DAS. At harvest same trend was obtained with two *at par* i.e . T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha and T<sub>4</sub>-Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha.

The maximum plant height in above treatments might be due to the favorable growing conditions in view of low crop-weed competition and weed free environment height under untreated control could be due to the competitive stress for available resources shared by the weeds (Singh *et al.*, 2003).

**Table 4.2 Evaluation of bio-efficacy of MACARENA( bio-stimulant) along with herbicides on plant height of soybean.**

Treatment	Plant height (cm)		
	30 DAS	60 DAS	At harvest
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	48.27	72.27	81.53
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	36.27	61.13	73.13
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	35.93	60.00	73.13
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	36.60	71.00	79.07
T <sub>5</sub> - MACARENA @ 625ml/ha	35.93	59.87	72.93
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	36.47	62.27	73.40
T <sub>7</sub> - Weedy check	35.60	58.07	72.27
<b>SE m±</b>	<b>2.39</b>	<b>3.40</b>	<b>1.78</b>
<b>CD (P=0.05)</b>	<b>NS</b>	<b>10.10</b>	<b>5.28</b>

#### 4.1.3 Number of branches (plant<sup>-1</sup>)

The data on number of branches of soybean recorded at 30, 60 DAS and at harvest as affected by application of herbicides are presented in Table 4.3 Different treatment of herbicides showed significant impact on number of branches at all the stages of soybean.

The result revealed that at 30 DAS there was no significant effect of treatment on soybean. While at 60 DAS treatment T<sub>1</sub>-Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha gave significantly higher number of branches than others at 30, 60 DAS and at harvest. However, it was *on par* to treatment T<sub>7</sub>- weedy check and at harvest same trend was observed.

The highest number of branches plant<sup>-1</sup> was observed under T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625ml/h at 60 DAS and at harvest and in comparable to treatments might be due to the reduction in crowding effect or weed population among the crop plants, which facilitate more space, nutrients, light, and moisture and reduces the competition ultimately resulting in more number of branches plant<sup>-1</sup>. These results are conformlty with those reported by Vyas and Jain (2003), Kushwah and Vyas (2005) and Vyas and Kushwah (2008).

**Table 4.3 Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on number of branches per plant of soybean.**

Treatment	Number of branches plant <sup>-1</sup>		
	30 DAS	60 DAS	At harvest
T- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.00	1.80	3.33
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.00	1.73	3.27
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	1.00	1.67	3.20
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.00	1.73	3.33
T <sub>5</sub> - MACARENA @ 625ml/ha	1.00	1.67	2.93
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.00	1.73	3.27
T <sub>7</sub> - Weedy check	1.00	1.57	2.67
<b>SE m±</b>	<b>00</b>	<b>0.07</b>	<b>0.19</b>
<b>CD (P=0.05)</b>	<b>NS</b>	<b>0.22</b>	<b>0.58</b>

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

The data on dry matter accumulation of soybean recorded at 30,60 DAS and at harvest are presented in Table 4.4 In general, dry matter increased up to at harvest.

The dry matter accumulation under T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha found highest which was at par with T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha and T<sub>6</sub>- Two hand weeding at 20 and 40 DAS at 30 DAS. However, at 60 DAS and at harvest, maximum dry matter accumulation was recorded under T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha followed by T<sub>6</sub>- Two hand weeding at 20 and 40 DAS and T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha and lowest dry matter accumulation was recorded under T<sub>7</sub>- weedy check.

The higher dry matter accumulation plant<sup>-1</sup> in above treatments might be due to lesser population of weeds which facilitate better utilization of resources and reduces the competition ultimately resulting in more dry matter accumulation plant<sup>-1</sup>.

Similar results have been reported by Mandloi *et al.* (2000), Tiwari *et al.* (2006) and Deore *et al.* (2008). The lowest dry matter accumulation was recorded under untreated control at all the time intervals of observations. It might be due to adverse effect of excessive crop-weed competition as evident from maximum dry matter production of weeds which resulted in reduction of nutrient uptake and dry matter accumulation by crop. Similar results have been reported by Deore *et al.* (2008).

#### 4.4 Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicide on dry matter accumulation of soybean.

Treatment	Dry matter accumulation (g plant <sup>-1</sup> )		
	30 DAS	60 DAS	At harvest
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	2.38	22.75	32.23
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.41	18.21	25.35
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	0.98	18.12	23.87
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.59	21.08	31.14
T <sub>5</sub> - MACARENA @ 625ml/ha	0.60	17.64	23.62
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.42	20.62	28.08
T <sub>7</sub> - Weedy check	1.12	14.71	19.53
<b>SE m±</b>	<b>0.26</b>	<b>0.47</b>	<b>0.66</b>
<b>CD (P=0.05)</b>	<b>NS</b>	<b>1.42</b>	<b>1.97</b>

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

Crop growth rate showed increasing trend up to 60 DAS and declined there after till harvest (fig 4.1). During 0-30 DAS, numerically highest values were obtained under T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha found highest which was at par with T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha and T<sub>6</sub>- Two hand weeding at 20 and 40 DAS at 30 DAS. minimum crop growth rate was registered under T<sub>7</sub>. Declined crop growth rate was caused by ageing in crop due to senescence of leaves which might have resulted due to competition from weeds for various growth factors *i.e.* solar radiation, nutrient, and water etc.

**Fig.4.1 Evaluation of bio-efficacy of MACARENA ( bio-stimulant) along with herbicides on crop growth rate at different duration of soybean.**

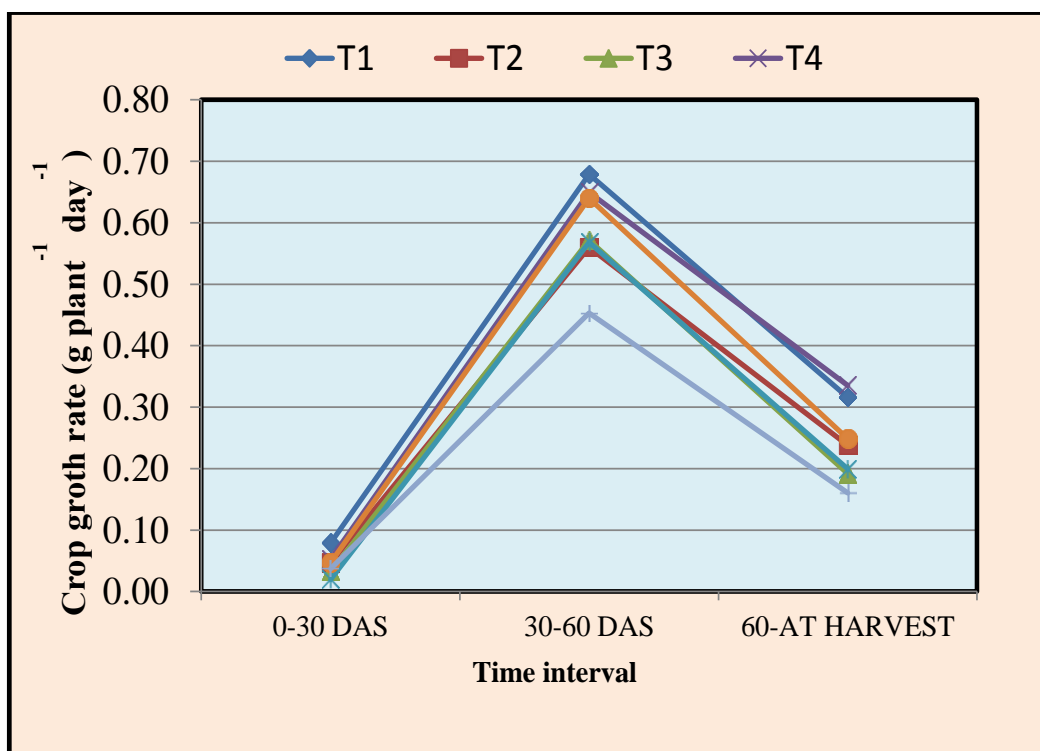
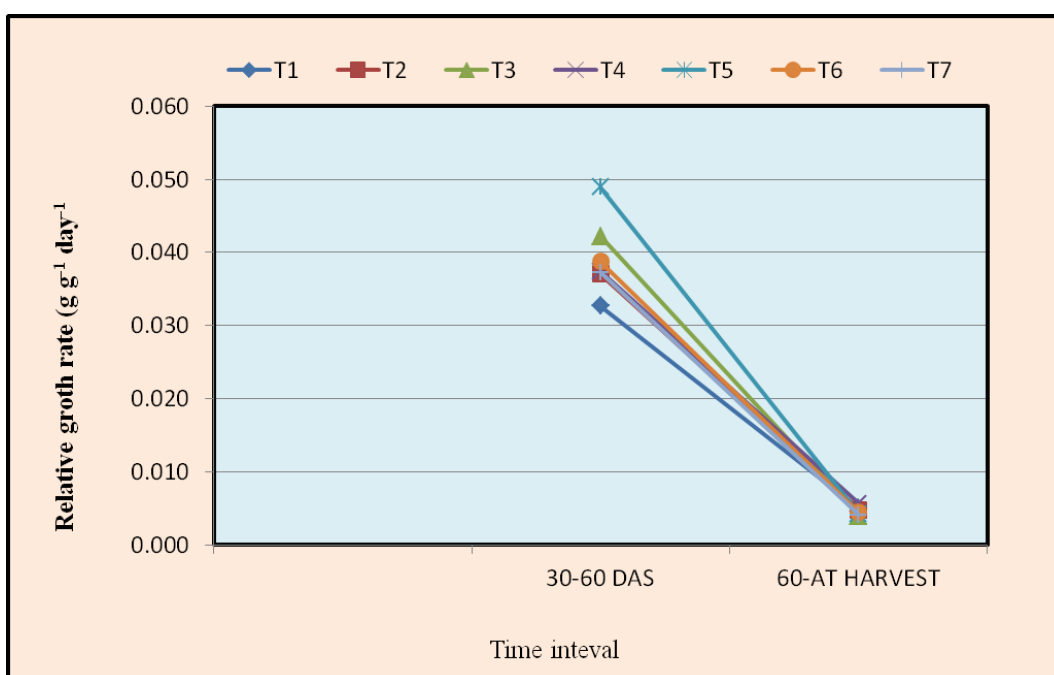


Fig Crop growth rate

#### 4.1.6 Relative growth rate ( $\text{g g}^{-1} \text{ plant}^{-1} \text{ day}^{-1}$ )

During 30-60 DAS, numerically maximum relative growth rate was observed under T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha found highest which was at par with T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha and T<sub>6</sub>- Two hand weeding at 20 and 40 DAS at 30 DAS. Minimum relative growth rate was registered under T<sub>7</sub>-weed check (fig 4.2).

Relative growth rate of soybean in above treatments was higher because of comparatively less crop-weed competition, which allowed more utilization of light, water and nutrient as well as more number of leaves available for photosynthesis, which resulted into more carbohydrate production. The increased sink size, stored the photo synthates very effectively and ultimately transformed in the shape of more dry matter accumulation which resulted in higher relative growth rate.



**Fig 4.2 Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on relative growth rate at different duration of soybean.**

#### 4.1.7 Leaf area (plant<sup>-1</sup>)

The data on leaf area of soybean recorded at 30 and 60 DAS are presented in Table 4.5. At 30 and 60 DAS, there was no effect of herbicides on leaf area of soybean.

**Table 4.5 Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on leaf area per plant of soybean.**

Treatment	Leaf area plant <sup>-1</sup> (cm <sup>-2</sup> )	
	30 DAS	60 DAS
T <sub>1</sub> - Sodium Acifluorfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	130.67	435.33
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	122.33	426.67
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	120.33	420.33
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	125.00	433.67
T <sub>5</sub> - MACARENA @ 625ml/ha	119.67	417.33
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	124.67	430.13
T <sub>7</sub> - Weedy check	118.67	411.33
<b>SE m±</b>	<b>1.58</b>	<b>3.20</b>
<b>CD (P=0.05)</b>	<b>NS</b>	<b>9.75</b>

## 4.2: Post-harvest observation

### 4.2.1 Number of pods plant<sup>-1</sup>

The data on number of pods plant<sup>-1</sup> of soybean as affected by application of new herbicides are presented in Table 4.6. Significant result was observed for number pods plant<sup>-1</sup>.

The maximum number of pods plant<sup>-1</sup> was recorded in T<sub>1</sub>- Sodium Acifluorfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha which was at par with T<sub>2</sub>- Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha, T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha and T<sub>6</sub>- Two hand weeding at 20 and 40 DAS. This was followed by T<sub>3</sub>- Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha and T<sub>5</sub>- MACARENA @ 625ml/ha. The minimum number of pods plant<sup>-1</sup> was recorded in T<sub>7</sub>- weedy check.

This result may be due to the less competition at critical periods of crop growth and better suppression of weeds, which allowed the crop to grow their

potential by absorbing sufficient nutrients, light, moisture and space which facilitate more translocation of photosynthates towards the reproductive parts as well as presence of favourable agro-climatic conditions due to removal of weeds, led to more number of pods plant<sup>-1</sup>. Similar results have been reported by Kumar *et al.* (2001), Vyas and Jain (2003) and Kothawade *et al.* (2006).

#### 4.2.2 Number of seeds pod<sup>-1</sup>

The data on number of seeds pod<sup>-1</sup> of soybean as affected by application of herbicides are presented in Table 4.6 There was significant result was observed for number seeds pod<sup>-1</sup>.

The maximum number of seeds pods<sup>-1</sup> was noted in treatment T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha which was statistically comparable to T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha. This was followed by T<sub>6</sub>- Two hand weeding at 20 and 40 DAS and T<sub>2</sub>- Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha. However, the minimum number of seeds pod<sup>-1</sup> was recorded in T<sub>7</sub>- weedy check.

#### 4.2.3 100- seed weight (g)

Data on 100- seed weight are presented in Table 4.6 Test weight of soybean seeds was influenced due to different herbicides.

Data showed that maximum seed index was recorded on T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha which was at par with T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha, T<sub>6</sub>- Two hand weeding at 20 and 40DAS, T<sub>2</sub>- Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha and T<sub>3</sub>- Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha. This was followed by T<sub>5</sub>- MACARENA @ 625ml/ha and minimum was recorded under T<sub>7</sub>- weedy check.

**Table 4.6 Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on yield attributing characters of soybean.**

Treatment	Pods plant <sup>-1</sup> (No.)	Seed pod <sup>-1</sup> (No.)	Seed index 100 seeds (g)
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	53.80	2.77	12.15
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	49.53	2.33	11.23
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	47.13	2.32	11.13
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	50.20	2.63	11.53
T <sub>5</sub> - MACARENA @ 625ml/ha	46.00	2.27	10.20
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	49.60	2.57	11.44
T <sub>7</sub> - Weedy check	45.80	2.23	9.98
<b>SE m±</b>	<b>1.65</b>	<b>0.06</b>	<b>0.37</b>
<b>CD (P=0.05)</b>	<b>4.91</b>	<b>0.19</b>	<b>1.08</b>

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

The data on seed yield influenced by different new herbicides are presented in Table 4.7. Data revealed that there is considerable effect on seed yield of soybean due to new herbicide application.

Data showed that treatment T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha which is at par with T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha. This is followed by T<sub>6</sub>- Two hand weeding at 20 and 40DAS and T<sub>2</sub>- Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha. The lowest seed yield was recorded in T<sub>7</sub>- weedy check.

Similar findings were also reported by Dubey *et al.* (2000), Mandloi *et al.* (2000), Kumar *et al.* (2001), Gaikward and Powar (2002), Raskar and Bhoi (2002), Tiwari *et al.* (2006), Karande *et al.* (2008), Dhane *et al.* (2009) and Yadav *et al.* (2009).

Higher seed yield under above treatments was due to the weed managed at critical period and early crop growth, higher dry matter production, high growth in terms of LAI, which resulted in higher production of photosynthesis, which acts as a source and greater translocation of food materials to the reproductive parts

resulted in superiority of yield attributing characters and ultimately high yield. Lower weed population and higher weed control efficiency also resulted in higher grain yield.

Contrarily, the poor growth of plants as well as development of yield attributing characters in weedy check might be due to less moisture, nutrient, space and light availability at the time of flowering and pod development adversely influenced the seed yield. The lower seed yield under weedy check may be due to the high weed interference.

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

The data on stover yield are presented in Table 4.7 With different new herbicides application, there was significant result was recorded for stover yield.

The maximum stover yield was recorded in T<sub>1</sub>- Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha and T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha. Both the treatment are at par, which was followed by T<sub>2</sub>- Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha and T<sub>3</sub>- Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha. The lowest stover yield was recorded in T<sub>7</sub>- weedy check.

The higher stover yield in above treatments might be due to lesser weeds during early crop growth period and give higher yield attributes and pod yield which leads to higher stover yield. While, in weedy check reverse trend was observed and therefore, the lowest stover yield was noted under this treatment. Similar findings were reported by Dhane *et al.* (2009).

#### **4.2.6: Harvest index (%)**

The data on harvest index are presented in Table 4.7 Non-significant variation was observed in harvest index due to application of different herbicides.

**Table 4.7 :Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on seed yield . stover yield and harvest index of soybean.**

Treatment	Seed yield (kg ha <sup>-1</sup> )	Stover yield (kg ha <sup>-1</sup> )	Harvest index (%)
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha +MACARENA @ 625ml/ha	1930	3870	33.28
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+MACARENA @ 625ml/ha	1600	3560	31.01
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	1470	3410	30.12
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1830	3860	32.16
T <sub>5</sub> - MACARENA @ 625ml/ha	1350	2920	31.62
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1650	3280	33.47
T <sub>7</sub> - Weedy check	411	804	33.83
<b>SE m±</b>	<b>43</b>	<b>89</b>	<b>-</b>
<b>CD (P=0.05)</b>	<b>124</b>	<b>262</b>	<b>NS</b>

### 4.3 Weed Studies

#### 4.3.1 Weed flora composition

The predominant weed species recorded in the experimental field were *Echinochloa colonum*, *Cyperus rotundus*, *Parthenium hysterophorus* L., *Digera arvensis*, *Celosia argentea*, and *Alternanthera spp.* are present in Table 4.8. The most dominant weed found in experimental field were *Alternanthera spp.* followed by *Parthenium hysterophorus* L. and *Celosia argentea*.

At harvest, the major weed species, which infested the field, were *Alternanthera spp.*, *Parthenium hysterophorus* L. and *Celosia argentea*.. Floristic composition of experimental field represented in below

**Table 4.8: Weeds species observed in the experimental field**

S No.	Scientific name	Famly	Common name
<b>Grasess</b>			
1.	<i>Echinochloa colonum</i> (L.)	Poaceae	Sawa
<b>Sedges</b>			
2.	<i>Cyperus rotundus</i> L.	Cyperaceae	Motha
<b>Broad leaf</b>			
3.	<i>Parthenium hysterophorus</i> L.	Asteraceae	Gajar ghash
4.	<i>Digera arvensis</i>	Amaranthaceae	Amaranthace
5.	<i>Celosia argentea</i>	Amaranthaceae	Siliari
6.	<i>Alternanthera spp</i>	Amaranthaceae	Reshmkata

### 4.3.2 Total and species wise weed density (No.m<sup>-2</sup>)

Total and species wise weed density were recorded at 30, 60 and 90 DAS. Total weed density as affected by different weed management practices are presented below. Whereas, species wise weed density have been presented in Table 4.9 to 4.15 It was observed that infestation of weeds was increased with time in all the treatments but the density of *Echinochloa colonum*, *Cyperus rotundus* and *Digera arvensis* was decreased at 90 DAS because of its short duration ontogeny. In general, minimum weed density was observed under hand weeding twice at 20 and 40 DAS (T<sub>6</sub>) and maximum in weedy check (T<sub>7</sub>) throughout the period of investigation irrespective to the time intervals of observations.

#### 4.3.2.1 Total weed density (No. m<sup>-2</sup>)

Total weed density of *Echinochloa colonum*, *Cyperus rotundus*, *Parthenium hysterophorus* L., *Digera arvensis*, *Celosia argentea*, and *Alternanthera spp.* were recorded at 30, 60 and 90 DAS and data are presented in Table 4.9 The total weed density was significantly influenced by different weed management treatments during all the stages of observations.

At 30 DAS minimum total weed density was observed under two hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>), and the maximum total weed density was recorded under Weedy check (T<sub>7</sub>). At 60 and 90 DAS, the significantly minimum total weed density was observed under two hand weeding at 20 and 40 DAS (T<sub>6</sub>). And the maximum total weed density was recorded under Weedy check (T<sub>7</sub>). The hand weeding twice at 20 and 40 DAS (T<sub>7</sub>), which was significantly superior for weed control over other treatments, while, it was inferior under weedy check (T<sub>7</sub>) as compared to others treatments. These results were in accordance to the findings of Hassan and Khan (2007), Singh *et al.* (2011).

**Table 4.9: Total weed population in Soybean as influenced by different weed control measures.**

Treatment	Weed population (No.m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	3.94 (15.00)	6.04 (36.00)	5.61 (31.00)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	5.15 (26.00)	6.96 (48.00)	6.52 (42.00)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	5.52 (30.00)	7.31 (53.00)	6.96 (48.00)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	4.53 (20.00)	6.36 (40.00)	6.20 (38.00)
T <sub>5</sub> - MACARENA @ 625ml/ha	6.12 (37.00)	8.22 (67.00)	7.18 (51.00)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	3.24 (10.00)	2.35 (5.00)	2.74 (7.00)
T <sub>7</sub> - Weedy check	6.75 (45.00)	8.51 (72.00)	7.65 (58.00)
<b>SEm±</b>	<b>0.29</b>	<b>0.35</b>	<b>0.34</b>
<b>CD (P=0.05)</b>	<b>0.85</b>	<b>1.05</b>	<b>1.01</b>

#### 4.3.2.2 Species wise weed density (No. m<sup>-2</sup>)

##### 4.3.2.2.1: *Echinochloa colonum* (No. m<sup>-2</sup>)

The data revealed from the table and observations is present in below Table 30 DAS, the significantly lowest density of *Echinochloa colonum* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>), Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha (T<sub>2</sub>), Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>3</sub>) and Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>4</sub>). Highest density of *Echinochloa colonum* was observed under weedy check (T<sub>7</sub>). At 60 DAS, the significantly lowest density of *Echinochloa colonum* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>3</sub>) and Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>4</sub>). Highest density of

*Echinochloa colonum* was observed under weedy check (T<sub>7</sub>). At 90 DAS, the significantly lowest density of *Echinochloa colonum* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>), Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>3</sub>) and Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>4</sub>). Highest density of *Echinochloa colonum* was observed under weedy check (T<sub>7</sub>).

**Table 4.10: Density of *Echinochloa colonum* in Soybean as influenced by different weed control measures**

Treatment	Weed population (No.m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	0.71 (0.00)	2.35 (5.00)	1.22 (1.00)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.58 (2.00)	3.24 (10.00)	1.58 (2.00)
T <sub>3</sub> -Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	0.71 (0.00)	1.87 (3.00)	1.22 (1.00)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	0.71 (0.00)	1.87 (3.00)	1.58 (2.00)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.55 (6.00)	3.67 (13.00)	1.22 (1.00)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.58 (2.00)	1.58 (2.00)	1.22 (1.00)
T <sub>7</sub> - Weedy check	2.74 (7.00)	3.54 (12.00)	1.58 (2.00)
SEm±	<b>0.12</b>	<b>0.10</b>	<b>0.06</b>
CD (P=0.05)	<b>0.34</b>	<b>0.30</b>	<b>0.17</b>

#### 4.3.2.2.2: *Alternanthera sessilis*

The data revealed from the table and observations is present in below Table. At 30, 60 and 90 DAS, the significantly lowest density of *Alternanthera sessilis* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par treatment. Highest density of *Alternanthera sessilis* observed under weedy check (T<sub>7</sub>). This similar trend of sequence is observed in the growth stages of crop.

**Table 4.11: Density of *Alternanthera sessilis* in Soybean as influenced by different weed control measures**

Treatment	Weed population (No.m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	2.12 (4.00)	2.55 (6.00)	2.74 (7.00)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	2.35 (5.00)	2.35 (5.00)	2.55 (6.00)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.55 (6.00)	3.54 (12.00)	3.67 (13.00)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	2.35 (5.00)	2.74 (7.00)	2.92 (8.00)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.92 (8.00)	3.67 (13.00)	3.81 (14.00)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.58 (2.00)	1.22 (1.00)	1.58 (2.00)
T <sub>7</sub> - Weedy check	3.24 (10.00)	3.67 (13.00)	3.81 (14.00)
<b>SEm±</b>	<b>0.12</b>	<b>0.14</b>	<b>0.17</b>
<b>CD (P=0.05)</b>	<b>0.35</b>	<b>0.41</b>	<b>0.50</b>

#### 4.3.2.2.3: *Parthenium hysterophorus*

The data revealed from the table and observations is present in below Table. At 30 DAS, the significantly lowest density of *Parthenium hysterophorus* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>) and Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>4</sub>). And highest density of *Parthenium hysterophorus* was observed under Weedy check (T<sub>7</sub>). At 60 and 90 DAS, the significantly lowest density of *Parthenium hysterophorus* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par. Highest density of *Parthenium hysterophorus* observed under weedy check (T<sub>7</sub>).

**Table 4.12: Density of *Parthenium hysterophorus* in Soybean as influenced by different weed control measures**

Treatment	Weed population (No.m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.22 (1.00)	2.35 (5.00)	2.55 (6.00)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	2.55 (6.00)	3.94 (15.00)	4.06 (16.00)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.35 (5.00)	3.94 (15.00)	4.18 (17.00)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	2.35 (5.00)	2.35 (5.00)	2.74 (7.00)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.12 (4.00)	3.39 (11.00)	3.54 (12.00)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.87 (3.00)	0.71 (0.00)	0.71 (0.00)
T <sub>7</sub> - Weedy check	2.92 (8.00)	3.81 (14.00)	3.94 (15.00)
<b>SEm±</b>	<b>0.11</b>	<b>0.13</b>	<b>0.17</b>
<b>CD (P=0.05)</b>	<b>0.32</b>	<b>0.39</b>	<b>0.51</b>

#### 4.3.2.2.4: *Digra arvensis*

The data revealed from the table and observations is present in below Table. At 30, 60 and 90 DAS, the significantly lowest density of *Digra arvensis* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par. Highest density of *Digra arvensis* observed under weedy check (T<sub>7</sub>). This similar trend of sequence is observed in the growth stages of crop

**Table 4.13: Density of *Digra arvensis* in Soybean as influenced by different weed control measures**

Treatment	Weed population (No.m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	2.35 (5.00)	2.92 (8.00)	3.08 (9.00)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	2.12 (4.00)	2.74 (7.00)	2.92 (8.00)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.74 (7.00)	2.55 (6.00)	2.74 (7.00)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha +MACARENA @ 625ml/ha	2.12 (4.00)	2.92 (8.00)	3.08 (9.00)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.55 (6.00)	3.24 (10.00)	3.39 (11.00)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	0.71 (0.00)	1.22 (1.00)	1.58 (2.00)
T <sub>7</sub> - Weedy check	2.35 (5.00)	3.24 (10.00)	3.54 (12.00)
<b>SEm±</b>	<b>0.10</b>	<b>0.14</b>	<b>0.14</b>
<b>CD (P=0.05)</b>	<b>0.29</b>	<b>0.41</b>	<b>0.43</b>

#### 4.3.2.2.5. *Celosia argentea*

The data revealed from the table and observations is present in below Table. At 30 DAS, the significantly lowest density of *Celosia argentea* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>) and Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>4</sub>). Highest density of *Celosia argentea* was observed under weedy check (T<sub>7</sub>). At 60 and 90 DAS, the significantly lowest density of *Celosia argentea* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par . Highest density of *Celosia argentea* observed under weedy check (T<sub>7</sub>).

**Table 4.14: Density of *Celosia argentea* in Soybean as influenced by different weed control measures**

Treatment	Weed population (No.m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.58 (2.00)	2.35 (5.00)	2.55 (6.00)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	2.35 (5.00)	2.74 7.00	3.08 (9.00)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.92 (8.00)	2.74 (7.00)	2.92 (8.00)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha +MACARENA @ 625ml/ha	1.58 (2.00)	3.08 (9.00)	3.24 (10.00)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.92 (8.00)	3.24 (10.00)	3.39 (11.00)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.58 (2.00)	1.22 (1.00)	1.58 (2.00)
T <sub>7</sub> - Weedy check	2.55 (6.00)	3.67 (13.00)	3.81 (14.00)
<b>SEm±</b>	<b>0.13</b>	<b>0.12</b>	<b>0.19</b>
<b>CD (P=0.05)</b>	<b>0.39</b>	<b>0.36</b>	<b>0.59</b>

**4.3.2.2.6: *Cyperus rotundus***

The data revealed from the table and observations is present in below Table. At 30, 60 and 90 DAS, the significantly lowest density of *Cyperus rotundus* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par treatment. Highest density of *Cyperus rotundus* observed under weedy check (T<sub>7</sub>). This similar trend of sequence is observed in the growth stages of crop

**Table 4.15: Density of *Cyperus rotundus* in Soybean as influenced by different weed control measures**

Treatment	Weed population (No.m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.87 (3.00)	2.74 (7.00)	1.58 (2.00)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	2.12 (4.00)	2.12 4.00	1.22 (1.00)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.12 (4.00)	3.24 (10.00)	1.58 (2.00)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	2.12 (4.00)	2.92 (8.00)	1.58 (2.00)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.35 (5.00)	3.24 (10.00)	1.58 (2.00)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.22 (1.00)	0.71 (0.00)	0.71 (0.00)
T <sub>7</sub> - Weedy check	3.08 (9.00)	3.24 (10.00)	1.22 (1.00)
<b>SEm±</b>	<b>0.09</b>	<b>0.12</b>	<b>0.08</b>
<b>CD (P=0.05)</b>	<b>0.27</b>	<b>0.35</b>	<b>0.23</b>

### 4.3.3 Total and species wise dry matter accumulation of weeds (g m<sup>-2</sup>)

The extent of dry matter accumulation of weeds denotes the competition greater is the competition between crop and weeds. The yield reduction of crop was directly related to the dry matter accumulation of weeds rather than density of weeds along. The total dry matter accumulation of weeds at different time intervals are presented in Table 4.8 and species wise dry matter accumulation are presented in Table 4.3.9 to 4.3.15.

#### 4.3.3.1. Total weeds dry matter accumulation (g m<sup>-2</sup>)

The total weed dry matter accumulation was significantly influenced by different weed management treatments at 30, 60 and 90 DAS and data are presented in Table 4.16 Significantly higher total dry matter of weed species namely *Echinochloa colonum*, *Cyperus rotundus*, *Parthenium hysterophorus L.*, *Digera arvensis*, *Celosia argentea*, and *Alternanthera spp.* were observed under treatments as compared to weedy check (T<sub>7</sub>). At 30, 60 and 90 DAS, the

significantly lowest dry matter accumulation under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par . Highest dry matter accumulation under weedy checks (T<sub>7</sub>). This similar trend of sequence is observed in the growth stages of crop.

**Table 4.16: Total weeds dry weight of Soybean as influenced by different weed control measures**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30DAS	60 AS	90 AS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	3.21 (9.80)	4.82 (22.72)	8.42 (70.45)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	4.11 (16.36)	5.68 (31.72)	8.14 (65.68)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	4.69 (21.54)	5.76 (32.66)	10.59 (111.57)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	3.72 (13.35)	5.33 (27.95)	10.24 (104.34)
T <sub>5</sub> - MACARENA @ 625ml/ha	4.92 (23.69)	6.96 (47.97)	11.09 (122.42)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.58 (2.00)	2.43 (5.40)	5.29 (27.51)
T <sub>7</sub> - Weedy check	5.12 (25.71)	7.68 (58.53)	12.55 (156.90)
<b>SEm±</b>	<b>0.25</b>	<b>0.27</b>	<b>0.53</b>
<b>CD (P=0.05)</b>	<b>0.73</b>	<b>0.80</b>	<b>1.59</b>

#### 4.3.3.2. Species wise dry matter accumulation of weeds (g m<sup>-2</sup>)

##### 4.3.3.2.1. *Echinochloa colonum*

The data revealed from the table and observations is present in below Table. At 30 DAS, the significantly lowest dry matter accumulation of *Echinochloa colonum* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>) and Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>3</sub>). Highest dry matter accumulation of *Echinochloa colonum* was observed under weedy check (T<sub>7</sub>). At 60 DAS, the significantly lowest dry matter accumulation of *Echinochloa colonum* was observed in the treatment under hand weeding at 20 and

40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>). Highest dry matter accumulation of *Echinochloa colonum* was observed under Weedy check (T<sub>7</sub>). At 90 DAS, the significantly lowest dry matter accumulation of *Echinochloa colonum* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>), Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>4</sub>) and MACARENA @ 625ml/ha (T<sub>5</sub>). And highest dry matter accumulation of *Echinochloa colonum* was observed under weedy check (T<sub>7</sub>).

**Table 4.17: Dry matter accumulation of *Echinochloa colonum* in Soybean as influenced by different weed control measures**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30 DAS	60 AS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	0.71 (0.00)	1.35 (1.32)	1.95 (3.32)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	2.52 (5.87)	3.14 (9.37)	2.39 (5.21)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	0.71 (0.00)	2.61 (6.33)	2.32 (4.88)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.87 (3.01)	2.51 (5.78)	1.90 (3.12)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.83 (7.53)	2.99 (8.43)	1.96 (3.35)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	0.91 (0.32)	1.58 (2.01)	1.90 (3.12)
T <sub>7</sub> - Weedy check	2.74 (7.03)	2.85 (7.63)	2.20 (4.32)
<b>SEm±</b>	<b>0.09</b>	<b>0.14</b>	<b>0.10</b>
<b>CD (P=0.05)</b>	<b>0.25</b>	<b>0.43</b>	<b>0.30</b>

#### 4.3.3.2.2 *Alternanthera sessilis*

The data revealed from the table and observations is present in below Table. At 30, 60 and 90 DAS, the significantly lowest density of *Alternanthera sessilis* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par. Highest density of *Alternanthera sessilis* observed

under Weedy check (T<sub>7</sub>). This similar trend of sequence is observed in the growth stages of weed.

**Table 4.18: Dry matter accumulation of *Alternanthera sessilis* in Soybean as influenced by different weed control measures**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.89 (3.08)	1.91 (3.15)	4.35 (18.45)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.55 (1.91)	2.54 (5.97)	4.10 (16.30)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	1.90 (3.11)	2.67 (6.64)	5.59 (30.78)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.91 (3.14)	2.30 (4.77)	5.17 (26.23)
T <sub>5</sub> - MACARENA @ 625ml/ha	1.66 (2.25)	3.22 (9.89)	5.81 (33.21)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	0.94 (0.38)	1.41 (1.50)	2.95 (8.23)
T <sub>7</sub> - Weedy check	1.80 (2.74)	3.08 (8.96)	5.88 (34.12)
<b>SEm±</b>	<b>0.08</b>	<b>0.11</b>	<b>0.25</b>
<b>CD (P=0.05)</b>	<b>0.24</b>	<b>0.32</b>	<b>0.74</b>

#### 4.3.3.2.3. *Parthenium hysterophorus*

The data revealed from the table and observations is present in below Table. At 30, 60 and 90 DAS, the significantly lowest density of *Parthenium hysterophorus* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par. Highest density of *Parthenium hysterophorus* observed under weedy check (T<sub>7</sub>). This similar trend of sequence is observed in the growth stages of weed.

**Table 4.19: Dry matter accumulation of *Parthenium hysterophorus* in Soybean as influenced by different weed control measures**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30 DAS	60 DAS	90 AS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.55 (1.90)	2.58 (6.14)	4.20 (17.12)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.47 (1.66)	2.60 (6.26)	4.76 (22.12)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.54 (5.95)	2.36 (5.06)	5.72 (32.23)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.46 (1.63)	3.10 (9.13)	5.07 (25.24)
T <sub>5</sub> - MACARENA @ 625ml/ha	1.38 (1.41)	3.09 (9.04)	5.39 (28.53)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	1.03 (0.56)	0.71 (0.00)	0.71 (0.00)
T <sub>7</sub> - Weedy check	2.08 (3.81)	3.46 (11.50)	6.42 (40.77)
<b>SEm±</b>	<b>0.06</b>	<b>0.11</b>	<b>0.23</b>
<b>CD (P=0.05)</b>	<b>0.19</b>	<b>0.33</b>	<b>0.69</b>

#### 4.3.3.2.4. *Digra arvensis*

The data revealed from the table and observations is present in below Table. At 30 and 90 DAS, the significantly lowest density of *Digra arvensis* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par treatment. And highest density of *Digra arvensis* observed under weedy check (T<sub>7</sub>). At 90 DAS, the significantly lowest dry matter accumulation of *Digra arvensis* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>). and Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha (T<sub>2</sub>). Highest dry matter accumulation of *Digra arvensis* observed under weedy check (T<sub>7</sub>).

**Table 4.20: Dry matter accumulation of *Digra arvensis* in Soybean as influenced by different weed control measures**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.25 (1.07)	1.96 (3.33)	3.58 (12.33)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.66 (2.24)	1.72 (2.47)	2.51 (5.78)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.55 (6.00)	2.16 (4.18)	4.12 (16.45)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.66 (2.26)	1.49 (1.73)	4.22 (17.35)
T <sub>5</sub> - MACARENA @ 625ml/ha	1.89 (3.09)	2.91 (7.99)	5.31 (27.67)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	0.71 (0.00)	1.10 (0.71)	3.04 (8.76)
T <sub>7</sub> - Weedy check	1.86 (2.97)	2.60 (6.27)	5.82 (33.32)
<b>SEm±</b>	<b>0.07</b>	<b>0.09</b>	<b>0.19</b>
<b>CD (P=0.05)</b>	<b>0.21</b>	<b>0.28</b>	<b>0.56</b>

#### 4.3.3.2.5. *Celosia argentea*

The data revealed from the table and observations is present in below Table. At 30 DAS, the significantly lowest dry matter accumulation of *Celosia argentea* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>), however, it was at par with Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>), and at 60 and 90 DAS, the significantly lowest density of *Celosia argentea* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par. Highest density of *Celosia argentea* observed under weedy check (T<sub>7</sub>).

**Table 4.21: Dry matter accumulation of *Celosia argentea* in Soybean as influenced by different weed control measures**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.23 (1.01)	2.26 (4.60)	3.84 (14.22)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.82 (2.83)	2.12 (4.00)	3.66 (12.87)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	1.78 (2.68)	2.18 (4.24)	4.79 (22.45)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.36 (1.34)	1.73 (2.48)	5.26 (27.15)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.20 (4.35)	2.71 (6.82)	5.07 (25.23)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	0.97 (0.45)	1.30 (1.18)	2.81 (7.40)
T <sub>7</sub> - Weedy check	2.17 (4.20)	3.28 (10.25)	6.46 (41.25)
<b>SEm±</b>	<b>0.11</b>	<b>0.14</b>	<b>0.22</b>
<b>CD (P=0.05)</b>	<b>0.31</b>	<b>0.40</b>	<b>0.66</b>

#### 4.3.3.2.6. *Cyperus rotundus*

The data revealed from the table and observations is present in below Table. At 30, 60 and 90 DAS, the significantly lowest density of *Cyperus rotundus* was observed in the treatment under hand weeding at 20 and 40 DAS (T<sub>6</sub>) which was not found any at par. Highest density of *Cyperus rotundus* observed under weedy check (T<sub>7</sub>). This Similar trend of sequence is observed in the growth stages of weed.

**Table 4.22: Dry matter accumulation of *Cyperus rotundus* in Soybean as influenced by different weed control measures**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	1.80 (2.74)	2.16 (4.18)	2.35 (5.01)
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	1.53 (1.85)	2.04 (3.65)	1.97 (3.40)
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	2.07 (3.80)	2.59 (6.21)	2.30 (4.78)
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	1.57 (1.97)	2.14 (4.06)	2.40 (5.25)
T <sub>5</sub> - MACARENA @ 625ml/ha	2.36 (5.06)	2.51 (5.80)	2.22 (4.43)
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	0.89 (0.29)	0.71 (0.00)	0.71 (0.00)
T <sub>7</sub> - Weedy check	2.34 (4.96)	3.80 (13.92)	1.90 (3.12)
<b>SEm±</b>	<b>0.11</b>	<b>0.11</b>	<b>0.12</b>
<b>CD (P=0.05)</b>	<b>0.32</b>	<b>0.31</b>	<b>0.36</b>

**4.3.4: Weed Control Efficiency of soybean as affected by different weeds**

Weed control efficiency of different weed species at 30 and 60 DAS are presented in Table 4.23. The data indicate that highest weed control efficiency was recorded under weed free two hand weeding at 20 and 40 DAS (T<sub>6</sub>) followed by Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>) and Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha (T<sub>4</sub>). And at 90 DAS two hand weeding at 20 and 40 DAS (T<sub>6</sub>) recorded significantly higher weed control efficiency followed by Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha (T<sub>2</sub>) and Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha (T<sub>1</sub>). This might be due to reduced density and dry weight of weeds to some extent with the pre-emergence application of Pendimethalin and Sulfenotrazon. These results are in accordance with the findings of Sharma (2009), Bhutada and Bhale (2013).

**Table 4.23: Weed Control Efficiency of soybean as affected by different weed control measures.**

Treatment	Dry matter accumulation (g m <sup>-2</sup> )		
	30 DAS	60 DAS	90 DAS
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	60.88	59.65	55.65
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	34.70	43.53	55.82
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	19.26	41.88	26.59
T <sub>4</sub> - Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	47.14	49.96	30.64
T <sub>5</sub> - MACARENA @ 625ml/ha	5.44	17.38	19.16
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	92.02	90.38	82.61
T <sub>7</sub> - Weedy check	0.00	0.00	0.00
<b>SEm±</b>	<b>8.00</b>	<b>4.37</b>	<b>7.34</b>
<b>CD (P=0.05)</b>	<b>23.76</b>	<b>12.98</b>	<b>21.82</b>

#### 4.3.5: Economlcs of treatments

The data on the economlcs *viz*, cost of cultivation, gross return, net return, and benefit: cost ratio presented in table 4.24

The cost of cultivation varied according to different herbicide combination and their combinations. Different herbicide combination, hectare<sup>-1</sup> cost of cultivation, was minimum with the application of along weedy check (T<sub>7</sub>) (12,685 Rs/ha<sup>-1</sup>) and increased with increase in the level of herbicide combinations (17,785 Rs/ha<sup>-1</sup>) under two hand weeding at 20 and 40 DAS (T<sub>6</sub>). Gross return increased significantly with each increment in herbicide combination and level. However, further, increase herbicide combination. Maximum gross return (88195 Rs/ha<sup>-1</sup>) was recorded with the application of Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha and maximum net return (71410 Rs/ ha<sup>-1</sup>) with . maximum B:C ratio (5.2).

**Table 4.24: Economlcs of soybean as influenced by different weed control measures.**

<b>Treatment</b>	<b>Gross return (Rs/ha)</b>	<b>Cost of cultivation (Rs/ha)</b>	<b>Net returns (Rs/h)</b>	<b>B:C ratio</b>
T <sub>1</sub> - Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000ml/ha + MACARENA @ 625ml/ha	88195	16785	71410	5.2
T <sub>2</sub> - Imazethapyr 10 SL@ 1000ml/+ MACARENA @ 625ml/ha	75485	16285	59200	4.6
T <sub>3</sub> - Fluazifop-p-butyl 13.4 EC @ 2000ml/ha + MACARENA @ 625ml/ha	70275	15885	54390	4.4
T <sub>4</sub> - Propanil 2.5% EC + Imazethapyr 3.7% ME @ 2000ml/ha + MACARENA @ 625ml/ha	84495	16785	67710	5.0
T <sub>5</sub> - MACARENA @ 625ml/ha	65235	15285	49950	4.2
T <sub>6</sub> - Two hand weeding at 20 and 40 DAS	78835	17785	61050	4.4
T <sub>7</sub> - Weedy check	27892	12685	15207	2.1
<b>SE m±</b>	-	-	-	-
<b>CD (P=0.05)</b>	-	-	-	-

## CHAPTER – V SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH

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The experiment entitled “**Evaluation of bio-efficacy of MACARENA (bio-stimulant) along with herbicides on soybean [*Glycine max* (L.) Merrill].” was carried out during *kharif* season (02 July to 22 October) of 2019 at Instructional cum Research Farm of IGKV, Raipur (CG). The details regarding experimental soil, weather condition, materials used, techniques adopted and various aspect of experiment during the course of investigation are briefly presented in this chapter. Soybean variety ‘JS 97-52’ (Jawahar Soybean 97-52) was grown as a test crop in Randomised block design (RBD) with 7 treatment and 3 replications. The crop was sown manually on 02 July after the onset of monsoon. The row and plant spacing was 30 cm × 10 cm using a seed rate of 75 kg ha<sup>-1</sup>. Recommended dose of 20:60:40 kg N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O ha<sup>-1</sup> was applied through urea, single super phosphate and muriate of potash as basal in rows uniformly to each plot.**

The soil of the experimental field was ‘*Vertisols*’ which is locally known as ‘*Kanhar*’. The soil of the experimental field was sandy clay loam in texture with pH 7.10. It was low in available nitrogen (220 kg ha<sup>-1</sup>), medium in available phosphorus (12.54 kg ha<sup>-1</sup>), and high in potassium (288 kg ha<sup>-1</sup>). Full dose of recommended dose of nitrogen, phosphorous and potassium were applied basally.

The experiment was laid out in Randomized Block Design with three replications and 21 treatments *viz.* Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>), Imazethapyr 10 SL@ 1000 ml/+ MACARENA @ 625 ml/ha (T<sub>2</sub>), Fluazifop-p-butyl 13.4 EC @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>3</sub>), Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), MACARENA @ 625 ml/ha (T<sub>5</sub>), Two hand weeding at 20 and 40DAS (T<sub>6</sub>) and Weedy check (T<sub>7</sub>). Planting geometry was 30 X 10 cm which was sown on 02/08/19 and harvested on 22/10/19. The crop received 1320 mm rainfall during the study period. Various observations were recorded during the investigation

including growth attributes, yield attributes, yields, and economics. Finally, data collected during experimentation were subjected to statistical analysis to draw valid conclusions.

**The salient findings of the present investigation are summarized below:**

1. JS-9752 variety of soybean recorded significantly higher plant height under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>). Which was at par with Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), and lowest plant height under Weedy check (T<sub>7</sub>).
2. At 90 DATS, number of branch plant<sup>-1</sup> (3.33) was recorded significantly maximum under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>), which was at par with Imazethapyr 10 SL@ 1000 ml/+ MACARENA @ 625 ml/ha (T<sub>2</sub>), Fluazifop-p-butyl 13.4 EC @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>3</sub>), Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), MACARENA @ 625 ml/ha (T<sub>5</sub>), and Two hand weeding at 20 and 40 DAS (T<sub>6</sub>).
3. At harvest, significantly maximum dry matter accumulation plant<sup>-1</sup> (32.23 g) was recorded under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>). Which was at par with Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), Two hand weeding at 20 and 40 DAS (T<sub>6</sub>).
4. Among all the treatments, significantly higher leaf area index at 60 DAT was recorded under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>). Which was at par with Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), Two hand weeding at 20 and 40DAS (T<sub>6</sub>).
5. Significantly higher crop growth rate CGR and RGR at different time interval of the crop was registered under T<sub>1</sub>- Sodium Acifluarfan (16.5%) +

Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha found highest which was at par with T<sub>4</sub>- Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha and T<sub>6</sub>- Two hand weeding at 20 and 40 DAS at 30 DAS. Minimum relative growth rate was registered under T<sub>7</sub>-weed check.

6. At harvest, registered significantly maximum number of pod plant<sup>-2</sup> (53.80) was recorded under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>), which was at par with Imazethapyr 10 SL@ 1000 ml/+ MACARENA @ 625 ml/ha (T<sub>2</sub>), Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), Two hand weeding at 20 and 40DAS (T<sub>6</sub>).
7. At harvest, significantly maximum number of seed pod<sup>-2</sup> (53.80) was recorded under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>). which was at par with Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), lowest plant height under weedy check (T<sub>7</sub>).
8. Seed index (100 seed) was recorded significantly maximum under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>), which was at par with Imazethapyr 10 SL@ 1000 ml/+ MACARENA @ 625 ml/ha (T<sub>2</sub>), Fluazifop-p-butyl 13.4 EC @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>3</sub>), Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>), and Two hand weeding at 20 and 40 DAS (T<sub>6</sub>).
9. Seed yield (1930 kg ha<sup>-1</sup>) was recorded significantly maximum under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>). Which was at par with Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>).
10. Significantly maximum stover yield (3870 kg ha<sup>-1</sup>) was recorded under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000

ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>). Which was at par with Propaquizafop 2.5% EC + Imazethapyr 3.7% ME @ 2000 ml/ha + MACARENA @ 625 ml/ha (T<sub>4</sub>).

11. The harvest index was computed non-significant. All treatments were at par except T<sub>7</sub>. Maximum harvest index (33.28%) was obtained under Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) and Minimum under (T<sub>7</sub>) (33.83%) (Weedy check).
12. Minimum total and species wise weed density and dry matter accumulation of *Echinochloa colonum*, *Cyperus rotundus*, *Parthenium hysterophorus L.*, *Digera arvensis*, *Celosia argentea*, and *Alternanthera spp.* were observed under Two hand weeding at 20 and 40 DAS (T<sub>6</sub>) followed by Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) and maximum in weedy check (T<sub>7</sub>).
13. Highest weed control efficiency was found under Two hand weeding at 20 and 40 DAS (T<sub>6</sub>) followed by Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) and lowest in weedy check (T<sub>7</sub>).
14. As regards the application of the integration of Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) recorded maximum gross return (88195 Rs/ ha<sup>-1</sup>), recorded net return (71410 Rs/ ha<sup>-1</sup>) with B: C ratio (5.2).

### **Conclusion**

1. The soybean (JS-9752) responded favorably to the Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) treatment for achieving higher growth attributes, as well as grain and straw yield.
2. Combined application of Two hand weeding at 20 and 40 DAS (T<sub>6</sub>) is most suitable for the minimization of total and species wise weed density and dry matter accumulation.
3. In term of weed control efficiency. the use of Two hand weeding at 20 and 40 DAS (T<sub>6</sub>) gave significantly superior result compare to other treatments.

4. The integration of Sodium Acifluarfan (16.5%) + Clodinafop propargyl (8% EC) @ 1000 ml/ha + MACARENA @ 625 ml/ha (T<sub>1</sub>) recorded maximum gross return (88195Rs/ ha<sup>-1</sup>), recorded net return (71410Rs/ha<sup>-1</sup>) with B: C ratio (5.2).

### **Suggestions for future research work**

With the knowledge gains about experiment during the investigation and result obtaining the following consideration should be made for future research work,

1. The present experiment should be repeated for at least two successive years to draw valid conclusions and recommendations.
2. There is a possibility to test other soybean varieties with the same/different herbicide treatment combinations under different eco-edaphic conditions to have a comprehensive outcome.
3. The study may also be taken on the impact of different herbicide and their combinations on soil micronutrient status on a long-term basis.
4. Study to be made on supplying herbicide through different sources organic and inorganic.

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## APPENDIX

**Weekly standard meteorological data during the crop growth (02 July to 22 October 2019).**

Meteorological week No.	Tem max. (°C)	Tem. min. (°C)	Rainfall (mm)	Relative Humidity (%) I	Relative Humidity (%) II	Wind Vel. (Kmph)	Evaporation (mm)	Sun Shine (hours)
29	35.67	26.22	3.72	82.71	52.85	4.34	5.48	7.25
30	32.82	25.91	0.88	86.28	72.14	4.97	3.5	4.08
31	28.14	24.38	14.45	90.42	85.14	11	2.05	0.42
32	29.8	25.11	26.51	89.85	83.28	9.94	3.21	2.48
33	30.94	25.75	1.57	88.85	73.28	7.47	3.24	4.28
34	31.71	25.02	8.4	92	73.85	4.88	3.1	2.88
35	30.57	24.98	8.42	92.42	76	5.1	2.54	1.05
36	30.5	25.05	33.94	94	84.14	5.14	1.97	1.24
37	29.9	24.92	1.91	91.28	75.85	8.17	2.72	3
38	32.85	25.47	0.34	88.85	63.28	3.8	3.95	8.12
39	30.6	24.64	18.2	91.14	72.85	3.94	2.94	4.84
40	31.68	24.15	8.45	89.83	65.85	4.8	3.66	6.68
41	31.41	23.67	0.17	91.28	64.28	2.5	3.41	6.26
42	31.1	19.04	1.42	91.42	60.28	2.31	3.28	6.18
43	28.01	22.18	4.6	92.28	74.28	4.15	1.8	2
44	31.06	22.64	0	92.57	53.57	1.4	2.81	6.42
45	30.24	19.25	0	90.14	51.42	1.41	2.81	6.52
46	29.62	15.98	0	90.28	40	1.84	2.71	8.81
47	30.14	15.4	0	88.85	38.85	1.45	2.98	8.3
48	30.46	15.23	0	89	37.66	1.06	2.7	6.8
Total	617.22	454.99	132.98	1803.45	1298.85	89.67	60.86	97.61

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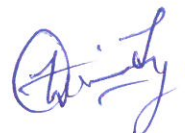
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