Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (*Plantago ovate* Forsk.) under Malwa Plateau of Madhya Pradesh

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by

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2021

CERTIFICATE – I

This is to certify that the thesis entitled ***"Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (Plantago ovate Forsk.) under Malwa Plateau of Madhya Pradesh"*** *submitted in partial fulfillment of the requirements for the Degree of* ***MASTER OF SCIENCE AGRICULTURE*** *in* ***HORTICULTURE (Plantation, Spice, Medicinal and Aromatic Crops)*** *of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bona-side research work carried out by* ***Mr. MANISH KUMAR*** *under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee and the Director of Instruction.*

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

Signature

(Kailash Chandra Meena)

Chairman of the advisory committee

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CERTIFICATE – II

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*This is to certify that the thesis entitled **"Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (Plantago ovate Forsk.) under Malwa Plateau of Madhya Pradesh"** submitted by **Mr. MANISH KUMAR** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, in partial fulfillment of the requirements for the degree of **Master of Science AGRICULTURE** in **HORTICULTURE** in the **Department of (Plantation, Spice, Medicinal and Aromatic Crops)** has been accepted after valuation by the external examiner and the Student's Advisory Committee after an oral examination on the same.*

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Place – Mandsaur
Date - (Manish Kumar)

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LIST OF ABBREVIATIONS

Symbol	Abbreviation	Stands for
/	-	Per
@	-	At the rate of
%	-	Percentage
^0C	-	Degree Celsius
-	cc g^{-1}	Cubic centimeter per gram
-	CD	Critical difference
	DF	Degrees of freedom
	viz.	Videlicet (Namely)
	var.	Variety
-	Cm	Centimeter
-	cm^2	Centimeter square
-	cv.	Cultivar
-	DAS	Days After Sowing
-	d.f.	Degrees of freedom
-	EMSS	Error Mean Sum of Squares
-	*et al.*	et-alii (And others)
-	Fig.	Figure
-	G	Gram
	G.P	Germination percentage
-	H	Hour
-	Ha	Hectare
-	MT	Metric tones
-	Kg	Kilogram
-	Max.	Maximum
-	mg	Milligram
-	Min.	Minimum
-	ml	Milliliter
-	mm	Millimeter
	M	Molar

	m^2	Meter square
-	PSB	Phosphate solubilizing bacteria
-	NS	Non-significant
-	B	Bio-fertilizer
	Q	Quintal
	q ha^{-1}	Quintal per hectare
	R.H.	Relative humidity
	Temp.	Temperature
	“ “	Quotation mark

Chapter - I

INTRODUCTION

Isabgol (*Plantago ovate* Forsk.) is one of the most important and export potential medicinal crops of India, which is locally known as Isabgul, Issabagolu, Ispaghol, Isakol, Isphagol etc. The name Isabgol is derived from two Persian worlds ‘Isap’ and ‘ghol’ meaning a horse ear, referring to the characteristics shape of its seeds. Isabgol belongs to family Plantaginaceae. It is subcaulescent softy hairy or woolly annual herb, short stemmed, highly cross pollinated *rabi* crop. The Isabgol plant height is about 28-40 cm. It has alternate leaves. Flowers are bisexual and favour out crossing may be due to protruding stigma, 45 to 70 in cylindric or ovoid, 2 to 4 cm long and about 0.5 cm broad spikes, capsules ellipsoidal about 8 mm long. The flowers are white, minute, seeds ovate and 1.8 to 3.8 mm long brown grey in colour and covered with a translucent membrane known as husk (Tyagi *et al*., 2016). The swelling property of the seed coat or husk after absorption of water is used in medicine in case of constipation and gastrointestinal disorders (Salimath *et al.,* 2019).

The seeds of isabgol are composed of many different types of chemicals that are used as medicine. It contains mucilage, fatty oil, Proteins, carbohydrates, mineral element, etc. Also those, psyllium seed contains amino acids, *i.e.* Valine, aniline, glycine, gluctomic acid, cystine, lysine, leucine and tyrosine. Psyllium seeds and husk are mild laxative, emmallient and demulcent, cooling, diuretic and worn in inflammatory condition of mucous membrane of grastro-intestinal and genital-urinary tract. It is also worn in curing of chronic dysentery, diarrhea, duodenal ulcer, constipation and piles (Tyagi *et al*., 2016).

The seeds of which are valued for mucilaginous rosy white husk used against constipation, irritation of digestive tract due to good sources of soluble fibre and is supposed to help in controlling blood pressure and lowering cholesterol. In adding, it is used for food industries in various preparations. Isabgol seed is separated from husk, gola, lali and khakho during processing.

The gola and lali have nutritional value which improve cattle food product. The khakho can be used for reducing the seepage losses in Isabgol (Prajapati *et al*., 2011).

It has been grown in a wide range of agro-climatic conditions, but it requires warm temperate regions with cool and dry weather conditions for growth and development of plants. The high rainfall areas are not suited for its cultivation. It requires 20^0C temperature for better seed germination. Infect cloudy weather, mild dew or even light showers causes heavy shedding of flowers and seeds with heavy losses in seed yield. However, it can be grown in all type of soils, but the light and well drained sandy loam having pH 7-8, has been found best for its successful cultivation and seed production (Tyagi *et al*., 2016). In India, it is commercially cultivated in the states of Madhya Pradesh, Gujarat and Rajasthan. In Madhya Pradesh it is largely grown in Neemuch and Mandsaur districts and covering an area of 15.209 thousand ha, production of 16.663 thousand metric tonnes and productivity of 1.09 metric tonnes ha^{-1} and in India, total area is 351.536 thousand ha and total production is 333.681 thousand metric tonnes with the national productivity 0.95 metric tonnes per ha (Hapis, 2019).

In the present agricultural practices, there is a number of microbial inoculants that used as bio-fertilizers; they induce Azospirillum and Azotobacter and phospho-bacterium, which have been given much attention as they are beneficial to plant growth and yield of crops under field inoculation. Bio-fertilizers are capable of mobilizing nutritive elements from unusable form to usable form through biological processes (Tien *et al.,* 1979). P-solubilizers are bio-fertilizers that solubilize the phosphorus in soil and succeed available to plants. They can improve growth, yield as well as the productivity of the isabgol (Galavi *et al*., 2011 and Rassi *et al*., 2012).

Bio-fertilizer are organic products containing living cells of different types of micro organisms which have the ability to convert nutritionally important elements from unavailable to available form through biological processes (Vessey,2003). The use of phosphate solubilizing bacteria assumes greater significance because it helps to convert insoluble organic phosphate into simple and soluble forms. Inoculation of seeds with *PSB* culture also increase nodulation, crop growth, nutrient availability and uptake and crop yield (Narolia *et al*., 2013). *Azotobacter*a free-living nitrogen fixing bacterium was found to fix atmospheric nitrogen and enhance the yields of many crop plants (Sexena and Rao, 2000).

In India, investigation on increasing the economic productivity in medicinal plants are urgently needed to select the potential variety having physiological superiority and to evolve high yielding variety through plant breeding. As such varietal evaluation with bio-fertilizer studies have been carried out mainly in cereals and pulses, but in medicinal plants they are completely lacking.

Keeping view, the present investigation is planned to be conducted to study the **"Influence of varieties and bio-fertilizer on growth and yield of Isabgol (*Plantago ovate* Forsk.) under Malwa plateau of Madhya Pradesh"** with the following objectives.

Objectives:

1. To determine the effect of bio-fertilizers on growth and yield of Isabgol.
2. To evaluate the performance of different varieties of Isabgol.
3. To study the interaction effects of bio-fertilizers and varieties of Isabgol.

Chapter- II

REVIEW OF LITERATURE

The literature pertinent to the various aspects of the present investigation entitled **“Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (*Plantago ovate* Forsk.) under Malwa Plateau of Madhya Pradesh”** is reviewed under the following heads:

2.1 Influence of varieties and bio-fertilizer on growth and yield of Isabgol

Saxena and Rao (2000) studied the response of isabgol to *Azotobacter* inoculation. A significant enhancement in the seed yield upon inoculation with *Azotobacter* was observed and this increase was further enhanced with the application of FYM and/or N fertilizer at 20 kg ha^{-1} However, the seed yield of isabgol was maximum with 40 kg N ha^{-1}, it was at par with that of other treatments, where 10 kg N ha^{-l} was given along with FYM or *Azotobacter* inoculation.

Pouryousef *et al*. (2007) examined and reported that Barvar Phosphate Bio-fertilizer (BPB) inoculation significantly increased seed yield, mucilage and seed P content of Isabgol. Animal manure and combined use of manure and chemical fertilizer resulted in a greater seed yield, mucilage yield, mucilage percentage, swelling factor and P content than sole application of chemical fertilizer.

Choudhary and Shivran (2009) observed that application of vermicompost @ 1.5 t ha^{-1} + 50% RDF significantly increased seed and straw yields over control. Protein content and swelling capacity were also increased with application of fertilizers/manures except FYM @ 8.0 t ha^{-1} and maximum was recorded under vermicompost @ 1.5 t ha^{-1} + 50% RDF. Results further revealed that seed and straw yields, total NPK uptake and available N content in soil at harvest were significantly higher with inoculation due to *Azotobacter* as well as *Azospirillum* over control.

Patel *et al.* (2010) reported that recommended dose through inorganic form with phosphate solublizing bacteria @ 5 kg ha^{-1} gave higher growth and yield attributes and was at par with recommended dose of fertilizer + *azotobacter* sp. @ 5 kg ha^{-1} + 5 t farm yard manure ha^{-1} and recommended dose of nitrogen + phosphate solublizing bacteria @ 5 kg ha^{-1} which were significantly superior to other treatments except test weight. This treatment also recorded significantly the highest grain and straw yields.

Prajapati *et al*. (2011) found that the promising genotypes of isabgol were evaluated from germplasms and experiments were carried out during eight consecutive years. Based on the quality and yield potentiality the genotype JI 26 (GI-3) recorded 1324 kg ha^{-1} yield and showed its superiority by producing 11.35 per cent higher than GI-2. The yield potential of JI-26 (GI-3) is 1632 kg ha^{-1}. The spikes of GI-3 are long, thin and dark green leaf, profuse tillers and has high stable yield. It possesses more number of seeds per spike and better grain quality. The GI-3 was recommended for commercial production in the 36^{th} Gujrat State Seed Sub-Committee Meeting.

Mehta *et al*. (2011) observed that influence of varying organic sources of nutrients on growth and yield of coriander. It was found that all organic and inorganic sources of nutrients with and without *Azotobacter* proved to be superior and exhibited higher yield over absolute control. Application of *Azotobacter* as sole as well as in combination with sheep manure, vermicompost and recommended doses of fertilizer resulted higher growth, yield attributes and yield over absolute control. The association of *Azotobacter* with all sources of nutrients proved beneficial and resulted higher growth and yield over without *Azotobacter*. Application of 7.5 t ha^{-1} sheep manure with *Azotobacter* resulted highest plant growth of 27.4, 54.2 and 90.3 cm at 40 DAS, 80 DAS and at maturity respectively as well as yield attributes, seed yield (789 kg ha^{-1}), net return (Rs 24325 ha^{-1}) and BCR (1.61) over rest of the treatments. Thus, it is inferred that application of 7.5 t ha^{-1} sheep manure with *Azotobacter* is better for realizing the highest yield, net return and BCR.

Darzi *et al*. (2012) determined the effects of bio-fertilizers on the morphological traits and seed yield in the anise. The results of present study demonstrated that the highest plant height, umbel number per plant, biological and seed yield were obtained after applying 10 t ha^{-1} vermicompost. Phosphate solubilizing bacterium also showed significant effects on umbel number per plant, biological yield and seed yield. The maximum umbel number per plant, biological yield and seed yield were obtained using the phosphate solubilizing bacterium twice.

Davari *et al.* (2012) reported that VC + RR + B was the most productive treatment, while FYM + RR + B was the most economical treatment with respect to increasing net profit. This was because of the higher price of vermicompost compared with FYM. Both of these combinations resulted in improved grain quality and nutrient uptake by grain. The present study thus indicates that a combination of FYM + RR + bio-fertilizers and VC + RR + bio-fertilizers had highest increased growth and yield attributing characters of wheat over control.

Mehta *et al.* (2012) observed the effect of various sources of organic manure (sheep manure and vermicompost) with and without bio-fertilizer (*Azotobacter sp.*) in fennel. Application of bio-fertilizer alone as well as in combination with sheep manure, vermicompost and recommended doses of fertilizer resulted in higher growth, yield attributes and yield over absolute control. The association of bio-fertilizers with all sources of nutrients proved beneficial and resulted in higher growth and yield. Application of recommended doses of fertilizer with seed inoculation by bio-fertilizer proved to be superior for realizing higher net return and benefit: cost ratio.

Raissi *et al*. (2012) reported that vermicompost significantly influenced the spike length, number of seed per spike, grains per spike, 1000 seed weight, seed yield and root length per hectare in Isabgol.

Tripathi *et al*. (2013) reported that the results on integrated nutrient management of isabgol. The RDF (50 kg N + 25 kg P + 25 kg K), vermicompost 2 t ha^{-1} alone, vermicompost 2 t ha^{-1} + 75% RDF, vermicompost 2 t ha^{-1} + 50% RDF, *azotobacter* 6 kg ha^{-1} + 75% RDF, *Azotobacter* 6 kg ha^{-1} + 50% RDF along with one control. Full dose of FYM, *azotobacter*, vermicompost, phosphorus, potash and 50 per cent of nitrogen as per the treatment dose were significantly increased the plant height, number of leaves per plant, number of tillers per plant, number of spikes per plant, length of spike, number of seed per spike with minimum number of days taken to maturity, seed yield as well as husk yield.

Firoozabadi and Baghizadeh (2013) experimented and reported that the highest seed yield and yield components and mucilage yields were obtained in combined use of chemical fertilizer and cattle manure treatments. Mucilage percentage and seed swelling factor were significantly higher in cattle manure application. It is also assessed that combined use of chemical fertilizer and cattle manure had significantly higher 1000 seed weight, spike per plant, seed per plant and dry matter compare to other treatments in Isabgol.

Narolia *et al.* (2013) results showed that application of phosphorus up to 20 kg P_2O_5 ha^{-1} significantly increased the plant height, number of tiller per plant, dry matter accumulation at harvest, protein concentration in seed and husk. As well as the inoculation of seed with PSB significantly enhanced the same characteristics over un-inoculated control in Isabgol.

Raissi *et al*. (2013) found significant effect of vermicompost on yield and mucilage over other treatments. Maximum swelling factor (22.63 mmM^3), N (0.33%) and K (0.39%) concentration, Protein (1.75%) and content of total carbohydrate (4.40 mg/g DW) were obtained with the animal manure in Isabgol.

Ali and Hassan (2014) investigated the response of black cumin plant to different treatments of cattle manure, bio-fertilizers and their combinations. The results revealed that growth characters and seed yield components were increased as a result of applying different fertilization treatments compared to untreated control.

Mor *et al.* (2014) reported that maximum nitrogen, phosphorus and potassium uptake of isabgol seed was observed under the application of SSP, 30 kg P_2O_5 ha^{-1} with PSB inoculation due to influence of different sources and levels of phosphorus and Bio-fertilizer (PSB) respectively, but in case of isabgol straw had shown non-significant response.

Shivran *et al*. (2014) recorded significantly higher seed and straw yields with vermicompost 1.5 t ha^{-1} + 50 % RDF over control in Isabgol. However, it was *at par* to application of vermicompost 3.0 t ha^{-1} alone. The harvest index was not affected by application of fertilizers/manures. Vermicompost 1.5 t ha^{-1} + 50 % RDF recorded maximum net returns which was significantly superior over rest of the treatments. The inoculation with bio-fertilizers *i.e*. Azotobacter and Azospirillum significantly increased the seed and straw yields over non inoculation. However, the harvest index remained unaffected.

Hadi *et al.* (2015) determined the effects of Nitrogen fixing bacteria and manure application on the seed yield and yield components in black cumin (*Nigella sativa* L.). The results showed that the highest plant height, 1000 seeds weight, seed number per follicle, follicle yield, seed yield and harvest index were obtained after using Azotobacter and Azospirillum, simultaneously. Results of this investigation showed that the maximum seed yield obtained when Azotobacter + Azospirillum inoculated with black cumin seeds and 5 ton manure ha^{-1} applied. According to the results of this investigation the integrated management of Azotobacter and Azospirillum with manure application is the best treatment for achieving the maximum quantitative characteristics of black cumin.

Mirshekari and Forouzandeh (2015) observed that grain yield, spike length, number of tillers, number of spike, 1000 seeds weight and mucilage content were significantly influenced by bio-fertilization in Psyllium.

Shivran *et al*. (2015) recorded that PSB inoculation significantly improved spikes $plant^{-1}$, spike length, seed spike, test weight, seed, straw and biological yields, protein, husk recovery (34.54%) swelling capacity (11.05 cc g). Blond psyllium should be fertilized with other nutrients along with inoculation from phosphate solubilizing bacteria to obtain higher productivity and profitability in isabgol.

Chaichi *et al*. (2015) results indicated that application of bio-fertilizers (single and integrated) significantly improved vegetative and generative growth as well as nutrient uptake in fenugreek. Application of the integrated fertilizer treatment of AS (*Azotobacter chrococum*+ *Pseudomonas fluorescence)* had the best positive effect on fenugreek growth characteristics compared to the other treatments and control.

Shirkhani and Nasrolahzadeh (2016) reported that grain yield, leaf area index, chlorophyll contents of maize was significantly higher with the application of azotobacter and vermicompost under normal and deficit irrigation.

Nasrollahzadeh Asl (2017) observed the significant effect of nitrogen and phosphate bio-fertilizers on plant height, branches per plant, pods per plant, seed in pod, oil percent, seed yield and harvest index of sesame. Maximum seed yield of 1274.37 and 12432.5 kg ha^{-1} was obtained from treatments of 200 kg ha^{-1} triple super phosphate and barvar-2 phosphate bio-fertilizer besides 100 kg ha^{-1} triple.

Upadhyay *et al*. (2018) studied the effect of different sources of nitrogen and bio-fertilizers on growth and yield of isabgol. The results indicated that plant height (cm), number of tillers plant^{-1}, number of spikes plant^{-1}, length of spike (cm), number of seed spike^{-1}, seed yield (q ha^{-1}), harvest index (%) can be increased by treatment (50% RDN through urea and 50% RDN through vermi-compost (40 kg N ha^{-1}) + bio-fertilizers as *azotobacter* + *PSB* 3 kg ha^{-1}).

Chaudhary *et al*. (2018) study results revealed that among different bio-fertilizers, minimum days taken for first cutting at 20 cm height, days taken for subsequent cutting at 20 cm height (second cutting), days taken for subsequent cutting at 20 cm height (third cutting), days taken for subsequent cutting at 20 cm height (fourth cutting), maximum yield of first cutting at 20 cm height (g), yield of subsequent cutting at 20 cm height (g) (Second cutting), yield of subsequent cutting at 20 cm height (g) (third cutting), yield of subsequent cutting at 20 cm height (g) (fourth cutting), yield per plot (kg) and yield per ha (q ha^{-1}) were recorded with treatment (*Azotobactor* + *PSB*).

Salimath *et al*. (2019) found that the influence of varieties and integrated nutrient management on yield parameters of isabgol. Among the two isabgol varieties higher value was recorded in Vallabh isabgol-1 in growth parameters *viz.,* 50% early seed germination (5.38), plant height (36.85 cm), number of leaves per plant (46.24), number of tillers per plant (10.40), leaf area index per plant (33.18 cm^2) and seed yield (12.30 q ha^{-1}) as compared to Gujarat Isabgol-2 (11.05 kg ha^{-1}). Whereas the higher values with INM treatments with respect to plant growth parameters were observed in N_{11}-75 % RD of FYM (7.5 t ha^{-1}) + 75% RD of NPK (37.5:18.75:22.50 kg ha^{-1}) + *Azospirillum* (5kg ha^{-1}) + *PSB* (3kg ha^{-1}) + $ZnSO_4$ (15 kg ha^{-1}) + $FeSO_4$ (7.5 kg ha^{-1}), higher plant height (36.85), number of tillers per plant (13.94), less number of days taken for 50% seed germination (4.43%), leaf area index (2.74), seed yield (12.30 q ha^{-1}).

Sahu *et al*. (2020) accumulated that the effect of integrated nutrient management on fenugreek, an experiment was laid out with 12 treatments comprised of graded level of recommended dose of nitrogen, phosphorous, potassium (RDF), FYM, vermicompost, neemcake, poultry manure and bio-fertilizers (*Rhizobium* + PSB). The results indicated that the growth and yield of fenugreek crop can be increased treatment T_{11} (50% RDF + Neem cake @ 1 ton ha^{-1}+ Rhizobium + PSB).

Chapter - III

MATERIALS AND METHOD

A field experiment was conducted on **"Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (*Plantago ovate* Forsk.) under Malwa Plateau of Madhya Pradesh"** at the department of PSMA "Horticulture Research Farm" College of Horticulture Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) from November 2020 to March 2021. The details of the materials used and methods followed during the course of the study are presented in this chapter.

3.1 Experimental site:

The field experiment was carried out at the department of PSMA "Horticulture Research Farm" College of Horticulture Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during *rabi* season of 2020-21. The College of Horticulture, Mandsaur is located at Malwa plateau in Western part of Madhya Pradesh at 23.45^0 to 24.13^0 North latitude, 74.44^0 to 75.18^0 East longitudes and at an altitude of 435.02 meters above mean sea level. This region falls under agro climatic zone no.10 of the state.

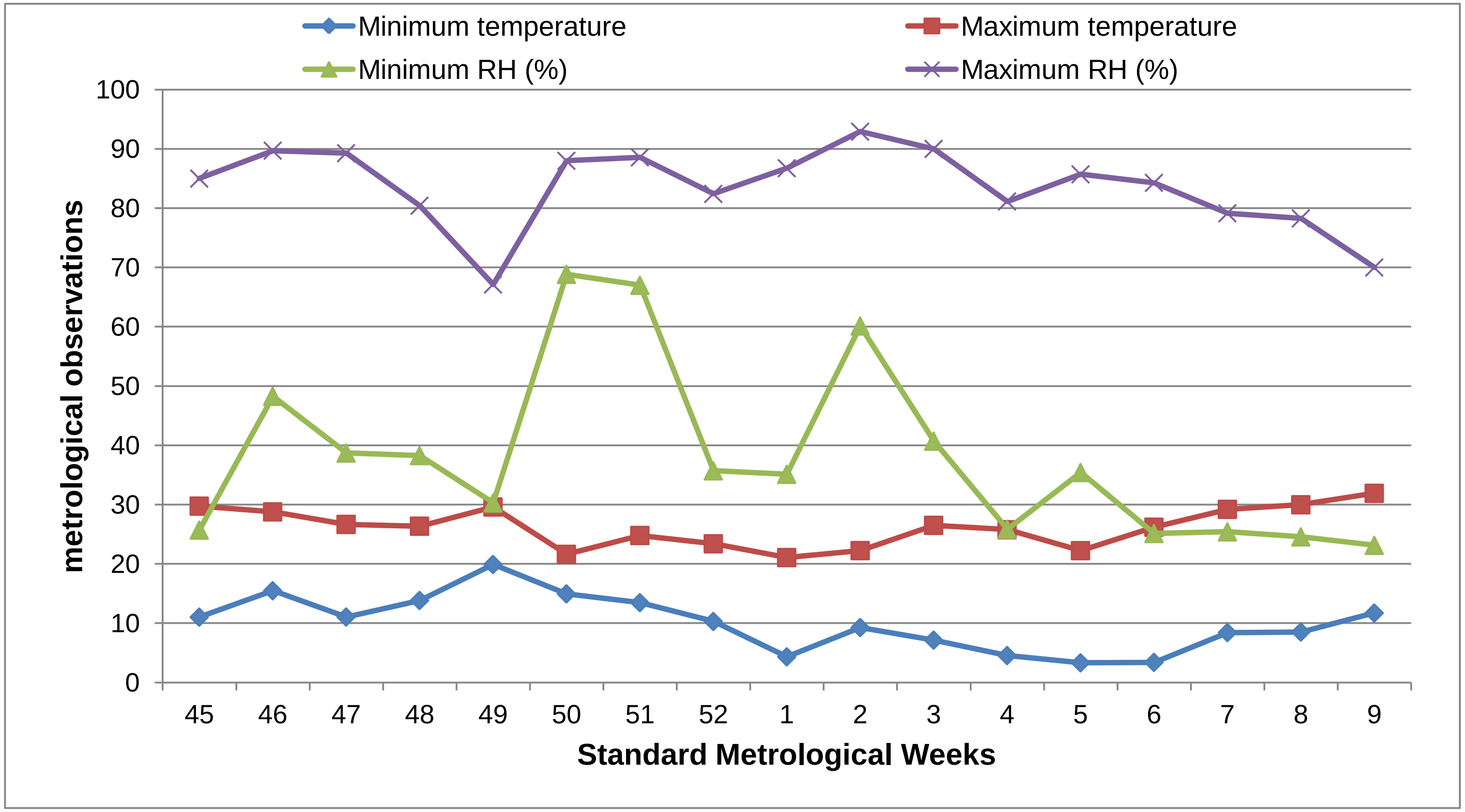
3.2 Climatic conditions of the experimental site:

Mandsaur belongs to sub-tropical and semi-arid climatic conditions having a mean maximum temperature of 40^0C and mean minimum temperature of 5^0C in summer and winter, respectively. It receives an annual average rainfall of 544.05 mm. South-West monsoon is responsible for major part of annual precipitation. Meteorological data recorded during the period of investigation are presented in Table 3.2.1 and are graphically shown in Fig.3.2.1.

Table-1(3.2.1): Meteorological data during the period of investigation from November- 2020 to March- 2021

Standard Metrological Week	Duration	Average weekly temperature (°C)		Relative Humidity (%)		Weekly rainfall (mm)
		Min.	Max.	Min.	Max.	
45	05 Nov - 11Nov	11.03	29.75	25.71	85.00	0
46	12 Nov - 18Nov	15.48	28.78	48.28	89.71	0
47	19 Nov - 25 Nov	11.05	26.67	38.71	89.28	0
48	26 Nov - 02 Dec	13.84	26.37	38.28	80.42	0
49	03 Dec - 09 Dec	19.90	29.60	30.28	67.14	0
50	10 Dec - 16 Dec	14.95	21.62	68.85	88.00	0
51	17 Dec - 23 Dec	13.47	24.80	67.00	88.57	0
52	24 Dec - 31 Dec	10.30	23.40	35.71	82.42	0
1	01 Jan - 07 Jan	4.33	21.08	35.12	86.75	0
2	08 Jan - 14 Jan	9.27	22.25	60.14	92.91	0
3	15 Jan - 21 Jan	7.15	26.51	40.71	90.00	0
4	22 Jan - 28 Jan	4.55	25.77	25.85	81.14	0
5	29 Jan - 04 Feb	3.32	22.24	35.42	85.71	0
6	05 Feb - 11 Feb	3.40	26.20	25.14	84.28	0
7	12 Feb - 18 Feb	8.42	29.21	25.42	79.14	0
8	19 Feb - 25 Feb	8.52	29.98	24.57	78.28	0
9	26 Feb – 04 Mar	11.72	31.91	23.14	70.00	0

Fig.-1(3.2.1): Weekly meteorological parameters observed during crop season 2020-21.



3.3 Soil characteristics of the experimental site:

To determine physico-chemical characteristics of the soil during the year of study, a soil sample is taken from different spots of the experimental field at a depth of 0-15 cm before application of fertilizer. A representative complex sample was prepared by processing and mixing them together and the sample was analyzed for physical and chemical properties. The result of analysis showed that the soil of experimental site is light black loamy texture, with low in availability of nitrogen, low in phosphorus and medium in potassium status.

Table-2(3.3.1): Physical and chemical composition of the soil sample of experimental site:

S. No.	Particulars	Value Obtained	Methods
	Physical Characters		
(a) (b) (c)	Sand % Silt% Clay%	35% 42% 28%	By International Pipette method (Piper, 1950)
	Chemical Characters		
(a)	Soil pH	6.5	Method No. 4, USDA Handbook No. 60 (Richards, 1956)
(b)	Electric conductivity (dSm^{-1})	0.18	EC meter
(c)	Available nitrogen (kg ha^{-1})	148.2 (low)	Alkaline KMnO4 method (Subbiah and Asija,1956)
(d)	Available phosphorus (kg ha^{-1})	19.75 (medium)	Olsen extraction method (Olsen *et al.,* 1954)
(e)	Available potassium (kg ha^{-1})	198.0 (high)	Flame photometer method (Metson,1956)

3.4 Experimental details, Design and layout of experiment

The experiment was laid out in open field with Factorial Randomized Block design. There were three replications in the experiment. The plan of layout of the experiment is given in Fig.3.4.1.

3.4.1 The details are as follows:

Location: Horticulture Research Farm, College of Horticulture, Mandsaur (M.P.)

3.4.1.1 Experimental details:

Name of crop	:	Isabgol (*Plantago ovate* Forsk.)
Season	:	*Rabi*, 2020-21
Design	:	Factorial Randomized Block Design
Number of replications	:	03
Number of treatments	:	12
Spacing	:	30 x 10 cm
Gross plot size	:	3.15 m^2 (2.1 x 1.5 m**)**
Total experimental area	:	195.05 m^2

3.4.1.2 Treatment detail:

Varieties (main plot)

V_1 = GI-1 (Gujrat isabgol-1)

V_2 = GI-2 (Gujrat isabgol-2)

V_3 = VI-1 (Vallabh isabgol-1)

V_4 = JI-4 (Jawahar isabgol-4)

Bio-fertilizers (sub plot)

B_0 = control

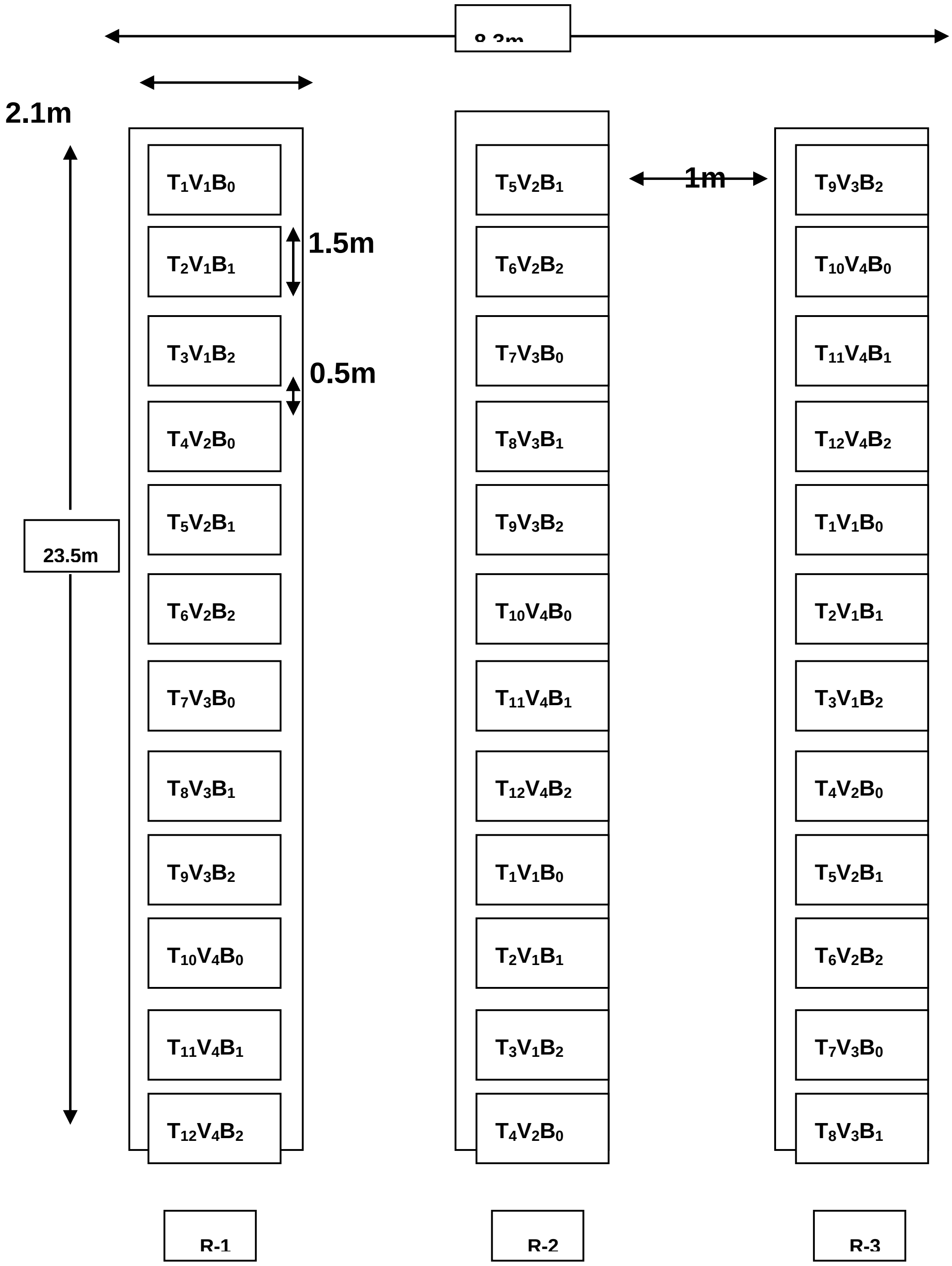
B_1 = *Azotobacter* (5kg ha^{-1})

B_2 = *PSB* (3 kg ha^{-1})

3.4.1.3 Treatment combination:

T_1	: $V_1 B_0$	T_7	: $V_3 B_0$
T_2	: $V_1 B_1$	T_8	: $V_3 B_1$
T_3	: $V_1 B_2$	T_9	: $V_3 B_2$
T_4	: $V_2 B_0$	T_{10}	: $V_4 B_0$
T_5	: $V_2 B_1$	T_{11}	: $V_4 B_1$
T_6	: $V_2 B_2$	T_{12}	: $V_4 B_2$

Fig.-2(3.4.1): Experimental design and layout;-



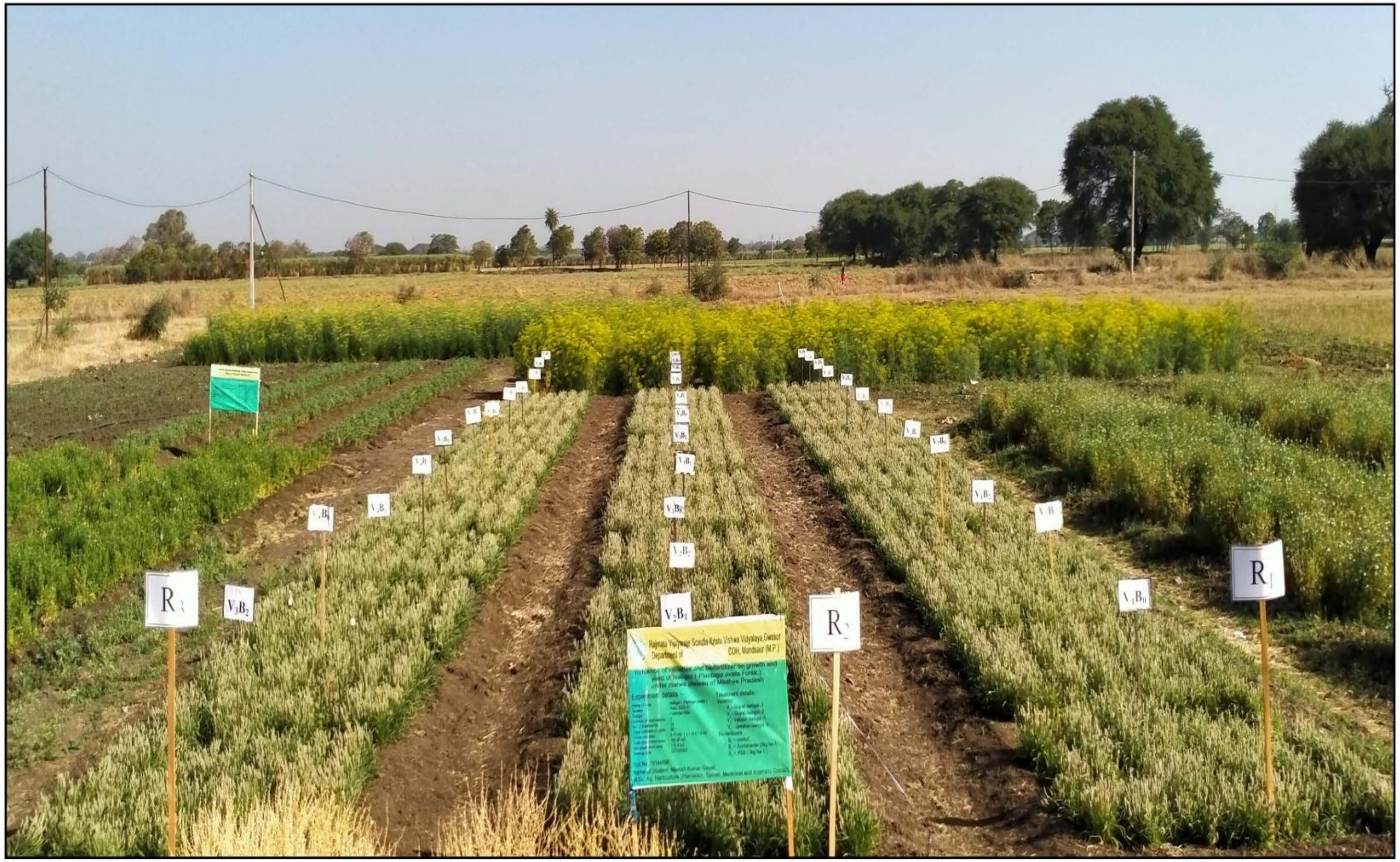


Plate 1:- Panoramic view of experimental field of isabgol

3.5 Cultural operation:

3.5.1 Seed source:

Isabgol *cv.* GI-1 (Gujrat isabgol-1), GI-2 (Gujrat isabgol-2), VI-1 (Vallabh isabgol-1) and JI-4 (Jawahar isabgol-4) obtained by All India Coordinated Research Projects on medicinal and aromatic plants, College of Horticulture, Mandsaur (Madhya Pradesh) has been taken for the experiment purpose. The plant is annual, stem less or short stemmed. It prefers warm temperate climate, having good yield potential of seed and husk and matures in 110-120 days after sowing.

3.5.2 Preparation of the experiment plot:

The experimental plot was ploughed twice by tractor drawn cultivator and leveled. The clods were crushed; weeds were removed and brought to fine tilth. The land was divided into plots of required size (2.1 m x 1.5 m). Provision was made for bunds and irrigation channels.

3.5.3 Bio-fertilizers:

Bio-fertilizers, *viz*., *Azotobacter* @ *(*5 kg ha^{-1}*)* and PSB @ (3 kg ha^{-1}) phosphate solubilizing bacteria were along with one control untreated plot used as sub treatment in the present experimental trail.

3.5.4 Sowing of seeds:

The seeds were used with the seed rate of 3-4 kg ha^{-1} and treated with Carbendazim 12%+ Mancozeb 63% WP @ 2 g kg^{-1} seeds. Line sowing was adopted with the spacing of 30 × 5 cm on 5th November 2020 with different varieties and bio-fertilizers. Furrows were properly covered with a thin layer of soil and the plots irrigated lightly just after sowing.

3.5.5 Thinning of seedlings:

Thinning was done manually at 25 days after sowing to remove the excess plants to maintain recommended spacing 5 cm.

3.5.6 Manures and fertilizers:

The calculated quantities of manures and fertilizers were applied to the respective plots. The sources of nutrients were nitrogen (Urea), phosphorus

(SSP) and potash (MOP) at the rate of 40:30:20 NPK kg ha^{-1}. Full dose of phosphorus and potash were applied as basal dose prior to sowing of isabgol. Nitrogen is applied in two split doses at 40 and 55 DAS. The calculated quantities of bio-fertilizer (PSB and Azotobacter) were applied as full dose at the time of sowing.

3.5.7 Aftercare:

3.5.7.1 Weeding and hoeing:

Two to three wedding and hoeing were done manually, first at 25-30 DAS and second at 60 DAS to control the season bound weeds. Hoeing is done to loosen the soil in order to encourage the growth of isabgol plants.

3.5.7.2 Irrigation:

For the establishment of the crop, first light irrigation was done just after sowing then subsequent irrigations were given after 30 and 70 days. The last irrigation was given at 90 days on milking stage.

3.5.7.3 Plant protection:

Incidence of downy mildew and aphid infestation was observed. To control downy mildew the plants were sprayed with Metalaxyl 4% + Mancozeb 64% WP @ 2 g $litre^{-1}$ of water and for the control of aphid sprayed imidacloprid 17.8% SL @ 5 ml /15 litre of water.

3.5.7.4 Harvesting:

The crop ready for harvest 110-120 days after sowing, when the crop turns yellowish and spikes turn brown in colour. The spikes were harvested in the month of March, when atmosphere was dry. Plants were cut 0.15 cm above the ground level with sickle. They were brought to the threshing yard and spread for drying.

3.5.7.5 Threshing:

Threshing was done on clean cemented floor. Seeds were separated by beating followed by winnowing. The weight of the seed was recorded and expressed in q ha^{-1}

3.6 Observation recorded:

3.6.1 Phenological parameters

1. Days to 50% germination
2. Days to 50% flowering
3. Days to maturity

3.6.2 Morphological parameter (30, 60, 90 DAS and at harvest)

1. Plant height (cm $plant^{-1}$)
2. Number of leaves ($plant^{-1}$)
3. Number of tillers ($plant^{-1}$)
4. Number of spikes ($plant^{-1}$)
5. Length of spike (cm)
6. Fresh weight (g $plant^{-1}$)
7. Dry weight (g $plant^{-1}$)

3.6.3 Yield and Yield attribute parameters

1. Number of seed ($spike^{-1}$)
2. Seed yield (g $plot^{-1}$)
3. Seed yield (q ha^{-1})
4. straw yield (q ha^{-1})
5. Biological yield (q ha^{-1})
6. Weight of 1000 seed (g)
7. Harvest index (%)
8. seed husk ratio

3.6.1 Phenological parameters

3.6.1.1 Days to 50% germination

Five plants were selected randomly in each plot, number of days taken for 50 per cent seed germination were analysis the mean values of all the observations were worked out.

3.6.1.2 Days to 50% flowering

Five plants were selected randomly in each plot, number of days taken for 50 per cent flowering were analysis the mean values of all the observations were worked out.

3.6.1.3 Days to maturity

Number of days was counted from sowing to till 100 per cent of spikes started drying in the plot and recorded as days to maturity.

3.6.2 Morphological parameter

3.6.2.1 Plant height (cm plant^{-1})

Five plants were randomly selected from each plot, tagged and plant height was measured from the ground level to the tip of the plant at 30, 60, 90 DAS and at harvest. The average plant height was worked out and expressed in centimeter (cm).

3.6.2.2 Number of leaves (plant^{-1})

The number of leaves counted from five tagged plants of each plot at 30, 60, 90 DAS and at harvest. The average number of leaves was worked out and expressed in number.

3.6.2.3 Number of tillers (plant^{-1})

Number of spikes per plant were counted at 60 and 90 DAS born on the whole plant and the average was computed.

3.6.2.4 Number of spikes (plant^{-1})

Number of spikes per plant were counted at 60 and 90 DAS born on the whole plant and the average was computed.

3.6.2.5 Length of spike (cm)

It was measured by measuring the length of 5 randomly selected spikes from each selected plant and then mean for each selected plant was calculated.

3.6.2.6 Fresh weight (g plant^{-1})

The five plants were collected from the each plot at 30, 60, 90 DAS and at harvest to record fresh weight and later on their mean was calculated and was expressed in grams.

3.6.2.7 Dry weight (g plant^{-1})

After taking fresh weight, the plants were kept in hot air oven at 60 ± 2^0c temperature for about 4 hours for 2 days till plant become fully dried. Final weight was recorded and mean was calculated at each stage and it is expressed in grams

3.6.3 Yield and Yield attribute parameters:

3.6.3.1 Number of seed (spike^{-1}) at harvest

Ten spikes were selected at random from the plant, which were used for seeds spike^{-1} and total seeds were counted. Then the average of seed spike^{-1} was worked out.

3.6.3.2 Seed yield (g plot^{-1})

All the pods from total plants of each plot were harvested, dried under shade and threshed. The weight of seeds from each plot was recorded and expressed as seed yield per plot in grams.

3.6.3.3 Seed yield (q ha^{-1})

After threshing and winnowing clean seeds obtained from the each plot were weighed and the weight was recorded in g plot^{-1}. This can be converted in to q ha^{-1} by using the formula given below.

$$\text{Seed yield (q ha}^{-1}\text{)} = \frac{\text{Seed yield (g) / plot (sq. m)} \times 10000}{\text{Size of plot (sq. m)} \times 1000 \times 100}$$

3.6.3.4 Straw yield (q ha^{-1})

Straw yield was calculated by subtracting the seed yield (q ha^{-1}) from the biological yield (q ha^{-1}).

3.6.3.5 1000 seed weight (g)

The thousand dried seeds were collected from the finally winnowed and cleaned produce of each plot, these seeds were weighed on electric balance, and weight was recorded and expressed as 1000 seed weight in grams.

3.6.3.6 Biological yield (q ha^{-1})

The biological yield was arrived by adding seed yield and straw yield and calculated for hectare area expressed in q ha^{-1}.

3.6.3.7 Harvest index (%)

The harvest index is the ratio between the economic yield and total biological yield. It is expressed as percent.

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

3.6.3.8 Seed husk ratio

To determine the husk content, one gram seed of respective sample was taken and was boiled with mild acid (0.1N HCl) for two minutes and subsequently washed nine times with hot (80°C) distilled water, each time using 10 ml. Total removal of mucilage was judged by the non-stickiness of the seeds. The husk yield per hectare was worked out by multiplying the total un-husked seed yield per hectare with the husk content in the seeds.

$$\text{Seed husk ratio} = \frac{\text{Economic yield}}{\text{Husk yield}}$$

3.7 Statistical Analysis of Data:

The experimental data recorded were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhatme (1985). The critical difference for the treatments the “F” test was found significant at 5% level of significance. To elucidate effects, comparison were worked out, wherever summary tables along with S.Em. ± and critical differences is given below and their analysis of variance is given in the appendices at the end.

3.7.1 Standard error of mean (S. Em.±):

It is the measure of the mean difference between sample estimate of mean (X) and the population parameters (μ) *i.e.* it is the measure of controlled variation present in a sample and is denoted by S,Emr

$$S.Em. \pm = \sqrt{EMSS/r}$$

Where,

EMSS = Error mean sum of squares

r = Number of replications

3.7.2 Critical difference (C.D. at 5%):

Critical difference is used to compare the observed differences among different treatments. If the difference is greater than critical difference, it is considered as significant and vice versa.

C D 5 % = S. E (d) x t (0.05)

Where,

S Ed. = Standard error of difference

T = table value at error degrees of freedom

Table-3(3.7.1): Template of analysis of variance:

Source of variation	**DF**	**SS**	**MSS**	**"F" value Calculated**	**"F" Table Value at 5%**
Replication	(r-1)	RSS	RMS	RMS/EMS	3.44
Treatment	(t-1)	TSS	TMS	TMS/EMS	2.26
Error	(r-1) (t-1)	ESS	EMS		
Total	(rt-1)	TSS			

Where,

r = Number of replications

t = Number of treatments

RSS = Replication sum of squares

TSS = Treatment sum of squares

ESS = Error sum of squares

SST = Total sum of squares

RMS = Replication mean sum of squares

TMS = Treatment mean sum of squares

EMS = Error mean sum of squares

Chapter - IV

EXPERIMENTAL RESULTS

The results of the field experiment entitled **"Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (*Plantago ovate* Forsk.) under Malwa Plateau of Madhya Pradesh"** conducted at Horticulture Research Farm, Department of Plantation, Spices, Medicinal, and Aromatic crops, College of Horticulture, Mandsaur (M.P.) during the *rabi* season 2020-21 in factorial randomized block design with three replications. The present study was carried with four levels of varieties Viz., Gujarat Isabgol-1 (GI-1), Gujarat Isabgol-2 (GI-2), Vallabh Isabgol-1 (VI-1) and Jawahar Isabgol-4 (JI-4) as main plot and with two levels of bio-fertilizer and one untreated (B_0-control, B_1-*Azotobacter* (5 kg ha^{-1}) and B_2-PSB (3 kg hac^{-1}) as sub plot on Isabgol. All the morphological parameters were recorded at 30, 60, 90 days after sowing and at harvest. All the data were analyzed statistically and analysis of variance for these data has been furnished in appendices. Interpretation of data has been made on the mean basis. The results are presented under the following sections:

4.1 Phenological parameter

4.2 Morphological parameters

4.3 Yield parameter and yield attributing

4.1 Phenological parameters

All the phenological data on were non-significant influenced with the different varieties and bio-fertilizer combinations during investigation are presented in Table 4.1.1 and graphically illustrated in Fig. 4.1.1& 4.1.2.

4.1.1 Days to 50% germination

Results revealed that, in the main plots, V_4-JI-4 (5.22) was found significantly early days to 50% germination among the varieties. Thought, V_3-VI-1 (6.11) lagged behind the former and was at par with the remaining varieties. V_1-GI-1 (6.67) was observed late days to 50% germination.

In the sub plots, B_1-*Azotobactor* (6.08) was found earliest in the days taken to 50% germination followed by B_0-control (6.08) but they were at par with each other. The maximum days to 50% germination (6.17) was recorded in the B_2-PSB.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (5.00) was attended early 50% germination and which was at par with V_4xB_2 (5.33), V_4xB_0 (5.33), V_3xB_2 (6.00) and V_3xB_1 (6.00) but significantly early over rest of the treatments. Thought, V_4xB_2 (5.33) lagged behind the former, which at par with V_4xB_2 (5.33), V_4xB_0 (5.33), V_3XB_2 (6.00), V_3xB_1 (6.00), V_3xB_0 (6.33), V_2xB_2 (6.33), V_2xB_0 (6.33) and V_1xB_0 (6.33) but significantly early with the remaining treatment combinations. V_1xB_2 (7.00) was possessed maximum days to 50% germination.

4.1.2 Days to 50% flowering

The analysis of variance shown that, in the main plots, V_4-JI-4 (61.67) was found significantly minimum days to 50% flowering with the remaining varieties. Thought, V_3-VI-1 (64.44) lagged behind the former, which was at par with V_2-GI-2 (64.89) and V_1-GI-1 (65.56). V_1-GI-1 (65.56) was took maximum days to 50% flowering.

In the sub plots, B_1-*Azotobactor* (64.00) was found earliest in the days taken to 50% flowering followed by B_0-control (64.08) and B_2-PSB (64.33) but they were at par with each other.

On perusal of data shown that, in the interactions, V_4xB_1 (61.00) was attended early 50% flowering and which was at par with V_4xB_2 (62.00), V_4xB_0 (62.00) and V_3xB_2 (64.00) but significantly early over rest of the treatments. Though, V_4xB_2 (62.00) lagged behind the former, which was significantly differed but at par with the remaining treatment combinations. V_1xB_2 (66.67) was accumulated maximum days to 50% flowering.

Gujrat Isabgol -1

Gujrat Isabgol -2

Vallabh Isabgol-1

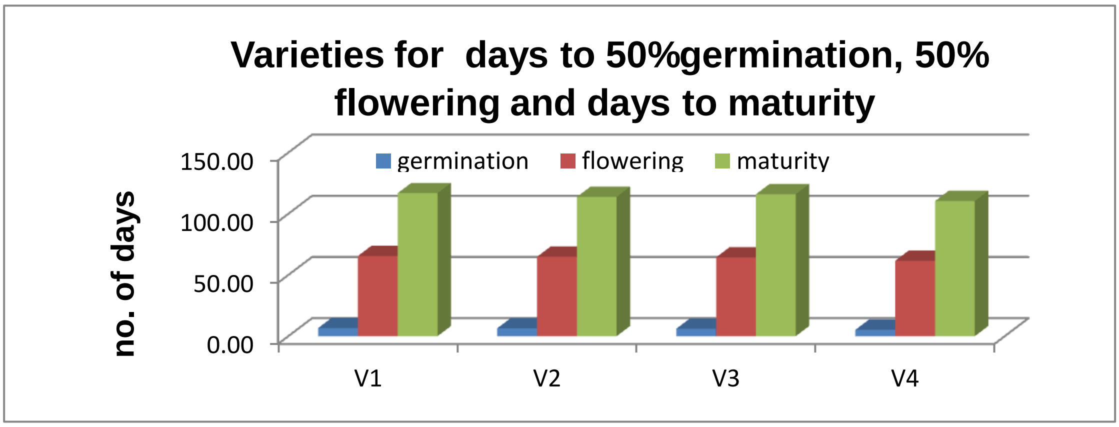
Jawahar Isabgol-4

Plate 2:- View of isabgol different varieties

Table-4(4.1.1): Influence of Varieties and Bio-fertilizer on Phenological Parameters in Isabgol

Treatment	Days to 50% germination	Days to 50% flowering	Days to Maturity
Varieties			
V_1 - Gujarat Isabgol -1	6.67	65.56	116.89
V_2 - Gujarat Isabgol -2	6.44	64.89	113.78
V_3 - Vallabh isabgol -1	6.11	64.44	116
V_4 - Jawahar isabgol-4	5.22	61.67	110.44
S. Em. ±	**0.22**	**0.62**	**0.49**
C.D. at 5%	**0.63**	**1.81**	**1.43**
Bio-fertilizers (B)			
B_0- Control	6.08	64.08	114.33
B_1 - Azotobacter (5kg ha^{-1})	6.08	64.00	114.33
B_2 - PSB (3kg ha^{-1})	6.17	64.33	114.17
S. Em. ±	**0.19**	**0.53**	**0.42**
C.D. at 5%	**0.55**	**1.56**	**1.24**
Interactions (Varieties X Bio-fertilizer)			
V_1XB_0	6.33	64.67	115.33
V_1XB_1	6.67	65.33	116.67
V_1XB_2	7.00	66.67	118.67
V_2XB_0	6.33	64.67	113.33
V_2XB_1	6.67	65.33	114.67
V_2XB_2	6.33	64.67	113.33
V_3XB_0	6.33	65.00	118.00
V_3XB_1	6.00	64.33	116.67
V_3XB_2	6.00	64.00	113.33
V_4XB_0	5.33	62.00	110.67
V_4XB_1	5.00	61.00	109.33
V_4XB_2	5.33	62.00	111.33
S. Em. ±	**0.37**	**1.07**	**0.85**
C.D. at 5%	**1.10**	**3.13**	**2.48**

Fig.-3(4.1.1): Influence of varieties and bio-fertilizers on days to 50%germination, 50% flowering and days to maturity of isabgol.



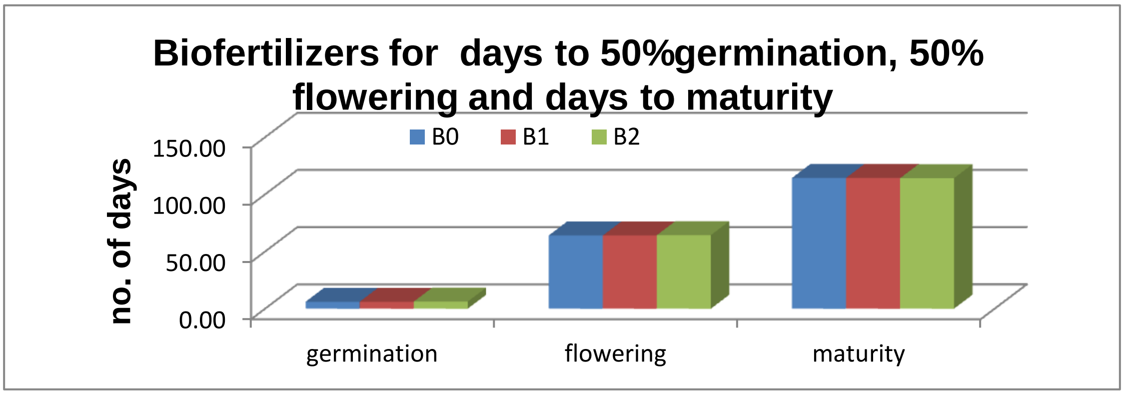
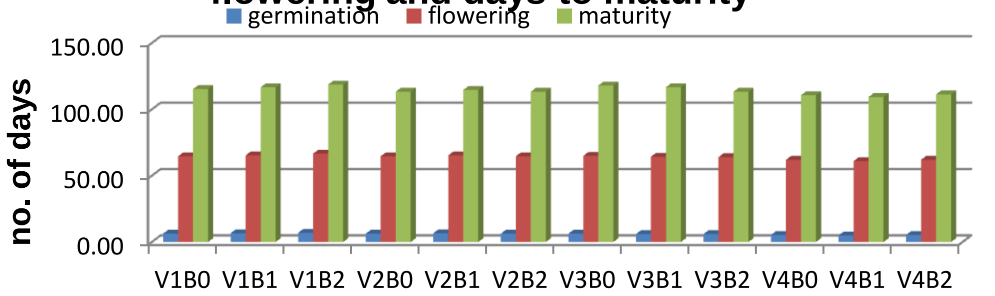


Fig.-4(4.1.2): Interactions of Variety x biofertilizers for days to 50%germination, 50% flowering and days to maturity



4.1.3 Days to maturity

Investigated that, in the main plots, V_4-JI-4 (110.44) was perceived significantly minimum days to maturity among the varieties. Thought, V_2-GI-2 (113.78) lagged behind the former but significantly superior over the remaining treatments. V_1-GI-1 (116.89) was seen maximum days to maturity.

In the sub plots, B_2-PSB (114.17) was found earliest in the days taken to maturity followed by B_1-*Azotobacter* (114.33) and B_0-control (114.33) but they were at par with each other maximum days to maturity.

The data shown that, in the interactions, V_4xB_1 (109.33) was taken early maturity which was at par with V_4xB_0 (110.67) and V_4xB_2 (111.33) but significantly early over rest of the treatments. Thought, V_4xB_0 (110.67) lagged behind the former but was at par with V_4xB_2 (111.33) and significantly superior with the remaining treatment combinations. V_1xB_2 (118.67) was perceived maximum days to maturity.

4.2 Morphological Parameters:

4.2.1 Plant height (cm plant^{-1})

Investigation pertaining to the significant difference among the varieties and bio-fertilizer and their interactions during different stages of plant growth and data are presented in Table. 4.2.1 and diagrammatically illustrated in Fig. 4.2.1& 4.2.2.

At 30 DAS

The experimental data exhibited that, in the main plots, V_4-JI-4 (7.91) was cumulated significantly maximum plant height among the varieties. Thought, V_3-VI-1 (7.26) lagged behind the former and was at par with V_1-GI-1 (7.22) but significantly superior over rest of the varieties. V_2-GI-2 (7.04) was noted minimum plant height.

In the sub plots, B_1-*Azotobactor* (7.78) was found significantly higher plant height among the treatments. Thought, B_2-PSB (7.50) come after highest but significantly superior with the remaining treatments. The minimum plant height (6.80) was seen in the B_0- control.

The data shown that, in the interactions, V_4xB_1 (8.29) was attended significantly highest plant height over rest of the treatments. Thought, V_4xB_2 (7.79) lagged behind the former but significantly superior with the remaining treatment combinations. V_2xB_0- control (6.41) was registered minimum plant height.

At 60 DAS

The findings revealed that, in the main plots, V_4-JI-4 (22.04) was observed maximum plant height followed by V_3-VI-1 (20.97) and they were significantly superior with the remaining varieties. V_2-GI-2 (20.50) was noted minimum plant height.

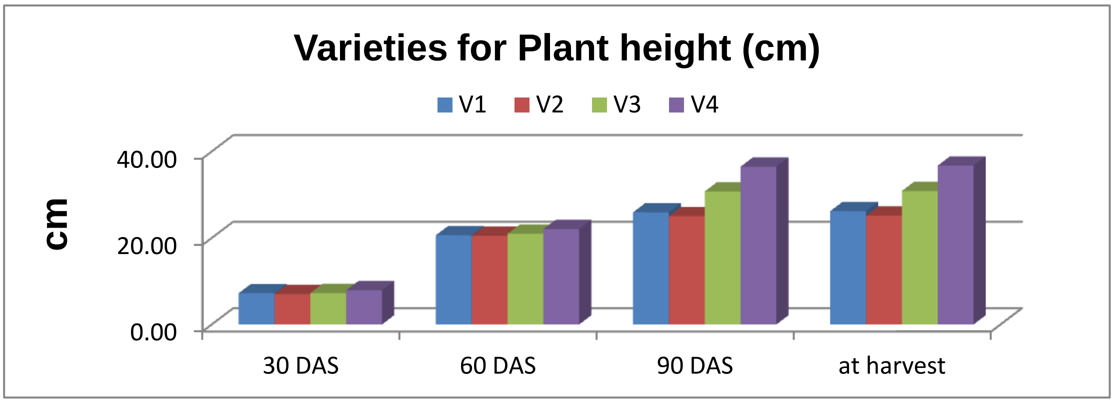
In the sub plots, B_1-*Azotobactor* (21.78) was found significantly higher plant height among the treatments. Thought, B_2-PSB (21.23) come after highest but significantly superior with the remaining treatments. The minimum plant height (20.09) was recorded in the B_0-control.

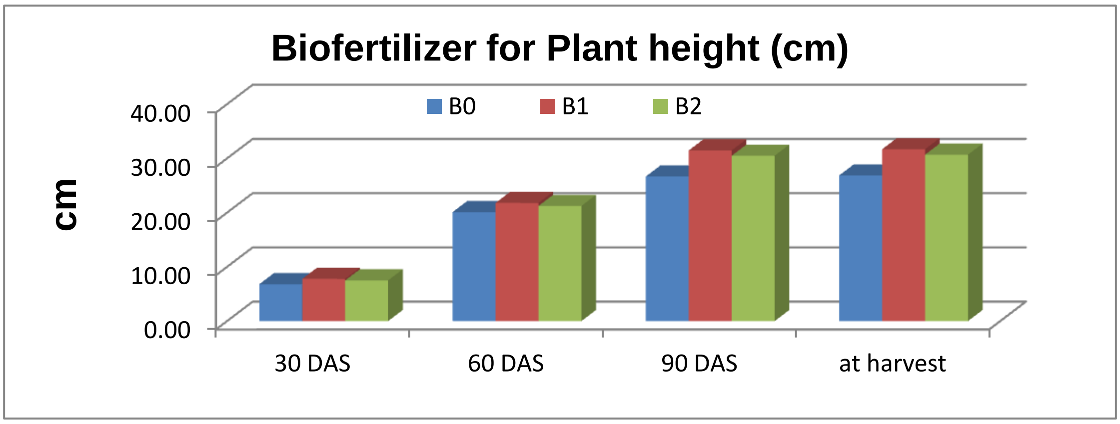
The analyzed of data shown that, in the interactions, V_4xB_1 (22.78) was received significantly maximum plant height among the treatments. Thought, V_4xB_2 (21.83) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0- control (19.38) was accumulated minimum plant height.

Table-5(4.2.1): Influence of Varieties and Bio-fertilizer on Plant height (cm) in Isabgol.

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	at harvest
Varieties				
V_1 - Gujarat Isabgol -1	7.22	20.62	25.91	26.19
V_2 - Gujarat Isabgol -2	7.04	20.5	25.04	25.17
V_3 - Vallabh isabgol -1	7.26	20.97	30.75	30.86
V_4 - Jawahar isabgol-4	7.91	22.04	36.48	36.72
S. Em. ±	**0.05**	**0.03**	**0.15**	**0.14**
C.D. at 5%	**0.14**	**0.08**	**0.45**	**0.42**
Bio-fertilizer (B)				
B_0- Control	6.80	20.09	26.66	26.85
B_1 - Azotobacter (5kg ha^{-1})	7.78	21.78	31.48	31.68
B_2 - PSB (3kg ha^{-1})	7.50	21.23	30.49	30.68
S. Em. ±	**0.04**	**0.02**	**0.13**	**0.12**
C.D. at 5%	**0.12**	**0.07**	**0.39**	**0.36**
Interactions (Varieties X Bio-fertilizer)				
V_1XB_0	6.59	19.45	24.23	24.61
V_1XB_1	7.65	21.53	27.04	27.37
V_1XB_2	7.43	20.89	26.47	26.58
V_2XB_0	6.41	19.38	22.58	22.66
V_2XB_1	7.43	21.24	26.53	26.67
V_2XB_2	7.28	20.87	25.99	26.18
V_3XB_0	6.53	19.99	27.38	27.5
V_3XB_1	7.75	21.57	32.95	33.05
V_3XB_2	7.50	21.33	31.92	32.03
V_4XB_0	7.65	21.52	32.47	32.63
V_4XB_1	8.29	22.78	39.37	39.62
V_4XB_2	7.79	21.83	37.59	37.92
S. Em. ±	**0.08**	**0.05**	**0.27**	**0.25**
C.D. at 5%	**0.24**	**0.14**	**0.78**	**0.72**

Fig.-5(4.2.1):Influence of varieties and bio-fertilizers on plant height (cm) of isabgol.





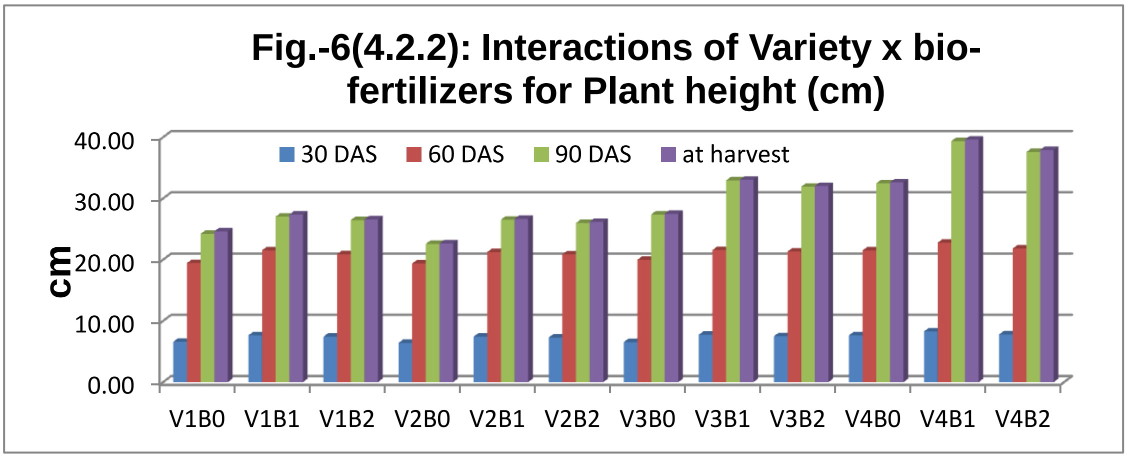


Fig.-6(4.2.2): Interactions of Variety x bio-fertilizers for Plant height (cm)

V_1B_0-Control

V_1B_1-Azotobacter

V_1B_2-PSB

V_2B_0-Control

V_2B_1-Azotobacter

V_2B_2-PSB

Plate 3:- Varietal performance of different biofertilizers in isabgol

V_3B_0-Control

V_3B_1- Azotobacter

V_3B_2-PSB

V_4B_0-Control

V_4B_1- Azotobacter

V_4B_2-PSB

Plate 4:- Varietal performance of different biofertilizers in isabgol

At 90 DAS

The present data indicated that, in the main plots, V_4-JI-4 (36.48) was found significantly maximum plant height in the varieties. Thought, V_3-VI-1 (30.75) lagged behind the former but significantly superior with the remaining treatments. V_2-GI-2 (25.04) was noted minimum plant height.

Study displayed that, in the sub plots, B_1-*Azotobactor* (31.48) was found significantly higher plant height followed by B_2-PSB (30.49) but were significantly superior with the remaining treatments. The minimum plant height (26.66) was seen in the B_0- control.

The data shown that, in the interactions, V_4xB_1 (39.37) was attended significantly highest plant height among the treatments. Thought, V_4xB_2 (37.59) come second highest but significantly superior over rest of the treatments. V_2xB_0- control (22.58) was cumulated lowest plant height.

At harvest

The data displayed that, in the main plots, V_4-JI-4 (36.72) was registered maximum plant height followed by V_3-VI-1 (30.86) but were significantly superior with the remaining varieties. V_2-GI-2 (25.17) was noted minimum plant height.

In the sub plots, B_1-*Azotobactor* (31.68) was observed significantly higher plant height among the treatments. Thought, B_2-PSB (30.68) come after highest but significantly superior with the remaining treatments. The lower plant height (26.85) was recorded in the B_0- control.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (39.62) was attended significantly maximum plant height with the treatments. Thought, V_4xB_2 (37.92) after lagged behind the former but significantly superior over rest of the treatments. V_2xB_0- control (22.66) was perceived minimum plant height.

4.2.2 Number of leaves (plant^{-1})

All the data of number of leaves per plant were significant influenced varieties data and application of bio-fertilizer combinations during different growth stages are presented in Table 4.2.2.1 and graphically illustrated in Fig. 4.2.2.1& 4.2.2.2.

At 30 DAS

Result exhibited that, in the main plots, V_4-JI-4 (11.53) was taken maximum number of leaves per plant followed by V_3-VI-1 (10.18) but they were significantly superior over rest of the varieties. V_2-GI-2 (8.78) was seen minimum number of leaves per plant.

In the sub plots, B_1-*Azotobactor* (10.67) was found significantly higher number of leaves per plant among the treatments. Thought, B_2–PSB (10.43) come after highest but significantly superior with the remaining treatments. The minimum number of leaves per plant (9.20) was recorded in the B_0- control.

The data shown that, in the interactions, V_4xB_1 (12.13) was attended significantly maximum number of leaves per plant among the treatments. Thought, V_4xB_2 (11.67) lagged behind the former but significantly superior with the remaining treatments. V_2xB_0- control (7.60) was observed minimum number of leaves per plant.

At 60 DAS

On perusal of data exhibited that, in the main plots, V_4-JI-4 (35.42) was found significantly maximum number of leaves per plant among the varieties. Thought, V_3-VI-1 (31.84) lagged behind the former but significantly superior with over rest of the varieties. V_2-GI-2 (26.76) was registered minimum number of leaves per plant.

Among sub plots, B_1-*Azotobactor* (33.08) was registered significantly higher number of leaves per plant with the treatments. Thought, B_2–PSB (31.77) lagged behind the former but significantly superior with the remaining treatments. The minimum number of leaves per plant (28.08) was perceived in the B_0- control.

The analysis of variance shown that, in the interactions, V_4xB_1 (37.40) was attended significantly maximum number of leaves per plant among the treatments. Thought, V_4xB_2 (35.87) lagged behind the former and significantly superior over rest of the treatments. V_2xB_0- control (22.73) was possessed minimum number of leaves per plant.

At 90 DAS

The data displayed that, in the main plots, V_4-JI-4 (100.57) was perceived maximum number of leaves per plant followed by V_3-VI-1 (86.18) but they were significantly superior over rest of the varieties. V_2-GI-2 (60.89) was found minimum number of leaves per plant.

In the sub plots, B_1-*Azotobacter* (87.66) was found maximum number of leaves per plant and which was at par with B_2-PSB (86.23) but significantly superior with the remaining treatments. Thought, B_2-PSB (86.23) lagged behind with former but significantly higher over rest of the treatments. The minimum number of leaves per plant (69.13) was recorded in the B_0- control.

The analyzed data shown that, in the interactions, V_4xB_1 (108.91) was attended highest number of leaves per plant followed by V_4xB_2 (107.07) but they were at par with each other but significantly superior over rest of the treatments. V_2xB_0- control (47.33) was observed lowest number of leaves per plant.

At harvest

Investigated that, in the main plots, V_4-JI-4 (102.11) was took significantly maximum number of leaves per plant in the varieties. Thought, V_3-VI-1 (87.43) lagged behind the former but significantly superior with the remaining varieties. V_2-GI-2 (61.44) was noted minimum number of leaves per plant.

In the sub plots, B_1-*Azotobacter* (88.40) was found higher number of leaves per plant followed by B_2-PSB (87.38) and which was at par with each other but significantly superior with the remaining treatments. The lowest number of leaves per plant (69.88) was seen in the B_0-control.

On perusal of data shown that, in the interactions, V_4xB_1 (110.29) was accumulated maximum number of leaves per plant followed by V_4xB_2 (108.86) and which was at par with each other than significantly superior over rest of the treatments. V_2xB_0- control (47.80) was accumulated minimum number of leaves per plant.

4.2.3 Number of tillers (plant^{-1})

All the varietal data of number of tillers per plant were significant influenced with the application of the different bio-fertilizer during different intervals of growth stages are presented in Table 4.2.3.1and graphically shown in Fig. 4.2.3.1& 4.2.3.2.

At 60 DAS

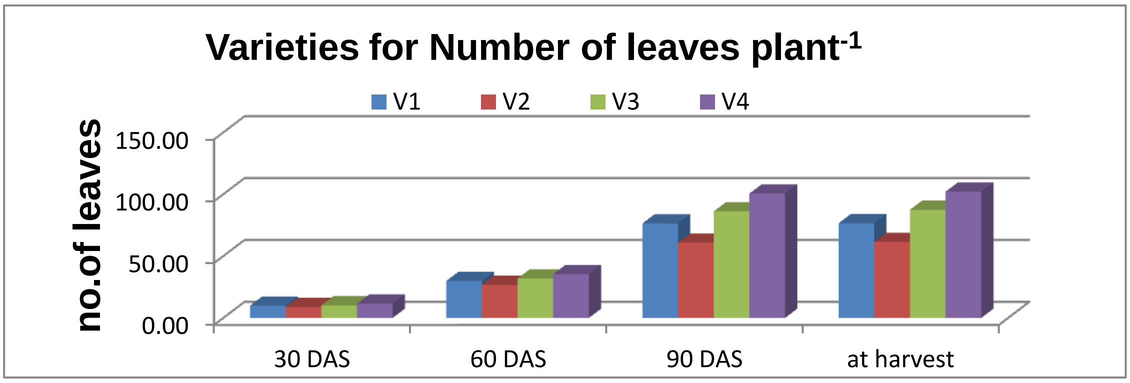
The present data indicated that, in the main plots, V_4-JI-4 (5.22) was accumulated maximum number of tillers per plant followed by V_3-VI-1 (4.31) but they were significantly superior over rest of the varieties. V_2-GI-2 (3.53) was recorded minimum number of tillers per plant.

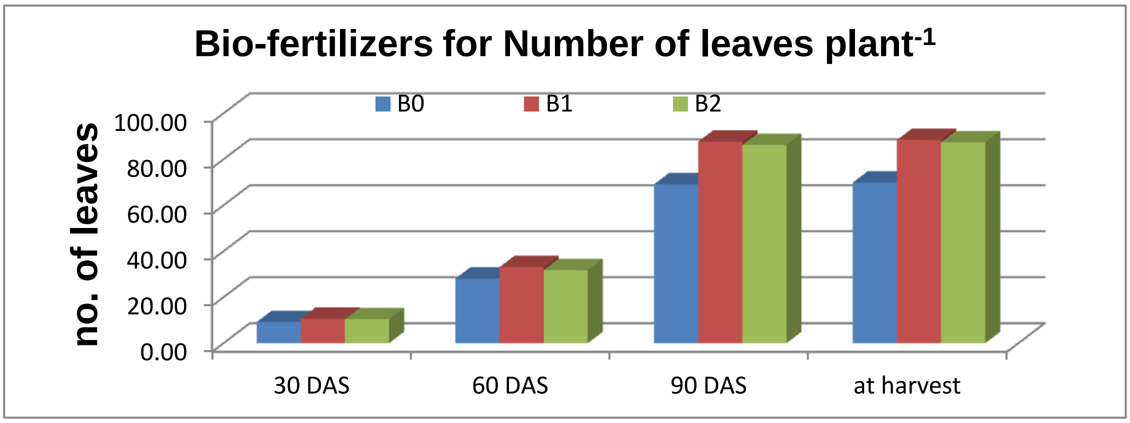
Among the sub plots, B_1-*Azotobacter* (4.70) was found significantly higher number of tillers per plant with the treatments. Thought, B_2-PSB (4.42) come after highest but significantly superior with the remaining treatments. The minimum number of tillers per plant (3.60) was recorded in the B_0- control.

Table-6(4.2.2.1): Influence of Varieties and Bio-fertilizer on Number of leaves plant^{-1} in Isabgol.

Treatment	Number of leaves plant^{-1}			
	30 DAS	**60 DAS**	**90 DAS**	**at harvest**
Varieties				
V_1 - Gujarat Isabgol -1	9.91	29.89	76.40	76.57
V_2 - Gujarat Isabgol -2	8.78	26.76	60.89	61.44
V_3 - Vallabh isabgol -1	10.18	31.84	86.18	87.43
V_4 - Jawahar isabgol-4	11.53	35.42	100.57	102.11
S. Em. ±	**0.06**	**0.25**	**0.64**	**0.66**
C.D. at 5%	**0.18**	**0.73**	**1.88**	**1.94**
Bio-fertilizer (B)				
B_0- Control	9.20	28.08	69.13	69.88
B_1 - Azotobacter (5kg ha^{-1})	10.67	33.08	87.66	88.4
B_2 - PSB (3kg ha^{-1})	10.43	31.77	86.23	87.38
S. Em. ±	**0.05**	**0.22**	**0.56**	**0.57**
C.D. at 5%	**0.16**	**0.63**	**1.63**	**1.68**
Interactions (Varieties X Bio-fertilizer)				
V_1XB_0	8.87	26.87	61.60	61.79
V_1XB_1	10.87	33.27	84.40	84.47
V_1XB_2	10.00	29.53	83.20	83.44
V_2XB_0	7.60	22.73	47.33	47.80
V_2XB_1	9.33	28.67	68.93	69.47
V_2XB_2	9.40	28.87	66.40	67.05
V_3XB_0	9.53	29.73	81.87	82.74
V_3XB_1	10.33	33.00	88.40	89.38
V_3XB_2	10.67	32.8	88.27	90.15
V_4XB_0	10.80	33.00	85.73	87.18
V_4XB_1	12.13	37.4	108.91	110.29
V_4XB_2	11.67	35.87	107.07	108.86
S. Em. ±	**0.11**	**0.43**	**1.11**	**1.14**
C.D. at 5%	**0.31**	**1.27**	**3.26**	**3.35**

Fig.-7(4.2.2.1): Influence of varieties and bio-fertilizers on number of leaves plant^{-1} of isabgol.





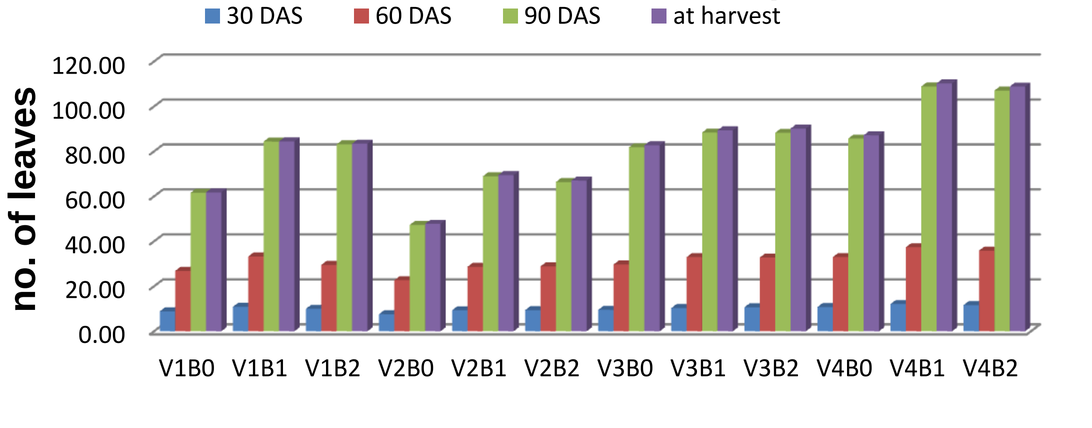


Fig.-8(4.2.2.2): Interactions of Variety x bio-fertilizers for Number of leaves plant^{-1}

The analyzed of data shown that, in the interactions, V_4xB_1 (5.67) was significantly attended maximum number of tillers per plant followed by V_4xB_2 (5.40) and which was at par with each other but they were significantly superior over rest of the treatments. V_2xB_0- control (2.67) was registered minimum number of tillers per plant.

At 90 DAS

Results shown that, in the main plots, V_4-JI-4 (14.00) was observed significantly higher number of tillers per plant among the varieties. Thought, V_3-VI-1 (12.16) lagged behind the former and significantly superior with the remaining varieties. V_2-GI-2 (10.59) was found lower number of tillers per plant.

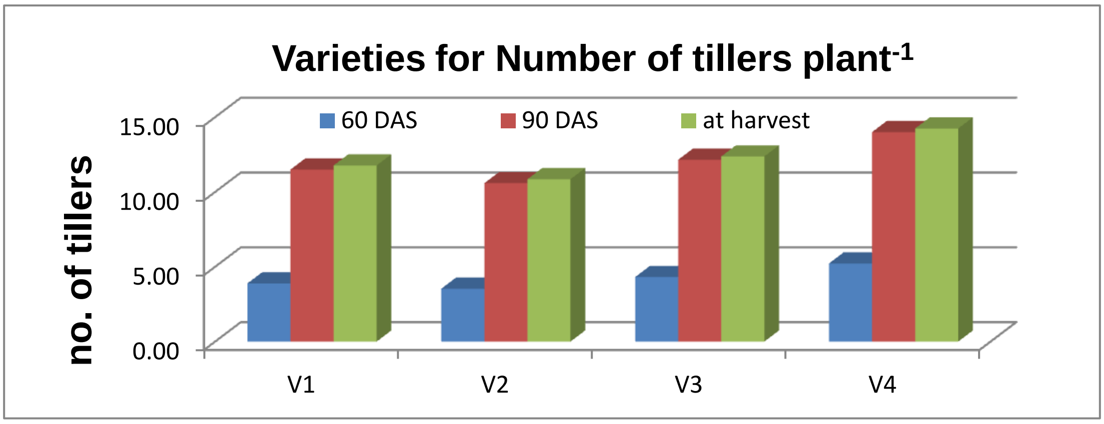
In the sub plots, B_1-*Azotobacter* (13.12) was found higher number of tillers per plant followed by B_2-PSB (12.34) but they were significantly superior with the remaining treatments. The minimum number of tillers per plant (10.73) was took in the B_0- control.

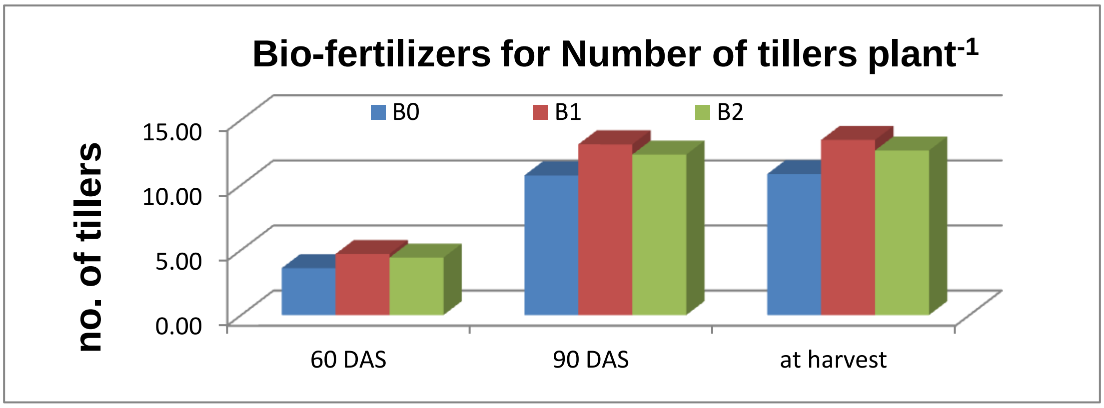
The data shown that, in the interactions, V_4xB_1 (14.91) was perceived maximum number of tillers per plant followed by V_4xB_2 (14.34) and which were at par with each other but they were significantly superior over rest of the treatments. V_2xB_0- control (8.90) was perceived minimum number of tillers per plant.

Table-7(4.2.3.1): Influence of Varieties and Bio-fertilizer on Number of tillers plant^{-1} in Isabgol.

Treatment	Number of tillers plant^{-1}		
	60DAS	90DAS	At harvest
Varieties			
V_1 - Gujarat Isabgol -1	3.89	11.50	11.77
V_2 - Gujarat Isabgol -2	3.53	10.59	10.85
V_3 - Vallabh isabgol -1	4.31	12.16	12.38
V_4 - Jawahar isabgol-4	5.22	14.00	14.24
S. Em. ±	**0.06**	**0.13**	**0.13**
C.D. at 5%	**0.17**	**0.38**	**0.39**
Bio-fertilizers (B)			
B_0- Control	3.60	10.73	10.83
B_1 - Azotobacter (5kg ha^{-1})	4.70	13.12	13.46
B_2 - PSB (3kg ha^{-1})	4.42	12.34	12.65
S. Em. ±	**0.05**	**0.11**	**0.11**
C.D. at 5%	**0.15**	**0.33**	**0.34**
Interactions (Varieties X Bio-fertilizer)			
V_1XB_0	3.20	9.90	10.00
V_1XB_1	4.40	12.97	13.27
V_1XB_2	4.07	11.63	12.04
V_2XB_0	2.67	8.90	9.00
V_2XB_1	4.07	11.70	12.06
V_2XB_2	3.87	11.17	11.51
V_3XB_0	3.93	11.37	11.47
V_3XB_1	4.67	12.90	13.24
V_3XB_2	4.33	12.20	12.43
V_4XB_0	4.60	12.76	12.86
V_4XB_1	5.67	14.91	15.25
V_4XB_2	5.40	14.34	14.62
S. Em. ±	**0.10**	**0.22**	**0.23**
C.D. at 5%	**0.29**	**0.65**	**0.67**

Fig.-9(4.2.3.1): Influence of varieties and bio-fertilizers on number of tillers $plant^{-1}$ of isabgol.





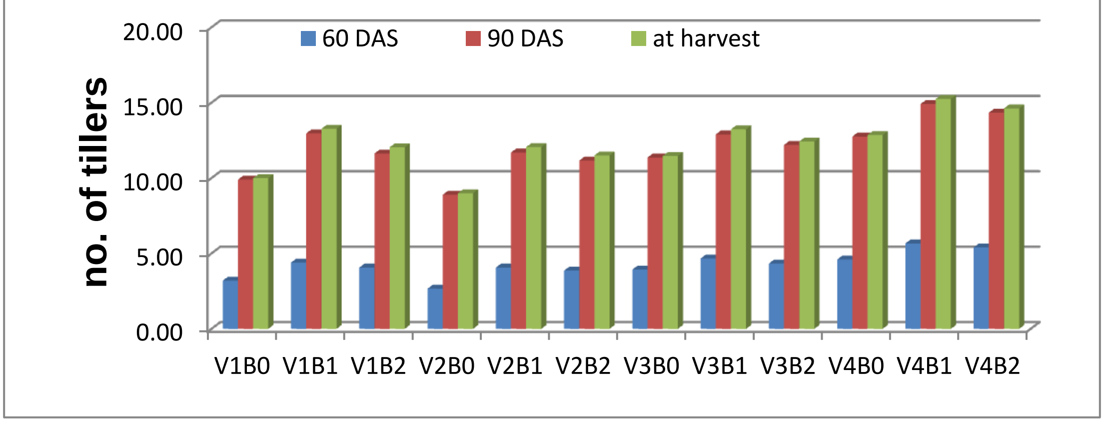


Fig.-10(4.2.3.2): Interactions of Variety x bio-fertilizers for Number of tillers $plant^{-1}$

At harvest

The findings revealed that, in the main plots, V_4-JI-4 (14.24) was cumulated significantly highest number of tillers per plant among the varieties. Thought, V_3-VI-1 (12.38) lagged behind the former but significantly superior with the remaining varieties. V_2-GI-2 (10.85) was seen minimum number of tillers per plant.

In the sub plots, B_1-*Azotobacter* (13.46) was found significantly higher number of tillers per plant with the remaining treatments. Thought, B_2-PSB (12.65) come after highest but significantly superior with the remaining treatments. The minimum number of tillers per plant (10.83) was recorded in the B_0- control.

On perusal of data shown that, in the interactions, V_4xB_1 (15.25) was registered number of tillers per plant followed by V_4xB_2 (14.62) and which were at par with each other but they were significantly superior over rest of the treatments. V_2xB_0- control (9.00) was noted lowest number of tillers per plant.

4.2.4 Number of spike (plant^{-1})

In overall data of number of spike per plant were significant influenced with the application of the different varieties and bio-fertilizer combinations during life plan of plant and are presented in Table 4.2.4.1 and graphically shown in Fig. 4.2.4.1& 4.2.4.2.

At 60 DAS

The data investigated that, in the main plots, V_4-JI-4 (13.27) was observed maximum number of spike per plant followed by V_3-VI-1 (9.60) but they were significantly superior with the remaining varieties. V_2-GI-2 (7.24) was perceived minimum number of spike per plant.

Among the sub plots, B_1-*Azotobacter* (10.98) was found significantly higher number of spike per plant among the treatments. Thought, B_2-PSB (10.00) come after highest but significantly superior with the remaining treatments. The minimum number of spike per plant (8.07) was recorded in the B_0- control.

The analysis of variance data shown that, in the interactions, V_4xB_1 (15.13) was attended significantly maximum number of spike per plant with the remaining treatments. Thought, V_4xB_2 (13.87) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0- control (5.67) was accumulated minimum number of spike per plant.

At 90 DAS

The present data indicated that, in the main plots, V_4-JI-4 (22.08) was found significantly maximum number of spike per plant among the varieties. Thought, V_3-VI-1 (18.32) lagged behind the former and significantly superior with the remaining varieties. V_2-GI-2 (15.44) was cumulated minimum number of spike per plant.

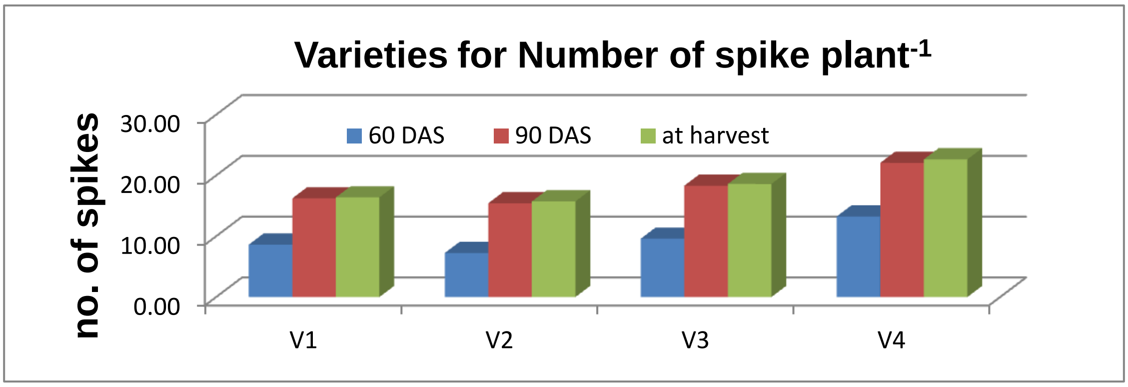
Among the sub plots, B_1-*Azotobacter* (19.19) was taken higher number of spike per plant followed by B_2-PSB (18.11) but they were significantly superior with the remaining treatments. The lower number of spike per plant (16.77) was recorded in the B_0-control.

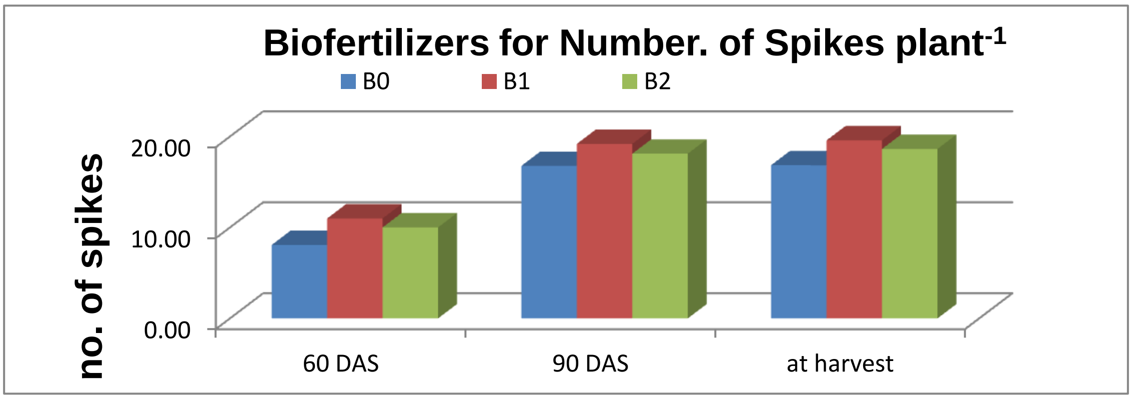
The data shown that, in the interactions, V_4xB_1 (23.81) was attended significantly maximum number of spike per plant among the treatments. Thought, V_4xB_2 (22.62) lagged behind the former, but significantly superior over rest of the treatments. V_2xB_0 - control (14.42) was perceived minimum number of spike per plant.

Table-8(4.2.4.1): Influence of Varieties and Bio-fertilizer on Number of Spikes plant^{-1} in Isabgol.

Treatment	Number of Spikes plant^{-1}		
	60DAS	**90DAS**	**At harvest**
Varieties			
V_1 - Gujarat Isabgol -1	8.62	16.24	16.40
V_2 - Gujarat Isabgol -2	7.24	15.44	15.73
V_3 - Vallabh isabgol -1	9.60	18.32	18.61
V_4 - Jawahar isabgol-4	13.27	22.08	22.66
S. Em. ±	**0.16**	**0.10**	**0.12**
C.D. at 5%	**0.47**	**0.29**	**0.36**
Bio-fertilizers (B)			
B_0- Control	8.07	16.77	16.84
B_1 - Azotobacter (5kg ha^{-1})	10.98	19.19	19.58
B_2 - PSB (3kg ha^{-1})	10.00	18.11	18.63
S. Em. ±	**0.14**	**0.08**	**0.11**
C.D. at 5%	**0.41**	**0.25**	**0.31**
Interactions (Varieties X Bio-fertilizer)			
V_1XB_0	7.87	15.32	15.32
V_1XB_1	9.47	17.47	17.69
V_1XB_2	8.53	15.93	16.19
V_2XB_0	5.67	14.42	14.72
V_2XB_1	8.47	16.47	16.73
V_2XB_2	7.60	15.43	15.75
V_3XB_0	7.93	17.49	17.49
V_3XB_1	10.87	19.01	19.38
V_3XB_2	10.00	18.47	18.95
V_4XB_0	10.80	19.83	19.83
V_4XB_1	15.13	23.81	24.50
V_4XB_2	13.87	22.62	23.64
S. Em. ±	**0.28**	**0.17**	**0.21**
C.D. at 5%	**0.81**	**0.50**	**0.63**

Fig.-11(4.2.4.1):Influence of varieties and bio-fertilizers on number of spikes plant^{-1} of isabgol.





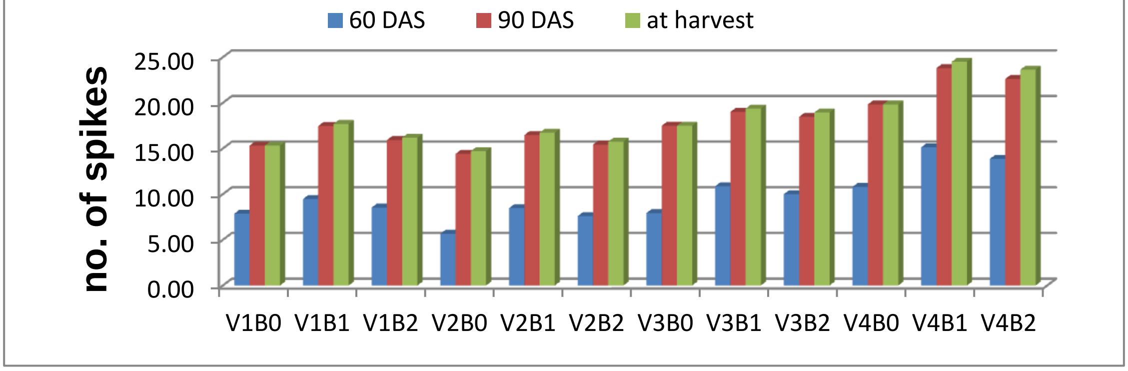


Fig.-12(4.2.4.2): Interactions of Variety x bio-fertilizers for Number of spikes plant^{-1}

At harvest

The result exhibited that, in the main plots, V_4-JI-4 (22.66) was found maximum number of spike per plant followed by V_3-VI-1 (18.61) but they were significantly superior with the remaining varieties. V_2-GI-2 (15.73) was perceived minimum number of spike per plant.

In the sub plots, B_1-*Azotobactor* (19.58) was significantly higher number of spike per plant among the treatments. Thought, B_2-PSB (18.63) after higher with significantly superior with the remaining treatments. The minimum number of spike per plant (16.84) was recorded in the B_0- control.

The analyzed of data shown that, in the interactions, V_4xB_1 (24.50) was cumulated significantly maximum number of spike per plant among the treatments. Thought, V_4xB_2 (23.64) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0 - control (14.72) was observed minimum number of spike per plant.

4.2.5 Length of spike (cm)

Investigations pertaining to the significant influenced with the application of the different varieties and bio-fertilizer combinations during different growth stages are presented in Table 4.2.5.1 and diagrammatically illustrated in Fig. 4.2.5.1& 4.2.5.2.

At 60 DAS

The present data indicated that, in the main plots, V_4-JI-4 (3.02) was found significantly maximum length of spike among the varieties. Thought, V_3-VI-1 (2.00) after highest, but significantly superior with the remaining varieties. V_2-GI-2 (1.47) was observed minimum length of spike.

In the sub plots, B_1-*Azotobactor* (2.40) was found significantly higher length of spike among the treatments. Thought, B_2-PSB (2.21) lagged behind the former but significantly superior over rest of the treatments. The minimum Length of spike (1.59) was recorded in the B_0-control.

The analysis of variance shown that, in the interactions, V_4xB_1 (3.55) was attended significantly maximum length of spike among the treatments. Thought, V_4xB_2 (3.15) lagged behind the former with significantly superior over rest of the treatments. V_2xB_0 - control (1.05) was registered minimum length of spike.

At 90 DAS

Results revealed that, in the main plots, V_4-JI-4 (5.01) was perceived maximum length of spike followed by V_3-VI-1 (4.09) but they were significantly superior with the remaining varieties. V_2-GI-2 (3.10) was observed minimum length of spike.

In the sub plots, B_1-*Azotobactor* (4.28) were noted statistically higher length of spike over rests the treatments. Thought, B_2-PSB (4.22) lagged behind the former but significantly superior over rest of the treatments. The minimum length of spike (3.44) was seen in the B_0-control.

The data shown that, in the interactions, V_4xB_1 (5.30) was attended maximum length of spike followed by V_4xB_2 (5.18) but they were significantly superior over rest of the treatments. V_2xB_0- control (2.27) was accumulated minimum length of spike.

At harvest

The result exhibited that, in the main plots, V_4-JI-4 (5.10) was accumulated significant highest length of spike among the varieties. Thought, V_3-VI-1 (4.16) come after highest, but significantly superior over rest of the varieties. V_2-GI-2 (3.13) was noted minimum length of spike.

In the sub plots, B_1-*Azotobactor* (4.35) was found statistically higher length of spike over the remaining treatments. Thought, B_2-PSB (4.28) come after highest, but significantly superior with the remaining treatments. The lower length of spike (3.48) was recorded in the B_0-control.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (5.38) was attended significantly highest length of spike in the treatments. Thought, V_4xB_2 (5.28) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0- control (2.27) was observed minimum length of spike.

4.2.6. Fresh Weight (g plant^{-1})

All the data of fresh weight were significant influenced with the application of the different varieties and bio-fertilizer combinations during plant life span are presented in Table 4.2.6.1 and diagrammatically illustrated in Fig. 4.2.6.1& 4.2.6.2.

At 30 DAS

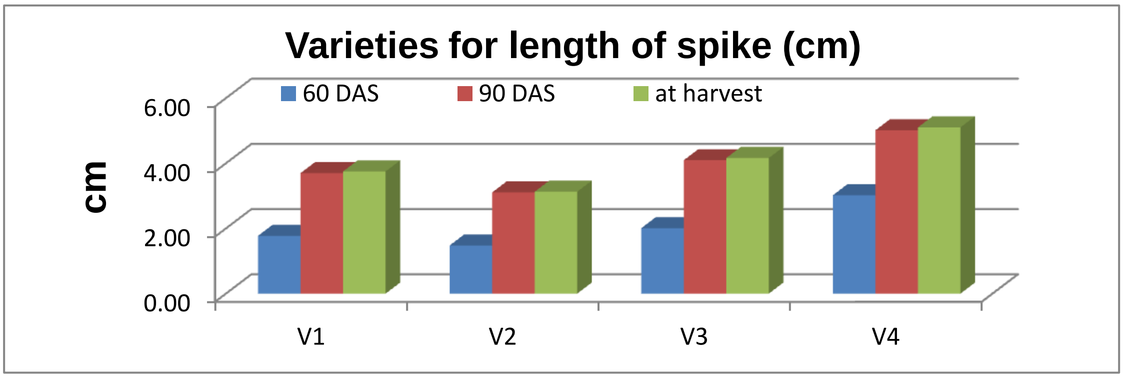
The analysis of variance exhibited that, in the main plots, V_4-JI-4 (2.58) was found significantly maximum fresh weight among the varieties. Thought, V_3-VI-1 (2.23) second highest and which was at par with V_1-GI-1 (2.20) but significantly superior over rest of the treatments. V_2-GI-2(1.94) was registered minimum fresh weight.

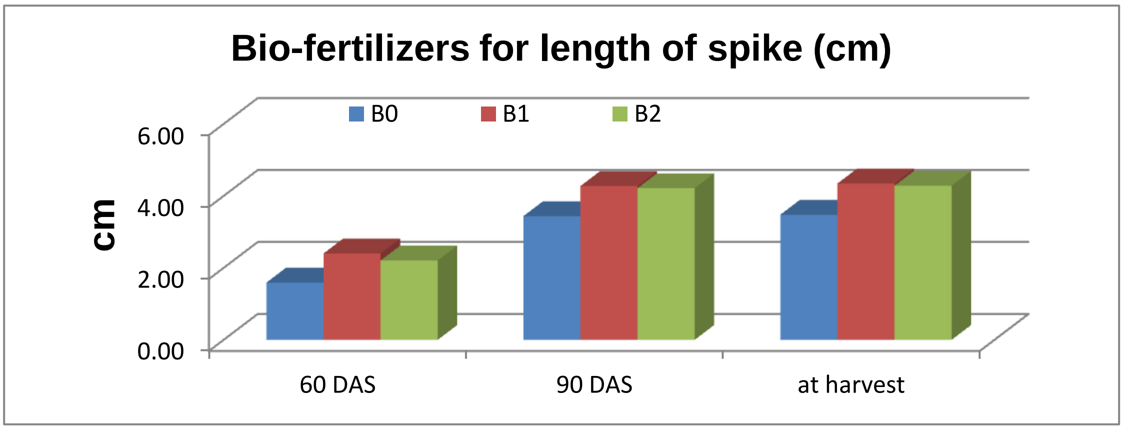
In the sub plots, B_1-*Azotobactor* (2.38) was observed higher fresh weight followed by B_2-PSB (2.30) but they were significantly superior with the remaining treatments. The lower fresh weight (2.03) was recorded in the B_0- control.

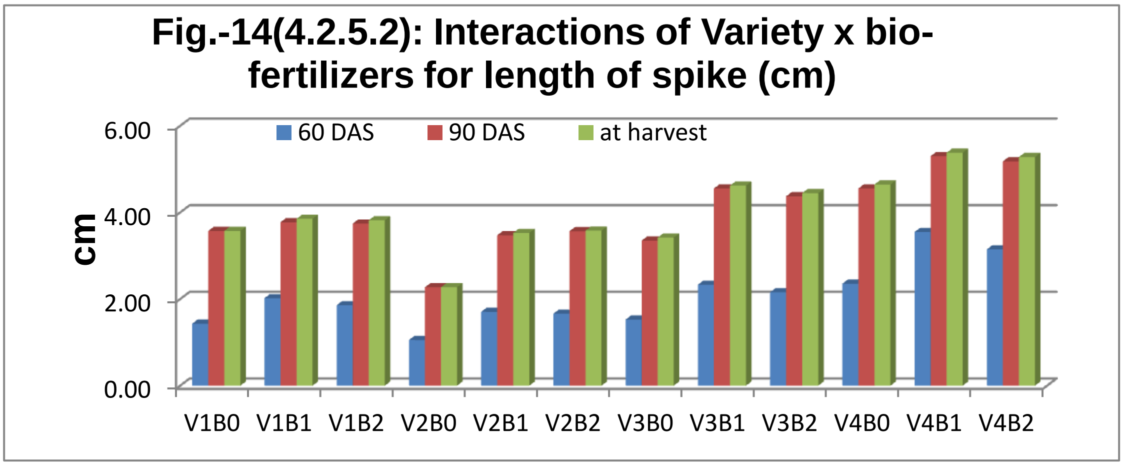
Table-9(4.2.5.1): Influence of Varieties and Bio-fertilizer on Length of spike (cm) in Isabgol

Treatment	Length of spike (cm)		
	60DAS	90DAS	At harvest
Varieties			
V_1 - Gujarat Isabgol -1	1.77	3.70	3.75
V_2 - Gujarat Isabgol -2	1.47	3.10	3.13
V_3 - Vallabh isabgol -1	2.00	4.09	4.16
V_4 - Jawahar isabgol-4	3.02	5.01	5.10
S. Em. ±	**0.03**	**0.01**	**0.01**
C.D. at 5%	**0.08**	**0.04**	**0.04**
Bio-fertilizers (B)			
B_0- Control	1.59	3.44	3.48
B_1 - Azotobacter (5kg ha^{-1})	2.40	4.28	4.35
B_2 - PSB (3kg ha^{-1})	2.21	4.22	4.28
S. Em. ±	**0.02**	**0.01**	**0.01**
C.D. at 5%	**0.07**	**0.04**	**0.03**
Interactions (Varieties X Bio-fertilizer)			
V_1XB_0	1.43	3.57	3.57
V_1XB_1	2.02	3.77	3.85
V_1XB_2	1.86	3.74	3.82
V_2XB_0	1.05	2.27	2.27
V_2XB_1	1.70	3.47	3.53
V_2XB_2	1.66	3.57	3.58
V_3XB_0	1.53	3.35	3.42
V_3XB_1	2.33	4.55	4.62
V_3XB_2	2.16	4.37	4.45
V_4XB_0	2.35	4.55	4.65
V_4XB_1	3.55	5.30	5.38
V_4XB_2	3.15	5.18	5.28
S. Em. ±	**0.04**	**0.03**	**0.02**
C.D. at 5%	**0.13**	**0.08**	**0.07**

Fig.-13(4.2.5.1):Influence of varieties and bio-fertilizers on length of spike (cm) of isabgol.







The analysis of variance shown that, in the interactions, V_4xB_1 (2.71) was accumulated significantly maximum fresh weight in all over the treatments. Thought, V_4xB_2 (2.63) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0- control (1.70) was registered minimum fresh weight.

At 60 DAS

Result investigated that, in the main plots, V_4-JI-4 (26.67) was found significantly maximum fresh weight among the varieties. Thought, V_3-VI-1 (20.38) lagged behind the former but significantly superior with the remaining varieties. V_2-GI-2 (11.81) was took minimum fresh weight.

Study displayed that, B_1-*Azotobacter* (22.00) was found significantly higher fresh weight among the treatments. Thought, B_2-PSB (20.00) come after highest, but significantly superior with all the treatments. The minimum fresh weight (15.37) was seen in the B_0-control.

The data shown that, in the interactions, V_4xB_1 (31.07) was observed significantly maximum fresh weight among the treatments. Thought, V_4xB_2 (27.53) come next highest, but significantly superior over rest of the treatments. V_2xB_0- control (10.76) was perceived minimum fresh weight.

At 90DAS

On perusal of data revealed that, in the main plots, V_4-JI-4 (60.36) was registered significantly maximum fresh weight among the varieties. Thought, V_3-VI-1 (50.56) come after highest, but significantly superior with the remaining varieties. V_2-GI-2 (39.94) was cumulated minimum fresh weight.

Study displayed that, in the sub plots, B_1-*Azotobacter* (53.76) was observed higher fresh weight followed by B_2-PSB (49.26) but they were significantly superior over the treatments. The lower fresh weight (43.56) was recorded in the B_0- control.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (65.55) was attended significantly maximum fresh weight among the treatments. Thought, V_4xB_2 (63.74) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0 - control (37.42) was noted minimum fresh weight.

At harvest

The findings revealed that, in the main plots, V_4-JI-4 (60.76) was recorded significantly maximum fresh weight among all the varieties. Thought, V_3-VI-1 (50.77) come after highest, but significantly superior with the remaining varieties. V_2-GI-2 (40.40) was seen minimum fresh weight.

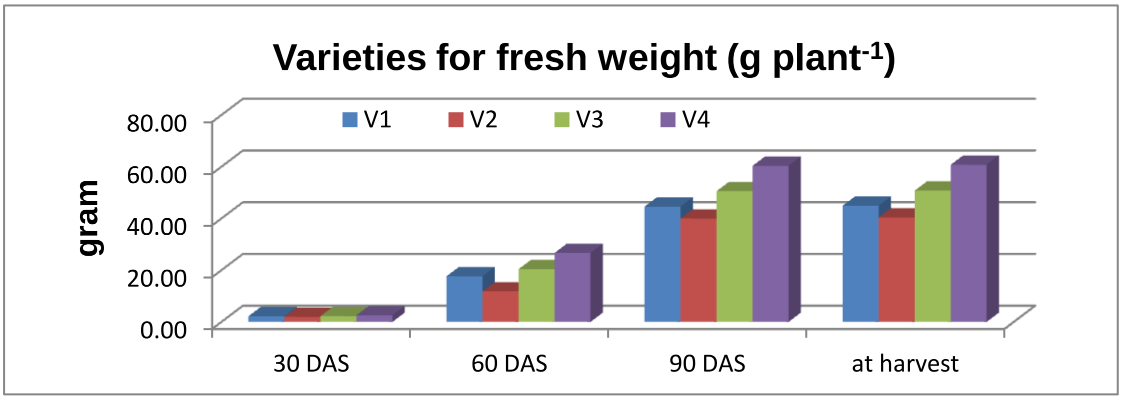
In the sub plots, B_1-*Azotobacter* (54.01) was found significantly higher fresh weight among the treatments. Thought, B_2-PSB (49.64) lagged behind the former but significantly superior with the treatments. The lower fresh weight (43.98) was recorded in the B_0- control.

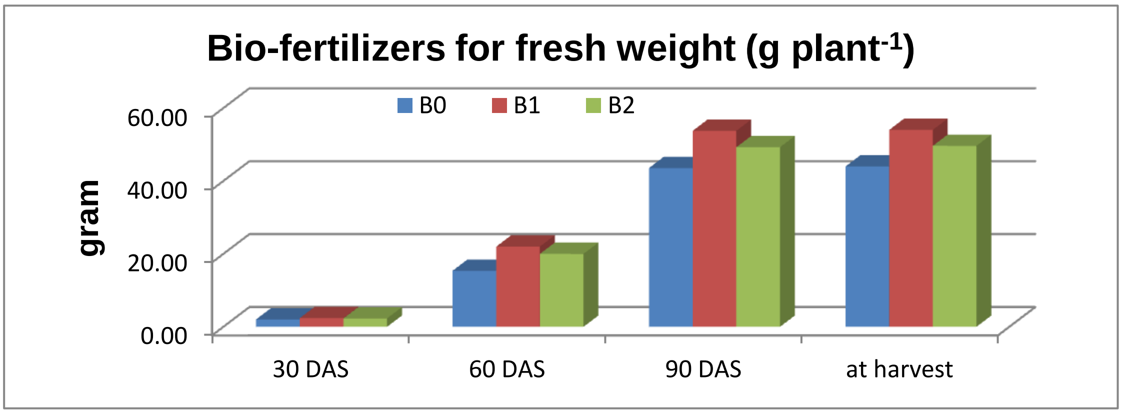
The analyzed of data shown that, in the interactions, V_4xB_1 (65.82) was taken significantly maximum fresh weight among the treatments. Thought, V_4xB_2 (64.42) lagged behind the former and significantly superior over rest of the treatments. V_2xB_0 - control (37.92) was observed minimum fresh weight.

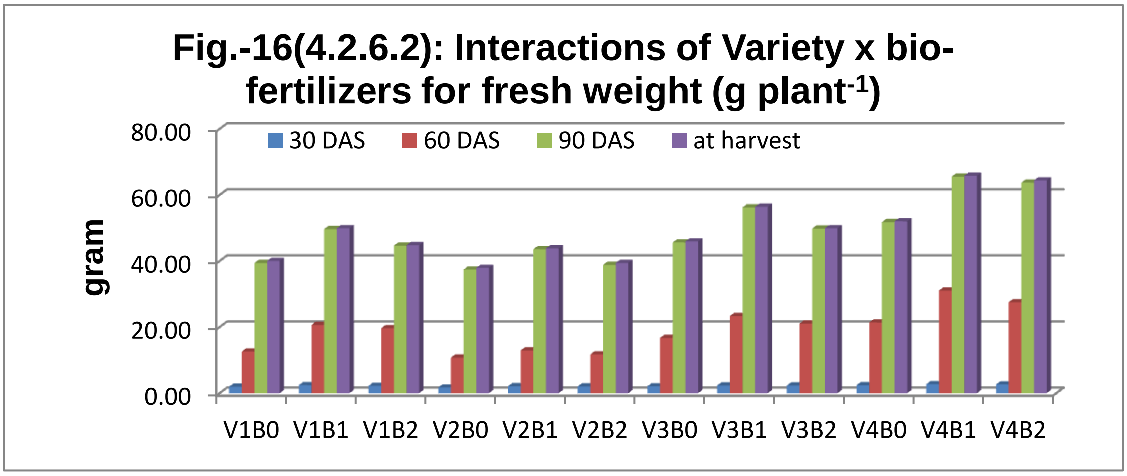
Table-10(4.2.6.1): Influence of Varieties and Bio-fertilizer on Fresh weight ($g\ plant^{-1}$) in Isabgol.

Treatment	Fresh weight ($g\ plant^{-1}$)			
	30 DAS	**60 DAS**	**90 DAS**	**at harvest**
Varieties				
V_1 - Gujarat Isabgol -1	2.20	17.64	44.58	44.92
V_2 - Gujarat Isabgol -2	1.94	11.81	39.94	40.40
V_3 - Vallabh isabgol -1	2.23	20.38	50.56	50.77
V_4 - Jawahar isabgol-4	2.58	26.67	60.36	60.76
S. Em. ±	**0.01**	**0.31**	**0.03**	**0.05**
C.D. at 5%	**0.04**	**0.9**	**0.08**	**0.16**
Bio-fertilizers (B)				
B_0- Control	2.03	15.37	43.56	43.98
B_1 - Azotobacter (5kg ha^{-1})	2.38	22.00	53.76	54.01
B_2 - PSB (3kg ha^{-1})	2.30	20.00	49.26	49.64
S. Em. ±	**0.01**	**0.27**	**0.02**	**0.05**
C.D. at 5%	**0.03**	**0.78**	**0.07**	**0.14**
Interactions (Varieties X Bio-fertilizer)				
V_1XB_0	1.95	12.60	39.42	40.03
V_1XB_1	2.41	20.67	49.68	49.93
V_1XB_2	2.22	19.67	44.65	44.79
V_2XB_0	1.70	10.76	37.42	37.92
V_2XB_1	2.09	12.93	43.59	43.85
V_2XB_2	2.04	11.73	38.82	39.43
V_3XB_0	2.07	16.73	45.63	45.94
V_3XB_1	2.31	23.33	56.22	56.43
V_3XB_2	2.30	21.07	49.83	49.93
V_4XB_0	2.41	21.4	51.79	52.03
V_4XB_1	2.71	31.07	65.55	65.82
V_4XB_2	2.63	27.53	63.74	64.42
S. Em. ±	**0.02**	**0.53**	**0.05**	**0.09**
C.D. at 5%	**0.06**	**1.56**	**0.13**	**0.27**

Fig.-15(4.2.6.1):Influence of varieties and bio-fertilizers on fresh weight (g plant^{-1}) of isabgol







4.2.7-Dry Weight (g plant^{-1})

Dry weight gram per plant was varied significantly among the different treatments and their interactions during life span of plant and data are presented in Table 4.2.7.1 and graphically illustrated in Fig. 4.2.7.1& 4.2.7.2.

At 30 DAS

Results shown that, in the main plots, V_4-JI-4 (0.85) was recorded significantly maximum dry weight gram per plant among the varieties. Thought, V_3-VI-1 (0.73) come after second and which was at par with V_1-GI-1 (0.72) but significantly superior with the remaining varieties. V_2-GI-2 (0.63) was possessed minimum dry weight gram per plant.

In the sub plots, B_1-*Azotobactor* (0.78) was found significantly higher dry weight gram per plant among the treatments. Thought, B_2-PSB (0.75) lagged behind the former but significantly higher over rest of the treatments. The minimum dry weight gram per plant (0.67) was seen in the B_0- control.

The data shown that, in the interactions, V_4xB_1 (0.90) was attended maximum dry weight gram per plant followed by V_4xB_2 (0.87) and which were at par with each other but they were significantly superior over rest of the treatments. Control V_2xB_0- control (0.57) was registered minimum dry weight gram per plant.

At 60 DAS

The present data indicated that, the main plots varieties, V_4-JI-4 (7.61) was perceived significantly highest dry weight gram per plant among the varieties. Thought, V_3-VI-1(5.96) come after highest, but significantly superior with the remaining varieties. V_2-GI-2 (3.50) was seen minimum dry weight.

In the sub plots, B_1-*Azotobactor* (6.25) was cumulated significantly higher dry weight gram per plant among the treatments. Thought, B_2-PSB (5.91) lagged behind the former but significantly superior over the treatments. The lower dry weight gram per plant (4.48) was registered in the B_0-control.

On perusal of data shown that, in the interactions, V_4xB_1 (8.35) was attended significantly maximum dry weight gram per plant among the treatments. Thought, V_4xB_2 (8.13) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0- control (3.22) was observed minimum dry weight.

At 90 DAS

Results revealed that, in the main plots, V_4-JI-4 (17.09) was recorded significantly maximum dry weight gram per plant over the varieties. Thought, V_3-VI-1 (14.22) lagged behind the former but significantly superior with the remaining varieties. V_2-GI-2 (11.99) was seen minimum dry weight.

In the sub plots, B_1-*Azotobacter* (15.13) was found significantly highest dry weight gram per plant among the treatments. Thought, B_2-PSB (14.32) come after highest but significantly superior over the treatments. The lowest dry weight gram per plant (12.89) was accumulated in the B_0- control.

In the interactions, V_4xB_1 (18.39) was taken significantly maximum dry weight gram per plant among the treatments. Thought, V_4xB_2 (17.94) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0 - control (11.36) was observed minimum dry weight.

At harvest

The Result exhibited that, in the main plots, V_4-JI-4 (17.19) was registered significantly maximum dry weight gram per plant with the varieties. Thought, V_3-VI-1 (14.27) after highest but significantly superior over the remaining varieties. V_2-GI-2 (12.10) was noted minimum dry weight.

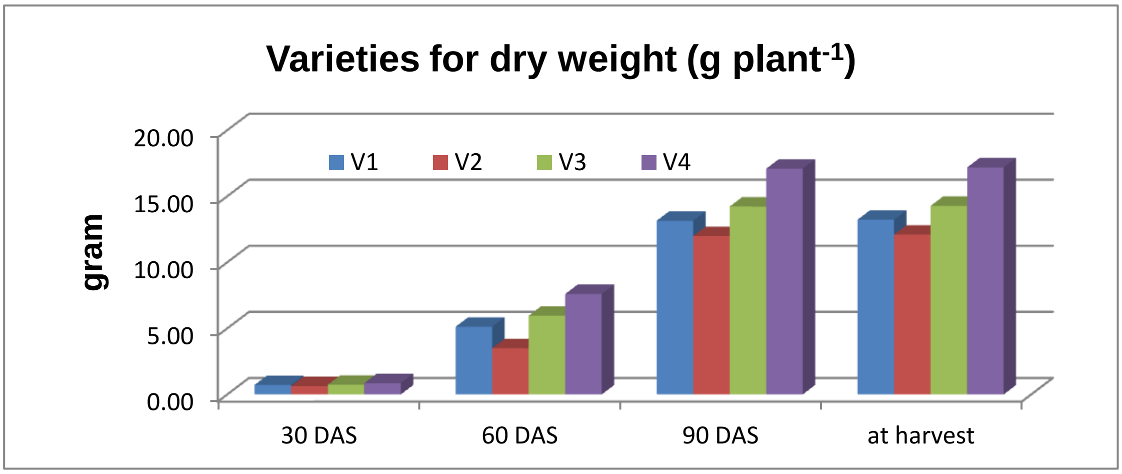
Among the sub plots, B_1-*Azotobacter* (15.19) was found significantly higher dry weight gram per plant with the treatments. Thought, B_2-PSB (14.41) after highest, but significantly superior with the remaining treatments. The minimum dry weight gram per plant (12.99) was seen in the B_0- control.

The analysis of variance shown that, in the interactions, V_4xB_1 (18.46) was accumulated significantly maximum dry weight gram per plant among the treatments. Thought, V_4xB_2 (18.11) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0 - control (11.48) was taken minimum dry weight.

Table-11(4.2.7.1): Influence of Varieties and Bio-fertilizer on Dry weight (g plant^{-1}) in Isabgol.

Treatment	Dry weight (g plant^{-1})			
	30 DAS	60 DAS	90 DAS	At harvest
Varieties				
V_1 - Gujarat Isabgol -1	0.72	5.12	13.15	13.23
V_2 - Gujarat Isabgol -2	0.63	3.50	11.99	12.10
V_3 - Vallabh isabgol -1	0.73	5.96	14.22	14.27
V_4 - Jawahar isabgol-4	0.85	7.61	17.09	17.19
S. Em. ±	**0.01**	**0.02**	**0.01**	**0.01**
C.D. at 5%	**0.02**	**0.07**	**0.02**	**0.04**
Bio-fertilizers (B)				
B_0- Control	0.67	4.48	12.89	12.99
B_1 - Azotobacter (5kg ha^{-1})	0.78	6.25	15.13	15.19
B_2 - PSB (3kg ha^{-1})	0.75	5.91	14.32	14.41
S. Em. ±	**0.001**	**0.02**	**0.01**	**0.01**
C.D. at 5%	**0.01**	**0.06**	**0.02**	**0.03**
Interactions (Varieties X Bio-fertilizer)				
V_1XB_0	0.64	3.52	11.86	12.01
V_1XB_1	0.80	6.04	14.42	14.48
V_1XB_2	0.73	5.81	13.16	13.20
V_2XB_0	0.57	3.22	11.36	11.48
V_2XB_1	0.67	3.85	12.9	12.96
V_2XB_2	0.66	3.42	11.71	11.86
V_3XB_0	0.69	4.86	13.41	13.48
V_3XB_1	0.76	6.74	14.81	14.86
V_3XB_2	0.74	6.29	14.46	14.48
V_4XB_0	0.79	6.33	14.95	15.01
V_4XB_1	0.90	8.35	18.39	18.46
V_4XB_2	0.87	8.13	17.94	18.11
S. Em. ±	**0.01**	**0.04**	**0.01**	**0.02**
C.D. at 5%	**0.03**	**0.12**	**0.03**	**0.07**

Fig.-17(4.2.7.1): Influence of varieties and bio-fertilizers on dry weight (g plant^{-1}) of isabgol.



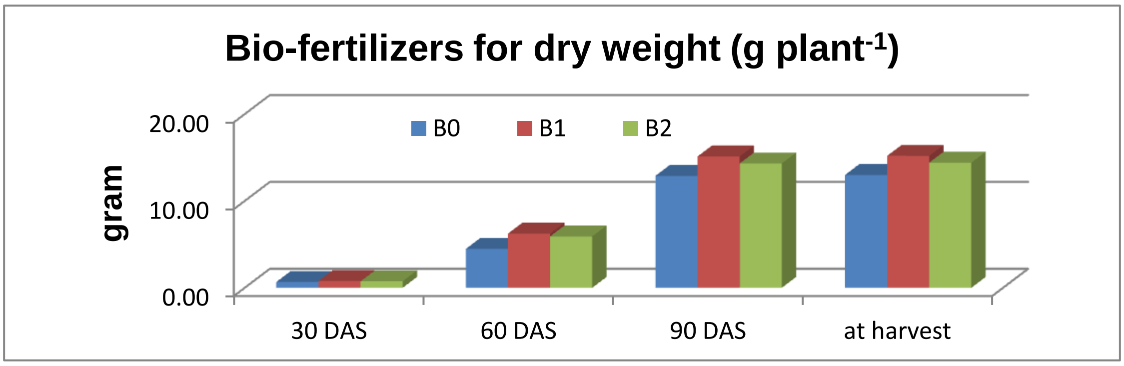
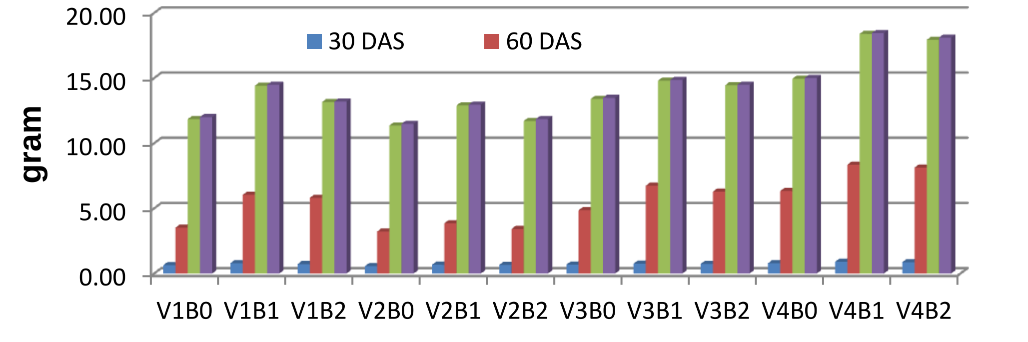


Fig.-18(4.2.7.2): Interactions of Variety x bio-fertilizers for dry weight (g plant^{-1})



4.3 Yield parameter and yield attributing

4.3.1 Number of seed ($spike^{-1}$)

The varietal data related to number of seed per spike were varied significant with the application of bio-fertilizer combinations during investigation are presented in Table 4.3.1 and diagrammatically illustrated in Fig 4.3.1.A&B.

On perusal of data shown that, in the main plots, V_4-JI-4 (83.28) was recorded significantly maximum number of seed per spike followed by V_3-VI-1 (82.03) but they were significantly superior with the remaining varieties. V_2-GI-2 (79.19) was noted minimum number of seed per spike.

Among the sub plots, B_1-*Azotobactor* (82.92) was found significantly higher number of seed per spike over rest of the treatments. Thought, B_2-PSB (82.36) come after highest, but significantly superior with the remaining treatments. The minimum number of seed per spike (79.48) was registered in the B_0-control.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (84.70) was attended significantly maximum number of seed per spike over rest of the treatments. Thought, V_1xB_1 (83.65) lagged behind the former and which was at par with V_3xB_1 (83.62), V_3xB_2 (83.54) and V_4xB_2 (83.54) but significantly superior over rest of the treatments. V_2xB_0 - control (78.53) was perceived minimum number of seed per spike.

4.3.2 Seed yield (g $plot^{-1}$)

The varietal data related to yield viz; seed yield gram per plot were varied significantly with the application of different bio-fertilizer combinations during investigation and are presented in Table 4.3.2 and graphically shown in Fig 4.3.2.A&B.

Results exhibited that, in the main plots, V_4-JI-4 (412.26) was registered significantly maximum seed yield gram per plot over rest of the varieties. Thought, V_3-VI-1 (315.62) lagged behind the former but significantly superior with the remaining varieties. V_2-GI-2 (237.93) was observed minimum seed yield gram per plot.

Among the sub plots, B_1-*Azotobactor* (342.69) was found significantly higher seed yield gram per plot followed by B_2-PSB (317.68) but they were significantly superior with the remaining treatments. The minimum seed yield gram per plot (267.73) was cumulated in the B_0-control.

The analysis of variance shown that, in the interactions, V_4xB_1 (459.00) was taken significantly maximum seed yield gram per plot among the treatments. Thought, V_4xB_2 (431.31) lagged behind the former but significantly superior over rest of the treatments. V_2B_0- control (213.63) was registered minimum seed yield gram per plot.

4.3.3 Seed yield (q ha^{-1})

Seed yield of varieties differed significantly with the application of different bio-fertilizer combinations during investigation and data are presented in Table 4.3.3 and graphically illustrated in Fig 4.3.3.A & B.

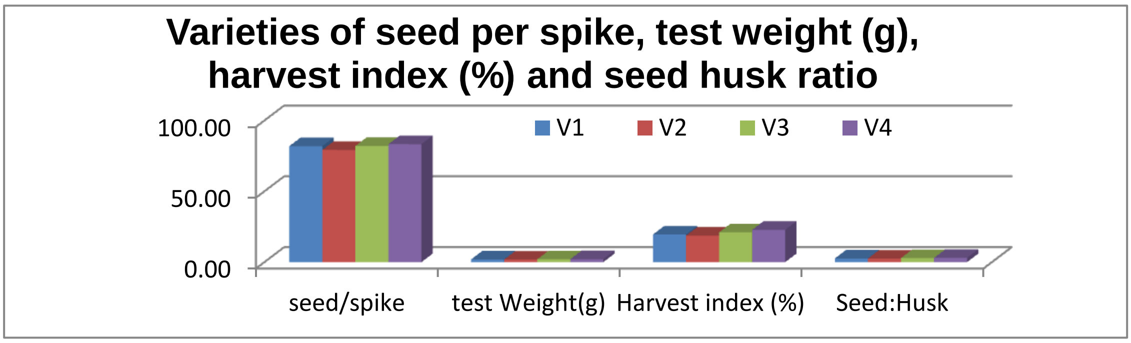
The data pertaining that, in the main plots, V_4-JI-4 (13.09) was received significantly highest seed yield followed by V_3-VI-1 (10.02) but they were significantly superior with the remaining varieties. V_2-GI-2 (7.55) was noted lowest seed yield.

In the sub plots, B_1-*Azotobactor* (10.88) was found significantly higher seed yield over rest of the treatments. Thought, B_2-PSB (10.09) lagged behind the former but significantly higher with the remaining treatments. The minimum seed yield (8.50) was perceived in the B_0-control.

Table-12(4.3.1-4): Influence of Varieties and Bio-fertilizer on Yield Parameter Number of seed spike^{-1}, Seed yield (g plot^{-1}), Seed yield (q ha^{-1}), Straw yield (q ha^{-1}) in Isabgol

Treatment	Number of seed spike^{-1}	Seed yield (g plot^{-1})	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})
Varieties				
V_1 - Gujarat Isabgol -1	81.85	271.65	8.62	35.47
V_2 - Gujarat Isabgol -2	79.19	237.93	7.55	32.78
V_3 - Vallabh isabgol -1	82.03	315.62	10.02	37.57
V_4 - Jawahar isabgol-4	83.28	412.26	13.09	44.21
S. Em. ±	**0.09**	**2.50**	**0.08**	**0.09**
C.D. at 5%	**0.25**	**7.33**	**0.23**	**0.27**
Bio-fertilizers (B)				
B_0- Control	79.48	267.73	8.50	34.82
B_1 - Azotobacter (5kg ha^{-1})	82.92	342.69	10.88	39.75
B_2 - PSB (3kg ha^{-1})	82.36	317.68	10.09	37.95
S. Em. ±	**0.07**	**2.16**	**0.07**	**0.08**
C.D. at 5%	**0.22**	**6.34**	**0.20**	**0.23**
Interactions (Varieties X Bio-fertilizer)				
V_1XB_0	78.87	233.47	7.41	32.62
V_1XB_1	83.65	307.18	9.75	38.53
V_1XB_2	83.03	274.31	8.71	35.28
V_2XB_0	78.53	213.63	6.78	31.48
V_2XB_1	79.70	260.9	8.28	34.93
V_2XB_2	79.33	239.27	7.60	31.93
V_3XB_0	78.92	277.37	8.81	36.14
V_3XB_1	83.62	343.66	10.91	38.62
V_3XB_2	83.54	325.82	10.34	37.93
V_4XB_0	81.59	346.47	11.00	39.02
V_4XB_1	84.70	459.00	14.57	46.95
V_4XB_2	83.54	431.31	13.69	46.66
S. Em. ±	**0.15**	**4.33**	**0.14**	**0.16**
C.D. at 5%	**0.44**	**12.69**	**0.40**	**0.46**

Fig.-19(4.3.1,6,7,8-A):Influence of varieties and bio-fertilizers on seed per spike, test weight (g), harvest index (%) and seed husk ratio



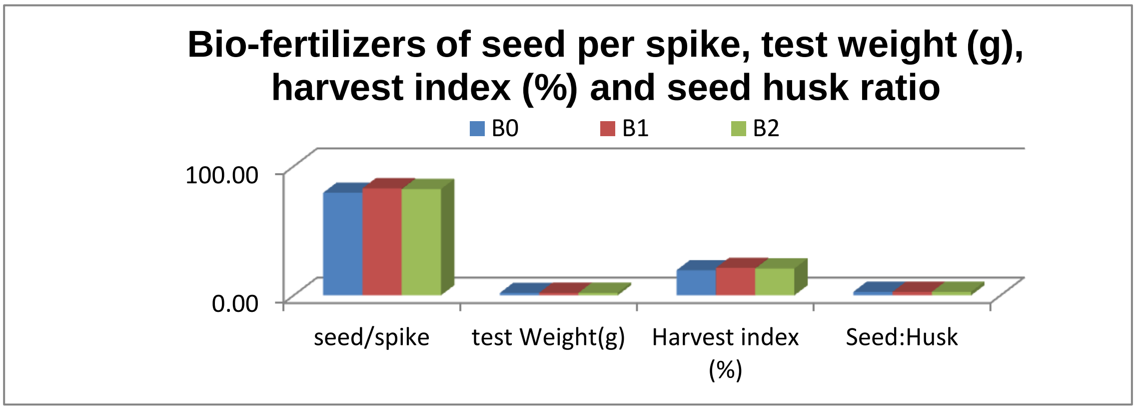
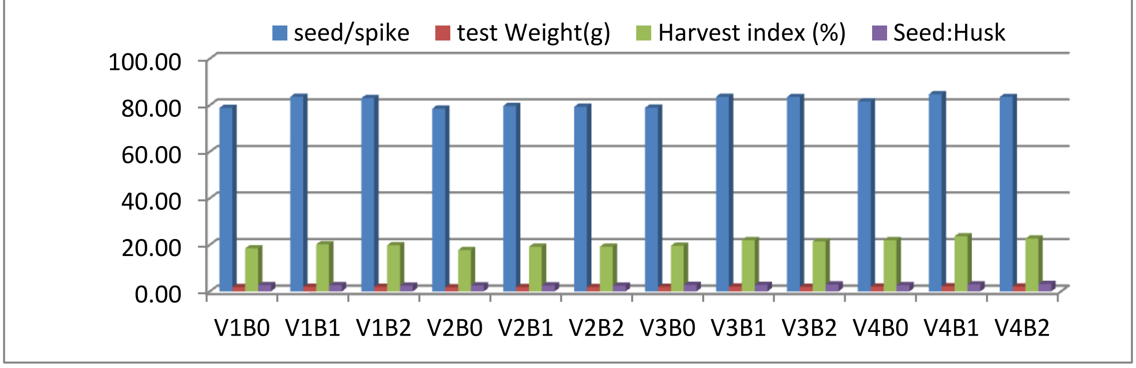


Fig.-20(4.3.1,6,7,8-B): Interactions of Variety x bio-fertilizers for seed per spike, test weight (g), harvest index (%) and seed husk ratio



The data shown that, in the interactions, V_4xB_1 (14.57) was recorded significantly maximum seed yield among all the treatments. Thought, V_4xB_2 (13.69) lagged behind the former but significantly superior over rest of the treatments. V_2xB_0- control (6.78) was assessed minimum seed yield.

4.3.6. Test weight (g)

All the data of test weight were significant influenced with the application of the different varieties and bio-fertilizer combinations during investigation and data are presented in Table 4.3.6 and diagrammatically shown in Fig. 4.3.6.A&B.

The present data shown that, in the main plots, V_4-JI-4 (2.08) was seen significantly maximum test weight among the varieties. Thought, V_3-VI-1 (1.96) second largest but they were significantly superior with the remaining varieties. V_2-GI-2 (1.82) was noted minimum test weight.

The sub plots, B_1-*Azotobactor* (1.99) was perceived significantly higher test weight over the remaining treatments. Thought, B_2-PSB (1.95) come after highest but significantly superior with the remaining treatments. The lower test weight (1.89) was recorded in the B_0- control.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (2.11) was attended maximum test weight followed by V_4xB_2 (2.08) and V_4xB_0 (2.04) and which were at par with each other but they were significantly higher over rest of the treatments. V_2xB_0- control (1.76) was observed minimum test weight.

4.3.5 Biological yield (q ha^{-1})

All the data of biological yield were varied significant with the application of different varieties and bio-fertilizer combinations during investigation and data are presented in Table 4.3.5 and graphically illustrated in Fig 4.3.5.A&B.

On perusal of data revealed that, in the main plots, V_4-JI-4 (57.30) was recorded significantly maximum biological yield in all over the varieties. Thought, V_3-VI-1 (47.59) next highest and was significantly superior with the remaining treatments. V_2-GI-2 (40.33) was taken minimum biological yield.

In the sub plots, B_1-*Azotobactor* (50.63) was accumulated significantly higher biological yield over rest of the treatments. Thought, B_2-PSB (48.03) after highest, but significantly superior with the remaining treatments. The minimum biological yield (43.32) was registered in the B_0-control.

The data shown that, in the interactions, V_4xB_1 (61.52) was attended maximum biological yield followed by V_4xB_2 (60.35) but they were significantly superior over rest of the treatments. Control V_2xB_0-control (38.27) was cumulated minimum biological yield.

4.3.7. Harvest Index (%)

All the data of harvest index were non-significant influenced with the application of the different varieties and bio-fertilizer combinations during investigation and are presented in Table 4.3.7 and graphically shown in Fig. 4.3.7.A&B.

Results revealed that, in the main plots, V_4-JI-4 (22.79) was recorded significantly maximum harvest index over the remaining varieties. Thought, V_3-VI-1 (21.01) come after highest, but significantly superior with the remaining treatments. V_2-GI-2 (18.70) was noted minimum harvest index.

Study displayed that, B_1-*Azotobactor* (21.27) was registered significantly higher harvest index among the treatments. Thought, B_2-PSB (20.78) lagged behind the former but significantly superior over rest of the treatments. The lower harvest index (19.45) was seen in the B_0-control.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (23.69) was observed significantly maximum harvest index with the remaining treatments. Thought, V_4xB_2 (22.69) lagged behind the former and at par with but significantly superior over rest of the treatment combinations. V_2xB_0-control (17.72) was perceived minimum harvest index.

4.3.4 Straw yield (q ha^{-1})

Straw yield were varied significant with the application of different varieties and bio-fertilizer combinations during investigation and data are presented in Table 4.3.4 and graphically illustrated in Fig 4.3.4.A&B.

On perusal of data revealed that, in the main plots, V_4-JI-4 (44.21) was found significantly maximum straw yield with the varieties. Thought, V_3-VI-1 (37.57) second highest, but was significantly superior with the remaining varieties. V_2-GI-2 (32.78) was registered minimum straw yield.

Among the sub plots, B_1-*Azotobacter* (39.75) was registered significantly higher straw yield over rest of the treatments. Thought, B_2-PSB (37.95) come after highest, but significantly superior with the remaining treatments. The minimum straw yield (34.82) was seen in the B_0- control.

The statistical analysis of data shown that, in the interactions, V_4xB_1 (46.95) was attended maximum straw yield and which was at par with V_4xB_2 (46.66) but significantly superior over rest of the treatments. V_2xB_0- control (31.48) was cumulated minimum straw yield.

4.3.8. Seed husk ratio

All the data of seed husk ratio were non-significant influenced with the application of the different varieties and bio-fertilizer combinations during investigation and are presented in Table 4.3.8 and graphically illustrated in Fig. 4.3.8.A&B.

The Result exhibited that, in the main plots, V_4-JI-4 (2.96) was cumulated significantly maximum seed husk ratio over rest of the varieties. Thought, V_3-VI-1 (2.84) lagged behind the former but significantly superior with the remaining varieties. V_2-GI-2 (2.51) was noted minimum seed husk ratio.

Study displayed that, B_1-*Azotobacter* (2.75) was found significantly higher seed husk ratio and which was at par with B_2-PSB (2.75) and B_0-

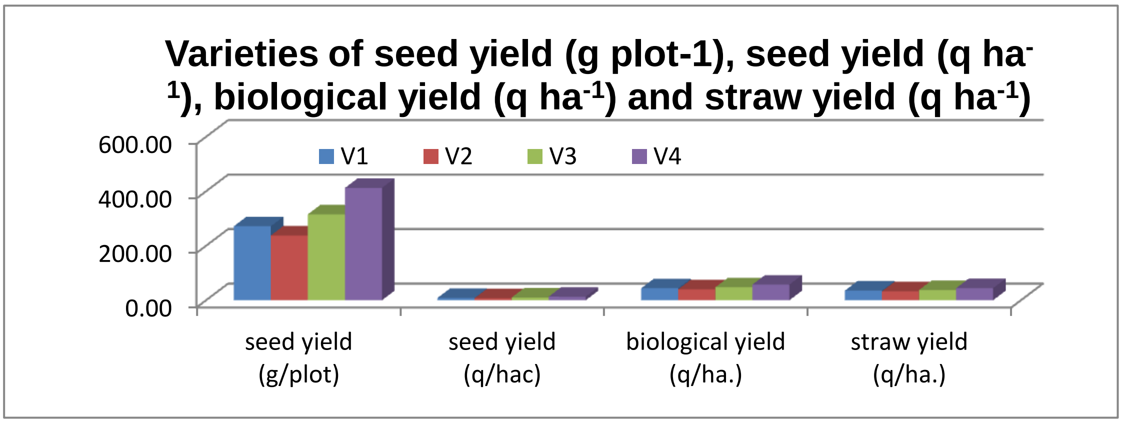
control (2.69). Thought, B_2-PSB (2.75) lagged behind the former but was at par with B_0- control (2.69). The minimum seed husk ratio (2.69) was seen in the B_0- control.

The analysis of variance shown that, in the interactions, V_4xB_2 (3.18) was attended significantly maximum seed husk ratio over the treatments. Thought, V_4xB_2 (3.02) after highest and which was at par with V_3xB_2 (2.94) lagged behind the former but significantly superior over rest of the treatments. V_2xB_2 (2.41) was accumulated minimum seed husk ratio.

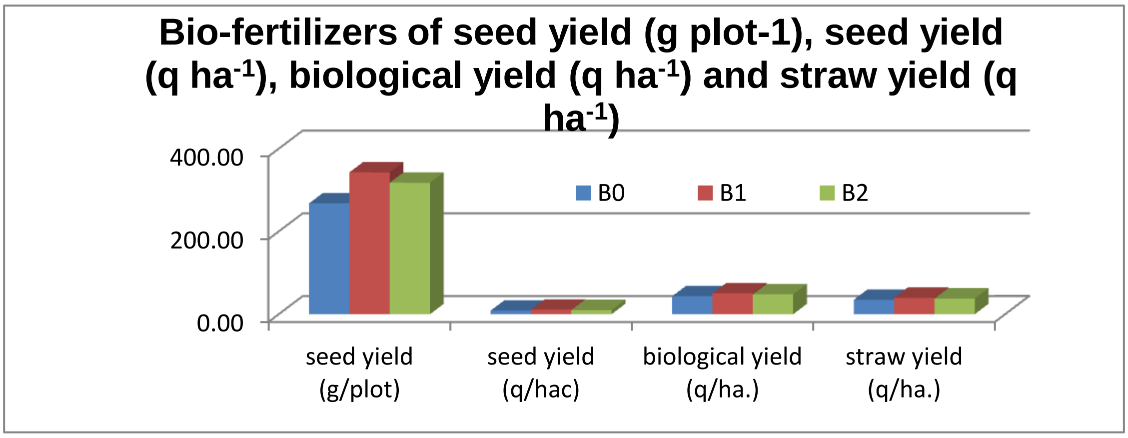
Table-13(4.3.5-8):Influence of Varieties and Bio-fertilizer on Yield Parameters (Biological yield (q ha^{-1}), Test weight (g), Harvesting index (%), Seed husk ratio in Isabgol.

Treatment	Biological yield (q ha^{-1})	Test weight (g)	Harvesting index (%)	Seed husk ratio
Varieties				
V_1 - Gujarat Isabgol -1	44.10	1.92	19.50	2.60
V_2 - Gujarat Isabgol -2	40.33	1.82	18.70	2.51
V_3 - Vallabh isabgol -1	47.59	1.96	21.01	2.84
V_4 - Jawahar isabgol-4	57.30	2.08	22.79	2.96
S. Em. ±	**0.05**	**0.01**	**0.19**	**0.03**
C.D. at 5%	**0.13**	**0.03**	**0.54**	**0.08**
Bio-fertilizers (B)				
B_0- Control	43.32	1.89	19.45	2.69
B_1 - Azotobacter (5kg ha^{-1})	50.63	1.99	21.27	2.75
B_2 - PSB (3kg ha^{-1})	48.03	1.95	20.78	2.75
S. Em. ±	**0.04**	**0.01**	**0.16**	**0.02**
C.D. at 5%	**0.11**	**0.02**	**0.47**	**0.07**
Interactions (Varieties X Bio-fertilizer)				
V_1XB_0	40.03	1.84	18.52	2.71
V_1XB_1	48.28	1.98	20.2	2.63
V_1XB_2	43.99	1.94	19.8	2.45
V_2XB_0	38.27	1.76	17.72	2.57
V_2XB_1	43.21	1.86	19.17	2.56
V_2XB_2	39.52	1.82	19.22	2.41
V_3XB_0	44.95	1.91	19.59	2.8
V_3XB_1	49.53	2.02	22.03	2.78
V_3XB_2	48.28	1.96	21.43	2.94
V_4XB_0	50.02	2.04	21.99	2.69
V_4XB_1	61.52	2.11	23.69	3.02
V_4XB_2	60.35	2.08	22.69	3.18
S. Em. ±	**0.08**	**0.02**	**0.32**	**0.05**
C.D. at 5%	**0.23**	**0.05**	**0.94**	**0.14**

Fig.-21(4.3.2-5-A): Influence of varieties and bio-fertilizers on seed yield (g plot^{-1}), seed yield (q ha^{-1}), biological yield (q ha^{-1}) and straw yield (q ha^{-1})



Varieties of seed yield (g plot-1), seed yield (q ha^{-1}), biological yield (q ha^{-1}) and straw yield (q ha^{-1})



Bio-fertilizers of seed yield (g plot-1), seed yield (q ha^{-1}), biological yield (q ha^{-1}) and straw yield (q ha^{-1})

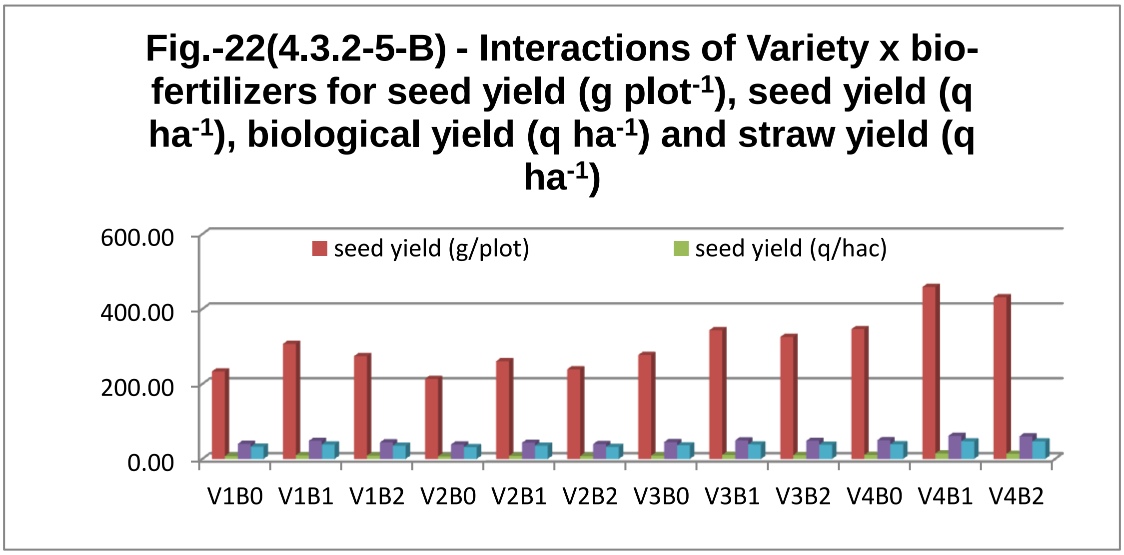


Fig.-22(4.3.2-5-B) - Interactions of Variety x bio-fertilizers for seed yield (g plot^{-1}), seed yield (q ha^{-1}), biological yield (q ha^{-1}) and straw yield (q ha^{-1})

Chapter - V

DISCUSSION

The findings of the present investigation entitled **"Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (*Plantago ovate* Forsk.) under Malwa Plateau of Madhya Pradesh"**as presented in previous chapter has been discussed in the present section in the light of the research work reported from India and abroad.

The investigation was carried out with four levels of varieties Viz; Gujarat Isabgol-1 (GI-1), Gujarat Isabgol-2 (GI-2), Vallabh Isabgol-1 (VI-1) and Jawahar Isabgol-4 (JI-4) as main plot and with two levels of bio-fertilizer and one untreated (B_0-control, B_1-*Azotobacter* and B_2-PSB) as sub plot on Isabgol. All the parameters were recorded at fixed interval of 30 days from 30 days after sowing to harvest. The results of the present investigation are discussed under the following sub-headings.

5.1 Phenological parameter:

5.1.1 Days to 50 % germination

Results revealed that, in the main plots, V_4-JI-4 (5.22) took minimum days to 50% germination and V_1-GI-1 (6.67) maximum days. However, in the sub plots, B_1-*Azotobactor* (6.08) was found significant earliest and B_2-PSB (6.17) late for days to 50% germination. In the interactions, V_4xB_1 (5.00) was also early in 50% germination and V_1xB_2 (7.00) late days to 50% germination. The highest primary root length and germination rates were obtained by phosphate bio-fertilizer. These results are in agreement with Chauhan and Tiwari, (2003). Enhancement of seedling growth due to bio-fertilizer treatment may also be due to release of growth promoting substances. Further, the maximum EC was recorded with application of bio-fertilizer found to be beneficial in early 50 % germination seed vigour by release of growth promoting substances (Sharma *et al.,* 2007). Similar results were reported by Ponmurgan and Gopi, (2006).

5.1.2 Days to 50 % flowering

The analysis of variance revealed that, in the main plots, V_4-JI-4 (61.67) took minimum days to 50% flowering and V_1-GI-1 (65.56) maximum days. However, in the sub plots, B_1-*Azotobactor* (64.00) was found significant earliest and B_2-PSB (64.33) late for days to 50% flowering. In the interactions, V_4xB_1 (61.00) was also early in 50% flowering and V_1xB_2 (66.67) late in the same. This might be due to individual varietal characters. The mean performances between various genotypes in isabgol for days taken to flowering have also been reported by (Dubey *et al*., 2009). Flowering initiation was significantly affected by bio-fertilizer treatments (Alahdadi *et al*., 2009).

5.1.3 Days to maturity

The experimental data exhibited that, in the main plots, V_4-JI-4 (110.44) was found minimum days to maturity and V_1-GI-1 (116.89) matured late. While, in the sub plots, B_2-PSB (114.17) was taken minimum and B_0-control (114.33) maximum days to maturity. Moreover, in the interactions, V_4xB_1 (109.33) was taken minimum V_1xB_2 (118.67) maximum days to maturity. The available soil nitrogen increased with bio-fertilizers may be due to better utilization of native nitrogen with increase in nitrogen fixation. Similarly, the marginal value of P and K might be due to mineralization of soil organic matter and solubilizing effect of acids produced during respirations. The results confirm the findings of Shivran *et al.* (2014) in blond psyllium.

5.2 Morphological attributes:

Among pre harvest observations, the plant height, number of leaves, number of tillers, number of spikes, length of spike, fresh weight and dry weight of plants were studied in isabgol. The morphological parameters of different varieties were significantly influenced with the application of bio-fertilizers.

5.2.1 Plant height (cm plant^{-1})

The result confirms that, in the main plots, V_4-JI-4 (7.91, 22.04, 36.48 and 36.72) had the maximum plant height as compared to V_2-GI-2 (7.04, 20.50, 25.04 and 25.17) which was lowest in the same trait. Whereas, in sub plots, B_1-

Azotobactor (7.78, 21.78, 31.48 and 31.68) attended maximum and B_0- control (6.80, 20.09, 26.66 and 26.85) minimum in plant height. Moreover, in the interactions, V_4xB_1 (8.29, 22.78, 39.37 and 39.62) also higher and V_2xB_0 - control (6.41, 19.38, 22.58 and 22.66) lower in the same trait at 30, 60, 90 DAS and at harvest respectively. The variation in plant height of isabgol might be due to the good nutritional environment in the rhizosphere as well as in the plant system which enhanced meristematic growth leading to increased plant height and dry matter production. These findings are in close conformity with the results of Sahu *et al.,* (2021). Recommended dose of organic and inorganic NPK fertilizers along bio-fertilizers combined application might resulted plants to higher nutrients utilization for plant growth towards production of bio-active substances in soil micro flora. Use of Azotobacter as soil application it acts like growth hormones effects supports the hypothesis through the accumulation of phytohormones, which enhanced root growth in isabgol, this may be due to synthesis of carbohydrates, towards the production of higher plant height and which had positive effect towards higher plant growth parameters plant height. Similar results are conformed by Yadav *et al.,* (2003), Venkatesh (2007), Nadim *et al*., (2011), Mirshekari and Forouzandeh (2015) and Shivran *et al*., (2016).

5.2.2 Number of leaves (plant^{-1})

The number of leaves varied significantly among the treatments during the different stages of plant growth. The reason for higher leaves could be attributed to increased availability of moisture, spacing and light of plants throughout the cropping season. In the present study confirmed that, among in the main plots, V_4-JI-4 (11.53, 35.42, 100.57 and 102.11) had the maximum number of leaves and V_2-GI-2 (8.78, 26.76, 60.89 and 61.44) minimum. While, in the sub plots, B_1-*Azotobactor* (10.67, 33.08, 87.66 and 88.40) accumulated higher and B_0- control (9.20, 28.08, 69.13 and 69.88) lower in the same. Furthermore, in the interactions, V_4xB_1 (12.13, 37.40, 108.91 and 110.29) also higher and V_2xB_0 - control (7.60, 22.73, 47.33 and 47.80) lower in the same trait at 30, 60, 90 DAS and at harvest respectively. The increase in number of leaves may be due to the production of high chlorophyll content with the application of balanced nutrition in the form of bio-fertilizer and also due to synthesis of plant growth regulators by bacteria in root zone, where it is absorbed by roots. These results were in close conformity with the findings of Tripathi *et al.,* (2013) in isabgol. The varietal performance to different genetical characteristics of particular variety and their difference in genotypic factor and adaptability of particular variety. The higher number of leaves in better synthesis of carbohydrates and their utilization for buildup of new cells and better absorption of nutrients which increased dry matter production were reported by several workers (Salimath *et al.,* 2019) in isabgol.

5.2.3 Number of tillers (plant^{-1})

The number of tillers varied significantly over the treatments during the different stages of plant growth. The reason for higher tillers could be attributed to increased availability of moisture, spacing and light of plants throughout the cropping season. The present data indicated that, among in the main plots, V_4-JI-4 (5.22, 14.00 and 14.24) had the maximum number of tillers and V_2-GI-2 (3.53, 10.59 and 10.85) minimum. While, in the sub plots, B_1-*Azotobactor* (4.70, 13.12 and 13.46) accumulated higher and B_0- control (3.60, 10.73 and 10.83) lower in the same. Furthermore, in the interactions, V_4xB_1 (5.67, 14.91 and 15.25) also higher and V_2xB_0 - control (2.67, 8.90 and 9.00) lower in the same trait at 60, 90 DAS and at harvest respectively. The more number of tillers per plant may be due to increased growth and development of plant in the form of height and number of leaves, which accumulated higher photosynthetes and hence increased number of tillers per plant. These results was in the close conformity with the findings of Raissi *et al.,* (2012) and Tripathi *et al.,* (2013) in isabgol. Similar results were observed by of Utgikar *et al.,* (2003) in Isabgol.

5.2.4 Number of spike (plant^{-1})

The result shown that, among the main plots, V_4-JI-4 (13.27, 22.08 and 22.66) found the maximum number of spike per plant as compared to V_2-GI-2 (7.24, 15.44 and 15.73) which was lowest in the same trait. Whereas, in the sub plots, B_1-*Azotobactor* (10.98, 19.19 and 19.58) attended maximum and B_0- control (8.07, 16.77 and 16.84) minimum in number of spike per plant. Moreover, in the interactions, V_4xB_1 (15.13, 23.81 and 24.50) also higher and V_2xB_0- control (5.67, 14.42 and 14.72) lower in the same trait at 60, 90 DAS and at harvest respectively. The higher yield of promising genotypes might be due to more number of branches and leaves which leads to the production of higher number of spike per plant that directly effect the seed yield. These findings are according to Salimath *et al.,* (2019) in isabgol. Moreover, these data leads to more longer period of vegetative growth which resulting in enhanced photosynthetic area and metabolic activities was responsible to bear more spikes of longer size, and spike length with application bio-fertilizers, which in turn played an important role in rapid cell division and elongation in the meristamatic tissues, root development and proliferation of enhancing early and more flowering, results increase, in number spikes, spikelet's per plant same findings observed by Salimath *et al.,* (2019).

5.2.5 Length of spike (cm)

Results shown that, among the main plots, V_4-JI-4 (3.02, 5.01 and 5.10) registered the maximum length of spike as compared to V_2-GI-2 (1.47, 3.10 and 3.13) which was lowest in the same trait. Whereas, in sub plots, B_1-*Azotobacter* (2.40, 4.28 and 4.35) attended maximum and B_0-control (1.59, 3.44 and 3.48) minimum in length of spike. Moreover, in the interactions, V_4xB_1 (3.55, 5.30 and 5.38) also higher and V_2xB_0 - control (1.05, 2.27 and 2.27) lower in the same trait at 60, 90 DAS and at harvest respectively. Bio-fertilizers helps in reducing phosphorus fixation by its chelating effect and also solubilized the fixed phosphorus accelerated increase and nitrogen fixation stage towards reproductive parameters with accelerating tillers, number of spikes per plant, spike length, dry matter production, increase towards yield attributing characters which helped to increase seed yield, Similar findings observed by Nadim *et al*., (2011), Tripati *et al*., (2013), Choudhary *et al*., (2014), Shivran *et al*., (2015) and Salimath *et al.,* (2019) in isabgol.

5.2.6 Fresh weight (g plant^{-1})

The result accumulated that, among the main plots, V_4-JI-4 (2.58, 26.67, 60.36 and 60.76) attended the maximum fresh weight as compared to V_2-GI-2 (1.94, 11.81, 39.94 and 40.40) which was lowest in the same trait. Whereas, in sub plots, B_1-*Azotobacter* (2.38, 22.00, 53.76 and 54.01) attended maximum and B_0-control (2.03, 15.37, 43.56 and 43.98) minimum in fresh weight.

Moreover, in the interactions, V_4xB_1 (2.71, 31.07, 65.55and 65.82) also higher and V_2xB_0 - control (1.70, 10.76, 37.42 and 37.92) lower in the same trait at 30, 60, 90 DAS and at harvest respectively. This may be due to the biological nitrogen fixation by azotobacter in the root zone of plant which helps in vegetative growth and period. Resulted increase in fresh and dry matter production. Also bio-fertilizers increasing metabolic activities of the plant that gave significant values for fresh weight. Researchers reported (Al-Fraihat *et al*., 2011) similar results. Moreover, bio-fertilizer significantly increased the biomass yield in Stevia according to Das *et al*., (2007), Sial *et al*., (2015).

5.2.7 Dry weight (g plant^{-1})

Among the main plots, V_4-JI-4 (0.85, 7.61, 17.09 and 17.19) accumulates the maximum dry weight as compared to V_2-GI-2 (0.63, 3.50, 11.99 and 12.10) which was lowest. Whereas, in sub plots, B_1-*Azotobactor* (0.78, 6.25, 15.13and 15.19) attended maximum and B_0- control (0.67, 4.48, 12.89 and 12.99) minimum in dry weight. Moreover, in the interactions, V_4xB_1 (0.90, 8.35, 18.39 and 18.46) also higher and V_2xB_0 - control (0.57, 3.22, 11.36 and 11.48) lower in the same trait at 30, 60, 90 DAS and at harvest respectively. The variation in the results of varieties might be due to different agro climatic conditions and genetical make up of particular as well as genotypic factor and their adaptability to soil and climatic conditions hence increased number of leaves, leaf area and number of tillers which helped in higher accumulation of carbohydrates and their utilization, apart from higher absorption of nutrients resulting in increased dry matter production were reported by several researchers (Kumar *et al*., 2009 and Tyagi *et al*., 2016). Similarly effect of bio-fertilizer on the dry weight of plant was due to increased nitrogen fixation and uptake which improvement the growth rate. Patel *et al*., 2016 on fennel crop. Other researchers (AL-Fraihat *et al*., 2011; Valadabadi & Farahani, 2011) also observed effect of bio-fertilizer on plant dry production rate of growth.

5.3 Yield and yield attributing parameter

Among the yield and yield attributing observations of variety such as the number of seed (spike^{-1}), seed yield (g plot^{-1}), seed yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}), weight of 1000 seed (g), harvest index (%) and seed husk ratio were studied in isabgol and were significantly influenced with the different bio-fertilizers.

5.3.1 Number of seed (spike^{-1})

The higher number of seed per spike were found in varieties, V_4-JI-4 (83.28) and V_2-GI-2 (79.19) lowest in the same trait. While, among the sub plots, B_1-*Azotobactor* (82.92) attended maximum and B_0-control (79.48) minimum in number of seed (spike^{-1}). Moreover, in the interactions, V_4xB_1 (84.70) also higher and V_2xB_0 - control (78.53) lower in the same trait. Azotobacter increased nitrogen concentration in the root zone of isabgol by increased, nitrogen assimilation by the plants which resulted enhanced grain yield. It is recommended that, the grain yield of isabgol can be enhanced and sustainable with the application of Azotobacter coupled with variety JI-4 Salimath *et al., (*2019) in isabgol.

5.3.2 Seed yield (g plant^{-1} and q ha^{-1})

The seed yield varied significantly in varieties with the application of bio-fertilizer of isabgol. It is confirmed from the results that, the main plots, V_4-JI-4 (412.26 g plot^{-1} & 13.09 q ha^{-1}) had the maximum seed yield as compared to V_2-GI-2 (237.93 g plot^{-1} & 7.55 q ha^{-1}) which was lowest in the same trait. Whereas, in the sub plots, B_1-*Azotobactor* (342.69 g plot^{-1} & 10.88q ha^{-1}) attended maximum and B_0 – control (267.73 g plot^{-1} & 8.50 q ha^{-1}) minimum in seed yield. Moreover, in the interactions, V_4xB_1 (459.00 g plot^{-1} & 14.57 q ha^{-1}) also higher and V_2xB_0 - control (213.63 g plot^{-1} & 6.78 q ha^{-1}) lower in the same trait. The bio-fertilizers inoculation significantly influenced the root shoot ratio of isabgol which resulted increased the grain yield. PSB helps in reducing phosphorus fixation by its chelating effect and also solubilized the fixed phosphorus leading to more uptake of nutrients and relected better yield attributes ultimately leads to higher seed and straw yield as reported by Singh and Singh, (2004). Azotobacter increased nitrogen concentration in the root zone of isabgol by increased, nitrogen assimilation by the plants which resulted enhanced grain yield. It is recommended that, the grain yield of isabgol can be enhanced and sustainable with the application of Azotobacter coupled with variety JI-4 Salimath *et al*., (2019). Azotobacter has biological nitrogen fixing potential in soils and releasing some growth regulators. Hence the enhanced the vegetative growth stage of plant towards physiological stage followed by reproductive. This correlation helped to increase the yield attributes, these traits had positive beneficial effect resulted higher seed and husk yield same findings revealed by Upadhyay *et al*., (2018) in isabgol.

5.3.3 Straw yield (q ha^{-1})

The main plots, V_4-JI-4 (44.21) had the maximum straw yield (q ha^{-1}) as compared to V_2-GI-2 (32.78) which was lowest in the same trait. Whereas, in the sub plots, B_1-*Azotobactor* (39.75) attended maximum and B_0- control (34.82) minimum in straw yield (q ha^{-1}). Moreover, in the interactions, V_4xB_1 (46.95) higher and V_2xB_0 - control (31.48) lower in the same traits. The bio-fertilizers help in natural fixation of atmospheric nitrogen, better root growth, higher availability and absorption of nutrients by the plants, which may have resulted in more growth and development in plant towards growth and reproductive parameters. Finally all these growth and reproductive yield attributes support to increase seed yield, husk yield, further the higher biological yield contributed towards higher straw yield and harvest index. Similar findings observed by Repsiene, (2001), Yadav *et al*., (2003), Nadim *et al*., (2011), Singh *et al*., (2011), Tripati *et al*., (2013), Choudhary *et al*., (2014), Nadukeri *et al*., (2014), Shirvan *et al*., (2014) and Shivran *et al*., (2015) in isabgol.

5.3.4 Weight of 1000 seed (gm)

On perusal of data revealed that, in the main plots, V_4-JI-4 (2.08) had the maximum weight as compared to V_2-GI-2 (1.82) which was lowest in the same trait. Whereas, in the sub plots, B_1-*Azotobactor* (1.99) attended maximum and B_0-control (1.89) minimum test weight of 1000 seed. Moreover, in the interactions, V_4xB_1 (2.11) also higher and V_2xB_0 - control (1.76) lower in the same trait. The higher 1000 seed weight might be due to used of azotobacter. Which leads to increase higher functional photosynthetic area, which in turn have resulted in increased seed size and seed filling. Similar findings observed by Repsiene, (2001) in isabgol.

5.3.5 Biological yield (q ha^{-1})

The results confirm that, in the main plots, V_4-JI-4 (57.30) had the maximum biological yield as compared to V_2-GI-2 (40.33) which was lowest in the same trait. Whereas, in the sub plots, B_1-*Azotobactor* (50.63) attended maximum and B_0 - control (43.32) minimum in biological yield. Moreover, in the interactions, V_4xB_1 (61.52) also higher and V_2xB_0 - control (38.27) lower in the same trait. The bio-fertilizers help in natural fixation of atmospheric nitrogen, better root growth, higher availability and absorption of nutrients by the plants, which may have resulted in more growth and development in plant towards growth and reproductive parameters. Finally all these growth and reproductive yield attributes support to increase seed yield, husk yield, further the higher biological yield contributed towards higher straw yield, biological yield and harvest index. Similar findings observed by Repsiene, (2001), Yadav *et al.,* (2003), Nadim *et al.,* (2011), Singh *et al.,* (2011), Tripati *et al.,* (2013), Choudhary *et al.,* (2014), Nadukeri *et al.,* (2014), Shirvan *et al.,* (2014) and Shivran *et al.,* (2015) in isabgol.

5.3.6 Harvest Index (%)

The results confirm that, among the main plots, V_4-JI-4 (22.79) had the maximum harvest index as compared to V_2-GI-2 (18.70) which was lowest in the same trait. Whereas, in sub plots, B_1-*Azotobactor* (21.27) attended maximum and B_0 - control (19.45) minimum in harvest index. Moreover, in the interactions V_4xB_1 (23.69) also higher and V_2xB_0- control (17.72) lower in the same trait at harvest respectively. The bio-fertilizers help in natural fixation of atmospheric nitrogen, better root growth, higher availability and absorption of nutrients by the plants, which may have resulted in more growth and development in plant towards growth and reproductive parameters. Finally all these growth and reproductive yield attributes support to increase seed yield, husk yield, further the higher biological yield contributed towards higher straw yield and harvest index. Similar findings observed by Salimath *et al*., (2019) in isabgol.

5.3.7 Seed husk ratio

The result revealed that, in the main plots, V_4-JI-4 (2.96) had the maximum seed husk ratio as compared to V_2-GI-2 (2.51) which was lowest in the same trait. Whereas, in sub plots, B_1-*Azotobactor* (2.75) attended maximum and B_0-control (2.69) minimum seed husk ratio. Moreover, in the interactions, V_4xB_2 (3.18) higher and V_2xB_2 (2.41) lower in the same trait at harvest respectively. The husk yield increased may be due to used of azotobacter and which helps releasing humus microbes, nitrogen fixing bacteria and some growth regulators results in the production of more vegetative growth of the plants than plants is more functional of photosynthesis. However results increased seed size and seed filling more than the increase higher seed yield and husk yield. Same findings reported by Nadim *et al.* (2011), Singh *et al*. (2011) and Tripati *et al*. (2013) in isabgol.

Chapter - VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

The present field experiment entitled **"Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (*Plantago ovate* Forsk.) under Malwa Plateau of Madhya Pradesh"** was conducted at Research Farm, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the year 2020-2021.

In this experiment took four varieties of isabgol viz. Gujarat Isabgol-1 (GI-1), Gujarat Isabgol-2 (GI-2), Vallabh Isabgol-1 (VI-1) and Jawahar Isabgol-4 (JI-4) as main plot and two bio-fertilizer and one untreated control plot (B_0-control, B_1-*Azotobacter* 5 kg ha^{-1} and B_2-PSB 3 kg ha^{-1}) as sub plot assessed for morphological, growth and yield attribute under field condition. The research experiment was laid out in a Factorial Randomized Block Design with three replications. All the parameters were recorded at 30, 60and 90 days after sowing and at harvest. The significant findings of the studies are summarized below.

6.1 Summary:

All the varietal phonological parameters i.e. days to 50% germination, days to 50% flowering, days to maturity were non-significantly influenced by different bio-fertilizers. However, the minimum days to 50% germination in the main plots, V_4-JI-4 (5.22), In the sub plots, B_1-*Azotobactor* (6.08) and in the interactions,V_4xB_1 (5.00), days to 50% flowering in the main plots, V_4-JI-4 (61.67), In the sub plots, B_1-*Azotobactor* (64.00) and In the interactions, V_4xB_1 (61.00), days to maturity in the main plots, V_4-JI-4 (110.44), In the sub plots, B_2-PSB (114.17) and in the interactions, V_4xB_1 (109.33) after sowing.

Among pre and at harvest observations, the plant height, number of leaves, number of tillers, number of spikes, length of spike, fresh weight and dry weight were studied in isabgol. All the varietal morphological characteristics were significantly influenced with the application of different bio-fertilizers. However, in main plots, V_4-JI-4 was recorded highest values of plant height (7.91, 22.04, 36.48 and 36.72 cm plant^{-1}) and in sub plots, B_1-*Azotobacter* was recorded highest values of plant height (7.78, 21.78, 31.48 and 31.68 cm plant^{-1}). Moreover, in the interactions,V_4xB_1 was recorded highest values of plant height (8.29, 22.78, 39.37 and 39.62 cm plant^{-1}), number of leaves in the main plots, V_4-JI-4 (11.53, 35.42, 100.57 and 102.11 plant^{-1}), in the sub plots, B_1-*Azotobacter* (10.67, 33.08, 87.66 and 88.40 plant^{-1}) and in the interactions, V_4xB_1 (12.13, 37.40, 108.91 and 110.29 plant^{-1}), number of tillers in the main plots, V_4-JI-4 (5.22, 14.00 and 14.24 plant^{-1}), in the sub plots, B_1-*Azotobacter* (4.70, 13.12 and 13.46 plant^{-1}) and in the interactions, V_4xB_1 (5.67, 14.91 and 15.25 plant^{-1}), number of spike in the main plots, V_4-JI-4 (13.27, 22.08 and 22.66 plant^{-1}), in the sub plots, B_1-*Azotobacter* (10.98, 19.19 and 19.58 plant^{-1}) and in the interactions,V_4xB_1 (15.13, 23.81 and 24.50 plant^{-1}), length of spike in the main plots, V_4-JI-4 (3.02, 5.01 and 5.10 cm), in sub plots, B_1-*Azotobacter* (2.40, 4.28 and 4.35 cm) and in the interactions,V_4xB_1 (3.55, 5.30 and 5.38 cm), fresh weight among the main plots, V_4-JI-4 (2.58, 26.67, 60.36 and 60.76g plant^{-1}), in sub plots, B_1-*Azotobacter* (2.38, 22.00, 53.76 and 54.01 g plant^{-1}) and in the interactions, V_4xB_1 (2.71, 31.07, 65.55 and 65.82 g plant^{-1}), dry weight the main plots, V_4-JI-4 (0.85, 7.61, 17.09 and 17.19 g plant^{-1}), in sub plots, B_1-*Azotobacter* (0.78, 6.25, 15.13 and 15.19 g plant^{-1}) and in the interactions, V_4xB_1(0.90, 8.35, 18.39 and 18.46 g plant^{-1}) at 30, 60, 90, days after sowing and at harvest respectively.

Among the yield and yield attributes traits i.e. number of seed per spike, seed yield (g plot^{-1} and q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}), weight of 1000 seeds (g) and harvest index (%) varied significantly with application of different varieties and bio-fertilizers. However, in the main plots V_4-JI-4 (83.28) was registered the highest value of number of seed spike, Among the sub plots, B_1-*Azotobacter* (82.92) and in the interactions, V_4xB_1 (84.70). Moreover, in the main plots, V_4-JI-4 registered maximum seed yield (412.26 g plot^{-1} & 13.09 q ha^{-1}), in the sub plots, B_1-*Azotobacter* (342.69 g plot^{-1} & 10.88q ha^{-1}) and in the interactions, V_4xB_1 (459.00 g plot^{-1} & 14.57 q ha^{-1}), straw yield in the main plots, V_4-JI-4 (44.21 q ha^{-1}), the sub plots, B_1-

Azotobactor (39.75 q ha^{-1}) and in the interactions, V_4xB_1 (46.95 q ha^{-1}), biological yield in the main plots, V_4-JI-4 (57.30 q ha^{-1}), in the sub plots, B_1-*Azotobactor* (50.63 q ha^{-1}) and in the interactions, V_4xB_1 (61.52 q ha^{-1}), test weight in the main plots, V_4-JI-4 (2.08 g), In the sub plots, B_1-*Azotobactor* (1.99 g) and in the interactions, V_4xB_1 (2.11 g). While, highest harvest index among the main plots, V_4-JI-4 (22.79 %), in sub plots, B_1-*Azotobactor* (21.27 %) and in the interactions V_4xB_1 (23.69 %). Moreover, seed husk ratio were non significantly in the main plots, V_4-JI-4 (2.96), in sub plots, B_1-*Azotobactor* (2.75) and in the interactions, V_4xB_2 (3.18).

6.2 Conclusion:

On the basis of present investigation, it could be concluded that, out of 12 treatment combinations.T_{11}- V_4xB_1 (JI-4 x *Azotobactor)* is found better for increasing the growth, quality and yield of isabgol.

6.3 Suggestions for future work:

Based on the current study, the following line of work may be suggested for future investigation

1. Same analysis can be repeated to conform the findings of present work.
2. Effect of varieties and bio-fertilizers on phytochemical constituents of seeds may be carried out.
3. Some approximate analysis may be checked.

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Appendix-I

Analysis of variance for the phonological parameter under different treatments

Source of variance	D.F.	Mean sum of square		
		Days to 50% germination	Days to 50% flowering	Days to maturity
Replication	2	0.03	1.78	8.03
Main plots	3	0.02	0.24	0.07
Sub plots	2	5.44	39.49	111.28
Interaction (MxS)	6	0.21	1.66	10.19
Error	22	0.42	3.41	2.15
Total	35			

Significant at 5% probability

Appendix-II

Analysis of variance for the growth attributes under Plant height (cm), Number of leaves plant^{-1}, Number of tillers plant^{-1} and Number of spikes plant^{-1} in Isabgol

Source of variance	D.F.	Mean sum of square													
		Plant height (cm)				Number of leaves plant^{-1}				Number of tillers plant^{-1}			Number of spikes plant^{-1}		
		30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	60 DAS	90 DAS	At Harvest	60 DAS	90 DAS	At Harvest
Replication	2	0.02	0.01	4.95	4.55	0.02	2.52	23.32	21.70	0.01	0.30	0.27	0.19	0.13	0.13
Main plots	3	2.05	5.97	51.70	51.99	14.91	53.73	850.24	866.94	2.61	11.87	14.46	17.62	11.79	15.46
Sub plots	2	1.95	6.65	373.62	375.70	34.60	177.83	3759.15	3987.60	7.17	28.19	27.69	89.65	118.92	131.61
Interaction (MxS)	6	0.11	0.27	2.60	2.86	2.16	3.95	58.80	55.70	0.10	0.48	0.49	1.13	1.14	1.89
Error	22	0.02	0.01	0.21	0.18	0.75	0.56	3.70	3.92	0.03	0.15	0.16	0.23	0.09	0.14
Total	35					52.44									

Significant at 5% probability

Appendix-III

Analysis of variance for the growth attributes under Length of spike (cm), Fresh weight (g $plot^{-1}$) and Dry weight (g $plot^{-1}$) in Isabgol

Source of variance	D.F.	Mean sum of square										
		Length of spike (cm)			Fresh weight g $plot^{-1}$				Dry weight g $plot^{-1}$			
		60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest
Replication	2	0.002	0.002	0.01	0.005	8.05	0.01	0.03	0.001	0.02	0.001	0.002
Main plots	3	1.43	1.75	1.87	0.26	92.43	208.90	202.29	0.03	7.01	10.26	9.90
Sub plots	2	6.05	8.65	9.28	0.93	513.74	1048.22	1042.91	0.11	39.60	64.51	64.31
Interaction (MxS)	6	0.06	0.24	0.22	0.01	9.48	16.72	18.55	0.001	0.73	1.20	1.28
Error	22	0.01	0.002	0.002	0.001	0.85	0.01	0.03	0.0003	0.01	0.0004	0.002
Total	35											

Significant at 5% probability

Appendix-IV

Analysis of variance for the yield and yield attributes parameters in Isabgol

Sources of variance	D.F.	Mean sum of square							
		Number of Seeds spike^{-1} at harvest	Seed yield g plot^{-1}	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological Yield (q ha^{-1})	Test Weight (g)	Harvest Index (%)	Seed husk ratio
Replication	2	0.02	36.63	0.04	0.11	0.02	0.0003	0.30	0.01
Main plots	3	27.29	11650.21	11.74	49.95	110.10	0.02	7.06	0.01
Sub plots	2	39.91	77181.05	77.78	321.27	714.56	0.16	43.75	0.59
Interaction (MxS)	6	3.20	713.46	0.72	9.12	14.22	0.001	0.30	0.09
Error	22	0.07	56.14	0.06	0.08	0.02	0.001	0.31	0.01
Total	35								

Significant at 5% probability

VITA

The author of this thesis Mr. **Manish Kumar, S/o Kishan Lal Goyal** was born on 23 September 1995 at Village and Post- Nimbod Ward no. - 01 and Tehsil - Dalouda, District- Mandsaur (Madhya Pradesh). He passed his high school certificate examination in the year 2010 from Tagore H.S. School, Nimbod and higher secondary school examination in the year 2012 from Govt. Higher Secondary School, Sarsod with 75.66 % and 56.00 %, respectively.

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For the partial fulfillment of the master's degree **"Influence of Varieties and Bio-fertilizer on Growth and Yield of Isabgol (*Plantago ovate* Forsk.) under Malwa Plateau of Madhya Pradesh"** under Mandsaur condition. This was successfully conducted by him and being submitted in the form of this thesis.

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