Effect of Bio-Fertilizers on Growth, Yield and Yield Attributing Characters in Onion (*Allium cepa* L.) var. AFLR

THESIS

Submitted to the

Rajmata VijayarajeScindia Krishi Vishwa Vidhyalaya Gwalior (M.P.)

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

AGRICULTURE

(Vegetable Science)

By

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2020

CERTIFICATE-I

This is to certify that the thesis is entitled **"Effect of bio-fertilizers on growth, yield and yield attributing characters in onion (*Allium cepa* L.)var. AFLR."** submitted in partial fulfillment of the requirement for the degree of Master of Science in Agriculture (Vegetable Science) of the Rajmata VijayarajeScindia Krishi Vishwa Vidhyalaya, Gwalior (M.P.) is a record of the bonafied research work carried out by **Miss. Nency Verma, ID No. 18131420** 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 degree or diploma (Certificate awarded etc.) or has been published. All the assistance and help received during the course of the investigation has been acknowledged by the scholar.

Place: Sehore Signature

Date: / / (Dr. R.K. Jaiswal)

Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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CERTIFICATE-II

This is to certify that the thesis is entitle **"Effect of bio-fertilizers on growth, yield and yield attributing characters in onion (*Allium cepa* L.)var. AFLR." Miss. Nency Verma, ID No. 18131420** to the Rajmata VijayarajeScindia Krishi Vishwa Vidhyalaya, Gwalior (M.P.) in partial fulfillment of the requirement for the degree of Master of Science in Agriculture (Vegetable Science) in **Department of Horticulture, R.A.K College of Agriculture, Sehore(M.P.)** has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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Place: Sehore

Date: / / **Nency Verma**

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LIST OF ABBREVIATIONS

Symbol	Legend
&	And
@	At the rate of
^{o}C	Degree Celsius
C.D.	Critical Difference
Cm	Centimeter
D	Transplanting Date
DAT	Days After Transplanting
d.f.	Degree of Freedom
FYM	Farm Yard Manure
et al.	And Others
Etc	And the rest
fig.	Figure (s)
G	Gram
Ha	Hectare
HI	Harvest Index
i.e.	That is
K	Potassium
Kg	Kilogram (s)
Kg/ha	Kilogram per hectare
Li	Litre
L	Linnaeus
MSS	Mean sum of square
Mg	Miligram
M	Meter (s)
N	Nitrogen
No	Number (s)
NS	Non- significant
P	Phosphorus
PSB	Phosphate Solubilizing Bacteria
T	Tonnes
T	Treatment
R	Replication
R.A.K	Rafi Ahmed Kidwai
RH	Relative Humidity
₹	Rupees
S.Em.±	Standard error of mean
S.S.	Sum of square
S.M.W.	Standard Meteorological week
VAM	Vesicular Arbuscular Mycorrhizae

CHAPTER-I
INTRODUCTION

Onion (*Allium cepa* L.*)* is one of the most important commercial vegetable crop grown all over the world, it belongs to family Alliaceae and commonly known as “pyaj” in Hindi. The crop is native of Asia (Jones and Mann, 1963). It is hardy bulbous plant annual for bulb production and biennial for seed production. The crop is very useful for human beings because it has several nutritional and medicinal values. It occupies an important position among vegetable crops in kitchen garden as well as commercial production and plays a vital role in Indian economy. The onion crop is widely used throughout the year as salad, culinary purpose for flavoring as spices in pickles, sauce and vegetable. Moreover, onion is the only vegetable in which India figures prominently in the world for production and export (Singh and Joshi,1978). Onion is an immense potential crop being part of medicinal value and hence, useful in fever, dropsy and chronic bronchitis. it is consumed as a vegetable and condiment. The green leaves, immature and matured bulbs are eaten raw or used in vegetable preparations.

It is an indispensable item in every kitchen and used to enhance flavor of different recipes. Nutritive value of onion varies from variety to variety, small size onion is more nutritive than big size, its major value is in flavor. Onion ranks medium in caloric low in protein and very low in vitamins.

The pungency of onion is due to presence of Sulphur compound in very small quantity (about 0.005%) in the volatile oil of the plant juice. The main compound is allyl propyl disulphide ($C_6H_{12}O_2$). The red colour of onion is due to the presence of pigment anthocynin and yellow colour is due to quercetin. It affords an excellent form of food iron and on this account many often be eaten freely with advantage by persons suffering from anemia.

India is the second largest producer of onion in the world followed by china, while India ranks first in terms of area. The major onion producing states are Maharashtra, Karnataka, Gujarat, Orissa, Andhra Pradesh, Bihar *etc*. some districts of West Bengal produce onion commercially. India having the total area (1258.0 Thousand ha), production (23262 Thousand MT) and productivity (18.1 t/ha)of onion in 2018 and the area (1431 Thousand Ha) with production (26148

Thousand MT) in 2019-2020. In Madhya Pradesh total area of onion is 150.87 Thousand ha with 3701.01 Thousand MT production and 17.50 t/ha productivity (Anonymous,2018).

There is a need to seek alternative nutrient source, which could be cheap and eco-friendly so that farmers may be able to reduce the investment made on fertilizer along with maintaining good soil environmental conditions leading to ecological sustainable farming, bio-fertilizers like VAM, *Azotobactor*, *Azospirillum* and organic fertilizers like vermi-compost, NADEP compost, FYM, poultry manure is very popular among the farmers and easily produced.

Usually little or no chemical fertilizer is added to this crop and hence characterized by low yield. Therefore, there is a need to study the possible ways of improving the yields of this crop. Bio-fertilizer have recently gained with momentum for affecting the sustainable increase in crop yield under various agro climatic conditions. Biofertilizers are live carrier based microbial preparations used in agriculture as low input resources to enhance the availability of plant nutrients or promote the growth by way of synthesizing growth factors. Role of bio-fertilizer on the crop growth and yield was documented by (Vijayakumar *et al.* 2000) and (Ramakrishnan and Thamizhiniyan 2004).

Therefore, taking into consideration the high cost of chemical fertilizers, its storage which will be more acute than what it is now. The pressure of increasing the food yield is high because of the increasing population which leaves with us no alternative source but to look for other aspects of increasing the yields. One of these means is the use of bio-fertilizers, out of which the *Azotobacter* and *Azospirillum* are important for non-leguminous crops to supplement the use of nitrogenous fertilizers. Keeping the above aspects in mind covering the following objectives-

Objectives:

1. To assess the best combination of biofertilizers on growth of onion.
2. To find out the best combination of biofertilizers for increasing the yield of onion.
3. To evaluate the economics of different treatments.

CHAPTER II

REVIEW OF LITERATURE

A good deal of research work has been done in India to evaluate the response of onion to applied biofertilizers as well as inorganic fertilizers. This has encouraged generating for farmers and vegetables growers. In view of these facts, the upto date literature available on these aspects has been reviewed in this chapter.

1. Effect of biofertilizers on growth and yield.
2. Effect of biofertilizers on quality.
3. Economics.

Effect of biofertilizers on growth and yield:

Nagaraju *et al* (2000) reported that the inoculated plant receiving 50% single super phosphate and rock phosphate and VAM showed significant increase in bulb diameter compared to plants that were supplemented with 100% phosphorus and no VAM.

Yadav *et al*. (2002) reported that application of *Azospirillum*gave significantly higher bulb yield of onion (320.99 q ha^{-1}) as compared to without *Azospirillum* (306.1 q ha^{-1}).

Alkaff *et al*. (2002) evaluated the effect of bio-fertilizer (halex2, containing a mixture of *Azospirillum, Azotobacter* and kiebsiella). Mineral fertilizer (100 kg urea/fed. 50 kg triple super phosphate/fed). Farm yard manure, with or without power4, on the bulb yield of onion cv. Baftaim. The highest increment in bulb diameter (14.2%) and height (12.3%) were recorded with the mineral fertilizer, while the lowest increment (10.3 and 8.4%, respectively) were recorded with bio- fertilizer. The highest rate of increase in total yield/fed (21.76%) was recorded with FYM followed by the mineral fertilizer and bio-fertilizer. Foliar application of power 4 (6g) decreased all character evaluated.

Jayanthilake *et al.* (2002) observed that two types of organic manures (FYM and vermicompost) and two types of biofertilizer (*Azotobacter* and *Azospirillum*) either alone or in combination with fertilizers. Plant height was highest at 100 day after transplanting upon treatment with biofertilizers + 5% recommended N through organic manures 50% N and 100% P and K through

chemical fertilizers, an additional increase of 14.25% in plant height was observed in plant treated with Azotobacter – vermicompost + chemical fertilizers compared to the control.

Singh *et al.* (2002)Studied the effect of vesicular avascular mycorrhiza (VAM) inoculation, along With Nitrogen, Phosphorus and Potassium fertilizer (100:50:100 kg/ha) recommended rate of application on onion and found that at 90 days after transplanting (DAT), VAM + N+P +K was superior to other treatments except N + P + K increasing in plant height.

Sharma *et al.* (2003) recorded that the highest onion bulb girth (21.8cm) was reported with combination of 150% (187 kg N, 49 kg P, and 75 kg /ha.) + 20 t FYM/ha.

Ruban (2007) revealed that the effect of different biofertilizer on the vegetative growth of onion. The treatment consisted of 5 and 10% *Azotobacter* and 5 and 10% Biophos applied to the onion cultivars Agri-found Dark Red (AFDR) and IIHR (yellow). The plant height in both cultivars was induced by 10% *Azotobacter* and 10% Biophos. Regarding the number of scapes. The 10% *Azotobacter* treatment was significantly enhanced in IIHR. Whereas the diameter of scales was influenced by *Azotobacter* in both cultivars.

Singh *et al.*(2008) reported that the treatments comprised: 100% recommended dose (RD) of N; 100%RD of N and P; 50% RD of NPK;100% RD of NPK; 150% RD of NPK; 100% NPK + 20kg $ZnSO_4$ /ha; 100% NPK + 20 kg S/ha; 100% NPK + 10t farmyard manure/ha. The highest bulb yield (34.70 t/ha) and dry matter yield (5.46 t/ha) was obtained with 100% NPK + 10 t farmyard manure /ha.

Hari *et al.* (2009) Observed that application of Vermicompost at 7 t/ha + 75% RNF (75.53 g and 202.85 q/ha) that significantly the highest bulb weight and bulb yield.

Sankar *et al.*(2009b) revealed that the effect of organic fertilizers on the performance of onion (cv. N 2-4-1) were studied in Coimbatore, Tamil Nadu, India during 2002-03 and 2003-04. The main plot treatments consisted of the foliar spraying of panchgavya (based on cow urine), humic substances or coconut water. The subplot treatments consisted of : recommended rates of NPK, 50% FYM (farmyard manure) + 50% neem cake, poultry manure, press mud, vermicompost or digested coir and 50% poultry manure + 50% neem

cake, press mud, vermicompost or digested coir. All organic manures were applied on equivalent weight of the recommended rate of N fertilizer (150kg/ha). In 2002-03 and 2003-04, the greatest plant height (59.27 and 67.90 cm, respectively), number of leaves (9.75 and 13.58) and average weight of bulb (55.40 and 61.60 g) were recorded for 3% panchagavya + 100% of the recommended rates of NPK. The marketable bulb yield was significantly improved by the addition of organic manures and application of organic growth stimulants. The highest marketable bulb yields (22.7 and 25.5 t/ha) were also recorded for 3% panchagavya + 100% of the recommended rates of NPK fertilizers.

Mengistu and Singh (1999) Studied that co-inoculation of *Azospirillum*and VAM on supplemented with 50kg N and 25kg P resulted in maximum equatorial (5.38 cm) and meridian (4.06 cm) in onion bulb diameter. Mengistu and Singh (1999) reported that co-inoculation of biofertilizers supplemented with 50 per cent reduced dose of N and P, gave maximum bulb yield (217-319 ha^{-1}) of onion.

Thilakavathy and Ramaswamy (1998) reported the highest onion bulb yield 18.37 t ha^{-1} compared with 16.59 t ha^{-1} control was obtained with 45 kg N+ 45 kg P + 30 kg ha^{-1} *Azospirillum and phosphorus bacterias.*

Wange (1998) found that the effect of inorganic N, alone or in combination with biofertilizer (*Azospirillum*), on the growth and yield of the onion. Application of *Azospirillum*+ N at 50 or 75 kg ha^{-1} and *Azospirillum*+ N at 50 kg ha^{-1} increased the growth and yield of onion compared to doses alone. All treatment and increased bulb yield by 13 per cent compared to application of 100 kg ha^{-1} alone.

Gupta *et al.* (1999) studied the effect of organic manure and inorganic fertilizer on growth yield and quality of kharif onion cv. Agrifound Dark Red. The organic manures evaluate were sunflower cake @ 19 q/ha, poultry manures @ 57 q/ha and FYM 214 q/ha and 72 q/ha. The inorganic fertilizer evaluated were urea @ 252 kg/ha. CAN 444 kg/ha and ammonium sulphate @ 565kg/ha. The control plot was maintained without any organic and inorganic fertilizer. The study revealed that FYM 272q/ha along with ammonium sulphate @ 565 kg/ ha were effective in increasing the growth.

Warade *et al.* (1996) reported that the*Azospirillum*was applied by seedling dipping for 15 minutes, the highest bulb yield (27.7 t ha^{-1}) was obtained with 40 t FYM ha^{-1} with NPK (100, 50 and 50 kg ha^{-1}, respectively), followed by 40 t FYM ha^{-1} plus NPK (75, 50 and 50 kg ha^{-1}, respectively) with biofertilizer inoculation and increased yield by 64.4 and 64.0 per cent, respectively compared with control which received no fertilizers.

Bhonde *et al.* (1997) seedling dipping for 5 minutes in a solution of *Azotobacter* (1500 g in 50 litre water) with 50 per cent N of recommended dose (not specified) gave the highest market yield 230.62 q ha^{-1} with net return of Rs 37196 ha^{-1} as compared to *Azotobacter*+ 25 per cent N and *Azotobacter*+ 100 per cent N at recommended rate. Application of *Glomus fasciculatu* + *Azotobacter chroococcum*+ 50 per cent of recommended P rate resulted in the greatest root length (30.50 cm), plant height (57.90 cm), bulb girth (19.20 cm) and bulb fresh weight (321.67 g per bulb).

Martinez *et al.* (1994) treated the onion seed bed and plot with *Azotobacter chroococcum* and observed increased seed germination by 30 to 64 per cent, yield by 28 per cent, and increased the average weight and diameter of onion bulbs.

Musmade and konde (1987) reported that increased germination rate in onion variety N-53 ranged from 89.5 percent in the treatment with *Azotobacter chroococcum* plus *Azospirillum lipoferum.* It was 85.5 percent in an untreated content seed treatment.

Gurubatham *et al.* (1989) reported that onion cv. N-53 applied with seed treatment of *Azospirillum* increased yield from 19.1 t ha^{-1} to 20.5 t ha^{-1}.

Dibut *et al.* (1993) in an experiment on onion reported that treatment with dilute *Azotobacter chroococcum* preparation at 5 litre ha^{-1} immediately after sowing increased plant population by 3.33 to 62 per cent, plant height, leaf number, bulb diameter and dry weight increased by anaverage of 26, 36, 72 and 175 per cent, respectively. Onion cv. N-53 seedlings growing in pots was inoculated with *Azotobacter* and *Glomus fasciculatum* increased fresh weight of plant compared with control (Kshirsagar *et al.* ,1994).

Desale (1980) studied that effect of bacterization with *Azotobacter* and *Azospirillum* culture under various levels of nitrogen on growth and yield of sorghum and maize. Observed that the application of increased dose of

nitrogen (0, 33, 66, and 100 kg N ha^{-1}) supplemented with *Azotobacter* and *Azospirillum* resulted in increased plant height, number of leaves, plant dry matter weight and grain yield of sorghum and maize.

Musmade *et al.* (1980) conducted a study on effect of inoculation of *Azospirillum* in yield of onion. they reported that 17.68 per cent increase in onion bulb due to *Azospirillum* inoculation over the uninoculated control.

Joi and shende (1976) conducted an experiment in Rahuri on onion by seedling dipping in an *Azotobacter* slurry for about 30 minutes before transplanting and *Azotobacte r*inoculation at 20 bags ha^{-1} (weight unspecified) alone, *Azotobacter*with 100 kg N ha^{-1} were applied in split dose. The highest bulb yield (399 q ha^{-1}) was obtained from plots receiving *Azotobacter* plus N, yield was increased 22 percent over uninoculated and 18 percent was obtained after inoculation of *Azotobacter*and combination with 40 cart load of FYM ha^{-1} and NPK (100,50 and 50 kg ha^{-1}, respectively) as compared with uninoculated.

Effect of biofertilizers on quality:

Mondal *et al.* (2004) found that in onion, application of neem seed powder, along with 75% of NPK through inorganic fertilizer gave highest vitamin C content (8.10 mg/100g).

Kamble (2006) observed that tha application of 75% RDF + 25% poultry manure gives maximum TSS (14.79%), ascorbic acid (12.47 mg/100g), and sugar percentage.

Singh *et al.* (2015) Reported that application of 50% recommended dose of NPK along with 50% recommended dose of vermicompost results in maximum quality bulbs(TSS,vitamin C, Reducing sugars, non-reducing sugars and total sugars) were also found in 100% vermicompost followed by 100% FYM as compared to other treatments.

Dilpreet *et al.* (2016) Revealed that the bulb diameter were maximum of *Azotobacter* along with recommended dose of fertilizers followed by *Azospirillum*along with recommended dose of fertilizers. Maximum TSS (13.90 brix) and ascorbic acid (14.1 mg/100g fresh weight) was found also *Azospirillum* with recommended dose of fertilizer.

Kumar *et al.* (2017) Reported that the TSS (14^0B), vitamin C (12.11 mg/100g), total sugars (10.52%), reducing sugars (6.23%) and non-reducing

sugar (4.28%) were found maximum in RDF (25%) + VAM + vermicompost (50%) + Azotobacter + boron treatment as compared to other treatment.

Gupta *et al.* (1999) studied revealed that FYM at 72.0q/ha along with ammonium sulphate at 565 kg/ha were effective in increasing the quality contributing characters such as colour, compactness, TSS and dry matter and gave the higher net return.

Mengistu and Singh (1999) Studied that biofertilization supplementation with half the recommended rate of N and P dual inoculation proved the best in improving the T.S.S. content of bulbs (13.11%).

Economics:

Yadav *et al*. (2005) on the basis of pooled data for three years. It is concluded that 75% recommended dose of nitrogen along with *Azospirillum*application gave significantly highest onion bulb yield (328.49 ha^{-1}) and net return of ₹31287 ha^{-1} with B:C ratio 1:10.

Nagaich and Singh (2004) reported that the minimum net profit of Rs. 30980/ha was obtained when potash and Sulphur were not applied and that net profit reached to its maximum amounting Rs. 46039/ha in plots where 80 kg k_2o and 60 kg S/ha were used.

Kore *et al.*(2006) Revealed that the response of garlic to the application of organic, inorganic and biofertilizer in various combinations and to exploit the possibility of economizing cost of fertilizer through nutrient management. The B:C ratio was higher in the treatment stated above. Thus, the treatments 10 t FYM or litres dung slurry in combination with 3 kg Azt + 3 kg PSB + 75% RDF ha-1 were found not only superior in performance but also economical and profitable.

Mandloi *et al.* (2008) found that the response of inorganic fertilizer on the growth and yield of onion. The treatments comprised 0.5 t vermicompost; 15.24 t NADEP/ha; 25 t FYM/ha; 3.28 t poultry manures/ha; recommended dose of N 125 P 60 K 100; 1.25 t Agric/ha.; and the control N 125 P 60 K 100 application proved the most beneficial for growing onion cv. N-53. It yielded the maximum upto 378.61q/ha. Onion bulb with the highest net return of Rs. 83 071/ha and B:C ratio of 3.72.

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled **" Effect of bio-fertilizers on growth, yield and yield attributing characters in onion (*Allium cepa* L.)var. AFLR."** was conducted during rabi 2019-2020. The details of the material used and methodology adopted during the course of investigation are presented in the chapter.

3.1 Experimental Site and Location

The experiment was carried out at the Horticulture Research Farm, R.A.K college of Agriculture, Sehore (M.P.) during rabi 2019-2020 i.e., from November 2019 to March 2020. The experimental site is situated in the western part of the Vindhya Plateau at 23.11º North latitude and 77.04º' East longitudes at an altitude of 502 meter above mean sea level in Madhya Pradesh. The topography of the experimental field is plain. The region lies under 5thagro-climatic zone of state

3.2Climatic Condition

Sehore belongs to sub-tropical zone. The summers here have a good deal of rainfall, while the winters have very little. The average temperature is about 25.3^{o} C. The rainfall here is around 1266 mm(49.8 inch per year).The highest temperature recorded in the month of May at around 33.8^{o} C whereas January is the coldest month with temperature 18.6^{o}C.Temperatures in the summer range from 25 to 45 ºC, while the temperature in winter is 10 to 25 ºC. Meteorological data recorded during the period of investigation are present in Table 1.

The data (Table 1) indicate that the minimum and maximum temperature during crop growth period varied 7.91ºC to 30.02 ºC. The relative humidity ranged between 24.62 to 99.85 %.

3.1 Meteorological data during the *Rabi* crop season of 2019-2020

Month	Standard Week No.	Dates	Temperature (℃)		Rainfall (mm)	R.H. (%)	
			Max.	Min.		Max.	Min.
November 2019	44	29-4 Nov	30.02	19.32	32.00	94.57	53.71
	45	5-11 Nov	29.97	18.6	0.00	90.00	43.57
	46	12-18 Nov	29.34	14.62	0.00	87.57	31.42
	47	19-25 Nov	28.37	12.22	0.00	86.85	35.42
	48	26-2 Dec	28.51	15.11	0.00	87.71	35.85
December 2019	49	3-9 Dec	25.01	12.25	0.00	87.14	39.14
	50	10-16 Dec	24.57	12.91	19.5	96.71	52.28
	51	17-23 Dec	22.11	9.68	0.00	99.85	57.71
	52	24-31 Dec	21.65	8.76	0.00	92.12	41.12
January 2020	1	1-7 Jan	20.18	9.85	0.00	97.85	59.42
	2	8-14 Jan	22.54	7.91	4.00	97.14	37.71
	3	15-21 Jan	20.88	9.38	0.00	98.42	57.85
	4	22-28 Jan	24.14	10.14	0.00	88.71	44.42
	5	29Jan -4 Feb	23.15	8.68	0.00	86.42	39.14
February 2020	6	5Feb-11Feb	23.72	8.85	0.00	84.71	33.71
	7	12 - 18 Feb	27.91	9.22	0.00	87.14	26.28
	8	19 -25 Feb	29.04	12.24	0.00	80.42	27.57
	9	26Feb-4 Mar	29.72	13.81	1.50	75.62	24.62
March 2020	10	5-11 Mar	27.61	13.78	0.00	65.85	27.85
	11	12-18 Mar	28.52	12.71	0.00	74.85	29.85

Source: Meteorological Observatory, R.A.K. College of Agriculture, Sehore (M.P.)

Fig. 1 Meteorological data during the *Rabi* crop season of 2019-2020

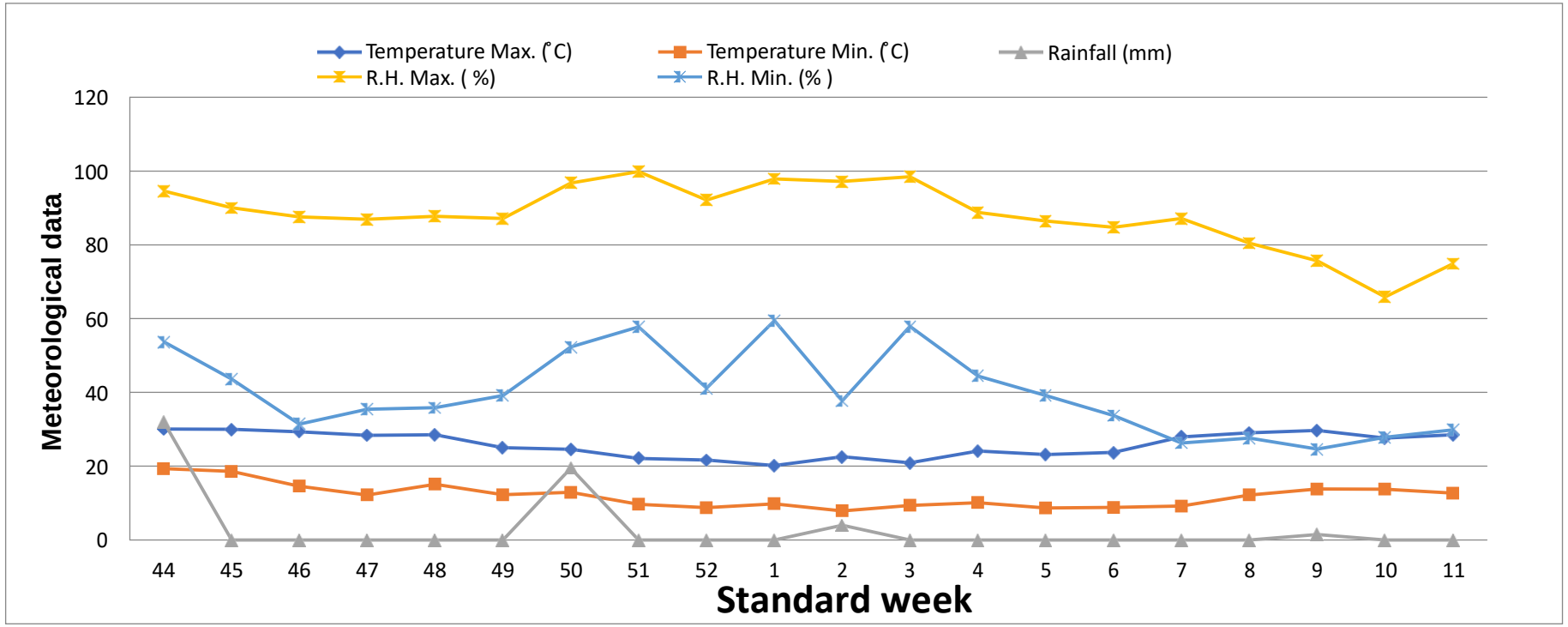
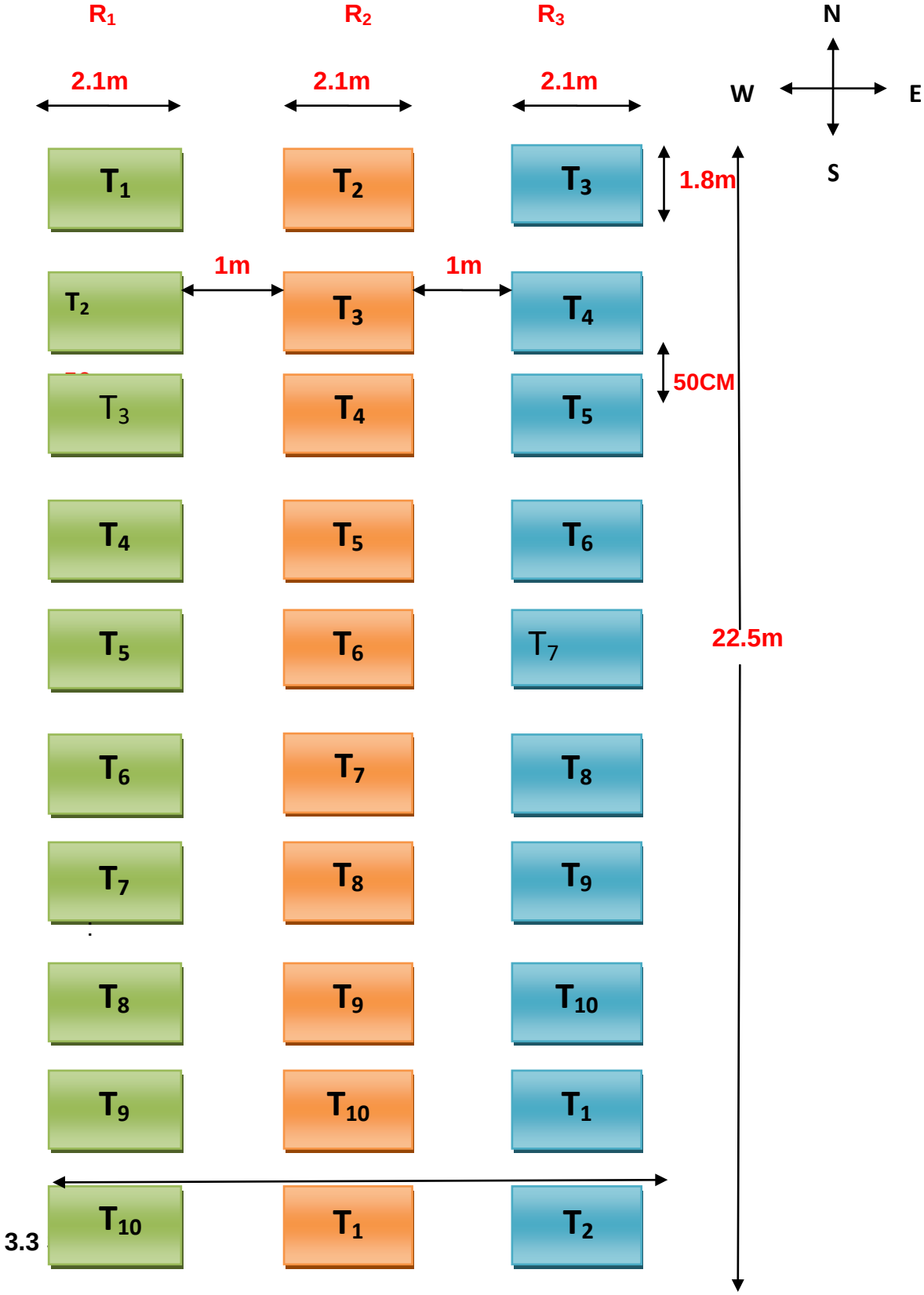


Fig.2 LAYOUT OF THE FIELD



Before laying out the experiment, random soil samples were collected from the different spots of the experimental field at 0-15 cm depth and the composite sample was prepared which was analyzed for various chemical properties of the soil. The soil of experimental field was medium black with good drainage facilities and uniform texture with low N and medium P_2O_5, K_2O status.

Table 3.2 Chemical properties of experimental field:

S. No.	Composition	Content	Category	Method used
	A. Mechanical composition			
1.	Sand (%)	25	-	Bouyoucos Hydrometer method (Piper, 1967)
2.	Silt (%)	38	-	
3.	Clay (%)	37	-	
4.	Textural class		Medium black	
	B. Chemical composition			
S. No.	**Particulars**	**Content**	**Level**	**Method adopted by**
1.	Organic Carbon (%)	0.60	Medium	Walkey& Black method (1934)
2.	Available Nitrogen N (kg/ha)	225.0	Low	Walkey& Black method (1934)
3.	Available Phosphorus P (kg/ha)	17.12	Medium	Olsen's method (Olsen *et al.*, 1954)
4.	Avalable Potassium K (kg/ha)	228.0	Medium	Flame photometer (Jackson, 1967)
5.	Soil P^H	7.8	Normal	pH meter (Jackson, 1967)
6.	Electrical Conductivity (mhos/cm)	0.4 ds/m	Normal	Conductivity meter at 25ºC (Jackson, 1967)

3.4 Previous cropping history of the experimental field:

Following cropping system was followed in the experimental field during the preceding four years:

Table 3.3 Previous history of the experimental field:

Year	Kharif	Rabi	Summer
2016-17	Ground nut	Potato	Black gram
2017-18	Okra	Fenugreek	Green gram
2018-19	Brinjal	Brinjal	Okra
2019-20	Bitter gourd	onion*	**.....**

* Experimental Crop

3.5 Experimental details

The experiment was laid out in randomized block design with nine treatments, replicated three times. The treatment details are given below:

1. Name of crop : Kharif onion (*Allium cepa* L.)
2. Design of experiment : Randomized Block Design
3. No of replication : 3
4. No of treatments : 10
5. Total number of plot : 30
6. Distance between replication : 1 m
7. Distance between plot : 50 cm
8. Distance between row : 15 cm to 15 cm
9. Distance between plant : 10 cm to 10 cm
10. Plot Size : 2.1 m x 1.8 m
11. Seed Rate : 10 kg/ha
12. Season : Rabi 2019-2020
13. Transplanting Date : 12 December 2019
14. Harvesting Date : 18 April 2020
15. Date of application of manure and fertilizer : 27 December 2019

Table 3.4 TREATMENT DETAILS :

Treatment	Doses
T_1	Control
T_2	Vermicompost (Vc) +*Azospirillum*full dose (5 t/ha +2 kg/ha)
T_3	Vc+VAM full dose (5 t/ha+2 kg/ha)
T_4	Vc+ PSB full dose (5 t/ha+2.5 kg/ha)
T_5	Vc+*Azospirillum* full dose +VAM (1/2 dose) 5 t/ha+ 2 kg/ha +1 kg/ha)
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)(5 t/ha+2 kg/ha+1.25 kg/ha)
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose) (5 t/ha+2 kg/ha+1 kg/ha)
T_8	Vc+*Azospirillum*+VAM+PSB(1/3dose)(5t/ha+666g/ha+666g/ha+833g/ha)
T_9	Vc+*Azospirillum*+VAM+PSB(1/2dose)(5t/ha+1kg/ha+1kg/ha+1.25 kg/ha)
T_{10}	Vc+*Azospirillum*+VAM+PSB(full dose)(5t/ha+2 kg/ha+2 kg/ha+2.5 kg/ha)

Table 3.5 Schedule of the field operations:

S.No.	Operation	Date	Remarks
1.	Raising of seedling	15/11/2019	Manually
2.	Ploughing Harrowing	5/12/2019 6/12/2019	By Tractor By Tractor
3.	Layout of the field	9/12/2019	Manually
4.	Transplanting	12/12/2019	Manually
5.	Gap filling	19/12/2020	Manually
6.	Irrigation schedule	12/12//2019 26/12/2019 04/01/2020 11/01/2020 20/01/2020 29/01/2020 08/02/2020 17/02/2020 25/02/2020 04/03/2020 16/03/2020 26/03/2020 04/04/2020 11/04/2020	Manually
7.	Fertilizer application	31/12/2019	Manually
8.	1st Sampling 2nd Sampling 3rd Sampling 4th Sampling	13/01/2020 27/01/2020 12/02/2020 13/03/2020	Manually
9.	1st weeding 2nd weeding	30/12/2020 19/02/2020	Manually
10.	Harvesting	18/04/2020	Manually
11.	Grading	20/04/2020 21/04/2020	Manually

3.6 Agronomical operation:

The schedule of different pre and post- sowing operations, carried out during the crop season and details of operations of crop raising are described as under.

3.6.1 Raising of seedling

The nursery beds were dug and prepared thoroughly. All the grass, roots, bricks pieces, residue of previous crop, weeds and other undesirable materials were removed from the beds. The nursery beds were prepared 1m wide and 3m long and elevated up to 20cm from ground levels. Ten kg treated seeds of onion were sown on the nursery beds in row 5cm apart from for one hectare. After sowing seeds were covered with a thin layered of sieved FYM.

Sprinkling of water with water cans was done immediately. This practice was repeated frequently as and when required to make the beds well moisturized till the germination. After germination of seeds, cover of FYM was removed. Weeding was done manually as and when weeds appeared in the nursery beds without disturbing the seedling.

3.6.2 Field preparation

The experimental area was ploughed and harrowed in order to bring the soil in well pulverized condition, plots were made according to the layout plan after leveling.

3.6.3 Transplanting and Gap filling

Seedling were uprooted from the nursery bed and transplanted in the plots at a spacing of 15 cm row-row and 13 cm plant-plant. Transplanting was done in the afternoon hours immediately followed by irrigation for proper establishment of the seedlings. A week after transplanting, gap filling was done.

3.6.4 Nutrient application

nutrients were applied through bio-fertilizers like*Azospirillum* (@2kg/ha)*, VAM* (@ 2kg/ha)and PSB (@2kg/ha) According to treatments. These all bio-fertilizers were applied with vermicompost (@5t/ha) after 20 days of transplanting.

3.6.5 Seed Rate and sowing

The nursery was sown on November 11, 2019. The seeds were treated with Bavistin @ 2 g/kg seed and then nursery was sown on November 15, 2019 manually. Then seedlings were transplanted manually in line by maintaining uniform distance 15 cmx10 cm in flat beds and roots covered with fine soil. Seedlings was sown at the depth of 5-7cm. The recommended seed rate of onion is about 10 kg ha^{1}

3.6.6 Irrigation

A light irrigation is given soon after seed sowing in nursery to ensure good germination. Then just after transplanting and Subsequent irrigations were given at different intervals as per crop requirement and temperature.

3.6.7 Weeding

Manual weeding was done twice at 20 and 45 days after sowing to reduce crop-weed competition.

3.6.8 Intercultural operations

Plant treatment with Trichoderma by drenching the soil near stem region with 10 g Trichoderma powder mixed in a liter of water.

3.6.9 Sampling

Sampling was done at 30 days up to harvesting for growth analysis. Five plants were randomly selected from each treatment and replication for the study in net plot.

3.6.10 Harvesting

The crop was harvested on April 18, 2020. Plants from each plot were digged out with bulb separately. The harvested plant of each plot was cut from neck, tagged and kept on floor for grading.

3.7 Observation recorded:

Observations with respect to following characters were recorded on five plants selected at randomly and tagged in each plot excluding the border plant and their means were worked out for statistical analysis.

3.7.1 Growth parameters:

3.7.1.1 Plant height (cm)

The height of individual plant was measured from the ground level to the tip of the longest leaf with the help of meter scale at 30, 45, 60 and 90 days after transplanting (DAT). It was recorded in centimeters (cm).

3.7.1.2 Number of leaves per plant

The number of leaves was counted in each five plant at 30, 45 and 60 days after transplanting.

3.7.1.3 Leaf length

Length of one leaf of selected plants was measured in centimeters (cm).

3.7.1.4 Leaf width

Leaf width of selected plants was measured with the help of meter scale. It was also recorded in centimeters (cm).

3.7.1.5 Neck thickness

Neck thickness of selected plant from each plot and replication was recorded with the help of vernier’s calipers and the mean neck thickness was work out.

3.7.1.6 Leaf Area per plant (cm^2)

Leaf area was measured with the help of linear measurement method. The average leaf area was recorded as mean value based upon the observations recorded on all the leaves attached to the selected five plants.

3.7.1.7 Leaf Area Index (LAI)

LAI was measured with mainly based on leaf area divided by ground area occupied by plant.

Leaf area index is the ratio of leaf area to ground area.

$$\text{LAI} = \frac{\text{Leaf area } (cm^2)}{\text{Ground area } (cm^2)}$$

3.7.2 Yield parameters:

3.7.2.1 Fresh weight of bulb (g)

Five bulbs from each treatment and replication was taken and average weight of bulbs was recorded.

3.7.2.2 Dry weight of bulb (g)

After taking fresh weight each bulb is chopped and then sun dried for two days. Then these bulbs were oven dried for 24 hours at 60^0c then weight of dried bulbs were recorded.

3.7.2.3 Polar diameter of bulb (cm)

Five bulbs from each treatment and replication were selected and polar diameter of selected bulbs were recorded with the help of Vernier's calipers and mean polar diameter was calculated.

3.7.2.4 Equatorial diameter of bulb (cm)

After taking polar diameter equatorial diameter of selected bulb were recorded with the help of Vernier's calipers and mean equatorial diameter was calculated.

3.7.2.5 Number of bolting per plot

Number of bolted plants per plot were counted before harvesting the crop.

3.7.2.6 Bolting percentage (%)

The bolting percentage was calculated by counting the number of bolted plants before harvesting.

3.7.2.7 number of scales per bulb

After harvesting selected bulbs from each plot are chopped into halves then, number of scales were counted.

3.7.2.8 Bulb yield (kg/plot)

The crop was harvested and bulbs of each plot were separately weighed in kilograms. The data for the yield per plot under different treatments were recorded and total yield of bulbs per plot in kilograms were recorded.

3.7.2.9 Bulb yield (q/ha)

After measuring the bulb yield per plot in kilograms were converted into quintal per hectare by multiplying with factor.

3.7.2.10 Marketable yield (kg/plot)

After grading of bulbs from each plot, weight of marketable (A, B and C grade) bulbs was separately recorded in kilograms.

3.7.2.11 Marketable yield (q/ha)

Weight of marketable (A,B and C grade) bulbs was converted into quintal per hectare by multiplying with factor.

3.7.3 Quality parameters

3.7.3.1 Total Soluble Solis (^{0} brix)

Bulbs were taken randomly from each plot and the estimation of total soluble solid was done with the help of Refractometer.

3.7.4 Economic analysis:

The economics of treatments is the most important consideration for making any recommendation to the farmer for its adoption.

3.7.4.1 Cost of cultivation (₹/ha)

The prices of inputs that were prevailing at the time of their use were considered for working out the cost of cultivation.

3.7.4.2 Gross return (₹/ha)

Gross return was worked out on the basis of market price of the produce at the time, when the produce was ready for sale.

3.7.4.3 Net return (₹/ha)

Net return (Rs/ha) was calculated by deducting all expenditure (Rs/ha) from gross return (Rs/ha). It is good indicator of suitability of a cropping system since this represents the actual income of the farmer.

Net returns (Rs/ha^{-1}) = Gross Return (₹ha^{-1}) – Cost of cultivation (₹ha^{-1})

3.7.4.4 Benefit Cost Ratio

The benefit cost ratio was calculated by dividing the net return with respective cost of cultivation. It is expressed as returns per rupee invested. Benefit Cost ratio was worked out by using the formula given below

B: C ratio = Gross returns (ha^{-1}) **/** ₹cost of cultivation (ha^{-1}) ₹

3.8 Statistical Analysis

The data recorded on various parameters were analyzed as per RBD design as suggested by Gomez and Gomez (1984). The results have been interpreted on the basis of 'F' test value and critical difference (CD) was calculated.

Table 3.6 Skeleton of ''analysis of variance'' (ANOVA)

Source of Variation(S.V.)	Degree of Freedom(D.f.)	Sum of Square(SS)	Mean sum of square(MSS)	F_{cal}	F_{tab}at 5%
Replication	r-1	SSR	MSR	MSR/MSE	-
Treatment	t-1	SST	MST	MST/MSE	-
Error	(r-1)(t-1)	SSE	MSE	-	-
Total	**rt-1**	**SST**	**-**	**-**	**-**

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

a) SEm± = √ MSE/r

b) C.D. = SEm± x √2 × t 5 % at error d.f.

c) MSE = SSE/ (r-1)(t-1)

d) C.V. = √ MSE / t x 100

Where;

r : Replication

t : Treatment

d.f. : Degree of freedom

SS : Sum of square

MSS : Mean sum of square

MSE : Error mean sum of square

S.Em± : Standard error of mean

CD : Critical difference

CV : Coefficient of variation

CHAPTER-IV

RESULT

The present investigation entitled **"Effect of bio-fertilizers on growth, yield and yield attributing characters in onion (*Allium cepa* L.)var. AFLR."**Was conducted at experimental field of Horticulture, R.A.K. college of agriculture, Sehore (M.P.). the result obtained from this investigation, according to different parameter has been present in this chapter.

The data of different parameter was analysed statically and presented in different tables and the ''ANOVA'' is provided in the Appendix I to XXXVII.

4.1 Growth parameters

4.1.1 Plant height (cm)

The plant height of onion plant was recorded at 30, 45, 60, and 90 DAT as shown in table 4.1, fig I and appendix (I) from the analysis of variance study, the plant height significantly affected at different stages of growth of plant.

At 30 DAT, The plant height significantly maximum recorded in treatment T_8 (29.27) and at par T_6 (28.97) followed by T_9(28.43) T_1(27.50), T_7(27.27), T_5(26.97), T_4(26.10)T_2(25.80)T_3(25.70)while the minimum plant height is reported in T_1(25.13).

At 45 DAT, The plant height significantly maximum recorded in treatment T_8 (38.37),and at parT_3 (37.90), followed by T_7 (37.87), T_4(37.70), T_6(37.70), T_5 (37.53), T_{10} (37.20), T_9(36.93), T_2(35.60) while the minimum plant height is recorded in T_1 (34.40).

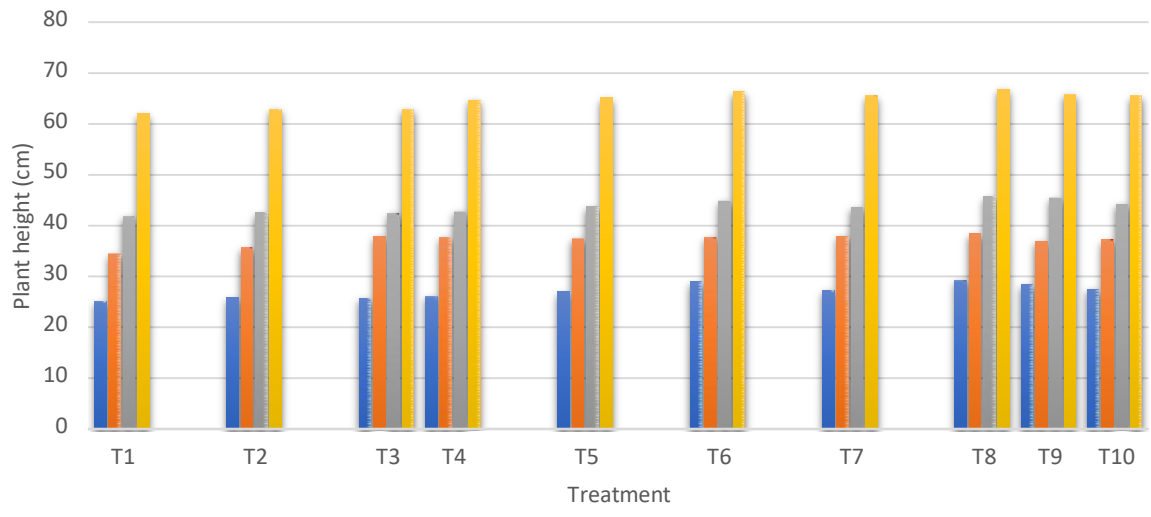
At 60 DAT, The plant height significantly maximum recorded in treatment T_8 (45.63), and at par T_9 (45.43) followed by T_6 (44.93), T_{10} (44.20), T_5(43.67), T_7(43.63), T_4 (42.80), T_2 (42.50), T_3(42.40) while the minimum plant height is recorded in T_1 (41.83).

At 90 DAT, The plant height significantly maximum recorded in treatment T_8 (66.80), and at par T_6 (66.27) followed by T_9 (65.83), T_7 (65.47), T_{10}(65.47), T_5(65.10), T_4 (64.67), T_2 (62.87), T_3(62.83) while the minimum plant height is recorded in T_1 (62.00).

Table 4.1 Plant Height (cm) of onion at 30, 45, 60 and 90 DAT

S. No	Treatment	Plant height (cm)			
		30D	45D	60D	90D
T_1	Control	25.13	34.40	41.83	62.00
T_2	Vermicompost (Vc) +*Azospirillum* full dose (5 t/ha) (2 kg/ha)	25.80	35.60	42.50	62.87
T_3	Vc+ VAM full dose (5 t/ha) (2 kg/ha)	25.70	37.90	42.40	62.83
T_4	Vc+ PSB full dose (5 t/ha) (2.5 kg/ha)	26.10	37.70	42.80	64.67
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)(5 t/ha)(2 kg/ha)(1 kg/ha)	26.97	37.53	43.67	65.10
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)(5 t/ha)(2 kg/ha)(1.25 kg/ha)	28.97	37.70	44.93	66.27
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)(5 t/ha)(2 kg/ha) (1 kg/ha)	27.27	37.87	43.63	65.47
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB (1/3 dose)(5 t/ha)(666 gm/ha)(666 gm/ha)(833 gm/ha)	29.27	38.37	45.63	66.80
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose)(5 t/ha)(1 kg/ha)(1 kg/ha)(1.25 kg/ha)	28.43	36.93	45.43	65.83
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose) (5 t/ha)(2 kg/ha)(2 kg/ha)(2.5 kg/ha)	27.50	37.20	44.20	65.47
S.Em±		**0.98**	**0.82**	**0.89**	**1.91**
C.D. (5%)		**2.91**	**2.44**	**2.65**	**5.68**

Fig. 3 Effect of bio-fertilizers on growth of height of onion plant on 30, 45, 60 and 90 DAT



4.1.2 Number of leaves per plant

The number of leaves of per plant was counted on 30DAT, 45DAT, 60DAT and 90 DAT. As shown in table 4.2, fig 2 and appendix (II) from the analysis of variance study, the number of leaves per plant influenced by various treatments.

Table 4.2 Number of leaves per plant at 30, 45, 60 and 90 DAT

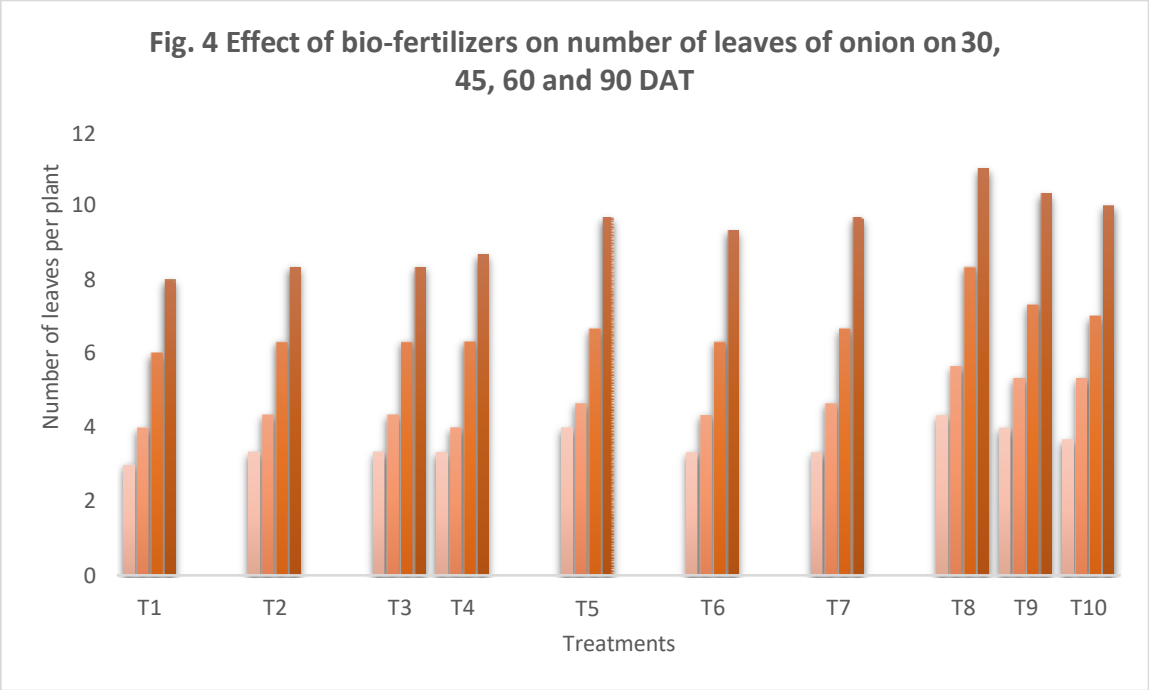
S. No	Treatment	Number of leaves per plant			
		30D	45D	60DA	90DA
T_1	Control	3.00	4.00	6.00	8.00
T_2	Vermicompost (Vc) +*Azospirillum*full dose (5 t/ha) (2 kg/ha)	3.33	4.33	6.33	8.33
T_3	Vc+ VAM full dose (5 t/ha) (2 kg/ha)	3.33	4.33	6.33	8.33
T_4	Vc+ PSB full dose (5 t/ha)(2.5 kg/ha)	3.33	4.00	6.33	8.67
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)(5 t/ha)(2 kg/ha)(1 kg/ha)	4.00	4.67	6.67	9.67
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)(5 t/ha)(2 kg/ha)(1.25 kg/ha)	3.33	4.33	6.33	9.33
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)(5 t/ha)(2 kg/ha) (1 kg/ha)	3.33	4.67	6.67	9.67
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)(5 t/ha)(666 gm/ha)(666 gm/ha)(833 gm/ha)	4.33	5.67	8.33	11.00
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose) (5 t/ha)(1 kg/ha)(1 kg/ha)(1.25 kg/ha)	4.00	5.33	7.33	10.33
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)(5 t/ha)(2 kg/ha)(2 kg/ha)(2.5 kg/ha)	3.67	5.33	7.00	10.00
S.Em±		**0.29**	**0.35**	**0.40**	**0.45**
C.D. (5%)		**0.85**	**1.03**	**1.18**	**1.34**

At 30 DAT, The number of leaves per plant was significantly maximum recorded in treatment T_8 (4.33) and at par T_5 (4.00) followed by T_9 (4.00) T_{10} (3.67)T_2(3.33), T_3 (3.33),T_4 (3.33),T_6 (3.33),T_7 (3.33),while the minimum plant height is reported in T_1(3.00).

At 45 DAT, The number of leaves per plant was significantly maximum recorded in treatment T_8 (5.67) and at par T_9 (5.33) followed by T_{10}(5.33)T_5(4.67),T_7(4.67),T_2(4.33),T_3(4.33)T_6(4.33)T_4(4.00) while the minimum plant height is reported in T_1(4.00).

At 60 DAT, The number of leaves per plant was significantly maximum recorded in treatment T_8 (8.33) and at par T_9 (7.33) followed by T_{10}(7.00)T_5(6.67),T_7(6.67),T_2(6.33),T_3(6.33)T_4(6.33)T_6(6.33) while the minimum plant height is reported in T_1(6.00).

At 90 DAT, The number of leaves per plant was significantly maximum recorded in treatment T_8 (11.00) and at par T_9 (10.33) followed by T_{10}(10.00)T_5(9.67),T_7(9.67),T_6(9.33),T_4(8.67)T_2(8.33)T_3 (8.33) while the minimum plant height is reported in T_1(8.00).



4.1.3 Leaf length (cm)

The increasing nature of length of leaf of the plant is recorded at 30, 45, 60 and 90 days after transplanting. As shown in table 4.3, figure 3 and appendix (III) from the analysis of variance study, the length of leaf isvariesdue to different treatments.

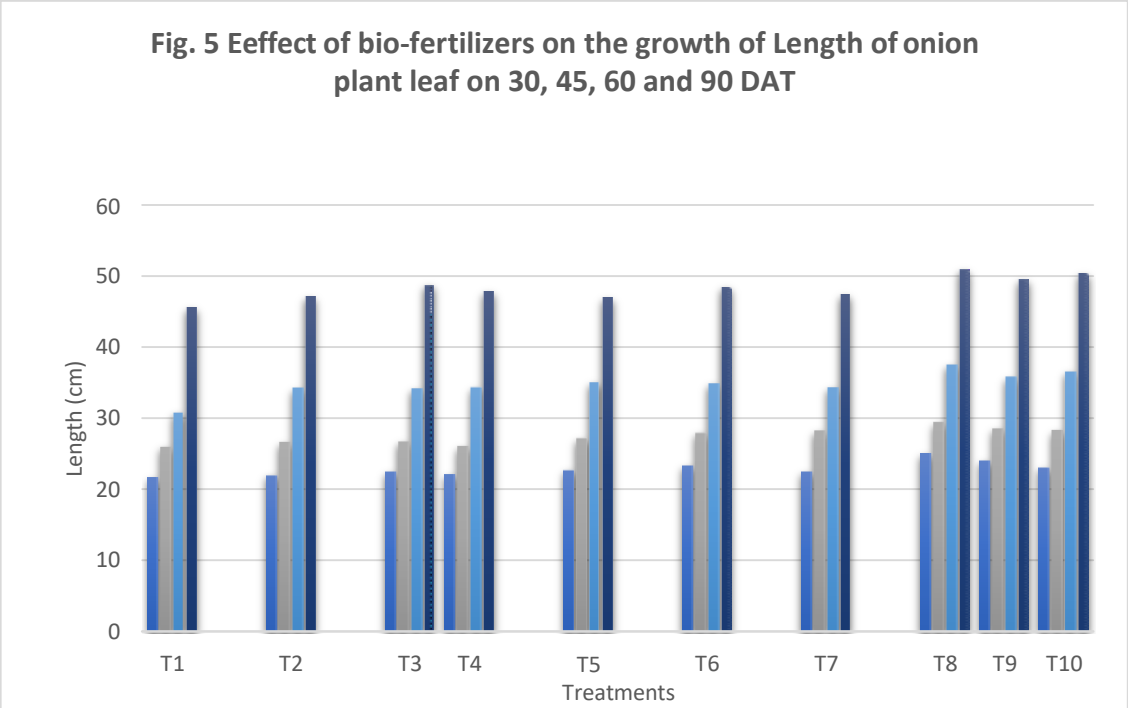
At 30 DAT, The length of leaves per plant was significantly maximum recorded in treatment T_8 (25.00) and at par T_9 (23.97) followed by T_6 (23.30)T_{10} (23.03),T_5 (22.73),T_3 (22.43),T_7 (22.43)T_4 (22.00)T_2 (21.97) while the minimum plant height is reported in T_1(21.63).

At 45 DAT, The length of leaves per plant was significantly maximum recorded in treatment T_8 (29.40) and at par T_9 (28.53) followed by T_7 (28.27)T_{10}

(28.23),T_6 (27.87),T_5 (27.17),T_3 (26.63)T_2 (26.50)T_4 (26.00) while the minimum plant height is reported in T_1(25.90).

Table 4.3 Leaf length (cm) at 30, 45, 60 and 90 DAT

S. No	Treatment	Leaf length (cm)			
		30 DAT	45 DAT	60 DAT	90 DAT
T_1	Control	21.63	25.90	30.70	45.53
T_2	Vermicompost (Vc) +*Azospirillum* full dose	21.97	26.50	34.20	47.07
T_3	Vc+ VAM full dose	22.43	26.63	34.07	48.67
T_4	Vc+ PSB full dose	22.00	26.00	34.30	47.80
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	22.73	27.17	34.97	46.97
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	23.30	27.87	34.80	48.40
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	22.43	28.27	34.30	47.40
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)	25.00	29.40	37.43	50.90
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose)	23.97	28.53	35.73	49.50
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	23.03	28.23	36.50	50.33
S.Em±		**0.70**	**0.80**	**1.06**	**1.13**
C.D. (5%)		**2.09**	**2.39**	**3.15**	**3.35**



At 60 DAT, The length of leaves per plant was significantly maximum recorded in treatment T_8 (37.43) and at par T_{10} (36.50) followed by T_9 (35.73)T_5

(34.97),T_6 (34.80),T_4 (34.30),T_7 (34.30)T_2 (34.20)T_3 (34.07) while the minimum plant height is reported in T_1(30.70).

At 90 DAT,The length of leaves per plant was significantly maximum recorded in treatment T_8 (50.90) and at par T_{10} (50.33) followed by T_9(49.50) T_3(48.67), T_6 (48.40),T_4(47.80),T_7(47.40)T_2 (47.07)T_5(46.97) while the minimum plant height is reported in T_1(45.53).

4.1.4 Leaf width (cm)

The width of the leaf is recorded at 30, 45, 60 and 90 days after transplanting. As shown in table 4.4, figure 4 and appendix (IV). From the analysis of variance study, the width of leaf is varies due to different treatments.

Table 4.4 Leaf width at 30, 45, 60 and 90 DAT

S. No	Treatment	Leaf width (cm)			
		30 DAT	45 DAT	60 DAT	90 DAT
T_1	Control	0.33	0.60	0.80	1.03
T_2	Vermicompost (Vc) +*Azospirillum* full dose	0.40	0.63	0.97	1.17
T_3	Vc+ VAM full dose	0.37	0.67	0.93	1.13
T_4	Vc+ PSB full dose	0.40	0.70	0.87	1.07
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	0.43	0.90	1.03	1.23
T_6	Vc+*Azospirillum* full dose+PSB (1/2 dose)	0.50	0.70	1.00	1.37
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	0.63	0.83	1.00	1.30
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)	0.67	1.20	1.53	1.80
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose)	0.50	0.97	1.23	1.77
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	0.37	0.97	1.13	1.77
S.Em±		**0.03**	**0.07**	**0.06**	**0.05**
C.D. (5%)		**0.10**	**0.19**	**0.18**	**0.15**

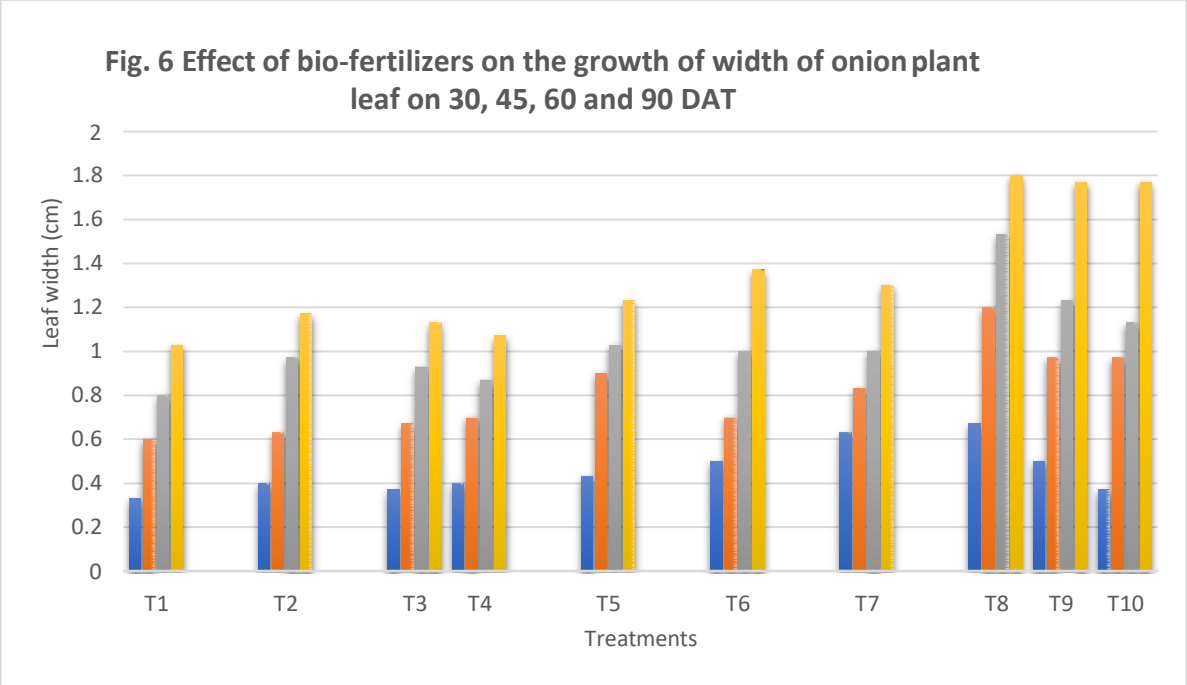
At 30 DAT, The width of leaves per plant was significantly maximum recorded in treatment T_8 (0.67) and at par T_7 (0.63) followed by T_6(0.50),T_9 (0.50),T_5(0.43),T_2(0.40),T_4(0.40), T_3(0.37), T_{10}(0.37) while the minimum width of leaf is reported in T_1(0.33).

At 45 DAT, The width of leaves per plant was significantly maximum recorded in treatment T_8 (1.20) and at par T_{10} (0.97), T_9 (0.97)followed byT_7 (0.83),T_5 (0.90),T_6 (0.70),T_4 (0.70), T_3 (0.67), T_2 (0.63) while the minimum width of leaf is reported in T_1(0.60).

At 60 DAT, The width of leaves per plant was significantly maximum recorded in treatment T_8 (1.53) and at par T_9 (1.23) followed by

T_{10}(1.13),T_5(1.03),T_7(1.00),T_6(1.00),T_2(0.97), T_3 (0.93), T_4(0.87) while the minimum width of leaf is reported in T_1(0.80).

At 90 DAT, The width of leaves per plant was significantly maximum recorded in treatment T_8 (1.80) and at par T_9 (1.77), T_{10}(1.77) followed by T_6(1.37),T_7(1.30),T_5(1.23),T_2(1.17), T_3 (1.13), T_4(1.07) while the minimum width of leaf is reported in T_1(1.03



4.1.5 Leaf area (cm^2)

Leaf area (cm^2) is recorded at 45 days after transplanting when leaves were growing to a maximum size. As shown in table 4.5, fig. 5 and appendix (V). from the analysis of variance study, the area of leaf per plant is varies due to application of different doses of bio-fertilizers.

At 30 DAT, The Leaf area per plant was significantly maximum recorded in treatment T_8 (241.5) and at par T_{10} (219) followed by T_7(203.5),T_9 (202.67),T_6(193.67),T_2(189.17),T_4(182.5), T_5(181.67), T_3(178) while the minimum leaf area is reported in T_1(174.67).

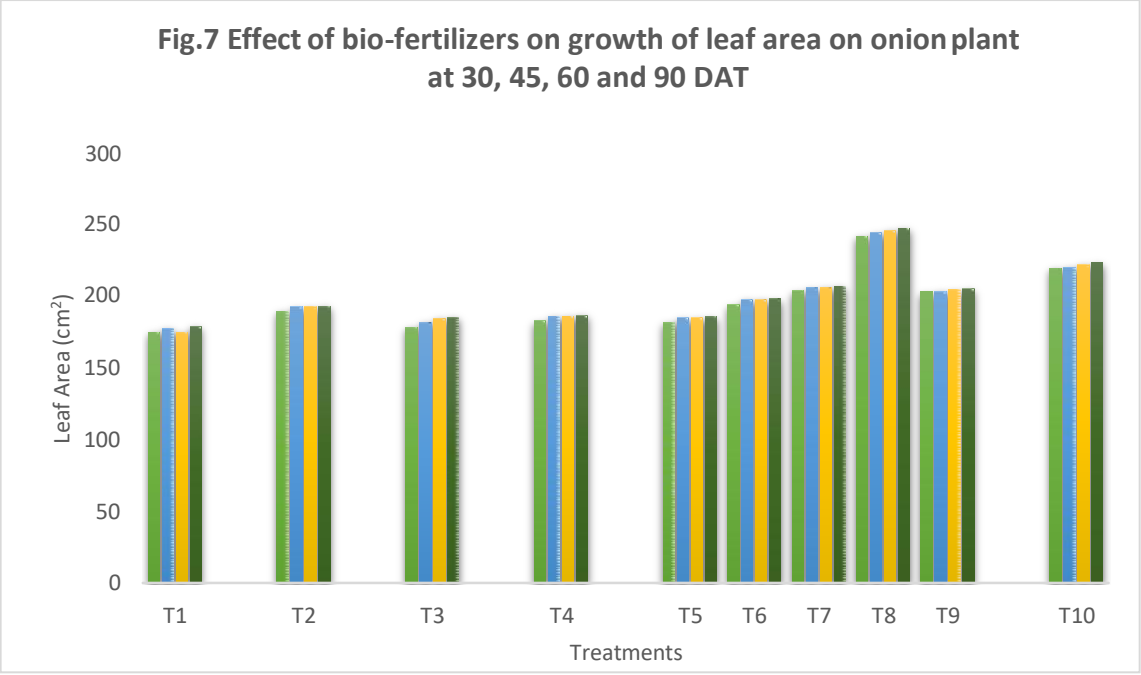
At 45 DAT, The leaf area per plant was significantly maximum recorded in treatment T_8 (243.83) and at par T_{10} (219.67), followed byT_7(205.5), T_9(203.17),T_6(197.50),T_2(192.17),T_4(185.5), T_5(184.5), T_3(181.5) while the minimumleaf area is reported in T_1(177.5).

At 60 DAT, The leaf area per plant was significantly maximum recorded in treatment T_8 (245.67) and at par T_{10} (222), followed byT_7(205.83), T_9(204),T_6

(197.5),T_2 (192.33),T_4 (185.83), T_5 (184.67), T_3 (184.33) while the minimumleaf area is reported in T_1(174.33).

Table 4.5 Leaf area (cm^2) at 30, 45, 60 and 90 DAT

S. No	Treatment	Leaf area (cm^2)			
		30 DAT	45 DAT	60 DAT	90 DAT
T_1	Control	174.67	177.5	174.33	178.8
T_2	Vermicompost (Vc) +*Azospirillum*full dose	189.17	192.17	192.33	192.8
T_3	Vc+ VAM full dose	178	181.5	184.33	184.93
T_4	Vc+ PSB full dose	182.5	185.5	185.83	186.33
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	181.67	184.5	184.67	185.33
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	193.67	197.5	197.5	198
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	203.5	205.5	205.83	206.43
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB (1/3 dose)	241.5	243.83	245.67	247.03
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose)	202.67	203.17	204	205
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	219	219.67	222	223.1
S.Em±		**6.97**	**12.04**	**13.08**	**14.50**
C.D. (5%)		**20.69**	**35.76**	**38.84**	**43.07**



At 90 DAT, The leaf area per plant was significantly maximum recorded in treatment T_8 (247.03) and at par T_{10} (223.1), followed byT_7(206.43),

T_9(205),T_6(198),T_2 (192.8),T_4 (186.33), T_5 (185.33), T_3 (184.93) while the minimumleaf area is reported in T_1(178.8).

4.1.6 Leaf area index (LAI)

The leaf area index recorded at 45 DAT when leaves were growing to maximum size. As shown in table 4.5, fig. 6 and appendix (VI). From the analysis of variance study, the area of leaf per plant is varies due to application of different doses of bio-fertilizer.

Table 4.6 Leaf Area Index at 30, 45, 60 and 90 DAT

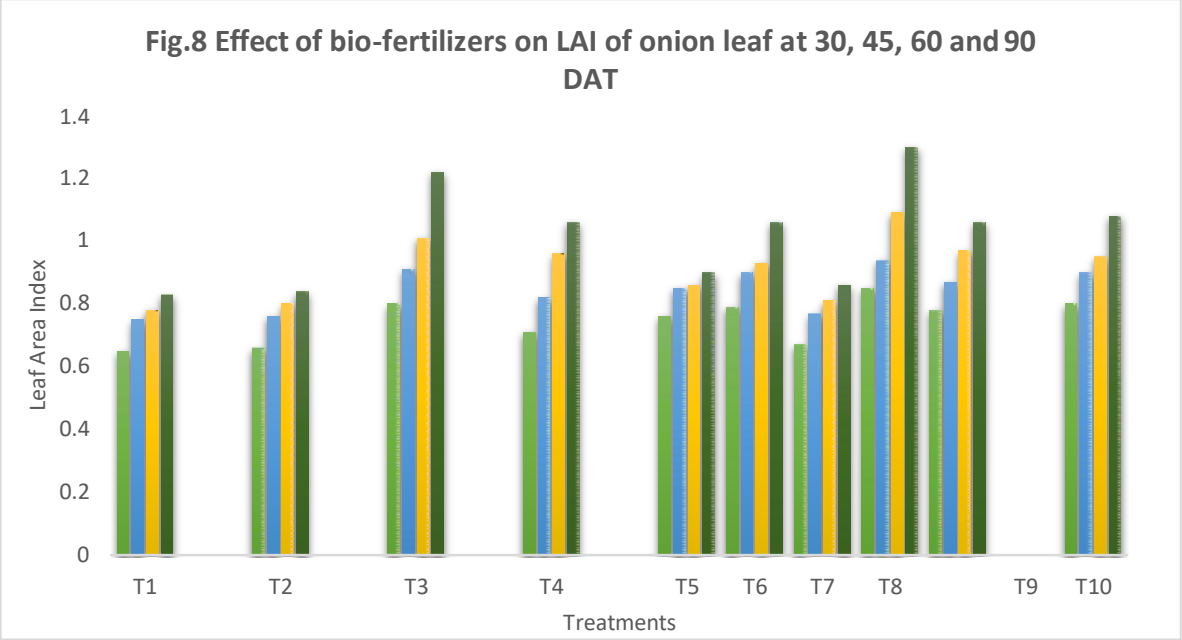
S. No	Treatment	Leaf area Index(LAI)			
		30 DAT	45 DAT	60 DAT	90 DAT
T_1	Control	0.65	0.75	0.78	0.83
T_2	Vermicompost (Vc) +*Azospirillum*full dose	0.66	0.76	0.80	0.84
T_3	Vc+ VAM full dose	0.80	0.91	1.01	1.22
T_4	Vc+ PSB full dose	0.71	0.82	0.96	1.06
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	0.76	0.85	0.86	0.90
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	0.79	0.90	0.93	1.06
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	0.67	0.77	0.81	0.86
T_8	Vc+*Azospirillum*(1/3dose)+VAM(1/3dose)+PSB(1/3 dose)	0.85	0.94	1.09	1.30
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2dose)+PSB(1/2 dose)	0.78	0.87	0.97	1.06
T_{10}	Vc+*Azospirillum*(full dose)+VAM(full dose)+PSB(full dose)	0.80	0.90	0.95	1.08
S.Em±		**0.04**	**0.05**	**0.07**	**0.10**
C.D. (5%)		**0.13**	**0.14**	**0.20**	**0.30**

At 30 DAT, The leaf area index was significantly maximum recorded in treatment T_8 (0.85) and at par T_3(0.80),T_{10}(0.80) followed by T_6(0.79),T_9 (0.78),T_5 (0.76),T_4 (0.71), T_7 (0.67), T_2 (0.66) while the minimum leaf area index is reported in T_1(0.65).

At 45 DAT, The leaf area index was significantly maximum recorded in treatment T_8 (0.94) and at par T_3(0.91) followed by T_6(0.90),T_{10}(0.90), T_9(0.87), T_5(0.85), T_4(0.82), T_7(0.77), T_2(0.76) while the minimum leaf area index is reported in T_1(0.75).

At 60 DAT, The leaf area index was significantly maximum recorded in treatment T_8 (1.09) and at par T_3(1.01), followed by T_9(0.97), T_4 (0.96), T_{10} (0.95), T_6(0.93), T_5(0.86), T_7 (0.81), T_2 (0.80) while the minimum LAI is reported in T_1(0.78).

At 90 DAT, The leaf area index was significantly maximum recorded in treatment T_8 (1.30) and at par T_3(1.22), followed by T_{10}(1.08), T_4(1.06), T_6 (1.06), T_9(1.06),T_5 (0.90), T_7 (0.86), T_2 (0.84) while the minimum leaf area index is reported in T_1(0.83).



4.1.7 Neck thickness (cm)

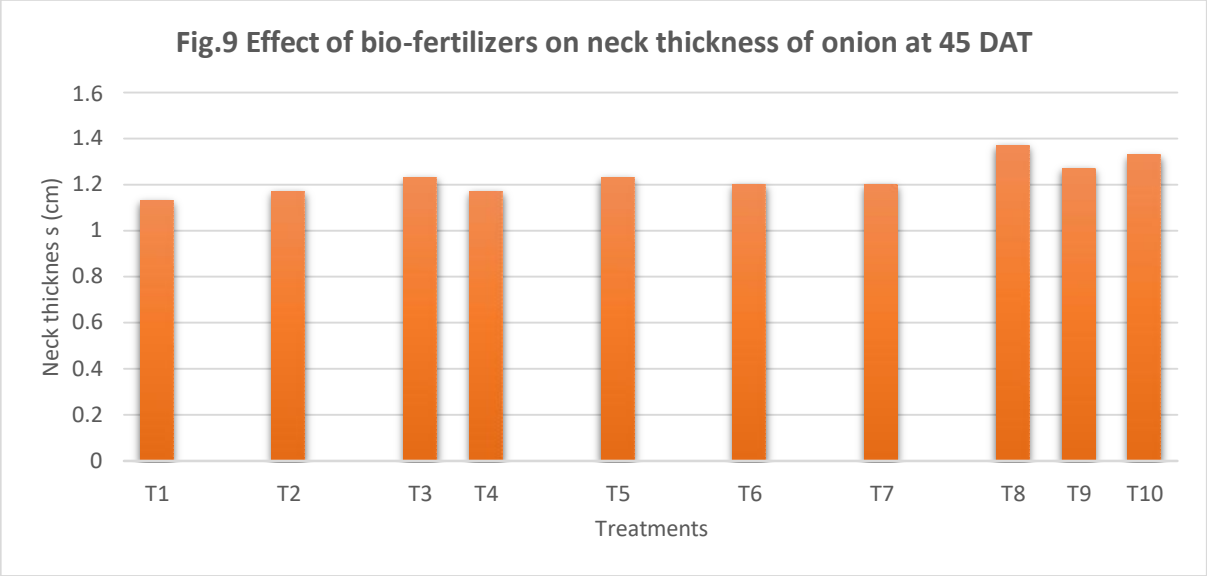
Neck thickness of was recorded at 45 days after transplanting with the help of Vernier's calipers. As shown in table 4.6, fig. 7 and appendix (VII).

Table 4.7 Neck thickness (cm) at 45 DAT

S. No	Treatment	Neck thickness (cm)
T_1	Control	1.13
T_2	Vermicompost (Vc) +*Azospirillum*full dose	1.17
T_3	Vc+ VAM full dose	1.23
T_4	Vc+ PSB full dose	1.17
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	1.23
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	1.20
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	1.20
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)	1.37
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose)	1.27
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	1.33
S.Em±		**0.04**
C.D. (5%)		**0.12**

At 45 DAT, The neck thickness was significantly maximum recorded in treatment T_8 (1.37) and at par T_{10}(1.33), followed byT_9(1.27), T_3(1.23), T_5(1.23),

T_6(1.20), T_7(1.20), T_2(1.17), T_4(1.17) while the minimum leaf area index is reported in T_1(1.17).



4.2 Yield parameter

4.2.1 Fresh weight of bulb (g)

Fresh weight of the bulb is taken from different treatments and measured in gram. As shown in table 4.7, fig. 8 and appendix (VIII). From the analysis of variance study, the fresh weight is varies due to different level of treatments.

Table 4.8 Fresh weight (g) and dry weight of bulb (g)

S. No.	Treatments	Fresh weight (g)	Dry weight(g)
T_1	Control	127.67	16.67
T_2	Vermicompost (Vc) +*Azospirillum*full dose	134.67	18.33
T_3	Vc+ VAM full dose	131.00	17.00
T_4	Vc+ PSB full dose	129.33	17.67
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	139.33	24.33
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	136.67	25.33
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	137.33	24.33
T_8	Vc+*Azospirillum*(1/3 dose)+VAM(1/3dose)+PSB(1/3 dose)	147.67	27.67
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB(1/2 dose)	144.67	26.67
T_{10}	Vc+*Azospirillum*(full dose)+VAM(full dose)+PSB(full dose)	143.00	26.00
S.Em±		**4.05**	**1.04**
C.D. (5%)		**12.03**	**3.09**

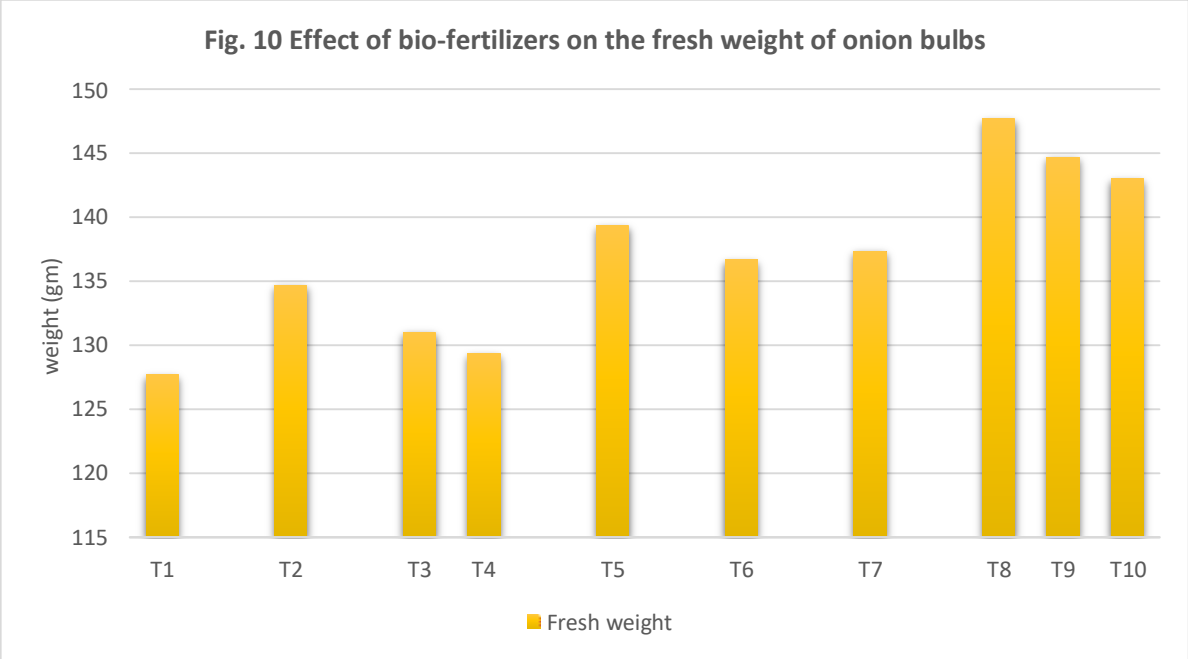
After harvesting of bulbs the fresh weight was significantly maximum recorded in treatment T_8 (147.67) and at par T_9 (144.67), followed byT_{10} (143.00), T_5

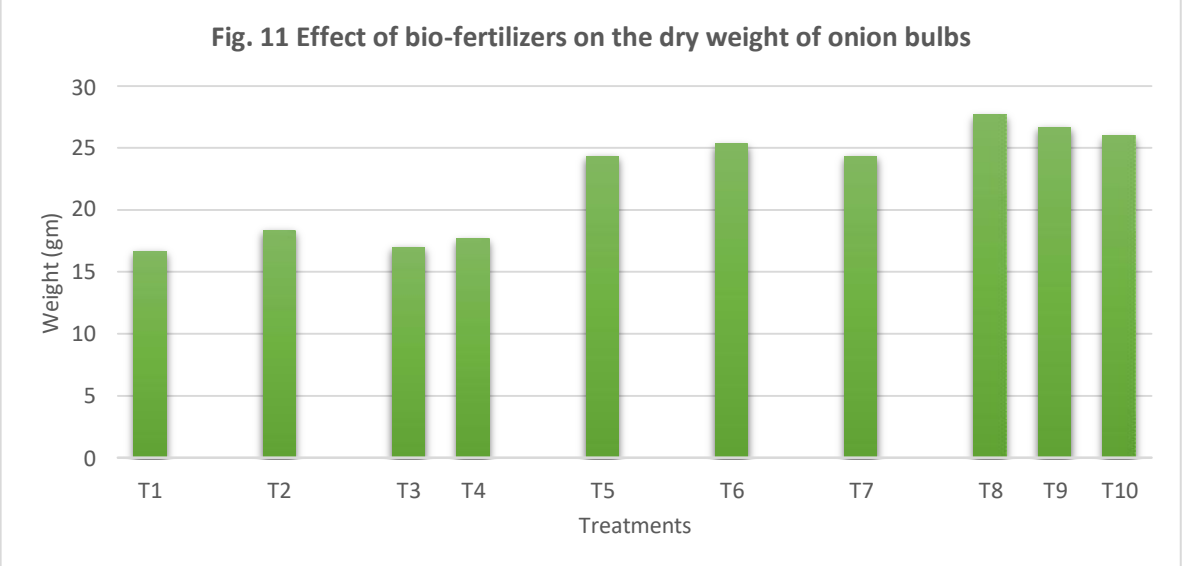
(139.33),T_7(137.33),T_6 (136.67),T_2(134.00), T_3(131.00), T_4 (129.33) while the minimum leaf area index is reported in T_1(127.67).

4.2.2 Dry weight of bulb (g)

Dry weight of the bulb is taken from different treatments and measured in gram. As shown in table 4.7, fig.9 and appendix (IX). From the analysis of variance study, the dry weight is varies due to different level of treatments.

After harvesting of bulbs the fresh weight was significantly maximum recorded in treatment T_8 (27.67) and at par T_9 (26.67), followed byT_{10} (26.00), T_6 (25.33),T_5 (24.33),T_7 (24.33),T_2 (18.33), T_4 (17.67), T_3 (17.00) while the minimum leaf area index is reported in T_1(16.67).





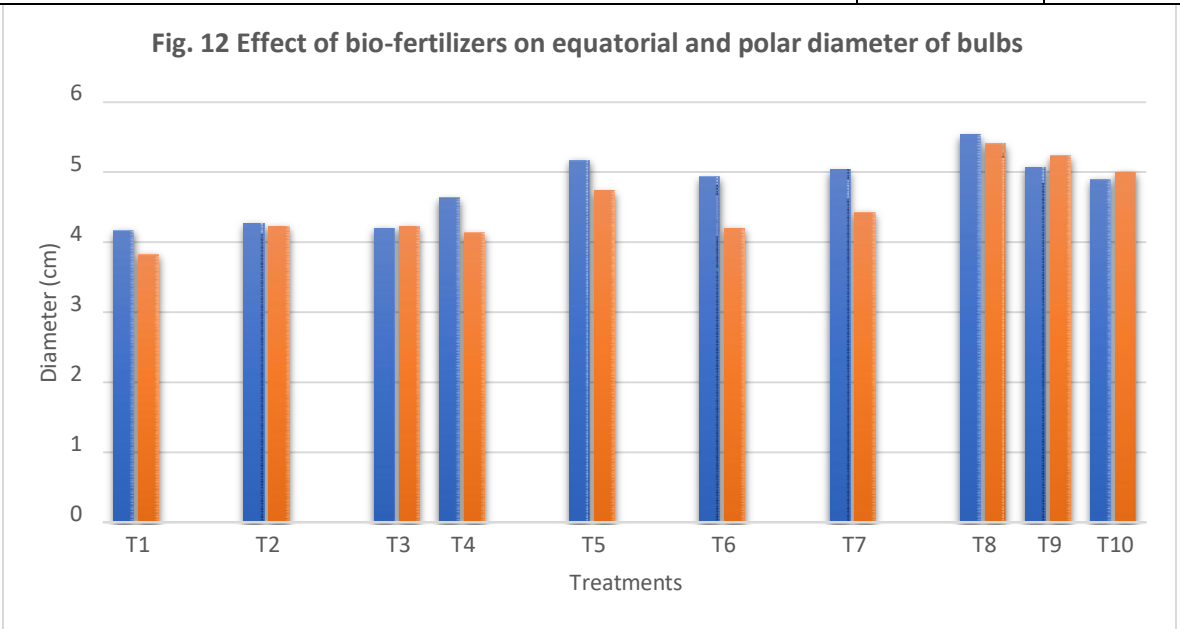
4.2.3 Equatorial diameter (cm)

The equatorial diameter of bulbs was recorded from different treatments. As shown in table 4.7, fig. 10 and appendix (X) from the analysis study, the equatorial diameter varies due to different level of treatments.

After harvesting the bulbs, The equatorial diameter of bulbs was significantly maximum recorded in treatment T_8 (5.53) and at par T_5 (5.17), followed byT_9 (5.07), T_7 (5.03),T_6 (4.93),T_{10} (4.90),T_4 (4.63), T_2 (4.27), T_3 (4.20) while the minimum leaf area index is reported in T_1(4.17).

Table 4.9 Equatorial diameter (cm) and polar diameter (cm)

S. No.	Treatments	Equatorial Diameter	Polar diameter
T_1	Control	4.17	3.83
T_2	Vermicompost (Vc) +*Azospirillum*full dose	4.27	4.23
T_3	Vc+ VAM full dose	4.20	4.23
T_4	Vc+ PSB full dose	4.63	4.13
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	5.17	4.73
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	4.93	4.20
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	5.03	4.43
T_8	Vc+*Azospirillum*(1/3dose)+VAM(1/3dose)+PSB(1/3dose)	5.53	5.40
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2dose)+PSB(1/2 dose)	5.07	5.23
T_{10}	Vc+*Azospirillum*(full dose)+VAM(full dose)+PSB(full dose)	4.90	5.00
S.Em±		**0.21**	**0.22**
C.D. (5%)		**0.62**	**0.64**



4.2.4 Polar diameter (cm)

The polar diameter of bulbs was recorded from different treatments. As shown in table 4.7, fig. 10 and appendix (XI) from the analysis study, the polar diameter varies due to different level of treatments.

After harvesting the bulbs, The neck equatorial diameter of bulbs was significantly maximum recorded in treatment T_8 (5.40) and at par T_9 (5.23), followed byT_{10} (5.00), T_5 (4.73),T_7 (4.43),T_6 (4.20),T_3 (4.23), T_2 (4.23), T_4 (4.13) while the minimum leaf area index is reported in T_1(4.17).

4.2.5 Number of bolting per plot

Number of bolted plants per plot were counted before harvesting. As shown in table 4.8, fig. 11 and appendix (XII). From the analysis study, the number of bolted plant is varies in different plots.

Before harvesting of bulbs the bolted plants were counted, the bolted plants recorded minimum in treatment T_8 (0.67) and at par T_2(1.00), T_4(1.00), T_6 (1.00),T_7(1.00),T_9(1.00) followed byT_{10}(1.67), while the maximum bolted plants recorded in T_3(2.00), T_5(2.00) and T_1(2.00).

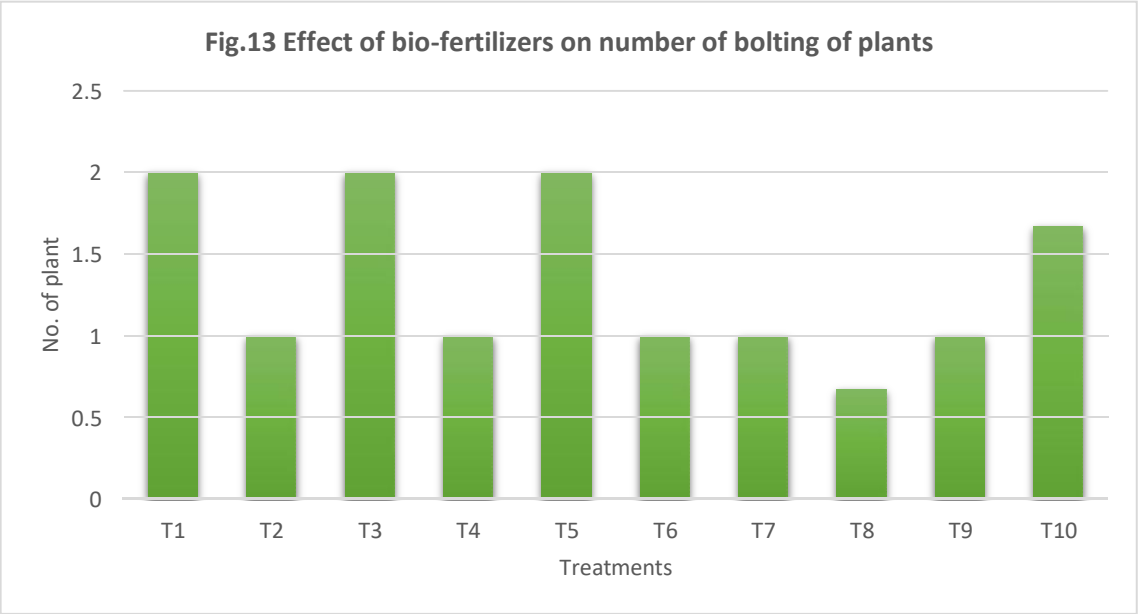
4.10 Number of bolting, Bolting percent (%)and number of scales

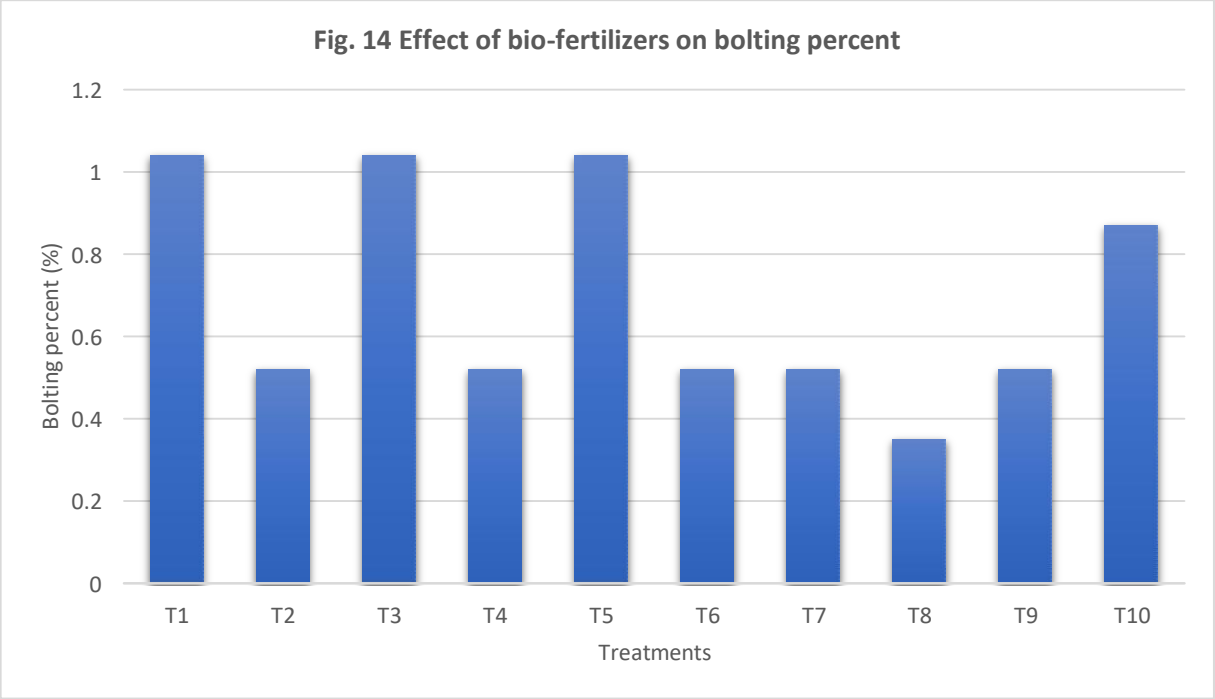
S. No..	Treatments	Number of bolting	Bolting %	No. of scales
T_1	Control	2.00	1.04	8.67
T_2	Vermicompost(Vc)+*Azospirillum*full dose	1.00	0.52	11.00
T_3	Vc+ VAM full dose	2.00	1.04	11.33
T_4	Vc+ PSB full dose	1.00	0.52	10.00
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	2.00	1.04	9.00
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	1.00	0.52	9.00
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	1.00	0.52	11.33
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)	0.67	0.35	12.67
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose)	1.00	0.52	10.33
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	1.67	0.87	12.00
S.Em±		**0.14**	**0.07**	**0.78**
C.D. (5%)		**0.42**	**0.22**	**2.30**

4.2.6 Bolting percentage (%)

Percentage of bolted plants per plot were calculated by number of bolted plants. As shown in table 4.8, fig. 12 and appendix (XIII). From the analysis study, the percentage of bolted plant is varies in different plots.

Before harvesting of bulbs the percentage of bolted plants were counted, the bolted plant percentage recorded minimum in treatment T_8 (0.35) and at par T_2 (0.52), T_4 (0.52), T_6 (0.52),T_7 (0.52),T_9 (0.52) followed byT_{10} (0.87), while the maximum bolted plants percentage recorded in T_3 (1.04), T_5 (1.04) and T_1(1.04).

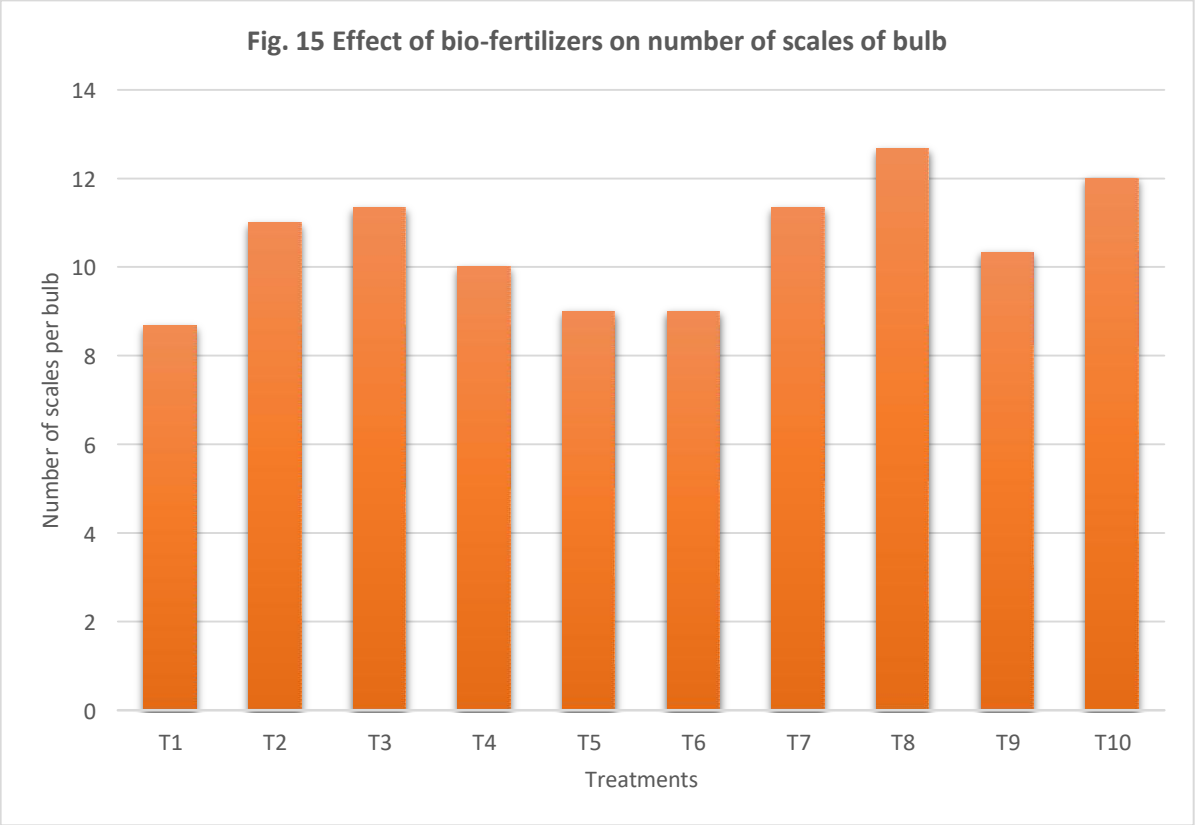




4.2.7 Number of scales per bulb

After harvesting of bulbs, number of scales were counted after chopped into halves. As shown in table 4.8, fig. 14 and appendix (XIV). From the analysis study, the number of scales is varies in different bulbs.

After harvesting of bulbs the number of scales of bulb were counted, the number of scales recorded maximum in treatment T_8 (12.67) and at par T_{10}(12.00), followed byT_7(11.33), T_3(11.33), T_2(11.00), T_9(10.33), T_4(10.00), T_6(9.00), T_5(9.00) while the minimum number of scales recorded in T_1(8.67).



4.2.8 bulb yield (kg/plot)

After harvesting the yield of bulbs of various treatments is measured in kilograms per plot.as shown in table 4.9, fig.15 and appendix (XV). From the analysis study, the yield of bulbs varies in different treatments.

After harvesting, the yield of bulbs were measured in kilograms, the yield of bulbs recorded maximum in treatment T_8 (11.40) and at par T_9 (11.37), followed by T_7 (10.77), T_{10} (10.57),T_6(10.40),T_5 (10.37),T_3 (9.87),T_4 (9.83), T_2(9.77) while the minimum bulb yield recorded in T_1(9.67).

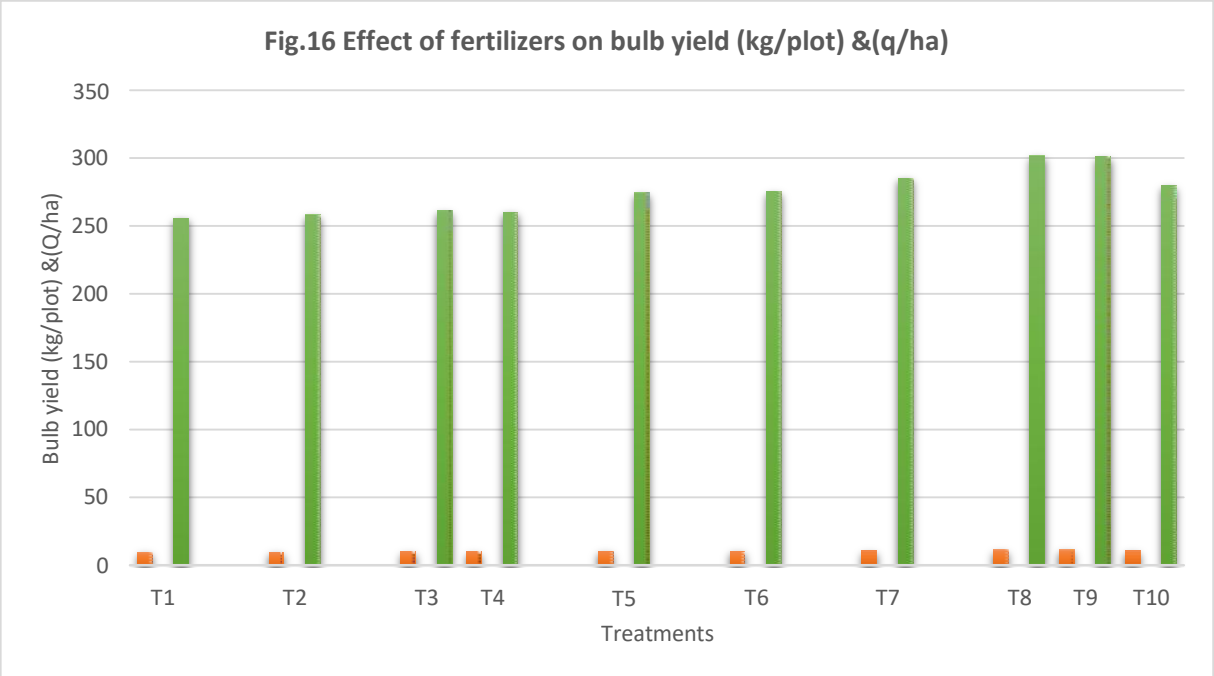
4.2.9 bulb yield (q/ha.)

After harvesting the yield of bulbs of various treatments is measured in kilogram per plot than converted into quintal per hectare. as shown in table 4.9, fig.16 and appendix (XVI). From the analysis study, the yield of bulbs varies in different treatments.

After harvesting, the yield of bulbs converted into quintal per hectare, the yield of bulbs recorded maximum in treatment T_8 (301.58) and at par T_9 (300.70), followed by T_7 (284.83), T_{10} (279.54),T_6 (275.13),T_5 (274.24),T_3 (261.02),T_4 (260.14), T_2 (258.37) while the minimum bulb yield recorded in T_1(255.73).

4.11 Bulb yield (kg/plot) and Bulb yield (q/ha)

S. No	Treatments	Bulb yield	
		Kg/plot	q/ha
T_1	Control	9.67	255.73
T_2	Vermicompost (Vc) +*Azospirillum*full dose	9.77	258.37
T_3	Vc+ VAM full dose	9.87	261.02
T_4	Vc+ PSB full dose	9.83	260.14
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	10.37	274.24
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	10.40	275.13
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	10.77	284.83
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)	11.40	301.58
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose	11.37	300.70
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	10.57	279.54
S.Em±		**0.31**	**8.27**
C.D. (5%)		**0.93**	**24.55**



4.2.9 Marketable yield (kg/plot)

After harvesting the yield of bulbs graded than measured in kilograms per plot. as shown in table 4.10, fig.16 and appendix (XVII). From the analysis study, the marketable yield of bulbs varies in different treatments.

After harvesting, the yield of bulbs were measured in kilograms, the yield of bulbs recorded maximum in treatment T_8 (10.62) and at par T_9 (10.38), followed by T_{10} (9.70), T_7 (9.53),T_5 (9.20),T_6(9.14),T_3(8.72),T_4(8.72), T_2 (8.13) while the minimum bulb yield recorded in T_1(9.67).

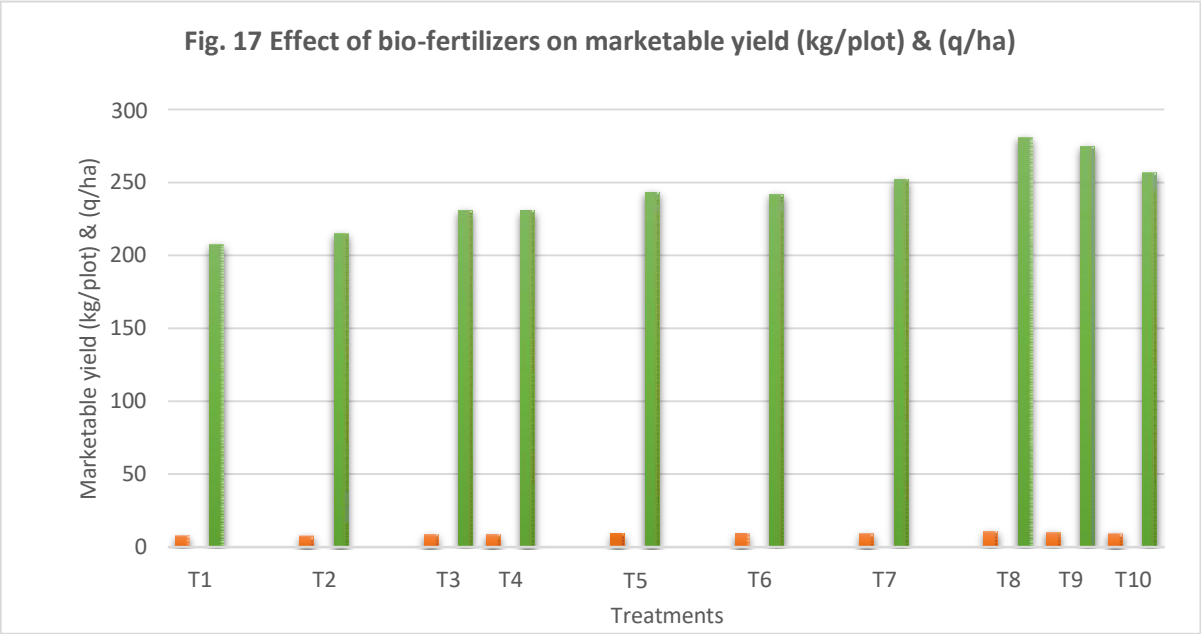
4.2.10 Marketable yield (q/ha.)

After harvesting the yield of bulbs of various treatments is graded and measured in kilogram per plot than converted into quintal per hectare. as shown in table 4.10, fig.17 and appendix (XVIII). From the analysis study, the yield of bulbs varies in different treatments.

After harvesting, the yield of bulbs converted into quintal per hectare, the yield of bulbs recorded maximum in treatment T_8 (280.86) and at par T_9 (274.68), followed by T_{10} (256.61), T_7 (252.20),T_5 (243.38),T_6 (241.79),T_3 (230.81), T_4 (230.81), T_2 (215.16) while the minimum marketable bulb yield recorded in T_1(207.67).

4.12 Marketable yield (kg/plot) and Marketable yield (q/ha)

S. No	Treatments	Marketable yield	
		Kg/plot	q/ha
T_1	Control	7.85	207.67
T_2	Vermicompost (Vc) +*Azospirillum*full dose	8.13	215.16
T_3	Vc+ VAM full dose	8.72	230.81
T_4	Vc+ PSB full dose	8.72	230.59
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	9.20	243.38
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	9.14	241.79
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	9.53	252.20
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)	10.62	280.86
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose)	10.38	274.68
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	9.70	256.61
S.Em±		**0.29**	**7.56**
C.D. (5%)		**0.85**	**22.46**



4.3 Quality parameter

4.3.1 Total Soluble Solid (TSS)

After harvesting the bulbs from different treatments Total Soluble Solid of bulbs were recorded, as shown in table 4.10, fig. 16 and appendix (XIX). From the analysis study, the TSS varies in bulbs of different treatments.

The TSS of bulbs recorded maximum in treatment T_8 (13.00) and at par T_{10} (12.67), followed by T_5(12.33), T_7 (12.33), T_9(12.33), T_3(12.00), T_6(12.00), T_2(11.33), T_4(11.33) while the minimum TSS recorded in T_1(11.00).

Table 4.13 Total Soluble Solid (TSS)

S. No	Treatment	TSS (^{0} brix)
T_1	Control	11.00
T_2	Vermicompost (Vc) +*Azospirillum*full dose	11.33
T_3	Vc+ VAM full dse	12.00
T_4	Vc+ PSB full dose	12.33
T_5	Vc+*Azospirillum* full dose + VAM (1/2 dose)	11.33
T_6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)	12.00
T_7	Vc + VAM full dose+*Azospirillum* (1/2 dose)	12.33
T_8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose)	13.00
T_9	Vc+*Azospirillum*(1/2dose)+VAM(1/2dose)+PSB (1/2 dose)	12.33
T_{10}	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose)	12.67
S.Em±		**0.42**
C.D. (5%)		**1.26**

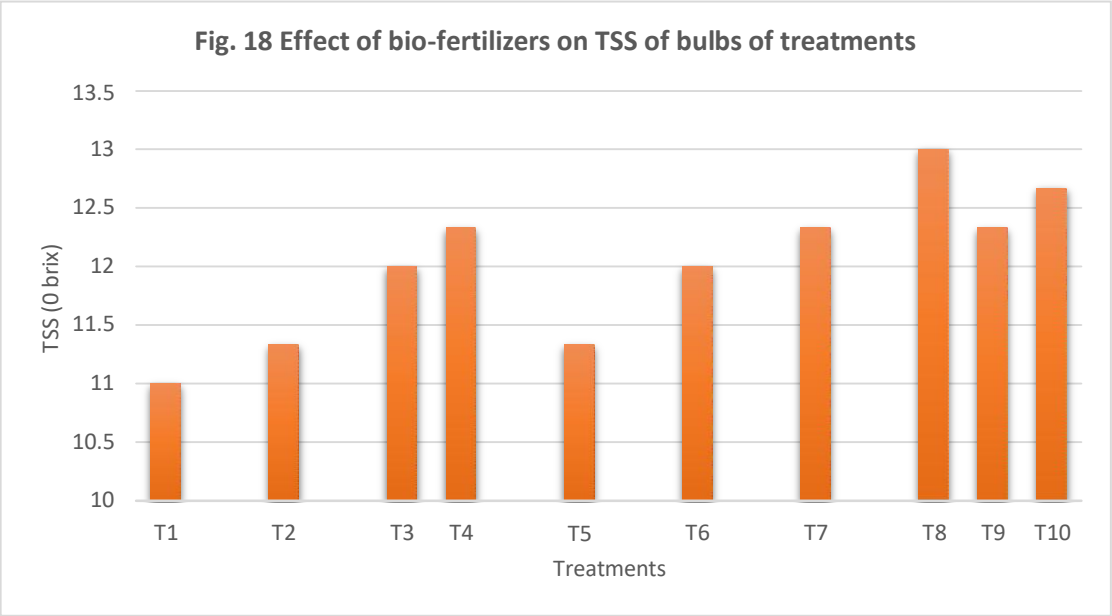
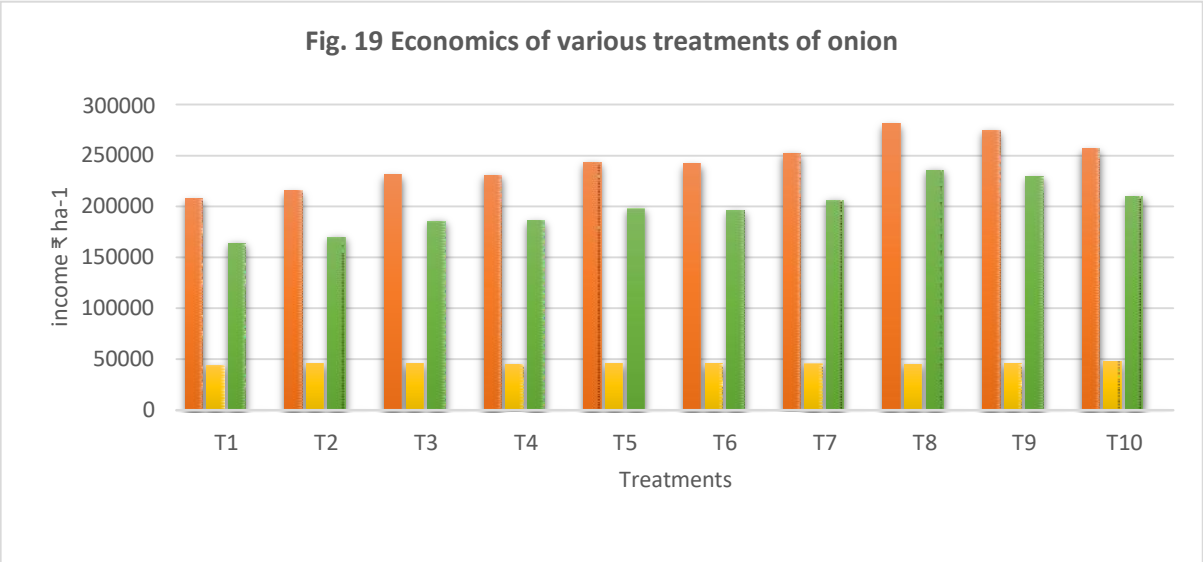


Table 4.14 Economics of various treatments of onion (Sale rate of onion bulb ₹10/kg)

S. No.	Gross income ₹ ha^{-1}	Expenditure ₹ ha^{-1}	Net income ₹ ha^{-1}	B:C Ratio
T_1	207670	44140	163530	4.70
T_2	215160	45390	169770	4.74
T_3	230810	45390	185420	5.08
T_4	230550	44740	185810	5.15
T_5	243380	45390	197990	5.36
T_6	241790	45690	196100	5.29
T_7	252200	46015	206185	5.48
T_8	280860	45172	235688	6.21
T_9	274680	45690	228990	6.07
T_{10}	256610	47240	209370	5.43



It is evident from the data obtained that a significantly maximum yield of bulb was recorded in T_8Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) along with net returns of 2,35,688 ₹/ha and benefit cost ratio of 6.21 followed by T_9 Vc +*Azospirillum*(1/2dose) + *VAM* (1/2 dose)+ PSB (1/2 dose) with net returns of 2,28,990 ₹/ha and benefit cost ratio of 6.07. while lowest net return of 1,63,530 ₹/ha and benefit cost ratio of 4.70 reported in T_1(control).

Plate-1 Layout preparation of onion field

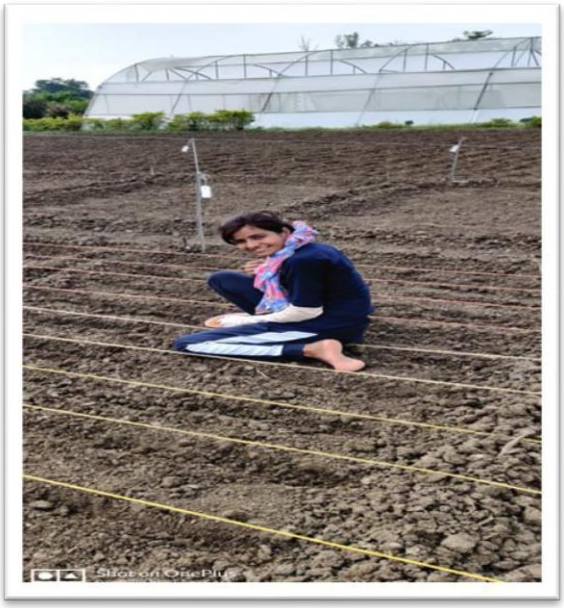


Plate-2 Transplanting in the field

Plate-3 Onion crop at 30 DAT

Plate-4 Grading of harvested bulbs

Plate-5 Measuring equatorial and polar diameter of bulbs

Plate-6 Counting of number of scales per bulb

CHAPTER V

DISCUSSION

In this chapter the detailed discussion is available on present investigation entitled **"Effect of bio-fertilizers on growth, yield and yield attributing characters in onion (*Allium cepa* L.)var. AFLR."** Was carried out at the Horticulture Research Farm, R.A.K. College of Agriculture, Sehore (M.P.) during *Rabi* season, 2019-20. The result obtained from present investigation is given in previous chapter and discussion available in present chapter in the light of research work done in India and anroad on similar aspects by other research workers and available review literature made earlier.

5.1 Effect of bio- fertilizers on growth parameters

Various parameters of onion such as plant height, no. of leaves per plant, leaf length, leaf width, leaf area, Leaf Area Index, neck thickness was studied at different growth stage of onion plant. The data presented on these parameters showed significant variation.

Among various treatments of onion, it was observed that the plant height was significantly increased in various growth stage(30, 45, 60 and 90 DAT).Plant height of treatment T_8(Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose)was found significantly superior at 30 DAT(29.27cm), 45 DAT(38.37cm), 60 DAT(45.63cm) and 90 DAT(66.80cm) as compared to others. Whereas, Treatment T_1(control) plant height observed lowest at 30DAT(25.13cm), 45DAT(34.40cm), 60 DAT(41.83cm) and 90 DAT(62.00cm).Probable increase in plant height may be due to increased soil nutrient uptake and effective translocation to various plant parts by the effect of biofertilizers.The result of this investigation concerning maximum plant height are consistent with the findings previously reported in onion by Dharmendra *et al.* (2001), Alkaff*et al*. (2002),Jayanthilake*et al.* (2002), Singh *et al.* (2002), Ruban (2007), Rather *et al.* (2003), Sankar *et al*. (2009b), Wange (1998), Bhonde (1997),Dibut*et al* (1993),Desale (1980).

Regarding the number of leaves per plant in various growth stages (30, 45, 60 and 90 DAT) Treatment T_8(Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose)was found significantly superior due to heavy vegetative

growth as compared to T_9T_{10} and T_7. However, lowest number of leaves per plant found were noticed in T_1(control) These findings are also consonance by Sankar,et al. (2009b), Desale (1980), Gupta *et al.* (1998), Dibut*et al* (1993).

At 30, 45, 60 and 90 DAT the length and the width of the leaves was found significantly highest in Treatment T_8(Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose). whereas, it was reported minimum in Treatment T_1(control). Probable reason for the increment in length and width of leaf is due to highly growth of overall plant. These results are in conformity with the findings of Gupta *et al.* (1998).

In the present study, the leaf area and leaf area index at 45DAT was found significantly maximum in Treatment T_8(Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) because of higher vegetative growthas compared to other treatments, and it was found minimum in T_1(control). The evaluation of yield variability in terms of growth and development is very complex since it includes the influence of external factors on all plant physiological processes. Leaf area increase photosynthesis ability of plant.

Neck thickness of bulbs differsignificantly, the highest neck thickness was observed in T_8(Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) whereas it was lowest in T_1(control). This may be due to the cell division and cell enlargement, which increase thickness of the neck of onion bulb. the similar result was supported by Alam*et al.*(2010).

5.2 Effect of bio- fertilizer on yield parameter

Various yield parameter of onion such as fresh and dry weight of onion, equatorial and polar diameter of bulb, number of bolting per plot, bolting percentage, no. of scales per bulb, bulb yield and marketable yield was recorded after harvesting of bulbs. The data presented on these parameters showed significant variation.

Fresh weight of bulb per plot due to different treatments was noticed, the superior weight of bulb per plot was found in T_8(Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose)and poorer is in treatment T_1(control). These finding related to result Sankar*et al*. (2009b), Musmade*et al.* (1980), Nagaraju*et al.* (2000)Singh *et al.* (2015), Sharma *et al.* (2003), Bhonde*et al.* (1997).

Dry weight of bulb per plot due to different treatments was noticed, the superior weight of bulb per plot was found in T_8(Vc +*Azospirillum*(1/3 dose) +

VAM (1/3dose) + PSB (1/3 dose)and poorer is in treatment T_1(control). These finding related to result of Singh, *et* al. (2008), Desale (1980), Rather *et al.* (2003), Martinez *et al*. (1994), Dibut*et al* (1993).

The data on the equatorial and polar diameter of bulb significantly influenced by the various levels of treatment. The treatment T_8(Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose)were found significantly superior which were at par with each other. However, the minimum equatorial and polar diameter was noticed in the treatment T_1(control). It may be due to rapid cell division and enlagement which leads to large size of bulb. Similar results were reported byAlkaff*et al*. (2002),Dilpreet*et al.* (2016), Mengistu and Singh (1999),Nagaraju*et al.* (2000),Sharma *et al.* (2003),Singh *et al.* (2015), Bhonde*eaal*.(1997), Dibut*et al* (1993), Desale (1980).

Number of bolting plant per plot and bolting percentage (%) differ significantly due to different treatments. The Minimum number of bolting plant per plot was found in T_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) and maximum bolted plants was recoded in T_1(control). Reason for the minimum number of bolting may be due to positive effect of temperature on the onion crop. Similar results were reported by Singh *et al.* (2008) and Sankar et al.(2009b) in onion

Number of scales per bulb varies significantly due to different treatments. The maximum number of scales per bulb was reported in T_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) while the minimum number of scales per bulb found in treatment T_1 (control). Similar result was reported by Ruban (2007).

Significantly maximum bulb yield per plot and per hectare yield q/ha was recorded in treatment T_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) which were at par with each other. While the minimum bulb yield per plot and per hectare was recorded in treatment T_1(control) higher yield may be due to increase in vegetative growth, accumulation of higher dry matter and enhanced the synthesis and translocation of photosynthates to the bulb. Judicious application of bio-fertilizers results in higher yield of onion bulb. The result of this investigation concerning maximum bulb yield per plot and per hectare is consistent with the findings previously reported by Yadav, *et al*.

(2002),Alkaff*et al*. (2002),Sankar *et al.* (2009b), Musmade*et al.* (1980), Singh, Iet*al.*(2008), Singh *et al.* (2015), Warade*et al*. (1996), Joi and Shende (1976).

5.3 Effect of bio-fertilizers on Quality parameter

Significantly higher Total Soluble Solid (TSS) was observed in the treatment T_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose)which were at par with each other. Whereas the lowest Total Soluble Solid reported in treatment T_1 (control). The increase in TSS of bulbs may be influenced by increased carbohydrates production during photosynthesis and the better translocation of photosynthates, also due to some improved physiological and biochemical activities in plant under the influence of bio-fertilizers. These results are consistent with the findings previously reported byMondal *et al*. (2004),Kamble (2006), Hari *et al.* (2009),Singh *et al.* (2015),Dilpreet*et al.* (2016), Kumar *et al.* (2017), Mengistu and Singh (1999), Gupta *et al*. (1999).

5.4 Effect of bio-fertilizers on economics of onion

It is revealed from the data obtained that that in T_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) significantly maximum gross income of 2,80,860 ₹/ha, net income of 2,32,688 ₹/ha and benefit cost ratio of 6.21 followed by T_9 and T_7. While lowest gross income of 2,07,670 ₹/ha, net income of 1,63,530 ₹/ha and benefit cost ratio of 4.70 reported in T_1 (control).

This may be due to the reason of the suitable growth habit of onion crop due to positive response of various biofertilizer treatments which influence the onion yield at high extent. These findings related to gross income, net income and benefit cost ratio are in agreement with the finding Mandloi*et al.* (2008), Kore *et al.* (2006), Nagaich and Singh (2004), Yadav *et al.* (2005).

CHAPTER- IV

SUMMARY, CONCLUSION AND SUGGESTION

6.1 Summary

The present investigation entitled **"Effect of bio-fertilizers on growth, yield and yield attributing characters in onion (*Allium cepa* L.)var. AFLR."** Was carried out at the Horticulture Research Farm, R.A.K. College of Agriculture, Sehore (M.P.) during *Rabi* season, 2019-20. The experiment was laid out in randomized block design with 3 replications. In this experiment, 9 treatment were observed for growth, yield, quality and economics of onion (*Allium cepa* L.). on the basis of results, the present investigation is summarized as follow:

Treatment T_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose), influenced majority of the growth characters like Plant height, number of leaves, length and width of leaves, leaf area (cm^2), Leaf Area Index, Neck thickness(1.37cm), and minimum in T_1 (control). The effects were significant. The increase in these parameters ultimately contributed towards the enhanced bulb yield.

Positive correlation inT_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose), has also been observed yield characters fresh weight(147.67 g) and dry weight(27.67g) of bulb, equatorial(5.53cm) and polar(5.40cm) diameter of bulb, number of scales per bulb(12.67), bulb yield per plot(11.40 kg) and minimum in T_1 (control).

Statistical analysis revealed non-significant differences between the treatments for the plant height of onion at 90 DAT.

Gross income significantly maximum yield of bulb was recorded in T_8Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) along with gross income of 2,80,860 ₹/ha , net returns of 2,35,688 ₹/ha and benefit cost ratio of 6.21 followed by T_9 Vc +*Azospirillum*(1/2dose) + *VAM* (1/2 dose)+ PSB (1/2 dose) with net returns of 2,28,990 ₹/ha and benefit cost ratio of 6.07. while lowest gross income of 2,07,670 ₹/ha net return of 1,63,530 ₹/ha and benefit cost ratio of 4.70 reported in T_1 (control).

6.2 Conclusion

On the basis of present investigation, it is concluded that among ten treatments for onion production, T_8 (Vc +*Azospirillum*(1/3 dose) + *VAM* (1/3dose) + PSB (1/3 dose) responded very well in terms of growth, yield and economics. The treatment resulted maximum fresh weight of bulb (147.67gm), dry weight of bulb(27.67gm), polar diameter(5.40), equatorial diameter(5.53), number of scales per bulb, bulb yield, TSS, Net return and B:C ratio. The second and third were T_{10}Vc + *Azospirillum*(full dose) + *VAM* (full dose) + PSB (full dose) and T_9 Vc +*Azospirillum*(1/2dose) + *VAM* (1/2 dose)+ PSB (1/2 dose).So these treatments can be recommended for commercial cultivation in sehore condition.

6.3 Suggestions for future studies

In the light of the experience gained during the investigation, sampling and the result obtained, it was felt that in future studies the following points should be considered:

1. These findings are based on one year data hence the experiment should be repeated for 2-3 years for obtaining absolute conclusion.
2. These treatments may be tested at different dates and season of sowing to determine the appropriate time and season of sowing in the agro-climatic conditions of the region.
3. Quantity of bio-fertilizers may also be change to assess the effect of different quantity on location during further trials

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APPENDIX

Appendix – I. Analysis of variance of data in respect of Plant Height (cm) at 30 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F k	F tab
REP	2	13.008667	6.5043333	2.2614446	3.37
TREAT	9	56.034667	6.2260741	2.1646986	**2.125**
ERROR	18	51.771333	2.8761852		
TOTAL	29				

Appendix – II. Analysis of variance of data in respect of Plant Height (cm) at 45 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.366	0.183	0.0907421	3.37
TREAT	9	39.941333	4.4379259	2.200584	**2.125**
ERROR	18	36.300667	2.0167037		
TOTAL	29				

Appendix – III. Analysis of variance of data in respect of Plant Height (cm) at 60 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	11.818667	5.9093333	2.4782082	3.37
TREAT	9	47.829667	5.3144074	2.228713	**2.125**
ERROR	18	42.921333	2.3845185		
TOTAL	29				

Appendix – IV. Analysis of variance of data in respect of Plant Height (cm) at 90 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	1.158	0.579	0.0842236	3.37
TREAT	9	139.428	15.492	2.2535275	**2.125**
ERROR	18	123.742	6.8745556		
TOTAL	29				

Appendix – V. Analysis of variance of data in respect of number of leaves at 30 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.266667	0.133333	0.545455	3.37
TREAT	9	4.7	0.522222	2.136364	**2.125**
ERROR	18	4.4	0.244444		
TOTAL	29				

Appendix – VI. Analysis of variance of data in respect of number of leaves at 45 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.866667	0.433333	1.206186	3.37
TREAT	9	9.333333	1.037037	2.886598	**2.125**
ERROR	18	6.466667	0.359259		
TOTAL	29				

Appendix – VII. Analysis of variance of data in respect of number of leaves at 60 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.866667	0.433333	0.92126	3.37
TREAT	9	12.53333	1.392593	2.96063	**2.125**
ERROR	18	8.466667	0.47037		
TOTAL	29				

Appendix – VIII. Analysis of variance of data in respect of number of leaves at 90 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	1.666667	0.833333	1.363636	3.37
TREAT	9	26	2.888889	4.727273	**2.125**
ERROR	18	11	0.611111		
TOTAL	29				

Appendix – IX. Analysis of variance of data in respect of Length of leaf at 30DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	7.094	3.547	2.3990831	3.37
TREAT	9	28.348333	3.1498148	2.1304391	**2.125**
ERROR	18	26.612667	1.4784815		
TOTAL	29				

Appendix – X. Analysis of variance of data in respect of length of leaf at 45DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	21.326	10.663	5.4973363	3.37
TREAT	9	37.755	4.195	2.1627427	**2.125**
ERROR	18	34.914	1.9396667		
TOTAL	29				

Appendix – XI. Analysis of variance of data in respect of length of leaf at 60 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	3.272	1.636	0.4840661	3.37
TREAT	9	86.493333	9.6103704	2.8435541	**2.125**
ERROR	18	60.834667	3.3797037		
TOTAL	29				

Appendix – XII. Analysis of variance of data in respect of length of leaf at 90 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	5.9486667	2.9743333	0.7781158	3.37
TREAT	9	73.420333	8.1578148	2.1341673	**2.125**
ERROR	18	68.804667	3.8224815		
TOTAL	29				

Appendix – XIII. Analysis of variance of data in respect of width of leaf at 30 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.038	0.019	5.516129	3.37
TREAT	9	0.352	0.039111	11.35484	**2.125**
ERROR	18	0.062	0.003444		
TOTAL	29				

Appendix – XIV. Analysis of variance of data in respect of width of leaf at 45 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.002667	0.001333	0.104046	3.37
TREAT	9	0.988333	0.109815	8.569364	**2.125**
ERROR	18	0.230667	0.012815		
TOTAL	29				

Appendix – XV. Analysis of variance of data in respect of width of leaf at 60 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.024	0.012	1.065789	3.37
TREAT	9	1.188333	0.132037	11.72697	**2.125**
ERROR	18	0.202667	0.011259		
TOTAL	29				

Appendix – XVI. Analysis of variance of data in respect of width of leaf at 90 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.012667	0.006333	0.810427	3.37
TREAT	9	2.476333	0.275148	35.20853	**2.125**
ERROR	18	0.140667	0.007815		
TOTAL	29				

Appendix – XVII. Analysis of variance of data in respect of leaf area (cm^2) at 30 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	6263.567	3131.783	7.204164	3.37
TREAT	9	11115.47	1235.052	2.841038	**2.125**
ERROR	18	7824.933	434.7185		
TOTAL	29				

Appendix – XVIII. Analysis of variance of data in respect of leaf area (cm^2) at 45 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	11766.34	5883.171	40.41372	3.37
TREAT	9	11759.67	1306.631	8.975738	**2.125**
ERROR	18	2620.325	145.5736		
TOTAL	29				

Appendix – XIX. Analysis of variance of data in respect of leaf area (cm^2) at 60 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	4224.15	2112.075	4.11799	3.37
TREAT	9	11505.51	1278.39	2.492523	**2.125**
ERROR	18	9232.017	512.8898		
TOTAL	29				

Appendix – XX. Analysis of variance of data in respect of leaf area (cm^2) at 90 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	6953.913	3476.956	5.514443	3.37
TREAT	9	12128.49	1347.611	2.137306	**2.125**
ERROR	18	11349.33	630.5182		
TOTAL	29				

Appendix – XXI. Analysis of variance of data in respect of Leaf Area Index (LAI) at 30 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.01014	0.00507	0.834746	3.37
TREAT	9	0.133763	0.014863	2.447039	**2.125**
ERROR	18	0.109327	0.006074		
TOTAL	29				

Appendix – XXII. Analysis of variance of data in respect of Leaf Area Index (LAI) at 45 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.004047	0.002023	0.325508	3.37
TREAT	9	0.124053	0.013784	2.217482	**2.125**
ERROR	18	0.111887	0.006216		
TOTAL	29				

Appendix – XXIII. Analysis of variance of data in respect ofLeaf Area Index (LAI) at 60 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.039387	0.019693	1.435452	3.37
TREAT	9	0.271213	0.030135	2.196534	**2.125**
ERROR	18	0.246947	0.013719		
TOTAL	29				

Appendix – XXIV. Analysis of variance of data in respect of Leaf Area Index (LAI) at 90 DAT

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.17096	0.08548	2.818848	3.37
TREAT	9	0.71067	0.078963	2.60395	**2.125**
ERROR	18	0.54584	0.030324		
TOTAL	29				

Appendix – XXV. Analysis of variance of neck thickness of bulb (cm)

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.008	0.004	0.84375	3.37
TREAT	9	0.149667	0.01663	3.507813	**2.125**
ERROR	18	0.085333	0.004741		
TOTAL	29				

Appendix – XXVI. Analysis of variance of data in respect Fresh weight (g) of bulb per plot

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	52.46667	26.23333	0.53364	3.37
TREAT	9	1204.133	133.7926	2.721615	**2.125**
ERROR	18	884.8667	49.15926		
TOTAL	29				

Appendix –XXVII. Analysis of variance of data in respect of Dry weight (g) of bulb per plot

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	15	7.5	2.314286	3.37
TREAT	9	527.8667	58.65185	18.09829	**2.125**
ERROR	18	58.33333	3.240741		
TOTAL	29				

Appendix –XXVIII. Analysis of variance of data in respect of Equatorial diameter of bulb

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.104	0.052	0.398411	3.37
TREAT	9	5.693667	0.63263	4.847049	**2.125**
ERROR	18	2.349333	0.130519		
TOTAL	29				

Appendix –XXIX. Analysis of variance of data in respect of Polar diameter of bulb

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.308667	0.154333	1.103257	3.37
TREAT	9	7.347	0.816333	5.835584	**2.125**
ERROR	18	2.518	0.139889		
TOTAL	29				

Appendix –XXX. Analysis of variance of data in respect of Number of bolting per plot

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.266667	0.133333	2.25	3.37
TREAT	9	7.333333	0.814815	13.75	**2.125**
ERROR	18	1.066667	0.059259		
TOTAL	29				

Appendix –XXXI. Analysis of variance of data in respect of bolting per cent per plot

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.072107	0.036053	2.25	3.37
TREAT	9	1.982933	0.220326	13.75	**2.125**
ERROR	18	0.288427	0.016024		
TOTAL	29				

Appendix –XXXII. Analysis of variance of data in respect of Number of scales per bulb

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	2.866667	1.433333	0.794661	3.37
TREAT	9	50.13333	5.57037	3.088296	**2.125**
ERROR	18	32.46667	1.803704		
TOTAL	29				

Appendix –XXXIII. Analysis of variance of data in respect of bulb yield (kg/plot)

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.702	0.351	1.198558	3.37
TREAT	9	10.92667	1.214074	4.145694	**2.125**
ERROR	18	5.271333	0.292852		
TOTAL	29				

Appendix –XXXIV. Analysis of variance of data in respect of bulb yield (q/ha)

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	491.3908	245.6954	1.19884	3.37
TREAT	9	7646.757	849.6397	4.145711	**2.125**
ERROR	18	3688.997	204.9443		
TOTAL	29				

Appendix –XXXV. Analysis of variance of data in respect of Marketable bulb yield (kg/plot)

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.512727	0.256363	1.046506	3.37
TREAT	9	21.5791	2.397677	9.787607	**2.125**
ERROR	18	4.409473	0.244971		
TOTAL	29				

Appendix –XXXVI. Analysis of variance of data in respect of Marketable bulb yield (q/ha)

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	358.0223	179.0112	1.043956	3.37
TREAT	9	15098.66	1677.629	9.783584	**2.125**
ERROR	18	3086.53	171.4739		
TOTAL	29				

Appendix –XXXVII. Analysis of variance of data in respect of Total Soluble Solid (TSS)

SOURCE OF VARIANCE	DF	SS	MSS	F cal	F tab
REP	2	0.266666667	0.133333333	0.246575	3.37
TREAT	9	10.96666667	1.218518519	2.253425	**2.125**
ERROR	18	9.733333333	0.540740741		
TOTAL	29				

Appendix – XXXVIII:General cost of the cultivation of onion treatment (/ ha^{1})

S. No.	Particulars	Quantity	Rate (₹ha^{-1})	Cost (₹ha^{-1})
1	Nursery preparation Cost of seed	2 labour 8kg	300 1250	600 8000
2	Land preparation a. M.B. Plough b. Planking and Leveling c. Layout of the field	 3 hours 1.5 hours 4 labour	 800/hour 800/hour 300	 2400 1200 1200
3	Manure and Fertilizer application a. Vermicompost b. Azospirillum c. PSB d. VAM	 5 tonnes ha^{-1} 2 kg ha^{-1} 2.5 kg ha^{-1} 2 kg ha^{-1}	 400 ₹ q^{-1} 1250 ₹ kg^{-1} 600 ₹ kg^{-1} 1250 ₹ kg^{-1}	 4000 2500 1500 2500
4	Transplanting	2 Labour	300	600
5	Inter cultural operation a. Gap filling b. Two hand weeding c. Plant protection measure 1. Trichoderma 2. Labour	 2 Labour 6 Labour 4 kg ha^{-1} 2	 300 300 360 ₹ kg^{-1} 300	 600 1200 600 1440 200
6	Irrigation a. Tube well charge b. Labour	 14 irrigation 14	 @ 450/irrigation 300	 6300 4200
7	Harvesting	20	300	6000
8	Grading	6	200	1200
9	Miscellaneous	-	-	1000
10	Total			47,240

Appendix – XXXIX: Cost of cultivation as per treatments on per hectare area basis for onion

S.No.	Treatments	(₹/ha)
1	Control	44,140
2	Vermicompost(Vc)+*Azospirillum*full dose(5 t/ha+2 kg/ha)	45,390
3	Vc+ VAM full dose (5 t/ha+2 kg/ha)	45,390
4	Vc+ PSB full dose (5 t/ha+2.5 kg/ha)	44,740
5	Vc+*Azospirillum* full dose+VAM (1/2 dose)(5 t/ha+2 kg/ha+1kg/ ha)	45,390
6	Vc+*Azospirillum* full dose+ PSB (1/2 dose)(5 t/ha+2 kg/ha+1.25 kg/ha)	45,690
7	Vc + VAM full dose+*Azospirillum* (1/2 dose)(5 t/ha+2 kg/ha+1 kg/ha)	46,015
8	Vc+*Azospirillum*(1/3 dose)+VAM (1/3 dose)+PSB(1/3 dose) (5 t/ha+666gm/ha+666 gm/ha+833 gm/ha)	45,172
9	Vc+*Azospirillum*(1/2dose)+VAM(1/2 dose)+PSB (1/2 dose) (5 t/ha+1 kg/ha+1 kg/ha+1.25 kg/ha)	45,690
10	Vc+*Azospirillum* (full dose)+VAM (full dose)+PSB (full dose) (5 t/ha+1 kg/ha+1 kg/ha+1.25 kg/ha)	47,240

VITA

The author of this thesis Miss. Nency Verma D/o Om Prakash Verma was born on 8thAugust 1995 at District Sehore (M.P.). She completed her High School (10th) in 2011with 7.6 C.G.P.A from and Higher Secondary School (12th) in 2013 with 63.2% marks from Jawahar Navodaya Vidhyalaya, Khiriya Devat, Distt.- Ashok Nagar (M.P.).

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