“Study on effect of bio-fertilizers on growth and yield of cauliflower”

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In

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(HORTICULTURE)

By

Bhoopendra Kumar Patel

Department of Horticulture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
College of Agriculture
Rewa (M.P.)

2017

CERTIFICATE-I

This is to certify that the thesis entitled, **"Study on effect of bio-fertilizers on growth and yield of cauliflower"** submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE in VEGETABLE SCIENCE** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. Bhoopendra Kumar Patel** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

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

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This is to certify that the thesis entitled **"Study on effect of bio-fertilizers on growth and yield of cauliflower"** submitted by **Mr. Bhoopendra Kumar Patel** to Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **VEGETABLE SCIENCE** in the **Department of Horticulture,** College of Agriculture, Rewa (M.P.) has after evaluation been approved by the Student's Advisory Committee after an oral examination of the same.

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Chairman of the Advisory Committee

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Declaration and undertaking

I, Bhoopendra Kumar Patel s/o shri Jhunni Lal Patel certify the work embodied in thesis **“Study on effect of bio-fertilizers on growth and yield of cauliflower"** is my own first hand bonafide work carried out by me under the guidance of Dr. U.S. Bose Assistant Professor/Scientist at Department of Horticulture, College of Agriculture, Rewa (M.P.).

The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

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Date

(Dr. U.S. Bose) Bhoopendra Kumar Patel
Major Advisor Signature of the student

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College of Agriculture, Rewa (M.P.) **(Bhoopendra Kumar Patel)**

Date ----------

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LIST OF ABBREVIATIONS

Words	**Abbreviations**
Centimetre	cm
Co-workers	*et al.*
Critical difference	C.D.
Degree centigrade	^{o}C
Degree of Freedom	d.f.
Days after transplanting	DAT
Figure	Fig.
Fisher's value	"F" value
Gram(s)	g
Hectare	ha
Kilogram(s)	kg
Mean sum of square	M.S.S.
Metre	m
Muriate of Potash	MOP
Nitrogen	N
Non-significant	N.S.
Number	No.
Per	/
Per cent	%
Phosphorus	P_2O_5
Potash	K
Potential of hydrogen ions	pH
Quintal	q
Rupees	Rs
Serial No.	S.No.
Significant at 5% level	*
Significant at 1% level	**
Single Super phosphate	SSP
Source of variation	S.V.
Sum of square	S.S.
Square	sq.
Standard error of means	S.Em$\pm$
Standard error of difference	S.Ed

CHAPTER-I

INTRODUCTION

Cauliflower (*Brassica oleracea* L var. *botrytis*) is an important member of Cruciferae and has probably been rightly described as an aristocrat of Cole family. The name cauliflower consists of two Latin words namely 'caulis' means cabbage and 'floris' means flower. It is grown throughout the country for its tender curds which are used as vegetable, soup and for pickling (Choudhury, 1996).The crop is reported to be a native of Southern Europe in the Mediterranean region and was introduced in India in 1822 from England (Chatterjee, 1986). It is the only vegetable crop which is next to potato (Singh, 1997).

Cauliflower has high protein and peculiar in stability of vitamin C after cooking (Singh, 1997). It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, magnesium etc. It also contains vitamin A (Singh, 1997). Hundred gram edible portion of cauliflower has high quality protein of cauliflower has high quality protein (2.6g), moisture (90.8 g), fat (0.4 g), carbohydrates (4.0 g), calcium (33.0 mg), phosphorous (57.0 mg), iron (1.5 mg), thiamine (0.04 mg). riboflavin (0.10 mg), vitamin C (56.0 mg) and energy (30 kcal) (Singh. 1998).

In India cauliflower is cultivated in an area of 433.9 thousand hectare with a production of 8573.3 thousand MT and productivity 19.8 t/ha. In MP it is grown in about 25.1 thousand hectare with a production of 703.8 thousand metric tonnes and productivity 28.1 t/ha (Anonymous, 2013-14).

Various bio-fertilizers which commonly used are *Azotobacter*, *Azospirillum*, Phosphate solubilizing bacteria, Vesicular arbuscular mycorrhiza etc. *Azotobacter* (free living) and *Azospirillum* (Associative symbiotic) are nitrogen fixing bacteria, fixes about 30 kg N/ ha (Asokan et al 2000). Apart from the ability to fix atmospheric nitrogen, these are also known for synthesis of biologically active growth promoting substances such as indole acetic acid, gibberellin and Vitamin B in culture media (Asokan et al, 2000). Phosphate solubilizing bacteria and Vesicular

arbuscular mycorrhiza are the important microbes in releasing and making available phosphorous by colonizing the root surface of growing plant root. They also improve the plant growth due to increase in nutrient uptake particularly phosphorus, zinc and other micronutrients, production of growth promoting substances and resistance to plant pathogens (Asokan et al, 2000)

A bio-fertilizer holds a vast potential for supply of major plant nutrients like nitrogen and phosphorus more economically. However, Bio- fertilizers are not a substitute of major nutrients but it supplement to the chemical fertilizer up to some extent for maximizing yield and agro eco-system as well. Keeping above facts in view, the present investigation entitled “Effect of bio-fertilizers on growth and yield of cauliflower” will be carried out with the following objectives:

1. To study the effect of seed treatment on germination
2. To study the effect of bio-fertilizers on growth and yield of cauliflower
3. To study the combined effect of organic, inorganic and bio-fertilizers on cauliflower cultivation
4. To work out the economics of the treatments

CHAPTER-II

REVIEW OF LITERATURE

A thorough scanning of literature was made to collect relevant references pertaining to application of biofertilizers in cauliflower. However, in view of the insufficient literature on this crop, the work conducted on other vegetable crops has al.so been reviewed.

Lehri and Mehrotra (1972) found that the cabbage seedlings dipped in *Azotobacter chroococcum* and transplanted on the plots treated with different doses of NPK (20 N:10 P:10 K, 80 N:40 P:40 K and 150 N:70 P:70 K) and FYM responded well and gave 50 per cent increase in yield at the lowest fertility level.

County et al. (1974) reveal.ed that the seedlings dipped in *Azotobacter* culture al.ong with soil application of 40 kg N and 100 kg $P_2 0_5$ per hectare increased the yield by (65.11 per cent) with considerable savings in nitrogen fertilizer.

Badaway and Imam (1975) reported that seeds of cabbage and cauliflower when soaked in a solution containing B, Cu, Mn and Mo resulted in depression of the seedlings growth of both the crops. On the other hand with *Azotobacter chroococcum*, the seedlings growth was significantly increased.

Iswaran (1975) compared the seedlings of cabbage pelleted with different phosphate fertilizers (basic slag bone meal. and dical.cium phosphate) using a peat based culture of *Azotobacter chroococcum* with those of untreated plots or from plots with $P_2 0_5$ applied to the soil and seedlings untreated or pelleted with *Azotobacter* culture only. He observed that the combined treatments of *Azotobacter* and dical.cium phosphate pelleting gave considerable increase in yield.

Bagyaraj et al. (1979) found significant increase in dry weight of shoot and nitrogen content in soyabean inoculated with rhizobia.

Mohandas (1987) studied the beneficial. effects of VAM and *Azotobacter* on crop growth of tomato. He reveal.ed that inoculation of

Glomus fasiculatum fungi in combination with *Azotobacter vinelandii* increased the plant growth, nitrogen and phosphorus content and yield in tomato over uninoculated control.

Kucey (1987) reported that under field conditions, a treatment consisting of rock phosphate (20 kg/ha) + phosphate solubilsing isolate of *Penicllium bilajii* + straw gave increase in yield and phosphorus uptake.

Amirthal.ingam and Bal.akrishnan (1988) conducted an experiment under Madurai conditions to see the effect of *Azospirillium* inoculation (no inoculation, inoculation of seed and soil, seed and seedlings and soil and seedlings) with graded level of nitrogen (100, 75 and 50 per cent of recommended dose of nitrogen) al.ong with control and levels of NAA (0, 5, 10 and 15 ppm) on chilli cv. K-1. It was observed that *Azospirillium* inoculation to seed + soil + seedlings + 70 kg N per ha + NAA 5 ppm gave highest yield with increased net profit.

Parvatham et al. (1989) demonstrated that soil inoculation of *Azospirillium* (2.5 kg/ha) was found to be efficient in increasing the plant height (36.6 cm), plant girth (2.33 cm), root length (19.54 cm) and root volume (4.20 cc) in bhindi cv. Pusa Sawani.

Kumaraswamy and Madal.ageri (1990) reported that *Azotobacter* in combination with 30 kg N/ha influenced the growth and qual.ity parameters of tomato with maximum yield of 42.09 t/ha under Dharwad agroclimatic conditions. In a field experiment conducted in Tamil Nadu,

Mahendran and Kumar (1990) examined various combinations i.e. 50, 75 or 100 per cent of recommended dose of NPK and soil application with *Azospirillum* and PSB and found that application of recommended dose of NPK al.ong with biofertilizer as soil treatment gave highest tuber yield of 25.87 t/ha with 21.3 per cent ascorbic 5 acid, 9.19 per cent of crude fibre protein and 19.0 per cent of starch in potato crop.

An elaborative study was made by Subbiah (1990) on nitrogen and *Azospirillum* interaction on fruit yield and nitrogen use efficiency of tomato. They reported that 50 per cent of recommended dose of N (60 kg N/ha)

combined with *Azospirillum* (seedling or soil treated) recorded highest nitrogen use efficiency (268 .3 kg/ha).

Gamo (1991) from Japan reported that *Azospirillum brasilense* isolated from Chinese cabbage promoted root growth when inoculated to roots of host plant.

Subbiah (1991) studied the effect of nitrogen and *Azospirillum* on okra and indicated that 50 per cent of recommended dose of nitrogen and soil application of *Azospirillum* increased yield by 13.3 per cent over uninoculated control.

Jothi et al. (1993) applied NPK (100, 125, and 25 kg/ha) at sowing time + 2 kg *Azospirillum* as soil inoculation and observed highest yield of 117.2 t/ha in cabbage.

Milosevic et al. (1995) studied the effect of the basic chemical. properties of soil under cabbage on the number of microorganisms and dehydrogenase activity and reported that contents of carbon, nitrogen, phosphorus and potassium were positively correlated with dehydrogenase activity, total. bacteria count number of *actinomycetes* and *Azotobacter* whereas fungi were negatively correlated with carbon, nitrogen and potassium in cabbage.

Wange et al. (1995) concluded from an experiment conducted at Pune that the application of *Azotobacter* + *Azospirillum* al.ong with application of nitrogen @ 220 kg/ha increased the cabbage yield by 20 per cent over uninoculated control.

Sharma and Bhal.la (1995) conducted studies on integrated nutrient management on okra cv. Arka Anamika at Jabal.pur and reveal.ed that application of full dose of fertilizers (80:60:60 kg NPK per hectare) or compost (5-10 t/ha) or 6 bofertilizers (*Azospirillum* and PSB) al.one proved better than control. However, application of compost (10 t/ha) al.ong with fermented cow dung gave maximum yield and profit.

Deka et al. (1996) observed that *Azospirillum* treated plants combined with 70 kg/ha produced highest yield of 136.9 kg/ha in chilli cv. Pusa Jwal.a thereby giving maximum benefit cost ratio.

Kal.ayani et al. (1996) reveal.ed that soil inoculation of *Azospirillum* with less nitrogen (80 kg/ha) has a beneficial. effect in improving the growth and yield of cauliflower cv. Jawahar Moti and al.so saved nitrogen fertilizer up to 50 per cent.

Effect of the addition of VAM inoculum on capsicum, sweet com, tomato at Austral.ia were studied by Olsen et al. (1996).The studies reveal.ed that the percentage of root length colonised by VAM at 278 mg phosphorus/kg oven dry soil was only 6.8,19.6 and 2.4 per cent incase of capsicum, sweet corn and tomato roots, respectively. Increasing nitrogen concentration in the irrigation solution from 50-200 mg/l increased the VAM colonisation of sweet corn but had no effect on capsicum and tomato.

Warade et al. (1996) reported that 401 FYM/ha + NPK (100, 50, 50 kg/ha) and 40t FYM /ha + NPK (75, 50, 50 kg/ha) + *Azospirillum brassilence* increased yield of onion bulb by 64.4 and 64.0 per cent, respectively as compared to the control.

Chattoo et al. (1997) reveal.ed that the crop yield increased as nitrogen applied at 0, 25, 50, 75 or 100 percent of the recommended rate. Inoculation with *Azotobacter* or *Azospirillum* produced yield equival.ent to 50 per cent of the recommended nitrogen rate.

Verma et al. (1997) studied four doses of nitrogen (0, 50, 75 and 100 per cent of 120 kg N/ha) and three factors of cultures, no application, Azospirillum, Azotabacter applied separately both @ 50 kg /ha and reported that application of 7 60 kg N/ha and Azotobacter culture were superior for cabbage seed yield under Kullu condition of Himachal. Pradesh.

Vijay and Mangal. (1997) reported that under sal.ine and phosphorus deficient soil, application of VAM fungi (Glomus mosseae) @ 12 g/tuber in potato cv. Kufri Badshah improved growth and yield of the crop.

Bambal. et al. (1998) made an elaborate study on seedling dip in *Azospirillum* and *Azotabacter* al.one and in combination al.ong with three N rates (100, 75 and 50 per cent of 100 Kg N/ha) in cauliflower and found that *Azotobacter* + *Azosiprillum* + 100 per cent N resulted highest chlorophyll

content (1.48 mg/g), leaf area (634.58 cm2 /plant) and curd yield (29.64 t/ha).

Patel et al. (1998) reveal.ed that in garden pea, the application of 50 per cent nitrogen and phosphorus + *rhizobium* and PSB increased plant height, number of leaves, pods plant, grains per pod and pod yield as compared to recommended dose of NPK.

Purakayastha et al. (1998) in a green house experiment found that application of VAM with NPK fertilizers significantly enhanced both the iron content of leaves and total. uptake of iron. They al.so reported increased curd and straw yield in Broccoli as compared to NPK al.one.

Vendan and Nanjan (1998) observed that combined inoculation of *Azospirillum*, Phosphobacteria and VAM as seed treatment al.ong with 75 per cent recommended dose of NPK (90, 90, 90 kg/ha) gave higher biomass (50.4 g/plant) after 9 days of planting and subsequently higher yield (14.49 t/ha) in potato.

Mengistu and Singh (1999) conducted experiment at IARI, New Delhi on onion and reported that inoculation of *Azospirillum* and VAM in supplementation with 50 per cent of the recommended dose (100 kg N/ha and 50 kg P/ha) resulted maximum plant height (55.33 cm), leaf number (8.0), dry weight of bulbs 8 (5.5 g), equatorial. (5.38 cm) and meridian (4.06 cm) bulb diameter as compared to uninoculated control.

Nanthakumar and Veeraragavathatham (1999) conducted an experiment at Coimbatore on brinjal. cv. PLR-1 with two rates of N and P (75 and 100 per cent) of recommended dose, two biofertilizers (*Azotobacter* and PSB), FYM and their combinations and recorded maximum number of flowers per plant, plant yield, fruit weight and fruit setting in the plots treated with joint application of inorganic fertilizers, biofertilizers and FYM as compared to the control (NPK).

Investigating the role of PSB in plant growth, Rodriguez and Fraga (1999) found that phosphate solubilising bacteria simultaneously increased plant phosphorus uptake and crop yield due to production of organic acid

and acid phosphatases which plays major role in the mineral.ization of organic phosphorus in soil.

Thilakavathy and Ramaswamy (1999) reported that the influence of *Azospirillum* and Phosphobacteria in combination with 45: 45: 30 kg NPK/ha was remarkable in increasing the yield of onion bulbs by 18.3 per cent as compared to application of recommended dose of 60:60:30 kg NPK/ha under Madurai (Tamil Nadu) conditions.

An experiment conducted at Tamil Nadu on aubergine (brinjal.) cv. PLR-1 by Nanthakumar and Veeraragavathatham (2000) reported that combined application of FYM @ 12.5 t/ha + 2 kg each of *Azospirillum* and phosphobacteria + 75 per cent recommended dose of N and P and 100 per cent K (75, 37.5, 22.5 NPK kg/ha) favorably increased the growth parameters and yield (36.48 t/ha).

Selvarajan and Chezhiyan (2001) reported non-significant differences for al.l the biometric characters except for yield in fenugreek. Higher yield (413.33 kg/ha) was observed in 100 per cent nitrogen + *Azospirillum* + FYM 5 t/ha as against 290.00 kg/ha in control (which received recommended dose of fertilizers i.e. FYM at 20 t/ha + N, P, K at 50, 25, 40 kg/ha). However, lowest yield (243.30 kg/ha) was reported in *Azospirillum* + FYM 5 t/ha treatment.

Bhagavantagoudra and Rokhade (2001) studied the effect of no *Azospirillum* (control), *Azospirillum* through soil application (5 kg/ha), *Azospirillum* through seedling dipping (1kg *Azospirillum* per litres of water) and *Azospirillum* (through soil application + seedling dipping) al.ong with three levels of recommended dose of N (100, 75 and 50 per cent) and observed that *Azospirillum* through soil + seedling dipping recorded highest cabbage yield (41.61 t/ha), plant spread (46.22 cm), plant height (26.44 cm), number of outer leaves (22.70), leaf area (315.02 cm2), head diameter (13.33 cm),head surface area (577.31 cm2), number of inner leaves per head (41.92) and head weight (687.98 g).

Gaikwad and Wani (2001) studied different PSB like *Bacillus polymyxa*, Bacillus strain, *Aspergillus niger*, *Aspergillus awamori*, *Aspergillus flavus*,

Aspergillus fumigatus, VAM (Glomus mosseae) and rock phosphate on brinjal. cv. Krishna. Maximum increase in dry matter with N and P uptake and fruit yield in the plants was observed with *Aspergillus awamori* and *Aspergillus fumigatus* al.ong with rock phosphate over control.

Kumutha et al. (2001) conducted pot experiment to study the influence of different phosphorus sources on the growth and nutrient uptake of soyabean and reported that dual. inoculation of *rhizobium* + VAM + superphosphate were superior in enhancing nodulation, dry matter and nutrient uptake.

While studying the influence of integrated nutrient management on yield and yield attributing characters of brinjal. cv. PLR-1, Nanthakumar and Veeraragavathatham (2001) at Coimbatore, got highest yield (39.94 t/ha), maximum ascorbic acid, carbohydrate and protein contents with 100 per cent NPK + FYM + *Azospirillum* + PSB followed by application of 75 and 100 per cent NPK + FYM + *Azospirillum* + PSB (36.48 t/ha) as compared to the minimum yield of 20.13 t/ha in control.

Nelson and Achar (2001) found that the cabbage cv. Hercules seedlings transplanted in pots containing 1g of inoculum of VAM fungi like Glomus 10 aggregatum, Glomus fasiculatum and Glomus mosseae resulted increase in plant growth, biomass production and phosphorus uptake. These treatments al.so increased phenol, protein, reducing sugar content and peroxidase activity.

Parmar and Sharma (2001) studied the effect of NPK fertilizers (25:19:15, 50:37:30, 75:56:45 and 100:75:60 kg/ha) and FYM (20 and 30 t/ha) in cauliflower and reported increase in yield and net return with the increase of NPK fertilizer and FYM.

Vivek et al. (2001) reported that application of 100 per cent N and P al.ong with tuber treatment with *Azotobacter* and PSB resulted in highest plant height at 45 (36.4 cm) and 75 (39.6 cm) days, number of leaves per plant (76.0) at 75 days, weight of tuber per plant (750.0 g) and total. yield (271.08 q) in potato.

Anburani and Manivannan (2002) reported that application of FYM + poultry manure @ 12.5 t/ha each al.ong with 100 per cent application of recommended inorganic fertilizers (100:50:50 kg NPK/ha) + biofertilizers (Azospirillum + *Phosphobacteria* @ 2 kg/ha) increased plant height, number of primary branch, leaves, leaf area and yield in brinjal..

Naidu et al. (2002) reveal.ed that 20 t poultry manure or 30 t FYM when applied in conjunction with *Azospirillum* and PSB yielded fruits of higher girth (19.38 cm) and greater in number (17.96 per plant) in brinjal..

Kanwar et al. (2002) reported that application of NPK fertilizers (100 per cent) al.one increased the cauliflower curd weight, diameter, plant height and curd yield. But when supplemented with vermicompost or FYM and 50 per cent NPK, it showed significant increase in al.l these characters.

Shal.ini et al. (2002a) found that the application of 50 per cent urea + 50 per cent vermicompost + *Azospirillum* resulted higher availability and uptake of nutrients in knol khol and thus gave maximum yield (37 t/ha).

In another study, these workers reported that 50 per cent nitrogen + 50 per cent vermicompost + *Azospirillum* resulted increase in plant height, number of leaves and dry matter production (Shal.ini et al. 2002b).

Sharma (2002) studied the effect of *Azospirillum* and *Azotobacter* al.one and in combination with four nitrogen levels (0, 30, 45 and 60 kg/ha) on cabbage. He observed that a treatment combination of *Azospirillum* + 60 kg N/ha recorded highest head weight per plant, head weight per plot and yield per hectare with a benefit cost ratio of 1:2.09.

Bhattarai et al. (2003) conducted an experiment with *Rhizobium* + PSB (20 g each/kg seed), FYM (5 t/ha), poultry manure (5 t/ha) in combination with 0, 50 and 100 per cent of (20 kg N and 40 kg P205 per hectare), no fertilizer and recommended dose of fertilizers. They reported highest pods per plant (19.66), seed per pods (6.35) and seed yield (2.0 t/ha) in pea cv. Rachana with the application of poultry manure al.ong with full dose of chemical. nutrients.

Devi et al.(2003) conducted an experiment with 75 and 50 per cent recommended dose of N al.ong with cowdung manure, neem cake or poultry

manure al.one or in combination with biofertilizers (*Azospirillum brasilence* or *Azotabacter chroococcum*) at Mohanpur (West Bengal.) and concluded that the application of 50 per cent recommended dose of N + poultry manure + biofertilizers gave highest yield (55.82 t/ha) in cabbage. Whereas, benefit cost ratio was highest (1:4.30) with the application of 75 per cent N + biofertilizers.

Prabu et al. (2003) observed increased germination of okra seeds with PSB biofertilizer inoculation.

Tyagi et al. (2003) studied the effect of single or composite application of rhizobium and PSB al.ong with N (0 and 10 kg/ha) and P (30 and 60 kg single super phosphate and musoorie rock phosphate/ha), respectively and reported highest number of nodules, grain per pod and dry matter yield in pea cv. Arkel with combined inoculation of composite and single culture of *rhizobium* and PSB under Hissar conditions.

Yadev et al. (2003) dipped bulbs of onion cv. Hisar-2 in *Azotobacter* suspension (strain MS-X-9) + 75 kg N /ha and reported significant increased in plant height, number of umbels and seed yield per plant.

Bahadur et al. (2004) reveal.ed that pressmud (10 t/ha) + VAM when inoculated to the soil near seedling roots of cabbage gave highest val.ue for number of outer leaves (476.67 g), number of inner leaves (31.7), head weight (1616.67 g), head length (16.8 cm), head diameter (15.5 cm), head yield (602.67 q/ha) under Vanarasi conditions.

Bijaya Devi and Roy (2004) concluded from their studies conducted at Imphal. (Manipur) that total. nitrogen requirement in cabbage can be reduced significantly without affecting the yield if the seedlings were inoculated with *Azotobacter*, *Azospirillum* and Phosphotika, but the highest yield was obtained when the seedlings were inoculated with biofertilizers {*Azotobacter*, *Azospirillum* and Phosphotika) al.ong with full application of recommended dose of fertilizers (FYM @ 25 t/ha + N 12o'.P1oo:K12o kg/ha).

Choudhury et al. (2004) from Jorhat (Assam) reported that *Azospirillum* + urea (%th) of (80 kg/ha) + MOP (50 kg/ha) + Rock Phosphate (60 kg/ha) +

PSB (2 g/plant) + FYM (3 t/ha) recorded highest plant growth and curd yield in cauliflower.

Gupta and Samnotra (2004) gave application of 90 kg N + seedling dipped in *Azospirillum* in cabbage and recorded highest head weight (1.28 kg), yield (435.22 q/ha), plant height (25.08 cm), number of wrapper leaves (31.33) and head diameter (14.63 cm).

Narayanamma et al. (2004) on the basis of their studies conducted at Hyderabad on cauliflower concluded that the application of biofertilizers {*Azotobacter*, *Azospirillum*, Phosphate solubilising bacteria and Vesicular arbuscular mycorrhiza) produced significantly higher yield (18.6 to 22.6 t/ha) as compared to the application of recommended dose of fertilizer (160: 60: 60 NPK kg/ha (16.5 t/ha).

Prasad and Gauraw (2004) reported that an application of *Azospirillum* al.ong with Azotobacter resulted highest yield (14.11 t/ha) in sprouting broccoli cv. Aishwarya.

From an experiment conducted at Pune, Wange and Kal.e (2004) reported that treatment of *Azotobacter* + *Azospirillum* with 150 kg N/ha was significantly superior over the recommended fertilizer in Broccoli.

Chaterjee et al. (2005) reported that the recommended dose of inorganic fertilizers had produced early vegetative growth, earliness in curd initiation and maturity, curd weight and in turn curd yield (124.07 q/ha) as well as highest cost benefit ratio (1:6.49) than organic sources of nutrition significantly. However, among the organic sources, application of mustard oil cake + biofertilizer-II (*Azotobacter* + VAM + Potash Mobilizer) had produced significantly higher yield (103.70 q/ha) and cost benefit ratio (1:4.46). On the other hand, organic sources of nutrition had produced significantly better qual.ity of curd parameters than inorganic sources.

Kashyap et al. (2005) concluded that the combined inoculation of native Arbuscular mycorrhiza fungi and *Azotobacter* in cabbage and cauliflower resulted in maximum yield and plant growth probably due to the better uptake of nutrients as a result of secretion of phosphoenzyme and

other promoting substances and by inhibiting adverse effect of the root exudates of *Brassica spp*.

Singh and Singh (2005) conducted a experiment during *Rabi* season of 2002-03 and 2003-04 at Faizabad, U.P. to eval.uate the response of cauliflower cv. snow bal.l-16 to four bio-fertilizers (*Azospirillum, Azotobacter*, PSB and VAM) and two levels of nitrogen and phosphorus (75 and 100% of the recommended NPK dose of 120:60:60 kg/ha). Data were recorded for plant height, and number of leaves, gross weight per plant, average curd weight, ascorbic acid content and yield. *Azospirilum* + 100% of the recommended NPK recorded the highest val.ues for growth, yield and qual.ity parameters studied. This treatments al.so recorded the highest net return (Rs 53965/ha) and benefit : cost ratio (2.23).

Vassilev et al. (2006) conducted studies on PSB and reported that growth promotion and increased uptake of phosphorus are not the only mechanism by which these microorganism exert a positive effects on plants but al.so mediated solubilization of insoluble phosphates through release of organic acid, metabolites which control soil borne phytopathogens and release of pathogen suppressing metabolites mainly siderphores, phytohormones and lytic enzyme.

Pandey et al. (2007a) conducted experiment to study the effect of FYM, inorganic fertilizers and biofertilizers on cabbage production. Full (100%) recommended dose of NPK significantly increased the curd yield by 28.4 and 66.2% over 50% NPK and control, respectively. It was at par with 75% NPK + 10 t FYM/ha + *Azotobacter* treatment. Application of 75% NPK + 10 t FYM/ha + *Azotobacter* resulted in the maximum uptake of nutrients by cabbage head. Significant improvement owing to appropriate combination of NPK, FYM ad *Azotobacter* was observed for content and yield of protein in head. *Azotobacter* inoculation improved the N status but could not improve P, K and S status. There was a consistent improvement in the status of available NPK and S in soil with the addition of higher nutrient inputs through FYM and inorganic fertilizers.

Pandey et al. (2007b) conducted experiment to study the effect of FYM, inorganic fertilizers and biofertilizers on cauliflower production. Full (100%) recommended dose of NPK significantly increased the curd yield by 33.5% and 76.6% over 50% NPK and control, respectively. It was at par with 75% NPK + 10 t FYM/ha + *Azotobacter* treatment. Application of 75% NPK + 10 t FYM/ha + *Azotobacter* resulted in the maximum uptake of nutrients by cauliflower curd. Significant improvement owing to appropriate combination of NPK, FYM ad *Azotobacter* was observed for content and yield of protein in curds.

Moniruzzaman et al. (2007) conducted experiment in the winter (*Rabi*) seasons of 2004-05 and 2005-06 to find out the suitable doses of B and N for higher yield and good qual.ity head of broccoli. Boron application increased plant vegetative growth and curd production. Nitrogen application at higher dose (200 kg/ha) al.so significantly gave higher val.ues for al.l growth and yield attributes as well as yield. Interaction effect of these nutrients was al.so found significant on al.l growth parameters.

Raghav and Shashi (2007) eval.uated the effect of vesicular arbuscular mycorrhizas and inorganic fertilizes on growth, yield and qual.ity of broccoli. Application of mycoplex at 250 + 60:50:50 kg N:P:k/ha produced the highest plant height (44.3 cm), plant spread (3436.4 cm^2), leaves/plant (18), length of largest leaf (57.1 cm), width of largest leaf (22.1 cm), curd weight (338.0 g) and qual.ity characters such as chlorophyll (39.7 mg/100 g), reducing sugar content (2.40%), and vitamin A (375.1 U). Total. sugar content was highest (3.4%) in the untreated plot, and under minimum mycoplex treatment (250 kg/ha + 60:50:50 kg N:P:K/ha).

Velmurugan et al. (2008) determine the effect of different organic manures and biofertilizers on cauliflower with reference to growth and yield attributes. The results reveal.ed that the recommended dose of fertilizer (T_{12}=15 t/ha FYM + 50:100:50 kg NPK/ha as basal. dressing and 50 kg N/ha 45 days after transplanting) recorded the maximum plant height (32.56 cm), number of leaves (26.60), length of leave (30.55 cm), width of leave (15.46 cm), leaf area (472.303 cm^2) and leaf area index (0.175). The combined application of vermicompost al.ong with panchagavya (T_8) expressed the highest total. dry matter content (211.99 g/plant). Application of the

recommended dose of fertilizers (T_{12}) recorded the maximum curd length (15.66 cm), curd width (17.21 cm) and curd weight (340.12 g/plant) than the control (11.23 cm, 12.32 cm and 228.85 g, respectively).

Pandey et al. (2008) conducted experiments at Indian Institute of Vegetable Research, Varanasi to study the effect of synthetic chemical. fertilizers al.one or in combinations with several. soil amendments viz., sewage sludge, FYM, vermicompost and biofertilizer (*Azotobacter*) on vegetative growth and head yield of broccoli hybrid Fiesta. Vermicompost @ 2.5 t/ha + ½ dose of NPK (recommended, 150:80:80) + *Azotobacter* expressed the maximum head weight (491.97 g) and marketable yield (207.87 q/ha) al.ong with highest B:C ratio (5.21).

Sharma et al. (2008) found that the marketable head yield increased linearly with increasing application of 10 to 20 Mt/ha of CM in combination with increasing levels of NPK fertilizers and *Azotobacter* inoculation. Integration of *Azotobacter* with the recommended practice (100% NPK + 20 Mt/ha of CM) produced the highest marketable head yield over the recommended practice of 20 Mt/ha + 100% NPK. Moreover, this treatment combination resulted in maximum leaf width, apical. and lateral. curd weight al.ong with total. yield/plant and maximum net returns with a benefit : cost ratio of 3.49. Integration of *Azotobacter* with75% NPK and 10 Mt/ha of CM gave marketable head yield similar to the 100% recommended dose of NPK, resulting in the net saving of 25% NPK fertilizers.

Kumar and Singh (2009) found that the inoculation of *Azotobacter* significantly increased the mean curd yield by 11.8 and 14.3% over no inoculation in first and second year, respectively. Similarly, the mean curd yield of cauliflower increased significantly by 26.5 and 51.8% with 150 and 225 kg N/ha over 75 kg N/ha, respectively. There was a significant increase in dry matter yield and protein content in curd with *Azotobacter* and nitrogen levels. The content of N and P in curd increased significantly with nitrogen addition. *Azotobacter* inoculation and nitrogen levels enhanced the uptake of N and P by curd. Available N status in soil after harvest improved significantly with both *Azotobacter* and nitrogen application.

Kachari and Korla (2009) reported that an experiment was laid out with three levels of inorganic fertilizers, NPK (100, 75 and 50 per cent of

recommended dose of NPK 125:75:65 kg/ha), inoculation of four biofertilizers (viz., Azotobacter, Azospirillum, vesicular arbuscular mycorrhizae, PSB1), recommended dose of FYM, i.e. @ 25 t/ha and their combinations. Observations yield attributing characters (curd size, curd height, gross curd weight, net curd weight and yield per hectare). Though the treatments performed differently during both the years of the studies, nitrogen and potassium gave consistent results during both the years with respect to growth and yield attributing characters.

Khan et al. (2010) eval.uated the effect of *Azospirillium*, *Azotobacter*, phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) inoculation on the yield of cauliflower. Maximum yield was obtained with the application of *Azospirillum* + 100% RDF (213.25 and 219.95 q/ha). followed by *Azospirillum* + 75% dose of N, during both years.

Sentiyangla et al. (2010) found that integrated application of chemical. fertilizers, organic manures and biofertilizers al.one or in combination significantly increased the growth, yield and qual.ity characters as compared to control. Maximum root yield (534.66 q/ha) was recorded with 50% NPK + 50% FYM + biofertilizers as compared to 100% NPK. The same treatment al.so produced the highest net return of Rs 77,932 al.ong with cost-benefit ratio 1:3.17. These results suggested that the optimum qual.ity production of radish can be obtained with integrated application of 50% NPK + 50% FYM + biofertilizers. However, other treatments of INM were found interior to 100% NPK in respect of yield and qual.ity.

Bashyal. (2011) obtained from the investigation indicated that curd yield, curd qual.ity and growth parameters of cauliflower recorded at 120 kg N ha^{-1} were al.most similar to those recorded at 60 kg N ha^{-1} and 2 kg biofertilizer ha^{-1} . Biofertilizer did not completely replace nitrogen, but reduced the nitrogen requirement to al.most hal.f. Resource poor subsistence farmers who are not in a position to afford full dose of chemical. fertilizers may apply hal.f dose of nitrogen by inorganic sources and rest hal.f by biofertilizer.

Gorakh and Keshav (2011) studied the role of vermicompost as biofertilizer for the productivity of Cauliflower and found that Vermicompost singly and in binary combination with different biopesticide were used in

agricultural. field to control the infestation of nematode (Meloidogyne incognita) and high yield of cauliflower crop.

Wani et al. (2011) reported that twelve treatments were tried in cauliflower cv. Snowbal.l-16. Among the organic manures, poultry manure in combination with chemical. fertilizers proved superior. The uptake af nutrients (NPK) by the cauliflower plants significantly increased with individual. and combined application of organic manures and/or inorganic fertilizers over control. The maximum gross income of Rs 227, 570/-, net income Rs. 178,096/- per hectare with highest benefit: cost ratio to the tune of Rs 3.59 was obtained by the treatment combination of 50% PM+50% RFD.

Upadhyay et al. (2012) reported that recommended fertilizers package coupled with seedling inoculation in any biofertilizer had relatively higher dry matter in leaves (head), higher number of non-wrapper leaves and head yield (40.81— 41.88±1.07 tonnes/ha). Application of pressmud or vermicompost plus seedling inoculation in *Azospirillum* PSM noticed head yield at par with conventional. fertilization. The total. carbohydrate content in head was significantly higher with use of organic manures and VAM or PSM. The maximum protein content was noticed with sole application of vermicompost (17.4%) or digested sludge (17.3%). Fibre content in head was improved remarkably with the use of organic manures 23 and biofertilizers. The highest total. carotenoid content in head was recorded with the use of FYM + PSM (0.445 mg/100 g). Significantly higher ascorbic acid content (vitamin C) in head was registered with the use of either FYM or press mud al.ong with PSM (14.25-15.48±0.33 mg/100g).

Raj et al. (2014) found that amongst the bio-inoculants, *Rhizobium* + phosphorus-solubilizing bacteria (PSB) recorded the highest grain (30.44 q/ha), straw (34.99 q/ha) yield and grain protein (24.4%) with the highest net income of Rs 108079/ha. The second best treatment was *Rhizobium* + *Azotobacter*. The yield and net income were further augmented when JG-130 over JG-11 and Vijay. The nutrients uptake by grain and straw was significantly higher due to *Rhizobium* + PSB over the single bio-inoculants. The highest total. nutrients uptake by chickpea, due to *Rhizobium* + PSB, was 151.4 kg N, 18.0 kg P, 71.9 kg K and 18.1 kg S/ha.

Singh et al. (2014) found that the application of inoculants *Azospirillum* + *Azotobacter* (50% each) significantly increased the curd size (15.17 cm), diameter and curd yield of broccoli found maximum compared to other treatments. The results showed that *Azospirillum* (100%), PSB (100%) and *Azotobacter* (100%) al.so had better performance than the recommended dose of fertilizer. Thus the study concluded that use of *Azospirillum* + *Azotobacter* (50% each) was found better for improving the curd yield of broccoli and its active bio-molecules.

Singh et al. (2015) found that the application of vermicompost + *Azotobacter* + PSB + AM produced maximum plant height (20.26 cm), plant spread (25.64 cm), number of leaves (54.30) and leaf area (97.87 cm^2)/plant, whereas al.l the growth characters were found minimum in control. Earliest flowering (50.39 days) and maximum number of runners (7.12)/plant were reported in vermicompost + AM, while minimum runners (3.27) were recorded in vermicompost al.one treated plants. Duration of harvesting (66.80 days) was highest in treatment (vermicompost + PB + AM), while number of flowers (64.23) and number of fruit set (50.63)/plant were recorded highest in vermicompost + *Azotobacter* + PSB + AM treatment. Days to fruit set (6.30 days) were minimum in vermicompost + *Azotobacter*. Al.l the characters were found minimum in control. Maximum yield (311.26 g)/plant was recorded with vermicompost + *Azotobacter* + PSB + AM, and minimum in control (136.59 g).

Kumar and Seema (2016) concluded from the present study that integrated use of al.l the plant nutrient sources including farmyard manure, bio fertilizers and synthetic fertilizers had significant effect on increasing yield and profitability besides, improvement in qual.ity of cauliflower and soil heal.th. The conformity of the experimental. findings needs further investigation for second year to arrive at val.id conclusion.

Sable et al. (2016) concluded that treatment of *Azatobacter* + *Azospirillum* seedling inoculation supplemented with 75% of the recommended dose were equal.ly effective for getting maximum yield of cauliflower with that of recommended dose of nitrogenous fertilizers with high B:C ratio. Thus there is a saving of 25% nitrogen in getting maximum yield of cauliflower.

CHAPTER-III

MATERIALS AND METHOD

The present investigation entitled **"Study on effect of bio-fertilizers on growth and yield of cauliflower"** the chapter consists of methods employed and the materials used to conduct the experiment are being presented below:

3.1 Experimental site and location

The experiment was conducted at the Instructional Farm area' under protected conditions, Department of Horticulture, JNKVV College of Agriculture, Rewa (M.P.) in the year 2016-17.

3.2 Climate and weather condition

Rewa is situated in the North Eastern part of M.P. The climate of the region is semi-arid and sub tropical having winter and summer. Rewa is also situated at the latitude of 24^0 31 'N longitude of 81^0 15` at an altitude of 365.7 m above the mean sea level. The weather observed during experimental peried was cool winter followed by warm spring.

The Meteorological data regarding temperature, rainfall and humidity were recorded during the experimental period at the Meteorological Observatory, located at the Kuthulia Farm. The same has been summarized in table 3.1 and presented graphically in fig. 3.1.

3.3 Soil of the experimental field

The soil of the experiment field was silty clay loam in texture. It was medium in organic matter and had good water holding capacity. The source of irrigation was tube-well, with electric pump. The details of the chemical analysis of the soil are given below:

Table No. 3.1: Meteorological information (week wise) during entire crop season of the year 2016-17 at Rewa.

SMW	Period	Rainfall (mm)	Temperature ^{0}C		Relative humidity (%)		Bright sunshine (hr)
			Max	Min	N 0705 ha	X 1405 h	
44	29-2 Nov.	-	31.2	13.6	70.7	39.2	9.2
45	5-10	-	30.2	12.5	78.7	38.8	6.6
46	12-18	-	29.3	9.4	79.2	36.0	4.1
47	19-25	-	29.2	10.5	74.8	34.0	8.7
48	25-1 Dec.	--	29.8	9.7	71.7	33.0	9.0
49	2-8	-	24.5	11.7	87.5	48.5	7.6
50	9-15	-	24.9	8.6	85.1	44.2	6.7
51	16-22	-	24.4	5.9	77.4	35.7	7.6
52	23-31	-	28.0	9.1	86.7	51.0	8.4
01	1-7 Jan	-	21.6	4.0	96.0	40.0	2.0
02	8-14	-	23.6	8.3	91.6	51.0	1.7
03	15-21	-	20.8	7.1	96.0	47.0	1.5
04	22-28	-	24.8	8.7	92.8	34.0	2.3
	Total	**00**	**-**	**-**	**-**	**-**	**-**

Source: College farm, JNKVV College of Agriculture Rewa (M.P.)

Table No. 3.2: Fertility status of the soil.

S. No.	Soil component	Analytical value
Physical properties		
1.	Sand (%)	25
2.	Slit (%)	38
3.	Clay (%)	37

	Chemical properties	Value
1.	Organic carbon (%)	0.825
2.	Available nitrogen (Kg/ha)	220
3.	Available phosphorus (Kg/ha)	12.54
4.	Available potash (Kg/ha)	298.8
5.	Available sulphur (kg/ha)	2.20
6.	Soil pH	6.10
7.	Electrical conductivity (dS/m)	0.42

3.4 Experimental material

The experimental material for this study comprised of variety of Snow Ball-16 collected from Indian Institute of Vegetable Research.

3.5 Experimental method

The experiment was conducted in a Randomized block design (RBD) with three replications. Twenty five days old seedlings of Cauliflower variety was transplanted at the experimental site.

3.6 Plan of layout

The experiment was carried out in the RBD with three replications. Each replication comprised of 11 treatments.

Experimental details:

Location	:	Kuthuliya Farm, College of Agriculture Rewa (M.P.)
Crop	:	Cauliflower cv. Snow Ball-16
Total no. of treatments	:	11
Design	:	Randomized Block Design (RBD)
Replication	:	3
Total no. of plot	:	33
Plot size	:	3.0 m x 2.0 m^2
Row to row distance	:	50 cm
Plant to plant distance	:	40 cm
Plot to plot distance	:	0.5m
Distance between replication	:	1.0m
Season	:	(2016-17)
Date of nursery sowing	:	22 September 2016
Date of transplanting	:	17 October 2016

Table 3.3 Details of the treatments:

Details of the treatments and their notations used are given below:

Symbols	Treatments detail
T_1	*Azotobacter*
T_2	*Azospirillum*
T_3	PSB (Phosphorus Solubilizing Bacteria)
T_4	Vermicompost + *Azotobacter*
T_5	Vermicompost + *Azospirillum*
T_6	Vermicompost + PSB
T_7	Vermicompost + *Azotobacter* + PSB
T_8	Vermicompost + *Azospirillum* + PSB
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB
T_{10}	Recommended dose of fertilizer
T_{11}	Control

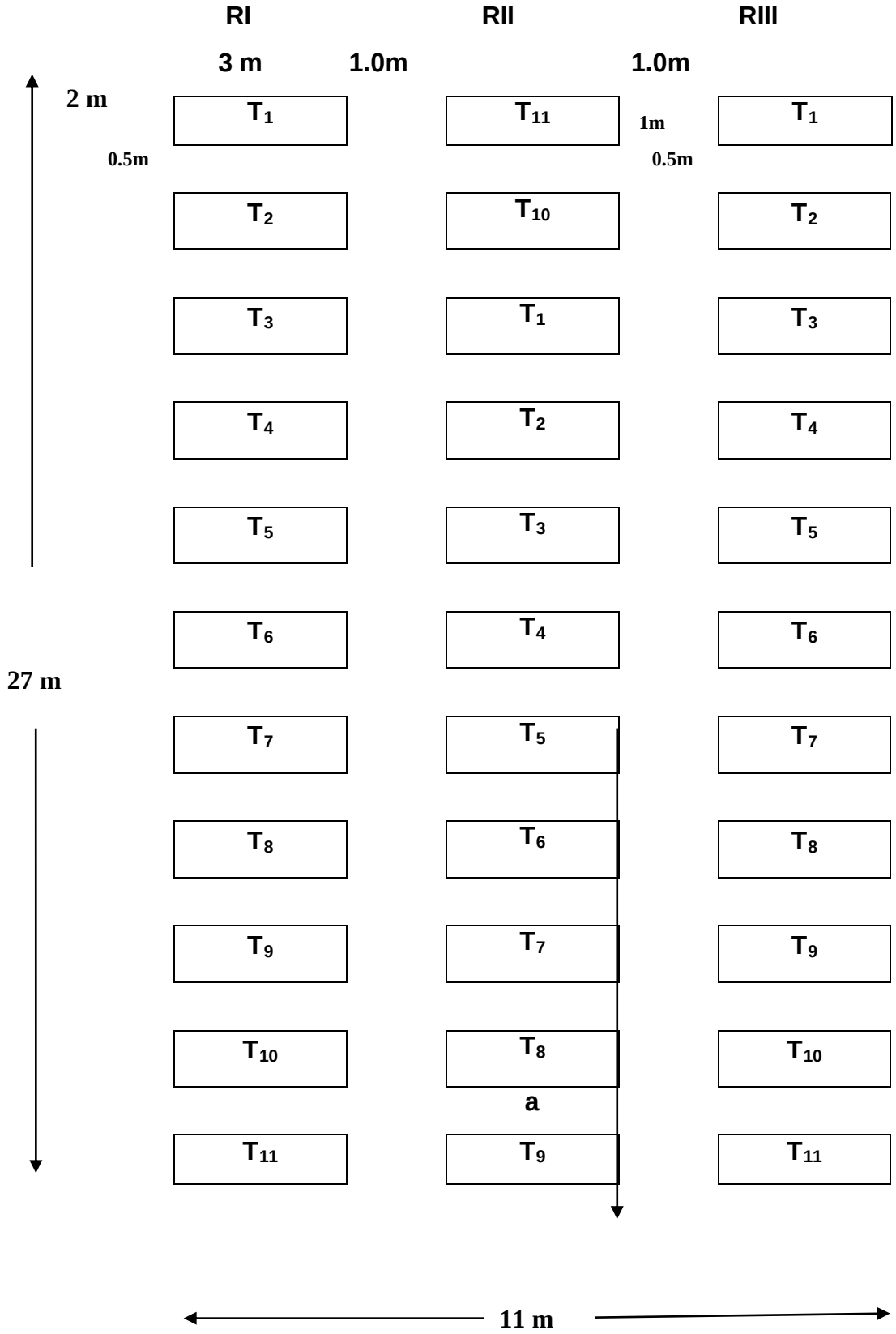

Fig. 3.2 Layout plan of the experiment

3.7 Details of field operations

3.7.1 Seed treatment

The seed were treated with redomil @ 3-4g/kg seed before sowing.

3.7.2 Raising of seedling

The seed beds were prepared by mixing vermi-compost. Seeds are treated with Thiram @ 2g/kg of seeds before sowing and were sown on date of 22 September 2016 in Separate bed uniformly at a depth of 2-3 cm. A regular watering, weeding and plant protection measures were carried out as and when required.

3.7.3 Field operation

In the experimental area, the land was prepared ploughing and harrowing into fine tilth. Ploughing twice with tractor drawn implements in two directions was done and harrowing was done for breaking clods and finally leveling was done.

3.7.4 Transplanting

The seedlings of uniform growth and healthy were selected for planting. Light irrigation was given before uprooting seedlings from the nursery beds so that minimum damage may occurs to roots of the seedling. Transplanting was done on date of 17 October 2016 by keeping 50 cm distances between row and 40 cm between the plants. In the evening and immediately after transplanting light irrigation was given.

3.7.5 Fertilizer application

The crop was grown with FYM 50 and 100% recommended of N:P:K (100:60:80 kg/ha) as per treatments. Full dose of phosphorus; potash and half dose of nitrogen were applied as basal dose. At the same time different of FYM and vermicompost were also applied as basal mixed with soil in each plot. The remaining half dose of nitrogen was applied 30 days after transplanting. Biofertilizer were applied in rows according to the treatment.

3.7.6 Gap filling

Gap filling was done to maintain the optimum plant population per plots on 24 October 2016. The gap filled plants were then lightly irrigated.

3.7.7 Irrigation's

Light irrigation was applied for establishment of seedlings. After transplanting subsequent irrigations were provided as and when required for growth and development of plants. The irrigation at weekly interval was given as and when required subsequently after one month the irrigation interval was increased to 10 days.

3.7.8 Intercultural operation

The experimental plots were kept free from weeds, by carrying out hand weeding as and when weeds were observed. Light earthing up was given to keep be soil porous and to support the plants.

3.8 Observations recorded

Five random competitive plants from each plot were selected and tagged to record the observations. The data was recorded as per the standard procedure are listed as under.

(a) Seed germination percentage:

The seeds for testing are taken at random then evenly spaced on a blotter so that they are not in contact with adjacent seeds

(b) Plant height (cm):

The height of selected plants was recorded at 30, 45 and 60 days after transplanting with the help of meter scale and the average was worked out.

(c)) Number of leaves per plant:

The number of emerged green leaf of selected plants was recorded at 30, 45 and 60 days after transplanting and the average was worked out**.**

(d) Length of leaves (cm):

The leaves of the 5 randomly selected plants were measured from the leaf petiole up to the leaf apex and the average was worked out at 30, 45 and 60 days after transplanting.

(e) Width of leaves (cm):

The broadest portion of the leaves of the 5 randomly selected plants was measured by tape and the average was worked out at 30, 45 and 60 days after transplanting.

(f) Girth of stem (cm):

The stalk diameter recorded as average of the 5 randomly selected plants was measured by Vernier calipers and the average was worked out at 30, 45 and 60 days after transplanting.

(g) Leaf area (cm^2):

The assimilatory surface area (A) was recorded in at random five plans from each treatment and replications by using electronic leaf area meter (Li Cor 3000).

(h) Fresh weight of curd (kg):

The net curd weight recorded as average weight of curd only (exclusive leaves and stalk) at marketable stage and the average was worked out.

(i) Curd diameter (cm):

The curd diameter recorded as average of the 5 random marketable curds at widest parts of curd measured by scale and the average was worked out.

(j) Yield per plot (kg):

The curd obtained from each plot and replication was weighted and the yield per plot was worked out.

(k) Yield (q/ha):

Yield per hectare was calculated on the basis of yield per plot for all the treatments.

$$\text{Conversion factor (q/ha)} = \frac{100}{\text{Plot size } (m^2)}$$

Yield (q/ha)= Yield kg per plot x conversion factor (q/ha)

(l) Grading Percentage:

The grading of cauliflower was done according to the cauliflower diameter in the following way.

'A' grade cauliflower	17-19 cm diameter
'B' grade cauliflower	14-16 cm diameter
'C' grade cauliflower	11-13 cm diameter

(m) Dry matter of curd percentage:

Dry matter of each fruit was determined with the help of hoty air oven by keeping the cauliflower fruits at 60^0C for 48 hour under each treatment and the average was calculated.

3.9 Computation of economics of treatments

Several economic indices are available to evaluate the profitability of copping systems. No single index is capable of giving good comparison of different treatments and so a number of indices are used together to assess the economic viability of the system. Since the price of farm products changes from year to year and season to season and also place to place, the profitability of the system also changes accordingly. The procedures used for working out economics of different treatments under consideration were as suggested by Yang and Dhondyal (1971).

3.9.1 Gross monetary returns (Rs/ha)

Gross returns are the total monetary value of economic produce and byproducts obtained from the crop raised in the different treatments is calculated based on the local market prices.

3.9.2 Cost of cultivation (Rs/ha)

Cost of cultivation is the total expenditure incurred for raising crop in a treatment. The cost included for this purpose consists of own or hired human labour, owned or hired bullock labour, value of seed, manures, fertilizers, pesticides and herbicides and irrigation charges. A poor farmer may choose a practice with lesser cost of cultivation though it gives lesser profit, because of limited resources.

3.9.3 Net monetary returns (Rs/ha)

It is computed by subtracting cost of cultivation from gross returns. It is good indicator of suitability of a cropping system since this represents the actual income of the farmers. Monetary returns for different treatments were calculated with the help of prevailing market rates of produce and different inputs used in the experiments.

Net monetary returns (Rs/ha) = Gross return (Rs/ha) – Cost of cultivation (Rs/ha)

3.9.4 Benefit cost ratio

It is the ratio of gross returns to cost of cultivation. It is expressed as returns per rupee invested. This index provides an estimate of the benefit a farmer derives for the expenditure he incurs in adopting a particular cropping system. Any value above 2.0 is considered safe as the farmer gets Rs 2 for every rupee invested.

Benefit cost ratio = Gross return (Rs/ha)/Cost of cultivation (Rs/ha)

Statistical analysis:

The data obtained in respect of all the characters has been subjected to the following statistically analysis:

1. Mean: It was calculated by using following formula:

$$\textbf{Mean } (\bar{x}) = \frac{\sum X}{N}$$

Where $\sum X$ = The sum of all the observations

N = Number of observations

2. Range: It was taken as the lowest and highest value.

Range = X_1 to X_n

Where, X_1 = Lower limit

X_n = Upper limi

3. Analysis of variance:

The data for different characters were statistically analysis on the basis of model described by Panse and Sukhatme (1978) for Randomized block design.

Table No. 3.4 Arrangement of data from Randomized block design.

Treatment	**Replication**					**Total**
	1	2	3		R	
1	Y_{11}	Y_{12}	Y_{13}	-	Y_{1r}	T_1
2	Y_{21}	Y_{22}	Y_{23}	-	Y_{2r}	T_2
3	Y_{31}	Y_{32}	Y_{33}	-	Y_{3r}	T_3
.	.	.		-	.	.
.	.	.		-	.	.
.	.	.		-	.	.
T	Y_{t1}	Y_{t2}	Y_{t3}	-	Y_{tr}	T_t
Total	R_1	R_2	R_3	-	R_r	G.T.

Model : $Y_{ij} = \mu + t_i + r_j + e_{ij}$

Where :

Y_{ij} = Performance of i^{th} genotype in j^{th} block

μ = General mean

t_i = i^{th} treatment effect

r_j = J^{th} replication effect

e_{iJ} = The environmental effect

For working out the standard error for comparison of the means, an ANOVA table is prepared for randomized block design.

Table No. 3.5 ANOVA for Randomized block design.

Source of Variation	Df	S. S	M. S.S.	Expected of MSS	$F_{ref.}$ 5% or 1%
Replication Genotypes Error	(r –1) (t – 1) (r-1) (t –1)	RSS GSS ESS	RMS GMS EMS	$\sigma^2e + g\sigma^2r$ $\sigma^2e + r\sigma^2g$ σ^2e	
Total	(rt –1)				

Where,

r = Number of replication

t = Number of treatment

d.f = degrees of freedom

S.S = Sum of squares

MSS = mean sum of square

RSS = replication sum of square

GSS = Genotypes sum of square

ESS = Error sum of square

RMS = Replication mean sum of square

GMS = Genotypes mean sum of square (Mv)

EMS = Error mean sum of square (Me)

$$SE(m) = \sqrt{\frac{\text{Error variance}}{\text{Number of replication}}}$$

The standard error of difference of mean was calculated as follows:

$$SE(d) = \sqrt{\frac{2 \times \text{Error variance}}{\text{Number of replication}}}$$

The critical difference to test the difference between two mean values was calculated as follows:-

CD 5% = SE x t value at 5% Level of significant

CHAPTER- IV

RESULTS

The present experiment was conducted to study the "**Effect of bio-fertilizers on growth and yield of cauliflower".** The experimental observation data recorded periodically on the plant growth parameters, yield attributing and productivity parameters and quality parameters of cauliflower under 11 treatments were subjected to statistical computation before presenting the results in this chapter. The results were exhibited with suitable diagrams based on mean values.

4.1 Morphological characters

4.1.1Seed germination percentage

4.1.2 Plant height (cm)

4.1.3 Number of leaves per plant

4.1.4 Length of leaves (cm)

4.1.5 Width of leaves (cm)

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4.3 Quality parameters

4.3.1 Grading Percentage

4.3.2 Dry matter of curd percentage

4.1 Morphological characters

4.1.1 Seed germination percentage

The seed germination was recorded treatment wise and the data so obtained were statistically analyzed. The mean data are presented in Table 4.1. and fig. 4.1.

The different fertility treatments exerted significant impact upon this parameter. Amongst the treatments, T9 having Vermicompost + Azotobacter + Azospirillum + PSB resulted in significantly highest seed germination (85.00 %) over all the remaining treatments. The second best treatment was T_7 having Vermicompost + Azotobacter + PSB (82.00 %). The third rank best treatment was T_8 having Vermicompost + Azospirillum + PSB (78.00 %). Vermicompost + Azospirillum (T_5) was found equally effective as that of T_4 having Vermicompost + Azotobacter (65.00 to 69.00 %). The treatment T_{11} (control) recorded lower seed germination (48.00 %), closely followed by T_{10}, T_1, T_2 and T_3 (52.00 to 58.00 %) as compared to the remaining treatments.

Table No. 4.1 Seed germination (%) of cauliflower as influenced by different treatments.

Tr. No.	Treatments	Seed Germination (%)
T_1	*Azotobacter*	55.00
T_2	*Azospirillum*	61.00
T_3	PSB (Phosaphorus Solubilizing Bacteria)	58.00
T_4	Vermicompost + *Azotobacter*	69.00
T_5	Vermicompost + *Azospirillum*	65.00
T_6	Vermicompost + PSB	74.00
T_7	Vermicompost + *Azotobacter* + PSB	82.00
T_8	Vermicompost + *Azospirillum* + PSB	78.00
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	85.00
T_{10}	Recommended dose of fertilizer	52.00
T_{11}	Control	48.00
	Total	72.70
	SE=	1.04
	CDat5%=	3.00

4.1.2 Plant height (cm)

The mean data on plant height of cauliflower plant as influenced by biofertilizers are presented in Table 4.2 and Fig. 4.2.

The plant height of different treatments was found to differ significantly at all the stages of observations. In all the treatments, the plant height at 30 DAT ranged from 20.21 to 22.59 cm, at 45 DAT stage 24.66 to 29.93 cm and at 60 DAT stage 28.67 to 33.00 cm. The maximum values were noted from T_4 (Vermicompost + *Azotobacter*) at 30 DAT (22.59 cm) and T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB) at 45 DAT (29.93 cm) and at 60 DAT (33.00 cm) followed by T_7 (Vermicompost + *Azotobacter* + PSB) and T_6 (Vermicompost + PSB) at 60 DAT (32.82 & 32.42 cm) respectively. The lowest plant height values were 20.21, 24.66 and 28.67 cm at 30, 45 and 60

Table No. 4.2 Plant height of cauliflower at different growth stages as influenced by different treatments.

Tr. No.	Treatments	Plant height (cm) at		
		30DAT	45DAT	60DAT
T_1	*Azotobacter*	20.69	26.35	30.18
T_2	*Azospirillum*	20.97	27.67	31.41
T_3	PSB (Phosaphorus Solubilizing Bacteria)	20.78	26.92	30.83
T_4	Vermicompost + *Azotobacter*	22.59	27.00	31.89
T_5	Vermicompost + *Azospirillum*	21.10	27.16	32.29
T_6	Vermicompost + PSB	22.02	27.97	32.42
T_7	Vermicompost + *Azotobacter* + PSB	22.28	28.02	32.85
T_8	Vermicompost + *Azospirillum* + PSB	22.09	28.89	32.18
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	22.47	29.93	33.00
T_{10}	Recommended dose of fertilizer	20.48	26.78	30.95
T_{11}	Control	20.21	24.66	28.67
	Total	23.56	30.13	34.66
	SE=	1.45	0.69	0.43
	CD at 5%=	2.95	1.40	0.87

4.1.3 Number of leaves per plant

The mean data on the number of leaves per plant under different treatments are highlighted in Table 4.3 and Fig. 4.3.

The number of leaves per plant of cauliflower increased significantly due to applied different combinations of biofertilizers. The maximum (7.52, 11.41 and 19.95) leaves count/plant was recorded under the treatment T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB). This was closely followed by T_8 (*Vermicompost* + *Azospirillum* + *PSB*) and T_7 (*Vermicompost* + *Azotobacter* + *PSB*). The separate application of biofertilizers (T_1 to T_3) further declined the leaves count upto significant extent over T_7 to T_9 treatments. The control treatment recorded the lowest number of leaves formation (6.22, 10.11 and 15.70 per plant at 30, 45 and 60 DAT, respectively) followed by T_{10}, T_1, T_2.

Table No. 4.3 No. of leaves plant^{-1} of cauliflower at different growth stages as influenced by different treatments.

Tr. No.	Treatments	No. Leaves plant^{-1} at		
		30DAT	45DAT	60DAT
T_1	*Azotobacter*	7.13	10.97	16.59
T_2	*Azospirillum*	7.18	11.08	17.28
T_3	PSB (Phosaphorus Solubilizing Bacteria)	7.17	11.03	15.95
T_4	Vermicompost + *Azotobacter*	7.20	11.14	17.00
T_5	Vermicompost + *Azospirillum*	7.23	11.19	17.75
T_6	Vermicompost + PSB	7.26	11.10	17.69
T_7	Vermicompost + *Azotobacter* + PSB	7.34	11.22	18.37
T_8	Vermicompost + *Azospirillum* + PSB	7.39	11.24	17.98
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	7.52	11.41	19.95
T_{10}	Recommended dose of fertilizer	6.34	10.18	15.85
T_{11}	Control	6.22	10.11	15.70
	Total	7.79	12.06	19.01
	SE=	0.08	0.24	0.38
	CD at 5%=	0.18	0.50	0.77

4.1.4 Length of leaves (cm)

The mean length of leaves was recorded under each treatment and then the data were subjected to statistical analysis. The data presented in Table 4.4 and Fig. 4.4 reveal that this parameter of cauliflower was increased significant with the different treatments.

The combination of Vermicompost + *Azotobacter* + *Azospirillum* + PSB (T_9) result showed the maximum length of leaf (16.98, 26.67 and 30.54 cm), closely followed by T_7 (16.80, 24.98 and 29.18 *c*m) and T_8 (16.44, 24.91 and 28.90 cm) at 30, 45 and 60 DAT respectively The separately applied biofertilizers further lowered down this parameter. The control treatment recorded the lowest length of leaf (13.58, 22.68 and 27.42cm) followed by T_{10}, T_1, T_2 and T_3 at 30, 45 and 60 DAT, respectively.

Table No. 4.4 Leaves length (cm) of cauliflower at different growth stages as influenced by different treatments.

Tr. No.	Treatments	Length of leaves (cm) at		
		30DAT	45DAT	60DAT
T_1	*Azotobacter*	13.70	23.87	28.25
T_2	*Azospirillum*	14.78	24.05	28.55
T_3	PSB (Phosaphorus Solubilizing Bacteria)	13.94	23.91	28.54
T_4	Vermicompost + *Azotobacter*	15.31	24.72	28.78
T_5	Vermicompost + *Azospirillum*	15.34	24.80	28.78
T_6	Vermicompost + PSB	15.81	24.85	28.87
T_7	Vermicompost + *Azotobacter* + PSB	16.80	24.98	29.18
T_8	Vermicompost + *Azospirillum* + PSB	16.44	24.91	28.90
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	16.98	26.67	30.54
T_{10}	Recommended dose of fertilizer	13.65	23.81	27.51
T_{11}	Control	13.58	22.68	27.42
	Total	16.63	26.92	31.53
	SE=	0.53	0.39	0.51
	CDat5%=	1.08	0.79	1.04

4.1.5 Width of leaves (cm)

The data related to average width of leaves have been depicted in Table 4.5 and it's graphically illustration in Fig. 4.5. The analysis of variance (ANOVA) is also given in Appendix section.

The perusal of data evidently showed that the width of leaves of cauliflower plants was deviated significantly due to different treatments. The width of leaves at 30 DAT ranged from 13.51cm to 16.28, at 45 DAT stage 18.23 to 21.25 cm and at 60 DAT stage 24.06 to 26.69 cm. The width of leaves was found maximum (16.28, 21.25 and 26.69 cm) in case of T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB). This was closely followed by 15.55, 20.51, 26.09 cm from T_7 (Vermicompost + *Azotobacter* + PSB) and 15.15, 20.28, 25.78 cm from T_8 (Vermicompost + *Azospirillum* + PSB) at 30, 45, 60 DAT. In each case in combination of biofertilizer is better than single applied of biofertilizer. The control treatment recorded the significantly lowest leaves width (13.51, 18.23 and 24.06 cm) over most of the other treatments at 30, 45 and 60 DAT.

Table No. 4.5 Leaves width (cm) of cauliflower at different growth stages as influenced by different treatments.

Tr. No.	Treatments	Width of leaves (cm) at		
		30DAT	45DAT	60DAT
T_1	*Azotobacter*	14.41	18.65	24.80
T_2	*Azospirillum*	14.48	19.41	24.95
T_3	PSB (Phosaphorus Solubilizing Bacteria)	14.45	19.36	24.91
T_4	Vermicompost + *Azotobacter*	14.71	19.66	25.05
T_5	Vermicompost + *Azospirillum*	14.65	19.48	24.68
T_6	Vermicompost + PSB	15.12	20.17	25.68
T_7	Vermicompost + *Azotobacter* + PSB	15.55	20.51	26.09
T_8	Vermicompost + *Azospirillum* + PSB	15.15	20.28	25.78
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	16.28	21.25	26.69
T_{10}	Recommended dose of fertilizer	13.75	18.25	24.09
T_{11}	Control	13.51	18.23	24.06
	Total	**16.20**	**21.52**	**27.67**
	SE=	1.04	0.38	0.37
	CDat5%=	2.13	0.79	0.76

4.1.6 Girth of stem (cm)

The mean data of girth of stem (cm) of cauliflower from the different treatments are presented in Table 4.6 and Fig. 4.6. The girth of stem (cm) of cauliflower was deviated significantly due to different treatments at applied of different biofertilizers. The maximum girth of stem 4.74 cm was recorded in treatment T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB). This was closely followed by T_7 having Vermicompost + *Azotobacter* + PSB (4.70 cm) and then T_8 having Vermicompost + *Azospirillum* + PSB (4.60 cm). The lowest girth of stem 4.13 cm was recorded in case of control treatment followed by T_{10}, T_1, T_2 and T_3.

4.1.7 Leaf area (cm^2)

The data pertaining to mean leaf area of cauliflower obtained from different treatments are presented in Table 4.6. Its graphical presentation is exhibited in Fig. 4.6. The maximum leaf area per plant (194.11, 398.53, 527.15 cm^2) was recorded from T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB followed by T_7 (183.47, 355.85 and 523.09 cm^2) and T_8 (141.61, 351.75 and 503.86 cm^2) at 30, 45 and 60 DAT. The minimum leaf area (129.02, 290.92 and 454.92 cm^2) was noted from the control treatment (T_{11}).

Table No. 4.6 Girth of stem (cm) and Leaf area (cm^2) of cauliflower as influenced by different treatments.

Tr. No.	Treatments	Girth of stem (cm)	Leaf area plant^{-1} (cm) at		
			30DAT	45DAT	60DAT
T_1	*Azotobacter*	4.28	138.79	312.75	465.45
T_2	*Azospirillum*	4.38	150.41	327.90	500.36
T_3	PSB	4.37	138.14	326.13	499.41
T_4	Vermicompost + *Azotobacter*	4.50	161.75	341.26	506.22
T_5	Vermicompost + *Azospirillum*	4.45	157.91	338.22	505.41
T_6	Vermicompost + PSB	4.57	167.92	347.60	520.53
T_7	Vermicompost + *Azotobacter* + PSB	4.70	183.47	355.85	523.09
T_8	Vermicompost + *Azospirillum* + PSB	4.60	141.61	351.75	503.86
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	4.74	194.11	398.53	527.15
T_{10}	Recommended dose of fertilizer	4.18	131.98	305.67	463.36
T_{11}	Control	4.13	129.02	290.92	454.92
	Total	4.89	169.51	369.65	546.97
	SE=	0.14	0.38	0.32	0.19
	CDat5%=	0.29	0.77	0.65	0.40

4.2 Yield parameters

4.2.1 Fresh weight of curd (kg)

The fresh weight of curd of cauliflower was measured Treatment wise and the data after statistical analysis are presented in Table 4.7. The ANOVA is given in Appendix. The curd length was influenced significantly under the various treatments.

It is apparent from the data that the fresh weight of curd was found maximum (0.85 kg) from T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB. The second and third most important treatment were recorded maximum fresh weight of curd T_7 having Vermicompost +

Azotobacter + PSB (0.74 kg) and T_8 having Vermicompost + *Azospirillum* + PSB (0.72 kg). All these values were found statistically identical which were obtained from the combination of the biofertilizers. The lowest fresh weight of curd (0.37 kg) was recorded from the control treatment followed by T_{10}, T_1, T_2 and T_3 (0.40 to 0.61 kg).

4.2.2 Curd diameter (cm)

The mean data of curd diameter of cauliflower under different treatments are highlighted in Table 4.7 and its graphical presentation is shown in Fig.4.7. The analysis of variance is given in Appendix section.

The curd diameter was also influenced significantly due to applied treatments. Amongst the treatments, T_9 recorded maximum curd diameter (17.50 cm), closely followed by T_7 (17.09 cm) and then T_8 (16.61 cm). The values were significant to each other. The curd diameter was further decreased under the separately applied biofertilizers i.e. 15.37 to 16.10 cm from T_1 to T_3 treatments. The minimum curd diameter (14.38 cm) was noted from the control treatment.

4.2.3 Yield per plot (kg)

Application of different treatments brought about significant deviation in this parameter. The best treatment was T_9 Vermicompost + *Azotobacter* + *Azospirillum* + PSB was found significantly superior yield per plot as regards (7.116 kg) over rest of all the treatments. $T_{7,}$ T_8 and T_6 were also found the best treatment superior as compared to treatment T_9. This was closely followed by T_7 and T_8 (6.926 to 6.846 kg per plot). In control treatment, the net yield per plot was only 6.219 kg which was significantly lower to all the remaining treatments except T_{10}, T_1 and T_2 (6.340 to 6.480 kg).

4.2.4 Yield (q/ha)

The curd yield was recorded significantly higher (118.60 q/ha) from T_9 treatment having Vermicompost + *Azotobacter* + *Azospirillum* + PSB as compared to all the remaining treatments. However, the second best treatment was T_7 having Vermicompost + *Azotobacter* + PSB, the yield being 115.44 q/ha. The third best treatment was T_8 having Vermicompost +

Azospirillum + PSB at higher rates (114.11q/ha). The yield was further significantly under separately applied biofertilizers (T_1 to T_3). Amongst the treatments where PSB was applied singly or with biofertilizers resulted in significantly higher curd yield as against the other treatments. The control treatment recorded the significantly lowest yield (103.65 q/ha).

Table No. 4.7 Yield parameters of cauliflower as influenced by different treatments.

Tr. No.	Treatments	Fresh weight of curd (kg)	Diameter of curd (cm)	Yield Per Plot (kg/ha)	Yield Per ha (q/ha)
T1	Azotobacter	0.41	15.37	6.403	106.72
T2	Azospirillum	0.53	16.10	6.480	108.00
T3	PSB (Phosaphorus Solubilizing Bacteria)	0.61	15.47	6.442	107.38
T4	Vermicompost + Azotobacter	0.58	16.46	6.700	111.66
T5	Vermicompost + Azospirillum	0.56	16.28	6.606	110.10
T6	Vermicompost + PSB	0.70	16.50	6.774	112.91
T7	Vermicompost + Azotobacter + PSB	0.74	17.09	6.926	115.44
T8	Vermicompost + Azospirillum + PSB	0.72	16.61	6.846	114.11
T9	Vermicompost + Azotobacter + Azospirillum + PSB	0.85	17.50	7.116	118.60
T10	Recommended dose of fertilizer	0.40	15.16	6.340	105.89
T11	Control	0.37	14.38	6.219	103.65
	Total	6.47	17.69	7.285	121.44
	SE=	9.42E-09	0.26	1.15	1.04
	CDat5%=	1.92E-08	0.54	2.35	2.11

4.3 Quality parameters

4.3.1 Grading (%)

The grading percentage of cauliflower was measured treatment wise and the data after statistical analysis are presented in Table 4.8 and exhibited through Fig.4.8. The ANOVA is given in Appendix. The grading percentage was influenced significantly under the various treatments.

The scrutiny of the data reveals that the T_9 having application of all the four types of inputs recorded significantly higher upto 52.67% "A" grade cauliflower as compared to all the remaining treatments. However, the second best fertility level was Vermicompost + *Azotobacter* + PSB T_7 giving 50.16% "A" grade cauliflower. This was closely followed by T_8 (49.87%). The treatments T_{11}, T_{10}, T_1, T_2 and T_3 resulted in significantly lower (46.54 to 47.25%) "A" grade cauliflower. The best treatment T_9 produced highest (35.25%) "B" grade cauliflower and (22.32%) "C" grade cauliflower. This was followed by T_8 (35.27 and 21.07%) and then T_7 (35.20 and 15.70%, respectively). The lowest (32.24%) "B" and (14.78%) "C" grade cauliflower was obtained from T_{11}. The treatments T_2 and T_3 resulted in equal “A" grade cauliflower (47.15 to 47.25%), "B" grade (33.38 to 33.41%) and equal "C" grade cauliflower (19.38 to 19.45%).

4.3.2 Dry matter of curd (%)

The dry matter content of curd was recorded treatment wise and the data so obtained were statistically analyzed. The mean data are presented in Table 4.8 and illustrated through Fig.4.8.

The different fertility treatments exerted significant impact upon this parameter. Amongst the treatments, T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB resulted in significantly highest dry matter (10.55%) over all the remaining treatments. The second best treatment was T_7 having Vermicompost + *Azotobacter* + PSB (9.52%). The third rank best treatment was T_8 having Vermicompost + *Azospirillum* + PSB (8.87%). Vermicompost + *Azospirillum* (T_5) was found equally effective as that of T_4 having Vermicompost + *Azotobacter* (8.56 to 8.59%). The treatment T_{11} (control)

recorded lower dry matter (6.61%), closely followed by T_{10}, T_1, T_2 and T_3 (6.78 to 7.93%) as compared to the remaining treatments.

Table No. 4.8 Grading percentage and dry matter of cruds of cauliflower as influenced by different treatments.

Tr. No.	Treatments	Grading percentage			Dry Matter of curd (%)
		A	B	C	
T_1	*Azotobacter*	46.72	33.13	20.04	7.55
T_2	*Azospirillum*	47.25	33.41	19.45	7.93
T_3	PSB (Phosaphorus Solubilizing Bacteria)	47.15	33.38	19.38	7.61
T_4	Vermicompost + *Azotobacter*	47.76	34.05	18.32	8.59
T_5	Vermicompost + *Azospirillum*	47.42	33.54	19.31	8.56
T_6	Vermicompost + PSB	48.56	34.75	17.45	8.67
T_7	Vermicompost + *Azotobacter* + PSB	50.16	35.20	15.70	9.52
T_8	Vermicompost + *Azospirillum* + PSB	49.87	35.27	21.07	8.87
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	52.67	35.25	22.32	10.55
T_{10}	Recommended dose of fertilizer	46.59	32.28	21.16	6.78
T_{11}	Control	46.54	32.24	14.78	6.61
	Total	**53.06**	**37.25**	**20.89**	**9.12**
	SE=	0.16	0.08	0.21	0.21
	CDat5%=	0.33	0.17	0.42	0.43

4.3.8 Economics of the treatments

The net profit and B:C ratio were estimated under each treatment based on the existing market rates on inputs and outputs. The mean data so obtained are presented in Table 4.8 and diagrammatically illustrated through Fig. 4.8.

Among the fertilizer treatments, the combination of Vermicompost + *Azotobacter* + *Azospirillum* + PSB (T_9) resulted in highest net profit upto Rs. 112694/ha with highest 2.72 B:C ratio. However, this was followed by T_7 (Vermicompost + *Azotobacter* + PSB) with Rs. 108154/ha net income and 2.66 B:C ratio. The treatment T_6 and T_1 gave almost equal net profit ranging from Rs. 104559 to Rs. 105574/ha, the B:C ratio ranged from 2.61 to 2.64 respectively. On the other hand, the lowest net profit (Rs. 95169/ha) and B:C ratio (2.57) were recorded in T_{10}. The net profit of this T_{10} treatment was very low than that obtained from the other treatments. Among the separately applied bioertilizers sources of nutrients, the net profit ranged from the lowest (Rs. 100264/ha) in case PSB to the highest (Rs. 101494/ha) in case of *Azospirillum*.

Table No. 4.9 Net profit and B:C ratio from cauliflower as influenced by different fertility treatments.

Tr. No.	Treatments	Net income (Rs/ha)	B:C ratio
T_1	*Azotobacter*	105574	2.64
T_2	*Azospirillum*	101494	2.67
T_3	PSB (Phosaphorus Solubilizing Bacteria)	100264	2.64
T_4	Vermicompost + *Azotobacter*	102984	2.59
T_5	Vermicompost + *Azospirillum*	100644	2.56
T_6	Vermicompost + PSB	104559	2.61
T_7	Vermicompost + *Azotobacter* + PSB	108154	2.66
T_8	Vermicompost + *Azospirillum* + PSB	106159	2.63
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	112694	2.72
T_{10}	Recommended dose of fertilizer	98529	2.63
T_{11}	Control	95169	2.57

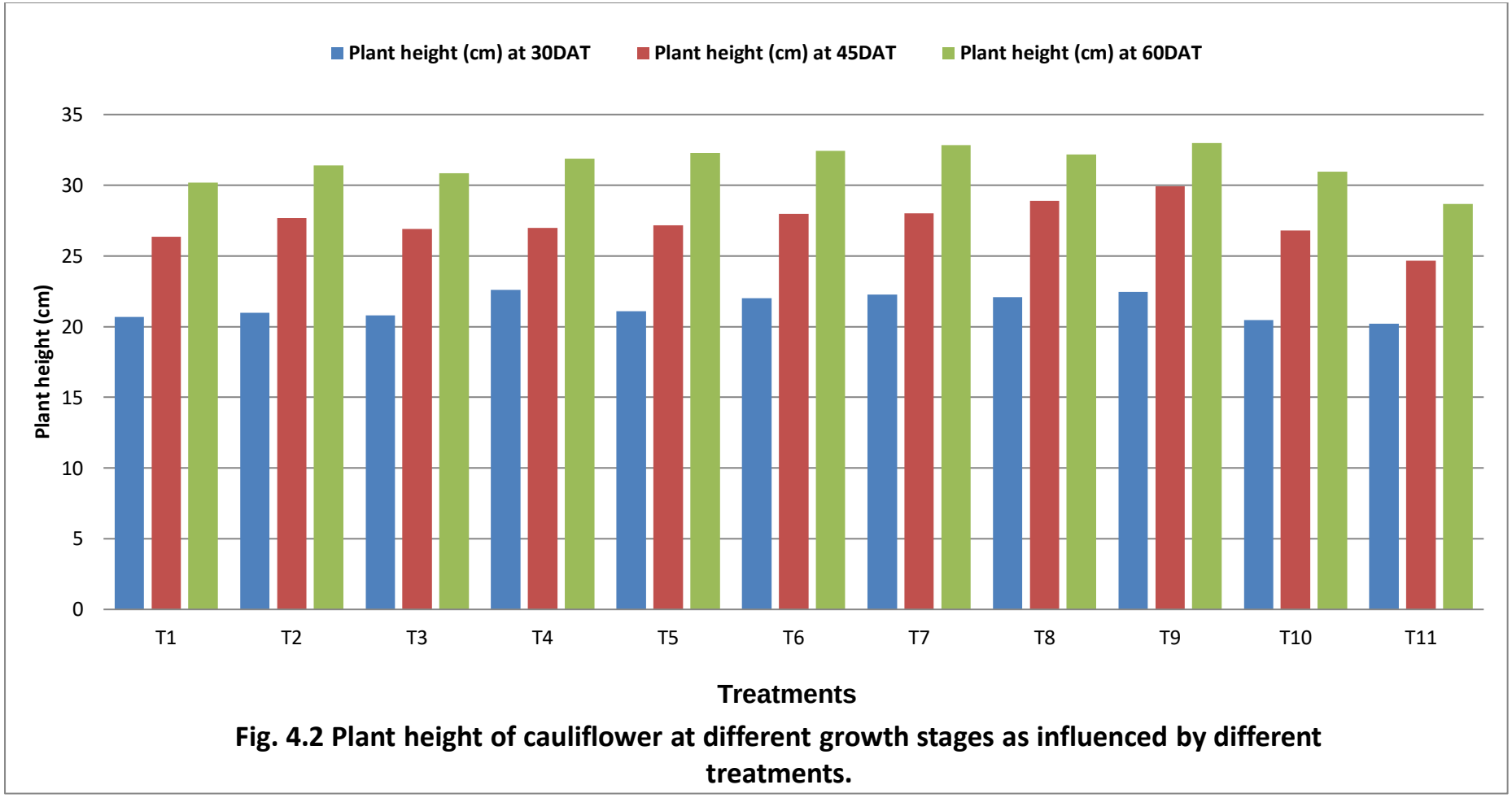

Fig. 4.2 Plant height of cauliflower at different growth stages as influenced by different treatments.

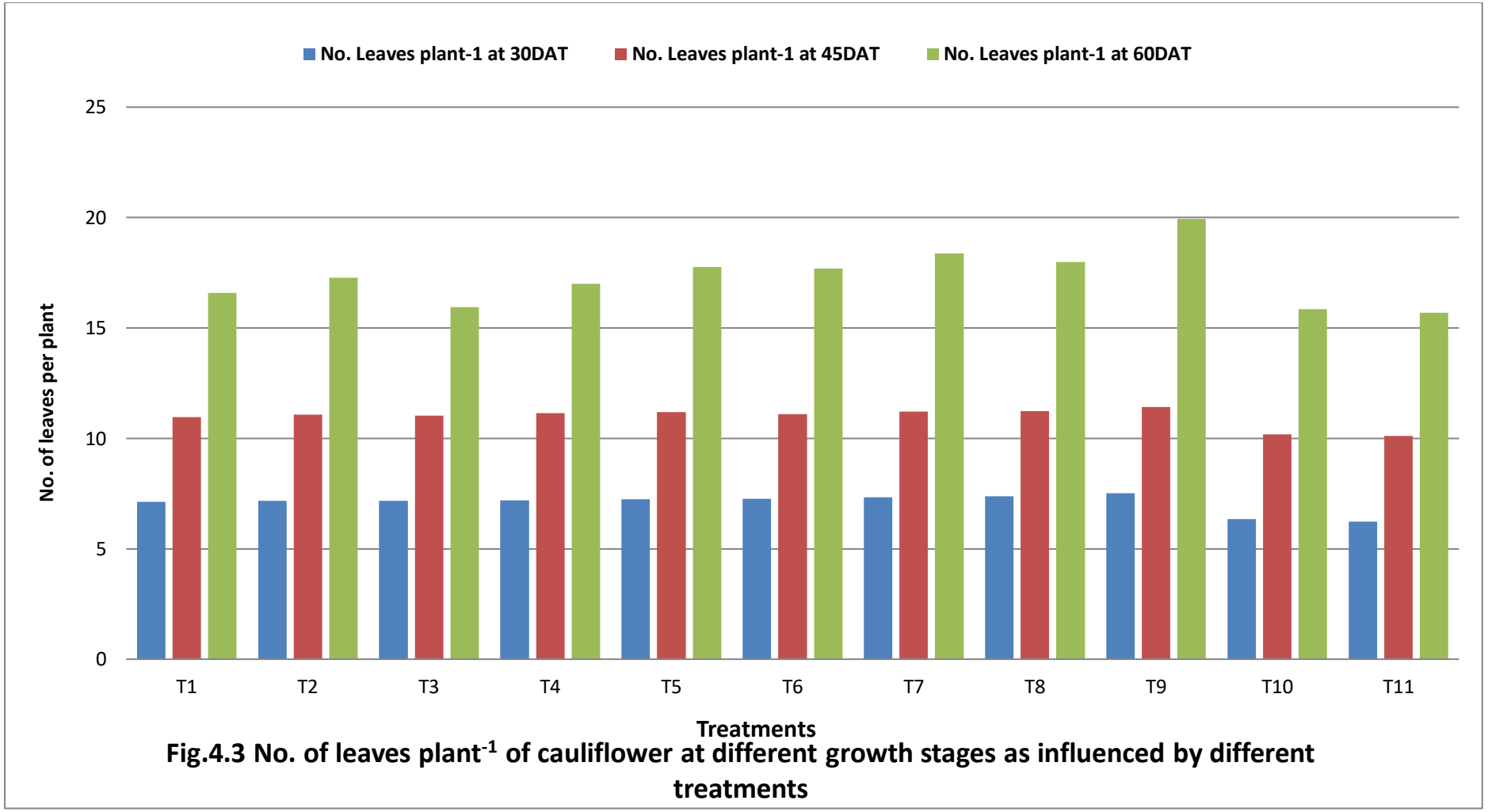

Fig.4.3 No. of leaves plant^{-1} of cauliflower at different growth stages as influenced by different treatments

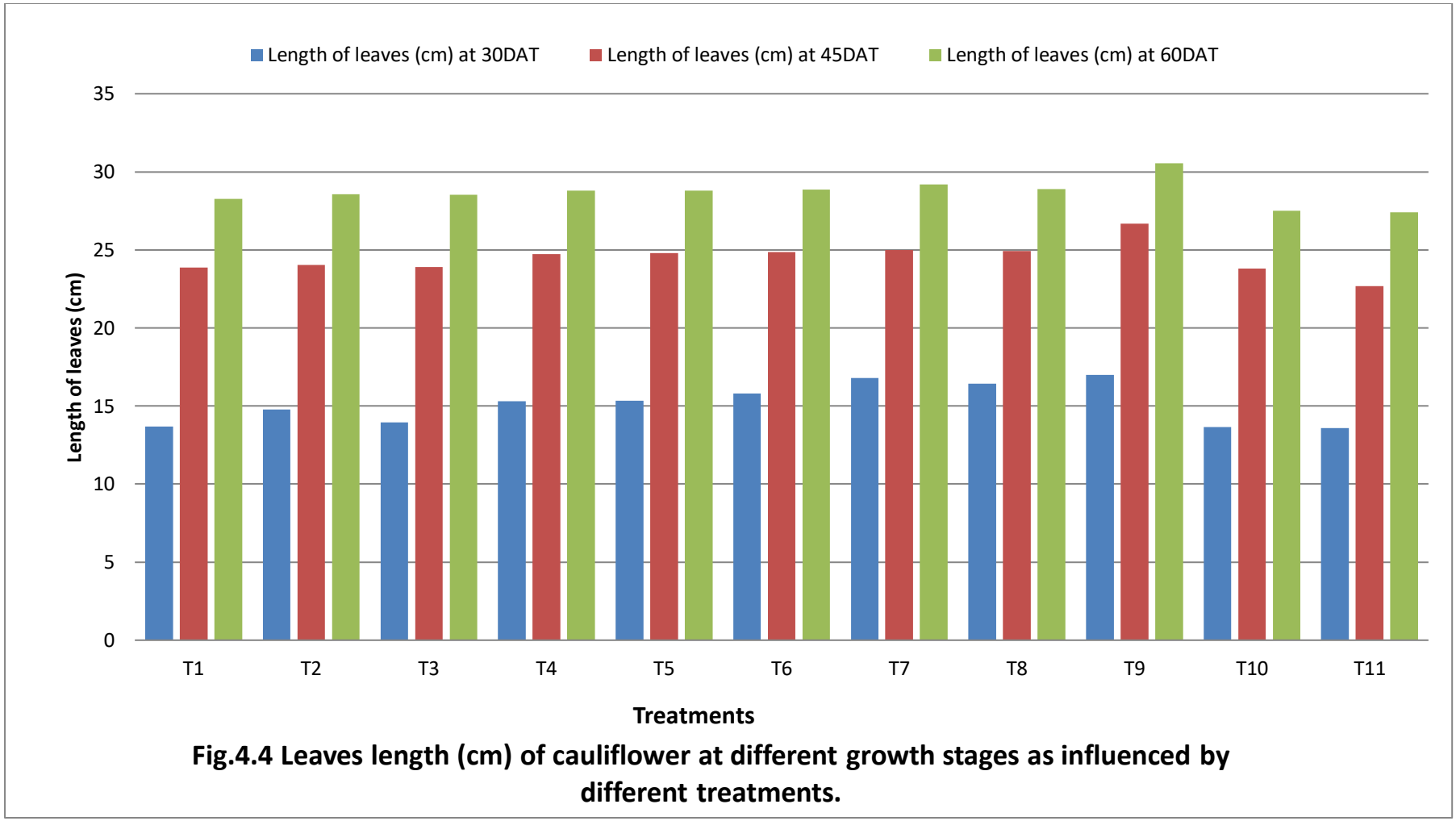

Fig.4.4 Leaves length (cm) of cauliflower at different growth stages as influenced by different treatments.

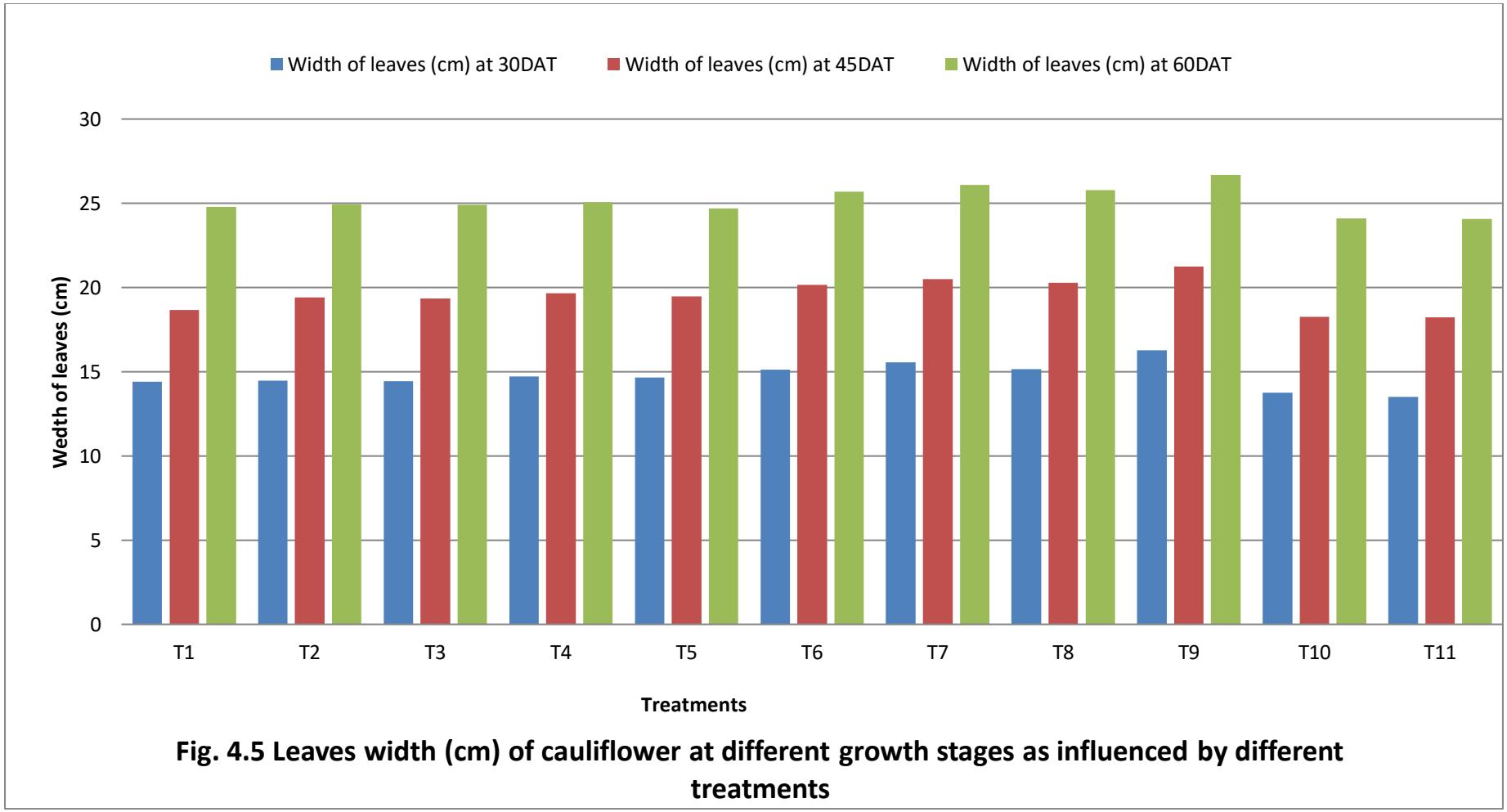

Fig. 4.5 Leaves width (cm) of cauliflower at different growth stages as influenced by different treatments

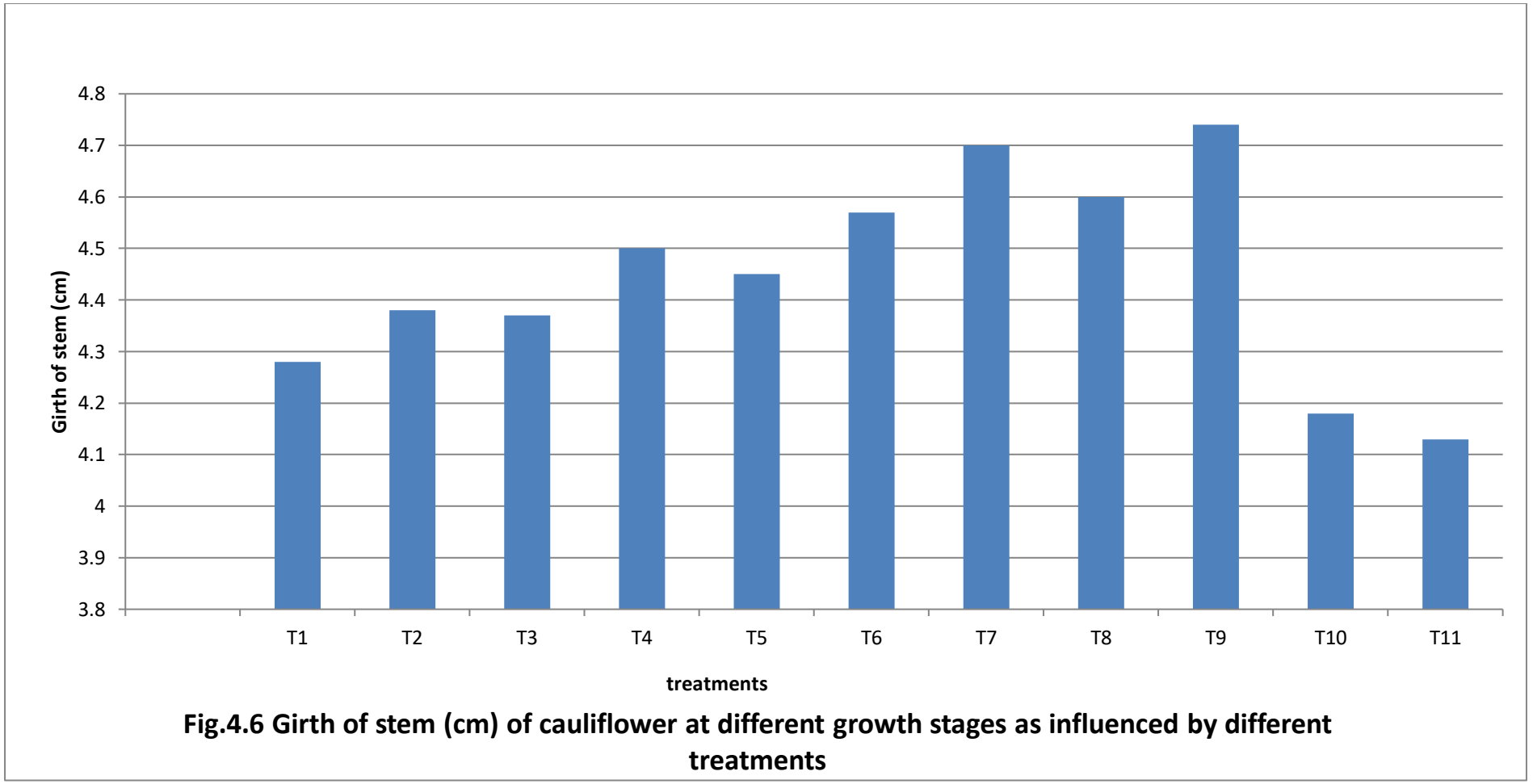

Fig.4.6 Girth of stem (cm) of cauliflower at different growth stages as influenced by different treatments

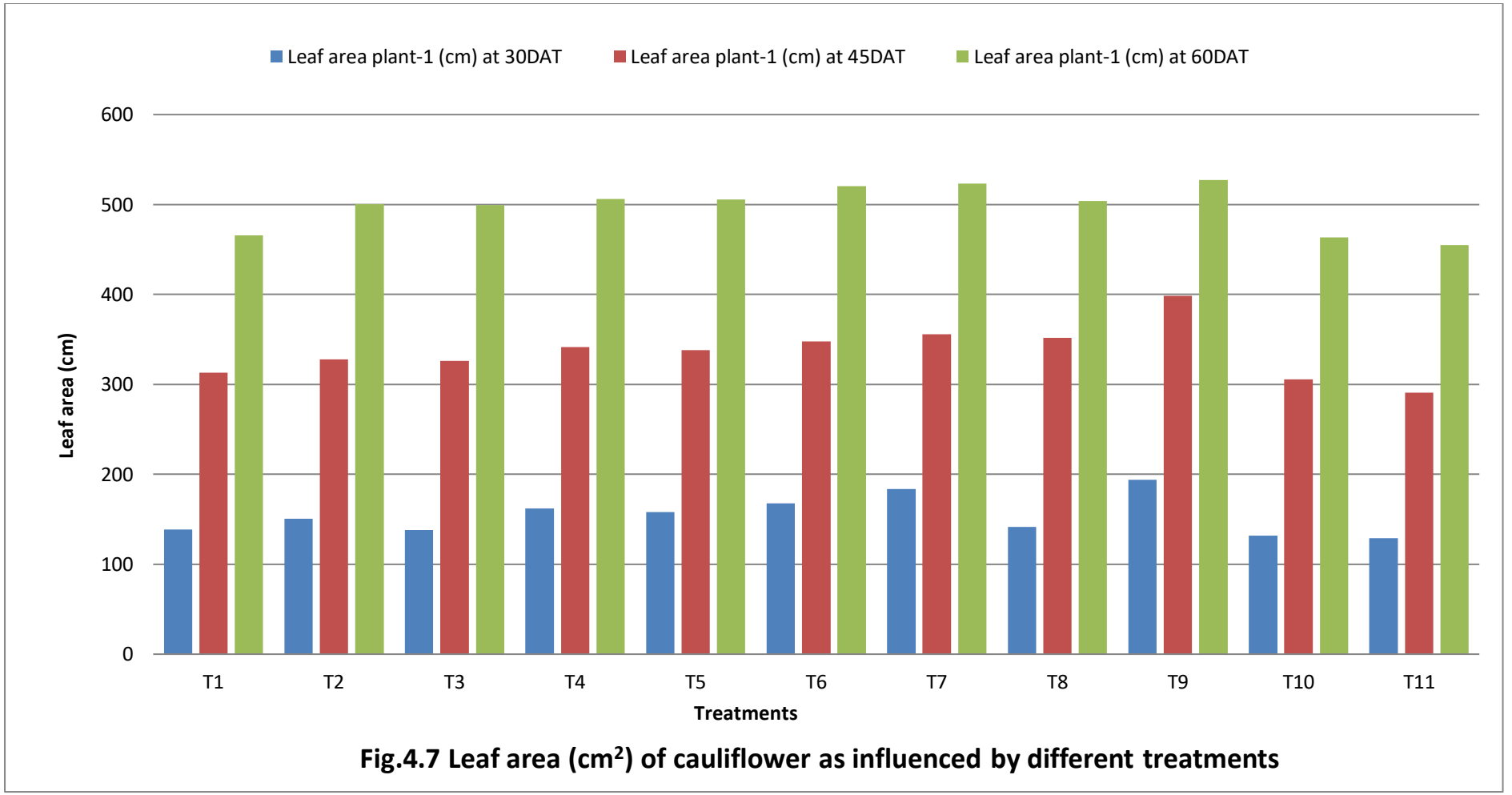

Fig.4.7 Leaf area (cm^2) of cauliflower as influenced by different treatments

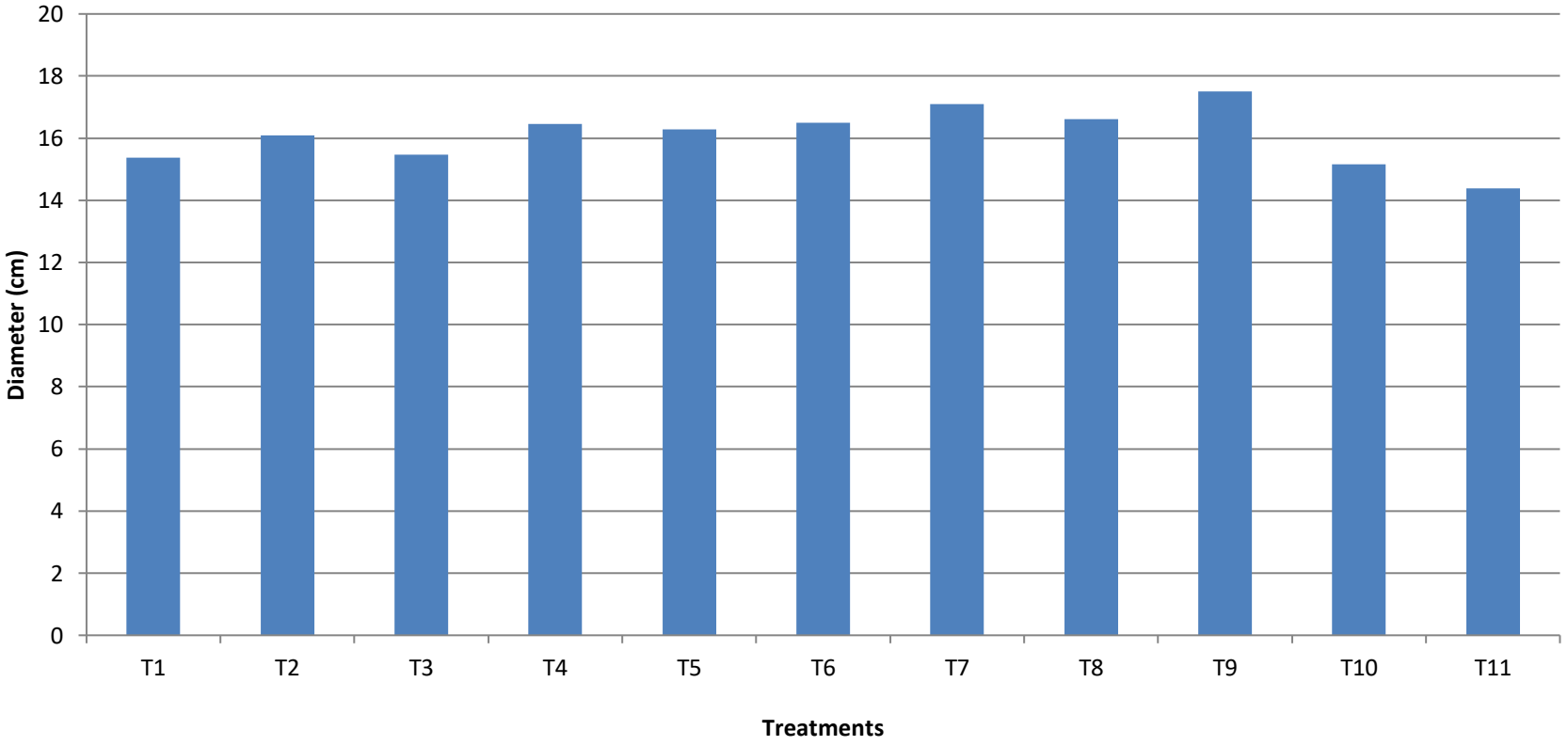

Fig.4.8 Diameter of curd (cm) of cauliflower as influenced by different treatments

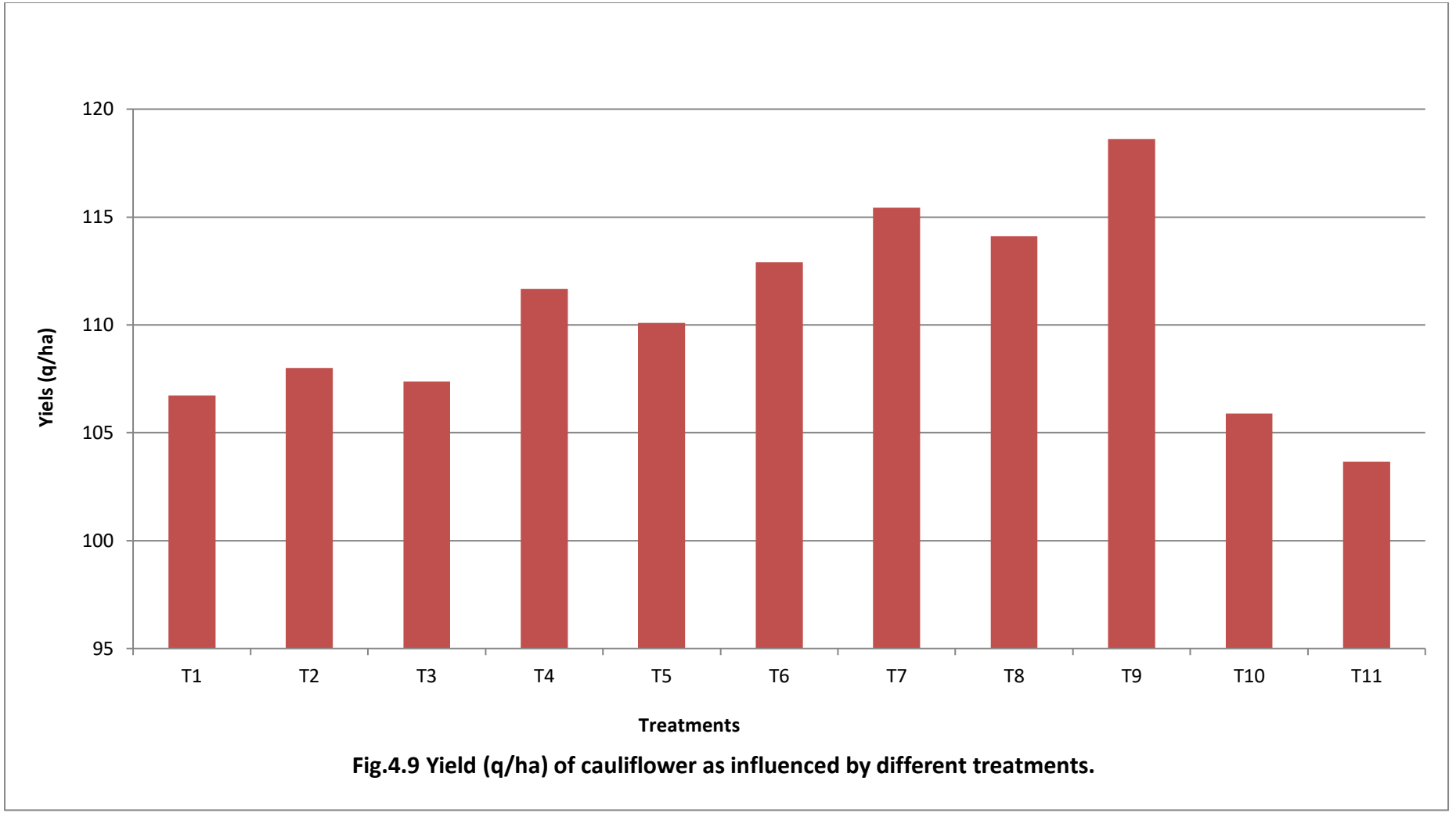

Fig.4.9 Yield (q/ha) of cauliflower as influenced by different treatments.

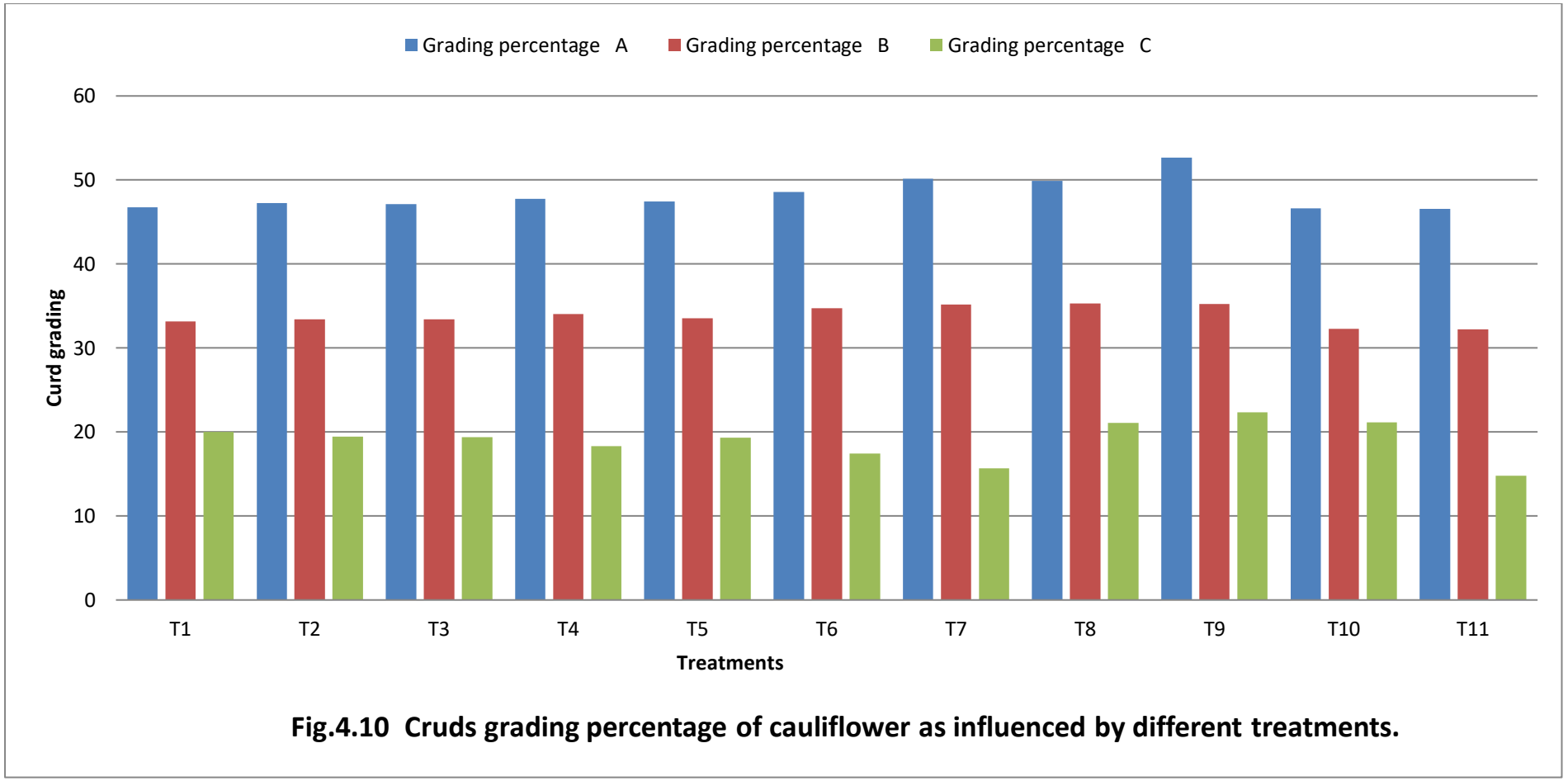

Fig.4.10 Cruds grading percentage of cauliflower as influenced by different treatments.

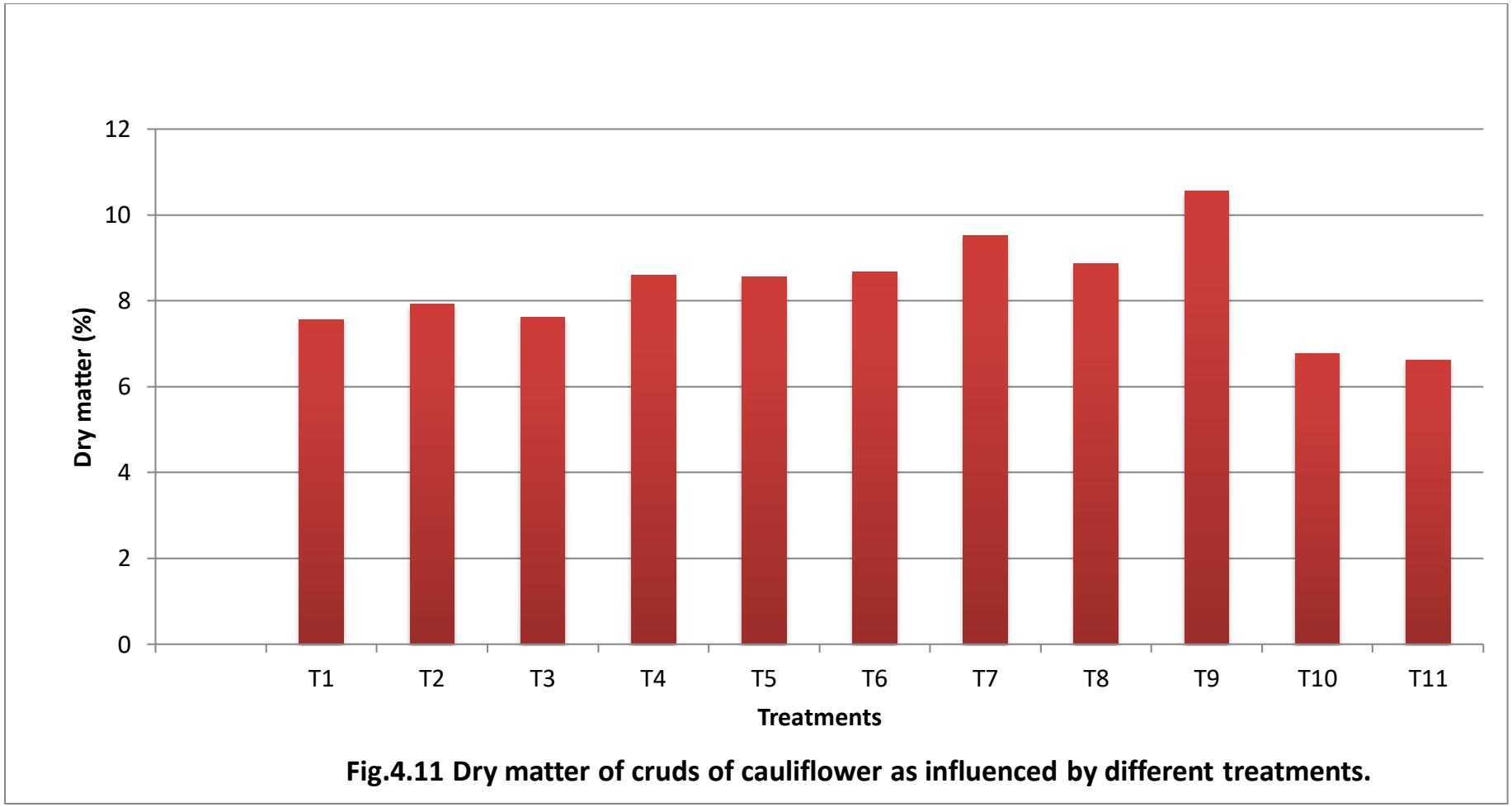

Fig.4.11 Dry matter of cruds of cauliflower as influenced by different treatments.

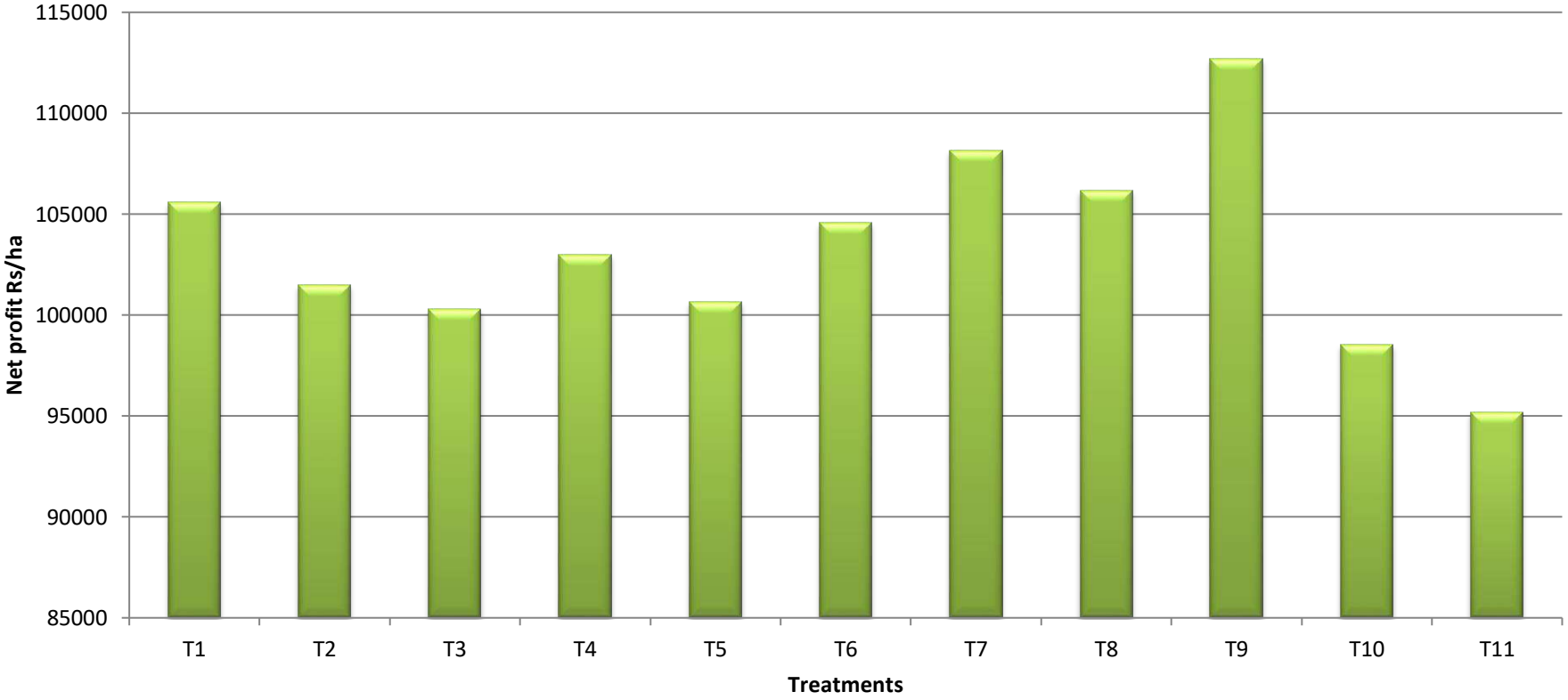

Fig.4.12 Net profit from Cauliflower as influenced by different fertility treatments.

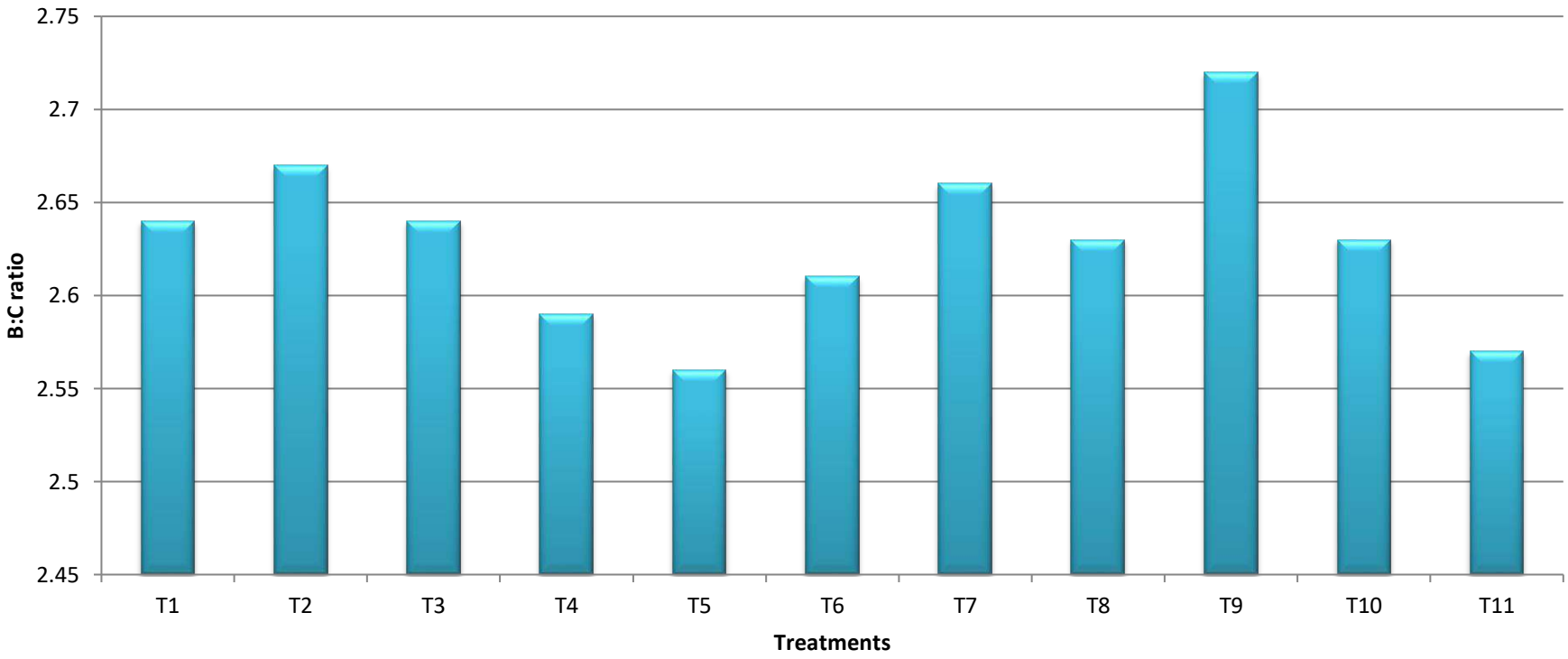

Fig.4.13 B:C ratio from cauliflower as influenced by different fertility treatments.

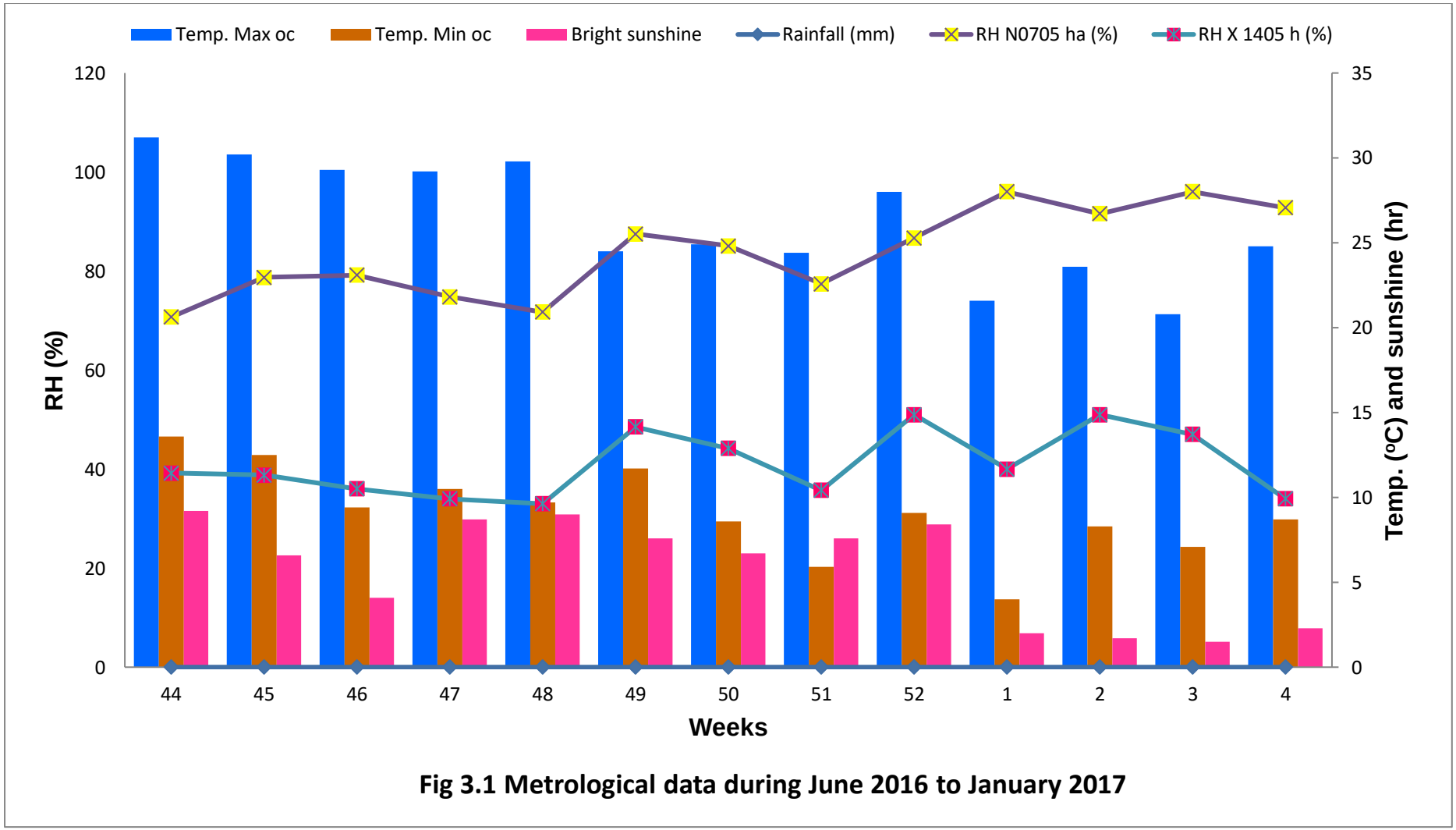

Fig 3.1 Metrological data during June 2016 to January 2017

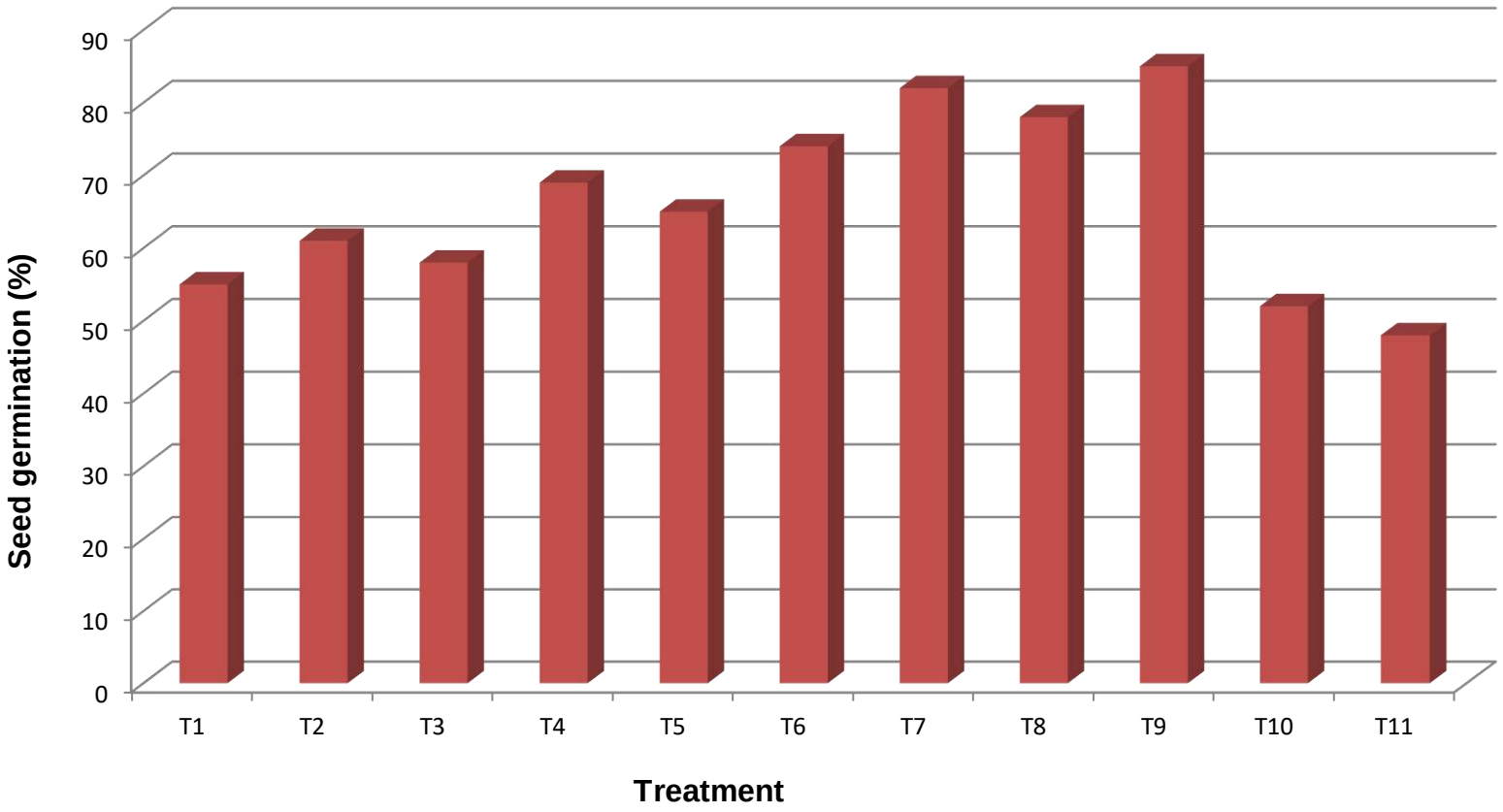

Fig. 4.1 Seed germination (%) of cauliflower as influenced by different treatments.

CHAPTER- V
DISCUSSION

The results of the present investigation entitled **"Study on effect of bio-fertilizers on growth and yield of cauliflower"** have been summarized in Summary Table 5.1 and discussed in the light of the work done. The findings have been discussed in the headings viz. growth, yield and quality parameters.

5.1 Morphological characters

The Treatment T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB resulted in significantly highest seed germination over all the remaining treatments. The second best treatment was T_7 having Vermicompost + *Azotobacter* + PSB. The third rank best treatment was T_8 having Vermicompost + *Azospirillum* + PSB. The treatment T_{11} (control) recorded lower seed germination, closely followed by T_{10}, T_1, T_2 and T_3 as compared to the remaining treatments.

The significantly maximum plant height (22.47, 29.93 and 33.00 cm) of cauliflower was recorded in treatment T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB) at 30, 45 and 60 DAT stages as compared to other treatments. This is closely followed by T_7 (22.28, 28.02 and 32.85 cm) and T_8 (22.09, 28.89 and 32.18 cm). The treatments T_{11} and T_{10} (Control and RDF) resulted in significantly lowest plant height at different level of growth.

The number of leaves per plant was, in general, increased steadily between 30, 45 and 60 days after transplanting (DAT) in all the treatments. At 30 days ranged from 6.22 to 7.52 leaves, at 45 days range from 10.11 to 11.41 leaves and at 60 days range from 15.70 to 19.95 leaves/plant in different treatments. The maximum leaves per plant of cauliflower was recorded in treatment T_7, T_8 and T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB (18.37, 17.98 and 19.95 leaves) and lowest found in T_{11} (15.70 leaves) at 60 DAT of cauliflower.

These findings are also in agreement with the findings of Badaway and Imam (1975), Mohandas (1987), Kalayani et al (1996), Patel et al (1998), Mengistu and Singh (1999), Nanthakumar and Veeraragavathatham (2000), Vivek et al (2001), Kanwar et al (2002), Yadev et al (2003), Choudhury et al (2004), Kashyap et al (2005), Moniruzzaman et al (2007), Kachari and Korla (2009) and Singh et al (2015).

The length of leaves per plant of cauliflower increased significantly with the different treatments having Vermicompost, *Azotobacter*, *Azospirillum*, PSB applied separately and their combinations. The significantly maximum length of leaves was observed under the treatments T_7 having Vermicompost + *Azotobacter* + PSB (16.80, 24.98 and 29.18 cm), T_8 having Vermicompost + *Azospirillum* + PSB (16.44, 24.91 and 28.90 cm) and T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB (16.98, 26.67 and 30.54 cm) as compared to other treatments at 30, 45 and 60 DAT. The minimum length of leaves found in control treatment T_{11} (13.58, 22.68 and 27.42 cm) at 30, 45 and 60 DAT.

In case of width of leaves of cauliflower, the plants responded significantly to various treatments. Application of Vermicompost*, Azotobacter, Azospirillum,* PSB i.e. T_8, T_7 and T_9 registered equally highest leaves width (15.15 to 16.28, 20.28 to 21.25 and 25.78 to 26.69 cm). Significantly lowest leaves width (13.51, 18.23 and 24.06 cm) was noted from the control treatment T_{11} (at 30, 45 and 60 DAT respectively).

These findings corroborate with the findings of Iswaran (1975), Vijay and Mangal (1997), Bhagavantagoudra and Rokhade (2001), Raghav and Shashi (2007) and Velmurugan et al (2008).

The girth of stem of cauliflower increase significantly with different treatments having Vermicompost*, Azotobacter, Azospirillum,* PSB. The significantly maximum leaf area was observed under the treatment T_9 (4.74 cm), followed by T_7 (4.70 cm) and then T_8 (4.60 cm) treatments, while, it was significantly lowest in control T_{11} treatment (4.13 cm).

The maximum leaf area (194.11, 398.53, 527.15 cm^2) was recorded from T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB followed by T_7 (183.47, 355.85 and 523.09 cm^2) and T_8 (141.61, 351.75 and 503.86 cm^2). The minimum leaf area (129.02, 290.92 and 454.92 cm^2) was noted from the control treatment T_{11} (at 30, 45 and 60 DAT respectively).

These findings are also in agreement with those of Parvatham et al (1989), Gamo (1991), Olsen et al (1996), Bambal et al (1998), Bhagavantagoudra and Rokhade (2001), Anburani and Manivannan (2002), Velmurugan et al (2008) and Singh et al (2015).

5.2 Yield parameters

The yield-attributing characters viz. curd diameter, fresh weight of curd, yield per plot (kg/plot) and yield per hac (q/ha) were influenced significantly due to different fertility treatments.

The treatments T_7, T_8 and T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB exhibited equally maximum curd diameter (17.09, 16.61 and 17.50 cm), while the control treatment (T_{11}) recorded the minimum curd diameter.

The fertility treatment T_9 comprising sources of biofertilizers registered significantly maximum yield per hac (118.60 q) and plot (7.116 kg) as compared to the remaining treatments. Similarly the fruit weight was also significantly higher upto 0.85 kg. The second best fertility treatment was T_7 recorded yield 115.44 q/ha and 6.926 kg/plot with fruit weight 0.74 kg and T_8 recorded yield 114.11 q/ha and 6.846 kg/plot with fruit weight 0.72 kg. The control treatment (T_{11}) recorded the minimum curd yield 103.65 q/ha and 6.219 kg/plot with fruit weight 0.37 kg followed by T_{10}, T_1 and T_2 (105.89 to 108.00 q/ha, 6.340 to 6.480 kg/plot with fruit weight 0.40 to 0.53 kg).

These findings are also in agreement with those of Lehri and Mehrotra (1972), County *et at.* (1974), Kucey (1987), Mahendran and Kumar (1990), Subbiah (1990), Subbiah (1991), Jothi et al (1993), Wange et al (1995), Warade et al (1996), Chattoo et al (1997), Nanthakumar and

Veeraragavathatham (1999), Selvarajan and Chezhiyan (2001), Nanthakumar and Veeraragavathatham (2001), Naidu et al (2002), Shalini et al (2002a), Bhattarai et al (2003), Bahadur et al (2004), Narayanamma et al (2004), Chaterjee et al (2005), Pandey et al (2007a), Pandey et al (2008), Kumar and Singh (2009), Khan et al (2010), Gorakh and Keshav (2011) and Singh et al (2014).

5.3 Quality parameters

Amongst the combined application of biofertilizers, T_{11} continued to be the best with respect to quality also. The significantly highest dry matter content (10.55%) and maximum number of "A" grade curds (52.67%) were recorded from the fertility treatment T_{11}. The second best fertility treatment was T_7 (Vermicompost + *Azotobacter* + PSB). On the other hand, the lowest values for dry matter (6.61 to 6.78%) and "A" grade curds (46.54 to 46.59%) were recorded under T_{11} and $T_{10.}$

These findings are also in agreement with those of Bagyaraj et al (1979), Kumaraswamy and Madalageri (1990), Mahendran and Kumar (1990), Gaikwad and Wani (2001), Kumutha et al (2001), Shalini et al, 2002b, Tyagi et al (2003), Pandey et al (2007b), Bashyal (2011), Upadhyay et al (2012) and Kumar and Seema (2016).

5.4 Economics

The higher monetary gain and less cost of cultivation are desirable traits for getting higher returns. It is revealed from the data obtained that a significantly maximum curd yield of cauliflower upto 118.60 q/ha was recorded from T_9 treatment having Vermicompost + *Azotobacter* + *Azospirillum* + PSB. Accordingly, the highest net return of Rs. 112694/ha and B:C ratio 2.72 was recorded from this treatment. The second best treatment was T_7 (Vermicompost + *Azotobacter* + PSB), the net return being upto Rs. 108154 with B:C ratio 2.66. The third best treatment was T_8 having Vermicompost + *Azospirillum* + PSB or T_1 *Azotobacter*. Lower net returns were obtained from the single applied biofertilizers PSB Rs. 100264/ha from *Azospirillum* to Rs. 101494/ha. The lowest net returns only Rs. 95169/ha

and B:C ratio 2.57 were noted from control. Thus, the income was obtained in accordance with the curd yield under the various treatments.

These findings are also in agreement with the findings of Amirthalingam and Balakrishnan (1988), Sharma and Bhalla (1995), Deka et al (1996), Parmar and Sharma (2001), Sharma (2002), Devi et al (2003), Singh and Singh (2005), Sharma et al (2008), Sentiyangla et al (2010), Wani et al (2011), Raj et al (2014) and Sable et al (2016).

CHAPTER- VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

6.1 Summary

The present "**Study on effect of bio-fertilizers on growth and yield of cauliflower"** was carried out during *Kharif* season of 2016-2017 at the Kuthuliya Farm, College of Agriculture, JNKVV, Rewa (M.P.). The experimental material for the present investigation was comprised of 11 treatments comprising biofertilizers which were tried in cauliflower cv. Snow Ball-16. The experiment was laid out in three replications in the Randomized Block Design and with the following objectives:

1. To study the effect of seed treatment on germination.
2. To study the effect of bio-fertilizers on growth and yield of cauliflower.
3. To study the combined effect of organic, inorganic and bio-fertilizers on cauliflower cultivation.
4. To work out the economics of the treatments.

The observations were recorded on the basis of five random competitive plants selected from each treatment separately for morphological, phonological and yield parameters were evaluated as per standard procedures. The analysis of variance components of growth and yield was worked out by Panse and Sukhatme (1967).

The important findings of the present investigation are summarized as below:

1. The significantly maximum plant height, number of leaves per plant, length of leaves, width of leaves, leaf area and girth of stem were recorded in T_9 treatment (Vermicompost + *Azotobacter* + *Azospirillum* + PSB) followed by T_7 and T_8 at 30, 45 and 60 DAT as

compared to other treatments. However, the minimum plant height and other morphological characters were observe under the treatment T_{11} (control) at 30, 45 and 60 DAT stages of plant growth.

2. The fresh weight of curd and curd diameter were significantly influenced by the different treatments. The treatment T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB), T_7 (Vermicompost + *Azotobacter* + PSB) and then T_8 (Vermicompost + *Azospirillum* + PSB) exhibited maximum fresh weight of curd and curd diameter, while, the control treatment recorded the minimum values.

3. The significantly maximum 118.60 q/ha curd yield was recorded under the treatment T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB) as compared to all other treatments. However, the lowest 103.65 q/ha curd yield was observed in treatment T_{11} (control).

4. The application of Vermicompost + *Azotobacter* + *Azospirillum* + PSB (T_9) recorded significantly maximum grade “A” cauliflower curd. This was followed by T_7 (Vermicompost + *Azotobacter* + PSB) and then T_8 (Vermicompost + *Azospirillum* + PSB). The minimum values of these parameters were recorded in control (T_{11}).

5. The dry matter content of curd was significantly influenced by the different treatments. The treatment T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB), T_7 (Vermicompost + *Azotobacter* + PSB) and then T_8 (Vermicompost + *Azospirillum* + PSB) exhibited dry matter content of curd, while, the control treatment recorded the minimum values.

6. The most remunerative treatment was T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB) which gave maximum net return (Rs 112694/ha) and B:C ratio (2.72). The second best treatment was T_7 (Vermicompost + *Azotobacter* + PSB) being Rs 108154/ha with B:C ratio 2.66. The third best treatment was T_8 (Vermicompost + *Azospirillum* + PSB) which gave net income up to Rs 106159/ha and B:C ratio 2.63.

6.2 Conclusion

On the basis of present investigation, it is concluded that the “study on effect of bio-fertilizers on growth and yield of cauliflower cv Snow ball-16” in term of growth, yield and net profit to all the treatments. The treatment T_9 having Vermicompost + *Azotobacter* + *Azospirillum* + PSB showed that the maximum yield of cauliflower (118.60 q/ha) and net income upto Rs 112694/ha with B:C ratio 2.72 as compared to other treatments. The best combination of bio-fertilizers T_9 (Vermicompost + *Azotobacter* + *Azospirillum* + PSB), T_7 (Vermicompost + *Azotobacter* + PSB) and T_8 (Vermicompost + *Azospirillum* + PSB) are more profitable and recommended for commercial cultivation for growth, yield and quality of cauliflower cv Snow Ball-16.

6.3 Suggestions for further work

1. The bio-frtilizers combination should be repeated in different agro-climatic conditions and those found suitable could be recommended for commercial cultivation.

2. Inorganic fertilizers with bio-fertilizers based recommendation should be popularized among the farmers to get sustainable yield of cauliflower.

3. The soil fertility levels may be remained after crop harvest in application of bio-fertilizers.

Table No. 6.1 Morphological and quality parameters of cauliflower as influenced by biofertilizers.

Treat.	Treatments details	Plant height (cm) at 60 DAT	Number of leaves/plant at 60 DAT	Length of leaves (cm) at 60 DAT	Width of leaves (cm) at 60 DAT	Girth of stem (cm)	Leaf area (cm^2) at 60 DAT	Grading percentage			Dry Matter of curd (%)
								A	B	C	
T_1	*Azotobacter*	30.18	16.59	28.25	24.80	4.28	465.45	46.72	33.13	20.04	7.55
T_2	*Azospirillum*	31.41	17.28	28.55	24.95	4.38	500.36	47.25	33.41	19.45	7.93
T_3	PSB (Phosaphorus Solubilizing Bacteria)	30.83	15.95	28.54	24.91	4.37	499.41	47.15	33.38	19.38	7.61
T_4	Vermicompost + *Azotobacter*	31.89	17.00	28.78	25.05	4.50	506.22	47.76	34.05	18.32	8.59
T_5	Vermicompost + *Azospirillum*	32.29	17.75	28.78	24.68	4.45	505.41	47.42	33.54	19.31	8.56
T_6	Vermicompost + PSB	32.42	17.69	28.87	25.68	4.57	520.53	48.56	34.75	17.45	8.67
T_7	Vermicompost + *Azotobacter* + PSB	32.85	18.37	29.18	26.09	4.70	523.09	50.16	35.20	15.70	9.52
T_8	Vermicompost + *Azospirillum* + PSB	32.18	17.98	28.90	25.78	4.60	503.86	49.87	35.27	21.07	8.87
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	33.00	19.95	30.54	26.69	4.74	527.15	52.67	35.25	22.32	10.55
T_{10}	RDF	30.95	15.85	27.51	24.09	4.18	463.36	46.59	32.28	21.16	6.78
T_{11}	Control	28.67	15.70	27.42	24.06	4.13	454.92	46.54	32.24	14.78	6.61
	S.Em±	0.43	0.38	0.51	0.37	0.14	0.19	0.16	0.08	0.21	0.21
	C.D. (5%)	0.87	0.77	1.04	0.76	0.29	0.40	0.33	0.17	0.42	0.43

Table No. 6.2 Yield parameters and economical grain cauliflower as influenced by biofertilizers.

Treat.	Treatments details	Fresh weight of curd (kg)	Curd diameter (cm)	Yield Per Plot (kg/ha)	Yield Per hac (q/ha)	Gross return (Rs/ha)	Total expenditure (Rs/ha)	Net income (Rs/ha)	B:C ratio
T_1	*Azotobacter*	0.41	15.37	6.403	106.72	160080	60506	105574	2.64
T_2	*Azospirillum*	0.53	16.10	6.480	108.00	162000	60506	101494	2.67
T_3	PSB (Phosaphorus Solubilizing Bacteria)	0.61	15.47	6.442	107.38	161070	60806	100264	2.64
T_4	Vermicompost + *Azotobacter*	0.58	16.46	6.700	111.66	167490	64506	102984	2.59
T_5	Vermicompost + *Azospirillum*	0.56	16.28	6.606	110.10	165150	64506	100644	2.56
T_6	Vermicompost + PSB	0.70	16.50	6.774	112.91	169365	64806	104559	2.61
T_7	Vermicompost + *Azotobacter* + PSB	0.74	17.09	6.926	115.44	173160	65006	108154	2.66
T_8	Vermicompost + *Azospirillum* + PSB	0.72	16.61	6.846	114.11	171165	65006	106159	2.63
T_9	Vermicompost + *Azotobacter* + *Azospirillum* + PSB	0.85	17.50	7.116	118.60	177900	65206	112694	2.72
T_{10}	RDF	0.40	15.16	6.340	105.89	158835	60306	98529	2.63
T_{11}	Control	0.37	14.38	6.219	103.65	155475	60306	95169	2.57
	S.Em±	9.42E-09	0.26	1.15	1.04	--	--	--	--
	C.D. (5%)	1.92E-08	0.54	2.35	2.11	--	--	--	--

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APPENDICES

Appendix-I

Cost of cultivation/ha for all the treatments for cauliflower

S. No.	Particulars	Unit	Qty	Rate/ unit (Rs)	Cost (Rs/ha)
A.	**Land preparation**				
1.	Ploughing with M.B. plough @ 0.4 ha/hr	Hrs.	2.5	500	1250
2.	Disc harrow	Hrs.	4	500	2000
3.	Planking and leveling	Hrs.	1	500	500
4.	Layout of the field	Labour	10	250	2500
B.	**Sowing**				
1.	Cost of seed (500 g/ha)		500 g		600
2.	Labour for sowing and transplanting	Labour	70	250	17500
C.	**Cost of fertilizer**				
	Urea (N_{100})		217 kg	Rs.13/kg	2821
	Single super phosphate (P_{60})		375 kg	Rs.22/kg	8250
	Murate of potash (K_{80})		133 kg	Rs.14/kg	1862
D.	**Gap filling**	Labour	5	250	1250
E.	**Irrigation**				
1.	Tube well charges – 6 irrigation (2 hrs/irrigation)	Hrs.	12	600	7200
2.	Labour for irrigation	Labour	6	250	1500
F.	**Harvesting, transporting and marketing**	Labour	30	250	7500
G	**Rental value**				100
H	**Interest of working capital 10%**				5473
	Total				**60306**

	Cost of biofertilizer			Rs/ha
1.	Azotobacter	15 kg	Rs.15/kg	225
2.	Azospirillum	15 kg	Rs.15/kg	225
3.	PSB (Phosaphorus Solubilizing Bacteria)	15 kg	Rs.33/kg	495
4.	Vermicompost	5 ton		**4000**

Appendix-II

Calculation of economical gain/ha from different treatment combinations of cauliflower.

Tr. No.	Treatments	Cauliflower yield (q/ha)	Gross return (Rs/ha)	Cost of cultivation	Expdt. on the treatment	Total expenditure (Rs/ha)	Net income (Rs/ha)	B:C ratio
T_1	Azotobacter	106.72	160080	60306	200	60506	105574	2.64
T_2	Azospirillum	108.00	162000	60306	200	60506	101494	2.67
T_3	PSB	107.38	161070	60306	500	60806	100264	2.64
T_4	Vermicopost + Azotobacter	111.66	167490	60306	4200	64506	102984	2.59
T_5	Vermicopost + Azospirillum	110.10	165150	60306	4200	64506	100644	2.56
T_6	Vermicopost + PSB	112.91	169365	60306	4500	64806	104559	2.61
T_7	Vermicopost + Azotobacter + PSB	115.44	173160	60306	4700	65006	108154	2.66
T_8	Vermicopost + Azospirillum + PSB	114.11	171165	60306	4700	65006	106159	2.63
T_9	Vermicopost + Azotobacter + Azospirillum + PSB	118.60	177900	60306	4900	65206	112694	2.72
T_{10}	Recommended dose of fertilizer	105.89	158835	60306	-	60306	98529	2.63
T_{11}	Control	103.65	155475	60306	-	60306	95169	2.57

Appendix-III

Analysis of variance for seed germination (%)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	0.727273	0.363636	0.083333	2.83
Treatments	10	4694.727	469.4727	107.5875	1.94
ERROR	20	87.27273	4.363636		
Total	35				

Appendix-IV

Analysis of variance for plant height (cm) at 30 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	18.73379	9.366894	2.219036	2.83
Treatments	10	22.83754	2.283754	0.541026	1.94
ERROR	20	84.42308	4.221154		
Total	35				

Appendix-V

Analysis of variance for plant height (cm) at 45 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	43.25585	21.62793	22.48489	2.83
Treatments	10	56.53642	5.653642	5.877655	1.94
ERROR	20	19.23775	0.961887		
Total	35				

Appendix-VI

Analysis of variance for plant height (cm) at 60 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	31.02044	15.51022	41.60933	2.83
Treatments	10	49.99702	4.999702	13.41272	1.94
ERROR	20	7.455164	0.372758		
Total	35				

Appendix-VII

Analysis of variance for number of leaves per plant at 30 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	1.034418	0.517209	32.86143	2.83
Treatments	10	5.200473	0.520047	33.04176	1.94
ERROR	20	0.314782	0.015739		
Total	35				

Appendix-VIII

Analysis of variance for number of leaves per plant at 45 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	12.68413	6.342064	52.36457	2.83
Treatments	10	5.4078	0.54078	4.465063	1.94
ERROR	20	2.422273	0.121114		
Total	35				

Appendix-IX

Analysis of variance for number of leaves per plant at 60 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	38.11982	19.05991	64.86373	2.83
Treatments	10	48.17402	4.817402	16.39434	1.94
ERROR	20	5.876909	0.293845		
Total	35				

Appendix-X

Analysis of variance for length of leaves (cm) at 30 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	38.92477	19.46238	33.88919	2.83
Treatments	10	49.92192	4.992192	8.692734	1.94
ERROR	20	11.4859	0.574295		
Total	35				

Appendix-XI

Analysis of variance for length of leaves (cm) at 45 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	53.53958	26.76979	87.60009	2.83
Treatments	10	30.29585	3.029585	9.91386	1.94
ERROR	20	6.111818	0.305591		
Total	35				

Appendix-XII

Analysis of variance for length of leaves (cm) at 60 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	73.59978	36.79989	69.71909	2.83
Treatments	10	20.96902	2.096902	3.972677	1.94
ERROR	20	10.55662	0.527831		
Total	35				

Appendix-XIII

Analysis of variance for width of leaves (cm) at 30 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	6.053745	3.026873	1.378475	2.83
Treatments	10	18.30665	1.830665	0.833707	1.94
ERROR	20	43.91625	2.195813		
Total	35				

Appendix-XIV

Analysis of variance for width of leaves (cm) at 45 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	70.62122	35.31061	116.6024	2.83
Treatments	10	27.12109	2.712109	8.955907	1.94
ERROR	20	6.056582	0.302829		
Total	35				

Appendix-XV

Analysis of variance for width of leaves (cm) at 60 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	72.02347	36.01174	126.4222	2.83
Treatments	10	20.08716	2.008716	7.051762	1.94
ERROR	20	5.697061	0.284853		
Total	35				

Appendix-XVI

Analysis of variance for leaf area (cm^2) at 30 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	90.33307	45.16654	153.8127	2.83
Treatments	10	13513.39	1351.339	4601.926	1.94
ERROR	20	5.872927	0.293646		
Total	35				

Appendix-XVII

Analysis of variance for leaf area (cm^2) at 45 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	81.29572	40.64786	193.0578	2.83
Treatments	10	25124.95	2512.495	11933.14	1.94
ERROR	20	4.210952	0.210548		
Total	35				

Appendix-XVIII

Analysis of variance for leaf area (cm^2) at 60 DAT

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	91.18548	45.59274	576.9086	2.83
Treatments	10	18780.42	1878.042	23763.84	1.94
ERROR	20	1.580588	0.079029		
Total	35				

Appendix-XIX

Analysis of variance for girth of stem (cm)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	104.0198	52.00989	1257.161	2.83
Treatments	10	1.203818	0.120382	2.909818	1.94
ERROR	20	0.827418	0.041371		
Total	35				

Appendix-XX

Analysis of variance for fresh weight of curd (kg)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	0.0088	0.0044	2.48E+13	2.83
Treatments	10	0.722891	0.072289	4.07E+14	1.94
ERROR	20	3.55E-15	1.78E-16		
Total	35				

Appendix-XXI

Analysis of variance for curd diameter (cm)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	82.12595	41.06297	284.4627	2.83
Treatments	10	24.87316	2.487316	17.23082	1.94
ERROR	20	2.887055	0.144353		
Total	35				

Appendix-XXII

Analysis of variance for yield per plot (kg)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	31.85573	15.92787	5.941593	2.83
Treatments	10	2.275563	0.227556	0.084886	1.94
ERROR	20	53.6148	2.68074		
Total	35				

Appendix-XXIII

Analysis of variance for yield (q/ha)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	37.51965	18.75983	8.669984	2.83
Treatments	10	626.1254	62.61254	28.93682	1.94
ERROR	20	43.27535	2.163767		
Total	35				

Appendix-XXIV

Analysis of variance for grading percentage of cruds (A)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	88.20765	44.10383	2820.43	2.83
Treatments	10	38.19856	3.819856	244.2789	1.94
ERROR	20	0.312745	0.015637		
Total	35				

Appendix-XXV

Analysis of variance for grading percentage of cruds (B)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	88.20765	44.10383	2820.43	2.83
Treatments	10	38.19856	3.819856	244.2789	1.94
ERROR	20	0.312745	0.015637		
Total	35				

Appendix-XXVI

Analysis of variance for grading percentage of cruds (C)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	92.78989	46.39495	519.6249	2.83
Treatments	10	159.1823	15.91823	178.2847	1.94
ERROR	20	1.785709	0.089285		
Total	35				

Appendix-XXVII

Analysis of variance for dry matter of curd (%)

SOURCE	DF	SS	MS	F CAL	f tab
REP	2	84.68031	42.34015	461.4502	2.83
Treatments	10	40.51822	4.051822	44.15936	1.94
ERROR	20	1.835091	0.091755		
Total	35				

CURRICULUM VITAE

Name – **Bhoopendra Kumar Patel**

Permanent address –
Village – Pipariya Digambar, Post- Hathna
Tehlis + District – Damoh (M.P.)
Date of birth – **15 Jan. 1990**

Institution	Degree	University	Year	OGPA/%
College of Agriculture Rewa (M.P.)	M.Sc.(Ag.) Agric. Eco. & F.M.	JNKVV, Jabalpur	2017	7.2
College of Agriculture Rewa (M.P.)	B.Sc. (Ag.)	JNKVV, Jabalpur	2015	6.8
Govt. Adarsh Multipurpose Higher Secondary Excellence School Damoh	12th (Agric.)	M.P. Board	2008	81.20

For the partial fulfillment of the master degree programme, he was allotted a field research experiment on **"Study on effect of bio-fertilizers on growth and yield of cauliflower"** which was successfully conducted by him and being submitted in the form of this thesis.