"EFFECT OF ORGANIC, INORGANIC AND BIO-FERTILIZER ON GROWTH AND YIELD OF ONION (*Allium cepa* L.) CV. GJRO-11"

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"Effect of organic, inorganic and bio-fertilizer on growth and yield of onion (*Allium cepa* L.) Cv. GJRO-11"

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ABSTRACT

An investigation entitled "Effect of organic, inorganic and bio-fertilizer on growth and yield of onion (*Allium cepa* L.) Cv. GJRO-11" was carried out at Horticultural Research Farm, College of Horticulture, Anand Agricultural University, Anand during the *Rabi* season of the year 2018-19. The experiment was carried out in Randomized Block Design with three replication comprising ten treatments. *Viz.,* T_1 - 100 % RDF (control), T_2 - 75 % RDF + 25 % N from FYM, T_3 - 75 % RDF + 25 % N from vermicompost, T_4 - 75 % RDF + 25 % N from castor cake, T_5 - 50 % RDF + 50% N from FYM, T_6 - 50 % RDF + 50% N from vermicompost, T_7 - 50 % RDF + 50% N from castor cake, T_8 - 50 % RDF + 25 % N from FYM + 5 ml Bio-NPK Consortium, T_9 - 50 % RDF + 25 % N from vermicompost + 5 ml Bio-NPK Consortium and T_{10} - 50 % RDF + 25 % N from castorcake + 5 ml Bio-NPK Consortium. The soil application of half dose of nitrogen and full dose of phosphorus and potash apply at the time of transplanting and remaining 50% nitrogen apply 30 DAT.

The soil application of 50% RDF (50: 37.5: 37.5 NPK kg/ha) + 25% N from vermicompost + 5 ml Bio-NPK consortium was most effective treatment and it recorded significantly maximum plant height (70.11 and 86.70 cm at 45 and 90 DAT respectively), minimum bolting per cent (4.38), average bulb weight (129.30 g), bulb volume (136.70 cc), neck thickness (1.11 cm), bulb yield (24.18 kg/plot and 497.60 q/ha) and TSS (13.47 ^{o}Brix), while number of leaves per plant was non-significant.

The maximum A and B grade bulb yield (395.98 q/ha and 91.50 q/ha, respectively) while minimum C grade bulb yield (10.01 q/ha) was recorded in application of 50% RDF + 25% N from vermicompost + 5 ml Bio-NPK Consortium.

Application of 50 % RDF + 50 % N from FYM was having significantly maximum avaibility of N, P_2O_5, K_2O and Organic carbon (369, 44.67, 331 kg/ha and 0.39 %, respectively).

Application of 50 % RDF + 25 % N through FYM + 5 ml Bio-NPK consortium (T8) recorded maximum Azotobacter, Azopirillum, PSB, KMB and Total count of bacteria.

It can be concluded from the present investigation that use of organic, inorganic and biofertilizers had a significant impact on the growth and yield of onion because the application of 50% RDF + 25% N from vermicompost + 5 ml Bio-NPK consortium shows maximum plant height, average bulb weight, bulb volume, neck thickness, bulb yield, A and B grade, T.S.S.

Application of 50 % RDF + 50 % N from FYM recorded significantly maximum avaibility of N, P_2O_5, K_2O and Organic carbon of the soil.

While application of 50 % RDF + 25 % N through Farm yard manure + 5 ml Bio-NPK consortium recorded maximum Azotobacter, Azopirrilum, PSB, KMB and Total count of bacteria.

Net realization and BCR was observed maximum in application of 50% RDF (50: 37.5: 37.5 NPK kg/ha) + 25% N from Vermicompost + 5 ml Bio-NPK Consortium.

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CERTIFICATE

This is to certify that the thesis entitled "Effect of organic, inorganic and bio-fertilizer on growth and yield of onion (*Allium cepa* L.) *cv.* GJRO-11" Submitted by **Mr. Kalpeshbhai Shivabhai Vaghela** in partial fulfillment of the requirements for the degree of Master of Science (Horticulture) in Vegetable Science of the Anand Agricultural University is a record of bonafide research work carried out by him under my personal guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: ANAND **(K. M. PATEL)**
Date: /07 /2019 **Major Advisor**

DECLARATION

This is to declare that the whole of research work reported here in the thesis for partial fulfillment of the requirement for the degree of **Master of Science (Horti.)** in **Vegetable Science** by the undersigned is a result of investigation done by me under direct guidance and supervision of **Dr. K. M. Patel**, Associate Professor & Head, Department of Horticulture, College of Agriculture-Vaso, Anand Agricultural University and no part of work has been submitted for any other degree so far.

Place: Anand **(Vaghela Kalpeshbhai S.)**

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1. INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important vegetable bulbous crops grown in India from ancient time. Onion is the "Queen of the kitchen". The edible portion is a modified stem which is known as 'bulb' and develops underground. Onion is preferred mainly because of its green leaves, immature and mature bulbs are either eaten raw or cooked as vegetables. It is popular as salad crop and mature onion bulbs are widely used as a cooked vegetable in soups stews and casseroles in addition to a flavouring agent in many additional dishes. It is one of the few versatile vegetable crops that can be kept for a fairly long period and can safely withstand the hazards of rough handling including long distance transportation.

Onion belongs to family Alliaceae. The origin of onion is Central Asia. The Allium genus comprises of 300 to 500 species, which are widely distributed in Northern temperate region (Thompson and Kelley, 1957). It is one of the most important vegetable cash crops grown throughout the year. Onion is considered to be the most important valuable vegetable all over the world. The edible portion is formed by swollen leaf sheath derived from bladed leaves and the inner ones are bulb scales. The entire unit is known as bulb and develops underground. It is one of the most widely and commonly used vegetables in different forms and purposes due to its flavour. It is used for flavouring or seasoning the food, both at mature and immature bulb stages. To a lesser extent, it is used in processing industry for dehydration in the form of flakes and powder, which are in great demand in the World market.

Onion also possesses nutritional and medicinal importance. Onion bulb is rich in minerals like phosphorus and calcium, and carbohydrates. It also contains proteins and vitamin C. The bulbs are acrid, sweet, aromatic, thermogenic, antiperiodic, antibacterial, aphrodisiac, expectorant, stimulant, carminative, appetite, stomachic, diuretic, anodyne and tonic. Besides these, it has several medicinal properties such as useful against malarial fever, jaundice, asthma, bronchitis, opthalmia, vomiting, ostalgia, lumbago, tumor, wounds, paralysis, arthralgia, leucoderma, skin disease, disorder of spleen, lever and respiratory tract. The outstanding characteristic of onion is pungency which is due to volatile oil known as Allyl-propyl-disulphide. It acts as a gastric stimulant and promotes digestion. It contain 87.5 percent water and provides

energy to the extent of 4 g calories, 20 I.U. vitamin A, 0.12 mg riboflavin, 0.1 mg niacin, 1.2 mg albuminoides and 0.4 mg ash per 100 g of fresh edible portion.

In world, India ranks 2nd in area and production of onion. India is prominent in the production and export of onion in the world. Onion is being grown in area of 1285 (‘000 ha) with total bulb production of 23262 (‘000 MT). (Anon., 2018). In India it is widely cultivated in Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Bihar, Andhra Pradesh, Rajasthan, Haryana and Tamil Nadu. Maharashtra ranks first in Onion production with a share of 27.72%.

In Gujarat, onion occupie an area of about (54488 ha) with total bulb production of 1416602 MT (Anon., 2018). The major onion growing districts are Bhavnagar, Rajkot, Amreli, Junagadh, Jamnagar, Porbandar, Kutch, Mehsana, Surat and Anand. Bhavanagar is a leading district for onion cultivation coverup 32,000 ha area and 870400 MT production. (Anon., 2018).

Usually onion is grown in the Northern part of the country during *rabi* season. However in the Southern and Western states it is grown in *rabi*, *winter* as well as in *kharif* season. India grows three types of onion i.e, Red, White and Yellow. The bulk of the onion produced in the India is of red variety. It is estimated that 50-60% of onion comes from the *rabi* crop and the rest comes from the *kharif* and *late kharif* crops. *Kharif* onions are sold immediately after harvest and the *rabi* onions which are harvested in April-May are stored up to November till the *kharif* crop comes to market.

As regard to the productivity the combined application of organic manures and inorganic fertilizers to increase yield has paramount importance. Use of inorganic fertilizers increases cost of cultivation. Secondly the sole application of inorganic fertilizers deteriorates soil fertility level day by day, which affect the production, economics of production and human health, while organic manure and bio-fertilizers are cheap, easily available and eco-friendly, giving quality produce, improving keeping quality, T.S.S. and pungency. It improves the physiochemical properties like soil structure, infiltration rate, porosity, water holding capacity, bulk density, etc. and also very useful for the sustainable crop production as well as soil fertility and productivity.

Organic manures acts as a buffering agents and supplies food for beneficial living organisms. Organic manures helps to control the plant parasitic nematodes and fungi up to some extent by altering the balance of micro-organisms in the soil. Farm

Yard Manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed FYM contain 0.5% N, 0.2% P_2O_5 and 0.5% K_2O. FYM increases the status of organic carbon, available nitrogen, phosphorus and trace elements in the soil, FYM also improves the physical condition of the soil.

Vermicompost is a natural organic fertilizer obtained after vermicomposting in which composting worms, through the natural digestive process, turn organic wastes into worm castings. It is an eco-friendly approved and improves aeration and water holding capacity of the soil, enriches soil microbial populations add plant hormone such as Auxin and Gibberellic acid, nitrogen fixing bacteria, actinomycetes and microbial association of mycorrhizae of plant root system and enzymes such as phosphatase and cellulase), enhance germination, plant and root growth (as it has a growth promoting humic substance that accelerate root development) and crop yield. Microbial activities in worms casting is 10-20 times higher than in the soil and organic matters that the worms ingests, it also attract deep burrowing earthworms already present in the soil. The nitrogen, phosphorus and potassium content in vermicompost are 3.0, 1.0 and 1.5 percent, respectively.

Castor cake is also called as castor meal. Castor cake is an organic by product of castor seed oil production. Castor cake is used as a natural fertilizer. It enhances the fertility of the soil. Castor cake contain 4.3% N, 1.8% P_2O_5, and 1.3% K_2O. It also contains trace nutrient like Manganese, Zinc and copper thus making a balanced fertilizer. They provide slow and steady nourishment, stimulation, protection from soil Nematodes and insects. It improves physical, chemical and biological properties of the soil.

Nitrogen is the most commonly deficient nutrient in the soil and gives considerable response in onion crop. It has the quickest and the most pronounced effect on plant growth and development and ultimately on crop yield.

Phosphorus is the second most important essential element after nitrogen. It plas key role in the vital energy transformation process and rightly called the “mineral of life”. It is a constituent of nucleic acid, phospholipids and co-enzyme NADP which is constituent of ATP an energy rich bond. Adequate phosphorus in the soil is essential for nitrogen uptake, root development, improvement in quality of bulbs hasten the maturity of crop and increase resistancy in disease.

Potassium is the third essential element to limit the plant growth and therefore, very common constituent of fertilizers. It increases the sugar content of bulb, imparts increased vigour and disease resistant to plant and helps in formation of protein and chlorophyll.

Biofertilizers are microbial preparation containg living cells of different micro-organisms which have the ability to mobilize plant nutrient of soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production. Biofertilizers are used in live formulation of beneficial micro-organism which is use for seed, root and soil. In recent years, biofertilizer NPK consortium are gaining much popularity. Bio-NPK consortium contain five strains of agriculturally beneficial microorganism (two Nitrogen fixer, two Phosphate solubilizer and one potash mobilizer) is the one time solution for all the macronutrient (N, P, and K) requirement of crop. Use of Bio-NPK consortium @ 3-5 ml for root dipping treatment can save up to 25% N, P, K chemical fertilizer with increase in growth and yield with reduction of soil, water and air pollution.

Keeping into consideration the above facts the investigation entitled **"Effect of organic, inorganic and bio-fertilizers on growth and yield of onion (*Allium cepa* L.) Cv. GJRO-11"** was carried out during *Rabi* season, 2018-19 at Horticulture Farm, B.A.College of Agriculture, Anand Agricultural University, with the following objective:

OBJECTIVE

1. To study the effect of organic, inorganic and bio-fertilizer on growth and yield of onion.

2. REVIEW OF LITERATURE

The growth and yield of any vegetable crop depends upon many factors, amongst them recommended dose of organic, inorganic and biofertilizer play an important role. The literature pertaining to the effect of organic, inorganic and biofertilizer on growh and yield of onion bulb is limited especially in respect to the research work carried out in our country. However, attempts have been made to review and report in brief the available literature concerning the investigation entitled **"Effect of organic, inorganic and biofertilizer on growth and yield of onion (*Allium cepa* L.) cv. GJRO-11".**

The relevant literature available has been reviewed and highlighted under the following broad topics:

2.1 Effect of organic fertilizers on growth and yield of onion.

2.2 Effect of inorganic fertilizers on growth and yield of onion.

2.3 Effect of biofertilizers on growth and yield of onion.

2.4 Effect of organic and inorganic fertilizers on growth and yield of onion.

2.5 Effect of organic and biofertilizers on growth and yield of onion.

2.6 Effect of inorganic and biofertilizers on growth and yield of onion.

2.7 Effect of organic, inorganic and biofertilizers on growth and yield of onion.

2.1 Effect of organic fertilizers on growth and yield of onion.

Bourdi and Malakouti (2007) carried out research work on the effect of different organic fertilizers (animal manure, compost, and vermicompost) on the yield and quality of red onion in Khosrowshahr and Bonab, Iran, during growing seasons of 2003 and 2004. They indicated that the highest yield (71.1 t/ha) was obtained with the application of vermicompost @ 6 t/ha.

Abdullah (2008) carried out research work on effect of vermicompost and vermiwash on the productivity of spinach (*Spinacia oleracea*), onion (*Allium cepa*) and potato (*Solanum tuberosum*) during 1998-2000. They obtained significantly higher bulb yield in treatment Vermiwash (1:10 v/v in water @ 1 kl/ha), whereas the average weight of bulb was significantly higher in Vermicompost @ 6 t/ha + Vermiwash (1:5 v/v in water @ 1 kl/ha).

Ansari (2008) carried out the investigation to study the effect of vermicompost and vermiwash in reclaimed sodic soils on the productivity of spinach (*Spinacia oleracea*), onion (*Allium cepa*) and potato (*Solanum tuberosum*) during 1998-2000 in Lucknow, India. They concluded that yield (6.48 t/ha) of onion was significantly higher in plots treated with vermiwash (1:10 v/v in water) and average bulb weight (65.37 g) was significantly greater in plots amended with vermicompost and vermiwash (1:5 v/v in water), whereas the highest organic carbon (0.79%) was present in treatment Vermicompost @ 6 t/ha + Vermiwash (Natural @ 1 kl/ha) but significantly higher available nitrogen was present in application of Vermicompost @ 6 t/ha + Vermiwash (1:10 v/v in water @ 1 kl/ha).

Lee *et al*. (2010) studied the effect of application methods of organic fertilizer on growth, soil chemical properties and microbial densities in organic bulb onion production during 2005–2006. They concluded that application of organic manures recorded higher total soluble solids in onion as compared to inorganically produced onion bulbs.

Khalel (2013) carried out an experiment on the effect of organic fertilizer on the growth and yield of green onion cv. White Local during 2012-2013. The results showed that poultry manure added at rate of 40 kg/100 m^2 produced maximum number of leaves per plant (27.62), yield, average weight of the bulb (86.42 g) and the average diameter of bulb (3.82 cm).

Meena *et al.* (2014) carried out research work on the effect of organic nitrogen management on yield, quality, economics and nutrient uptake of onion during summer season of 2004 and 2005 with the use of (FYM, VC and PM) and rates of inorganic manures (100 %, 125 %, 150 % RND) on yield, quality and economics of onion (Pusa Red) on a sandy clay-loam soil low in available N and medium in available phosphorus and potassium. They observed that the application of organic manure significantly influenced the yield attributes and bulb yield of onion over 100 % RDN as urea (control).

Naik *et al.* (2014) carried out an experiment on the effect of different organics on yield and quality of organically grown onion during *rabi* 2009-10 to 2011-12. The results revealed that leaf length (44.0cm) and average bulb weight (50.5g) was significantly higher in Vermicompost + Castorcake.

Chavan *et al.* (2016) carried out research work on the effect of different organic manures on growth and yield of onion (yield of onion (*Allium cepa* L.) during kharif season-2014. They observed the maximum values of growth parameters like plant height (57.18 cm) and number of leaves (9.90) at harvest in treatment 50% N through poultry manure + 50% N through neem cake. The yield contributing characters like weight of bulb (126.64 g), diameter of bulb (65.47 mm), yield per plot (19.49 kg), and yield per hectare (54.13 t) were found significantly maximum in treatment 50% N through vermicompost + 50% N through poultry manure.

Adeyeye *et al.* (2017) studied the comparative effect of organic and inorganic fertilizer treatments on the growth and yield of onion (*Allium cepa* L.). They result revealed that the maximum number of leaves (8.50) and bulb weight (50.60g) was under application of 10 t/ha Poultry Manure.

Mahala *et al.* (2018) studied the yield and quality of *rabi* onion (*Allium cepa* L.) influenced by integrated nutrient management. They concluded that application of 5 t/ha Poultry Manure increased fresh weight of bulb (65.90g), bulb yield (305.08 q/ha) and TSS (11.14%).

Singh and Sharma (2018) studied the efficacy of farmyard manure for growth and yield of onion (*Allium cepa* L.) cv. N-53. They concluded that the 280 t/ha FYM (140% N) recorded maximum plant height (47.87 cm), number of leaves per plant (11.85), fresh weight of bulb (116.7g) and bulb diameter (5.6 cm).

2.2 Effect of inorganic fertilizers on growth and yield of onion.

Deho *et al.* (2002) studied the NPK trial on onion. They concluded that the application of 80 N + 60 P_2O_5 + 40 K_2O (kg/ha) gave the highest number of leaves (11.6), plant height (39.07 cm) and bulb yield (2869 kg/ha).

Khan *et al.* (2007) carried out research work on the response of onion (*Allium cepa* L.) growth and yield to different levels of nitrogen and zinc in swat valley during 2003-04. They reported the maximum plant height, number of leaves, bulb weight and bulb yield with application of 100 kg N/ha through chemical fertilizer.

Mandloi *et al.* (2008) carried out research work on the effect of organic manures and inorganic fertilizers on growth and yield of onion (*Allium cepa* L.) during winter season of 2004-05 at the Krishi Vigyan Kendra, Kuthulia. They concluded that the plant height (59.05cm), number of leaves per plant (11.40), fresh weigh of bulb (56.79g) and bulb yield (378.61 q/ha) were significantly maximum under RDF (125 N: 60P: 100 K kg/ha).

Ghanti and Sharangi (2009) carried out research work on the effect of bio-fertilizers on growth, yield and quality of onion cv. Sukhsagar during the winter season of two consecutive years 2006-07 and 2007-08. They reported that the plant height was maximum (43.46cm) with the application of Azotobacter+VAM. No. of leaves was maximum in *Azotobacter* + *Azospirillum*. The plants raised under NPK 100% produced the maximum bulb weight 67.45g. TSS % was found maximum (12.29%) from NPK 100%. It is therefore, concluded that Azotobacter+Azospirillum combination is the best for onion as compared to others so far as the sustainability in production and environmental consideration are concerned.

Ibrahim Abuga (2014) studied the effect of inorganic fertilizer on onion production. They concluded that application of NPK @ 10 g/polybag boosted the performance of onion.

Banjare *et al.* (2015) carried out an experiment on the effect of organic substances on yield and quality of onion during the year 2012-13. They concluded that 100 per cent recommended doses of fertlizers (RDF) resulted into maximum neck thickness (1.25 cm), average weight of bulb (66.98 g), yield (34.87 t/ha) and TSS (8.71%).

Mollah *et al.* (2015) conducted research work on the effect of organic manures on the yield and quality of seeds of onion during the period of September, 2010 to June 2011. They observed that among different treatments, inorganic fertilizer Urea, TSP, MOP, Gypsum, Zinc oxide and Boric acid at the rate of 250, 275, 150, 110, 3 and 5 kg/ha, respectively along with Cowdung 7.5 t/ha was the best for true seed production of onion.

Vedpathak and Chavan (2016) carried out an experiment on effects of organic and chemical fertilizers on growth and yield of onion (*Allium cepa* L.). They concluded that bulb yield (9.105 kg/plot) was significantly maximum under Chemical fertilizer- 100 N: 50 P: 50 K kg/ha.

Bhati *et al.* (2018) studied the effect of levels of inorganic fertilizers, organic manure and bio-fertilizers on plant growth attributes of onion (*Allium cepa* L.) cv. N-53 under hot arid region of western Rajasthan, India. They clearly shown that application of 100% inorganic fertilizers significantly increased plant height (54.58 cm) at 90 DAT, followed by 20 t/ha FYM over the other treatments. While in number of leaves per plant (6.77) was maximum under 20 t/ha FYM.

Sahu and Singh (2018) studied the effect of integrated nutrient management and bio-enhancer on yield and yield attribute of *rabi* onion (*Allium cepa* L.) during the year 2015-16. They found significantly maximum equatorial diameter of bulb (5.41 cm), neck thickness (1.65 cm) and bulb weight (66.98 g) with application of 100% RDF (100 N: 80 P: 80 K kg/ha).

2.3 Effect of biofertilizers on growth and yield of onion.

Ghanti and Sharangi (2009) carried out an experiment on the effect of bio-fertilizers on growth, yield and quality of onion cv. Sukhsagar during the winter season of two consecutive years *i.e.* 2006-07 and 2007-08. They concluded that Azotobacter + Azospirillum combination was found as the best for onion as compared to others so far as the sustainability in production and environmental consideration are concerned.

Sridevi *et al.* (2010) conducted research work on the effect of combined inoculation of AM fungi and *Azospirillum* on the growth and yield of onion. They concluded that inoculation of AM fungi and *Azospirillum* significantly increased the plant height (61.19 cm), bulb diameter (4.91 cm) and bulb yield (310.73 q/ha) over their respective control.

2.4 Effect of organic and inorganic fertilizers on growth and yield of onion.

Geetha *et al.* (1999) found that the dry matter content in the onion bulbs and potash uptake at various stages of growth increased with the application of FYM (25 t/ha) and muriate of potash (200 kg/ha). The recommended dose of FYM + NPK produced significantly highest bulb yield (370.39 q/ha).

Mondal *et al.* (2004) carried out research work on the integrated management of organic and inorganic sources of nutrient to improve productivity and qualitative characters of rice and onion in rice-onion cropping sequence during 2002-03. They revealed that application of neem seed powder, along with 75% of NPK through inorganic fertilizer gave significantly highest number of leaves per plant (13.58), bulb yield (15.25 t/ha) and bulb diameter.

Patil *et al*. (2007) carried out research work on the response of garlic to organic and inorganic fertilizers at Maharashtra during *rabi* 2005. They reported that the combined application of 25 % RDF with 75 % N through FYM @ 20 t/ha gave maximum plant height at 120 DAP (71.90cm), number of leaves (10.80), higher marketable garlic bulb yield (19.34 t/ha) as compared to other treatments which were statistically at par with 100% RDF and 50 % RDF + 50 % N supplied as FYM.

Singh *et al.* (2008) studied the effect of integrated use of FYM and inorganic fertilizers on yield and uptake of nutrients by onion during the winter season of 1998-99 to 1999-2000. They observed that the highest bulb yield (34.70 t/ha) of onion was recorded under 100% NPK + 10 t/ha FYM and it was statistically on par with 150% NPK. The lowest yield of onion bulbs (20.05 t/ha) was recorded in control treatment.

Chuda *et al*. (2009) carried out on the experiment on effect of integrated nutrient management on growth, yield and quality of *kharif* onion under terraced condition of Nagaland. They results revealed that 50% NPK+50% FYM recorded significantly higher plant height (45.45 cm), number of leaves/plant (12.67), neck thickness (2.95 cm), bulb size (5.84 cm), doubling (1.78%), bulb yield (141.47 q/ha), and TSS (12.11°Brix).

Hari *et al.* (2009) studied the Effect of organic manures in combination with 'N' fertilizer on growth and yield of onion under irrigated condition of Central Telangana Zone of Andhra Pradesh during *rabi* 2005-06 and 2006-07. They observed that application of 7 t/ha Vermicompost +75% RNF significantly produced highest bulb weight (75.53 g) and bulb yield (202.85 q/ha); whereas application of 20 t/ha Neem cake +75% RNF was highest in T.S.S (%).

Krishnamurthy *et al.* (2009) counducted research work on the effect of integrated nutrient management on soil nutrient status and balance in onion production under irrigated condition during *rabi* season of 2002-03. They repated that the integrated use of organics and fertilizers produced significantly higher bulb yield.

Sharma *et al.* (2009) carried out research work on the effect of vermicompost, farmyard manure and chemical fertilizers on yield, nutrient uptake and soil fertility in okra (*Abelmoschus esculentus*) - onion (*Allium cepa*) sequence in wet temperate zone of Himachal pradesh during 2004 and 2005. They reported significantly highest yield of onion (8.38 and 12.56 t/ha during 2003-04 and 2004-05), organic carbon (13.9 g/kg), and available N (303 kg/ha), P (28.1 kg/ha), K (345 kg/ha) was obtaine in 12.5 t/ha vermicompost + 100% NPK was at par with application of 25 t/ha FYM + 100% NPK.

Mohd *et al.* (2011) studied the effect of organic and inorganic fertilizers on growth, yield and quality of garlic cv. GG-1 at Navsari during *rabi* season in the year 2007-2008. They reported that 25 % RDF + 75 % through FYM showed maximum number of leaves per plant 120 at DAP (10.86), height of plant at 120 DAP (68.27 cm), bulb yield (179.43 q/ha) and TSS (46.28 ^{o}Brix compared to other treatments.

Reddy *et al.* (2011) carried out research work on the integrated effect of vermicompost and nitrogen fertilizers on soil nutrient status and yield of onion-radish cropping system during *kharif* (onion) and *rabi* (radish) seasons of 2007-08. They observed that application of 10 t/ha vermicompost + 120 kg N/ha recorded significantly maximum fresh bulb yield (24.45 t/ha) at harvest. However, the radish crop grown during *rabi* responded favourably to the residual and cumulative treatments and the highest root yield (23.43 t/ha) was recorded application of 10 t/ha vermicompost + 120 kg N/ha.

Jawadagi *et al.* (2012) carried out an experiment on the effect of different sources of nutrients on growth, yield and quality of onion (*Allium cepa* L.) Cv. Bellary Red during *rabi* 2006-07 and *kharif* 2007-08. They observed significantly maximum, leaf length and number of leaves with the application of RDF (125: 50: 125 NPK kg/ha) + FYM (30 t/ha) followed by the application of 50% FYM (12.50 t/ha) + 50% Vermicompost (2 t/ha) + Biofertilizers in both the seasons.

Singh *et al*. (2012) carried out research work on the effect of NPK with different doses of organic manures on growth and yield of garlic (*Ailium sativum* L.) Var Yamuna Safed-2 during the *rabi* season of 2006-07. They reported that 50 % RDF + 25 t/ha FYM was found superior with respect to plant height (71.05cm), bulb diameter (4.0cm), bulb yield (8.57 t/ha), TSS (21.00 ^{o}Brix) and benefit cost ratio under Allahabad agro-climatic condition.

Barman *et al.* (2013) carried out an experiment on the combined effect of organic manure and potassium on growth and yield of onion cv. bari piaz-1 during the year 2010-2011. They reported that the combination of 10 t cowdung and 250 kg K/ha gave the higher plant height (22.79 and 46.60 cm at 40 and 70 DAT), number of leaves (6.40 at 70 DAT), individual bulb weight (51.23 g) and bulb yield (12.83 t/ha); whereas the control treatment gave the lower plant height, number of leaves, diameter of bulb, individual weight of bulb and bulb yield (9.16 t/ha).

Mandal *et al.* (2013) carried out research work on the proportional substitution of chemical fertilizers with vermicompost on the growth and production potential of onion during winter 2009-2010. They reported that the application of 50% vermicompost + 50% NPK recorded maximum plant height (42.7 cm), neck diameter (1.31 cm), average bulb weight (78.4 g) and bulb yield (52.26 t/ha) of onion, while maximum TSS (15.01 Brix) observed in 100% VC.

Azam *et al.* (2013) conducted research work on the effect of different source of nutrients on the performance, growth and quality of summer onion during *rabi* season 2008-2009. They observed that higher level of inorganic NPK S (120:45:85:40 kg/ha) + 5 t/ha cowdung produced significantly higher plant height (39.57 cm), number of leaves per plant (7.83) and yield (18.76 t/ha). The results also indicated that the same treatment recorded the highest single bulb weight.

Damse *et al.* (2014) conducted research work on the effect of integrated nutrient management on growth and yield of garlic during *rabi* 2010-11, 2011-12 and 2012-13. They conducted that application of 100:50:50:50 kg NPKS + 20 t/ha FYM was maximum plant height (61.43cm) and neck thickness (0.75cm), wereas 75:40:40:40 kg/ha NPKS + 7.5 t/ha FYM + 3.5 t/ha poultry manure produced better bulb yield (150.41 q/ha) and benefit cost ratio (1.68).

Shilpi *et al.* (2014) carried out an experiment on the effect of organic manures and inorganic fertilizers on growth, yield and quality of brinjal cv. Pant Rituraj during winter season 2012-2013. They result revealed maximum plant height (47.33cm), number of leaves per plant (103.77), fruit diameter (8.88 cm) and fruit yield (75.93 t/ha) under 25% RDF + 75% Neemcake over all the treatment.

Sultana *et al.* (2014) studied the influence of integrated organic-inorganic nitrogen on growth and nutrient concentration of summer onion during *kharif* (March to October) season. They reported that treatment 80 kg N/ha supplied from urea and 40 kg N/ha substituted by cowdung gave the highest plant height (39.25cm), bulb weight (30.40 g) and bulb yield (12.16 t/ha) followed by treatment 80 kg N/ha supplied from urea and 40 kg N/ha substituted by vermicompost.

Mohanty *et al.* (2015) studied the effect of nutrient management on the growth and productivity of onion during winter 2010-2011. They concluded that 50% FYM +50% NPK gave maximum plant height (38.20 cm), whereas 50% PM + 50% NPK gave maximum number of leaves (12.30), However the maximum bulb weight (71.20g) and bulb yield (353.80 q/ha) was recorded in treatment 50% VM + 50% NPK.

Singh *et al.* (2015) carried out an experiment on the efficacy of different sources of nutrients and bio-fertilizers on the growth yield and quality of onion during the winter season 2013-14. They concluded that application of 50% recommended dose of NPK along with 50% recommended dose of the vermicompost resulted in maximum vegetative growth (Plant height, number of leaves, neck thickness) and

bulb growth (bulb weight, bulb length, diameter and size) which is at par with (50% recommended NPK + 50 % FYM), recommended dose of NPK. Similarly, maximum yield per hectare was found in 50% recommended NPK + 50% vermicompost as compared to control.

Rabari *et al.* (2016) studied that the effect of nutrient management on growth, TSS content, bulb yield and net realization from onion bulb during the years 2011-12 in *rabi* season on loamy sand soil. They reported maximum plant height (78.80 cm), bulb yield (13.38 t/ha) and TSS (33.33 %) under the 75 % RDF + 1.25 t/ha Vermicompost.

Shah *et al.* (2016) studied the effect of inorganic and organic manures on growth, yield and quality of onion cv. 'Pusa Madhvi' under valley condition of garhwal Himalaya during *rabi* season, 2013-2014. The results showed that maximum plant height (73.18 cm) and leaf length (56.10 cm) was recorded under the 75% RDF + 25% poultry manure. While the maximum number of leaves (13.60), bulb diameter (6.59 cm), fresh weight of bulb (159.79 g) and bulb yield (41.88 q/ha) was recorded highest under 75% RDF + 25% vermicompost.

Sinha *et al.* (2017) studied the integrated nutrient management approach for increasing growth, yield and economics of onion during *rabi* season. They concluded that the application of 25% N of RDF as inorganic + 75% N from poultry manure as organic source showed significant influence on plant height (51.2 cm), number of leaves/ plant (8.56), length of leaves (42.92 cm), bulb diameter (5.85 cm), average bulb weight (49.64 g), bulb volume (60.28 cc), total yield (288.41 q/ha) with highest trend in this treatment, which was found better over the 25% N of RDF as inorganic + 75% N from vermicompost, sole application of poultry manure (100% N of RDF was supplemented through poultry manure) and remaining all treatments.

Singh and Singh (2018) studied the effect of integrated nutrient management on growth and yield of onion (*Allium cepa* L.) Cv. Nasik red during *rabi* season 2014-2015. They significantly influenced the growth and yield parameters of onion such as plant height (57.33cm), number of leaves sheath / per plant (10.00), stem girth of plant (2.31cm), fresh weight of bulb (120.39gm), diameter of bulb (6.95cm), bulb yield/plot (3.10kg), and bulb yield/ha (29.6t) under the treatment 10 t/ha vermicompost + 75% RDF.

2.5 Effect of organic and biofertilizers on growth and yield of onion.

Indira and Singh (2014) conducted experiment on the effect of vermicompost and biofert1lizer on yield and quality of *rabi* onion (*Allium cepa* L.) cv. Puna Red during *rabi* season of 2008-2009. They recorded significantly highest bulb yield (269.52 q/ha), weight of bulb (42.13 g) and TSS was recorded under vermicompost @ 20 t/ha and *Azotobacter* seed treatment.

Meena *et al.* (2014) carried out an experiment on the effect of organic nitrogen management on yield, quality, economics and nutrient uptake of onion during summer season of 2004 and 2005 to find out the effect of various sources (FYM, VC and PM) and rates of inorganic manures (100 %, 125 %, 150 % RND) on yield, quality and economics of onion (Pusa Red) on a sandy clay-loam soil low in available N and medium in available phosphorus and potassium. Result revealed that the application of organic manure significantly influenced the yield attributes and bulb yield of onion over control (100 % RND as urea).

Shedeed *et al.* (2014) carried out research work on the effectiveness of bio-fertilizers with organic matter on the growth, yield and nutrient content of onion (*Allium cepa* L.) plants during two seasons 2011 and 2012. They found that the Organic manure 20 % + Bio-fertilizers obtained maximum bulb weight (23.94 g).

Somashekar (2014) conducted research work on the effect of different combinations of organic manures and supplementation of bio-fertilizers on growth, yield and quality of onion during rabi, 2013-14. They observed that among different organic manures, farmyard manure (50%) + vermincompost (25%) + neem cake (25%) + *Azospirillum* and PSB @ 5 kg/ha each can be considered as the best treatment for obtaining higher growth and bulb yield.

Dhaker *et al.* (2017) studied the effect of different organic manures on yield and quality of onion (*Allium cepa* L.) during *rabi* season 2016-17. They revealed that application of organic manure significantly influenced the diameter of bulb (8.77cm), average bulb weight (129.08g), bulb yield (219.44 q/ha) and total soluble solid (12.04^{o}B) with 100% RDF through Vermicompost + PSB + Azotobactor.

2.6 Effect of inorganic and biofertilizers on growth and yield of onion.

Gajbhiye *et al.* (2003) studied the effect of biofertilizers on growth and yield parameters of tomato. They observed that the Biofertilizers in combination with chemical fertilizers (*Azotobacter* with 150 kg N + 60 kg P + 60 kg K/ha) as the best

treatment which significantly influenced plant height, number of primary branches per plant, number of fruits per plant, weight of fruits per plant and fruit size.

Aswani *et al.* (2005) carried out an experiment on the effect of nitrogen and bio-fertilizer on yield and quality of *rabi* onion (*Allium cepa* L.) cv. Puna Red during *rabi* season. They concluded that the application of 100 kg N/ha significantly increased bulb yield and quality attributes, while treatment combination (100 kg N/ha + Azotobacter with seedling dipping) gave highest bulb yield (269.52 q/ha) and fresh weight of bulb (49.14 g), followed by treatment 75 Kg N/ha + Azotobacter with seedling dipping.

Yadav *et al.* (2005) studied the effect of different biofertilizers in association with phosphorus on growth and yield of onion (*Allium cepa* L.), a white onion var. JNDWO. They reported the maximum bulb yield under treatment combination of 75 % recommended P_2O_5 + *Azospirillum* biofertilizer application.

Mahanthesh *et al.* (2008) studied the influence of integrated nutrient management on bulb yield, bulb size and other characters of onion bulbs in *rabi* season under irrigated situation. The results revealed the application of *Azospirillum* + 100 % N + PK (*Azospirillum* + 125:50:125 NPK kg/ha) as the best in improving the bulb yield (339.02 q/ha), bulb weight (54.66 g), bulb volume (65.16 ml), neck diameter (1.90 cm), bulb diameter.

Waghmode *et al.* (2010) carried out an experiment on the effect of biofertilizer and gibberellic acid on growth and yield of onion during *rabi* season 2005-2006. They concluded that the application of gibberellic acid (100 ppm) along with bio-fertilizer (*Azospirillum* + PSB 6 kg/ha and VAM @ 10 kg/ha) was effective in increasing bulb yield (43.5 t/ha).

Kumar *et al.* (2011) carried out an experiment on the efficacy of bio-fertilizers with NPK on growth and yield of onion (*Allium cepa* L.) cv. NASIK RED during the *rabi* season of the year 2008-09. They concluded that the application of *Azospirillum* + 100% NPK as the best effective treatment maximum plant height (43.14 cm), neck thickness (1.48 cm), diameter of bulb (7.16 cm), weight of bulb (187.32 g) and bulb yield (12.26 kg/plot).

Sedera *et al.* (2012) studied the effect of bio and mineral fertilizers on vegetative growth and productivity of spring onion during the two successive winter seasons of 2007-08 and 2008-09. They observed that combination between 100% chemical fertilizers (NPK) and biofertilizers (nitrobeine, phosphorene and potassaiumage) on vegetative growth, bulb yield and its components as well as yield quality.

Yogita and Ram (2012) carried out research work on the effect of chemical and bio-fertilizers on quality of onion. They showed maximum TSS (13.27%) with the application of (100 kg N + 50 kg P + 70 kg K/ha + 2 kg/ha *Azotobacter* + 1.9 kg/ha VAM) in onion.

Abdullahi and Sheriff (2013) studied the effect of Arbuscular Mycorrhizal fungi and chemical fertilizer on growth and shoot nutrients content of onion under field condition in northern sudan savanna of nigeria during the year 2008-2009. They found that the plants inoculated with Arbuscular mycorrhizal fungi and combined application of NPK (60-30-50 kg/ha) produced plants with highest growth parameters like plant height (30.58 cm) and number of leaves (13.66) respectively as compared to un-inoculated plants with high dosages (120-60-50 kg/ha NPK) of fertilizers.

Brinjh *et al.* (2014) studied the effect of integrated nutrient management on growth, yield and quality in onion cv. Pusa Madhvi. They observed that maximum plant height (73.33cm) was recorded under the 75% RDF + 25 % Vermicompost, while length of leaves (64cm), number of leaves (13.33) and neck thickness (1.69cm) were found in 75% RDF + 25% Azotobacter. Whereas, yield (42.33 t/ha) were observed in 75% RDF + 25% Phosphobacteria and all the growth and yield parameters were recorded minimum under control. The quality parameters in respect of TSS (14 ^{0}Brix) were found maximum under the 75% RDF + 25% Azotobacter and minimum under control.

Dilpreet *et al.* (2016) carried out an experiment on the effect of different combinations of bio-fertilizer along with inorganic fertilizers and organic manures on growth, yield and quality of onion during *kharif* season of 2014. They observed that the number of leaves per plant (13.4), plant height 90 DAT (83.8 cm) and bulb diameter (5.6cm) was maximum with the application of *Azotobacter* along with recommended dose of fertilizers. Minimum neck thickness was recorded in treatment where *Azospirillium* was applied along with recommended dose of fertilizers. Likewise, the *Azospirilum* produced the maximum bulb weight (138.3g) and total yield (299.6 q/ha) when it was applied with recommended dose of fertilizer.

Singh *et al.* (2017) carried out research work on role of biofertilizer and chemical fertilizer for sustainable onion (*Allium cepa* L.) production. They concluded that the chemical fertilizer (120 kg N + 60 kg P + 80 kg K) with inoculation of *Azospirillum* + VAM produced maximum plant height (51.96 cm), number of leaves per plant (11.96), leaf length (45.71 cm) as well as yield and its attributing components like bulb diameter (5.85cm), bulb weight (81.44g), bulb volume (92.8cc) and bulb yield (467.61 q/ha). However, inoculation of *Azospirillum* + VAM with

seedling treatment as well as soil application at the fertility level of (90kg N + 45kg P + 60kg K) was the most effective combination for higher net return and B: C ratio (3.47).

Vachan and Tripathi (2018) carried out an experiment on influence of bio-fertilzer with recommended doses of fertlizer on plant growth, yield, quality and economics of onion (*Allium cepa* L.) Cv.NHRDF RED-2 during *rabi* season in 2016-17. They result releavent that 100% RDF + *Azospyrillum* + PSB, has recorded significantly higher plant height (84.02 cm), length of leaves (37.20 cm), number of leaves (10.20), diameter of bulb (45.50 mm), fresh weight of bulb (41.87g) at 50, 75 and 100 DAT and fresh bulb yield (368.82 q/ha) was recorded significantly higher than the other treatments.

2.7 Effect of organic, inorganic and biofertilizers on growth and yield of onion.

Jayathilake *et al.* (2003) studied the integrated nutrient management in onion during *rabi* (cool season) 2001-2002 at students farm, college of Agriculture, Rajendranagar, Hyderabad in India. They revealed that the growth attributing characters of onion viz., plant height, number of leaves/plant, yield attributes such as bulb weight, bulb yield and quality of the bulb significantly increased with application of biofertilizers (*Azotobacter* or *Azospirillum*) in combination with 50% N through organic manure (VC or FYM) + 50% of recommended N and 100% PK through chemical fertilizer.

Jayathilake *et al.* (2006) studied that the productivity and soil fertility status as influenced by integrated use of n-fixing biofertilizers, organic manures and inorganic fertilizers in onion during *rabi* season 2001-2002. They observed that application of *Azospirillum* in combination with 50 % N through VC and 50 % N and total P and K through chemical fertilizers recorded significantly highest bulb yield (42.0 t/ha) and available N (267.86 kg/ha), P (37.00 kg/ha), which was at par with the bulb yield (40.7 t/ha) and available N (264.86 kg/ha), P (35.61 kg/ha) recorded with *Azotobacter* in combination with 50 % N through VC and 50 % N and total P and K through chemical fertilizers. Whereas the highest population of *Azospirillum* (137.33 x 104 CFU/g soil) was recorded in the treatment with *Azospirillum* in combination with VC and FYM followed by inoculation of *Azospirillum* with VC and chemical fertilizers.

Kore *et al.* (2006) studied the nutrient management in garlic during *rabi* season 2004-2005. They reported that plant height (73.13 cm), number of leaves per plant (11.70) and bulb yield (10.57 t/ha) was found maximum in the plants receiving nutrients @ 10 t FYM + 3 kg *Azotobactor* + 3 kg PSB + 75 % RDF.

Singh and Pandey (2006) studied that the effect of integrated nutrient management on yield of and nutrient uptake by onion and on soil fertility during *rabi* seasons of 1997-98 and 1998-99. They reported that the bulb yield (38.86 t/ha) of onion obtained with 75% NPK + 10 t FYM/ha + *Azotobacter*, being at par with 100% recommended dose of fertilizer, whereas significantly maximum available Nitrogen (257.5 kg/kg) and Phosphorus (17.0 kg/kg) present in 75 % NPK + Azotobacter + 10 t/ha FYM.

Patel Kurajibhai (2007) studied the combined effect of nitrogen, organic manures and biofertilizer on growth, yield and quality of onion (*Allium cepa* L.) varieties during 2003-04 and 2004-05. They result releavent that the application of 100kg N/ha + 20 t FYM/ha gave maximum plant height (65.38, 76.35 and 82.27 cm at 60. 75 and 90 DAT), number of leaves (7.50, 9.43 and 10.91 at 60, 75 and 90 DAT), neck thickness (1.23 cm), bulb weight (136.4 g), bulb volume (148.6 cc), bulb yield (65.97 t/ha), "A" grade bulb (59.62 t/ha) and TSS (13.85 ^{0}Brix) and minimum bolting per cent (4.24).

Yadav *et al*. (2008) carried out an experiment on the effect of inorganic, organic fertilizer and bio-fertilizer on yield and yield attributes of *rabi* onion during the year 2002-03. They concluded that about 25% nutrient required by onion could be supplemented by making effective combination of chemical fertilizers with FYM and biofertilizers.

Adagale *et al.* (2009) carried out an experiment on the effect of integrated nutrient management on growth and yield of onion seed production during the *rabi* season 2005-06. They concluded that among growth attributes plant height, number of leaves were significantly influenced by different organic, inorganic fertilizer, biofertilizers and their combinations.

Chumyani *et al.* (2012) carried out research work on the effect of integrated nutrient management on growth, yield and quality of tomato during 2009-10. They result revealed that application of 50% NPK + 50% FYM + biofertilizers gave significantly maximum fruit yield (486.89 q/ha), vitamin C (56.73 mg/100 g of fruit) and TSS (5.07 ^{o}Brix).

Jawadagi *et al*. (2012) studied the effect of planting geometry and organic sources of nutrient on keeping quality of onion cv. Bellary Red. They reported that application of 50% FYM (12.50 t/ha) + 50 % VC (2 t/ha) + biofertilizers (*Azospirillum* and *PSB* @ 5 kg/ha each) with 15 cm x 10 cm spacing recorded maximum values 13.27, 13.36 and 49.28 per cent of TSS and marketable bulbs in onion at 120 DAS, followed by the crop nourished with 50% FYM (12.50 t/ha) + 50%

VC (2 t/ha) + biofertilizers (*Azospirillum* and phosphate solubilizing bacteria @ 5 kg/ha) with 15 x 15 cm spacing.

Banjare *et al.* (2015) conducted an experiment at Raipur to study the effect of organic substances on yield and quality of onion cv. Agrifound light red during the year 2012-13. They reported that 100 % recommended doses of fertlizers (RDF) resulted into maximum diameter, neck thickness, average weight of bulb, maximum A+ grade bulbs and average weight of bulb. Cent per cent RDF also showed beneficial effect in increasing total yield and total soluble solids which was at par with the treatment containing RDF (75%) + vermicompost (3 t/ha) + PSB (2 kg/ha) + *Azotobacter* (2 kg/ha).

Nainwal *et al.* (2015) carried out research work on the response of garlic to integrated nutrient management practices in a sodic soil of Uttar Pradesh, India concluded that application of recommended dose of inorganic fertilizer (100% NPK) supplemented with 20 t/ha of FYM coupled with inoculation of PSB and *Trichoderma* was maximum plant height (60.7cm), number of leaves (9.2), fruit weight (52.43 g), yield (60.86 q/ha)of garlic and organic carbon (4.3 g/kg), available Phosphorus (22.2 kg/ha) and available Potash (390 kg/ha) of the soil after harvest.

Thangasamy and Lawande (2015) conducted an experiment to standardize integrated nutrient management for sustainable onion production. They reported that application of 75% RDF + 7.5 t/ha FYM + 3.75 t/ha PM gave the highest average bulb weight (72.3 g), available phosphorus (32.5 kg/ha) and potash (616 kg/ha). While application of 75% RDF + 7.5 t/ha VC gave highest available Nitrogen (164 kg/ha) present in the soil after crop harvest. Integrated use of 75% recommended fertilizers along with organic manures and biofertilizers produced bulb yield at par with the 150:50:80:50 kg/ha NPKS + 20 t/ha FYM and improved soil organic carbon. Besides yield, integrated use of fertilizer, manures and biofertilizers increased TSS. Combined application of fertilizers, organic manures and bio-fertilizers maintained initial soil available NPKS status. Adoption of this practice saved 25% inorganic fertilizers and protect environment from pollution.

Jat *et al.* (2018) conducted research work on the influence of organic, inorganic fertilizers and biofertilizers on growth, yield and quality of onion. They concluded that organic, inorganic and bio fertilizer can be effectively used for improving growth, yield, and quality of onion if applied at proper time and manner in suitable doses or concentrations.

3. MATERIALS AND METHODS

This chapter deals with the details of materials used and methods adopted in conducting the investigation are described and presented here.

3.1 GENERAL

3.1.1 Experimental Site

The experiment was carried out at the Horticultural Research Farm, College of Horticulture, Anand Agricultural University, Anand, during the year 2018-19.

3.1.2 Location

Anand is located in Agro-climatic zone III (Middle Gujarat) of Gujarat state. It is situated on 22^0 35' N latitude 72^0 56' E longitude and has an altitude of 45.1 meter above Mean Sea Level (MSL).

3.1.3 Climate and Weather conditions

The climate of Anand region is semi-arid and sub-tropical type. Winter is mild cool and dry, while summer is hot and dry. October to May is sunny months generally receiving an average of eight to nine hours sunshine per day. Temperature during hot weather commences by about end of February and ends by about middle of June. Winter sets in the middle of October and continues till the end of February. Monsoon is warm and moderately humid. It commences by the end of June and ends by the middle of September. In this region monsoon is often erratic and uncertain, in respect of total rainfall and its distribution. The meteorological data on the average weekly maximum and minimum temperature, rainfall and relative humidity recorded at the Meteorological observatory AAU, Anand (during experimental period *i. e.* 11^{th} October, 2018 to 30/04/2019) are given in Appendix-I

3.2 SOIL

The soil of the experimental site was sandy loam, locally known as "*Goradu*". Soils respond well to manure, fertilizer and irrigation, so it is suitable for onion cultivation. The water table is more than 10 m in depth. Hence, there is no problem of high water table in the area. A composite soil sample was collected from an experimental plot to a depth of 0-15 cm. Soil was analyzed for determining the Physico-chemical properties and it is presented in Table 3.2

Table 3.1: Physico-chemical properties of the experimental soil

Sr. No.	Properties		Soil depth (15-30cm)	Method employed
[A]	**Physical**			
	(a)	Course Sand (%)	0.74	International Pipette method (Piper, 1950)
	(b)	Fine Sand (%)	80.87	
	(c)	Silt (%)	11.16	
	(d)	Clay (%)	7.23	
	(e)	Textural classes	Loamy sand	
[B]	**Chemical**			
	(a)	Soil pH (1:2.5, soil: water ratio)	7.42	Potentiometric method (Jackson, 1973)
	(b)	Electrical conductivity (dSm^{-1}) (1:2.5, soil: water ratio)	0.28	Schofield method (Jackson, 1973)
	(c)	Organic carbon (%)	0.25	Walklely and Black's rapid titration method (Jackson,1973)
	(d)	Available N (kg ha^{-1})	220.25	Alkaline permanganate method (Subbiah and Asija, 1956)
	(e)	Available P_2O_5 (kg ha^{-1})	28.22	Olsen method (Jackson, 1973)
	(f)	Available K_2O (kg ha^{-1})	258.32	Flame photometer method (Jackson, 1973)

3.3 VARIETY

3.3.1 Gujarat Junagadh Red Onion-11

The bulbs of this variety are medium in size, round to oblong and red in colour. This variety is recommended for planting in Gujarat state in the *rabi* season. The average production of onion bulb is 320 q/ha, which is higher than Agrifound Light Red, Pilipatti and Talaja Local. This variety shows less incidence of purple blotch and thrips attack. Average TSS is 12.94 ^{o}Brix.

3.4 EXPERIMENTAL DETAILS

Crop	:	Onion (*Allium cepa* L.)
Variety	:	GJRO-11
Experimental design	:	Randomized Block Design
Number of treatments	:	10
Number of replications	:	Three (3)
Total number of plots	:	30
Gross plot size	:	3.0 x 2.0 m
Net plot size	:	2.7 x 1.8 m
Spacing	:	15 x 10 cm
Number of plants/plot	:	400
Path between plots	:	0.5 m
Width of irrigation channels	:	1.00 m

3.5 TREATMENT DETAILS:

Sr. No.	Treatment No.	Treatment
1	T_1	100 % RDF (control)
2	T_2	75 % RDF + 25 % N from FYM
3	T_3	75 % RDF + 25 % N from vermicompost
4	T_4	75 % RDF + 25 % N from castor cake
5	T_5	50 % RDF + 50% N from FYM
6	T_6	50 % RDF + 50% N from vermicompost
7	T_7	50 % RDF + 50% N from castor cake
8	T_8	50 % RDF + 25 % N from FYM + 5 ml Bio-NPK Consortium
9	T_9	50 % RDF + 25 % N from vermicompost + 5 ml Bio-NPK Consortium
10	T_{10}	50 % RDF + 25 % N from castorcake + 5 ml Bio-NPK Consortium

3.6 EXPERIMENTAL DESIGN AND LAYOUT

The experiment was laid out in the field adopting Randomized Block Design with thirteen treatments, replicated three times. The plot size was kept 3.00 m in length and 2.0 m in breadth. Each treatment was allocated to individual plot with the help of random process. The layout plans have been shown in Fig.-3.1.

3.7 CULTURAL OPERATIONS

3.7.1 Field preparation

The experimental field was thoroughly ploughed and cross-ploughed with the help of mould board plough and cross harrowing was done with tractor and the soil was brought to a good tilth. The beds of 3 x 2 m^2 size were prepared, paths and channels were also prepared as per layout.

3.7.2 Nursery raising

For raising a crop for bulb production, onion seeds were sown on nursery beds to raise seedlings for transplanting in the main field. Flat beds of about 10 meter long and 1.2 meter width were prepared. The nursery beds were manured with well rotten farmyard manure @ 20 kg per bed. Seeds were broadcasted on well prepared beds and covered with soil. Seed beds were irrigated regularly with the help of watering can. Seed sowing was done in October 2018. The seedlings were ready within sevan weeks for transplanting.

3.7.3 Transplanting

The field was well prepared and manured with the incorporation of FYM, vermicompost and castor cake as per the individual treatment at the time of transplanting. At transplanting, the main field was marked 15 cm in row to row and 10 cm in plant to plant. Sevan week's old healthy seedlings were dipped in 5 ml Bio-NPK consortium as per treatment and transplanted in main field on 4th December 2018.

3.7.4 Treatment application

(i) Inorganic fertilizers

The recommended dose of NPK for onion in this zone (Middle Gujarat condition) is 100:75:75 kg/ha. As per treatment combination nitrogen was applied through urea. Phosphorus and potash were applied through single super phosphate and muriate of potash, respectively. Full dose of phosphorus, potassium and half dose of nitrogen were applied as basal dose just before transplanting and rest half dose of nitrogen was applied 30 days after transplanting as per treatment.

(ii) Organic mannure

The dose of NPK through FYM, vermicompost and castorcake was supplemented as basal dose before transplanting of onion seedlings as per treatments. The nutrient composition of used organic manures were as follows.

Sr. No.	Source	Nutrient composition (%)		
		N	P	K
1.	FYM	0.5	0.2	0.5
2.	Vermicompost	3.0	1.0	1.5
3.	Castor cake	4.3	1.8	1.3

(iii) Biofertilizers

Onion seedlings were treated with Bio-NPK Consortium and after that transplanting was done as per treatment.

3.7.5 Irrigation, weeding and hoeing

For the establishment of the crop, first light irrigation was given just after transplanting of seedling then subsequent irrigations were given at 10 days interval and irrigation was withheld before 10 days of harvesting. Onion is a shallow rooted crop, therefore shallow hoeing was done twice or thrice for weed control. Hand weeding was also done as and when required.

3.7.6 Plant protection measures

In order to protect the crop from insect pest and diseases standard methods of plant protection were followed whenever needed.

3.7.7 Harvesting

The onion bulbs were harvested on 30/04/2019 when the maturity indices were judged based on changes in colour of leaves, as they turned yellowish and the top started falling. The bulbs were harvested by hand pulling. After the harvest the bulbs were left in respective plots for sun curing for three days. After curing, the stalks were cut from the bulbs leaving neck portion. Then the bulbs were graded as ‘A’ ‘B’ and ‘C’ and sold in the market.

3.8 OBSERVATIONS RECORDED

3.8.1 Growth parameters

Five plants were selected at random from the net plot of each treatment to record the observations.

(i) Plant height (cm) at 45 and 90 DAT

Five plants were selected randomly in each plot and tagged. Plant height was measured from the ground level to the top of the highest leaf at 45 and 90 DAT. The meter scale was used to measure the height.

(ii) Number of leaves per plant at 45 and 90 DAT

Five plants were selected randomly in each plot and tagged. Total number of leaves was counted from selected and tagged plants at 45 and 90 days after transplanting.

(iii) Bolting (%)

It is the ratio of bolted plant to the total number of the plant which was worked out by following formula and expressed in percentage.

$$\text{Bolting (\%)} = \frac{\text{Bolted plant / plot}}{\text{Total no. of the plants / plot}} \times 100$$

3.8.2 Yield attributes

(i) Average bulb weight (g)

Weight of five randomly selected bulbs recorded in ‘g’ by weighing in weighing balance. Average fresh weight was calculated.

(ii) Bulb volume (cc)

The volume of five selected bulb were taken after harvest of fruits at peak fruiting. The fruit volume was measured by using measuring cylinder. Measuring cylinder was filled up to the 1000 ml mark with water and bulb was dipped in it. Then amount of water displaced was measured by taking the difference between initial volume and final volume (volume obtained after taking out bulb from the cylinder and expressed in cc).

(iii) Neck thickness (cm)

Neck thickness of bulb was measured with the help of Vernier Calipers from five randomly selected plants.

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

The bulbs harvested from each plot were weighed separately and recorded in kilogram (kg).

1. **Bulb yield (kg per plot)**

   Plot yield was recorded in kilograms after the harvesting of bulbs.

2. **Bulb yield (tone per hectare)**

   Total yield of plot was recorded in kilograms and then the yield was converted per hectare basis.

(v) Grading of bulbs

The bulbs were graded on the basis of following criteria's with weighing observations.

- A grade (> 65 g)
- B grade (45-65 g)
- C grade (< 45 g)

(vi) TSS (ºBrix)

Five onion bulbs were cut into pieces from each treatment and five readings were recorded from the extract of the estimation of TSS with the help the Erma Hand Refractometer and value obtained was corrected at 20^0C (A.O.A.C., 1984).The mean value was worked out and expressed in terms of percentage.

3.8.3 Nutrient status of soil

3.8.3.1 Chemical analysis of soil

3.8.3.1.1 Available nitrogen in soil by alkaline potassium permanganate method

Procedure:

20g of the soil sample was taken in distillation flask. In which 20 ml of water and 100 ml of 0.32% $KMnO_4$ solution was added. With the addition of 100 ml of 2.5% NaOH solution in such a way that it runs down the neck to the bottom of the flask without mixing. Approximately 25 ml of 4% boric acid was pipetted out into a 250 ml conical flask and 4 drop of mixed indicator solution was added in the mixture. A glass receiver tube was attached to the still and placed in the flask so that its end is below the surface of the boric acid in the flask. The cooling water was then started flowing in the condenser. Then burner was lighted. About 150 ml was distilled over, and then received flask and tube were disconnected to prevent sucking back. The boric acid was back titrated with a standard sulphuric acid. At the end point the blue color just disappears.

Calculation:

$$\textbf{Available N (\%)} = \frac{(R-B) \times 0.014 \times \text{Normality of } H_2SO_4}{\text{Weight of Soil}} \times 100$$

Where, R = reading of test sample B = reading of blank sample

3.8.3.1.2 Available phosphorus in soil by Olsen's method

Procedure:

5 g of soil sample was taken into 250 ml conical flask. In which, tea spoon of activated charcoal and 100 ml of 0.5M $NaHCO_3$ solution was added and shaken for 30 minutes on a mechanical shaker. Filtration of suspension was done through a Whatman No. 42 filter paper. After 5 ml aliquot of the suspension was taken in 25 ml volumetric flask with addition of 5 ml ammonium molybdate solution and a little quantity of distilled water and was shaken well. 1 ml of working $SnCl_2$ solution in each 25 ml volumetric flask was added to make volume up to 25 ml with distilled water and shake well. The transmittance of the solution in the colorimeter during the time of 5 minutes after and 20 minutes before the addition of $SnCl_2$ solution was measured with the use of red filtered in spectrophotometer.

Calculation:

$$\textbf{Available P (kg/ha)} = \frac{\text{R x Volume of extract}}{\text{Volume of aliquoted}} \times \frac{2.24 \times 106}{\text{weight of sample x } 106}$$

Available P_2O_5 (kg/ha) = Available P x 2.29

3.8.3.1.3 Available potassium in soil by flame photometry method

Procedure:

5 g soil was taken in 150ml conical flask, in which 50 ml of ammonium acetate solution was added and shaken for 30 minutes on an electric shaker. This mixture was filtered through a Whatman's No. 1 filter paper. 2 drop of butyl alcohol was added in each filtrate. Which was fed to the flame photometer and the reading was note down.

Calculation:

Available K_2O (kg/ha) = ppm x 2.24

Table 3.2: Initial Available NPK status in soil sample of the experimental soil

Sr. No	Soil Characteristics	Value (0-15cm depth) kg/ha	Reference
1.	Nitrogen	220.25	Alkaline potassium permanganate method
2.	Phosphorus	28.22	Olsen's method
3.	Potassium	258.32	Flame photometry method

3.8.4.1 Microbial Population analysis of soil at initial and after harvest

Procedure:

Soil Samples were collected before fertilizer application and after harvesting of the crop. Samples are stored in polythene bags and kept at 40 C till processed. Bacterial counts were done by taking 10 g soil sample in sterile 90ml D/W, shaken for 1 h and 1 ml sample was taken aseptically from it and transferred in 9 ml D/W containing dilution method tubed to make up to 10-8 dilution method and 0.1 ml from it spreader on different media i. e. Jonson media, NFB media, Sperber media, Nutrient Agar media, and Aleksandrow media plates and incubated for 3-5 days and counts were taken by calculating cfu/g.

Calculation:

$$\textbf{Final Count (cfu/g)} = \frac{\text{Number of isolated colonies x Dilution factor}}{\text{Aliquot taken}}$$

3.9 STATISTICAL ANALYSIS

The data collected for different observation will be subjected to statistical analysis of variance technique as described by Panse and Sukhatme (1976). The method of 'Analysis of variance' will be RBD and treatment means of all characters studied will be further compared by means of critical differences at 5% level of significance employing 'F' test. The C.V. % will be also worked out.

3.10 ECONOMICS (₹)

Cost of cultivation for each treatment was worked out separately. Gross return (₹/ha) was obtained by converting the harvest into monetary terms at the prevailing market rate during the course of investigation. Net return was obtained by deducting cost of cultivation from gross return. The benefit : cost ratio was calculated with the help of following formula.

$$\text{Benefit cost ratio} = \frac{\text{Gross return (₹)}}{\text{Total cost of cultivation (₹)}}$$

4. RESULTS AND DISCUSSION

This chapter highlight the research results of the field investigation entitled "**Effect of organic, inorganic and biofertilizer on growth and yield of onion (*Allium cepa* L.) Cv. GJRO-11**". The experiment was conducted during the *Kharif* season of 2018-19 at the Horticultural Research Farm, College of Horticulture, Anand Agricultural University, Anand, Gujarat. The data recorded on various aspects were tabulated and also illustrated graphically wherever necessary and subjected to statistical analysed. The results pertaining to each aspect have been presented and described along with statistical inferences under the following headings.

4.1 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON GROWTH PARAMETERS

4.1.1 Plant height (cm) at 45 and 90 DAT

4.1.2 Number of leaves per plant at 45 and 90 DAT

4.1.3 Bolting percent

4.2 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON YIELD PARAMETERS

4.2.1 Average bulb weight (g)

4.2.2 Bulb volume (cc)

4.2.3 Neck thickness (cm)

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

4.2.5 Grading of bulbs

- A grade (> 65 g)
- B grade (45-65 g)
- C grade (< 45 g)

  Note: Doubling bulb also comes under C grade.

4.2.6 TSS (ºBrix)

4.3 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON NUTRIENT STATUS OF SOIL

4.3.1 Initial and after harvest nutrient status of soil (Organic Carbon, N, P, K)

4.3.2 Initial and after harvest microbial count of soil

4.1 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON GROWTH PARAMETERS

4.1.1 Plant height (cm) at 45 and 90 DAT

The data pertaining to plant height of onion under various treatments at different growth stages are presented in Table 4.1 and also depicted in fig. 4.1.

In general, plant height increased with the advancement of growth stage and was found to be maximum at 90 DAT. Growth in term of plant height was rapid up to 45 DAT, thereafter height increased up to 90 DAT but at slow rate. An examination of data revealed that plant height significantly varied due to integrated nutrient management. It is obvious from the data that application of 50% RDF + 25% N from vermicompost + 5 ml Bio-NPK consortium (T_9) gave maximum plant height (70.11 and 86.70 cm at 45 and 90 DAT respectively), which is significantly superior over rest of the treatments except T_6, T_8 and T_{10} at 45 and 90 DAT, however minimum plant height (54.21 and 71.19 cm at 45 and 90 DAT respectively) was recorded with 75% RDF + 25% N from FYM (T_2) during 45 and 90 DAT.

It is quite clear from the data that application of biofertilizer increased the plant height when applied with 50 % RDF and 25 % N through either FYM, VC or Castor cake in comparision to application of 50 % RDF and 50 % N through FYM, VC or Castor cake. Application of 5 ml/l Bio-NPK consortium seedling dipping treatment along with 50% RDF + 25 % N from VC (T_9) produced significantly maximum plant height over application of 50% RDF + 50 % N from FYM or Castor cake, 75 % RDF + 25 % N from FYM, VC or Castor cake, and Control but it was significantly at par when Bio-NPK consortium applied with combination of chemical (50 % RDF) and organic manure (25 % N from FYM or Castor cake) at 45 and 90 DAT.

This may be due to application of integrated nutrient management perhaps, increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants, organics substances improved the overall physio-chemical and biological environment of the effective root zone, resulting promotes

soil aggregation and root development, and biofertilizer also fixed nitrogen from air to soil to improve growth and development which ultimately improving the plant height.

Table 4.1 Effect of organic, inorganic and biofertilizer on plant height (cm) of onion cv. GJRO-11

Treatment No.	Treatment	Plant height (cm)	
		45 DAT	90 DAT
T_1	100% RDF (Control)	61.75	77.57
T_2	75% RDF + 25% N from FYM	54.21	71.19
T_3	75% RDF + 25% N from VC	56.71	75.67
T_4	75% RDF + 25% N from CC	55.47	74.77
T_5	50% RDF + 50% N from FYM	57.07	75.93
T_6	50% RDF + 50% N from VC	67.67	83.53
T_7	50% RDF + 50% N from CC	62.19	77.70
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	68.03	84.57
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	70.11	86.70
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	68.57	85.73
S.Em. ±		**2.54**	**3.38**
C. D. at 5%		**7.56**	**10.05**
C.V. %		**7.09**	**7.38**

It might be due application of vermicompost along with NPK which indirectly influences the physical conditions of the soil and support better aeration to the plant root, absorption of water, induction of N, P and K exchange and application of biofertilizer improve nutrient status of soil there by increase vegetative growth of plant resulting increase plant height. Similar result finding were also reported by Jayathilake *et al.* (2003), Jayathilake *et al.* (2006), Adagale *et al*. (2009), Sharma *et al.* (2009), Mandal *et al.* (2013), Shingh *et al*. (2013), Banjare *et al.* (2015), Maneesh kumar (2015), Thangasamy and Lawande (2015), Jat *et al.* (2018) Singh and Singh (2018) in onion and Kore *et al.* (2006) in garlic.

4.1.2 Number of leaves per plant at 45 and 90 DAT

Statistical analysis of data revealed that there were non-significant differences between the treatments for the number of leaves per plant present in Table 4.2 with different combined treatments.

Table 4.2 Effect of organic, inorganic and biofertilizer on number of leaves per plant of onion cv. GJRO-11

Treatment No.	Treatment	No. of leaves/plant	
		45 DAT	90 DAT
T_1	100% RDF (Control)	7.73	10.40
T_2	75% RDF + 25% N from FYM	7.27	9.53
T_3	75% RDF + 25% N from VC	7.53	10.13
T_4	75% RDF + 25% N from CC	7.40	10.07
T_5	50% RDF + 50% N from FYM	7.63	10.20
T_6	50% RDF + 50% N from VC	8.00	10.73
T_7	50% RDF + 50% N from CC	7.93	10.47
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	8.07	10.90
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	8.13	11.07
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	8.07	11.00
S.Em. ±		**0.28**	**0.32**
C. D. at 5%		**NS**	**NS**
C.V. %		**6.29**	**5.23**

However, numerically maximum number of leaves per plant (8.13 and 11.07 at 45 DAT and 90 DAT) were recorded in treatment T_9 (50 % RDF + 25 % VC + Bio-NPK consortium) and minimum number of leaves per plant (7.27 and 9.53 at 45 DAT and 90 DAT) were obtained in T_2 (75% RDF + 25 % FYM). Similar results have been reported by Jayathilake *et al.* (2003), Jayathilake *et al.* (2006), Adagale *et al*. (2009), Sharma *et al.* (2009), Mandal *et al.* (2013), Banjare *et al.* (2015), Maneesh kumar (2015), Shingh *et al*. (2013), Thangasamy and Lawande (2015), Jat *et al.* (2018) Singh and Singh (2018) in onion.

4.1.3 Bolting percent

It is depicted from the data presented in Table 4.3 that there was significant variation in bolting percent of onion crop with the application of nutrients through organic, inorganic and biofertilizers and their combinations. Minimum bolting percent (4.38) was recorded in 50 % RDF through chemical fertilizers + 25 % N from VC + 5 ml Bio-NPK Consortium (T_9) and 50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium (T_{10}) which was at par with T8, and T6 *i.e.* 4.53 and 4.77, respectively. Whereas, maximum bolting percent (6.20) was recorded in the treatment T_5 *i.e* application of 50% RDF through chemical fertilizers + 50 % N from FYM. The bolting percent was reduced 49.50 % as compared to over 50% RDF through chemical fertilizers + 50 % N from FYM.

Table 4.3 Effect of organic, inorganic and biofertilizer on bolting per cent of onion cv. GJRO-11

Treatment No.	Treatment	Bolting (%)
T_1	100% RDF (Control)	5.29
T_2	75% RDF + 25% N from FYM	5.48
T_3	75% RDF + 25% N from VC	5.33
T_4	75% RDF + 25% N from CC	5.46
T_5	50% RDF + 50% N from FYM	6.20
T_6	50% RDF + 50% N from VC	4.77
T_7	50% RDF + 50% N from CC	5.09
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	4.53
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	4.38
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	4.38
S.Em. ±		**0.15**
C. D. at 5%		**0.44**
C.V. %		**5.08**

Premature emergence of flower stalk in bulb crop called premature bolting. Premature bolting is a result of cool temperature in early stages (up to 60 days), excess of N fertilization, over edged seedlings and excess nutrition in onion plant. Probable reasons for this may be due to the bolting percentage was significantly

decreased with an increase in nitrogen levels, which caused more vegetative growth and resulted in suppressed bolting. Bolting in onion is induced by the interaction of more than one factors *viz,* temperature, cultivar, time of planting, age of seedlings at the time of transplanting, poor quality-seed, availability of nutrient, during seedling stage in nursery bed and during growth in field etc. Similar results have been reported by Chuda *et al.* (2009) in onion.

4.2 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON YIELD PARAMETERS

4.2.1 Average bulb weight (g)

The data pertaining to bulb weight as influenced by combined application of organic, inorganic and biofertilizer have presented in Table-4.4 and also depicted in fig. 4.2.

Combined application of organic, inorganic and biofertilizers caused significant improvement in average bulb weight. The significantly maximum average bulb weight (129.30 g) was obtained in the plants grown under the application of 50 % RDF + 25 % N through VC + 5ml Bio-NPK consortium (T_9) but it was at par when Bio-NPK consortium applied with combination of chemical (50 % RDF) + organic manure (25 % N from FYM (T8) or Castor cake (T_{10})) and 50 % RDF + 50 % N from VC (T_6) producing the average bulb weight of 121.13, 118.73 and 118.64 g, respectively. The minimum bulb weight (99.73 g) was noticed in 75 % RDF through chemical fertilizer + 25 % N from FYM.

This might be due to the fact that integrated nutrient improved the vegetative growth in general and thereby high rate of photosynthesis, enhanced chlorophyll synthesis, translocation of more photosynthates to the storage organ of bulb resulting in enhancement in bulb weight of onion in perticular. Similar results have been also reported by Jayathilake *et al.* (2003), Hari *et al.* (2009), Mandal *et al.* (2013), Banjare *et al.* (2015), Mohanty *et al.* (2015), Shingh *et al.* (2015), Singh and Singh (2018) in onion crop.

Table 4.4 Effect of organic, inorganic and biofertilizer on average bulb weight of onion cv. GJRO-11

Treatment No.	Treatment	Bulb weight (g)
T_1	100% RDF (Control)	111.60
T_2	75% RDF + 25% N from FYM	99.73
T_3	75% RDF + 25% N from VC	106.13
T_4	75% RDF + 25% N from CC	105.80
T_5	50% RDF + 50% N from FYM	108.33
T_6	50% RDF + 50% N from VC	118.64
T_7	50% RDF + 50% N from CC	112.93
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	118.73
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	129.30
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	121.13
S.Em. ±		**4.89**
C. D. at 5%		**14.52**
C.V. %		**7.47**

4.2.2 Bulb volume (cc)

The data regarding bulb volume as influenced due to organic, inorganic and biofertilizer are presented in Table-4.5.

The table 4.5 shows that there was a profound effect on bulb volume by integrated use of organic, inorganic and biofertilizer. The combined application of 50% RDF + 25% N from VC + 5 ml Bio-NPK consortium (T_9) produced significantly highest bulb volume (136.70 cc) which was statistically at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having bulb volume of 131.80, 128.87 and 128.40 cc, respectively. The lowest bulb volume (107.07 cc) was noticed in 75 % RDF through chemical fertilizer + 25 % N from FYM.

The volume and weight of onion bulbs have direct relation to diameter and length of bulb. The integrated application of organic, inorganic and biofertilizers gave appreciable increment in volume and weight of bulb. Significant maximum bulb volume and bulb weight were produced by plants when grown with the application of 50 % RDF +25 % N from VC + 5 ml Bio-NPK consortium, 50 % RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium, 50 % RDF +25 % N from FYM + 5 ml Bio-NPK consortium and 50 % RDF + 50 % N from VC. Similar results have been reported by Mahanthesh *et al*. (2008), Singh *et al.* (2017), Shinha *et al.* (2017) in onion crop.

Table 4.5 Effect of organic, inorganic and biofertilizer on bulb volume (cc) of onion cv. GJRO-11

Treatment No.	Treatment	Bulb volume (cc)
T_1	100% RDF (Control)	120.17
T_2	75% RDF + 25% N from FYM	107.07
T_3	75% RDF + 25% N from VC	117.53
T_4	75% RDF + 25% N from CC	116.67
T_5	50% RDF + 50% N from FYM	119.23
T_6	50% RDF + 50% N from VC	128.40
T_7	50% RDF + 50% N from CC	123.07
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	128.87
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	136.70
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	131.80
S.Em. ±		**2.90**
C. D. at 5%		**8.61**
C.V. %		**4.08**

4.2.3 Neck thickness (cm)

The data on neck thickness as influenced with organic, inorganic and biofertilizer are presented in Table-4.6.

Table 4.6 shows that there was a profound effect on neck thickness of onion bulb by integrated use of organic, inorganic and biofertilizer. The combined application of 50% RDF + 25% N from VC + 5ml Bio-NPK consortium (T_9) produced significantly maximum neck thickness (1.11 cm) which was statistically at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having neck thickness of 1.07, 0.97 and 0.96 cm, respectively. The lowest neck thickness (0.69 cm) was noticed in 75 % RDF through chemical fertilizer + 25 % N from FYM.

Table 4.6 Effect of organic, inorganic and biofertilizer on neck thickness (cm) of onion cv. GJRO-11

Treatment No.	Treatment	Neck thickness (cm)
T_1	100% RDF (Control)	0.84
T_2	75% RDF + 25% N from FYM	0.69
T_3	75% RDF + 25% N from VC	0.81
T_4	75% RDF + 25% N from CC	0.84
T_5	50% RDF + 50% N from FYM	0.84
T_6	50% RDF + 50% N from VC	0.96
T_7	50% RDF + 50% N from CC	0.86
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	0.97
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	1.11
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	1.07
S.Em. ±		**0.05**
C. D. at 5%		**0.16**
C.V. %		**10.40**

This might be due to the increase nitrogen levels, which caused more vegetative growth resulting enhancement in cell multiplication and cell elongation, and also increase number of leaves and leads to increased neck thickness of the bulb. Similar results reported by Mahanthesh *et al.* (2005) and Chuda *et al.* (2009), Kumar *et al.* (2011), Mandal *et al.* (2013), Brinjh *et al.* (2014), Singh *et al.* (2015) in onion.

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

Effect of different treatments on total bulb yield (kg/plot and q/ha) is presented in Table 4.7 and also depicted in fig. 4.3. A perusal of mean value from Table 4.7 indicated overall trend of total bulb yield of onion. The total bulb yield varied significantly and ranged from 335.39 q/ha to 497.60 q/ha.

Application of 50 % RDF + 25 % N from VC + 5 ml Bio-NPK consortium (T_9) recorded significantly maximum total bulb yield (497.60 q/ha), which was at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having bulb yield of 473.39, 465.02 and 449.31 q/ha, respectively. Whereas, the minimum total bulb yield (335.39 q/ha) were recorded under application of 75 % RDF + 25 % N from FYM (T_2). Similar results reported by Kore *et al.* (2006) in garlic and Jayathilake *et al.* (2006), Hari *et al.* (2009), Reddy *et al.* (2011), Jawadagi *et al*. (2012), Mandal *et al.* (2013), Jat *et al.* (2018) in onion crop.

Table 4.7 also reveal that biofertilizers increased the total bulb yield of onion, when the combination with other sources of nutrients (organic and inorganic). It is also notable from the data presented in Table 4.7 that biofertilizer works better with VC in comparision to FYM.

The highest total bulb yield were recorded under 50 % RDF + 25 % N from VC + 5 ml Bio-NPK consortium (T_9) and it may be due to major nutrient avaibility and supplied by organic, inorganic and biofertilizers will be utilized quickly and other essential nutrients available slowly released by organic substances. The combination of three nutrient sources helped to increased growth parameters and yield contributing characters resulting good bulb yield.

Table 4.7 Effect of organic, inorganic and biofertilizer on bulb yield (kg/plot and q/ha) of onion cv. GJRO-11

Treatment No.	Treatment	Bulb yield	
		kg/plot	q/ha
T_1	100% RDF (Control)	19.39	398.97
T_2	75% RDF + 25% N from FYM	16.30	335.39
T_3	75% RDF + 25% N from VC	18.06	371.60
T_4	75% RDF + 25% N from CC	17.07	351.17
T_5	50% RDF + 50% N from FYM	18.52	381.00
T_6	50% RDF + 50% N from VC	21.84	449.31
T_7	50% RDF + 50% N from CC	20.42	420.10
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	22.60	465.02
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	24.18	497.60
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	23.01	473.39
S.Em. ±		**0.95**	**19.60**
C. D. at 5%		**2.83**	**58.23**
C.V. %		**8.19**	**8.19**

The results indicated that the applications in combination of inorganic fertilizers with organic manures and biofertilizers were highly beneficial. The increase in yield appeared to be due to increased growth of plants in respect to height of plants, number of leaves and leaf length of plant. The healthy top growth might be responsible for higher rate of photosynthesis. The higher amount of photosynthesis might have been accumulated in bulbs there by increasing the size of bulbs as indicated by diameter and average bulb weight which are the important yield contributing traits. The combined effect of the treatments as discussed under growth parameters might have definitely been responsible for increase in yield with these treatments as compared to the rest of the treatments. The factors which reflect on yield significantly improved with the addition of vermincompost. The beneficial role of added organic manures in improving soil physical, chemical and biological

properties is well known, which in turn helps in better nutrient absorption by plant and resulting into higher yield. Application of organic manure, due to its quick fermentation process have significantly enhanced the availability of native and applied macro and micronutrients in soil as a consequence of which net weight of bulb would have increased. Further, it is relevant to note that, VC seems to be directly responsible in increasing crop yields by accelerating the respiratory process which increasing cell permeability with hormone acceleratory growth and combination of all these processes.

4.2.5 Grading of bulbs

The bulbs were graded on the basis of following criteria's with weighing observations.

- A grade (> 65 g)
- B grade (45-65 g)
- C grade (< 45 g)
- Doubling bulbs also comes under C grade.

4.2.5.1 A grade bulbs (> 65 g)

The data pertaining to 'A' grade bulbs in weight are presented in Table 4.8 and also depicted in fig. 4.4. It reveals the differences in 'A' grade bulb percentage due to different treatments.

The highest 'A' grade bulb (395.98 q/ha) was observed in the treatment 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium (T_9). This treatment was found at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having 'A' grade bulb of 371.67, 369.00 and 353.37, respectively. Whereas, the minimum 'A' grade bulb (270.03 q/ha) were recorded under application of 75 % RDF + 25 % N from FYM (T_2). Similar results have been reported by Krishnamurthy (2009) in onion.

4.2.5.2 B grade bulbs (45-65 g)

The data pertaining 'B' grade bulbs are presented in Table 4.8 and also depicted in fig. 4.4. It revealed that there was significant differences in 'B' grade bulbs due to various treatments in the range of 91.50 to 28.81 q/ha.

The highest 'B' grade bulbs (91.50 q/ha) was recorded in treatment 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium (T_9). This treatment was at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF

+25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having 'B' grade bulb of 90.88, 84.43 and 83.88 q/ha, respectively. Whereas, the minimum 'B' grade bulb (28.81 q/ha) were recorded under application of 75 % RDF + 25 % N from FYM (T_2). Similar results have been reported by Krishnamurthy (2009) in onion.

Table 4.8 Effect of organic, inorganic and biofertilizer on grading of bulbs of onion cv. GJRO-11

Treatment No.	Treatments	Grading of Bulbs (q/ha)		
		A grade	B grade	C grade
T_1	100% RDF (Control)	327.37	46.84	24.69
T_2	75% RDF + 25% N from FYM	270.03	28.81	36.69
T_3	75% RDF + 25% N from VC	298.77	41.02	31.96
T_4	75% RDF + 25% N from CC	287.79	29.42	34.02
T_5	50% RDF + 50% N from FYM	307.89	44.92	28.33
T_6	50% RDF + 50% N from VC	353.37	83.88	12.21
T_7	50% RDF + 50% N from CC	342.11	61.80	16.19
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	369.00	84.43	11.66
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	395.98	91.50	10.01
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	371.67	90.88	10.77
S.Em. ±		14.56	3.05	1.05
C. D. at 5%		43.26	9.06	3.13
C.V. %		7.59	8.75	8.43

4.2.5.3 C grade bulbs (< 45 g)

The data pertaining to 'C' grade bulb are presented in Table 4.8 and also depicted in fig. 4.4. It revealed that the differences in 'C' grade bulbs due to different treatments were significant.

The lowest percentage of 'C' grade bulb (10.01 q/ha) was recorded in treatment 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium (T_9). This treatment was at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK

consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having 'C' grade bulb of 10.77, 11.66 and 12.21 q/ha, respectively. Whereas, the maximum 'C' grade bulb (36.69 q/ha) were recorded under application of 75 % RDF + 25 % N from FYM (T_2). Similar results have been reported by Krishnamurthy (2009).

4.2.6 TSS (ºBrix)

The total soluble solids of onion bulb recorded under different treatments have been presented in Table 4.9.

Application of 50 % RDF + 25 % N from VC + 5 ml Bio-NPK consortium (T_9) recorded significantly maximum total soluble solids (13.47 ºBrix), which was at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having total soluble solids of 13.37, 13.18 and 13.15 ºBrix, respectively. Whereas, the minimum total soluble solids (11.71 ºBrix) were recorded under application of 75 % RDF + 25 % N from FYM (T_2).

Application of biofertilizer in combinations with organic and inorganic fertilizer levels were also found beneficial in increasing the total soluble solids over other treatment combination. This may be due to the known fact that the organic manures are capable of supplying adequate macro and micro nutrients which might played major role in quality improvement through desirable enzymatic changes taking place during growth and development of bulbs. Effect of vermicompost in improving soil nutrition is well established fact and integrated use of inorganic and biofertilizer with vermicompost and further enhanced the effect on quality rendered by high total soluble solids. The beneficial effect of biofertilizers may be attributed to increase the activity of microbes which might have resulted in release of more amount of gibberellins, auxins and cytokinins. These growth hormones, in turn accelerate the physiological process like synthesis of carbohydrates and might have other proximate substances. The results are in confirmation with the view of Chuda *et al.* (2009), Jawadagi *et al.* (2012), Indira and Singh (2014), Thangasamy and Lawande (2015) and Rabari *et al.* (2016) in onion crop.

Table 4.9 Effect of organic, inorganic and biofertilizer on total soluble solids (ºBrix) of onion cv. GJRO-11

Notation	Treatment	TSS (ºBrix)
T_1	100% RDF (Control)	12.48
T_2	75% RDF + 25% N from FYM	11.71
T_3	75% RDF + 25% N from VC	12.47
T_4	75% RDF + 25% N from CC	12.28
T_5	50% RDF + 50% N from FYM	12.51
T_6	50% RDF + 50% N from VC	13.15
T_7	50% RDF + 50% N from CC	12.96
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	13.20
T_9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	13.47
T_{10}	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	13.37
S.Em. ±		**0.28**
C. D. at 5%		**0.82**
C.V. %		**3.75**

4.3 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON NUTRIENT STATUS OF SOIL

4.3.1 Initial and after harvest nutrient status of soil (Carbon, N, P, K)

The data pertaining to available nutrient status of the soil are significantly presented in Table 4.10.

Application of 50 % RDF + 50 % N from FYM (T_5) recorded significantly maximum avaibility of N, P, K and Organic carbon, which was available nitrogen and potash at par with 50% RDF + 50 % N from Castor cake (T_7), 50% RDF +25 % N through FYM + Bio-NPK consortium (T_8) and 50% RDF + 25% CC + 5 ml Bio NPK consortium (T_{10}), but organic carbon and phosphorus at par with 50% RDF + 50% N from CC and 50% RDF + 50% N from VC. Whereas, the minimum avaibility of N, P, K and Organic carbon were recorded under application of 100% RDF (T_1).

Organic carbon per cent increased in soil in treatment with addition of FYM, vermicompost, castor cake and biofertilizers. The organic carbon content in the soil is

slightly higher under combined application of biofertilizers and chemical fertilizers. This may be due to increased microbial and enzymatic activity and increase in root growth which subsequently increased the soil organic carbon content.

Combined application of inorganic and organic fertilizers increased available N, P_2O_5 and K_2O in the soil. Higher available soil nitrogen with respect to different organic nutrient sources as compared to inorganic sources might be due to slow releasing nature of organic manure which helps in reducing the nutrients loss and synergetic effect of microbes in the soil enhance their or symbiotic nitrogen fixing capabilities. Similar results were also reported by Shinha *et al*. (2017).

Similarly, higher availability of phosphorus under organic manure and biofertilizer might be due to the production of organic acid by phosphorus solubilizing bacteria present in soil, which act as a chelating agent and form stable complex with Fe and Al abundantly available in acid soil and thereby releasing phosphorus to the soil solution making it available for more uptakes by the plant. These results are in close conformity with the findings of Shinha *et al*. (2017).

There was a marked variation in availability of K_2O in the soil due to integration of organic, inorganic and biofertilizers. Relatively less availability of inorganic fertilizers treated soil might be attributed to the fact that with organic manure and biofertilizer decline potassium status of soils which may be due to the fact that humification of plant residues and soil organisms produce a type of organic matter with high CEC capable of holding soil K. Moreover, humus retains divalent cations (Mg ++ & Ca++) more strongly than monovalent cations. Weaker retention of potassium relative to Ca and Mg may increase K availability but at the same time it renders the K more liable to leaching. The results of the present investigation are in agreement with the finding of Shinha *et al*. (2017).

Improvement in the status of available nutrients in the soil after harvest of the crop might be due to addition of nutrients through application of organic, inorganic and biofertilizers. The increased N, P and K soil status might also be due to the buildup soil organic carbon content which encouraged the biological activities of soil micro-organisms. From these studies it is clearly seen that use of inorganic fertilizers along with FYM, VC, Castor cake and biofertilizers resulted in significant improvement in available N, P and K status of the soil. Similar trends of results were reported Jayathilake *et al.* (2006), Singh and Pandey (2006), Sharma *et al.* (2009), Nainwal *et al.* (2015), Thangasamy and Lawande (2015) and Shinha *et al*. (2017).

Table 4.10 Effect of organic, inorganic and biofertilizer on available nutrient status of the soil of onion cv. GJRO-11

Treatment No.	Treatment	Available Nutrient status of the soil			
		O.C (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potash (kg/ha)
	Initial	0.25	220.25	28.22	258.32
T1	100% RDF (Control)	0.25	254.33	33.00	266.00
T2	75% RDF + 25% N from FYM	0.26	282.67	36.67	296.00
T3	75% RDF + 25% N from VC	0.29	260.00	34.33	280.33
T4	75% RDF + 25% N from CC	0.27	271.00	35.33	291.00
T5	50% RDF + 50% N from FYM	0.39	369.00	44.67	331.00
T6	50% RDF + 50% N from VC	0.36	350.67	41.67	324.33
T7	50% RDF + 50% N from CC	0.36	357.33	42.33	326.67
T8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	0.30	340.00	39.67	323.67
T9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	0.34	293.00	37.33	302.67
T10	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	0.33	327.67	39.00	321.67
S.Em. ±		0.01	14.66	1.38	5.39
C. D. at 5%		0.03	43.55	4.11	16.01
C.V. %		6.26	8.17	6.25	3.05

4.3.2 Initial and after harvest microbial count of soil

The data pertaining to initial and after harvest microbial count of soil was Significantly presented in Table 4.11.

Application of 50 % RDF + 25 % N through FYM + 5 ml Bio-NPK consortium (T_8) recorded maximum Azotobacter, Azopirrilum, PSB, KMB and Total count of bacteria. Whereas, the minimum Azotobacter, Azopirrilum, PSB, KMB and Total count of bacteria in Control.

Table 4.11 Effect of organic, inorganic and biofertilizer on microbial count of onion cv. GJRO-11.

Treatment No.	Treatment	cfu/g of soil				
		Azotobacter	Azopirrilum	PSB	KMB	Total count
	Initial	2.4×10^3	2.1×10^3	1.9×10^3	2.9×10^3	4.0×10^7
T_1	100% RDF (Control)	2.8×10^3	6.1×10^4	4.3×10^4	2.8×10^4	4.5×10^7
T_2	75% RDF + 25% N from FYM	4.8×10^4	3.5×10^4	2.4×10^5	3.9×10^5	5.6×10^8
T_3	75% RDF + 25% N from VC	3.9×10^4	3.0×10^4	2.1×10^5	3.4×10^5	4.9×10^8
T_4	75% RDF + 25% N from CC	3.1×10^4	2.5×10^4	1.8×10^5	2.9×10^5	4.1×10^8
T_5	50% RDF + 50% N from FYM	5.2×10^4	3.9×10^4	3.3×10^5	5.0×10^5	6.2×10^8
T_6	50% RDF + 50% N from VC	4.4×10^4	3.2×10^4	2.7×10^5	4.5×10^5	5.7×10^8
T_7	50% RDF + 50% N from CC	3.8×10^4	2.8×10^4	2.5×10^5	4.0×10^5	5.1×10^8
T_8	50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium	7.1×10^5	6.1×10^5	5.2×10^5	6.2×10^5	7.3×10^9
T9	50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	6.0×10^5	5.5×10^5	4.7×10^5	5.8×10^5	6.9×10^9
T10	50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	4.1×10^5	4.4×10^5	3.5×10^5	5.1×10^5	6.3×10^9

FYM treatments improved the microbial count at harvesting time as compared to other biofertilizer treatments. It might be due to slow releasing of nutrients from FYM. Farm yard manure is a carrier of organic carbon and organic dry matter. Due to this reason, organic carbon and microbial count improved in onion with the application of FYM alone or in combination with biofertilizers. Similar trends of results were reported Dilpreet *et al*. (2017).

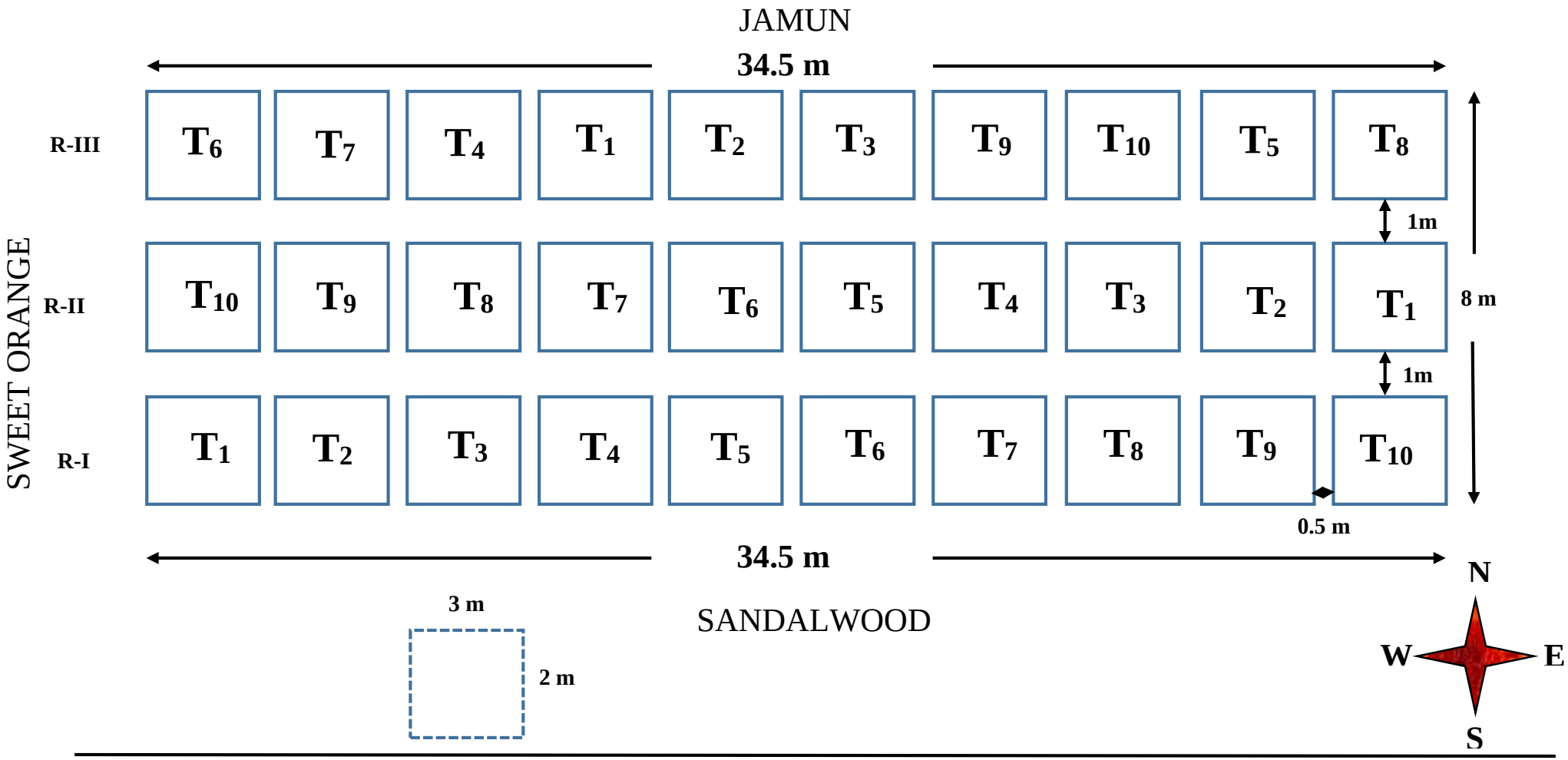
4.4 ECONOMICS

Higher money value and less cost of cultivation are desirable characters for getting higher returns. Hence, economics of the treatment was worked out and the data pertaining to economics of different treatment is depicted in Table 4.3.1 and fig.4.5. The cost of cultivation incurred in various treatments is presented in Appendix III.

Table 4.12 Economics different treatment of organic, inorganic and biofertilizer for onion

Treatment No.	Yield (q/ha)	Gross realization (₹/ha)	Total cost of production (₹/ha)	Net realization (₹/ha)	BCR (₹)
T_1	398.97	319176	87893.13	231282.87	2.63
T_2	335.39	268312	91561.68	176750.32	1.93
T_3	371.60	297280	92949.18	204330.82	2.20
T_4	351.17	280936	92255.43	188680.57	2.05
T_5	381.00	304800	95229.12	209570.88	2.20
T_6	449.31	359448	98004.12	261443.88	2.67
T_7	420.10	336080	96616.62	239463.38	2.48
T_8	465.02	372016	90123.12	281892.88	3.13
T_9	497.60	398080	91510.62	306569.38	3.35
T_{10}	473.39	378712	90816.87	287895.13	3.17

Significantly maximum bulb yield of 497.60 q/ha was obtained in treatment T_9 (50% RDF + 25% N from Vermicompost + 5 ml Bio-NPK consortium). Maximum benefit cost ratio 3.35 was observed under the treatment T_9 due to high net realization 306569.38 ₹/ha. While, lowest bulb yield 335.39 q/ha and net realization of 176750.32 ₹/ha along with benefit cost ration 1.93 was observed in treatment T_2.



TREATMENT DETAILS

T_1	100 % RDF (control)	T_6	50 % RDF + 50% N from vermicompost
T_2	75 % RDF + 25 % N from FYM	T_7	50 % RDF + 50% N from castor cake
T_3	75 % RDF + 25 % N from vermicompost	T_8	50 % RDF + 25 % N from FYM + 5 ml Bio-NPK Consortium
T_4	75 % RDF + 25 % N from castor cake	T_9	50 % RDF + 25 % N from vermicompost + 5 ml Bio-NPK Consortium
T_5	50 % RDF + 50% N from FYM	T_{10}	50 % RDF + 25 % N from castor cake + 5 ml Bio-NPK Consortium

Fig.-3.1: LAYOUT PLAN OF EXPERIMENT

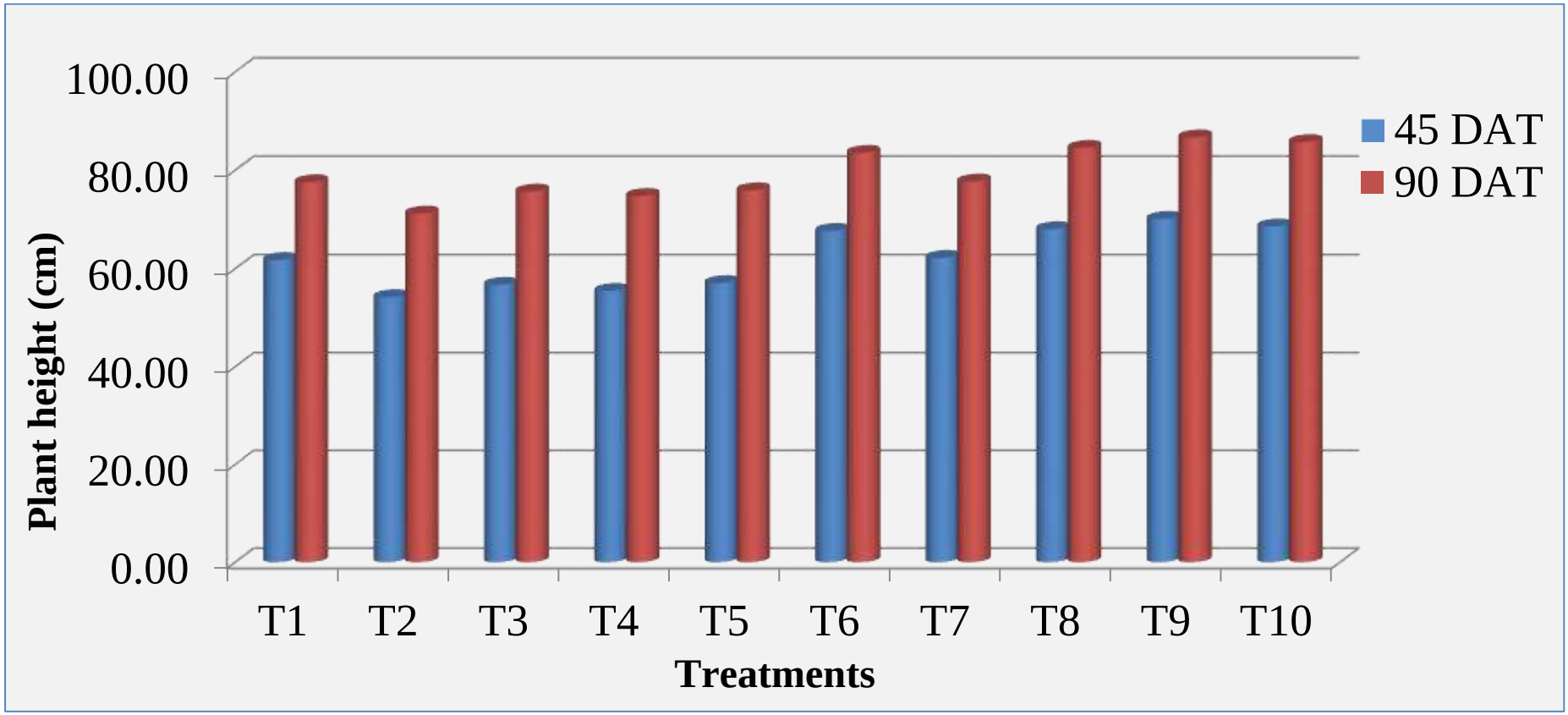


Fig 4.1: Effect of organic, inorganic and biofertilizer on plant height of onion at 45 and 90 DAT

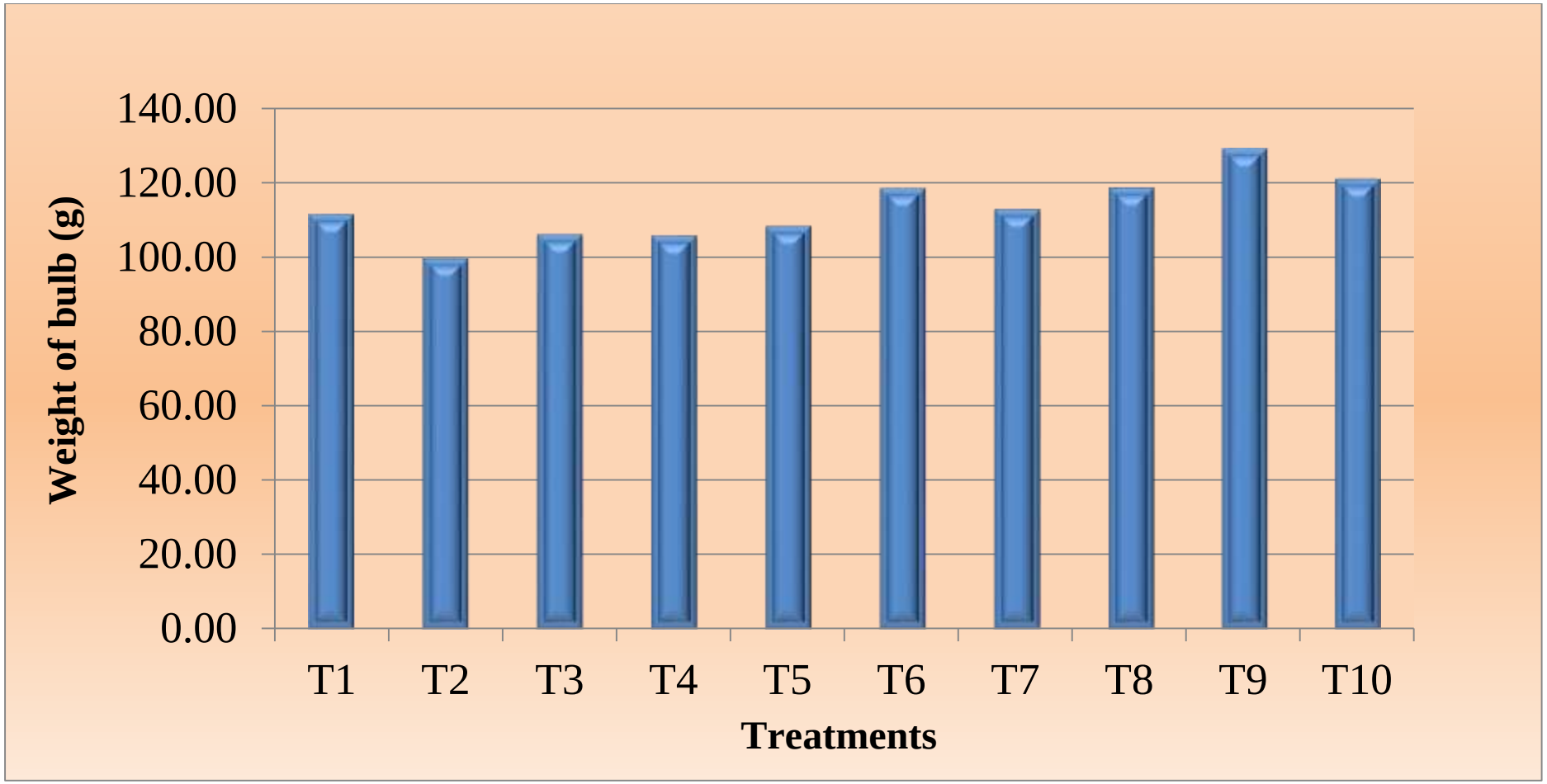


Fig 4.2: Effect of organic, inorganic and biofertilizers on bulb weight of onion at harvest

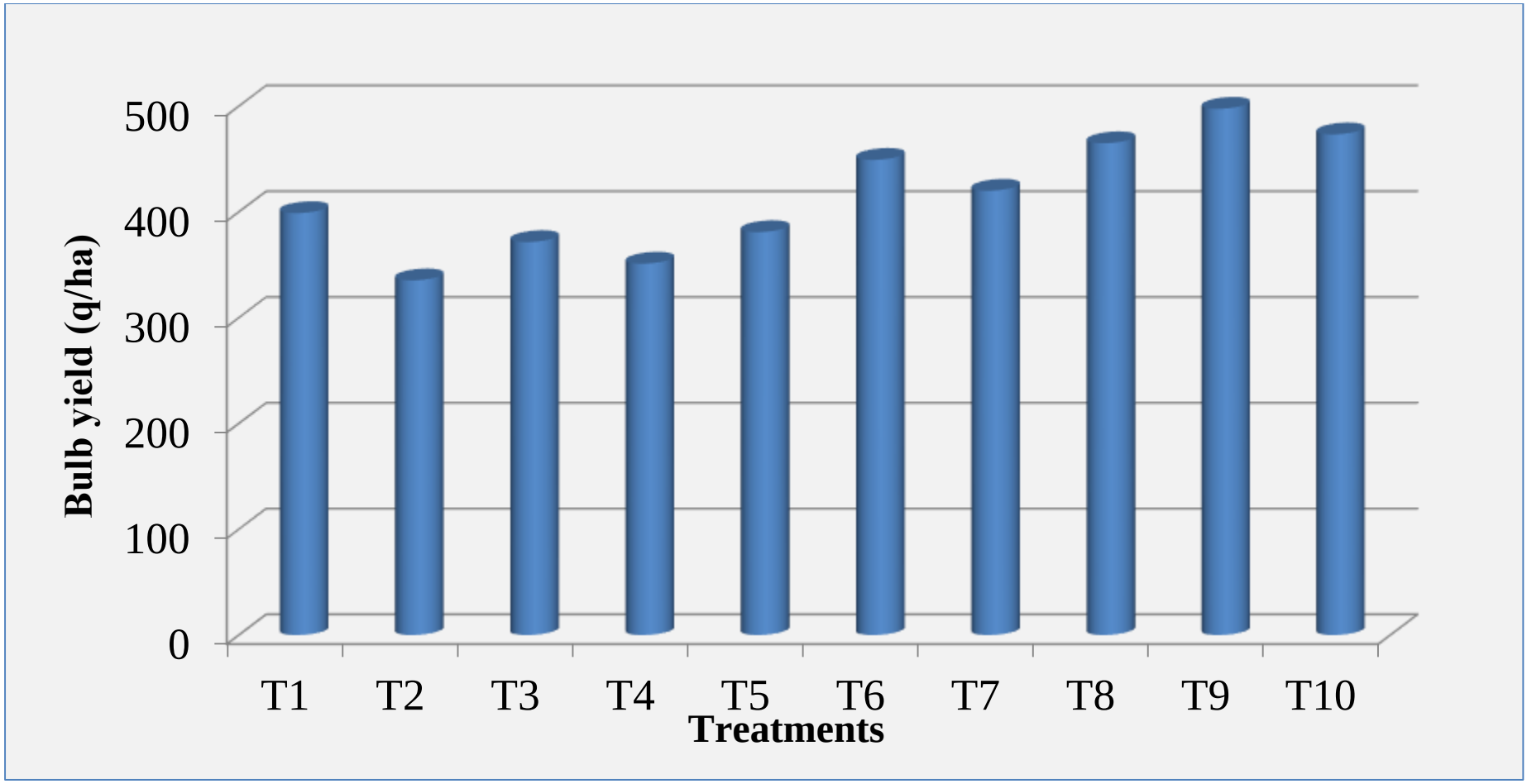


Fig 4.3: Effect of organic, inorganic and biofertilizers on bulb yield of onion cv. GJRO-11

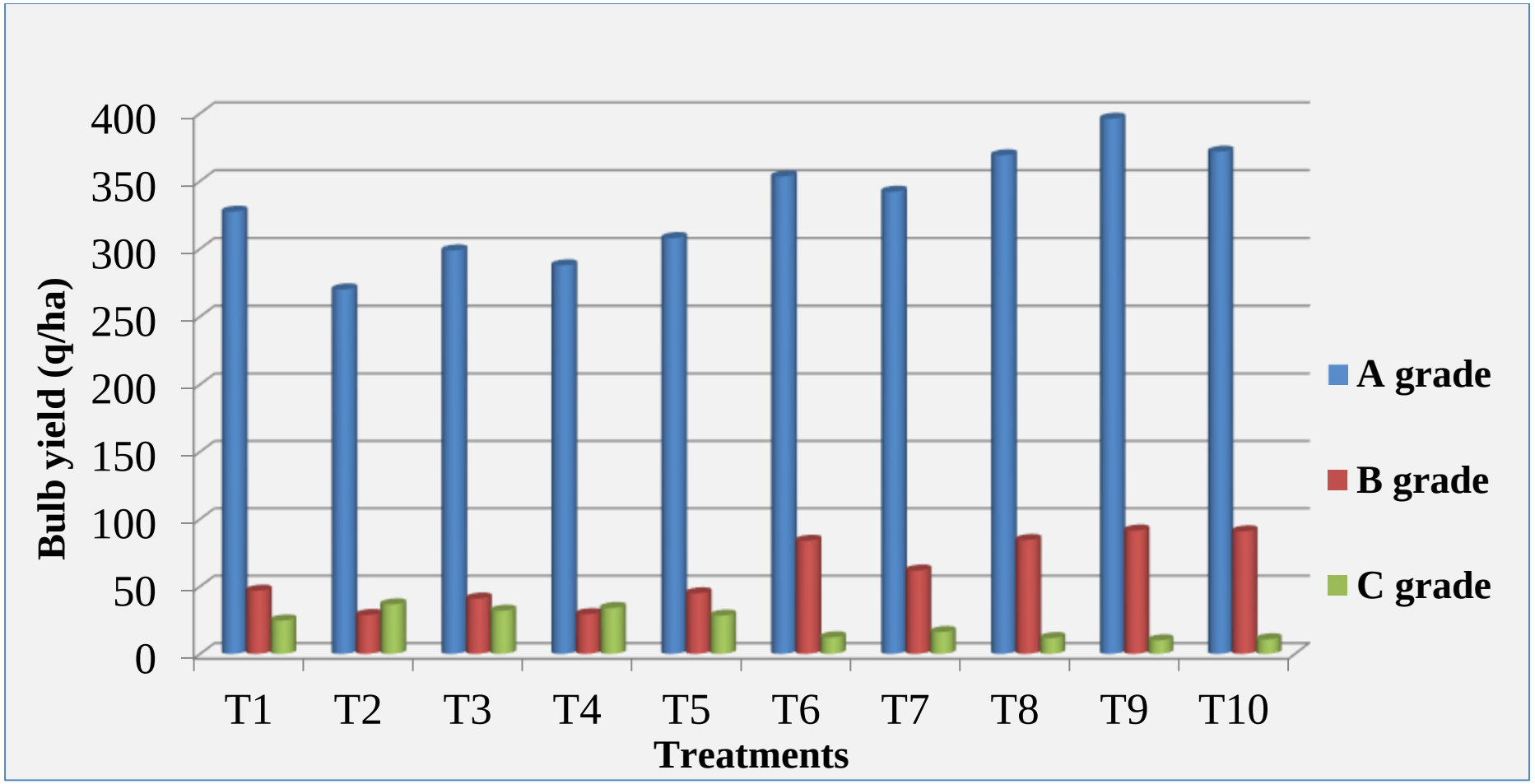


Fig 4.4: Effect of organic, inorganic and biofertilizers on grading of bulbs on weight basis 'A', 'B' and 'C' grade (q/ha) of onion

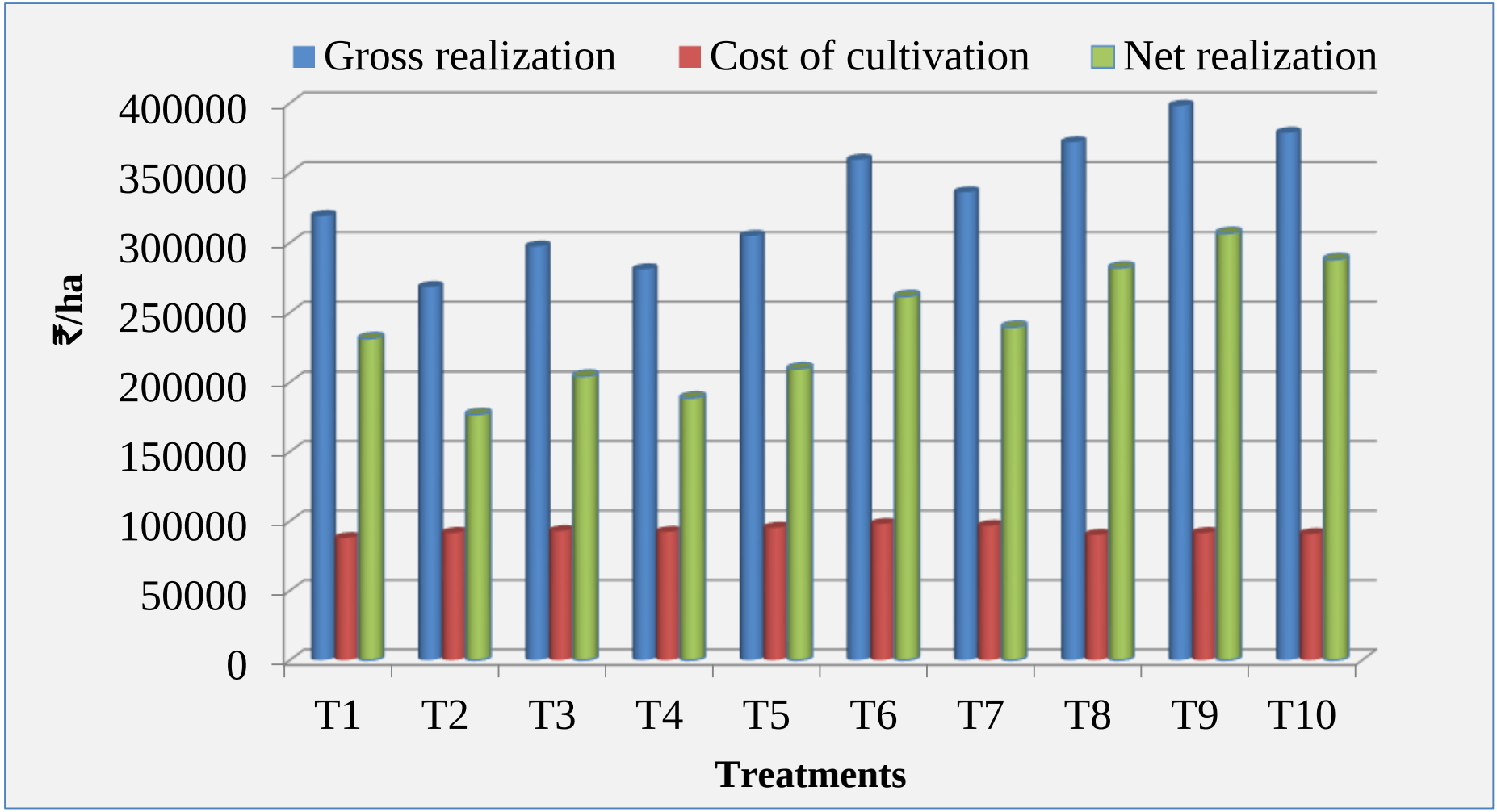


Fig 4.5: Economics of different treatments

5. SUMMARY AND CONCLUSION

An investigation entitled "Effect of organic, inorganic and biofertilizer on growth and yield of onion (*Allium cepa L.*) Cv. GJRO-11" was carried out during the *kharif* season of 2018-19 at Horticultural Research Farm, College of Horticulture, Anand Agricultural University, Anand, Gujarat. The experiment was conducted in Randomized Block Design with ten treatment in three replications. The plot size of 3.0 x 2.0 m was provided with inorganic and organic sources of fertilizers as per treatment viz., 100% RDF (Control) (T_1), 75% RDF + 25% N from FYM (T2), 75% RDF + 25% N from VC (T3), 75% RDF + 25% N from CC (T_4), 50% RDF + 50% N from FYM (T_5), 50% RDF + 50% N from VC (T_6), 50% RDF + 50% N from CC (T_7), 50% RDF + 25% N from FYM + 5 ml Bio-NPK Consortium (T_8), 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium (T_9) and 50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium (T_{10}). Onion variety 'Gujarat Junagadh Red onion-11' was sown on 11th October, 2018 and transplanted on 4th Dec, 2018 keeping row to row and plant to plant spacing of 15 x 10 cm. The observations were recorded for growth and yield attribute. The methods of investigation on different aspects during the course of study have been presented in chapter III. The results obtained on different aspects are detailed in chapter IV and have been discussed in preceding chapter IV. In this chapter silent findings of the experiment have been summarized as under:

5.1 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON GROWTH PARAMETERS

5.1.1 Plant height

The maximum plant height (70.11 and 86.70 cm at 45 and 90 DAT respectively) was recorded with combined application of 50% RDF + 25% N from vermicompost + 5 ml Bio-NPK consortium, followed by 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6).

5.1.2 Number of leaves per plant

There was a non-significant variation observed in number of leaves/plant with organic, inorganic and biofertilizers treatments.

5.1.3 Bolting percent

Minimum bolting per cent (4.38%) was recorded in 50 % RDF through chemical fertilizers + 25 % N from VC + 5 ml Bio-NPK Consortium and 50 % RDF through chemical fertilizers + 25 % N from CC + 5 ml Bio-NPK Consortium. Whereas, maximum bolting percent (6.20 %) was recorded in the treatment T_5 with application of 50% RDF through chemical fertilizers + 50 % N from FYM.

5.2 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON YIELD PARAMETERS

5.2.1 Average bulb weight (g)

Significantly highest average bulb weight (129.30 g) was observed due to integrated use of 50 % RDF + 25 % N through VC + 5ml Bio-NPK consortium, which showed statistical at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6).

5.2.2 Bulb volume (cc)

The bulb volume also showed same trends as noted in bulb weight. The highest bulb volume (136.70 cc) was recorded in 50% RDF + 25% N from VC + 5 ml Bio-NPK consortium. Which was statistical at par with 50% RDF +25 % N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF +25 % N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6).

5.2.3 Neck thickness (cm)

Significantly maximum neck thickness (1.11 cm) was noticed with the combined application of 50% RDF + 25% N from VC + 5ml Bio-NPK consortium which was at par with 50% RDF + 25% N from Castor cake + 5 ml Bio-NPK consortium (T_{10}), 50% RDF + 25% N from FYM + 5 ml Bio-NPK consortium (T_8) and 50% RDF + 50% N from VC (T_6) having bulb volume of 1.07, 0.97 and 0.96 cm, respectively.

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

There was a profound effect of combined application of organic, inorganic and biofertilizers on bulb yield q/ha. Significantly highest bulb yield (497.60 q/ha) was produced when the plants grown under the influence of integrated use of 50 % RDF + 25 % N from VC + 5 ml Bio-NPK consortium, which was at par with T_{10}, T_8 and T_6.

The minimum bulb yield (335.39 q/ha) were recorded under application of 75 % RDF + 25 % N from FYM (T_2).

5.2.5 Grading of bulbs

5.2.5.1 A grade (> 65 g)

The A grade bulbs differed significantly and it varied from 395.98 to 270.03 q/ha. The maximum A grade bulb yield (395.98 q/ha) was recorded in 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium (T_9), which was at par with T_{10}, T_8 and T_6, while the minimum yield of A grade bulb yield (270.03 q/ha) was noted in 75 % RDF + 25 % N from FYM (T_2).

5.2.5.2 B grade (45-65 g)

The B grade bulb yield differed significantly and it varied from 91.50 to 28.81 q/ha. The maximum B grade bulb yield (91.50 q/ha) was recorded in 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium and the minimum yield of B grade bulb (28.81 q/ha) was noted in 75 % RDF + 25 % N from FYM.

5.2.5.3 C grade (< 45 g)

The C grade bulb yield differed significantly with different onion treatments and it ranged from 10.01 to 36.69 q/ha. The minimum C grade bulb yield (10.00 q/ha) was recorded in the 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium and the maximum yield of C grade bulb (36.69 q/ha) was recorded in 75 % RDF + 25 % N from FYM**.**

5.2.6 TSS (ºBrix)

The TSS content in bulb was higher in combined use of organic, inorganic and biofertilizers. The plants grown under influence of combined application of 50 % RDF + 25 % N from VC + 5 ml Bio-NPK consortium and produced highest TSS content in bulb (13.47 ºBrix). The lowest TSS (11.71 ºBrix) was noted in 75 % RDF + 25 % N from FYM (T_2).

5.3 EFFECT OF ORGANIC, INORGANIC AND BIOFERTILIZER ON NUTRIENT STATUS OF SOIL

5.3.1 Nutrient status of soil (Organic carbon, N, P and K)

Application of 50 % RDF + 50 % N from FYM (T_5) recorded significantly maximum avaibility of N (369 kg/ha), P_2O_5 (44.67 kg/ha), K_2O (331 kg/ha) and O.C (0.39 %) While, the minimum avaibility of N (254.33 kg/ha), P_2O_5 (33 kg/ha), K_2O (266 kg/ha) and O.C (0.25%) were recorded under application of 100 % RDF (T_1).

5.3.2 Initial and after harvest microbial count of soil

Application of 50 % RDF + 25 % N through FYM + 5 ml Bio-NPK consortium (T_8) recorded maximum Azotobacter, Azopirrilum, PSB, KMB and Total count of bacteria. Whereas, the minimum Azotobacter, Azopirrilum, PSB, KMB and total count of bacteria in control.

5.4 ECONOMICS

The integrated use of organic, inorganic and biofertilizers caused appreciable enhancement in net return with higher benefit cost ratio. The plot treated with 50% RDF+25% N from VC + 5 ml Bio-NPK consortium produced significantly highest net return (306569.38 ₹/ha) with better benefit cost ratio (3.35), While application of 50% RDF+25% N from castor cake + 5 ml Bio-NPK consortium ranked second in merit. The lowest net return (176750.32 ₹/ha) and inferior benefit cost ratio (1.93) was obtained in treatment T_2 (75% RDF + 25% N from FYM).

CONCLUSION

The results of experimentation "Effect of organic, inorganic and biofertilizers on growth and yield of onion cv. GJRO-11" confirmed the efficiency of integration of organic, inorganic and biofertilizers for better growth and yield of onion. Recommended dose of inorganic fertilizers (100:75:75 kg NPK/ha) could not perform well in increasing growth and yield of onion. Among the various combinations, it can be concluded that overall performance of the 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium (T_9) enhanced vegetative growth *i.e.*, plant height, number of leaves and reduce bolting percent and yield parameters *i.e.*, average bulb weight, bulb volume, neck thickness, bulb yield, grading of bulbs and TSS.

Application of 50 % RDF + 50 % N from FYM recorded significantly maximum avaibility of N, P_2O_5, K_2O and Organic carbon of the soil (T_5).

The application of 50 % RDF + 25 % N through FYM + 5 ml Bio-NPK consortium recorded maximum Azotobacter, Azopirrilum, PSB, KMB and Total count of bacteria.

Maximum net realization and BCR was observed maximum in application of 50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium (T_9).

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APPENDICES

APPENDIX-I

Details of weather parameters recorded during the period of investigation

Month & year	Std. week	Date	Temperature (ºC)			Sun-shine hours	Mean R. H. (%)
			Max.	Min.	Mean		
Oct.-2018	41	07-13	37.2	20.4	28.8	9.0	62.2
	42	14-20	37.2	19.8	28.5	9.0	61.8
	43	21-27	36.8	16.7	26.8	9.8	57.2
	44	28-03	35.5	17.4	26.5	9.9	53.5
Nov.-2018	45	04-10	34.3	14.6	24.5	9.6	58.3
	46	11-17	34.5	14.4	24.5	9.3	61.5
	47	18-24	34.4	16.1	25.3	9.2	63.5
	48	25-01	30.9	13.9	22.4	8.1	61.1
Dec.-2018	49	02-08	30.1	13.6	21.8	7.1	65.9
	50	09-15	28.1	11.1	19.6	8.6	60.6
	51	16-22	27.7	9.1	18.4	9.3	59.7
	52	23-29	24.0	7.1	15.5	8.3	47.4
Jan.-2019	1	01-05	28.7	8.2	18.5	9.3	59.3
	2	06-12	26.5	9.4	18.0	9.1	60.1
	3	13-19	29.7	10.7	20.2	9.5	62.9
	4	20-26	25.5	10.7	18.1	9.2	62.5
	5	27-02	26.9	10.9	18.9	9.3	56.5
Feb.-2019	6	03-09	27.5	10.1	18.8	8.2	60.7
	7	10-16	30.7	12.7	21.7	9.4	58.9
	8	17-23	32.0	14.1	23.1	9.8	64.0
	9	24-02	31.6	15.2	23.4	9.2	51.0
Mar.-2019	10	03-09	31.1	14.6	22.8	9.1	54.5
	11	10-16	32.5	15.4	24.0	9.5	44.4
	12	17-23	35.9	17.5	26.7	9.8	48.5
	13	24-30	39.3	19.7	29.5	9.7	51.6

Appendix-II

Calender of field operations carried out during the course of investigation for onion crop

Sr. No.	Field operation	Date of operation
A	Date of sowing in nursery	11-10-2018
B	Field preparation	
1	Field layout	12-11-2018
2	Preparation of beds	03-12-2018
C	Transplanting	
1	Transplanting	04-12-2018
2	Gap filling	12-12-2018
D	Herbicide application	05-12-2018
E	Fertilizer application	
1	Basal dose : Full dose of P_2O_5 and K_2O	03-12-2018
2	Top dressing : a. 50% of total nitrogen	04-12-2018
	b. 50% of total nitrogen	01-01-2019
F	Irrigation	
	I	04-12-2018
	II	13-12-2018
	III	24-12-2018
	IV	01-01-2019
	V	10-01-2019
	VI	19-01-2019
	VII	29-01-2019
	VIII	08-02-2019
	IX	18-02-2019
	X	27-02-2019
	XI	08-03-2019
	XII	15-03-2019
I	Insecticide and fungicide application	
	I	25-12-2018
	II	12-01-2019
	III	30-01-2019
G	Hand weeding	06-01-2019
		13-02-2019
H	Harvesting	30-03-2019

APPENDIX – III

Cost of cultivation and other details of cost incurred

(A) Details of fixed cost of cultivation practices

Sr. No.	Particular	Input	Rate	Cost (₹/ha)
A	**Land preparation**			
	1. Tractor cultivation	3 hrs	350/hr	1050
	2. Harrowing and planking	2 hrs	350/hr	700
B	**Sowing**			
	1. Cost of sowing of seeds and Transplanting	80 L	178/day	14240
	2. Preparation beds and irrigation channels	4 L	178/day	712
	3. Cost of FYM	4 L	178/day	712
	4. Application of FYM	20 t	1 ₹/kg	20000
	5. Cost of seeds	10 kg	600/kg	6000
	6. Total irrigation: 12 (Rs 500 for each irrigation/ha + 2L)	2 L + 12 irrigation	178/day + 500 each irrigation	10272
C	**After care operations**			
	Gap filling	1 L	178/day	178
	Spray of Bavistin + spraying charge Spray of Roger + spraying charge	2 SL + 1.5 kg 2 SL + 1.5 L	312/day + 500/kg 312/day + 550/l	1374 1449
D	**Harvesting** (80 L)	25 L	178/day	14240
E	**Land revenue**	--	--	750
	Total Cost (A+B+C+D+E)	**--**	**--**	**71677**

F	**Variable cost**			
1.	100 % RDF			
	1. Urea	218 kg	5.92/kg	1291
	2. SSP	417 kg	7.8/kg	3253
	3. MOP	125 kg	18/kg	2250
2.	75% RDF + 25% N from FYM			
	1. Urea	163 kg	5.92/kg	965
	2. SSP	313 kg	7.8/kg	2442
	3. MOP	94 kg	18/kg	1692
	4. FYM	5000 kg	1 ₹/kg	5000
3.	75% RDF + 25% N from Vermicompost			
	1. Urea	163 kg	5.92/kg	965
	2. SSP	313 kg	7.8/kg	2442
	3. MOP	94 kg	18/kg	1692
	4. Vermicompost	1250 kg	5 ₹/kg	6250
4.	75% RDF + 25% N from Castor cake			
	1. Urea	163 kg	5.92/kg	965
	2. SSP	313 kg	7.8/kg	2442
	3. MOP	94 kg	18/kg	1692
	4. Castor cake	625 kg	9 ₹/kg	5625
5.	50% RDF + 50% N from FYM			
	1. Urea	109 kg	5.92/kg	646
	2. SSP	208 kg	7.8/kg	1623
	3. MOP	63 kg	18/kg	1134
	4. FYM	10000 kg	1 ₹/kg	10000
6.	50% RDF + 50% N from Vermicompost			
	1. Urea	109 kg	5.92/kg	646
	2. SSP	208 kg	7.8/kg	1623
	3. MOP	63 kg	18/kg	1134
	4. Vermicompost	2500 kg	5 ₹/kg	12500
7.	50% RDF + 50% N from Castor cake			
	1. Urea	109 kg	5.92/kg	646
	2. SSP	208 kg	7.8/kg	1623

	3. MOP	63 kg	18/kg	1134
	4. Castor cake	1250 kg	9 ₹/kg	11250
8.	50% RDF + 25% N from FYM + Bio-NPK consortium			
	1. Urea	109 kg	5.92/kg	646
	2. SSP	208 kg	7.8/kg	1623
	3. MOP	63 kg	18/kg	1134
	4. FYM	5000 kg	1 ₹/kg	5000
	5. Bio-NPK consortium	1 Litter	400 ₹/l	400
9.	50% RDF + 25% N from Vermicompost + Bio-NPK consortium			
	1. Urea	109 kg	5.92/kg	646
	2. SSP	208 kg	7.8/kg	1623
	3. MOP	63 kg	18/kg	1134
	4. Vermicompost	1250 kg	5 ₹/kg	6250
	5. Bio-NPK consortium	1 Litter	400 ₹/l	400
10.	50% RDF + 25% N from Castor cake + Bio-NPK consortium			
	1. Urea	109 kg	5.92/kg	646
	2. SSP	208 kg	7.8/kg	1623
	3. MOP	63 kg	18/kg	1134
	4. Castor cake	625 kg	9 ₹/kg	5625
	5. Bio-NPK consortium	1 Litter	400 ₹/l	400
	Total Variable Cost			

Note: Total cost has been carried over to Appendix (B)

(B) Detail of treatment cost

Treatment	Cost of Treatment (₹/ha)	Application Charge (₹/ha)	Total cost of Treatment (₹/ha)
T_1: 100% RDF (Control)	6794	712	7506
T_2: 75% RDF + 25% N from FYM	10099	712	10811
T_3:75% RDF + 25% N from VC	11349	712	12061
T_4:75% RDF + 25% N from CC	10724	712	11436
T_5:50% RDF + 50% N from FYM	13403	712	14115
T_6:50% RDF + 50% N from VC	15903	712	16615
T_7:50% RDF + 50% N from CC	14653	712	15365
T_8:50% RDF + 25% N from FYM + 5 ml Bio- NPK Consortium	8803	712	9515
T_9:50% RDF + 25% N from VC + 5 ml Bio-NPK Consortium	10053	712	10765
T_{10}:50% RDF + 25% N from CC + 5 ml Bio-NPK Consortium	9428	712	10140

Note:

1. Tractor @ 350/hr
2. L: Labor @ 178 ₹/day
3. Cost of Urea @ 5.92 ₹/kg
4. Cost of SSP @ 7.8 ₹/kg
5. Cost of MoP @ 16.80 ₹/kg
6. Cost of irrigation @ 500 ₹/irrigation
7. Application of herbicide/foliar spray of fertilizer 312 ₹/ha
8. Seed cost : 600 ₹/kg
9. SL: Skilled labour @ 312 ₹/day
10. Vermicompost @ 5 ₹/kg
11. FYM @ Rs 1 ₹/kg
12. Caster cake @ 9 ₹/kg
13. Bio NPK consortium @ 200 ₹/500 ml
14. Onion @ 8 ₹/kg

(D) Total cost incurred for different treatment combination

Sr. No.	Treatment	Fixed cost (A) (₹)	Variable cost (B) (₹)	Cost of cultivation (A+B) (₹)	Interest on (A+B) @ 12% for 6 months (₹ha^{-1})	Supervision charges on (A+B) @ 10% for 6 months (₹ha^{-1})	Total cost of Cultivation (₹)
1	T_1	71677	7506	79183	4750.98	3959.15	87893.13
2	T_2	71677	10811	82488	4949.28	4124.40	91561.68
3	T_3	71677	12061	83738	5024.28	4186.90	92949.18
4	T_4	71677	11436	83113	4986.78	4155.65	92255.43
5	T_5	71677	14115	85792	5147.52	4289.60	95229.12
6	T_6	71677	16615	88292	5297.52	4414.60	98004.12
7	T_7	71677	15365	87042	5222.52	4352.10	96616.62
8	T_8	71677	9515	81192	4871.52	4059.60	90123.12
9	T_9	71677	10765	82442	4946.52	4122.10	91510.62
10	T_{10}	71677	10140	81817	4909.02	4090.85	90816.87

Table E total income, total cost and net income

Treatment No.	Yield (q/ha)	Gross realization (₹/ha)	Total cost of production (₹/ha)	Net realization (₹/ha)	BCR
T_1	398.97	319176	87893.13	231282.87	2.63
T_2	335.39	268312	91561.68	176750.32	1.93
T_3	371.60	297280	92949.18	204330.82	2.20
T_4	351.17	280936	92255.43	188680.57	2.05
T_5	381.00	304800	95229.12	209570.88	2.20
T_6	449.31	359448	98004.12	261443.88	2.67
T_7	420.10	336080	96616.62	239463.38	2.48
T_8	465.02	372016	90123.12	281892.88	3.13
T_9	497.60	398080	91510.62	306569.38	3.35
T_{10}	473.39	378712	90816.87	287895.13	3.17

CERTIFICATE

This is to certify that I have no objection for supplying to any scientist only one copy of any part of this thesis for rendering reference service in library of documentation centre.

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