Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. Gola under Semi Arid Conditions

अर्द्धशुष्कीय परिस्थितियों में बेर (*जिजीफस मॉरीशिआना* लामा.) की 'गोला' किस्म के वृद्धि प्राचलों पर कार्बनिक खादों एवं उर्वरक स्तरों का प्रभाव

Rajbala Choudhary

THESIS

Master of Science in Agriculture
(Horticulture)

2016

DEPARTMENT OF HORTICULTURE
S.K.N. COLLEGE OF AGRICULTURE, JOBNER
S.K.N. AGRICULTURE UNIVERSITY JOBNER– 303 329

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Thesis

Submitted to the
Sri Karan Narendra Agriculture University, Jobner
in partial fulfillment of the requirements for
the degree of

Master of Science

in the
Faculty of Agriculture
(Horticulture)

by

Rajbala Choudhary

2016

Sri Karan Narendra Agriculture University, Jobner

S.K.N. College of Agriculture, Jobner

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ACKNOWLEDGEMENTS

It is a great pleasure for me to express sincere and deepest sense of gratitude and indebtedness to my esteem major advisor Dr. O.P. Garhwal (Asstt. Professor) Department of Horticulture, S.K.N. College of Agriculture, Jobner for his invaluable inspiring guidance and encouragement during the course of present investigation and preparation of the manuscript.

It is my unique privilege and duty to express sincere gratitude and regards to the members of advisory committee namely, Dr. M.R. Choudhary (Professor and Head), Department of Horticulture, Dr. S.S. Yadav (Professor), Department of Agronomy and Dr. R.P. Ghasolia (Asstt. Professor) Department of Plant Pathology, S.K.N. College of Agriculture, Jobner for providing suggestions and guidance as and when needed.

I extend my deep and heartful gratitude to Dr. M.R. Choudhary (Professor and Head), Department of Horticulture, Dr. S.N. Sharma (Former Dean), Dr. R.C. Kumawat (Dean), S.K.N. College of Agriculture, Jobner and Dr. B.S. Shekhawat (Director of Education) SKNAU, Jobner for providing necessary facilities during the course of investigation.

I feel gratified to record my cordial thanks to Dr. A.K. Soni (Professor), Dr. M.K. Sharma (Assoc. Professor), Dr. L.N. Bairwa (Assoc. Professor), Dr. S.P. Singh (Asstt. Professor), Department of Horticulture Dr. B.L. Yadav (Professor), Department of Soil Science and Agricultural Chemistry and Dr. D.L. Bagari (Asstt. Professor), Department of Plant Physiology for their valuable co-operation in completing this investigation smooth and easy.

The help provided by Dr. B.M. Sharma (Farm Manager), Dr. S.L. Sharma (STA), Dr. C.S. Pareek (STA) and other non-teaching staff members of the Department of Horticulture is also unforgettable.

I offer my sincere thanks to my seniors Mr. Hari Dayal, Mr. Arun, Mr. Suresh, Ms. Deepika, Mr. Manoj, Mr. Ashok, Ms. Priyanka, Ms. Bhawana, Ms. Kavita, Ms. Sajana, colleagues Sunita Koodi, Prem Raj, Ramavtar, Omprakash, Leela, Sunita verma, Manju, Sunita Kumawat and dear juniors Komal, Pratistha, Lata, Puspendra and friends Virendra, Rashmi, Bhuli, Suman, Jyoti, Sushila and Gopali for their regular support, motivation and inspiration.

My vocabulary falls short to express heartiest regards to Sh. Ladu Ram Haritwal-Smt. Narayani Devi (grand parents), Sh. Richhpal Haritwal -Smt. Geeta Devi (parents), Sh. Banwari-Smt. Saroj (Uncle-Anti), Mr. Ram Kisor (Uncle), Sh. Hajari- Smt. Saroj (Bhaya-Bhabhi), Chandra Kala, Pradeep, Suresh, Rahul, Manoj and Renu (brother's and sister's) all family members and relatives without whose blessing, affection and encouragement, I could not have completed this task successfully.

I extend my cordial thanks to Mr. Shankar Yadav, Shivum computer's Jobner for typing the script neatly and efficiently within a very short period.

Last but not the least, a million thanks to almighty Jwala Mata that made it possible to complete this task and made every job a success for me.

Place : Jobner

Dated: / /2016 (Rajbala Choudhary)

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ABBREVIATIONS/SYMBOLS

S.No.	Name	Symbol
1.	At the rate of	@
2.	Benefit : cost ratio	B:C ratio
3.	Centimetre	cm
4.	Coefficient of variation	CV
5.	Critical difference	CD
6.	Cultivar	cv.
7.	Degree Celsius	^{0}C
8.	Degree of freedom	Df
9.	Desi siemens per meter	dS/m
10.	Electrical conductivity	EC
11.	Etcetera	etc
12.	Farm yard manure	FYM
13.	Figure	Fig.
14.	Gram	g
15.	Hectare	ha
16.	Hours	hrs
17.	Kilogram	kg
18.	Mega gram per cubic meter	Mg/m
19.	Meter	m
20.	Milligram per gram	mg/g
21.	Muriate of potash	MoP
22.	Non-significant	NS
23.	Number	No.
24.	Poultry manure	PM
25.	Quintal	q
26.	Randomized block design	RBD
27.	Recommended dose of fertilizers	RDF
28.	Rupee	₹
29.	Single super phosphate	SSP
30.	Standard error of mean	SEm $\pm$
31.	Standard meteorological week	SMW
32.	Tonne	t
33.	Total soluble solids	TSS
34.	That is	*i.e.*
35.	Vesicular arbuscular mycorhiza	VAM
36.	Which are	*viz.*
37.	Vermicompost	VC

Chapter-I

INTRODUCTION

Indian jujube or ber (*Zizyphus mauritiana* Lamk.) is one of the most common fruit, indigenous to an area joined from India to china. The genus *Zizyphus* has been derived from 'Zizaif' which is the Arabic name of the fruit (Baily, 1947). The ber belongs to the family Rhamnaceae which has about 50 genera and more than 600 species (Pareek, 1983). It has been under cultivation for over 4000 years in China and India (Mehra, 1967).

In India, ber is being cultivated on an area of about 4845 hectares with production of 66,296 metric tonnes (Anonymous, 2014). Madhya Pradesh, Bihar, Punjab, Haryana, Gujarat and Rajasthan are the major ber growing states. In Rajasthan, it is grown in an area of 930 hectares with production of 7870 metric tonnes (Anonymous, 2014). In Rajasthan, ber orchards are mainly available around Tijara, Alwar, Deeg, Chomu, Jaipur and Jodhpur region.

Pareek (1983) also reported that cultivation of ber requires the least input and care. It has a remarkable adaptability enabling it to grow in a wide range of agro-climatic situation and soils (Rana *et al*., 1979). Ber fruit is a very nutritious and rich source of ascorbic acid (90-280 mg/100g), vitamin 'A' (55 mg/ 100g), Thiamine (0.13 mg/100g), Riboflavin (0.19 mg/100g), total soluble solids (17-20%), acidity (0.21%), Beta carotene (81 µg/100g), protein (0.8 g/100g), fat (0.3 g/100g), carbohydrate (17 g/100g), calcium (4 mg100/g), phosphorus (9 mg /100g), and iron (1.8 mg/100g) (Yadav and Singh, 2001). Bakshi and Singh (1974) reported that ber fruits contain more vitamin 'C', protein and minerals in comparison to apple and mango.

The Indian jujube is grown chiefly for its fruits which may be eaten fresh, dried or canned, smoked and pickled or used in drinks. Several products like ber butter, ber squash or juice, ber murabba, ber pulp, ber jam and dehydrated or dried products may also be made out of ber fruits (Pareek, 1983 and Yamdgni,

1985). Various Ayurvedic and Yunani medicines contain ber extract which is said to be blood purifier and also help in digestion. The medicinal value of various parts of the tree and fruits of *Zizyphus sp.* are many and yet not fully exploited. The seeds kernels are aphrodisiac and decoction from root and bark is good for dysentery and diarrhea. Ber tree is important host plant for insect *Laccifer lacca* (Kerr.) which secrets a resinous substance on the twigs which is the raw materials for shellac preparation.

Among the different cultivars of ber, Gola is an extremely drought hardy, early & extensively grown variety. The fruits are round in shape & skin is golden yellow when ripe. The T.S.S. content of pulp is 16.0-20.0 per cent, vitamin 'C' content ranges from 70-130 mg/100g, acidity varies from 0.14-0.25 per cent and average yield is about 80 kg per tree.

The cultivation of this crop in arid and semi arid regions is mainly done but, due to one or another reason farmers are not harnessing the desired production potential of the crop. The potent reason for lesser productivity could be attributed to poor management. Ber produces fruits continuously for a long time, thus it needs proper and integrated nutrients to have regular feeding at vegetative as well as reproductive phase of the tree. The intensively cultivated soils do have the problems of fast depletion of plant nutrients and become deficient not only in macro but also in micro nutrients (Singh *et al*., 1998).

It is well documented that growth and yield of trees are greatly influenced by a wide range of nutrients. The role of nutrient elements either alone or in combination with other sources (organic manures/fertilizers) has been well established in many fruit crops; while such studies are very meagrely available in ber (Katiyar *et al*., 2012).

Some estimate revealed that nutrients removed by crop is far an excess nutrients added through fertilizers, resulting in a negative balance of 5.5 million tonnes of NPK (Sarkar, 2000). An approach involving chemical fertilizers and

organic manures to bridge this gap between nutrient demand and supply for giving a boost to crop production is only the solution. The situation further aggravates for the light soil of Rajasthan, where nutrient use remains much lesser than the removal (Gupta, 2001).

Integration of organic manures and chemical fertilizers is a system approach in nutrient management especially in semi arid regions emphasizes the need to increase the nutrient use efficiency and economise the use of costly mineral fertilizers by associating for the residual effects of the applied fertilizers. This approach is not only reliable way to obtain high fruit productivity with substantial fertilizer economy but also ensure concept of ecological soundness leading to sustainable Agriculture. The conclusions from long term experiment also support that a suitable combination of organic and inorganic sources will not only sustains soil fertility and crop productivity but also maintain higher levels of quality of produce (Pillai *et al*., 1985 and Nambair, 1994).

In India, the mixed farming system with livestock raising is an integral part of crop production. The availability of large quantity of FYM being rich in organic matter is the need for supplementing the nutrient. The organic manure (FYM) not only provides nutrient to the plant but also improves the soil texture by binding effect to soil aggregates. Organic manure increases CEC, water holding capacity and phosphate availability of the soil besides improving the fertilizer use efficiency and microbial population of soil, it reduces nitrogen loss due to slow release of nutrients.

In recent, past vermicompost is becoming an important substitute of FYM. Vermicompost means a mixture of worm casting, organic materials, humus, living earthworms, their cocoons and other organisms. Vermicompost is a slow releasing organic manure which contains most of the macro as well as micro nutrients in chelated form and fulfill the nutrient requirement of plant for longer period. Vermicompost helps in reducing C:N ratio, increased humic acid content,

cation exchange capacity and water soluble carbohydrates (Talashilkar *et al.*, 1999). It also contains biological active substance such as plant growth regulators.

Similarly, poultry manure is also an excellent organic manure which is concentrated sources of nitrogen and other essential nutrients. It has direct effect on plant growth. It is well documented that it increased nutrient uptake.

Among the nutrients, nitrogen is an essential macronutrient which has great significance in growth, development and metabolism of plant. Nitrogen is abundantly available (70-80%) in the atmosphere but the plants cannot take it directly from the atmosphere, hence nitrogen requirement of the plant is generally met out with the use of chemical fertilizer however, on the other hand, some microorganism can fix atmospheric nitrogen in the plant roots, which has been estimated the biological fixation contributes. The balanced fertilization in ber is an important factor to boost growth attributes, nitrogen is the most deficient element especially in coarse texture sandy soils of Rajasthan. The soil of Jobner contains about 115-120 kg nitrogen per hectare. Availability of nitrogen is important for growing plant as it is major indispensable constituent of protein and nucleic acid. Being a part of plant hormones, it is involved in regulating plant growth and development. An adequate supply of Nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally leading to higher productivity. Deficiency of nitrogen first appears on older leaves due to high mobility of the element. It's deficiency causes interveinal yellowing, development of anthocyanine pigment, rolling of leaves, chlorosis and necrosis.

Similarly, phosphorus is also an indispensable constituent of nucleic acids, phospholipids and several enzymes which have great importance in the transformation of energy in the plant system, metabolism and in respiration in plants (Yawalker *et al*., 1962) and has beneficial effect on early root development, plant growth and quality of produces (Brady, 1974). Indian soils are

poor to medium status in available phosphorus. Soil of Jobner contains 16-17 kg phosphorus per hectare. Further only 30 per cent of the available phosphorus is used for plant and remaining part is converted to insoluble phosphorus in soil. Phosphorus plays a key role in the formation of energy rich bound phosphate (ADP and ATP).

Likewise, potassium also plays an important role in crop productivity. Soil of Jobner contains about 142 kg potassium per hectare. It functions as an activator of numerous enzymes like pyruvic kinase, cytoplasmic enzymes and therefore, cause pervasive effect on metabolic events, it is always involved in the movement of carbohydrate and synthesis in case of potassium deficiency. There are also evidences of direct involvement of potassium in photosynthesis through its relation with chloroplast, where it is highly concentrate the fat in leaf tissues. Metabolic activities of chloroplast are also influenced by potassium level in these organelles. Potassium activates the fat producing enzymes in the plant.

Keeping these facts in view, a field experiment entitled **"Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under Semi Arid Conditions"** conducted at Horticulture Farm, S.K.N. college of agriculture, Jobner during July, 2015 to February, 2016 with the following objectives:

i. To study the comparative effect of organic manures and inorganic fertilizers on vegetative growth of ber.
ii. To find out the suitable fertility level and organic sources for better vegetative growth of ber.
iii. To study the soil and physiological parameters in pre bearing age of ber.

Chapter-2
REVIEW OF LITERATURE

A brief review of research work related to the **"Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under Semi Arid Conditions"** is being presented in this chapter. An attempt has been made to cite all available literature on ber but due to paucity of adequate published information relevant research findings on other related crops have also been incorporated.

2.1 Effect of organic manures

2.1.1 Effect on growth parameters

Goramnagar *et al*. (2000) reported application of 15 kg FYM + 360 g N + 180 g P_2O_5 per plant produced tall bushy plants with increased leaf area and plant spread in Nagpur orange.

Chundawat (2001) conducted an experiment on integrated nutrient management in tropical and subtropical fruits and found the beneficial effects of nitrogen fixing bacteria (*Azotobacter* and *Azospirillum*) and VAM on some fruit crops.

Saraf *et al*. (2004) concluded that application of 10 kg FYM per plant alone or combination with NPK was the effective treatment to boost up the all around growth of pomegranate plants.

Devadas and Kuriakose (2005) reported that application of 250 g poultry manure, *Azospirillum* and PSB at 650 mg each along with NPK @

8:4:8 g per plant of pineapple cv. Mauritius significantly affect the growth parameters.

Singh *et al*. (2007) studied the nutrient management practices in guava cv. Sardar through organic and inorganic sources. Application of vermicompost @ 10 kg, 50 per cent recommended dose of NPK and PSB @ 200 g per plant enhanced vegetative growth.

Umar *et al.* (2008) reported that maximum plant height (20.29 cm), plant spread (27.65 $cm^{2)}$ and leaf area (69.05 cm^2) in strawberry cv. Chandler which was significantly higher with the application of 50 per cent nitrogen through poultry manure and remaining quantity in the form of urea in combination with *Azotobacter*.

Singh *et al*. (2009) evaluated the response of organic manures and inorganic fertilizers on vegetative growth of ber cv. Banarasi Karaka. The maximum plant height, plant spread and trunk girth were recorded with the soil application of (FYM+100%NPK+*Azotobacter*+PSB) treatments.

Umar *et al.* (2009) conducted an experiment on strawberry cv. Chandler at SKUAST-J, Udheywalla (Jammu) during 2005-06 and 2006-07 to study the effect of organics FYM integrated with urea + *Azotobacter* and observed that maximum plant height (21.24 cm), plant spread (28.16 cm^2) and leaf area (74.95 cm^2) were found with the application of 25 per cent nitrogen through FYM augmented with *Azotobacter* .

Mishra *et al*. (2011) conducted an experiment on ber cv. Gola at SKN college of agriculture, Jobner (Raj.) and found that soil application of 22 kg vermicompost + 0.82 kg urea + 1.15 kg SSP + 0.41 kg MoP per tree and foliar spray of thiourea @ 0.5 per cent significantly increased the plant height, plant spread and leaf area.

Yadav *et al*. (2011) observed that growth characters of papaya *viz.* plant height (140.30cm) and plant girth (37.45cm) in cv. Pusa Dwarf improved significantly with the application of vermicompost (10 kg) + NPK (100%) + *Azotobacter* (25 g) per plant.

Dadheech and Choudhary (2012) reported that significant increase in growth characters of ber with combined application of 0.825 kg urea, 1.150 kg SSP, 0.410 kg MoP and 22 kg vermicompost per tree along with foliar spray of 0.5 percent thiourea.

Katiyar *et al*. (2012) also found that maximum growth of rejuvenated ber tree cv. Banarasi Karaka was obtained when NPK @ 1000:500:250 g with 50 kg FYM per plant were applied through DAP, urea and MoP respectively just after pruning at CSAUAT, Kanpur (U.P.) during 2009-11.

Singh *et al.* (2012) evaluated the influence of various levels of organic
and inorganic nutrient sources on vegetative growth of four years old aonla trees cv. NA-7 at Central horticultural experiment station (CIAH), Godhra (Gujarat). The growth in terms of plant height (64.08 cm), plant spread (51.37 cm), root stock girth (9.0 cm) and scion girth (6.08) improved

significantly with the application of 60 kg FYM + NPK @ 400:200:300 g per plant and 75 kg FYM + NPK @ 500:250:375 g per plant, respectively during 2007 and 2008.

Akinwumi *et al.* (2013) conducted an experiment on two cultivars of guava seedling namely ‘Allahabad’ and ‘White Delicious’ at National Horticultural Research Institute, Ibedan, Nigeria. The stem girth and canopy volume in Allahabad and plant height in ‘White Delicious’ cultivar significantly improved with the four applications of poultry manure (2.8 q/ha) as organic fertilizer and NPK 15:15:15 (75 kg/ha) as inorganic fertilizer per year.

Bhardwaj (2014) found that the medium of vermicompost + sand + pond soil (1:1:1) with 2 cm cocopeat at top of poly bags gave the highest seedling height, leaf area and stem girth of papaya seedling.

Garhwal *et al.* (2014) reported that the combined application of 80 kg FYM and 750 g nitrogen per plant led to significant increase in plant height (15.20%), plant spread (N-S, 18.03% and E-W, 18.99%) and canopy volume (81.81%) over initial level in Kinnow mandarin at SKRAU, Bikaner (Raj.) during 2008. However, highest trunk diameter (9.47%) was obtained with the application of 80 kg FYM alone.

Lal and Dayal (2014) investigated at KVK, Pali (Raj.) and found that maximum tree height (319.28 cm), tree spread (11.37 m^2) and stem girth (45.24 cm) in acid lime (*Citrus aurantifolia* Swingle) were observed when

50 per cent RDF + 50 per cent dose of NPK through goat manure were applied.

Mehraj *et al*. (2014) carried out an investigation at Bangla Agricultural University, Bangladesh during the period from June 2011 to March 2012 for evaluation of the performance of strawberry to different organic matters. They observed that maximum leaf area (68.3 cm^2), number of runners (5.5) and number of stolon (7.6) were observed when vermicompost was applied 1 kg per pot whereas maximum plant height (22.9 cm) was observed with the application of poultry manure @ 1 kg per pot in strawberry.

Nazir *et al*. (2015) reported that treatment combination of poultry manure + *Azotobacter* + wood ash + PSB + mustard oil cake significantly improved plant height (23.39 cm), plant spread (24.21 cm) and runners (13.03) per plant in strawberry cv. Senga Sengana at SKUAST-K, Srinagar (J&K).

Singh *et al*. (2015) conducted an experiment at BHU, Varanasi (U.P.) during 2012-14 on strawberry and found significant improvement in plant height (20.26 cm), plant spread (25.64 cm^2) and leaf area (97.87 cm^2) per plant when vermicompost (10 t) + *Azotobacter* (7 kg) + PSB (6 kg) + *Azospirilum* (5 kg) per hectare were applied.

Similarly, Wani *et al*. (2015) also reported that highest vegetative growth (15.25 mean leaves per plant and 21.50 cm mean plant spread) in strawberry was observed at Dry land Agriculture Research Station

Budgam, SKUAST-K, Srinagar (J&K) with application of nutrients through 75 per cent organic manures and 25 per cent inorganic fertilizers.

2.1.2 Effect on yield and quality

Faqir *et al*. (2000) studied the effect of FYM and inorganic fertilizers applied alone or in combination on the productivity of guava. However, the yield was significantly increased when all the three major elements (NPK) were applied along with rottened FYM. TSS content was not affected with any of the treatment.

Rathi and Bist (2004) observed that organic manures and biofertilizers with or without inorganic fertilizers had significant effect on yield and fruit quality of Pant Pear-18. The treatment consisting of 50 kg FYM + 37.50 g VAM + 350 g N + 225 g P_2O_5 + 150 g K_2O per tree gave maximum fruit yield (43.33 and 60.30 kg, respectively) in both the years.

Shivaputra *et al*. (2004) observed that application of 75 per cent RDF + vermicompost (2 t/ha) was the most effective treatment in terms of increasing yield of papaya cv. Sunset Solo.

Bhobia *et al*. (2005) found maximum fruit yield (85 kg/plant) of seven years old trees of guava cv. Hisar Surkha with the application of 40 per cent nitrogen through urea and 60 per cent nitrogen through FYM.

Devadas and Kuriakose (2005) reported that application of 250 g poultry manure, *Azospirillum* and PSB at 650 mg each along with NPK at

8:4:8 g per plant of pineapple cv. Mauritius significantly improved the quality parameters of fruits.

Dudi *et al.* (2005) conducted a trial on twelve years old Kinnow trees to study the influence of four levels each of nitrogen (0, 375, 750 and 1125 g/plant) and FYM (0, 50, 100 and 150 kg/plant) on yield and quality of fruits. Application of 750 g N and 150 kg FYM effectively increased the fruit yield (185 and 190 kg/plant, respectively).

Ram *et al*. (2005) found maximum yield (150.25 kg/tree), TSS (13.5^0Brix) and acidity (0.54%) contents in fruits of guava treated with 10 kg FYM + 250 g N + 100 g P_2O_5 + 250 g K_2O + *Azotobacter* per tree.

Singh *et al*. (2008) evaluated the effect of integrated nutrient management on quality of 'NA-10' aonla fruits. The maximum TSS and minimum acidity content were recorded with the application of 50 per cent NPK through inorganic sources and 50 kg FYM.

Bashir *et al*. (2009) conducted an experiment at Horticultural Research Station, Bahawalpur, Pakistan during 2004-05 and 2005-06 to determine the optimum dose of FYM and NPK fertilizers for improving yield and fruit quality of guava. Maximum yield per plant (63.78 kg) and TSS content (11.35%) were obtained in fruits of guava with application of 40 kg FYM + 1.0 kg each of NPK per plant.

Mahendra *et al. (*2009) reported that maximum fruit yield and quality parameters *viz.,* TSS and minimum acidity contents in fruits were recorded

with the soil application of FYM + NPK (100%) + *Azotobacter* + PSB in ber fruit cv. Banarasi Karaka at NDUA, Faizabad (U.P.) during the year 2005-06 and 2006-07.

Umar *et al.* (2009) conducted an experiment on strawberry cv. Chandler at SKUAST-J, Udheywalla (Jammu) during 2005-06 and 2006-07. The fruit quality *viz.* TSS (6.81^0Brix) content was noted highest in fruits obtained from plants supplied with 25 per cent nitrogen through FYM + 75 per cent nitrogen in the form of urea + *Azotobacter*. However, the maximum yield of 372.89 g per plant was obtained with the application of 100 per cent nitrogen in the form of urea along with *Azotobacter.*

Mishra *et al*. (2011) conducted an experiment on ber cv. Gola at SKN college of agriculture, Jobner (Raj.) and found that soil application of 22 kg vermicompost + 0.82 kg urea + 1.15 kg SSP + 0.41 kg MoP per tree and foliar spray of thiourea @ 0.5 per cent significantly increased the fruit yield and quality of fruits.

Yadav *et al*. (2011) observed that combined application of vermicompost (10 kg) + NPK (100%) + *Azotobacter* (25 g) per plant significantly improved the physio-chemical characters *viz.,* TSS (11.32^0Brix) and acidity (0.133%) contents in fruits of papaya cv. Pusa Dwarf at NDUAT, Faizabad (U.P.) during two consecutive years *i.e.* 2008-09 and 2009-10 as compared to other treatments.

Devi *et al.* (2012) also reported that maximum yield (114 kg/plant) in four years old guava cv. Sardar was observed with the application of FYM

at (26 kg/plant) + *Azotobacter* + phosphorous solubilizers + potash mobilizers each at (100 g/plant) in two splits (January and August) in a year. However, maximum TSS content (12^0Brix) was observed with the application of poultry manure @ 10 kg/plant.

Dwivedi *et al*. (2012) conducted an experiment on four years old guava trees during 2007-2008 to study the effect of bio-fertilizers and of organic manures (FYM) on yield and quality of 'Red Fleshed' guava. The maximum fruit yield for the rainy and winter season crops were 38.2 and 19.0 kg per tree respectively, with the application of 250 g *Azotobactor* + 20 kg FYM. Similarly, highest TSS content *i.e.*16.10 and 17.90^0Brix for rainy and winter season crops, respectively were obtained with the application of VAM.

Katiyar *et al*. (2012) conducted an experiment at CSAUAT, Kanpur (U.P.) during 2009-11 and reported that maximum yield per tree (30.08 kg), TSS (16.41^0brix) and lower acidity (0.21%) in thirty five years old rejuvenated ber tree cv. Banarasi Karaka when NPK @ 800:400:200 g with 50 kg FYM per plant were applied through DAP, urea and MoP respectively just after pruning.

Shivakumar *et al*. (2012) conducted an experiment at UAS, Dharwad, (Karnataka) during 2006-07 to 2007-08 and reported that application of FYM (154.3 t/ha) equivalent to 100 percent recommended dose of nitrogen (RDN) gave significantly higher fruit yield (173.9 t/ha) of papaya cv. Pusa Surya as compared to control with RDF and other organic manures.

Mustafa *et al.* (2013) revealed that soil application of FYM (15 kg) + ½ dose of NPK (1000:400:400g RDF) + $FeSo_4$ (200 g) per plant and foliar spray of $ZnSo_4$ (0.5%) + $CuSo_4$ (0.4%) significantly improved the fruit yield (47.75 kg) and TSS content (10.75%) in aonla cv. NA-7 at K.V.K. Farm, Ratlam (M.P.) during 2009-10.

Sharma *et al*. (2013) reported that application of nitrogen through FYM and inorganic fertilizers in a ratio of 1:3 with *Azotobacter* obtained highest fruit yield (41.14 kg/plant) in guava at SKUAST-J, Chatha (Jammu) while, *Azotobacter* + 50 per cent of N through FYM + 50 per cent of N through inorganic fertilizer per tree showed highest TSS content (12.95^0Brix).

Bohane and Tiwari (2014) conducted an experiment on ber cv. Gola at College of Horticulture, Mandsaur (M.P.) and observed that the application of 50 per cent recommended dose of NPK as vermicompost + 50 per cent RDF as NPK + 50 g *Azotobacter* + 50 g PSB per plant significantly increased TSS content (20.85^0Brix) and TSS/Acid Ratio (160.38).

Garhwal *et al.* (2014) reported that application of 80 kg FYM per plant significantly increased the fruit yield (25.22 kg/tree), TSS content (12.11^oBrix) and acidity (0.79%) in fruits of Kinnow mandarin at SKRAU, Bikaner (Raj.) during 2008. Khehra (2014) also conducted an experiment on lemon cv. Baramasi at PAU, Ludhiana (Punjab) to study the impact of integrated use of inorganic fertilizer (N), organic manure (FYM) and biofertilizer (*Azotobacter*) during 2009. The substantial improvement in fruit

quality could be achieved with the application of FYM (75 Kg/tree), inorganic nitrogen (350 g/tree) along with biofertilization (*Azotobacter* 18 g/tree).

Lal and Dayal (2014) found that maximum yield (7.58 kg tree^{-1}) and best quality fruits with TSS (10.42%) and acidity (6.06%) in acid lime (*Citrus aurantifolia* Swingle) were observed with the application 50 per cent RDF + 50 per cent dose of NPK through goat manure at KVK, Pali (Raj.).

Mehraj *et al*. (2014) observed that maximum TSS content (10.2%) was found with the application of vermicompost (1kg/pot) in strawberry at Bangla Agricultural University, Bangladesh during the period from June 2011 to March 2012.

Shukla *et al.* (2014) found that application of 10 kg vermicompost per plant + *Azotobacter* + PSM + *T. Harzianum* + organic mulching significantly improved the yield (45.4 kg/tree), TSS content (12.5^{0}Brix) and acidity (0.31%) in guava fruit during 2007-11 at CISH, Lucknow (U.P.).

Vanilarasu and Balakrishnamurthy (2014) conducted an experiment on quality attributes and shelf life of banana cv. Grand Naine (AAA) at TNAU, Coimbatore (T.N.) during 2009-10 and revealed that the treatment T10 (Farmyard manure @ 10 kg + Neem cake @ 1.25 kg + Vermicompost @ 5 kg and Wood ash @ 1.75 kg/plant + Triple green manuring with sunhemp + Double intercropping of Cow pea + biofertilizers *viz.* VAM @ 25 g, *Azospirillum* @ 50 g, PSB @ 50 g and *Trichoderma harzianum* @ 50

g/plant) registered the maximum quality attributes like TSS (23.23%) and acidity (0.82%) in the fruits.

Mohapatra *et al*. (2015) found that invariably integrated application of fertilizers and manures as control recorded significantly maximum TSS (13.87^0Brix) and acidity (0.58%) with respective highest values than rest of the treatments in cashew appple. Among the sole application of organic inputs (100% nitrogen) either through vermicompost + bio-fertilizers @ 200 g or through FYM + bio-fertilizers @ 200 g or 25 per cent N each as FYM + recycling of organic residue + in situ green manuring or green leaf manuring + bio-fertilizers @ 200 g were proved to be significantly better for various quality parameters of cashew apple.

Nazir *et al*. (2015) conducted an experiment on strawberry cv. Senga Sengana at Division of Fruit Science, SKUAST-K, Srinagar (J&K) and reported that treatment combination of poultry manure + *Azotobacter* + wood ash + PSB + mustard oil cake significantly improved the yield (238.95 g/plant) and different physico-chemical characters *viz.,* TSS content (9.01^0Brix), acidity (0.857%) and TSS/acidity ratio (11.12). Similarly, Tiwari *et al*. (2015) also revealed that combined application of 50 per cent pruning on previous season growth + 40 kg FYM per tree + 100 per cent RDF (1000:500:1000 g/plant NPK) significantly improved the yield (145 kg/plant) and TSS content (13.97^oBrix) in aonla fruits cv. Francis at NDUAT, Faizabad (U.P.).

2.2 Effect of inorganic fertilizers

2.2.1 Effect on growth parameters

Sharma and Kore (1990) conducted a field experiment on ber trees upto five years old with the application of different doses of N (50, 100 or 150 g), P_2O_5 (25 or 50 g) and K_2O (25 or 50 g) per tree in a year. They found that maximum tree height, crown spread and trunk girth were decreased with increased level of N and K_2O but increased with rising level of P_2O_5.

Sharma *et al.* (1990) observed maximum plant height (4.67m) with the application of 100 g N, 50 g P_2O_5 and 25 g K_2O per tree per year in Dehradun cultivar of litchi. However, lower dose of N (50 g) had resulted into greater height (4.19 m) as compared to higher doses.

Singh and Ahlawat (1996) reported that maximum plant growth in terms of height (42.49%), spread (51.60%), shoot length (215.5%), Leaf area (21.84 cm^2) and number of secondary branches per primary branch (8.5) were observed in thirteen years old ber tree cv. Umran at HAU, Hisar (Haryana) when 2.0 per cent urea and 1.0 per cent zinc sulphate were applied as foliar spray.

Sheo and Singh (1999) conducted an experiment at ICAR Research Complex for NEH Region, Umiam (Meghalaya) and observed that seedling growth of Karun Jamir (*C. aurantium*) and Cleopatra mandarin (*C. reshmi*) was significantly increased by spraying with combinations of urea (0.5%) +

GA_3 (50 ppm) + zinc sulphate (0.2%) and urea (0.5%) + GA_3 (50 ppm) in the 3rd and 8th months of age.

Singh and Suryanaryana (1999) reported that improvement in growth (height, and girth of pseudostem) in banana cv. Cavendish was observed when nitrogen was applied @ 200 g per plant in 4 split doses (2, 4, 6 and 8 months after planting).

Shukla *et al.* (2000) pointed out that the shoot growth, plant height, spread, and canopy volume (m^3) were maximum with the application of 500 g nitrogen per tree in Kinnow mandarin.

Rathore and Chandra (2002) conducted an experiment on eight years old ber [*Ziziphus mauritiana*] in Rajasthan and found that application of N @ 500 g + foliar spray of urea (1.5%) + zinc sulphate (0.5%) significantly increased in plant height (35.45%), plant spread from north to south (105.06%), and stem girth (18.63%) in July, 2000 to February, 2001. Similarly, Lal and Dhaka (2003) also conducted an experiment at Jobner, (Raj.) during 1994-98 to determine the most effective combination of P and K for improving the growth of ber (*Zizyphus mauritiana* L.) cv. Umran. The treatments consisted of 3 levels of P_2O_5, i.e. 0, 250 and 500 g P_2O_5 per plant/year and 3 levels of K_2O, i.e. 0, 50 and 100 g K_2O/plant per year and found that maximum stem girth (53.79 cm) was recorded with the application 100 g K_2O per plant without P_2O_5 treatment combination. However, shoot length and plant spread were not affected significantly.

Lal *et al*. (2003) also reported that four levels of N (0, 250, 500 and 750 g/plant) in combination with three levels each of P_2O_5 (0, 250 and 500 g/plant) and K_2O (0, 50 and 100 g/plant) were applied to ten years old plants of ber cv. Umran grown in Rajasthan and found maximum plant height (3.12 m), plant spread (21.64 m^2) when 500 g N, 500 g P_2O_5 and 50 g K_2O per plant were applied.

Singh and Agarwal (2003) conducted an experiment on Naval Orange and reported that application of N in 2 spilt doses in July 2000 and March 2001 + foliar spray of N @ 1.5 per cent + application of zinc sulphate @ 0.5 per cent in September 2000 and March 2001 had significant effect on vegetative growth in terms of plant height, plant spread and stem girth.

Girardi and Mourao (2004) reported that nitrogen applied at 22.2 to 50.0 g per tree had a significant effect on plant height, trunk diameter and canopy volume of sweet orange cv. Valencia.

Bhobia *et al*. (2005) studied the effect of organic and inorganic nitrogen on growth of seven years old trees of guava cv. Hisar Surkha. Plant growth in terms of height and spread were recorded maximum with the application of 800 g nitrogen per plant through inorganic sources.

Prasad (2005) conducted an experiment at Jodhpur (Raj.) from 1990-91 to 1993-94 on ber (*Zizyphus mauritiana* L.) cv. Gola and observed that maximum plant height, plant canopy and stem girth were increased with the increase in the N dose up to 500 g per plant. Further, increase in

the N dose did not significantly increased the values of these parameters. The application of P also increased plant height and plant canopy over the control.

Kundu *et al*. (2011) studied the effect of biofertilizers and inorganic fertilizers in Amrapali mango trees of ten years old at BCAU, Mohanpur (W.B.) during 2005-07. The growth *viz.* plant height (17.01%), basal girth (15.77%) and spread (E-W,12.73% and N-S, 11.53%) before flowering significantly improved with the application of NPK (100%) + *Azotobacter* (250 g $tree^{-1}$) + VAM (250 g $tree^{-1}$).

Devashi (2012) reported that Nitrogen in the form of urea significantly influenced the vegetative growth of sapota cv. Kalipatti at JAU, Junagarh (Gujarat). The greatest tree height (7.26 m) and tree spread (N-S, 8.11 m and E-W, 8.13 m) were obtained with the application of 900 g N per tree in the form of urea.

2.2.2 Effect on yield and quality

Sharma and Azad (1989) stated that eight years old trees of litchi cv. Dehradun received N at 50, 100 or 150 g and P_2O_5 and K_2O, each of 25 or 50 g for every year of tree age, in different combinations. The trial was carried out for 3 year. Results indicated that average fruit yield was recorded highest (13.9 kg/tree) in trees receiving N (100 g) + P_2O_5 (50 g) + K_2O (25 g) per tree.

Ghosh and Mitra (1990) also carried out with seven years old trees of litchi cv. Bombai receiving an annual total of 200-600 g N, 100-300 g P_2O_5 and 200-600 g K_2O per tree as urea, SSP and MoP applied in 2 equal split doses in January and August. The maximum fruit yield (59.6 kg/tree) was obtained by applying 600g N + 200 g K_2O per tree and the leaf N, P and K concentrations were observed 1.38-1.50, 0.14-0.18 and 0.88-1.04 per cent, respectively. However, application of 400 g N + 300 g P_2O_5 + 600 g K_2O per tree gave maximum fruit TSS content (18.7%).

Sharma and Kore (1990) also observed in a field experiment of five years old trees of ber. Treatments of N at 50, 100 or 150 (g/year), P_2O_5 at 25 or 50 (g/year) and K_2O 25 or 50 (g/year) of tree age were applied and the trial was carried out over 5 years, with increasing dose of N, P and K doses each year with tree age. The fruit yield, TSS and acidity content were decreased with increasing N and K_2O doses but increased with rising P_2O_5 doses. However, the fruit yield was recorded highest (26.33 kg/tree) in trees receiving 50 g N + 50 g P_2O_5+ 25 g K_2O per year of tree age.

Lui (1992) reported that nitrogen applied at 0.25 to 1.75 kg per plant had a significant effect on the fruit yield of mandarin plant grown on soil of medium and poor fertility. It was shown that application of optimum dose of 1.18 kg N per plant produced a yield of 40-46 kg per plant whereas, 1.03 kg N per plant produced a yield of 35-91 kg per plant.

Dhatta *et al.* (1993) Studied the effect of N, P and K treatment on yield of fully grown Umran ber trees and reported that the highest yield

(21.75 kg/tree) was observed with 400 g N + 100 g P_2O_5 + 200 g K_2O per tree.

Bhatia *et al*. (2001) also recorded highest yield (49.8 kg/tree), TSS content (10.8%) and acidity (0.50%) in fruits of guava cv. L-49 with application of @ nitrogen 600 g per plant.

Mahalle *et al*. (2001) recorded maximum TSS content (24.33^0Brix) in custard apple with application of 375 g N + 187.5 g P_2O_5 + 187.5 g K_2O per plant. Similar results were also reported by Sen and Chauhan (1983) in pomegranate.

Lal and Dhaka (2003) conducted an experiment at Jobner (Raj.) during 1994-98 to determine the most effective combination of P and K for improving the yield and quality of ber cv. Umran. The treatments consisted of 3 levels of each P, i.e. 0, 250 and 500 g P_2O_5 and K, i.e. 0, 50 and 100 g K_2O per plant year and found that maximum fruit yield (57.70 kg/plant) was recorded with the application 500 g P_2O_5 and 50 g K_2O per plant. The best quality fruits with TSS (15.61%) and acidity (0.113%) contents were obtained under 500 g P_2O_5 per plant without K_2O treatment combination.

Jadhao *et al.* (2005) recorded maximum fruit yield (42.84 kg/plant) with the application of 650 g N + 300 g P_2O_5 + 300 g K_2O per plant in guava cv. Sardar. Similarly, the maximum fruit yield per plant (69.64 kg in rainy and 22.65 kg in winter season) were recorded with 150 g N + 50 g P_2O_5 + 75 g K_2O per plant in guava cv. Pant Prabhat (Kumar *et al*., 2005).

Likewise, Madhavi *et al.* (2005) obtained highest fruit yield (23.63 kg/plant) in guava cv. Sardar when 500 g N + 200 g P_2O_5 + 500 g K_2O per plant were applied.

Prasad (2005) conducted an experiment in Jodhpur (Raj.) from 1990-91 to 1993-94 on ber cv. Gola and observed that maximum fruit yield (54.45 and 50.41 kg/plant) were obtained with application of N @ 750 and 500 g per plant. The application of P also increased fruit yield per plant over the control. The results indicated that 500 g N and 250 g P per plant were optimum for the enhancement of the yield and quality of ber fruits under rainfed conditions in western Rajasthan.

Quaggio *et al*. (2006) investigated the effect of NPK on lemon yield. The maximum fruit yield averaged over sixth harvest was reached with the dose of 240 kg N + 27 kg P_2O_5 + 225 kg K_2O per hectare in three splits from early spring to late summer.

Ranjan and Ghosh (2005) observed that application of 400 g nitrogen per plant showed maximum TSS (8.5^0Brix) and acidity (2.20%) in aonla fruits.

Sharma *et al.* (2009) observed that foliar application of nutrients (urea 1.0%, zinc sulphate 0.5% and potassium sulphate 1.0%) with growth regulators (GA_3 50 ppm and NAA 20 ppm) significantly increased the fruit yield (119.2 and 103.5 kg/tree) of ber over control.

Ziauddin (2009) observed that application of 200 g N + 150 g P + 200 g K per plant combined with organic booster slurry @ 6 litre per plant of banana cv. Ardhapuri was found to be the best over all the treatments produced maximum yield (81.8 t/ha) at MAU, Parbhani (M.H.) during 1998-99 and 1999-2000.

Dalal *et al*. (2011) conducted an experiment at PAU, Ludhiana (Punjab) during 2007-08 and reported that foliar application of urea (2%) and zinc sulphate (0.5%) at flowering, peanut size of fruits and second growth phase significantly increased the fruit yield (71.33 kg/tree) of fifteen years old ber trees over control (52.19 kg/tree). Similarly, Dayal *et al*. (2011) reported that highest fruit yield (42.12 kg/tree) and TSS content in fruits of fifteen years old trees of ber cv. Gola when 500 g per plant each of nitrogen and phosphorus and foliar spray of zinc sulphate (0.6%) were applied during 2004-05 and 2005-6 at KVK, Pali (Raj).

Kundu *et al*. (2011) studied the effect of biofertilizers and inorganic fertilizers in Amrapali mango trees of ten years old at BCAU, Mohanpur (W.B.) during 2005-07. The application of NPK (100%) + *Azotobacter* + VAM significantly increased the fruit yield (98.1 kg/plant) and TSS (19.55^0Brix). However, the acidity (0.32%) was improved with the treatment of NPK (100%).

Arora *et al*. (2012) conducted an experiment at PAU, Ludhiana (Punjab) on grape cv. Perlette during 2005-06. The significantly higher yield (10.3 kg/vine) and quality parameters *viz.* TSS (19.15%), acidity

(0.48%) and TSS/Acid ratio (37.3) were obtained with the application of 75 g N, 50 g P_2O_5 and 150 g K_2O per vine.

Similarly, Devashi (2012) also reported that nitrogen in the form of urea significantly improved the yield and quality of sapota cv. Kalipatti at JAU, Junagarh (Gujarat). The maximum fruit yield (163.30 kg/tree) was obtained with the application of 900 g N per tree in the form of urea.

Likewise, Dhomane and Kadam (2013) conducted an experiment on guava cv. Sardar growing at Instructional-cum Research Farm, Department of Horticulture, College of Agriculture, Latur during 2009 to 2010. The results of the experiment revealed that integration of organic manures and inorganic fertilizers was more effective in increasing yield and quality of guava trees than the inorganic fertilizers alone. Among the various combinations, 75 per cent of nitrogen through urea along with 25 per cent nitrogen through neem cake was found to be the best over most of the treatments in respect of yield per tree (58.1 kg), yield per hectare (23.26 t) and highest B: C ratio (8.94).

2.3 Effect of organic manures and inorganic fertilizers on physiology and nutrient status of leaf

Singh and Khan (1996) reported highest leaf nutrient in mango cv. Dashehari when 1000:500:1000 g NPK per tree were applied in soil and 0.6:0.6:1.0 per cent NPK applied as foliar spray.

Koumey *et al.* (2000) found a significant positive correlation between the availability of nutrients in soil and their concentration in orange leaves.

They showed that application of FYM (150 kg/tree) alone or combined with (N 1500 g + P_2O_5 440 g + K_2O 600 g/tree) fertilizers increased nutrients concentration in orange leaves.

Girardi and Mourao (2004) reported that nitrogen applied at 22.2 to 50.0 g per tree had a significant effect on chlorophyll content in leaves of sweet orange cv. Valencia.

Shivaputra *et al.* (2004) investigated the effect of VAM fungi and vermicompost on NPK and chlorophyll content in papaya leaf. The increase in NPK and chlorophyll contents were observed when 75 per cent RDF + vermicompost (2 t/ha) were applied to the plants.

Athani *et al.* (2005) studied the effect of organic manures and inorganic fertilizers on nutrient content in leaves of guava cv. Sardar. Maximum nitrogen (1.64%), phosphorus (0.327%) and potassium (1.30%) content were found in the plants received 75 per cent RDF + 10 kg vermicompost per plant.

Kumar *et al.* (2005) found that the different levels of N, P and K fertilizers significantly influenced the leaf nutrient status of guava cv. Pant Prabhat analyzed during the months of June and January, with maximum leaf nitrogen (2.16% and 1.71%), phosphorus (0.135% and 0.118%) and potassium (1.23% and 0.87%), respectively.

Bhattarai and Tomar (2009) found that application of 100 per cent recommended dose of NPK + 50 kg vermicompost or 75 per cent recommended dose of NPK + 68.75 kg vermicompost per tree significantly

increased the nutritional status in leaves of ten years old walnut trees at YSPUHF, Solan (H.P.).

Sharma *et al.* (2009) found that P and K contents in leaves of ber increased significantly by spray of potassium sulphate (1.0%) and NAA (20 ppm). Whereas nitrogen contents in leaves was increased by foliar application of urea (1.0%) and zinc sulfate (0.5%) during 2002 and 2003.

Ziauddin (2009) observed that application 200 g N + 150 g P + 200 g K per plant combined with organic booster slurry @ 6 litre per plant was found to be the best over all the treatments enhanced the nutrient (NPK) concentration in index leaf tissues of banana cv. Ardhapuri at MAU, Parbhani (M.H.) during 1998-99 and 1999-2000.

Dalal *et al*. (2011) conducted an experiment at PAU, Ludhiana (Punjab) during 2007-08 and reported that foliar application of urea (2%) and zinc sulphate (0.5%) at flowering, peanut size of fruits and second growth phase significantly increased the N content in leaves of fifteen years old ber trees.

Kundu *et al*. (2011) studied the effect of biofertilizers and inorganic fertilizers in Amrapali mango trees of ten years old at BCAU, Mohanpur (W.B.) during 2005-07 and found that leaf mineral composition *viz*., nitrogen (1.88%), phosphorus (0.15%) and potassium (1.21%) before flowering significantly improved with the application of NPK (100%) + *Azotobacter* (250 g/tree) + VAM (250 g/tree).

Mishra *et al*. (2011) conducted an experiment on ber cv. Gola at SKN college of agriculture, Jobner (Raj.) and found that soil application of

22 kg vermicompost + 0.82 kg urea + 1.15 kg SSP + 0.41 kg MoP per tree and foliar spray of thiourea @ 0.5 per cent significantly increased the relative leaf water content (RLWC) and chlorophyll content in leaves of ber.

Shashibala *et al.* (2011) carried out an investigation on three years old orchard of aonla cv. Banarasi at CSAUAT, Kanpur (U.P.) during 2008-09 and found that application of 75 per cent RDF + 100 kg FYM + *Azotobacter* + *Azospirillum* + PSB per tree significantly improved the nitrogen (1.610%), phosphorus (0.156%) and potassium (0.924%) content in leaves.

Dadheech and Choudhary (2012) reported that significant increase in relative leaf water content (RLWC) with combined application of 0.825 kg urea, 1.150 kg SSP, 0.410 kg MoP and 22 kg vermicompost per tree along with foliar spray of 0.5 per cent thiourea in ber.

Sharma *et al*. (2013) reported that application of nitrogen through FYM and inorganic fertilizers in a ratio of 1:3 with *Azotobacter* obtained highest nitrogen and phosphorus content (1.76% and 0.26%, respectively) in guava leaves at SKUAST-J, Chatha (Jammu). However, the highest leaf potassium (1.25%) content was obtained with the application of *Azotobacter* + 50 per cent of N through FYM + 50 per cent of N through inorganic fertilizers in winter season guava.

Bohane and Tiwari (2014) conducted an experiment on ber cv. Gola at College of Horticulture, Mandsaur (M.P.) and observed that the application of 50 per cent recommended dose of NPK through vermicompost + 50 per cent RDF through NPK + 50 g *Azotobacter* + 50 g

PSB significantly increased Chlorophyll content in leaves spad value (71.00) over other treatments.

Garhwal *et al.* (2014) reported that application of 80 kg FYM per plant significantly increased the N (28.17%) and K (6.28%) in leaves of Kinnow mandarin at SKRAU, Bikaner (Raj.) during 2008.

2.4 Effect of organic manures and inorganic fertilizers on physico-chemical properties of soil`

Hayes and Naidu (1998) revealed the effect of manures and fertilizers application on organic matters and physical properties of soil. Addition of fertilizers with organic manures resulted in increased soil organic matter content, water holding capacity, porosity, infiltration capacity, hydraulic conductivity and available N, P_2O_5, and K_2O content in the soil.

Koumey *et al.* (2000) found a significant positive correlation between the availability of nutrients in soil and their concentration in orange leaves. They showed that application of FYM (150 kg) + N (1500 g) + P_2O_5 (440 g) + K_2O (600 g) per tree had the highest available N, P_2O_5 and K_2O in soil.

Devadas and Kuriakose (2005) reported that application of 250 g poultry manure, *Azospirillum* and PSB @ 650 mg each along with NPK at 8:4:8 g per plant significantly improved the organic carbon, available P and K in soil of pineapple orchard cv. Mauritius.

Shashibala *et al.* (2011) carried out an investigation on three years old orchard of aonla cv. Banarasi at CSAUAT, Kanpur (U.P.) during 2008-09 and found that application of 75 per cent RDF + 100 kg FYM +

Azotobacter + *Azospirillum* + PSB per tree significantly increased the nitrogen (239.42 kg/ha), phosphorus (24.10 kg/ha) and potassium (201.40 kg/ha) contents in soil.

Singh *et al.* (2012) reported the application of 60 kg FYM + NPK @ 400:200:300 g per plant and 75 kg FYM + NPK @ 500:250:375 g per plant, respectively during 2007 and 2008 significantly improved the available N (220.15 kg/ha), P_2O_5 (24.18 kg/ha) and K_2O (124.15 kg/ha) content in soil of four years old aonla orchard at Central Horticultural Experiment Station (CIAH), Godhra (Gujarat). However, maximum improvement in bulk density (1.30 Mg/m^3) and organic carbon (6.3 g/kg) content of soil observed when neem cake + FYM + CPP treatment were applied.

Mustafa *et al.* (2013) revealed the soil application of FYM (15 kg) + ½ dose of NPK (1000:400:400g RDF) + $FeSo_4$ (200g) per plant and foliar spray of $ZnSo_4$ (0.5%) + $CuSo_4$ (0.4%) significantly improved the soil nitrogen (150.53 kg/ha), phosphorus (10.09 kg/ha) and potassium (324.30 kg/ha) in aonla orchard cv. NA-7 at K.V.K.Farm, Ratlam (M.P.) during 2009-10.

Garhwal *et al.* (2014) reported that the combined application of 80 kg FYM and 750 g nitrogen per plant led to significantly increased soil nitrogen at 0-15, 15-30 and 30-60 cm depths (41.18, 51.36 and 27.71%, respectively) over initial level in Kinnow mandarin orchard at SKRAU, Bikaner (Raj.) during 2008. However, the highest soil phosphorus at 15-30 cm depth (12.50%) and soil potassium at 0-15, 15-30 and 30-60 cm depths (0.74, 2.27 and 0.75%, respectively) were obtained with the application of 80 kg FYM per plant alone.

Shukla *et al.* (2014) found that application of 10 kg vermicompost per plant + *Azotobacter* + PSM + *T. Harzianum* + organic mulching significantly improved the average organic carbon (0.48%), nitrogen (65.8 mg/kg), phosphorus (34.4 mg/kg) and potassium (270 mg/kg) in soil of guava orchard during 2007-11 at CISH, Lucknow (U.P.).

Tiwari *et al*. (2015) also revealed that combined application of 50 per cent pruning on previous season growth + 40 kg FYM per tree + 100 per cent RDF (1000:500:1000 g/plant NPK) significantly improved the organic carbon (0.47%), nitrogen (241.1 kg/ha), phosphorus (18.96 kg/ha) and potassium (246.2 kg/ha) in soil of fifteen years old aonla orchard cv. Francis at NDUAT, Faizabad (U.P.).

Chapter-3

MATERIALS AND METHODS

The field experiment entitled **"Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under Semi Arid Conditions"** conducted at Horticulture Farm, S.K.N. college of agriculture, Jobner (Rajasthan) during July, 2015 to February, 2016. The details of experimental materials used and criteria adopted for the evaluation of treatments during the course of investigation are being presented in this chapter.

3.1 Agro-climatic conditions of the experimental site

3.1.1 Experimental site

The field experiment was carried out at Horticulture Farm, Department of Horticulture, S.K.N. College of Agriculture, Jobner (Rajasthan) during July, 2015 to February, 2016. Geographically, Jobner is situated 45 km away in west of Jaipur district of Rajasthan at 26^0 05' North latitude and 75^0 28' East longitudes and at an altitude of 427 meters above mean sea level. This region falls in Agroclimatic zone III-a (Semi-Arid Eastern Plain).

3.1.2 Climate and weather conditions

The climate of this region is a typically semi-arid, characterized by aridity of atmosphere scarcity of water with extremes of temperature during both summers and winters. The average annual rainfall of this tract varies from 300 mm to 400 mm and is mostly received during the month of July to September. During summer, temperature may go as high as 48^0C while in winter, it may fall as low as -1.5 ^{0}C. The relative humidity fluctuates between 43 to 87 per cent. There is hardly any rain during winter and summers. As the climate affects the growth, yield and quality of agricultural product, climatic variables are presented in this chapter. The mean weekly weather parameters of the experimentation recorded at the college meteorological observatory have been presented in table 3.1 and graphically depicted in figure 3.1. The data presented in table 3.1 reveals that season witnessed a very low rainfall of 357.1 mm during the experimentation.

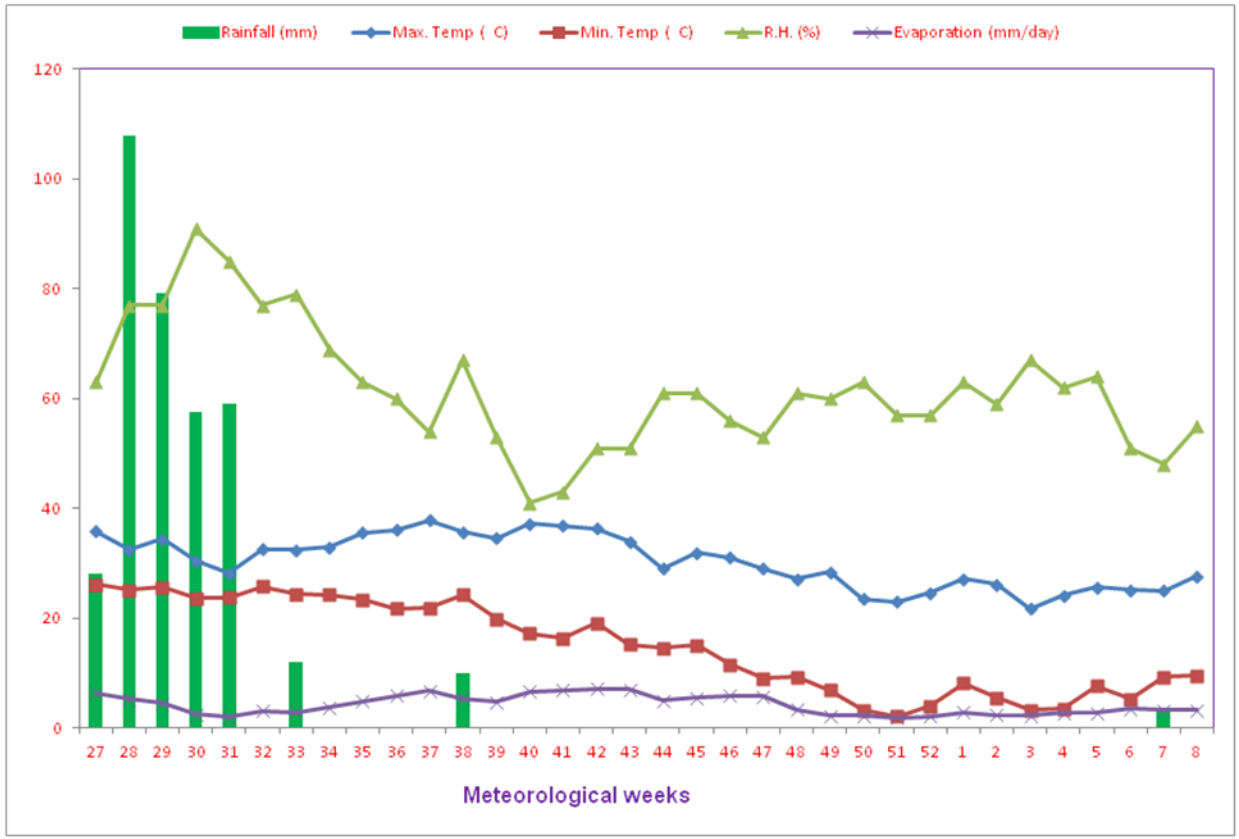

Fig. 3.1 Mean weekly meteorological data during the experimentation (July, 2015 - February, 2016)

Table 3.1 Mean weekly meteorological data during the experimentation (July, 2015 - February, 2016)

SMW* NO.	Period		Temperature (°C)		Mean R.H. (%)	Evaporation (mm/day)	Rainfall (mm)
	From	To	Max.	Min.			
27	02/07/2015	08/07/2015	35.9	26.2	63	06.4	028.0
28	09/07/2015	15/07/2015	32.4	25.2	77	05.3	107.8
29	16/07/2015	22/07/2015	34.5	25.6	77	04.5	079.2
30	23/07/2015	29/07/2015	30.4	23.6	91	02.5	057.5
31	30/07/2015	05/08/2015	28.2	23.8	85	02.0	059.0
32	06/08/2015	12/08/2015	32.6	25.8	77	03.1	-
33	13/08/2015	19/08/2015	32.4	24.4	79	02.9	012.0
34	20/08/2015	26/08/2015	32.9	24.3	69	03.7	-
35	27/08/2015	02/09/2015	35.6	23.4	63	04.9	-
36	03/09/2015	09/09/2015	36.1	21.7	60	05.9	-
37	10/09/2015	16/09/2015	37.9	21.9	54	06.8	-
38	17/09/2015	23/09/2015	35.7	24.3	67	05.4	010.0
39	24/09/2015	30/09/2015	34.6	19.8	53	04.8	-
40	01/10/2015	07/10/2015	37.2	17.2	41	06.6	-
41	08/10/2015	14/10/2015	36.8	16.3	43	06.9	-
42	15/10/2015	21/10/2015	36.4	19.1	51	07.1	-
43	22/10/2015	28/10/2015	33.9	15.2	51	07.0	-
44	29/10/2015	04/11/2015	29.1	14.6	61	05.0	-
45	05/11/2015	11/11/2015	31.9	15.1	61	05.5	-
46	12/11/2015	18/11/2015	31.0	11.6	56	05.9	-
47	19/11/2015	25/11/2015	29.1	09.0	53	05.8	-
48	26/11/2015	02/12/2015	27.2	09.3	61	03.4	-
49	03/12/2015	09/12/2015	28.4	06.9	60	02.3	-
50	10/12/2015	16/12/2015	23.5	03.2	63	02.3	-
51	17/12/2015	23/12/2015	23.0	02.1	57	01.9	-
52	24/12/2015	31/12/2015	24.7	04.0	57	02.1	-
1	01/01/2016	07/01/2016	27.2	08.1	63	02.9	-
2	08/01/2016	14/01/2016	26.1	05.5	59	02.4	-
3	15/01/2016	21/01/2016	21.7	03.3	67	02.2	-
4	22/01/2016	28/01/2016	24.1	03.5	62	02.8	-
5	29/01/2016	04/02/2016	25.7	07.7	64	02.8	-
6	05/02/2016	11/02/2016	25.2	05.2	51	03.5	-
7	12/02/2016	18/02/2016	25.0	09.3	48	03.2	003.6
8	19/02/2016	25/02/2016	27.6	09.6	55	03.2	-

*Standard meteorological week

3.2 Soil characteristics of the experimental site

In order to evaluate the physical and chemical properties and fertility of soil samples from 0-15 cm depth were taken from ten random spots of the experimental site prior to treatment application and representative composite sample was prepared by mixing and processing of all soil samples together. The homogeneous composite soil sample was prepared by grinding and passing it through 2 mm sieve and analyzed to determine physico-chemical properties of soil. The results of these analyses along with methods used for determination are presented in table 3.2. It is apparent from data that the soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen and medium in phosphorus and potassium content. Water of this area is partially saline in nature. The pH and EC of water were 7.9 and 2.85 dS/m respectively.

Table 3.2 Physico-chemical properties of soil of the experimental site

S.No.	Parameters	Values	Methods and reference
A.	**Mechanical analysis**		
(i)	Coarse sand (%)	26.4	International Pipette Method (Piper, 1950)
(ii)	Fine sand (%)	55.4	-do-
(iii)	Silt (%)	8.2	-do-
(iv)	Textural class	Loamy sand	-do-
B.	**Physical analysis**		
(i)	Bulk density (Mg/m^3)	1.52	Method No 38, USDA Hand Book No. 60 (Richards, 1954)
(ii)	Particle density (Mg/m^3)	2.56	Method No 39, USDA Hand Book No. 60 (Richards, 1954)
(iii)	Total porosity (%)	41.55	Method No. 40, USDA Hand Book No. 60 (Richards, 1954)
(iv)	Field capacity (%)	12.51	Method No. 33, USDA Hand Book No. 60 (Richards, 1954)

(v)	Moisture retention (%)		Pressure plate apparatus method (Singh, 1980)
	at 15 bar	3.2	
	at 0.33 bar	10.8	
C.	**Chemical composition**		
(i)	Organic carbon (%)	0.18	Walkley and Black's Rapid titration method (Piper,1950)
(ii)	Available nitrogen (kg N/ha)	128.00	Alkaline permanganate method (Subbiah and Asija, 1956)
(iii)	Available phosphorus (kg P_2O_5/ha)	17.00	Olsen's method (Olsen *et al.,* 1954)
(iv)	Available potash (kg K_2O/ha)	146.00	Flame photometer method (Metson, 1956)
(v)	ECe of saturation extract at 25^0C (dS/m)	1.12	Method No. 4, USDA Hand Book No. 60 (Richards, 1954)
(vi)	pH (1:2 soil water suspension)	8.2	Method No. 21 (b), USDA Hand Book No. 60 (Richards, 1954)

3.3 Selection of plants

The plants of uniform size, vigorous and approximately three years age after budding were selected in the orchard of ber cv. Gola. Each selected tree represented for one replication in each treatment. In all sixty uniform plants were selected from the ber block (6 m x 6 m spacing) for this study.

3.4 Experimental design and layout

The experiment was laid out in Randomized Block Design and replicated three times. The treatments were randomly allotted to different trees, using random number table of Fisher and Yates (1963). The other details of experiment are given below:

(1.) Crop : Ber

(2.) Cultivar : Gola

(3.) Age of plant : 3 years

(4.)	Planting system	:	Square
(5.)	Planting distance	:	6 m x 6 m
(6.)	Total treatment combinations	:	20
(7.)	Replications	:	3
(8.)	Total number of plants under study	:	60
(9.)	Duration of work	:	8 months (July, 2015 to February, 2016)
(10.)	Experimental design	:	Randomized block design (RBD)

3.5 Treatments details

The experiment was comprised of four levels of organic manures (control, FYM @ 20 kg/plant, vermicompost @ 6 kg/plant and poultry manure @ 8 kg/plant) and five levels of RDF (control, 50% RDF, 75% RDF, 100% RDF and 125% RDF) thereby making 20 treatment combinations. These treatments with their symbols are given in table 3.3.

3.6 Preparation of basins

Weed and grasses were removed beneath the trees and then a trench of 1.0 feet deep, 1.5 feet wide and 140 cm away from main trunk was dug out under tree canopy for manuring and fertilization.

Therefore, basins of fixed size (1.5 m diameter) were prepared with 6 inch high bunds all around the tree to hold the irrigation water.

3.7 Treatment application

3.7.1 Organic manure application

Organic manures as FYM, vermicompost and poultry manure in the present investigation alone or in combination with inorganic fertilizers containing NPK were applied in soil. As per treatment schedule, FYM @ 20 kg per tree,

Table 3.3 Treatments with their symbols

Treatments	Symbols
(A) Organic Manures	
i) Control	M_0
ii) FYM @ 20 kg/plant	M_1
(iii) Vermicompost @ 6 kg/plant	M_2
(iv) Poultry manure @ 8 kg/plant	M_3
(B) Fertility Levels (NPK)	
(i) Control	F_0
ii) 50% RDF	F_1
iii) 75% RDF	F_2
(iv) 100% RDF	F_3
v) 125% RDF	F_4

FYM= Farm yard manure

RDF= Recommended dose of fertilizersvermicompost @ 6 kg per tree and poultry manure @ 8 kg per tree were incorporated in soil in respective treatments of present experiment. The full dose of organic manures was applied as soil application in July, 2015.

Table 3.4 Nitrogen, phosphorus and potassium content in various organic manures

NUTRIENTS (%)	FYM	VC	PM
NITROGEN	0.48	1.67	1.42
PHOSPHORUS	0.26	0.82	2.04
POTASSIUM	0.53	1.50	0.97

3.7.2 Inorganic fertilizers (NPK)

The inorganic fertilizers (nitrogen, phosphorus and potassium) were applied through urea containing 46 per cent nitrogen, single super phosphate containing 16 per cent phosphorus and muriate of potash containing 60 per cent potassium, respectively. The recommended doses of fertilizers 1100 g urea, 1400 g SSP and 200 g MoP per tree were applied. Full dose of SSP, MoP and half dose of urea in various treatments were applied as basal dose in July, 2015. Remaining half dose of urea was applied before flowering. The fertilizers were applied to the top soil around the plant. The fertilizers uniformly mixed into the soil and then levelled. Irrigation was applied immediately after application of manures and fertilizers.

3.8 Cultural operations

Different cultural operations like preparation of basins, weeding & hoeing, manuring and fertilization, irrigation, plant protection measures and harvesting of fruits etc. were carried out during period of investigation are presented in table 3.5.

Table 3.5 Cultural operations

S.NO.	PARTICULARS	DATES
1.	PREPARATION OF BASIN	13.07.2015
2.	MANURING AND FERTILIZATION	(I) 15.07.2015 (II) 18.09.2015
3.	WEEDING AND HOEING	(I) 10.08.2015 (II) 13.10.2015
4.	APPLICATION OF MALATHION 50EC (0.05%) TO CONTROL FRUIT FLY	(I) 27.10.2015 (II) 20.11.2015
5.	SPRAYING OF KARATHANE 48EC (0.01%) TO CONTROL POWDRY MILDEW	(I) 27.08.2015 (II) 29.09.2015
6.	IRRIGATION (DUE TO NO RAINFALL)	(I) 18.09.2015 (II) 05.10.2015
7.	INITIATION OF HARVESTING OF FRUITS	08.01.2016

3.9 Observations recorded

The following parameters were studied for evaluating the effect of different treatments. The treatment effects were evaluated in terms of growth, physiology, yield and quality of ber and soil properties of ber orchard. A methodology of individual aspect is briefly described in the following paragraphs.

3.9.1 Vegetative growth attributes

Growth attributes of experimental plants were recorded twice in a year, before application of treatments in the month of July, 2015 and at full bloom stage in the month of October, 2015 and gain in these parameters were calculated. The number of primary branches per plant and average leaf area was measured at full bloom stage in the month of October, 2015.

3.9.1.1 Plant height

The height of plants were recorded from ground surface to the apex of the longest branch with the help of thread and meter scale in centimetres.

3.9.1.2 Trunk girth

Trunk girth of plants were measured 2.0 cm above the point of budding with the help of thread and meter scale in centimetres.

3.9.1.3 Plant spread

Spread of plants were measured in two opposite direction (E-W and N-S) with the help of thread and meter scale and average spread of the tree was calculated in centimetres.

3.9.1.4 Number of primary branches

Number of primary branches were calculated by the count of branches emerges from the main trunk of experimental plant.

3.9.1.5 Length of primary branches

The ten randomly tagged primary branches were from all direction of the plant used for length of primary branch measurement. The length of primary branches was measured with the help of thread and meter scale in centimeters. The average length of primary branch was recorded as mean value to calculate actual length of primary branch.

3.9.1.6 Number of secondary branches per primary branch

Number of secondary branches were calculated by the count of branches that were emerges from the tagged ten primary branches and average of all secondary branches was calculated.

3.9.1.7 Leaf area

The methodology for leaf sampling as suggested by Bhargava *et al.* (1990) for ber was followed. Composite leaf samples consisting mainly sixth leaf which was approximately 24 days old, either from secondary or tertiary branches were taken at full bloom stage in the month of October, 2015 from experimental plant. The sample size was taken 10 leaves in each sample from all directions of the plant. From tagged branches the average leaf area was determined using Leaf Area Meter, LICOR-3000 Lincoln, USA and expressed as cm^2.

3.9.2 Fruit yield

3.9.2.1 Fruit yield per plant

Ripened fruits were harvested and the weight was recorded by summing up the total of fruits at different pickings obtained during January 8, 2016 to February 25, 2016 from each experimental plant.

3.9.2.2 Fruit yield per hectare

It was calculated by the following formula:

$$\text{Yield (q/ha)} = \frac{\text{Yield per plant (kg)}}{100} \times 278 \text{ (plant/ha)}$$

3.9.3 Quality components

3.9.3.1 Total soluble solids

TSS content in juice for 10 randomly selected fruits from each experimental plant was recorded with the help of Zeiss^{Tm} hand refractometer (0-50 ^{0}Brix) (Toshiba, New Delhi, India) on percentage basis at 20^{0}C temperature and the average TSS was calculated.

3.9.3.2 Acidity

The per cent acidity in randomly selected fruits from each experimental plant were estimated by titrating 10 ml of aliquot prepared by macerating the

sample against 0.1 N NaOH using phenolphthalein as an indicator. The total acidity was worked out of citric acid as given by the method (A.O.A.C., 1980).

$$\text{Acidity (\%)} = \frac{0.0064 \times \text{NaOH used (ml)} \times 100}{\text{ml of sample taken}}$$

3.9.4 Physico-biochemical observations of plant

The methodology for leaf sampling as suggested by Bhargava *et al.* (1990) for ber was followed. Composite leaf samples consisting mainly sixth leaf which was approximately 24 days old, either from secondary or tertiary branches were taken at full bloom stage in the month of October, 2015 from experimental plant. The sample size was taken 10 leaves in each sample from tagged branches of the plant from all directions.

3.9.4.1 Nutrient content in leaves

Nitrogen content

Estimation of nitrogen in leaf samples was done with wet digestion of plant samples with H_2SO_4 and H_2O_2 by colorimetric method using Spectronic-20 after development of colour with Nessler's reagent (Snell and Snell, 1949).

Phosphorus content

Estimation of phosphorus in leaf samples was done with wet digestion of plant samples with Tri-acid mixture of HNO_3: H_2SO_4:$HClO_4$ (10:1:4) using Vanado-molybdo-phosphoric acid yellow colour method (Jackson, 1973).

Potassium content

Estimation of potassium in leaf samples was done with wet digestion of plant samples with Tri-acid mixture of HNO_3: H_2SO_4:$HClO_4$ (10:1:4) using Flame photometric method (Bhargava and Raghupathi, 1993).

3.9.4.2 Relative leaf water content

Leaf discs ($1cm^2$) in diameter were initially weighted and floated over the water for 4-5 hours. After that turgid weight was recorded and drying the leaf discs at 70^0C till constant weight obtained. The relative water was calculated through a formula given by Salvik (1974).

$$RLWC\ (\%) = \frac{\text{Fresh weight of leaf - Oven dry weight of leaf}}{\text{Turgid weight of leaf - Oven dry weight of leaf}} \times 100$$

3.9.4.3 Total chlorophyll content in leaves

Total chlorophyll content of leaves was determined using the method advocated by Arnon (1949) by taking 100 mg fresh leaf material. Samples were homogenized in 80% acetone and centrifuged for 10 minutes at 2000 rpm and volume of supernatant was made to 10 ml. The resultant absorbance of clear supernatant was measured by Spectrophotometer at 652 nm.

$$\text{Total chlorophyll (mg/g)} = \frac{A_{(652)} \times 29 \times \text{total volume (ml)}}{\alpha \times 1000 \times \text{weight of sample (g)}}$$

Where, α = is the path length = 1 cm

3.9.5 Physico-biochemical observations of soil

The soil samples were collected from experimental site at 0-15 cm depth for analysis before application of treatments in the month of July, 2015 and after harvesting of the fruits in the month of February, 2016.

3.9.5.1 Water retention at 1500 and 33 kPa

Water retention per cent of soil at 1500 and 33 kPa was calculated by pressure membrane apparatus (Singh, 1980).

3.9.5.2 Bulk density of soil

The bulk density of soil was determined by Relative density bottle (Richards, 1954).

3.9.5.3 Organic carbon content in soil

The methodology for calculating organic carbon in soil was calculated by Walkely and Black rapid titration method (Piper, 1950).

3.9.5.4 Available nutrient status of soil

Available N

The available N in soil was determined and calculated through alkaline permanganate method (Subbiah and Asija, 1956).

Available P_2O_5

The available P_2O_5 in soil was determined and calculated through Olsen's method (Olsen *et al*., 1954)

Available K_2O

The available K_2O in soil was determined and calculated through Flame photometer method (Metson, 1956).

3.10 Economics of different treatment

The expenditure incurred on all cultural operations and the cost of inputs applied to each experimental plant were taken into account to determine cost of cultivation while the gross return were calculated by multiplying the fruit yield against each treatments with prevailing market price of ber fruits.

Economics of different treatments was worked out in terms of net return per hectare. Treatment wise benefit : cost (B:C) ratio was also calculated to ascertain economic viability of the treatment. The Computation details of economics for each treatment are given in appendix-XIV.

Gross return (₹/ha) = Return from fruit yield

Net return = Gross return - Total cost of cultivation

$$\text{B : C} = \frac{\text{Net return (₹/ha)}}{\text{Total cost of cultivation (₹/ha)}}$$

3.11 Statistical analysis

To test the significance of variation in the data obtained from various growth, yield and quality characters, the technique of statistical analysis of

variance was suggested by Fisher (1950) for Randomized Block Design. Significance of difference in the treatment effect was tested through ‘F’ tests at 5 per cent level of significance and CD (critical difference) was calculated, wherever the results were significant. The analysis of variance for all the data discussed are given in the appendices I to XIV at the end.

Results are summarized in tables and suitable graphical representations of the data have also been in the succeeding chapter.

Chapter-4

EXPERIMENTAL RESULTS

Results arising out of the experiment entitled **"Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under Semi Arid Conditions"**conducted at Horticulture Farm, S.K.N. college of agriculture, Jobner (Rajasthan) during July, 2015 to February, 2016 are presented in this chapter. Data pertaining to the different treatments on vegetative growth, yield and quality parameters of ber and nutrient status of plant and soil were analyzed statistically to their significance. The data recorded for important characters have also been presented graphically for elucidation of the important trends, wherever, found necessary. Analysis of variance of various characteristics has also been presented in the appendices I to XIV.

4.1 Vegetative growth attributes

Vegetative growth parameters *viz.,* plant height, trunk girth, plant spread, length of primary branches and number of secondary branches per primary branch were measured twice in a year, before application of treatments in the month of July, 2015 and again in the month of October, 2015 and difference between these periods was considered as 'gain'. The number of primary branches and leaf area was measured at full bloom stage of experimental plants in the month of October, 2015.

4.1.1 Gain in plant height (cm)

The data regarding gain in plant height is presented in table 4.1 revealed that application of different organic manures significantly influenced the gain in plant height. The maximum gain in plant height (77.15 cm) was observed in treatment M_2 (Vermicompost @ 6 kg/plant) which is significantly superior than rest of the treatments except M_3 (Poultry manure @ 8 kg/plant). Application of

treatment M_2 recorded 16.68 per cent gain in plant height as compared to control.

A further reference to data (Table 4.1) shows that application of various fertility levels (NPK) also significantly enhanced plant height during experimentation. The highest gain in plant height (78.75 cm) was observed under treatment F_4 (125% RDF). However, there were no significant differences found between treatment F_4 and F_3 to influence the gain in plant height. Application of treatment F_4 recorded 24.72, 12.84 and 5.90 per cent gain in plant height as compared to control, F_1 and F_2, respectively.

4.1.2 Gain in trunk girth (cm)

The data presented in table 4.1 indicates that application of different organic manures and fertility levels (NPK) brought about non-perceptible variation to gain in trunk girth.

4.1.3 Gain in plant spread (cm)

The data presented in table 4.2 exhibit that gain in plant spread in East-West and North-South directions were significantly affected due to application of different organic manures and fertility levels (NPK).

The maximum gain in plant spread (111.85 cm in E-W and 109.58 cm in N-S direction) was recorded under treatment M_2 (Vermicompost @ 6 kg/plant). This treatment was found statistically at par with treatment M_3 in both directions. The increase in plant spread under treatment M_2 was registered (26.18% in E-W and 26.07% in N-S direction) over control.

In a similar fashion, the maximum gain in plant spread (118.51 cm in E-W and 115.17 cm in N-S direction) was recorded in treatment F_4 (125% RDF) which was statistically at par with F_3 (100% RDF). The increase in plant spread under F_4 was registered 52.03% in E-W and 53.37% in N-S direction higher over control.

Table 4.1 Effect of organic manures and fertility levels on plant height and trunk girth of ber

Treatments	Gain in plant height (cm)	Gain in trunk girth (cm)
Organic manures		
M_0 (Control)	66.12	2.55
M_1 (FYM @ 20 kg/plant)	72.04	2.65
M_2 (Vermicompost @ 6 kg/plant)	77.15	2.76
M_3 (Poultry manure @ 8 kg/plant)	75.30	2.71
SEm±	1.29	0.07
CD (P=0.05)	3.69	NS
Fertility levels (NPK)		
F_0 (Control)	63.14	2.52
F_1 (50% RDF)	69.79	2.62
F_2 (75 % RDF)	74.36	2.70
F_3 (100 % RDF)	77.22	2.74
F_4 (125 % RDF)	78.75	2.75
SEm±	1.44	0.08
CD (P=0.05)	4.16	NS

4.1.4 Number of primary branches per plant

The critical examination of the data in table 4.3 and fig. 4.1 revealed that the application of different organic manures significantly influenced the number of primary branches per plant. The maximum number of primary branches (22) were recorded with treatment M_2 (Vermicompost @ 6 kg/plant) as compared to M_1 (FYM @ 20 kg/plant) and control, but it was statistically at par with M_3 (Poultry manure @ 8 kg/plant). The increase in number of primary branches per plant in treatment M_2 was found to be 18.60 and 9.94 per cent over control and M_1, respectively.

The number of primary branches had also affected significantly due to various fertility levels (NPK). The application of treatment F_4 (125% RDF) recorded maximum number of primary branches (22.15) which was statistically at par with treatment F_3 (100% RDF) but significantly higher as compared to other treatments. The increase in number of primary branches with the application of treatment 125% RDF was registered 24.16, 13.10 and 6.44 per cent more number of primary branches over control, F_1 and F_2, respectively.

4.1.5 Gain in average length of primary branch (cm)

The data pertaining in table 4.3 revealed that the application of different organic manures significantly influenced the length of primary branches. The maximum gain in average length of primary branch (91.25 cm) was recorded with M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant) but found significantly superior over M_1 and control. The increase in gain in length of primary branch under the M_2 was found to be 31.86 and 13.49 per cent higher as compared to control and M_1 (FYM @ 20 kg/plant), respectively.

Similarly, the application of various fertility levels (NPK) also significantly influenced the average length of primary branches. The maximum gain in length of primary branch (97.28 cm) was recorded withF_4 (125% RDF), which was found significantly higher over rest of the treatments except F_3 (100% RDF). The

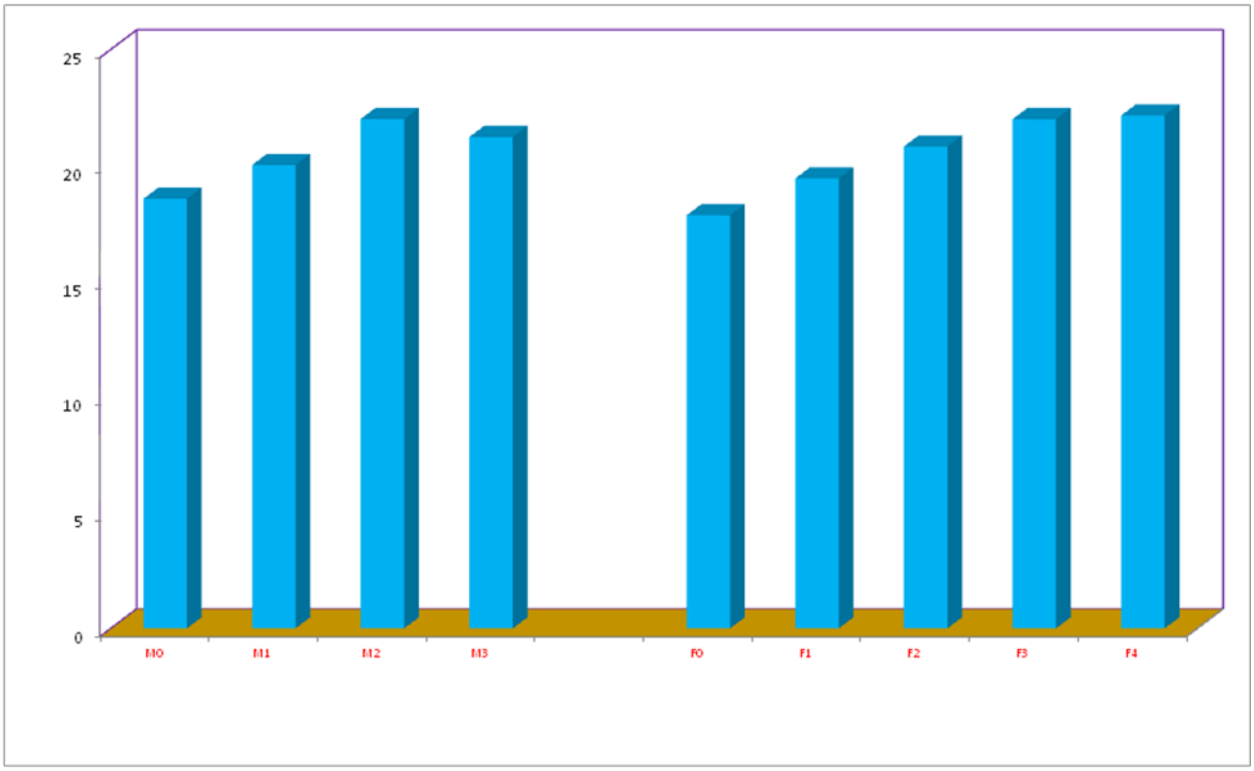

Fig. 4.1 Effect of organic manures and fertility levels on number of primary branches of ber

Table 4.2 Effect of organic manures and fertility levels on plant spread of ber

Treatments	Plant Spread	
	Gain in E-W direction (cm)	Gain in N-S direction (cm)
Organic manures		
M_0 (Control)	88.64	86.92
M_1 (FYM @ 20 kg/plant)	101.54	98.20
M_2 (Vermicompost @ 6 kg/plant)	111.85	109.58
M_3 (Poultry manure @ 8 kg/plant)	110.36	107.31
SEm±	2.25	2.92
CD (P=0.05)	6.43	8.37
Fertility levels (NPK)		
F_0 (Control)	77.95	75.09
F_1 (50% RDF)	94.66	92.35
F_2 (75 % RDF)	108.48	105.22
F_3 (100 % RDF)	115.89	114.68
F_4 (125 % RDF)	118.51	115.17
SEm±	2.51	3.27
CD (P=0.05)	7.25	9.44

Table 4.3 Effect of organic manures and fertility levels on number and length of primary branches of ber

Treatments	Number of primary branches per plant	Gain in average length of primary branch (cm)
Organic manures		
M_0 (Control)	18.55	69.20
M_1 (FYM @ 20 kg/plant)	20.01	80.40
M_2 (Vermicompost @ 6 kg/plant)	22.00	91.25
M_3 (Poultry manure @ 8 kg/plant)	21.22	89.28
SEm±	0.36	2.02
CD (P=0.05)	1.02	5.78
Fertility levels (NPK)		
F_0 (Control)	17.84	56.69
F_1 (50% RDF)	19.43	75.71
F_2 (75 % RDF)	20.81	87.63
F_3 (100 % RDF)	21.99	95.36
F_4 (125 % RDF)	22.15	97.28
SEm±	0.40	2.26
CD (P=0.05)	1.15	6.52

increase in length of primary branch under this treatment was registered to be 71.60, 28.49 and 11.01 per cent more over control, F_1 and F_2, respectively.

4.1.6 Gain in number of secondary branches per primary branch

The data regarding to gain in number of secondary branches per primary branch were given in table 4.4 and fig. 4.2 indicated that application of different organic manures had significant effect on the gain in number of secondary branches per primary branch. The maximum gain in number of secondary branches (8.51) was observed in M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant). The increase in number of secondary branches in M_2 was registered 83.01 per cent over control.

The number of secondary branches per primary branch was also influenced significantly with the application of various fertility levels (NPK). The maximum gain in number of secondary branches (8.62) was observed in F_4 (125% RDF) which was statistically at par with F_3 (100% RDF). The increase in number of secondary branches in F_4 was found to be 99.08, 39.03 and 13.42 per cent higher than control, F_1 and F_2, respectively.

4.1.6.1 Interaction effect (M x F)

Interactive effect between different organic manures and fertility levels (NPK) significantly affected the gain in number of secondary branches per primary branch (Table 4.5). The treatment combination M_2F_4 (Vermicompost @ 6 kg/plant + 125% RDF) recorded significantly highest number of secondary branches (10.39) which remained statistically at par with treatment combination of M_2F_3 (Vermicompost @ 6 kg/plant + 125% RDF), M_3F_4 (Poultry manure @ 8 kg/plant + 125% RDF) and M_3F_3 (Poultry manure @ 8 kg/plant + 100% RDF).

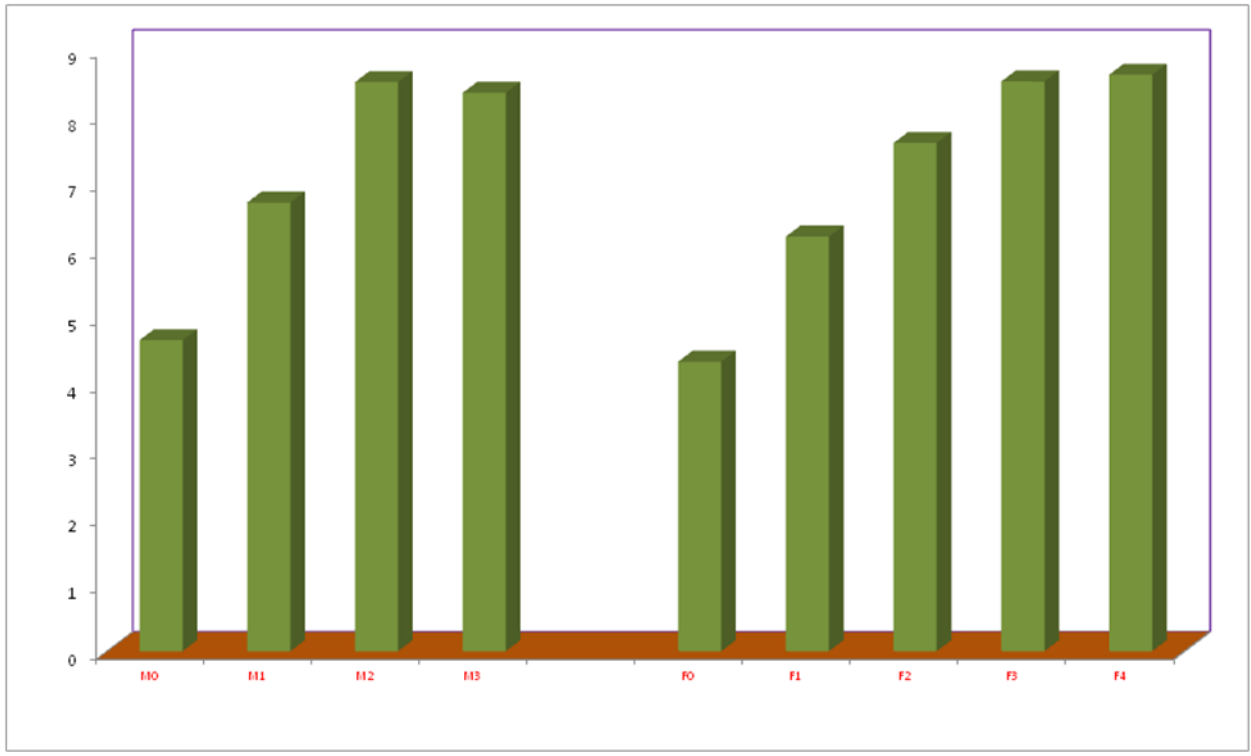

Fig. 4.2 Effect of organic manures and fertility levels on number of secondary branches per primary branch of ber

Table 4.4 Effect of organic manures and fertility levels on number of secondary branches per primary branch and leaf area of ber

Treatments	Gain in number of secondary branches per primary branch	Average leaf area (cm^2)
Organic manures		
M_0 (Control)	4.65	23.23
M_1 (FYM @ 20 kg/plant)	6.71	26.12
M_2 (Vermicompost @ 6 kg/plant)	8.51	29.12
M_3 (Poultry manure @ 8 kg/plant)	8.35	28.11
SEm±	0.14	0.58
CD (P=0.05)	0.40	1.66
Fertility levels (NPK)		
F_0 (Control)	4.33	23.42
F_1 (50% RDF)	6.20	25.56
F_2 (75 % RDF)	7.60	26.76
F_3 (100 % RDF)	8.52	28.65
F_4 (125 % RDF)	8.62	28.83
SEm±	0.15	0.65
CD (P=0.05)	0.45	1.87

Table 4.5 Interactive effect of organic manures and fertility levels on number of secondary branches per primary branch of ber

Treatments	M_0	M_1	M_2	M_3
F_0	2.86	4.12	5.23	5.13
F_1	4.09	5.90	7.48	7.34
F_2	5.01	7.23	9.16	8.99
F_3	5.62	8.11	10.28	10.09
F_4	5.68	8.20	10.39	10.20
SEm±				0.31
CD (P=0.05)				0.89

4.1.7 Average leaf area (cm^2)

A perusal of data (Table 4.4) indicated that average leaf area of ber was significantly influenced by different organic manures and fertility levels (NPK). The maximum leaf area (29.12 cm^2) was recorded under treatment M_2 (Vermicompost @ 6 kg/plant) whereas, it was noted minimum under control but significant difference could not be registered between M_2 and M_3 except M_1 and control. The leaf area under treatment M_2 was found to be 25.35 and 11.48 per cent higher than control and M_1, respectively.

Data further indicated that among various fertility levels (NPK), treatment F_4 (125% RDF) showed the maximum average leaf area (28.83 cm^2) which was statistically at par with treatment F_3 but found significantly superior than rest of the treatments. The increase in leaf area under F_4 was registered 23.10 per cent higher than control.

4.2 Fruit yield

The data pertaining to the effect of organic manures and fertility levels (NPK) *viz.,* fruit yield (kg/plant) and fruit yield (q/ha) of ber are summarized in table 4.6.

Table 4.6 Effect of organic manures and fertility levels on fruit yield of ber

Treatments	Yield (kg/plant)	Yield (q/ha)
Organic manures		
M_0 (Control)	8.03	22.32
M_1 (FYM @ 20 kg/plant)	12.00	33.36
M_2 (Vermicompost @ 6 kg/plant)	15.31	42.56
M_3 (Poultry manure @ 8 kg/plant)	14.59	40.56
SEm±	0.26	0.70
CD (P=0.05)	0.73	2.01
Fertility levels (NPK)		
F_0 (Control)	7.61	21.16
F_1 (50% RDF)	11.01	30.60
F_2 (75 % RDF)	13.82	38.41
F_3 (100 % RDF)	14.86	41.31
F_4 (125 % RDF)	15.11	42.02
SEm±	0.29	0.78
CD (P=0.05)	0.83	2.26

4.2.1 Fruit yield per plant (kg)

It is amply clear from the data presented in table 4.6 and fig. 4.3 explicit that different organic manures significantly influenced the yield per plant.

Fruit yield per plant was significantly higher under treatment M_2 (Vermicompost @ 6 kg/plant) *i.e.* 15.31 kg per plant as compared to control. This treatment was statistically at par with treatment M_3 (Poultry manure @ 8 kg/plant). The increase in fruit yield in M_2 was registered 90.66 and 27.58 per cent higher than control and M_1, respectively.

Similarly, application of various fertility levels (NPK) had also significantly influenced the fruit yield per plant. The maximum fruit yield (15.11 kg/plant) was found under treatment F_4 (125% RDF) which was statistically at par with F_3. The increase in fruit yield was registered 98.55 per cent per cent higher in F_4 over control.

4.2.1.1 Interaction effect (M x F)

A critical examination of data presented in table 4.7 revealed that the treatment combination of different organic manures and fertility levels (NPK) were brought perceptible variation in fruit yield. The maximum fruit yield was (18.54 kg/plant) obtained in treatment combination M_2F_4 (Vermicompost @ 6 kg/plant + 125% RDF). This treatment combination was proved to be significantly superior than rest of the treatment combinations in respect to fruit yield kg per plant except M_2F_3, M_3F_4, M_3F_3 and M_2F_2 which were found statistically at par.

Table 4.7 Interactive effect of organic manures and fertility levels on fruit yield (kg/plant) of ber

Treatments	M_0	M_1	M_2	M_3
F_0	4.90	7.32	9.34	8.90
F_1	7.08	10.58	13.50	12.87
F_2	8.89	13.28	16.95	16.15
F_3	9.56	14.29	18.23	17.37
F_4	9.72	14.53	18.54	17.67
SEm±				0.57
CD (P=0.05)				1.66

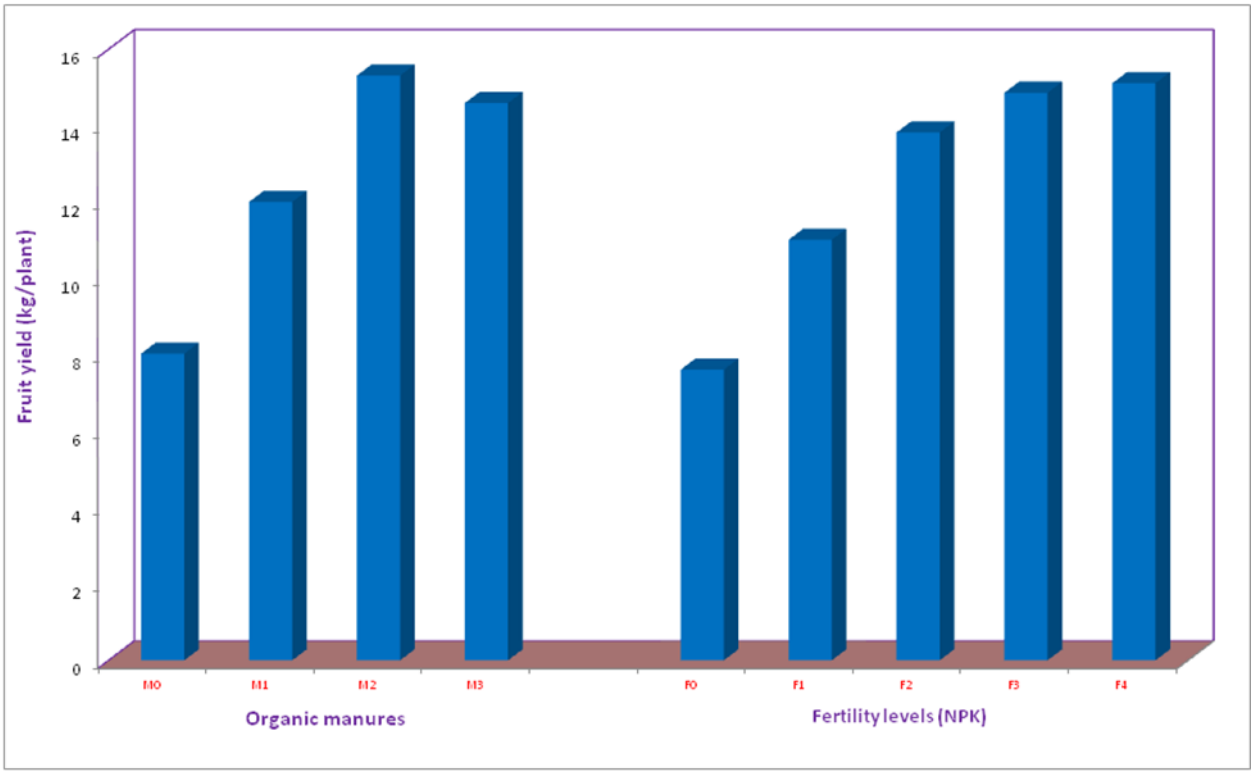

Fig. 4.3 Effect of organic manures and fertility levels on fruit yield (kg/plant) of ber

4.2.2 Fruit yield per hectare (q)

It is inferred from the data (Table 4.6 and fig. 4.4) that different organic manures tended to significantly increased the fruit yield per hectare. Treatment M_2 (Vermicompost @ 6 kg/plant) was found significantly superior over rest of the treatments except M_3 (Poultry manure @ 8 kg/plant). The application of M_2 significantly increased fruit yield (42.56 q/ha) by 27.58 and 90.68 per cent more than M_1 and control, respectively.

Similarly, the effect of various fertility levels (NPK) was also found to be significant in increasing fruit yield per hectare (Table 4.5). Application of treatment F_4 (125% RDF) recorded the highest fruit yield (42.02 q/ha) and was found statistically superior over rest of the treatments expect F_3 (100% RDF). The increase in fruit yield due to F_4 was registered 98.58, 37.32 and 9.40 per cent higher as compared to control, F_1 and F_2, respectively.

4.2.2.1 Interaction effect (M x F)

Integration of different organic manures and fertility levels (NPK) significantly affected the fruit yield per hectare (Table 4.8). The highest fruit yield (51.54 q/ha) was recorded under treatment combination M_2F_4 (Vermicompost @ 6 kg/plant + 125% RDF) which was found statistically at par with M_2F_3, M_3F_4, M_3F_3 and M_2F_2. The increase in fruit yield in this treatment was registered 278.69 per cent higher over control.

Table 4.8 Interactive effect of organic manures and fertility levels on fruit yield (q/ha) of ber

Treatments	M_0	M_1	M_2	M_3
F_0	13.61	20.35	25.96	24.74
F_1	19.69	29.42	37.54	35.77
F_2	24.71	36.92	47.11	44.89
F_3	26.57	39.71	50.67	48.28
F_4	27.03	40.40	51.54	49.11
SEm±				1.57
CD (P=0.05)				4.53

4.3 Quality components

The data pertaining to the effect of different organic manures and fertility levels (NPK) on quality of ber fruits have been summarized in table 4.9.

4.3.1 Total soluble solids (^{0}Brix)

The data regarding to total soluble solids mentioned in table 4.9 revealed that application of different organic manures gave significant results. The maximum total soluble solids (19.55^{0}Brix) was observed in treatment M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3. The increase in TSS content in fruits was registered 6.36 and 12.68 per cent higher in treatment M_2 over M_1 and control, respectively.

The total soluble solids in fruits also influenced significantly with the application of various fertility levels (NPK). The maximum total soluble solids (20.19^{0}Brix) was observed in treatment F_4 (125% RDF) which was statistically at par with F_3 (100% RDF). The increase in total soluble solids in F_4 was found to be 23.64, 12.98 and 6.49 per cent higher than control, F_1 and F_2, respectively.

4.3.2 Acidity (%)

The data given in table 4.9 clearly revealed that application of different organic manures decrease acidity content in fruits significantly. The minimum acidity (0.397%) was recorded in treatment M_2 (Vermicompost @ 6 kg/plant) whereas, maximum in control (0.448%). However, treatment M_2 (Vermicompost @ 6 kg/plant) did not differ significantly with M_3 but it was found significantly superior in rest of the treatments.

The acidity content in fruits also affected significantly by application of various fertility levels (NPK). The application of treatment F_4 (125% RDF) recorded minimum acidity (0.367%) in fruits which was statistically at par with F_3 (100% RDF) but significantly higher to other treatments. The decrease in acidity content in fruits with the application of treatment F_4 was registered 31.60, 22.34 and 13.90 per cent lesser over control, F_1 and F_2, respectively.

Table 4.9 Effect of organic manures and fertility levels on total soluble solids and acidity content in fruits of ber

Treatments	TSS (^{0}Brix)	Acidity (%)
Organic manures		
M_0 (Control)	17.35	0.448
M_1 (FYM @ 20 kg/plant)	18.38	0.421
M_2 (Vermicompost @ 6 kg/plant)	19.55	0.397
M_3 (Poultry manure @ 8 kg/plant)	19.31	0.414
SEm±	0.29	0.007
CD (P=0.05)	0.82	0.020
Fertility levels (NPK)		
F_0 (Control)	16.33	0.483
F_1 (50% RDF)	17.87	0.449
F_2 (75 % RDF)	18.96	0.418
F_3 (100 % RDF)	19.90	0.383
F_4 (125 % RDF)	20.19	0.367
SEm±	0.32	0.008
CD (P=0.05)	0.93	0.023

Table 4.10 Effect of organic manures and fertility levels on nitrogen, phosphorus and potassium content in leaves of ber

Organic manures	N content (%)	P content (%)	K content (%)
Organic manures			
M_0 (Control)	1.96	0.088	1.49
M_1 (FYM @ 20 kg/plant)	2.11	0.105	1.60
M_2 (Vermicompost @ 6 kg/plant)	2.25	0.119	1.73
M_3 (Poultry manure @ 8 kg/plant)	2.22	0.116	1.69
SEm±	0.02	0.002	0.02
CD (P=0.05)	0.07	0.007	0.07
Fertility levels (NPK)			
F_0 (Control)	1.83	0.086	1.38
F_1 (50% RDF)	2.03	0.101	1.53
F_2 (75 % RDF)	2.22	0.111	1.66
F_3 (100 % RDF)	2.29	0.118	1.76
F_4 (125 % RDF)	2.30	0.120	1.79
SEm±	0.03	0.003	0.03
CD (P=0.05)	0.07	0.007	0.07

4.4 Physico-biochemical observations of plant

The data pertaining to the effect of different organic manures and fertility levels (NPK) on physico-biochemical properties of plants *viz.,* nutrient content, relative leaf water content and total chlorophyll content in leaves of ber have been summarized in table 4.10 and 4.11.

4.4.1 Nutrient content in leaves

Nutrient concentration in plant tissues and nutrient uptake are most important estimates for judging the soil fertility. It also indicated that the nutrient requirement regarding the N, P and K content in leaves of ber had influenced by different organic manures and fertility levels (NPK) are presented in table 4.10.

4.4.1.1 Nitrogen content (%)

It is obvious from the data (table 4.10) that N content in leaves was influenced by different organic manures. The maximum N content in leaves (2.25%) was found under treatment M_2, which was statistically at par with M_3. This treatment registered 14.79 and 6.63 per cent more than N content in leaves of ber control and M_1, respectively.

Similarly, N content in leaves was also influenced significantly by application of various fertility levels (NPK). Highest N content in leaves (2.30%) was observed under treatment F_4 (125% RDF) followed by F_3 (100% RDF) and the lowest value of it was obtained under control. The treatment F_4 and F_3 recorded 25.68 and 25.13 per cent higher N content in ber leaves than control.

4.4.1.2 Phosphorus content (%)

The data presented in table 4.10 indicated that the application of different organic manures significantly increased the P content in leaves. The maximum P content in leaves (0.119%) was observed in treatment M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant). The increase in P content in leaves in M_2 was registered 35.23 and 13.33 per cent higher than control and M_1 (FYM @ 20 kg/plant), respectively.

The data presented in same table also exhibited that application of various fertility levels (NPK) had significant effect on P content in leaves of ber. The treatment F_4 (125% RDF) exhibited highest P content (0.120%) in leaves which was statistically at par with treatment F_3 (100% RDF). The increase in P content in leaves in treatment F_4 was found to be 39.53, 18.81 and 8.11 per cent over control, F_1 and F_2, respectively.

4.4.1.3 Potassium content (%)

Data have also been presented in table 4.10 regarding effect of different organic manures on K content in leaves. Among all the treatments, the maximum K content in leaves (1.73%) was recorded under treatment M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant). Treatment M_2 showed 16.11 and 8.12 per cent increase in K content in leaves over control and M_1 (FYM @ 20 kg/plant), respectively.

Similarly, K content in leaves was also influenced significantly by application of different fertility levels (NPK). Highest K content in leaves (1.79%) was observed under treatment F_4 which was statistically at par with F_3. The increase in K content in leaves under treatment F_4 was registered 29.71, 16.99 and 7.83 per cent higher than control, F_1 and F_2, respectively.

4.4.2 Relative leaf water content (%)

Data pertaining to relative leaf water content are presented in table 4.11 revealed that different organic manures influenced the relative leaf water content of ber plants. The highest relative leaf water content (64.11%) was observed under M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant). However, the minimum relative leaf water content was found under control (55.28%). The treatment M_2 showed 15.97 per cent increase in relative leaf water content over control.

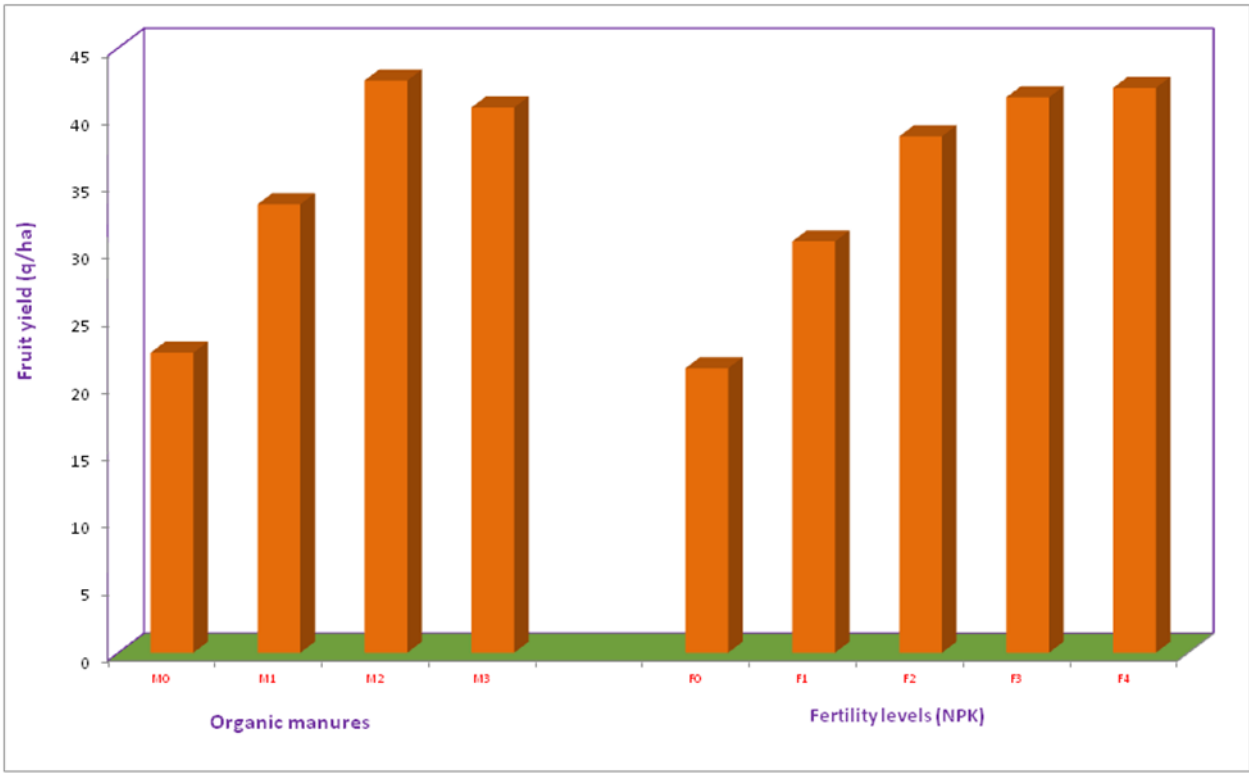

Fig. 4.4 Effect of organic manures and fertility levels on fruit yield (q/ha) of ber

Table 4.11 Effect of organic manures and fertility levels on relative water content and chlorophyll content in leaves of ber

Treatments	RLWC (%)	Total chlorophyll content (mg/g)
Organic manures		
M_0 (Control)	55.28	0.98
M_1 (FYM @ 20 kg/plant)	60.46	1.19
M_2 (Vermicompost @ 6 kg/plant)	64.11	1.84
M_3 (Poultry manure @ 8 kg/plant)	63.48	1.75
SEm±	1.03	0.04
CD (P=0.05)	2.95	0.11
Fertility levels (NPK)		
F_0 (Control)	53.29	0.80
F_1 (50% RDF)	57.75	1.20
F_2 (75 % RDF)	61.83	1.53
F_3 (100 % RDF)	65.38	1.80
F_4 (125 % RDF)	65.91	1.87
SEm±	1.15	0.04
CD (P=0.05)	3.33	0.12

Regarding the application of various fertility levels (NPK), maximum relative leaf water content (65.91%) was observed under F_4 (125% RDF) which was statistically at par with F_3 (100% RDF) whereas, the minimum relative leaf water content under control was registered 23.68 per cent lesser as compared to F_4.

4.4.3 Total chlorophyll content (mg/g)

The data related to the total chlorophyll content in ber leaves are presented in table 4.11 revealed that application of different organic manures and fertility levels significantly influenced the total chlorophyll content in leaves of ber.

Total chlorophyll content in leaves was recorded the maximum (1.84 mg/g) under M_2 (Vermicompost @ 6 kg/plant). However, it was found minimum (0.98 mg/g) under control. The treatments M_2 remained statistically at par with treatment M_3. The increase in total chlorophyll content of leaves under treatment M_2 was registered as 87.75 per cent higher over control.

It is amply clear from the same table that among the various fertility levels (NPK), treatment F_4 (125% RDF) recorded the maximum chlorophyll content (1.87 mg/g), whereas, the minimum was recorded in control (0.80 mg/g). However, significant difference could not be registered in treatment F_4 and F_3. The increase in total chlorophyll content in leaves under treatment F_4 was found to be 133.75, 55.83 and 22.22 per cent over control, F_1 and F_2, respectively.

4.5 Physico-biochemical observations of soil

The data pertaining to the effect of different organic manures and fertility levels (NPK) on physico-biochemical properties of soil *viz.,* water retention, bulk density, organic carbon and available nutrient status of soil of ber orchard have been summarized in table 4.12 to 4.14.

4.5.1 Water retentions at 1500 and 33 kPa (%)

Values regarding water retention per cent of soil at 1500 and 33 kPa are displayed in table 4.12 clearly indicated that different organic manures

Table 4.12 Effect of organic manures and fertility levels on water retention at 1500 and 33 kPa in soil

Treatments	Water retention (%) at 1500 kPa	Water retention (%) at 33 kPa
Organic manures		
M_0 (Control)	3.75	11.77
M_1 (FYM @ 20 kg/plant)	6.90	14.41
M_2 (Vermicompost @ 6 kg/plant)	6.76	13.88
M_3 (Poultry manure @ 8 kg/plant)	6.70	13.61
SEm±	0.14	0.29
CD (P=0.05)	0.39	0.82
Fertility levels (NPK)		
F_0 (Control)	5.88	13.25
F_1 (50% RDF)	5.90	13.31
F_2 (75 % RDF)	6.02	13.36
F_3 (100 % RDF)	6.15	13.40
F_4 (125 % RDF)	6.19	13.77
SEm±	0.15	0.32
CD (P=0.05)	NS	NS

Table 4.13 Effect of organic manures and fertility levels on bulk density and organic carbon content in soil

Treatments	Bulk density (Mg/m^3)	Organic carbon (%)
Organic manures		
M_0 (Control)	1.55	0.269
M_1 (FYM @ 20 kg/plant)	1.43	0.332
M_2 (Vermicompost @ 6 kg/plant)	1.49	0.319
M_3 (Poultry manure @ 8 kg/plant)	1.49	0.311
SEm±	0.04	0.009
CD (P=0.05)	0.11	0.026
Fertility levels (NPK)		
F_0 (Control)	1.51	0.293
F_1 (50% RDF)	1.50	0.302
F_2 (75 % RDF)	1.49	0.305
F_3 (100 % RDF)	1.49	0.305
F_4 (125 % RDF)	1.48	0.333
SEm±	0.04	0.010
CD (P=0.05)	NS	NS

significantly influenced the water retention in soil. Treatment M_1 (FYM @ 20 kg/plant) exhibited maximum water retention in soil at 1500 and 33 kPa (6.90% and 14.41%, respectively) whereas, minimum was observed in control but significant differences in water retention at 1500 and 33 kPa could not be registered among treatments M_1, M_2 and M_3.

The data presented in same table also exhibited that application of various fertility levels (NPK) did not influence water retention per cent in soil at 1500 and 33 kPa.

4.5.2 Bulk density (Mg/m^3)

A critical examination of the data given in table 4.13 revealed that effect of different organic manures significantly decrease bulk density of soil. The minimum bulk density (1.43 Mg/m^3) was recorded in treatment M_1 (FYM @ 20 kg/plant) whereas, it was found maximum in control (1.55 Mg/m^3) but treatment M_1 did not differ significantly with M_2 and M_3.

Data mentioned in same table clearly indicated that bulk density of soil did influenced significantly by application of various fertility levels (NPK) did not affect significantly.

4.5.3 Organic carbon content (%)

The data exhibited in table 4.13 explicit that application of different organic manures significantly affected the organic carbon content in soil recorded significantly higher organic carbon content (0.332%) in soil under treatment M_1 (FYM @ 20 kg/plant) over control but M_2 and M_3 treatments which were found statistically at par.

It may be seen that organic carbon content in soil was not affected significantly by application of various fertility levels (NPK).

4.5.4 Available nutrient status of soil

4.5.4.1 Available N (kg/ha)

Data pertaining to the effect of different organic manures on available N in soil are presented in table 4.14. The application of different organic manures showed significant effects on available N in soil. The maximum available N in soil (147.11 kg/ha) was observed in treatment M_2 (Vermicompost @ 6 kg/plant), which was statistically at par with M_3. The increase in available N status of soil in M_2 was found to be 18.02 and 7.74 per cent more over control and M_1, respectively.

The data presented in same table also indicated that application of various fertility levels (NPK) significantly increased the available status of N in soil. The application of treatment F_4 (125% RDF) exhibited maximum available N *i.e*. 156.21 kg per hectare. The results indicated that F_4 was found statistically at par with F_3 for available N in soil. The available N status of soil in treatment F_4 was registered 34.50 per cent over control.

4.5.4.2 Available P_2O_5 (kg/ha)

The critical examination of data given in the table 4.14 revealed that the significant effect on available P_2O_5 in soil was observed. The maximum P_2O_5 in soil (19.11 kg/ha) was recorded with application of treatment M_2 (Vermicompost @ 6 kg/plant) which was found statistically at par with treatment M_3 (Poultry manure @ 8 kg/plant). The available P_2O_5 status of soil in treatment M_2 was found to be 19.81 and 8.27 per cent more over control and M_1, respectively.

The same table also revealed that application of various fertility levels (NPK) significantly affected the P_2O_5 availability in soil. The treatment F_4 (125% RDF) registered significantly higher available P_2O_5 *i.e.* 19.95 kg per hectare in soil as compared to control, F_1 and F_2, whereas, treatment F_4 remained statistically at par with F_3. The available P_2O_5 status of soil in treatment F_4 was also registered 34.61 per cent higher than control.

4.5.4.3 Available K_2O (kg/ha)

A persual of data presented in table 4.14 showed that the application of different organic manures significantly increase the available status of K_2O in

Table 4.14 Effect of organic manures and fertility levels on available N, P_2O_5 and K_2O content in soil

Treatments	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Organic manures			
M_0 (Control)	124.65	15.95	145.85
M_1 (FYM @ 20 kg/plant)	136.54	17.65	148.91
M_2 (Vermicompost @ 6 kg/plant)	147.11	19.11	160.00
M_3 (Poultry manure @ 8 kg/plant)	145.61	18.88	156.81
SEm±	2.88	0.42	3.79
CD (P=0.05)	8.24	1.21	11.21
Fertility levels (NPK)			
F_0 (Control)	116.14	14.82	142.82
F_1 (50% RDF)	129.48	16.69	146.73
F_2 (75 % RDF)	140.30	18.30	147.52
F_3 (100 % RDF)	150.26	19.73	157.91
F_4 (125 % RDF)	156.21	19.95	161.24
SEm±	3.22	0.47	4.24
CD (P=0.05)	9.29	1.37	12.60

soil. The maximum available K_2O in soil (160.00 kg/ha) was found in treatment M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant). This treatment showed 9.70 and 7.45 per cent increase in available K_2O in soil as compared to control and M_1, respectively.

The same table also exhibits that K_2O availability in soil was influenced significantly by various fertility levels (NPK). Maximum availability of K_2O in soil was observed under treatment F_4 (125% RDF) being 161.24 kg per hectare. However, the values of F_4 and F_3 did not differ significantly. The increase in available K_2O in soil under to treatment F_4 was found to be 12.90, 9.89 and 9.30 per cent higher than control, F_1 and F_2, respectively.

4.6 Economics

4.6.1 Net returns

A perusal of data pertaining to net returns as presented in table 4.15 and fig. 4.5 showed that net returns was influenced significantly due to application of different organic manures and fertility levels (NPK). Application of treatment M_2 (Vermicompost @ 6 kg/plant) fetched highest and significantly more net returns (₹120464/ha) over rest of the treatments but statistically at par with M_3 (Poultry manure @ 8 kg/plant). Application of treatment M_2 registered an increase of 138.50 per cent higher net returns over control.

It is also evident from data that maximum net return (₹119967/ha) was recorded with application of treatment F_4 (125% RDF) which was statistically at par with F_3 (100% RDF), but significantly higher than rest of the treatments.

4.6.1.1 Interaction effect (M x F)

A perusal of data in table 4.16 revealed that combined effect of different organic manures and fertility levels (NPK) was found significant on net return (₹/ha). The maximum net return (₹153869/ha) was recorded with treatment combination of M_2F_4 (Vermicompost @ 6 kg/plant + 125% RDF). The treatment combination M_2F_4 was found significantly higher over all the treatment

combinations except M_2F_3, M_3F_4, M_3F_3 and M_2F_2 which were found statistically at par.

Table 4.16 Interactive effect of organic manures and fertility levels on net returns (₹/ha)

Treatments	M_0	M_1	M_2	M_3
F_0	16193	41449	57225	54010
F_1	38215	75481	101271	95878
F_2	57166	104362	138430	131236
F_3	63493	114378	151523	143660
F_4	64184	115972	153869	145842
SEm±				5398
CD (P=0.05)				15590

4.6.2 B:C ratio

The critical examination of data (Table 4.15 and fig. 4.6) showed that application of different organic manures and fertility levels significantly affected the B:C ratio and recorded maximum B:C ratio of 2.39 in treatment M_2 (Vermicompost @ 6 kg/plant). This treatment was found to be significantly higher over control and M_1 but statistically at par with M_3 (Poultry manure @ 8 kg/plant). The increase in B:C ratio with treatment M_2 was recorded 109.65 per cent higher than control.

Data given in same table further revealed that various fertility levels (NPK) also affected the B:C ratio significantly. The maximum B:C ratio (2.48) was observed under treatment F_3 (100% RDF) which was found to be significantly higher over rest of the treatments expect F_4 (125% RDF). The increase in B:C ratio under treatment F_3 was found to be 155.67, 45.03 and 6.90 per cent higher as compared to control, F_1 and F_2, respectively whereas, minimum B:C ratio (0.97) was recorded in control.

4.6.1.2 Interaction effect (M x F)

A perusal of data in table 4.17 revealed that combined effect of different organic manures and fertility levels (NPK) was found significant on B:C ratio. The maximum B:C ratio (2.96) was recorded with treatment combination M_2F_3 (Vermicompost @ 6 kg/plant). The treatment combination M_2F_3 was found significantly higher over all the treatment combinations except M_2F_4, M_3F_3, M_3F_4, and M_2F_2 which were found statistically at par.

Table 4.17 Interactive effect of organic manures and fertility levels on B:C ratio

Treatments	M_0	M_1	M_2	M_3
F_0	0.42	1.04	1.23	1.20
F_1	0.94	1.79	2.07	2.03
F_2	1.37	2.41	2.77	2.71
F_3	1.48	2.57	2.96	2.90
F_4	1.46	2.54	2.94	2.88
SEm±				0.07
CD (P=0.05)				0.20

Table 4.15 Effect of organic manures and fertility levels on net returns and B:C ratio

Treatments	Net returns (₹/ha)	B:C ratio
Organic manures		
M_0 (Control)	47850	1.14
M_1 (FYM @ 20 kg/plant)	90329	2.07
M_2 (Vermicompost @ 6 kg/plant)	120464	2.39
M_3 (Poultry manure @ 8 kg/plant)	114125	2.35
SEm±	2414	0.03
CD (P=0.05)	6912	0.09
Fertility levels (NPK)		
F_0 (Control)	42219	0.97
F_1 (50% RDF)	77711	1.71
F_2 (75 % RDF)	107799	2.32
F_3 (100 % RDF)	118264	2.48
F_4 (125 % RDF)	119967	2.46
SEm±	2699	0.03
CD (P=0.05)	7795	0.10

Chapter-5

DISCUSSION

The results of the investigation entitled **"Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under Semi Arid Conditions"** showed significant variation on growth, yield, quality and physico-biochemical observations of plant and soil with the application of different organic manures and fertility levels (NPK). Efforts have been made to discuss the significant findings of the experiment. In this chapter, pertinent to literatures of other workers and existing evidences have been cited in order to support the findings of the present investigation.

5.1 Effect of organic manures

5.1.1 Vegetative growth attributes

The findings of present investigation showed that application of organic manures significantly affected the plant growth. The application of treatment M_2 (Vermicompost @ 6 kg/plant) increased gain in plant height, plant spread, number of primary branches, length of primary branch, number of secondary branches per primary branch and leaf area as compared to M_3 (Poultry manure @ 8 kg/plant), M_1 (FYM @ 20 kg/plant) and control (Table 4.1 to 4.4).

The better growth and development of plant under this treatment might be due to fact that organic manures not only provide plant nutrients but also improve physical condition of soil in respect of granulation, friability, porosity and developed a balanced nutritional environment favourable to both soil rhizosphere and soil plant system. It also alters various enzymatic activities in plants such as perioxidase, cataylase etc., which promotes cell elongation, root and shoot growth and carbohydrate metabolism.

The improvement in plant height by the application of organic manures like vermicompost might be due to better moisture retention capacity, supply of micronutrients and easy availability of major nutrients of soil (Reddy *et al*. 1998). Improvement in soil parameters might have helped in increasing the absorption of nutrients from soil, enhanced carbohydrate assimilation and production of new tissues, which ultimately increased vegetative growth.

5.1.2 Fruit yield

Yield is a complex character which depends on yield contributing characters. Application of organic manures significantly affected the fruit yield per plant as well as per hectare. However maximum values were recorded with application of treatment M_2 (Vermicompost @ 6 kg/plant) followed by M_3 *i.e.* poultry manure @ 8 kg per plant (Table 4.6).

The significant improvement in fruit yield on account of vermicompost application was largely a function of improved growth *i.e*. multiplication, cell elongation, tissue differentiation and therefore consequent increase in yield attributes and yield (Singh and Meena, 2004). The increase in yield with application of vermicompost may also be ascribed to sustained availability of balanced nutrient throughout the growing period and which resulted increased vegetative growth. The narrow C:N ratio might also due have helped in increased nutrient uptake and synthesis of carbohydrates which ultimately enhanced yield.

Vermicompost also contain humic acid and solubilizing bacteria, which might have solubilize the native nitrogen, phosphorus and potash and micro nutrients in the soil/root zone of the plant and thereby increasing their availability to the plants (Singh *et al.,* 1997).Marimuthu *et al.* (2002) also reported an increase yield with the application of vermicompost might be due to higher availability and uptake of plant nutrient, growth substances and favourable C:N ratio throughout the crop period.

5.1.3 Quality components

The results obtained in present investigation revealed that application of treatment M_2 (Vermicompost @ 6 kg/plant) significantly improved the quality *viz.,* TSS and acidity content in fruits of ber as compared to other treatments followed by M_3 *i.e.* poultry manure @ 8 kg per plant (Table 4.9).

The potential role of organic fertilization on various aspects of crop growth can be ascribed due to its direct effect on availability of vital nutrients and indirectly via release of growth hormones, vitamins and augmenting microbial population etc. during its process of decomposition (Gaur *et al.* 1973). The increase in TSS content and decrease in acidity content in fruits might be clear to better availability of desired and required quantity of nutrients for longer period in root zones of plant resulting from its solubilization of organic matter and chelation of available nutrients.

5.1.4 Physico-biochemical parameters of plant

The maximum nutrients content (N, P and K), relative leaf water content and total chlorophyll content in leaves (Table 4.10 and 4.11) were also recorded maximum under treatment M_2 (Vermicompost @ 6 kg/plant) closely followed by M_3 (Poultry manure @ 8 kg/plant). It might be due to when vermicompost is added to soil, complex nitrogenous compounds slowly break down and make steady N supply throughout growth period of plant, which might be attributed to more N availability and its subsequent uptake. Phosphorus and potassium uptake also had similar pattern as that of N, which might be attributed to maintain ideal soil pH leading to correct nutrients deficiencies and more solubilization of native phosphate in to available form from the soil due to action of various organic acids liberated during decomposition of vermicompost. Further beneficial effect of organic manures on improving soil physical properties in terms of better

root penetration might have also helped in increasing biomass and their concentration in leaves (Kaminwar and Rajagopal, 1993).

The physiological parameters like relative leaf water content and total chlorophyll content in leaves also improved with application of organics which could be attributed due to better root growth and activities resulting in maximum water and nutrient uptake. Higher root activities had a large influence on plant water status (relative leaf water content) through its effect on water uptake from soil (Gajri and Parihar, 1985).

5.1.5 Physico-biochemical properties of soil

Application of organic manures significantly improved water retention, bulk density, organic carbon and N, P_2O_5 and K_2O availability in the soil (Table 4.12 to 4.14).

The application of treatment M_1 (FYM @ 20 kg/plant) which closely followed by treatment M_2 (Vermicompost @ 6 kg/plant) and M_3 (Poultry manure @ 8 kg/plant) gave significantly higher build up of water retention, organic carbon and decrease bulk density of soil. The additive effect of FYM/ vermicompost/ poultry manure is beneficial for maintaining higher organic carbon level (Acharya *et al*., 1988).The addition of manures itself adds sufficient amount of organic matter to the soil and solubilizes plant nutrient and improve physical conditions of the soil by accelerating porosity, aeration and water holding capacity (Bhriguavanshi, 1988).

Incorporation of FYM in soil also increases the carbon sequestration in soil and subsequently increased yield of roots and plant residues, which adds a good amount of biomass to the soil (Singh *et al.,* 1997).

The application of treatment M_2 ((Vermicompost @ 6 kg/plant) significantly increased the available status of NPK in soil ascribed to the beneficial role of

organic manures in mineralization of native as well as addition of own nutrient content which enhance the available nutrient pool of soil. Organic manures increased available nitrogen content of soil might have been attributed to the greater multiplication of soil microbes, which could convert organically bound nitrogen to inorganic form (Bellakki and Badarnur, 1997). The enhanced available nitrogen content of soil may also be due to favourable soil conditions under vermicompost treatment which helped in the mineralization of soil nitrogen leading to higher build up of available N (Tate, 1999).

The organic manures, on decomposition, solubilize insoluble P and K fractions through release of various organic acids, which results in significant improvement in available P and K status of the soil and prevent the fixation of available nutrients by the chelation effect (Tandon, 1987).

5.2 Effect of inorganic fertilizers

5.2.1 Vegetative growth attributes

The findings of present investigation showed that application of NPK through inorganic fertilizers significantly affect the vegetative growth *viz.,* gain in plant height, plant spread, number of primary branches, length of primary branch, number of secondary branches per primary branch and leaf area. Treatment F_4 (125% RDF) significantly increased the vegetative growth (Table 4.1 to 4.4) over rest of the treatments except treatment F_3 (100% RDF).

The better growth and development of plant under this treatment might be due to better nutritional environment in root zone as well as in plant system. Nitrogen, phosphorus and potash are most indispensable among all mineral nutrients for growth and development of plant as it is basis of fundamental constituents of all living matter present. The biological role of NPK as an essential constituent of chlorophyll and nucleic acid, in harvesting solar energy,

energy transformation from phosphorylated compound, transfer of genetic information, regulation of cellular metabolism and structural unit compound is well known. All these are found abundantly in the growing and storage organ, promote healthy root, shoot and full development (Devlin and Witham, 1986).

The results are also close conformity with the findings of Shukla *et al.* (2000) in kinnow mandarin, Lal and Dhaka (2003) in ber, Singh et al. (2003) in Naval orange, *Bhobia et al.* (2005) in guava, Prasad (2005) in ber and Devashi (2012) in sapota.

5.2.2 Fruit yield

The significant improvement in fruit yield with application of treatment F_4 (125% RDF) which was statistically at par with F_3 (100% RDF) were recorded and showed in table 4.6. The application of inorganic fertilizers might have also increased the availability of nutrients directly which in turned increased fruit yield.

The findings of present investigation are in agreement with those of Jadhao *et al.* (2005) in guava, Madhavi *et al.* (2005) in guava, Pradad (2005) in ber, Quaggio et al. (2006) in lemon, Sharma *et al.* (2009) in ber, Dalal *et al.* (2011) in ber, Dayal *et al.* (2011) in ber, Devashi (2012) in sapota and Dhomane and Kadam (2013) in guava.

5.2.3 Quality components

It is well documented fact that application of nutrients specially nitrogen, phosphorus and potassium significantly affect the quality attributes in terms of TSS and acidity content in fruits. The application of treatment F_4 (125% RDF) significantly improved the quality parameters. Arora *et al.* (2012) reported that potassium is a major nutrient element essential for translocation of sugar and increase TSS content in fruits. The increase in TSS content and decrease in

acidity content in ber fruits may also be due to increased activity of nitrate reductase enzyme and enhanced synthesis of certain amino acid and proteins.

Similar results also obtained by Sen and Chauhan (1983) in pomegranate, Bhatia *et al.* (2001) in guava, Mahalle *et al.* (2001) in custard apple, Kundu *et al.* (2011) in mango and Arora *et al.* (2012) in grape.

5.2.4 Physico-biochemical parameters of plant

Both nutrients concentration and their uptake are important parameters for judging the capacity of soil to supply available nutrients. The maximum nutrients content (N, P and K), relative leaf water content and total chlorophyll content in leaves (Table 4.10 and 4.11) were recorded maximum under treatment F_4 (125% RDF) closely followed by F_3 (100% RDF). This might be due to the improved translocation of nitrogenous compounds and nutrients from various plant parts, synthesis of common precursor of chlorophyll, ammonia assimilating enzymes etc.

The results are aggrement with the findings of Singh *et al.* (1996) in mango, Giradi and Mourao (2004) in sweet orange and Kumar *et al.* (2005) in guava.

5.2.5 Physico-biochemical properties of soil

Application of treatment F_4 (125% RDF) closely followed by F_3 (100% RDF) significantly increased the availability of nutrients (N, P_2O_5 and K_2O) in soil.

Application of inorganic fertilizers (NPK) significantly influenced the physico-biochemical properties of soil after harvesting of fruits. It can be understood in the light of differential solubility of nitrogen and readily availability of P and K fertilizer to the plants. The results obtained are also in close conformity with that of Shukla *et al.* (2004).

5.3 Interaction effect (M x F)

The interactive effect of different organic manures and fertility levels (NPK) found significant for number of secondary branches, fruit yield, net returns and B:C ratio. The maximum number of secondary branches, fruit yield per plant and per hectare and net returns were observed in treatment M_2F_4 *i.e.* vermicompost @ 6 kg/plant + 125% RDF closely followed by M_2F_3 (Vermicompost @ 6 kg/plant + 100% RDF), M_3F_4 (Poultry manure @ 8 kg/plant + 125% RDF), M_3F_3 (Poultry manure @ 8 kg/plant + 100% RDF) and M_2F_2 (Vermicompost @ 6 kg/plant + 75% RDF) treatment combinations (Table 4.4, 4.7, 4.8 and 4.16, respectively) while as, M_2F_3 *i.e.* vermicompost @ 6 kg/plant + 100% RDF gave maximum B:C ratio (Table 4.17).

The interactive effect of treatments showed that application of organic manures at the same level of inorganic fertilizers resulted maximum fruit yield per plant and per hectare under treatment combination M_2F_4 (Vermicompost @ 6 kg/plant + 125% RDF) and M_2F_3 (Vermicompost @ 6 kg/plant + 100% RDF). Such type of increased in yield have been reported to be associated with the release of macro and micro flora nutrients during the course of microbial decomposition. Organic manures also functions as source of energy for soil micro flora which bring about the transformation of inorganic nutrients held in soil or applied through inorganic fertilizers in a form that is readily utilized by the plants. The balance response of organic manures and inorganic fertilizers to fruit yield might also be attributed to the availability of sufficient amount of nutrients in balanced form to the plants.

The combined effect of inorganic fertilizers and organic manures (vermicompost, poultry manure and FYM) might have supplied adequate amount of nutrients and favoured the metabolic and auxin activity in plants which resulted better values for yield attributing traits and fruit yield of ber (Ahlawat *et al.,* 2000).

The results are also close conformity with the findings of Shivaputra *et al*. (2004) in papaya, Mishra *et al*. (2011) in ber, Yadav *et al*. (2011) in papaya, Bohane and Tiwari (2014) in ber and Shukla *et al.* (2014) in guava.

5.4 Economics

Net returns and benefit : cost ratio of different treatment combinations presented in table 4.16 and 4.17 clearly revealed that application of treatment M_2F_4 (Vermicompost @ 6 kg/plant + 125% RDF) gave maximum net returns (₹153869 /ha) which was significantly superior over rest of the treatment except M_2F_3 (Vermicompost @ 6 kg/plant + 100% RDF), M_3F_4 (Poultry manure @ 8 kg/plant + 125% RDF), M_3F_3 (Poultry manure @ 8 kg/plant + 100% RDF) and M_2F_2 (Vermicompost @ 6 kg/plant + 75% RDF) treatment combinations. However, Maximum B:C ratio (2.96) was recorded under treatment M_2F_3 (Vermicompost @ 6 kg/plant + 100% RDF) which was significantly superior over rest of the treatments except M_2F_4, M_3F_3, M_3F_4 and M_2F_2 treatment combinations.

The increase in net returns of crop under combined application of vermicompost with inorganic fertilizers might be due to better root proliferation under favourable soil environment, which turn resulted higher uptake and efficient utilization of added nutrients throughout the growth period, which might have resulted higher production. The higher net returns under these treatments could be ascribed to the higher fruit yield of ber obtained under M_2F_4 treatment.

Chapter-6

SUMMERY AND CONCLUSION

The salient findings emerging out of the field experiment entitled **"Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under Semi Arid Conditions"** presented and discussed in the preceding chapters are being summarized in this chapter.

6.1 Effect of organic manures

6.1.1 Growth parameters *viz.,* gain in plant height, plant spread (E-W and N-S), number of primary branches, length of primary branch, number of secondary branches per primary branch and leaf area had significant effect with the application of organic manures. The treatment M_2 (Vermicompost @ 6 kg/plant) recorded maximum values of these parameters which was statistically at par with M_3 (Poultry manure @ 8 kg/plant).

6.1.2 Fruit yield per plant and per hectare were also significantly enhanced with the application of treatment M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant).

6.1.3 Quality components *viz.,* TSS and acidity content in fruits were significantly improved with the application of treatment M_2 (Vermicompost @ 6 kg/plant) followed with M_3 (Poultry manure @ 8 kg/plant).

6.1.4 Physico-biochemical observations of plant *viz.,* nutrient content (NPK), relative leaf water content and total chlorophyll content in leaves were significantly increased with the application of treatment M_2 (Vermicompost

@ 6 kg/plant) as compared to rest of the treatments but it was found statistically at par with M_3 (Poultry manure @ 8 kg/plant).

6.1.5 Similarly, physico-biochemical observations of soil *viz.,* water retention (at 1500 and 33 kPa), bulk density and organic carbon content in soil were significantly improved with the application of treatment M_1 (FYM @ 20 kg/plant) which was statistically at par with M_2 and M_3, while as, available nutrient status (NPK) in soil were significantly increased with application of treatment M_2 (Vermicompost @ 6 kg/plant) which was statistically at par with M_3 (Poultry manure @ 8 kg/plant).

6.1.6 Application of treatment M_2 (Vermicompost @ 6 kg/plant) gave significantly highest net returns per hectare and B:C ratio over rest of the treatments except M_3 (Poultry manure @ 8 kg/plant).

6.2 Effect of fertility levels (NPK)

6.2.1 The application of fertility levels in treatment F_4 (125 % RDF) significantly increased the growth parameters *viz.,* gain in plant height, plant spread (E-W and N-S), number of primary branches, length of primary branch, number of secondary branches per primary branch and leaf area over rest of the treatments except F_3 (100 % RDF) which could not showed significant difference in these parameters.

6.2.2 Fruit yield per plant and per hectare were significantly enhanced with the application of treatment F_4 (125 % RDF) which was statistically at par with F_3 (100 % RDF).

6.2.3 Quality components *viz.,* TSS and acidity content in fruits were significantly improved with the application of treatment F_4 (125 % RDF), but it was found statistically at par with F_3 (100 % RDF).

6.2.4 Physico-biochemical observations of plant *viz.,* nutrient content (NPK), relative leaf water content and total chlorophyll content in leaves were also significantly increased with the application of treatment F_4 (125 % RDF) in rest of the treatments except F_3 (100 % RDF) which was found statistically at par.

6.2.5 Similarly, physico-biochemical observations of soil *viz.,* available nutrient status (NPK) of soil were also significantly increased with the application of treatment F_4 (125 % RDF) in all the treatments except F_3 (100 % RDF) which was found statistically at par.

6.2.6 Application of treatments F_4 (125 % RDF) gave significantly highest net returns per hectare over rest of the treatments except treatment F_3 (100 % RDF). However, maximum B:C ratio was found in treatment F_3 (100 % RDF) which was statistically at par with F_4 (125 % RDF).

Conclusion

On the basis of the results emerged out from the experiment conducted, it can be concluded that combined application of the M_2F_4 (Vermicompost @ 6 kg/plant + 125% RDF) was found significantly superior to rest of the treatments except treatment combinations M_2F_2 (Vermicompost @ 6 kg/plant + 75% RDF), M_3F_3 (Poultry manure @ 8 kg/plant + 100% RDF), M_3F_4 (Poultry manure @ 8 kg/plant + 125% RDF) and M_2F_3 (Vermicompost @ 6 kg/plant + 100% RDF) which were statistically at par in respect to fruit yield and net returns per hectare.

Apportioning the vermicompost @ 6 kg per plant + recommended dose of NPK @ 75 per cent (M_2F_2) is worth recommendable as it fetched comparable fruit yield (47.11 q/ha) and net returns (₹138430/ha) from ber.

The results are only indicative and require further experimentation to arrive at more consistent conclusion.

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Effect of Organic Manures and Fertility Levels on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under Semi Arid Conditions

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ABSTRACT

A field experiment entitled "Effect of Organic Manures and Fertility Levels on Growth Parameters of ber (*Zizyphus mauritiana* Lamk.) cv. 'Gola' under semi arid conditions" under loamy sand soils was conducted at horticulture farm, S.K.N. college of agriculture, Jobner (Jaipur) during July, 2015 to February, 2016. It consisted of 20 treatment combinations with four levels of organic manures (control, FYM @ 20 kg/plant, vermicompost @ 6 kg/plant and poultry manure @ 8 kg/plant) and five levels of RDF (control, 50% RDF, 75% RDF, 100% RDF and 125% RDF) in Randomized Block Design with three replications.

The application of vermicompost @ 6 kg per plant among the different organic manures proved significantly superior over rest of the treatments in respect to growth parameters (Plant height, plant spread, number of primary branches, length of primary branch, number of secondary branches per primary branch and leaf area), fruit yield, quality components (TSS and acidity content), physico-biochemical parameters of plant (N, P and K content, RLWC content, chlorophyll content in leaves) and available N, P_2O_5 and K_2O content in soil except poultry manure @ 8 kg per plant. The water retention at 1500 and 33 kPa, bulk density and organic carbon content in soil were significantly affected by application of FYM @ 20 kg per plant which was statistically at par with vermicompost @ 6 kg plant and poultry manure @ 8 kg plant than control.

Similarly, result showed that application of 125 per cent RDF (F_4) also significantly enhanced all the parameters except water retention at 1500 and 33 kPa, bulk density and organic carbon content in soil as compared to control, 50 per cent and 75 per cent of RDF which was statistically at par with 100 per cent RDF (F_3).

Application of vermicompost @ 6 kg per plant with 125 per cent RDF (M_2F_4) proved the best treatment combinations in terms of number of secondary branches per primary branch, fruit yield and net returns where as vermicompost @ 6 kg per plant with 100 per cent RDF (M_2F_3) proved best in respect to B:C ratio as compared to other treatment combinations.

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अर्द्धशुष्कीय परिस्थितियों में बेर (*जिजीफस मॉरीशिआना* लामा.) की 'गोला' किस्म के वृद्धि प्राचलों पर कार्बनिक खादों एवं उर्वरक स्तरों का प्रभाव

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अनुक्षेपण

श्री कर्ण नरेन्द्र कृषि महाविद्यालय, जोबनेर के उधान प्रक्षेत्र की बलुई दोमट मृदा पर जुलाई 2015 से फरवरी 2016 के मध्य बेर की गोला किस्म के वृद्वि प्राचलों पर कार्बनिक खादों एवं उर्वरक स्तरों के अध्ययन हेतु एक प्रयोग सम्पन्न किया गया। इस प्रयोग में कार्बनिक खादों के चार उपचारों (नियंत्रण, गोबर की खाद @ 20 किग्रा/पौधा, कैचुआ खाद @ 6 किग्रा/पौधा, मुर्गी खाद @ 8 किग्रा /पौधा) एवं उर्वरकों के पांच स्तरो (नियंत्रण, उर्वरको की 50 प्रतिशत, 75 प्रतिशत, 100 प्रतिशत एवं 125 प्रतिशत अनुशंसित मात्रा) के कुल 20 उपचार समूहों को यादृच्छिक खण्ड अभिकल्पना के अर्न्तगत तीन पुनरावृत्तियों में लिया गया।

परिणामों से ज्ञात हुआ कि कार्बनिक खादों के अर्न्तगत केचुआ खाद @ 6 किग्रा/पौधा युक्त उपचार (M_2) का अनुप्रयोग मुर्गी की खाद @ 8 किग्रा/पौधा वाले उपचार (M_3) सें सांख्यिकीय रूप से समान परन्तु अन्य उपचारों की तुलना में बेर के वृद्वि प्राचलों (पौधे की उचाई, पौधे का फैलाव, प्रति पौधा प्राथमिक शाखाओ की संख्या, प्राथमिक शाखाओ की लम्बाई, प्रति प्राथमिक शाखा द्वितीयक शाखाओ की संख्या एवं पर्ण क्षेत्र) फल उपज, गुणवत्ता घटक (कुल घुलनशील पदार्थ एवं अम्लता), पौधे के भैतिक एवं जैव रासायनिक प्राचलो (पर्ण मे नत्रजन, फॉस्फोरस तथा पोटाश की मात्रा, पानी का सापेक्ष तथा कुल पर्णहरित की मात्रा) में सार्थक प्रभाव देखा गया। जबकि मृदा में 1500 एवं 33 किलो पास्कल पर पानी का ठहराव, मृदा भार घनत्व तथा मृदा में जैविक कार्बन तत्व की मात्रा गोबर की खाद @ 20 किग्रा / पौधा युक्त उपचार (M_1) में सार्थक रूप से अधिक पाये गये, परन्तु यह उपचार नियंत्रण के अलावा सभी उपचारों में सांख्यिकीय रूप से समान पाया गया।

इसी प्रकार उर्वरकों की विभिन्न अनुशंसित मात्रा के उपचारों में से 125 प्रतिशत अनुशसित दर (F_4)युक्त उपचार के अनुप्रयोग से मृदा में 1500 एवं 33 किलो पास्कल पर पानी का ठहराव, मृदा भार घनत्व तथा मृदा में जैविक कार्बन तत्व के अतिरिक्त सभी प्राचलों में बढवार की दृष्टि से यह उपचार, नियंत्रण, 50 प्रतिशत एवं 75 प्रतिशत अनुशंसित मात्रा वाले उपचार से सार्थक रूप से श्रेष्ट पाया गया। परन्तु सांख्यिकी दृष्टिकोण से 100 प्रतिशत अनुशंसित मात्रा युक्त उपचार (F_3) में सार्थक रूप से कोई अन्तर नही पाया गया।

परिणामों ने यह भी दर्शाया कि कार्बनिक खादों मे केंचुआ खाद @ 6 किग्रा/ पौधा एवं उर्वरकों में 125 प्रतिशत अनुशंसित मात्रा युक्त उपचार समूह (M_2F_4) में बेर की द्वितीयक संख्याओ की संख्या, फल उपज तथा शुद्व लाभ अन्य उपचार समूहों की तुलना में सार्थक रूप से अधिक दर्ज किया गया, जबकि उपचार समूह कैचुआ खाद @ 6 किग्रा/पौधा + 100 प्रतिशत अनुसंशित उर्वरक युक्त उपचार समूह (M_2F_3) का अनुप्रयोग लाभ : लागत अनुपात में अन्य उपचार समूहो में श्रेष्ठ पाया गया।

Appendix - I

* स्नातकोत्तर छात्रा, उद्यान विज्ञान विभाग, श्री कर्ण नरेन्द्र कृषि महाविद्यालय, (एस.के.एन. कृषि विश्वविद्यालय, जोबनेर), जोबनेर।

** स्नातकोत्तर (कृषि) के उद्यान विज्ञान विषय में उपाधि प्राप्ति की आंशिक पूर्ति हेतु वर्तमान शोध कार्य **डॉ. ओ.पी. गढ़वाल**, सहायक आर्चाय, उद्यान विज्ञान विभाग, श्री कर्ण नरेन्द्र कृषि महाविद्यालय, (एस.के.एन. कृषि विश्वविद्यालय, जोबनेर) के निर्देशन में पूर्ण किया गया।

Analysis of variance for gain in plant height and trunk girth of ber

Source of variation	d.f.	Mean sum of squares	
		Gain in plant height (cm)	Gain in trunk girth (cm)
R	2	30.849	0.164
M	3	638.415**	0.153
F	4	263.571**	0.092
M x F	12	0.531	0.00003
Error	38	24.960	0.070

**Significant at 5% level

Appendix - II

Analysis of variance for gain in plant spread of ber

Source of variation	d.f.	Mean sum of squares	
		Gain in E-W direction (cm)	Gain in N-S direction (cm)
R	2	103.916	128.428
M	3	4534.951**	4602.016**
F	4	1277.982**	1194.347**
M x F	12	9.088	9.069
Error	38	75.704	128.239

** Significant at 5% level

Appendix – III
Analysis of variance for number and length of primary branches of ber

Source of variation	d.f.	Mean sum of squares	
		Number of primary branches per plant	Gain in average length of primary branch (cm)
R	2	4.111	63.680
M	3	52.982**	4489.505**
F	4	25.496**	1139.350**
M x F	12	0.054	12.516
Error	38	1.917	61.240

**Significant at 5% level

Appendix - IV
Analysis of variance for gain in number of secondary branches per primary branch and leaf area of ber

Source of variation	d.f.	Mean sum of squares	
		Gain in number of secondary branches per primary branch	Average leaf area (cm^2)
R	2	0.388	5.182
M	3	52.132**	293.479**
F	4	36.364**	75.786**
M x F	12	0.135**	0.116
Error	38	0.287	10.380

**Significant at 5% level

Appendix - V

Analysis of variance for fruit yield of ber

Source of variation	d.f.	Mean sum of squares	
		Yield (kg/plant)	Yield (q/ha)
R	2	2.347	1.120
M	3	160.976**	1244.087**
F	4	121.852**	941.721**
M x F	12	2.098**	16.215**
Error	38	0.986	7.368

**Significant at 5% level

Appendix - Vl

Analysis of variance for total soluble solids and acidity content in fruits of ber

Source of variation	d.f.	Mean sum of squares	
		TSS (^{0}Brix)	Acidity (%)
R	2	1.360	0.00002
M	3	40.030**	0.0357**
F	4	11.282**	0.0051**
M x F	12	0.022	0.00002
Error	38	1.243	0.0008

**Significant at 5% level

Appendix - VII

Analysis of variance for nitrogen, phosphorus and potassium content in leaves of ber

Source of variation	d.f.	Mean sum of squares		
		N content (%)	P content (%)	K content (%)
R	2	0.006	0.00002	0.005
M	3	0.259**	0.0029**	0.170**
F	4	0.483**	0.0023**	0.344**
M x F	12	0.0005	0.00001	0.0004
Error	38	0.008	0.0001	0.008

**Significant at 5% level

Appendix - VIII

Analysis of variance for relative leaf water content and chlorophyll content in leaves of ber

Source of variation	d.f.	Mean sum of squares	
		RLWC (%)	Total chlorophyll content (mg/g)
R	2	34.117	0.011
M	3	243.601**	3.203**
F	4	341.784**	1.988**
M x F	12	0.375	0.011
Error	38	15.940	0.022

**Significant at 5% level

Appendix - IX

Analysis of variance for water retention at 1500 and 33 kPa in soil

Source of variation	d.f.	Mean sum of squares	
		Water retention (%) at 1500 kPa	Water retention (%) at 33 kPa
R	2	0.205	1.327
M	3	0.250**	0.499**
F	4	34.685	19.751
M x F	12	0.004	0.001
Error	38	0.285	1.236

**Significant at 5% level

Appendix - X

Analysis of variance for bulk density and organic carbon content in soil

Source of variation	d.f.	Mean sum of squares	
		Bulk density (Mg/m^3)	Organic carbon (%)
R	2	0.0123	0.0006
M	3	0.0810**	0.0111**
F	4	0.0006	0.0028
M x F	12	0.0000004	0.00001
Error	38	0.0220	0.0012

**Significant at 5% level

Appendix - Xl

Analysis of variance for available N, P_2O_5 and K_2O content in soil

Source of variation	d.f.	Mean sum of squares		
		Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
R	2	140.109	1.767	52.905
M	3	1601.731**	31.447**	570.877**
F	4	3108.941**	56.020**	406.878**
M x F	12	4.328	0.092	0.164
Error	38	124.196	2.701	215.535

**Significant at 5% level

Appendix - Xll

Analysis of variance for net returns and B: C ratio

Source of variation	d.f.	Mean sum of squares	
		Net returns (₹/ha)	B:C ratio
R	2	19729036	0.007
M	3	16230180988**	5.130**
F	4	13190062720**	5.036**
M x F	12	259447226**	0.054**
Error	38	87430296	0.014

**Significant at 5% level

Appendix – XIII

(A) Common cost of cultivation of ber (Excluding the cost of individual treatments)

S.No.	Particulars	Unit	Rate per Unit (₹)	Cost (₹/ha)
I.	**Variables**			
(A)	**Labour charges**			
1.	Preparations of basins	20 man days	200	4000.00
2.	Application of manures & fertilizers	10 man days	200	2000.00
3.	Irrigation	4 man days	200	800.00
4.	Weeding & hoeing	10 man days	200	2000.00
5.	Spraying of insecticides	5 man days	200	1000.00
6.	Application of fungicides	5 man days	200	1000.00
7.	Watch & ward	52 man days	200	10400.00
8.	Picking, transportation & marketing	40 man days	200	8000.00
9.	Miscellaneous	5 man days	200	1000.00
	Sob Total			**30200.00**
(B)	**Material inputs**			
1.	Irrigation cost	2 irrigation	800/Irrigation	1600.00
2.	Malathion (50EC) @ 0.05%	1.39 litre	325/litre	452.00
3.	Karathane (48EC) @ 0.01%	278 ml	185/100ml	514.00
	Sub total			**2566.00**
II.	**Fixed cost**			
1.	Rental value of land	-	-	3000.00
2.	Interest on working capital	-	-	1700.00
3.	Depreciation	-	-	800.00
	Sub total			**5500.00**
	Total			**38266.00**

Common cost of cultivation = I (A+B) + II = 38266.00

(B) Treatment cost

S.No.	Particulars	Rate per Unit (₹)
1.	FYM	30.00/q
2.	Vermicompost	500.00/q
3.	Poultry manure	300.00/q
4.	Urea	5.68/Kg
5.	SSP	6.00/Kg
6.	MoP	8.40/Kg

Appendix-XIV

Comparative economics of various treatment combinations in ber

S.No.	Treatments	Common cost (₹/ha)	Treatment cost (₹/ha)	Total cost (₹/ha)	Fruit yield (q/ha)	Total return (₹/ha)	Net returns (₹/ha)	B: C ratio
1.	M_0F_0	38266	0	38266	13.61	54459	16193	0.42
2.	M_0F_1	38266	2270	40536	19.69	78751	38215	0.94
3.	M_0F_2	38266	3404	41670	24.71	98836	57166	1.37
4.	M_0F_3	38266	4539	42805	26.57	106298	63493	1.48
5.	M_0F_4	38266	5674	43940	27.03	108124	64184	1.46
6.	M_1F_0	38266	1668	39934	20.35	81383	41449	1.04
7.	M_1F_1	38266	3938	42204	29.42	117685	75481	1.79
8.	M_1F_2	38266	5072	43338	36.92	147700	104362	2.41
9.	M_1F_3	38266	6207	44473	39.71	158851	114378	2.57
10.	M_1F_4	38266	7342	45608	40.40	161580	115972	2.54
11.	M_2F_0	38266	8340	46606	25.96	103831	57225	1.23
12.	M_2F_1	38266	10610	48876	37.54	150147	101271	2.07
13.	M_2F_2	38266	11744	50010	47.11	188440	138430	2.77
14.	M_2F_3	38266	12879	51145	50.67	202668	151523	2.96
15.	M_2F_4	38266	14014	52280	51.54	206149	153869	2.94
16.	M_3F_0	38266	6672	44938	24.74	98948	54010	1.20
17.	M_3F_1	38266	8942	47208	35.77	143086	95878	2.03
18.	M_3F_2	38266	10076	48342	44.89	179578	131236	2.71
19.	M_3F_3	38266	11211	49477	48.28	193137	143660	2.90
20.	M_3F_4	38266	12346	50612	49.11	196454	145842	2.88

Ber sold @ ₹ 4000 per q