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" STUDIES ON EFFECT OF LIQUID BIO-FERTILIZERS ON MORPHO-PHYSIOLOGICAL AND BIO-CHEMICAL PARAMETERS INFLUENCING YIELD OF GROUNDNUT (*Arachis hypogaea* L.) VARIETIES DURING *KHARIF* SEASON "

by

Shri. RANSING SUKDEV KISANRAO
(Reg. No. 9905)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA

in partial fulfilment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

AGRICULTURAL BOTANY (PLANT PHYSIOLOGY)

DEPARTMENT OF BOTANY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI – 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA

2004

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AGRICULTURAL BOTANY (PLANT PHYSIOLOGY)

Approved by

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MAHARASHTRA, INDIA

2004

CANDIDATE'S DECLARATION

I hereby declare that this thesis or a part thereof has not been submitted by me or any other person to any other University or Institute for degree or diploma

Place : M.P.K.V., Rahuri

Date : 28 / 1 /2004

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This is to certify that the thesis entitled **"STUDIES ON EFFECT OF LIQUID BIO-FERTILIZERS ON MORPHO-PHYSIOLOGICAL AND BIO-CHEMICAL PARAMETERS INFLUENCING YIELD OF GROUNDNUT (*Arachis hypogaea* L.) VARIETIES DURING *KHARIF* SEASON"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India, in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in **AGRICULTURAL BOTANY (PLANT PHYSIOLOGY)** embodies the results of piece of *bona fide* research work carried out by **Shri. SUKDEV KISANRAO RANSING,** under my guidance and supervision and that no part of the thesis has been submitted to any other University for degree or diploma or publication in other form. The assistance and help received during the course of this investigation and sources of references has been duly acknowledged.

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CERTIFICATE

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Place : M. P. K. V., Rahuri

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Date : 28/ 1 /2004

Ransing

(S. K. Ransing)

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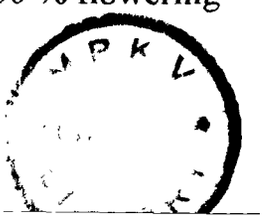
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LIST OF ABBREVIATIONS

AGR	Absolute Growth Rate
@	At the rate of
AH	At harvest
AR	Acetylene reduction
B.N.F.	Biological nitrogen fixation
BR	*Bradyrhizobium*
C.D.	Critical difference
cm	Centimeter (s)
°C	Degree centigrade
CGR	Crop Growth Rate
cv.	Cultivar
DAA	Days after anthesis
DAS	Days After Sowing
dm^2	Decimeter square
DM	Dry matter
DRB	Deleterious rhizobacteria
DW	Dry weight
et al.	Et alli (and others)
etc.	Et cetera
Fig.	Figure (s)
FYM	Farm yard manure
FW	Fresh weight
g	Gram (s)
ha	Hectare (s)
HI	Harvest Index
h	Hour (s)
i.e.	Id est (That is)
K	Potassium
kg	Kilogram (s)

List of Abbreviations contd...

L	Litre (s)
LA	Leaf Area
LAD	Leaf area duration
LAI	Leaf area index
m	Meter (s)
mm	Millimeter (s)
MSS	Mean sum of squares
N.S.	Non-significant
N	Nitrogen
No.	Number
NAR	Net assimilation rate
NPR	Nodulation promoting rhizobacteria
NMR	Nuclear magnetic resonance
P	Phosphorus
PGPR	Plant growth promoting rhizobacteria
%	Per cent
PSB	Phosphate solubilizing bacteria
q	Quintal (s)
RGR	Relative growth rate
RH	Relative humidity
SS	Sum of squares
S.E.	Standard error
SMK	Sound mature kernel
V	Variety
VAM	Vesicular – arbuscular micorrhizae
viz.	Videlicet (namely)
wt.	Weight
YIB	Yield increasing bacteria

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ABSTRACT

" Studies on effect of liquid biofertilizers on morpho-physiological and biochemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) varieties during *kharif* season "

By

Shri. S.K. Ransing

A candidate for the degree
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DOCTOR OF PHILOSOPHY (AGRICULTURE)
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AGRICULTURAL BOTANY
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2004

Research Guide	:	Dr. B. L. Lad
Department	:	Agril. Botany (Plant Physiology)

Considering the benefit of liquid biofertilizer in groundnut, the present investigation entitled "Studies on effect of liquid biofertilizers on morpho-physiological and bio-chemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) varieties during *kharif* season" was undertaken during *kharif* season of the year 2000 and 2001 to study the effect of fertilizers and liquid biofertilizer so as to increase the productivity of groundnut.

The forty five treatment combinations formed from three varieties *viz.*, ICGV – 86590 (V_1), JL – 24 (V_2), SB XI (V_3) and three levels of fertilizers i.e. recommended dose of fertilizers (RDF) (F_1), 75 per cent of RDF (F_2) and 50 per cent of RDF (F_3) as main plots and five treatments of liquid biofertilizers (Lb_1, Lb_2, Lb_3, Lb_4, Lb_0) as subplot were studied in split plot design with three replications.

The observations on growth, phenology, biochemical parameters, root nodulation and dry matter production were recorded periodically at an interval of 30 DAS during the crop growth cycle. The data on dry pod yield and yield contributing characters were recorded at harvest.

The growth studies indicated that the plant height, number of leaves, number of primary and secondary branches were higher in the variety ICGV – 86590 (V_1). The recommended dose of fertilizer (F_1) and liquid biofertilizer treatment (Lb_4) showed superior values of these characters among the different levels of fertilizers and liquid biofertilizer treatments respectively.

Phenological studies revealed that wide variability was exhibited by different varieties. The variety JL – 24 (V_2) and SB XI (V_3) required less number of days required for initiation of flowering, 50 per cent flowering and physiological maturity under different levels of fertilizer and liquid biofertilizer treatments.

Significant differences within the varieties, fertilizer levels and biofertilizers were observed on chlorophyll content of leaves both in terms of total chlorophyll as well as its components 'a' and 'b'. The total chlorophyll and its components were higher in the variety ICGV – 86590 (V_1) under the recommended dose of fertilizers and liquid biofertilizer treatments *Rhizobium* (Lb_4) and Bioplin (Lb_1) respectively.

As regards to the nodulation studies variety ICGV – 86590 (V_1) produced the higher number of nodules per plant and its dry matter over rest of the varieties JL-24 (V_2) and SB XI (V_3). It is also observed that recommended dose of fertilizer produced significantly highest

number of root nodules and its dry weight. While liquid biofertilizer treatment *Rhizobium* (Lb_4) and Bioplin (Lb_1) produced higher root nodules and its dry weight than rest of the treatments.

The dry matter production and its partitioning into different plant parts played an important role in obtaining better yield. The data regarding dry matter accumulation in leaves, stem, pods and the total dry matter and mean dry weight of pods were accumulated in the variety ICGV –86590 (V_1) than rest of the varieties. While recommended dose of fertilizer (F_1) produced higher dry matter as compared with rest of the fertilizer levels. Considering liquid biofertilizer treatments it was higher with almost all the treatments over control.

The total dry matter production was significantly affected by varieties, fertilizer levels and liquid biofertilizer treatments. Where variety ICGV – 86590 (V_1) produced higher total dry matter over rest of the varieties. However, recommended dose of fertilizer (F_1) in combination with *Rhizobium* (Lb_4) followed by Bioplin (Lb_1) produced significantly higher total dry matter production over rest of the treatments.

The data on growth functions revealed that growth functions *viz.*, AGR, RGR, NAR and CGR recorded higher values for the variety ICGV-86590 particularly under recommended dose of fertilizers and different liquid biofertilizer treatments.

The dry pod yield and yield contributing components indicated significant differences within the varieties fertilizer levels and liquid biofertilizer treatments of groundnut during both the years of the experiment. The variety ICGV-86590 (V_1) produced higher dry pod yield than variety JL – 24 (V_2) and SB XI (V_3).

Different fertilizer treatment had a significant impact on dry pod yield. It was the maximum and significantly the highest in recommended dose of fertilizer (F_1) than 75 per cent of RDF (F_2) and 50 per cent of RDF (F_3).

The liquid biofertilizer treatments differed significantly in respect of their influence on dry pod yield. The higher dry pod yield was recorded due to different liquid biofertilizers over control. The treatments *Rhizobium* (Lb_4) was found to be superior followed by Bioplin (Lb_1) over rest of the treatments.

The high dry pod yield of the variety ICGV – 86590 (V_1), in recommended dose of fertilizer (F_1) and liquid biofertilizer treatments was not only attributed to one or more yield components but was also complimented by the physiological parameters like plant height, number of leaves, chlorophyll content in leaves, number of root nodules at all the growth stages. The major yield contributing components in groundnut are number of pegs per plant, number of pods per plant, dry weight of pods per plant, 100 pod weight and 100 kernel weight, harvest index etc. The high yielding variety ICGV – 86590 (V_1) recorded higher values of these components at the time of harvesting which led to higher yield followed by JL – 24 (V_2) and the lowest values were observed in the variety SB XI (V_3) which resulted in lowest yield than V_1 and V_2 during both the years. The increase in dry pod yield showed a close relationship with these components as all these components were increased by application of recommended dose of fertilizers (F_1) and liquid biofertilizer treatments *Rhizobium* (Lb_4) and Bioplin (Lb_1) over rest of the treatments.

It is indicated that the 'N' status of the soil after harvest was improved due to the variety ICGV – 86590 (V_1), recommended dose of fertilizer (F_1). While the minimum 'N' content in soil was evident under variety SB XI (V_3) and 50 per cent of RDF (F_3).

The NPK uptake was influenced significantly in present investigation. Nitrogen uptake was higher by the variety ICGV – 86590 (V_1) followed by SB XI (V_3) and lowest 'N' uptake was observed due to the variety JL – 24 (V_2). Similarly the 'N' uptake was significantly the highest under recommended dose of fertilizers, whereas liquid biofertilizers had significant impact on uptake of 'N' by the groundnut. However, 'P' uptake varied within the varieties and it was higher under recommended dose of fertilizer and in combination with liquid biofertilizer also.

The variety ICGV – 86590 (V_1) utilized maximum 'K' followed by variety SB XI (V_3) while 'K' uptake from the soil was maximum under the recommended dose of fertilizer RDF (F_1) and different treatments of liquid biofertilizers.

The comparison of varieties revealed that the high yielding variety ICGV – 86590 (V_1) utilized more 'K' from the soil than SB XI (V_3) and JL-24 (V_2). The decrease in 'K' status of soil after harvest, as observed in the present investigation is a general trend in case of legume crops.

Thus, as per the objectives of the present investigation on the effect of liquid biofertilizer on groundnut, there was increase in pod yield which varied from 10 to 33 per cent due to different liquid biofertilizer treatments.

Abstract contd... **S. K. Ransing**

The application of recommended dose of fertilizers and seed inoculation with liquid biofertilizer (*Rhizobium* and Bioplin) cultures would be better proposition for *kharif* groundnut which accrue the benefit in a real sense.

In general, it was observed that the variety ICGV- 86590 (V_1), application of recommended dose of fertilizer (F_1) and liquid biofertilizer treatments *Rhizobium* (Lb_4) followed by Bioplin (Lb_1) were found to superior than all other treatments in the present investigations.

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INTRODUCTION

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the principal economic crops of the world, ranking 13th among the food crops. The crop is now grown through out the tropical and sub tropical regions of the world (Antony, *et al.* 2000). Groundnut is a crop of global economic significance not only for its widespread production but for wider areas of processing and consumption.

Oil seed map of the world shows that groundnut is the king of oilseeds, which plays an important role in human life. It has been described as natures master piece of food values containing 36 to 54 per cent oil with 21-24 per cent protein and has a high energy value of 2,363 KJ/ 100 g. Seeds are used for oil extraction, as food, and also as an ingredient in confectionery products. After oil extraction, the residual cake is processed largely used as an animal feed and to some extent it is also used for human consumption. The haulms are valued as fodder (Bandopadhyay *et al.* 2000).

India shares one-third of the world production. Over 12 per cent of the total groundnut produced in the country is utilized for seed purpose, 6 per cent for domestic use, 81 per cent for oil extraction and about 1 per cent for export (Bandopadhyay *et al.* 2000).

Thoiugh India is at the top in total area and production among the major oilseed producing countries in the world, it is almost at the bottom in productivity. Although the yield potential of 25-30 q ha^{-1} has been demonstrated, the productivity on national basis has remained constant at 8-9 q ha^{-1} for several years.

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During the year 2000-2001 the area under cultivation under groundnut crop in India was 6.73 million hectares with a production of 6.22 million tonnes with productivity of 924 (kg ha^{-1}).

About 91 per cent of total groundnut area and production in India are confined to Andhra Pradesh, Gujrat, Karnataka, Tamil Nadu, Maharashtra and Orissa. The rest of the area and production is scattered mainly in Rajasthan, Uttar Pradesh, Madhya Pradesh and Punjab.

About 80 per cent of groundnut area in India is sown in the *Kharif* season and is under rainfed condition. The proportion of irrigated area under groundnut cultivation is about 20 per cent only (Bandopadhyay *et al.* 2000).

Considering the oilseeds scenario of Maharashtra State, the area under groundnut cultivation during the year 2000-2001 was 4.6 lakh hectares with production of 6.84 lakh tonnes. Productivity of groundnut in Maharashtra state is low (1000 kg ha^{-1}) as compared with the summer season (1261 kg ha^{-1}) (Anonymous, 2002).

The low yield levels particularly in groundnut are attributed for growing the crop mostly in rainfed areas and in marginal lands with low inputs, lack of supply of quality seeds, poor plant populations, inadequate fertilization, lack of plant protection and also the inefficient post harvest technology. All these factors have jointly contributed to low and unstable yields in this crop.

There is considerable scope for increasing productivity since the yield of summer groundnut is almost 1.5 to 2 times more as compared to that of *Kharif* groundnut.

Different methods to increase the production and productivity of oil seed crops such as introduction of high yielding varieties, use of plant protection measures, use of fertilizers,

biofertilizers and micronutrients, appropriate post harvest technology are being introduced.

The cost of nitrogenous fertilizers has been increasing constantly over the years. The present day intensive agriculture requires high input of nitrogenous fertilizers. Large-scale use of chemical fertilizers causes the problems of pollution and deterioration of soil structure. Also the phosphatic fertilizers are mainly imported and therefore, the country has to depend on others for its supply and price policy. The price hike of phosphatic fertilizers often increases the cost of cultivation and reduces the net profit per hectare.

Phosphorus plays a key role in various physiological process concerning root production, nodulation, N_2 – fixation. Deficiency of P would retard symbiotic N_2 – fixation by way of checking nodule growth (Mc Lachlan and Norman, 1991).

It is thus, necessary to find out a technology to reduce the dose of phosphatic fertilizer through recent techniques of using biofertilizers.

In present decade use of eco-friendly microbes particularly biofertilizers has become as an essential component of integrated nutrient management.

Groundnut is a soil enriching food legume. Biological nitrogen fixation (BNF) by legumes in association with *Rhizobium* is one of the most important means for converting large quantities of nitrogen gas from air and to make it available to the plants. The bacteria infect the legume roots and form root nodules. The legume *Rhizobium* association can fix 50-300 kg of nitrogen ha^{-1} in one crop season and can leave behind substantial quantities of nitrogen in soil for succeeding crop. The quantity of nitrogen fixed varies with the kind of legume and agro-ecological conditions available. In order to

derive greater benefit from legumes grown in rotations and as intercrops with non-legumes it is necessary that legume seeds should be inoculated with specific *Rhizobium* (Anandan, 2000).

Now the practice of seed inoculation with an effective culture of *Rhizobium* is becoming increasingly popular in India. Microorganisms, which could be used as biofertilizers, including bacteria, fungi and blue green algae. The inoculum carrying these organisms need to be applied to enhance their activity in the rhizosphere.

It may be possible to integrate the use of more than one bio-fertilizer and organic manure for increasing crop yields. *Rhizobium*, *Azotobacter*, mycorrhizae, phosphate solubilizers, etc. could be used together or separately. In India, where mixed cropping and double cropping is followed, the combined application of more than one biofertilizer holds great promise. Combined use of biofertilizers, organic manures and small dose of chemical fertilizers would not only give higher yields but help to maintain soil health and reduce pollution problem created by continuous application of high doses of chemical fertilizers (Anandan, 2000).

Use of biofertilizers not only make the atmospheric nitrogen available to the plants but also solubilise and mobilize soil fixes phosphorus and improved phosphorus uptake in plants. They also enhance plant growth due to release of hormones, vitamins and auxins etc. They also help in proliferating beneficial microorganisms which in turn suppress soil born plant diseases. In present era, known biofertilizers are broadly categorized in : Nitrogen fixing microorganisms, phosphate solubilizing and mobilizing microorganisms and growth promoting substances excreting microorganisms.

The biological nitrogen fixation has been estimated to contribute more than 175 million tonnes of nitrogen, out of which symbiotic nitrogen accounts for almost 40 per cent. The amount of nitrogen fixed by biofertilizers will be much cheaper than the nitrogen obtained by other source either through organic or inorganic fertilizers. The amount of nitrogen fixed in crop by biofertilizers has a well-documented effect on its succeeding crops in terms of yield and nitrogen economy. Vis-à-vis chemical fertilizers do not have such a effect on succeeding crop mainly nitrogenous fertilizers. Besides nitrogen, phosphorus is also an important nutrient as per the requirement of crops. Most of the soil and hardly about 1-2 per cent of it is incorporated into the above ground parts of plants. Solubilization and mobilization of this fixed form of phosphorus may also be enhanced by the use of biofertilizers. In biofertilizers, there are so many microorganisms, which produce many substances like plant growth promoting substances in the rhizosphere of plants (Dubey, 2000).

The bacteria that provide some benefit to plants are of two general types, those that form symbiotic relationship with them and those that are free-living in the soil, but are often found near, on, or even within the roots of plants. Beneficial free-living soil-bacteria are usually referred to as plants growth-promoting rhizobacteria (PGPR) (Pal *et al.*, 1999).

Some of these such a *Rhizobium* spp. have considerable potential to acts the composition and activity of rhizosphere microflora and some promote nodulation by rhizobia and thus are called nodulation promoting rhizobacteria (NPR) (Kloepper *et al.*, 1988). The beneficial effect of these bacteria has been variously

attributed to their ability to produce various compounds including phytohormones, organic acids and siderophores, to phosphate solubilization, to antibiotics that suppress deleterious rhizobacteria or to some other unidentified mechanisms (Glick, 1995).

Use of composite strains of *Rhizobium* for legume seed inoculation has been found economically prospective for soybean, French bean (Das and Bhaduri, 1975) and other legumes (Raut *et al.*, 1980). The underlying principle is that at least one of the many strains used in composite culture might establish well and provide culture has the advantage of being able to be used to inoculate different crops and also achieve a suitable interaction depending on the prevailing edaphic conditions.

Poor quality and failure of inoculation response in the field are two burning issues associated with *Rhizobium* biofertilizer in India. Shorter shelf-life, contamination in the carrier and non-availability of a protective carrier material (like good quality peat) chiefly contribute to the poor quality of bio-fertilizers. Death of rhizobia on the inoculated seed is one of the important factors contributing of failure of inoculation response in the field. Lot of research has been done in India on *Rhizobium* strain selection and inoculation response studies. However, research conducted on the inoculant production and formulation technologies is limited. A break through is needed in the inoculate technology to improve the quality and field efficacy of bio-fertilizers in India to make them commercially viable and acceptable to farmers (Hegde, 2000).

Recent studies have shown that it is possible to make rhizobia to survive in a liquid medium for more than six months with the help of cell protectants.

Interest in liquid inoculant formulations is growing rapidly all over the world. Many inoculant manufacturers are excited about the possibility of reducing the high costs and problems associated in the processing and sterilization of carrier materials. Particularly in India, for biofertilizers manufactures, carrier (lignite or coal) is the single most component adding to the manufacturing cost in terms of its transportation, pulverization, neutralization and sterilization. Even countries having good quality peat available have switched over to liquid inoculants. Farmers also have shown liking for liquid inoculant for its greater convenience and benefits such as longer shelf life, better survival on the seed and better nodulation, cost savings on carrier material, no contamination, superior in quality and performance and convenience of handling, storage and transportation.

In view of above considerations the present investigations were, undertaken with the following objectives.

1. To study the effect of liquid biofertilizers on yield and yield contributing characters of groundnut.
2. To study the effect of liquid biofertilizers on physiological parameters of groundnut.
3. To study the dry matter production and partitioning as influenced by the liquid biofertilizers.
4. To study the influenced of liquid biofertilizers on protein and oil content of groundnut kernel.
5. To study the effect of liquid biofertilizers on biochemical characters *viz.*, chlorophyll content in leaves and leghaemoglobin content in root nodules.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Groundnut (*Arachis hypogaea* L.) is an important oil seed crop of India and is considered as king of oilseeds. It is extensively cultivated in *kharif* and summer season and plays vital role in human nutrition.

Although the yield potential of 25-30 q ha^{-1} has been demonstrated the productivity on national basis has remained constant at 8-9 q ha^{-1} for several years. The low yield levels particularly in groundnut are attributed for growing the crop mostly in rainfed areas and in marginal lands with low inputs, lack of supply of quality seeds, poor plant populations, inadequate fertilization, lack of plant protection and also the inefficient post harvest technology. All these factors have jointly contributed to low and unstable yields in this crop.

Different methods to increase the production and productivity of oil seed crops such as introduction of high yielding varieties, use of plant protection measures, use of fertilizers, biofertilizers and micronutrients, appropriate post harvest technology are being introduced.

Fertilizer is one of the important production factor for groundnut. It is known fact that plant utilise 30-50 per cent, 15-20 per cent and 40-60 per cent of applied N, P and K, respectively. the remaining goes as a loss in the form of leaching or volatilisation or fixation because of hormones and enzymes naturally produced in the plants are insufficient for the mobilisation and conversion of nutrients into basic plant tissues for optimum plant growth (Ghosh *et al.*, 1999).

Groundnut normally uses symbiotically fixed nitrogen for growth and development but limitations inherent in the symbionts or environment may restrict the symbiotic nitrogen fixation and results in nitrogen deficiencies. These limitations can be corrected by nitrogen fertilization. It has been reported that inoculation of symbionts will have beneficial effect in terms of nitrogen fixation in groundnut (Antony, 2000).

Eventhough groundnut is the most important oil seed crop of India the information on growth, nodulation, biochemical parameters etc. in relation to use of fertilizer and biofertilizer alone or in combination on growth, nodulation, biochemical parameters nitrogen fixation yield and nutrient uptake by groundnut are meager.

An attempt is made to compile the literature to review on effect of fertilizer and liquid biofertilizer in relation to physiological aspects of groundnut and related crops herein in this chapter.

2.1 Growth

Groundnut yield is relatively low in India although it is grown in a large area. The use of nitrogenous fertilizers is limited when the crop is usually grown on drylands. Hence *Rhizobium* is the alternate source of nitrogen supply to meet the crop nitrogen requirement. Groundnut being nonspecific to different types of *Rhizobia*, inoculation of right strains possessing competitive advantage over the native strains with this in mind (Gaur *et al.* 1974).

Shridhar *et al.* (1989) studied groundnut cultivars JL-24, VRI-1 and CO-2 with four *Rhizobium* cultures *viz.*, IGR 40, NC 92 and TNAU 14 and uninoculated control were evaluated in the field experiment at Regional Research Station, Vridhachalam and reported

that all the tested strains increased the nodulation in all the groundnut varieties. All the tested *Rhizobium* cultures increased the growth of the plants except IGR-40 on 45th DAS in JL-24 and in VRI-1 groundnut, over the uninoculated control. The varieties VRI-1 and CO-2 yielded the highest (1783 kg ha^{-1}) and (1744 kg ha^{-1}) when inoculated with TNAU-14 *Rhizobium* cultures which were significantly superior to the respective controls. While the variety JL-24 had given highest yield (1811 kg ha^{-1}) when inoculated with NC-92 *Rhizobium* cultures which is significantly superior to control (1655 kg ha^{-1}).

Kloepper *et al.* (1991) have shown that plant growth promoting rhizobacteria (PGPR) represents a diverse subgroup of rhizosphere colonizing bacteria. The host list of PGPR now includes barley, bean, canola (rapeseed), cotton, maize, groundnut, rice, vegetables, wheat and weedy species. In addition to increasing crop yields, different strains of PGPR can exert various effects on plants including biological control of soil born pathogens, promotion of legume nodulation by nitrogen fixing rhizobia, and enhancement of seedling emergence rates. Reported mechanism of action for PGPR have focussed on the indirect mechanisms of siderophore, antibiotic or hydrogen cyanide production. Such a indirect mechanisms reduce the population densities of deleterious microorganisms and thereby results in increased plant growth. Direct growth promotion by PGPR in the absence of deleterious microorganisms has been recently described.

Shaheen and Rahmatullah (1994) conducted laboratory experiment on groundnut cultivars *viz.*, cv. Banki and ICGS-44 with soil inoculation of *Rhizobium* strains NC-92 and Rudy patric. They

found that growth and N fixation of both cultivars was significantly increased by inoculation. Nodulation did not occur without inoculation. The Rudy Patric strain significantly increased shoot growth, shoot N content. Nodule number and weight compared with NC-92. However, physiological efficiency was greatest in Banki when inoculated with NC-92.

Dey *et al.* (1999) suggested that a *myriad* microorganisms is commonly present in the rhizosphere of a growing plant. The nature of these microorganisms depends on the types of root exudates and substrate availability. Several categories of rhizosphere bacteria are currently recognised including disease-causing pathogens, deleterious rhizobacteria (DRB), plant growth promoting rhizobacteria (PGPR) and symbiotic bacteria. Evidence is increasing that the saprophytic free living microflora of the rhizosphere have the potential to influence plant growth and crop yield substantially (Chanway *et al.* 1991).

According to Pal *et al.* (1999) the bacteria that provide some benefit to plants are of two general types, those that form a symbiotic relationship with them and those that are free living in the soil, but are often found near, on, or even within the roots of plants. Beneficial free living soil bacteria are usually referred to a plant growth promoting rhizobacteria (PGPR). Some of these such as *Rhizobium* spp. have considerable potential to alter the composition and activity of rhizosphere microflora and some promote nodulation by rhizobia and thus are called nodulation promoting rhizobacteria (NPR) (Kloepper *et al.*, 1988). The beneficial effect of these bacteria has been variously attributed to their ability to produce various compounds including phytohormones, organic acids and siderophores

to fixation of atmospheric nitrogen, to phosphate solubilization, to antibiotics that suppress deleterious rhizobacteria or to some other unidentified mechanisms (Glick, 1995). Motile rhizobacteria may colonise the rhizotic zones of the plant more profusely than non-motile organisms resulting in better rhizosphere activity and nutrient transformation. They may also eliminate deleterious rhizobacteria from the rhizosphere by niche exclusion had given better plant growth.

Dey *et al.* (2000) ascribed the ability of specific root colonizing bacteria or rhizobacteria to increase growth and yield of crop plants currently is attracting considerable attention. Beneficial free living soil bacteria isolated from the rhizosphere, which have been shown to improve plant health or increase yield, are usually referred to as plant growth promoting rhizobacteria (PGPR) or by one group workers in China as yield increasing bacteria (YIB) (Tang, 1994).

Nautiyal (2000) reviewed the literature concerning that the microbial processes in the rhizosphere of plants are crucial to plant and soil health. Not much is known at present about the effect of rhizosphere microbial community on plant yield, and soil quality. Processes in the rhizosphere influence plant disease, plant nutrition and root architecture by affecting the dynamics of microbial populations and communities. Therefore, there is interest to manipulate the rhizosphere microflora, which could in turn impact soil health, plant health, yield and sustainability.

Gupta *et al.* (2001) showed that the Rhizobacteria isolated from mungbean roots were screened for their plant growth promontory effects on mungbean under aseptic pot culture conditions.

The effect varied from stunted growth to elongation of root and shoot to neutral responses. Out of 121 isolates tested, application of 16 isolates resulted in better growth of mungbean plants throughout the 30 days experiment causing an improvement to plant growth by 62 % to 106 % relative to the control (Judged from the dry mass) of these, 3 were classified as *Pseudomonas* sp., 9 as *Bacillus* sp. and 4 as *Enterobactor* sp.

2.1.1 Plant height

Rao *et al.* (1983) studied interrelationship of yield components with plant height, branches, mature pods, pod weight and hundred kernel weight. Significant positive association was observed for pod yield per plant with plant height. The correlation coefficients between yield and its components were partitioned into direct and indirect effects while hundred kernel weight had positive direct influence on pod yield per plant followed by plant height, number of mature pods and branches per plant.

Joshi *et al.* (1987) further compared the rhizosphere microflora of seven groundnut varieties [Virginia (var. hypogaea) : 3; Spanish (var. Vulgaris) : 4], grown under field conditions was made at different stages of crop growth and stated that Virginia types in general, harboured higher number of bacteria (including *Azotobactor*), than did Spanish forms. Gram negative and non-spore forming bacteria were predominant in rhizosphere of all varieties. Bacterial population was positively correlated with leaf, root and plant height and nodule number.

2.1.2 Primary and secondary branches

Rao *et al.* (1983) conducted the field experiment comprised twenty strains of groundnut, both exotic and indigenous at J.N. Agril. University Groundnut Research Centre, Khargaone during monsoon season. Correlation coefficient among different character combinations have significantly negative have shown significant negative associations between plant height Vs branches, number of mature pods, hundred pod weight, hundred kernel weight and pod yield per plant.

They observed correlation coefficient between yield and its components and oil (%) were partitioned into direct and indirect effects. Hundred kernel weight had positive direct influence on pod yield per plant followed by plant height, mature pods per plant and branches per plant.

Chen (1989) noticed in the field trials in 13 sites in Zhejiang, groundnut seeds were inoculated with *Rhizobium* strain 1046 in peat inoculum containing 200 million bacteria/g, applied at 3.25 kg for 105 kg seeds/ha. Seed inoculation increased number of branches/plant by 29.4 %.

Dubey (1998) noticed from the field experiment conducted during the rainy season (*Kharif*) of 1991-92 on swell-shrink soil (Vertisols), to study the effect of single and integrated use of bio and chemical fertilizers on rainfed soybean (*Glycine max* L. Merr.). Highest symbiotic traits were found under treatment *Bradyrhizobium* (BR) + Vesicular-arbuscular mycorrhizae (VAM) + phosphate solubilizing bacteria (PSB) (T_7), but growth parameters *viz.*, height, branches, pods/plant, under the treatment NPK + BR PSB + VAM (T_{15}).

2.1.3 Leaves

Dubey (1998) noticed from the field experiment conducted during the rainy season (*Kharif*) of 1991-92 on swell-shrink soil (Vertisols), to study the effect of single and integrated use of bio and chemical fertilizers on rainfed soybean (*Glycine max* L. Merr.). Highest symbiotic traits were found under treatment *Bradyrhizobium* (BR) + Vesicular – arbuscular mycorrhizae (VAM) + phosphate solubilizing bacteria (PSB) (T_7), but growth parameters, *viz.*, height, branches pods/plant, under the treatment NPK + BR PSB + VAM (T_{15}); and leaves/plant under treatments T_7 and T_{15}. The highest seed yield obtained with the integrated use of BR, PSB and T_7 which was equivalent to yield recorded with T_{15} (½ NPK + BR + PSB + VAM).

2.1.4 Flowers

Antony *et al.* (2000) opined that flowering is basically being controlled by environmental factors particularly the duration of light periods (photoperiod) also is being influenced by other factors such as plant nutrition. It is clear from the data that nitrogen significantly increased the total number of flower in all the genotypes and extent of increase was more in JL-24 and S 206 as compared to Mardur local and ICGS-76. The increase in number of flowers due to nitrogen application could be attributed to an increase in plant height, which inturn provides more space by increasing the number of nodes per plant. Since groundnut bears flowers in the leaf axis of nodal junctions, the increase in the number of nodes could as well contribute to increase number of flowers per plant.

2.2 Biochemical parameters (chlorophyll and leghaemoglobin)

2.2.1 Chlorophyll

Lee *et al.* (1990) reported that in a field experiment that groundnuts cv. Saedltangkong when inoculated with *Rhizobium* sp. inoculation increased chlorophyll concentration, N uptake, N fixation, total plant dry weight, number of pods/plant and 1000 seed weight.

Wankhede *et al.* (1991) observed that groundnuts cv. SB-XI grown in the field in the 1988 *Kharif* (monsoon) season were seed inoculated with *Rhizobium* with and without 2 or 4 g Mo/kg seed, or were not inoculated. Nodule number and dry weight/plant, chlorophyll content and pod yield were highest in plants inoculated with *Rhizobium* + 4 g Mo/kg. Mean pod yield was 1.27 t/ha in SB-XI and 2.06 t/ha in JL-24.

Wankhede *et al.* (1992) observed from the experiment on groundnut cv. SB-XI and JL-24 grown in the 1988 rainy season with the treatments (a) seed inoculated with *Rhizobium*; (b) inoculated with *Rhizobium* + 2 g Mo/kg seed; (c) inoculated with *Rhizobium* + 4 g Mo; (d) not inoculated. Nodule number and nodule dry weight/plant increased with inoculation and were highest in treatment (c). All seed treatments increased seed oil concentration and leaf chlorophyll concentration, while pod yield was 1.61, 1.75, 1.86 and 1.41 t/ha in treatment (a), (b), (c) and (d) respectively.

2.2.2 Leghaemoglobin

Appleby (1984) from the studies carried out at Canerra, Australia and concluded that all known natural N_2 – fixing symbiosis involving *Rhizobium* require the presence of a leghaemoglobin. The recent demonstration of Hb (apparently closely related to Lb) in

parasponia nodules and of Hb in several non-legume actinorhizae symbiosis leads to the prediction that Hb genes will be found to be widespread in the pant kingdom and may not have to be inserted to help achieve new symbiosis.

The function of leghaemoglobin seems confirmed as facilitation of O_2 flux to respiring *Rhizobium* at extremely low, non-toxic free O_2 concentration, although confusion remains about the nature of, or even the necessity for *Rhizobium* protective respiration at higher O_2. In this respect the *Rhizobium* strain ORS 571, which fixes N_2 vigorously in aerated culture, may be worthy of intensive study. Even though its natural, N2- fixing association with sesbania includes Lb, will be O_2 - tolerant features of this organism permit the establishment of engineered symbiosis of lesser complexity than present legume symbiosis.

Sankar *et al.* (1984) reported that bold and medium seeded Virginia type (cv. M-13 and Mk-374) groundnut cultivars had higher nodule number and dry weight leghaemoglobin content, N uptake, leaf area and dry matter accumulation, over small seeded Valencia and Spanish type cultivars (Gangapuri and J-11). Seed size within a cultivar had no significant effect in any of the characters studied. Increased dose of phosphorus was found to influence nodulation more than host plant growth. Virginia types responded to even lower doses (30 kg P_2O_5 / kg) of phosphorus where Valencia or Spanish types responded to above 60 kg P_2O_5/ ha only. Presumably due to their fast growth and shorter duration.

Sairam *et al.* (1989) indicated that effect of phosphorus levels and *Rhizobium* inoculation in nodulation leghaemoglobin content and nitrogen uptake was studied in fodder cowpea at NDRI

karnal. Application upto 90 kg phosphorus / ha and inoculation with *Rhizobium* culture resulted in improved nodulation and higher leghaemoglobin content of root nodules along with an increase in nitrogen uptake, available soil nitrogen content and dry matter production.

Bal and Siddique (1991) have shown that the high lipid accumulation in the absence of N fixation supported the hypothesis that in groundnut nodules lipid bodies were utilized as a supplementary source of 'C' and energy for N fixation.

2.3 Nodulation

Pawar and Ghulghule (1980) noticed that the large pinkish root nodules were very effective in nitrogen fixation. Nodule initiation started soon after sowing and the peak period for nitrogen fixation coincide with the flowering stage in pulses.

More *et al.* (1981) studied in a field experiment on effect of different commercial inoculants of *Rhizobium* under different levels of nitrogen on nodulation and yield of groundnut. The Pune, Bangalore, Hissar and Hyderabad cultures produced maximum number of nodules as compared to other cultures tried and preferred 15 kg N/ha through urea. A beneficial effect of seed inoculation with *Rhizobium* over the uninoculated control was also observed in respect of dry weight of nodules and plant, pod yield and nitrogen content in both shoot and root. Among the various commercial inoculants used Pune, Bangalore and Hyderabad cultures produced maximum number and dry weight of nodules, dry weight of plant, nitrogen content of shoot and root and pod yield under the level of 15 kg N/ha. This has

clearly indicated that it is possible to save 5 kg N/ha with one application of the *Rhizobium* inoculants.

Joshi *et al.* (1981) observed that effect of *Rhizobium* inoculation and nitrogen application on root nodulation of groundnut and reported that bacterial inoculation significantly increased nodule number and nodule weight per plant as compared to uninoculated at all the stages of groundnut.

Kene *et al.* (1988) pointed out that the nodulation and nodule N content in groundnut cv. Ak 12-24 were increased by seed inoculation alone and with increasing rates of N (0, 12.5 and 25 kg/ha).

Kulkarni (1989) reported that removing the cotyledons 3, 6 or 9 days after the emergence of groundnut seedlings decreased the root and shoot dry matter and nodulation by 59.4, 37.1 and 29.4 %, respectively. The adverse effects were more pronounced in cv. J-11 and GG-2 than in cv. JL-24. It was suggested that cotyledons provided early plant vigour, which stimulated nodulation in groundnuts.

Wange (1990) suggested that the inoculation response and competitive ability of introduced rhizobia strains compared with native strains were studied in groundnut nodulation experiments. Results suggested that native stains and higher nitrogenous activity and greater competitive ability than introduced strains resulting in greater inoculation responses.

Tripathi and Sandria (1993) tested three *Rhizobium* strains (GT_1, GT_2 GK) on local groundnut variety. All the strains significantly increased the nodular mass compared with the control.

Strain GT_2 proved better than others as it gave maximum straw, pod and seed yield.

2.3.1 Root length

Turner *et al.* (1991) found that *Bacillus subtilis*, when added as a seed treatment, consistently colonized the roots of groundnuts at rates exceeding 10^4 c.f.u./g of root tissue when evaluated /20 d after planting. Yield increase from 1982 to 1985 which ranged from 3.5 to 3.7 per cent with only two incidences of negative responses in 24 tests. Groundnut responded most favourably to the bacterial seed treatment when subjected to stresses, such as limited water availability, poor rotational practices, caused by early plantings.

Treatment of groundnut seed with *B. subtilis* was associated with improved germination and emergence, increased nodulation by *Rhizobium* sp. enhanced plant nutrition and increased root growth. It was concluded that the means by which *B. subtilis* may affect yield in groundnuts are multiple and were not operative at the same time, making predictions of degree of yield responsiveness difficult.

Mane *et al.* (1993) reported that groundnut plants inoculated either with VAM or *Rhizobium* shared a definite increase in root length, root weight, biomass production, N_2 fixation, P uptake and yield of groundnut. The inoculation with either of the symbiants resulted in absorption of greater amount of phosphorus. Mycorrhiza and *Rhizobium* inoculation proved effective in improving growth, nodulation, N-fixation, phosphorus uptake and yield of groundnut LG-19.

Singh *et al.* (1999) carried out field experiment during winter season of 1993-94. Sixteen treatment combinations consisted of two levels of each *viz.*, nitrogen and *Rhizobium* inoculation (control, 20 kg N/ha, seed inoculation with *Rhizobium* and 20 kg N/ha + seed inoculation) and four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5/ha) were tried. The level of nitrogen (with and without *Rhizobium* inoculation) had marked influence on grain yield of lentil. Application of nitrogen @ 20 kg/ha, seed treatment with *Rhizobium* culture and their combined use was significantly superior to control in respect of grain yield. Increasing level of phosphorus upto 60 kg P_2O_5/ha progressively increased the nodule number/plant. Phosphorus application favoured better rooting and its proliferation, which in turn resulted into more nodules per plant and might have enhanced N fixation that lead to higher grain yield.

2.3.2 Number of nodules

Kulkarni *et al.* (1986) reported that effect of 0-80 kg P_2O_5 and 0-50 kg K_2O/ha on nodulation N accumulation dry matter production, and pod yield of groundnuts were studied during the rainy seasons of 1982-83. Application of 50 kg P_2O_5/ha increased the number and weight of nodules, N content, dry matter accumulation and pod yield. Effect of K applications on nodulation was not consistent. However, during the first year K increased the nodule number.

Reddy *et al.* (1990) reported in the field trials in the *kharif* (monsoon) season of 1984-87, groundnuts cv. TMV-2, JL-24 and Kadiri-3 seeds were treated with 3 strains of *Rhizobium* (NC-92,

NC-43-3 and TAC-176) and the fungicide Dithane M-45 (mancozeb) and the crop was grown 0 or 40 kg P_2O_5/ha as single superphosphate, seed treatment with Dithane M-45 increased seed germination in all 3 cultivates. Seed treatment with *Rhizobium* increased the number of nodules per plant irrespective of fungicide treatment.

Melli (1990) observed in field experiment in 1986 at Patancheru on an alfisol, groundnuts cv. ISV 18 and ISV 20 were given 0 or 10 kg N + 17 kg P_2O_5/ha or inoculated with *Rhizobium* + 0 or 17 kg P_2O_5/ha. The number of primary nodules/plant ranged from 36.7 with N + P to 65.3 with inoculation and were higher in ISV 18 than in ISV 20 showed no response to inoculation.

Rajeswari (1991) demonstrated in a pot culture experiment the effect of 0, 15 or 30 kg N/ha as KNO_3 or NH_4Cl with or without slurry inoculation with the *Rhizobium* strain NC-92 on nodulation plant dry weight and nitrogenase and nitrate reductase (NR) activities of groundnuts cv. Robout 33-1 were studied. Rhizobial inoculation produced higher nodule number and nitrogenase and NR activities compared with no inoculation. Nitrogenase and NR activities were highest 60 d after sowing whereas nodule number and plant dry weight were highest 90 d after sowing. NH_4Cl produced higher nodule numbers, plant dry weight and nitrogenase activity and KNO_3 gave higher NR activity. All parameters measured were higher with 30 kg N.

Deshmukh and Dev (1993) noticed in the field experiment conducted in winter season of 1988-89 showed that number of nodules/plant and the dry pod yield/ha of groundnut were significantly higher under the package of practices recommended by

ICRISAT, Patancheru, Andhra Pradesh. In general, groundnut cv. ICGS 11 and ICGS 44 produced more nodules/plant than cv. SB-XI. Cultivars ICGS 11, ICGS 21 and ICGS 44 produced similar but significantly higher dry pod yield/ha than cv. SB-XI. However, dry haulm yield/ha was not affected by different package of practices or by groundnut genotypes.

Kalaiselven *et al.* (2000) from the field experiment conducted during *rabi* season of 1995-96 to 1997-98 to study the performance of different *Rhizobium* strains on the root nodulation dry weight of nodules, yield attributes and yield of groundnut and seven strains of *Rhizobium* from groundnut crop were evaluated. The pooled results revealed that all the strains produced significantly higher nodules/plant, dry weight of nodules and dry pod yield of groundnut over inoculated control under irrigated condition. Among the different strains tried. TNAU 14, ICG 40 and NC 92 were found to be superior.

Thakare and Rasal (2000) had evaluated fifteen isolates of *Rhizobium* from groundnut crop and reported better nodulation (40 to 49/plant), dry weight of nodules (106 to 124 mg/plant), shoot (10.4 to 11.6 g/plant), root (3.2 to 3.8 g/plant), pod yield (22.0 to 25.8 q/ha) and dry matter yield (36.8 to 45.0 q/ha) over untreated control. An average increase in yield of pods and dry matter due to inoculation was 20.6 and 34.8 per cent respectively over control. Among the isolates, *Rhizobium* were considered most efficient strain for groundnut in their respective zone.

2.3.3 Dry matter of nodules

Rahman *et al.* (1992) concluded that the *Rhizobium* inoculation either alone or in presence of phosphate and potash fertilizers increased nodule number, nodule weight and stover weight of groundnut crop significantly.

Soddi *et al.* (1994) studied from field response of cowpea to the dual inoculation of VAM and *Rhizobium* at different fertilizer levels and reported that nodule number and dry weights were highest in the dual inoculated plants at 50 % N and P. However, nodule dry weight did not differ significantly between 50 and 10 % of N and P. A similar trend was observed in plant height and grain yield also percentage root colonization and VAM sporulation were highest at 50 % N and P in the dual inoculated plants which did not differ significantly with the recommended dose. However, shoot P concentration and N content were highest significantly in the recommended N and P. The principal effect of VAM on nodulation and nitrogen fixation is undoubtedly P mediated. VAM fungi are known to help in uptake of P, Zn, Cu and Fe which results in higher photosynthetic activity and in turn biological nitrogen fixation.

Anabusezhiyan (1994) observed that *Aspergillus awamori, Penecillium* species and VAM alongwith sulphur and phosphorus significantly increased the number and dry weight of nodules per plant of groundnut.

Pant and Katiyar (1996) conducted a field trial on groundnut cv. Kaushal and revealed that seed inoculation + 10 t FYM + 20 kg N ha^{-1} gave higher nodule dry weight. Application of 100 kg nitrogen ha^{-1} alone suppressed nodulation than all other treatments except the untreated control.

2.4 Dry matter

2.4.1 Dry weight of leaves

Polara *et al.* (1991) conducted a pot culture experiment with groundnuts cv. TG-17 grown in a clay soil, dry matter accumulation during 0-25, 25-75 and 75-105 DAS (vegetative, reproductive and pod development stages respectively) was 4.8, 43.8 and 51.4 % respectively of the total dry matter and nutrient accumulation were highest in shoots, followed by pods and roots, uptake of different nutrients during the vegetative, reproductive and pod development stage was 4.6-11.9, 42.3-88 and 6.4-53.0 %, respectively of the total nutrient uptake. Uptake of Ca, Mg and K was highest during the reproductive stage, that of P, Mn and Fe during the pod development stage and that of N almost equal during the reproductive and pod development stages.

Normon and Chongo (1992) demonstrated in a field experiment in Luyengo, Swaziland Subterranea cv. Maroon was sown on 1 November 1988 at 60 x 10 cm spacing and was grown without fertilizer under rainfed conditions. Dry matter accumulation in the vegetative organs continued upto 69 day after anthesis (DAA), necessitating sharing of photosynthates between the vegetative and reproductive sinks. However, there was a preferential distribution of assimilates from current photosynthesis of the leaves and stems to the reproductive organs.

2.4.2 Dry weight of stem

Champawat (1991) demonstrated the effects in pot trials of micorrhizal inoculation with *Glomus fasciculatum* or no inoculation on dry weight of stem and N and P content of groundnut

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cv. M-13 grown in sterilized or unsterilized soil with or without P fertilizers were studied. The highest shoot and root dry weight and N and P contents were obtained with inoculated plants in sterile soil without P followed by the same treatment with P added. Plants in sterile soil with no inoculation or P had lowest dry weight and N and P content.

Hasan *et al.* (1992) observed from the field trials conducted in 1987 and 1988 at Bangladesh Agricultural Research Institute with Dhaka-1 and Zhingabadam groundnut cultivars suggested the *Rhizobium* inoculation strain Rah-805 either alone or in presence of phosphate and potash fertilizers increased root nodulation number, nodule weight, dry shoot weight, stover weight and pod yields of the crops significantly.

2.4.3 Dry weight of pegs and pods

Dubey (1998) noticed from the field experiment conducted during the rainy season (*kharif*) of 1991-92 on swell-shrink soil (Vertisols), to study the effect of single and integrated use of bio and chemical fertilizers on rainfed soybean (*Glycine max* L. Merr.). Highest symbiotic traits were found under treatment *Bradyrhizobium* (BR) + Vesicular-arbuscular mycorrhizae (VAM) + phosphate solubilizing bacteria (PSB) (T_7) and recorded maximum pod weight and seed/plant under this treatment. Whereas, 1000 seed weight was also under T_{15}. Average nodulation, growth and yield attributes indicated that the difference among the treatments was non-significant. The highest seed yield obtained with the integrated use of BR, PSB and T_7, which was equivalent to yield recorded with T_{15} (1/2 NPK + BR + PSB + VAM).

2.4.4 Total dry weight

More *et al.* (1981) revealed that maximum number and dry weight of nodules and dry matter weight per plant of groundnut were increased under the level of 15 kg N ha^{-1} through urea along with inoculant *Rhizobium* over uninoculated plant.

Rajeswari (1990) conducted an experiment on groundnut and reported that Rhizobial inoculation in combination with applied nitrogen increased nodule number, dry weight of nodules and total dry matter per plant at all the three stages of sampling. Application of 30 kg N ha^{1} was found to have higher complementary effect on the parameters compared to 15 kg nitrogen ha^{-1} or no nitrogen application.

Wankhede *et al.* (1991) pointed out that groundnut cv. SB-XI and JL-24 grown at Akola, Maharashtra in the 1988/89 *kharif* (monsoon) season were seed inoculated with *Rhizobium* and/or treated with 2 g Mo/kg seeds. Pod yield was 1.11 g/plant without seed treatment and highest (1.41 g) with *Rhizobium* + Mo. Dry matter accumulation was increased by both *Rhizobium* and Mo, and was highest in the dual treatment. Mean yield was 1.30 g/plant in JL-24 and 1.16 in SB-XI.

Kshirasagar *et al.* (1994) conducted field trial during *rabi* season of the year 1990-91 on the Agricultural College Farm, Pune in which the seeds of French been (cv. Waghya) were inoculated with different *Rhizobium* strains and multistrain treatment by a slurry method. The *Rhizobium phaseoli* strains used under study were No. 1, 3, 5, 9, 23 and multistrain. Control was maintained and

treatments were replicated thrice from the data it is revealed that mean dry matter yield number of nodules/plant, dry weight of nodules were influenced by inoculation of *Rhizobium* strains and were statistically significant over control.

Jeyabal *et al.* (1999) reported that the integrated application of *Rhizobium*, phosphobacteria and fertilizers produced greater dry matter of groundnut than application of fertilizers alone.

Naidu (2000) reviewed the literature concerning that nitrogen is essential for proper growth and productivity of groundnut. Though groundnut variety TMV–2 possessed more number of nodules per plant, they could not influence the increase of pod yield over TPT-1. Maximum dry weight was obtained due to seed inoculation with the *Rhizobium* strain.

2.5 Phenology

Zablotowicz and Focht (1981) revealed that cowpea is drought tolerant legume. However, the nitrogen fixation process is sensitive to water stress, maximum nitrogenous activities were observed at flowering and pod filling stage in groundnut.

2.5.1 Physiological maturity

Chen (1989) noticed in the field trials at 13 sites in Zhejiang, groundnut seeds were inoculated with *Rhizobium* strain 1046 in peat inoculum containing 200 million bacteria/g, applied at 3.25 kg for 105 kg seeds/ha. Seed inoculation prolonged the growing period by 14 days.

2.6 Growth functions

2.6.1 Absolute growth rate (AGR)

Narayanan *et al.* (1991) conducted a field trial in 1987, growth and nutrient uptake in 45 days old plant of 6 grain legumes were assessed at recommended (N + P + K at 25 + 22 + 42 kg/ha) and high (NPK at 50 + 44 + 84 kg/ha) fertility levels (Recommended fertilizer and Half fertilizer, respectively) and conducted that groundnuts were the most efficient in dry matter production. Half fertilizer increased dry matter production especially in groundnuts, cowpeas and green gram (*Vigna radiata*) compared with Recommended fertilizer. Absolute growth rate (AGR) of plants of different legumes was in the order groundnut > cowpeas > pigeonpea > *V. radiata* > black gram (*V. mungo*) < chickpeas. Half fertilizer increased the AGR but did not change the RGR, which characteristically varied in different legumes. Half fertilizer increased the N, P and K uptake but decreased their utilization efficiency (dry matter production/unit nutrient per week).

2.6.2 Relative growth rate (RGR)

Baskar *et al.* (2000) reviewed the literature concerning that application of P @ 90 kg ha^{-1} registered higher yield and yield contributing parameters of soybean. Phosphorus application improved leaf area per plant, CGR, RGR and dry matter production were increased significantly with increment in phosphorus doses upto 80 kg P_2O_5 ha^{-1}.

2.6.3 Net assimilation rate (NAR)

Singh and Mishra (1998) reported that growth characters like seed germination, LAI, NAR, CGR leaf weight ratio, specific leaf weight, harvest index, plant dry weight, chlorophyll content, length and weight of root and shoot, biomass were considerably increased by application of biofertilizers. The foliar spray of rhizobial suspension increased the chlorophyll content and growth.

2.6.4 Crop growth rate (CGR)

According to Samarasinghe *et al.* (1989) the groundnut cultivars Chico, Pronto (Spanish) early bunch (Virginia) and McRan (Valencia) were grown in the field in Ontario, Canada, at 10, 20 and 30 plants/M^2. LAI, CGR and total dry matter production increased with increasing plant density in all cultivars. Chico and Pronto has significantly higher harvest index than McRan and early bunch; increasing plant density decreased harvest index in all cultivars except Pronto, CGR and rate of pod filling were highest in Pronto. In Pronto, McRan and early bunch, CGR increased until 62 day after sowing decreased before pod filling and then increased to high levels due to increased demand for assimilates during rapid seed development. In Chico, CGR increased until about 90 day after sowing and declined thereafter. Final seed yield was highest in the Spanish type cultivars, due to greater partitioning of dry matter into the seeds and a higher rate.

2.7 Yield and yield contributing characters

Jain *et al.* (1988) reported that *kharif* legumes tested against respective *Rhizobium* inoculation and fertilizers and found

that the seed treatment with *Rhizobium* culture and application of recommended fertilizers being at par in terms of soybean equivalent and net returns proved superior than the control. However, yield per plant was increased in all the crops by seed inoculation with *Rhizobium* culture.

From this it is concluded that inoculation of *Rhizobium* significantly increased the yield of groundnut by 14.4 % and of soybean by 10.69 % over no inoculation. The increase in yield was due to favourable effect of *Rhizobium* on pod number and test weight. Similar results were also reported by Muhammed *et al.* (1973) in groundnut and Varshney (1981) in soybean.

Dubey (1997) observed a significant increase in the yield of soybean from single as well as combined inoculation of PSM and *Bradyrhizobium japonicum* as compared to uninoculated control, which was to the tune of 16.7 to 33.9 per cent. Further, increase in yield was observed from combined inoculation of PSM with *Bradyrhizobium japonicum* which was 3.7-14.3 per cent and 7.3-9.2 per cent, over the single inoculation of PSM and *Bradyrhizobium japonicum* respectively. Combination of *Bradyrhizobium japonicum* with PSM *viz.*, Microphos and Narmadaphos produced higher yield.

Yadav and Shrivastava (1997) revealed that application of P @ 60 kg ha^{-1} combined with seed inoculation with phosphate solubilizing bacteria (PSB) resulted in producing the highest values of all the growth and yield attributing characters of chickpea but the differences were non significant from those obtained due to P_2O_5 application alone except pod weight per plant in 1994-95. Averaged over two years the grain yield increased significantly with 40 kg P_2O_5

ha^{-1} plus PSB. Thus, it could be possible to save 20 kg P_2O_5 ha^{-1} with the use of PSB.

Ghosh and Pois (1998) conducted a field trial on five leguminous crops (soybean, groundnut, kalai, green gram and lentil) which were inoculated with homologous *Rhizobium*, *Bacillus polymixa* (Phosphate solubilizing organism) and *Glomus fasciculatum* in different combinations. When three organisms were taken at a time, the triple inoculation in legumes showed potential for better crop yield.

Upadhyay *et al.* (1999) revealed that yield and yield attributes of green gram were significantly increased by application of phosphorus and *Rhizobium* inoculation. The application of 40 kg P_2O_5 ha^{-1} along with *Rhizobium* inoculation produced the highest yield.

Baronia (2000) carried out field experiment on Research Farm during 1996-97 in *rabi* season on French bean cv. 'Arkakoma'. The results revealed that biofertilizers and fertilizers alone and in combination influenced yield attributes *viz.*, number of green pods $plant^{-1}$ (10.05), weight of green pods $plant^{-1}$ (59.91 g) and green pod yield $hectare^{-1}$ (132 g) significantly.

2.7.1 Number of pegs

Sekhon *et al.* (1995) concluded from the field experiment conducted at the PAU, Ludhiyana during *rabi* 1991-92 and 1992-93 to assess the influence of nitrogen fertilization (0, 15, 30, 45, 15 + 15 and 30 + 15 kg N/ha) and *Rhizobium* inoculation (inoculated and uninoculated) on biological nitrogen fixation, growth and yield of field pea (*Pisum sativum* L.). A significant increase in

number of nodules and their dry weight, nitrogenase activity and leghaemoglobin content was observed with the treatment of *Rhizobium*, however, the higher levels of nitrogen reduced these microbiological traits. Plant height, dry matter accumulation, number of pods/plant, number of seeds/pod and test weight increased either significantly or numerically with seed inoculation and nitrogen application. On an average, the treatment of *Rhizobium* increased the grain yield by 7.8 and 8.5 per cent over the uninoculated control during the two consecutive years. The grain yield increased significantly upto 30 kg N/ha. Interestingly, application of 15 kg N/ha with inoculation produced almost the same yield as that is obtained with the application of 30 kg N/ha without inoculation. The combination of *Rhizobium* inoculation + 15 kg N at the time of sowing + 15 kg N/ha top-dressing at flower initiation (60 days) produced maximum grain yield.

2.7.2 Number of pods

Raju and Verma (1984) reported the response of green gram (*Vigna radiata* var. pusa Baisakhi) to varying levels of nitrogen application (15, 30, 45 and 60 kg ha^{-1}) in presence and absence of *Rhizobium*. Pod number per plant and hundred seed weight were obtained maximum in *Rhizobium* + 15 kg N ha^{-1} treatment. The highest grain yield of 853 kg ha^{-1} accounting for 39 per cent increase over control was recorded by *Rhizobium* + 15 kg N ha^{-1}.

Shrivastava and Verma (1984) concluded that twenty one treatment combinations (three nitrogen treatments and seven techniques of phosphorus application) exhibited significant response of field pea to inoculation of seed with *Rhizobium* culture in respect

to number of pods, grain yield with consistent improvement in almost all the characters under study. Nitrogen application @ 20 kg ha^{-1} also favourably influenced all the yield attributing characters. However, *Rhizobium* inoculation proved advantageous in comparison to starter dose of nitrogen application.

2.7.3 Dry weight of pods

Nagaraj and Kumar (1986) studied dry matter, nutrient uptake and their partitioning into leaf, root, stem and pods of GAUG 10 and Kadiri 3 varieties of groundnut at 5 growth stages. GAUG 10 had higher dry matter production (50 g per plant) and higher nutrient uptake (0.3 to 2.0 g per plant) than Kadiri 3 (11.6 g and 0.03 to 4.43 per plant, respectively). Requirement of nutrients was higher during 60 to 90 days growth stage. The partitioning of the nutrient to pod increased after 90 days. About 45 per cent of N was translocated to pods in both varieties.

2.7.4 Hundred pod weight

Varshney (1989) carried out a field trial on groundnut and soybean. The treatments consisted of three nitrogen levels (0, 20 and 40 kg N ha^{-1}) in main plot and *Rhizobium* in subplot. The yield was increased with progressive increase in the level of nitrogen. In groundnut crop maximum yield was recorded at 40 kg N ha^{-1} and it was at par with 20 kg N. The plots receiving nitrogen had more number of pods and test weight resulting in higher yield.

Tomar *et al.* (1993) ascribed the result that application of PSB significantly increased the seed yield of black gram over the control. The increase in seed yield was 9.5 and 22.5 per cent in 1990

and 1991, respectively. Seed inoculation also significantly increased the number of pods per plant and seed index, seed yield of blackgram increased with increasing levels of phosphate. Application of 60 kg P_2O_5 ha^{-1} was significantly superior for seed yield, though it did not differ significantly with 80 kg P_2O_5 ha^{-1}. Number of seeds per pod responded upto 60 kg P_2O_5 ha^{-1}, significantly.

2.7.5 Hundred kernel weight

Jena *et al.* (1990) conducted a field experiment during rainy season (*Kharif*) of 1986 and 1987 to find out the effect of N, P and K on yield and yield attributes in rainfed 'JL-24' groundnut (*Arachis hypogaea* L.). Application of N and P increased the pods/plant, kernels/pod, 100 kernel weight and pod yield. K had no significant influence on the pod yield. N @ 20 and 40 kg/ha produced 1.46 and 1.48 t/ha, giving 0.48 and 0.50 t ha^{-1} more yield respectively than the control.

2.7.6 Shelling percentage

Vaddoria and Patel (1992) derived an information on yield correlations from data on 10 yield related characters in 50 Virginia runner groundnut varieties grown during *kharif* 1986 at Junagadh pod yield was significantly correlated with harvest index, shelling percentage, number of mature pods/plant, 100 seed weight and number of primary branches/plant at both the genotypic and phenotypic levels, path analysis revealed that harvest index exerted the highest positive direct effect on pod yield followed by number of primary branches/plant.

2.7.7 Pod yield

Kulkarni *et al.* (1984) reported in the study conducted during the rainy season of 1981 and 1982 both J-11 (Spanish bunch) and Robut 22-1 (Virginia bunch) varieties of groundnut responded to inoculation with *Rhizobium* strains NC 92, NGR-234, resulting in an increase in yield ranging from 9.8 to 40.8 %. Inoculation of Robut 33-1 with NC-92 *Rhizobium* resulted in an increase in nodulation dry weight of plants and pod yield (40.8 %). *Rhizobium* strains NC-92 were found to be superior to NGR-234.

Chauhan *et al.* (1988) demonstrated in trials with 6 groundnut cultivars grown on an alluvial soil, application of 17.6 kg P/ha increased average pod yields from 2.55 to 2.98 t/ha; further increase in P rates gave no additional yield cv. S_1 and TG_{17} gave highest yields of 3.74 and 3.56 t/ha respectively compared with 2.24-2.88 t/ha in other cultivars.

Kune *et al.* (1989) pointed out from the experiment conducted in 1974-80 on farms in the Vidarbha region, Maharashtra, seed inoculation with *Rhizobium* increased average seed yields by 32.8 % in green gram (*Vigna radiata*) 21.5 % in black gram (*V. mungo*) 15.5 % in pigeonpeas, 29.3 % in chickpeas and 36.5 % in groundnuts.

Mahale *et al.* (1991) noticed in 3 year trials (1985-87) conducted with 3 groundnut cultivars that average pod yields increased from 1.52 to 1.75 t/ha with application of 25 kg N/ha and were not further increased with 50 kg N/ha. Yields with 0, 25 and 50 kg P_2O_5/ha were 1.54, 1.68 and 1.88 t, respectively cv. UF-70, SB-XI and M-13 produced of 1.91, 1.76 and 1.43 t, respectively.

Geethalakshmi *et al.* (1993) conducted an experiment to study the individual and combined effect of inorganic, organic and biological nutrient sources on groundnut yield. From the pooled analysis of two years data it is seen that integration of all the sources of nutrients (NPK + FYM + *Rhizobium* + enriched FYM + Gypsum) registered the highest groundnut pod yield of 1387 kg/ha, recording 52 % increased yield than NPK fertilization alone (912 kg/ha). The increased yield recorded in this treatment could be attributed to the synergistic effect of different nutrient sources, which affected the groundnut growth, yield and quality characters positively.

2.7.8 Haulm yield

Sanoria and Prasad (1984) conducted an experiment employing combined cultures of *Rhizobium* H45/H44 and *Azotobacter* B 4 at 50, 100 and 150 kg P_2O_5 ha^{-1} RHH 45 + *Azotobacter* B 4 to 50 kg P_2O_5 ha^{-1} gave maximum grin yield of bengal gram but straw yield was maximum with H 44 + *Azotobacter* B4. However, the grain yield was not significantly affected by treatments. Grain and straw yields showed positive dependence on nodulation.

Detroja *et al.* (1997) carried out a field experiment at Junagadh and reported that phosphorus did not exert significant effect on pod and haulm yield of groundnut. Seed inoculation with *Pseudomona striata* recorded higher pod yield, haulm yield after harvest and in pooled results over inoculation.

Rooge *et al.* (1998) noticed that the P solubilizing cultures (*Bacillus polymysa* or Biophos) with equal proportion of single superphosphate and Mussorie rock phosphate significantly

increased the number of pods per plant, hundred seed weight, seed yield and straw yield in soybean than the respective uninoculated checks.

Gowri *et al.* (2000) keeping in new the importance of agro-forestry system especially in drylands for enhancement of crop productivity. A field experiment was carried out during the rainy season (*kharif*) 1995 and reported that pod and haulm yield of groundnut were significantly influenced by the cropping systems, nitrogen and phosphorus levels.

2.7.9 Oil yield

Joshi *et al.* (1981) have shown that seed inoculation with *Rhizobium* increased the number of nodules and pods/plant and 100 seed weight and gave yields of 1.27 t seed ha^{-1} in groundnuts and 0.97 t ha^{-1} in soybeans compared with 1.11 and 0.88 t ha^{-1} respectively, without seed inoculation. Increasing N rates from 0 to 40 kg/ha increased groundnut yield from 1.12 to 1.25 t and soybean yield from 0.83 to 1.02 t. Oil and protein yields shown similar effects.

2.7.10 Harvest index

Bell *et al.* (1993) reported that the partitioning of dry matter between vegetative and reproductive yield components was analysed for 4 diverse groundnut cultivars (Chico, Mc Cubbin, Early Bunch and Mani Pintar) at a range of sowing dates and plant populations in subtropical Queensland, Australia, Rates of accumulation of pods (pod addition) varied significantly with both cultivar and sowing date. Within cultivars, much of this variation

could be attributed to variation in crop growth rate during the critical pod addition period. The proportion of current assimilate distributed to pods depended on inherent cultivar characteristics and also correlated well with the current CGR relative to the CGR during pod addition (that is, with relative source activity). Neither plant density nor spatial arrangement had any significant effect on patterns of assimilates distribution. All cultivars appeared capable of remobilizing stored assimilater to maintain constant rates of pod yield increase despite fluctuations in CGR, which might be expected to produce short term source limitations to pod yield accumulation. The harvest index (HI) increased linearly during the entire pod fill period in all cultivars except the very early maturing Spanish cv. Chico. Neither density nor spatial arrangement affected rate as increase in HI except in Chico, where increased density produced increased rates of increase in HI variation in the rate of HI increase among sowing date was small.

2.8 Soil and plant analysis for NPK content and uptake

Gillber *et al.* (1987) studied nitrogen fixation in seven groundnut genotypes by ^{15}N – isotope dilution using a non-nodulating cultivar of groundnut as the non-fixing reference plant and emphasized that nitrogen fixation varied between 100 kg N/ha in genotype J-11 and 153 kg N ha^{-1} in Robout 33. The amount of plant available soil N was small. So that 86-92 % of plant nitrogen was derived from N_2 fixation. Thus differences N_2 fixation between genotypes closely reflected differences in their total N accumulation.

Sahrawat *et al.* (1988) in a field experiment determined the amount of N, P, K, Ca, Mg, Zn, Fe and Mn observed by

groundnut Robout 33-1 and non-nodulating line at fertilizer levels of 0 and 200 kg N ha^{-1} and reported that the amounts of nutrient elements in the plant parts were greater for N, followed by K, Ca, Mg, P, Fe, Mn and Zn in descending order.

Dutta *et al.* (1988) studied the seasonal pattern of acetylene reduction (AR) and shoot N accumulation in a groundnut cultivar shoot N accumulation by all the cultivars was maintained until shortly before maturity and it occurred faster over the reproductive growth phase than over the earlier phase. This suggested that the commonly observed low plant AR values for groundnut over the production growth phase may be result of factors other than sink competition. There were significant interactions of cultivars with stage of crop growth for plant AR, nodule mass and specific nitrogenase activity. Virginia types generally showed better nodulation, higher N_2 fixing capacity than Valencia types and significant differences were observed between cultivars within a botanical type.

Kucey and Toomsan (1988) revealed that inoculation with *Brady rhizobium* resulted in increased seed yields and amount of N in plants in most cases. Inoculated groundnut received an average of 62 N kg ha^{-1}. Of this nitrogen, 55 to 77 per cent remained in the stover.

Yashiki *et al.* (1991) studied the contribution of fertilizer, soil and atmospheric N to total N accumulation by groundnuts by using ^{15}N labelled fertilizer and observed that the concentration of ^{15}N derived from fertilizer was highest in roots and higher in gynophores than in other organs at the mid-ripening stage ^{15}N concentration decreased to 5 – 10 % of the maximum in all

organs as a large amount of fixed N accumulated. The contribution of Nitrogen derived fertilizer to total N content at flowering, mid-ripening and harvest was 29.4, 7.6 and 5.9 % respectively in whole plants and was 5.5 % in seeds at harvest. Percentage absorption of fertilizer N at the three stages was 7.1, 26.5 and 38.5 % respectively in whole plants. Contribution of fertilizer soil and atmospheric N to total N accumulation at harvest were 6, 15 and 79 % respectively.

Khan *et al.* (1989) observed by using path coefficient analysis the direct and indirect contributions of soil nutrients and NPK fertilizer to yield of groundnuts cv. JL-24 grown in a field trials in 1984-85. On the basis of percentage contribution to yield the nutrients were ranked as soil P (62 %) fertilizer P (28 %), soil N (28 %) soil K (5 %). Direct percentage contribution of soil and fertilizer nutrients was greater than indirect contribution to groundnut yield.

Rajeswari (1991b) conducted an experiment on groundnuts cv. Robut 33-1 where not inoculated with *Rhizobium* strain NC 92 and given KNO_3 or NH_4Cl at 15 or 30 kg N/ha or no N fertilizer plant N, P and Ca contents were higher in inoculated than in uninoculated plants. Inoculated plants given 30 kg N as NH_4Cl had the highest plant N, P and Ca contents.

Raverkar (1995) reviewed the literature concerning that one decades research work carried out by author in India and abroad, revealed that various bio-fertilizers have a significant beneficial impact on peanut, soybean, french bean, tomato, wheat and leguminous nitrogen fixing trees. In addition to this, the role of vesicular arbuscular mycorrhizal (VAM) fungi in improving the

nitrogen fixation in legumes and in nitrogen transfer from legumes to non-legumes under intercropping systems, through VAM-hyphal bridges built between the root systems was also noted. From these studies, it could be envisaged that bio-fertilizers have ability to improve the production in sustainable manner, soil quality apart from keeping an environment safe.

Balasubramaniyan (1995) from the field experiments with bio-fertilizers have shown that they can met, on an average, 25 % of the total N requirement of the crops, thus saving one fourth of the inorganic fertilizer input for the crops. Similarly, the use of 'Phosphobacteria' (P-solubilizing bacteria) has shown that nearly 25 to 50 % of the P requirement of the crops could be met by solubilizing the fixed soil P by this bio-fertilizer.

Grewal *et al.* (1989) demonstrated in field experiment on a sandy loam soil, application of 17 or 26 kg P/ha significantly, increased nodulation, dry matter accumulation and N, P and K uptake in seed, shells and haulms of groundnut cv. M-145.

Mane *et al.* (1993) reported that groundnut plants inoculated either with VAM or *Rhizobium* shared a definite increase in root length, root weight, biomass production, nodulation, N_2 fixation, P uptake and yield of groundnut. The inoculation with either of the symbionts resulted in absorption of greater amount of phosphorus mycorrhiza and *Rhizobium* inoculation proved effective in improving growth, nodulation, N-fixation, phosphorus uptake and yield of groundnut LG-19.

More and Jadhav (1997) conducted a field trial at Parbhani on soybean and observed that nodule number, weight and volume and N content and uptake in crop were significantly increased

due to application of cobalt over control. Application of cobalt through soil, seed or foliar alongwith *Rhizobium* inoculation was more effective in enhancing the nodulation, yield and uptake of nitrogen in the crop.

Christopher (1999) reported that groundnut removes fairly large quantities of nutrients from the soil. Cultivation of groundnut will therefore, deplete the soil rapidly unless the soil is adequately manured. Increasing the levels of K particularly in low K soils showed prominent increase in yield under different soil types and agro-climatic conditions in India. Organic manures addition results in various favourable changes in the soil like building up of organic matter, good soil aggregation, improvement in soil physical properties, long lasting supply of macro and micro nutrients etc.

2.9 Oil and protein content

2.9.1 Oil

Wankhede *et al.* (1992) observed from the experiment on groundnuts cv. SB-XI and JL-24 grown in the 1988 rainy season with the treatments (a) seed inoculated with *Rhizobium*; (b) inoculated with *Rhizobium* + 2 g Mo/kg seed; (c) inoculated with *Rhizobium* + 4 g Mo; (d) not inoculated. Nodule number and nodule dry weight/plant increased with inoculation and were highest in treatment (c). All seed treatments increased seed oil.

Arunachalam *et al.* (1993) derived the information on yield correlations from regression analysis of data on oil, fatty acids and N content in seeds, root and the whole plants and pod yield per plant in 9 advanced lines of groundnut raised during the rainy season

(July-November 1988) at New Delhi. Positive significant correlations were found for oil content.

Rajendran and Veeraputhiran (2001) reviewed that being an oil seed crop, sunflower responds well with phosphorus fertilization. Seed yield and oil content also increased by P application. Phosphorus application also increased the uptake of N, P, K, Ca, Mg and S nutrients.

2.9.2 Protein

Dubey *et al.* (1986) stated that increasing rates of P_2O_5 and or K_2O from 0 to 20, 40 or 60 kg/ha applied in groundnuts given 20 kg N/ha increased the number of pods/plant, pod yields and 100 seed weight. Seed protein content increased from 20.06 to 26.75 % with increase in P rates; it was 24.62 % with 20 kg K_2O and 21.81 % with 40 kg K_2O.

Martinez *et al.* (1988) studied in a field trial at Santiago de las Vegas, natural nodulation of 14 Cuban groundnut lines and 7 introduced lines by native strains of *Rhizobium* and its effect on yield and quality characters were investigated over a 3 years period. Total nodule dry weight/plant was generally higher in Cuban lines, but the trend for nodule number/plant was not so clear cut. Seed weight/pod, protein yield/pod and crude oil yield/pod were generally higher in Cuban lines than in introduced lines.

MATERIAL AND METHODS

3. MATERIAL AND METHODS

The experiment "Studies on effect of liquid biofertilizers on morpho-physiological and bio-chemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) varieties during *Kharif* season", was carried out at the Instructional Farm of the Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri during the *Kharif* season of 2000 and 2001. The details of the material used and methods adopted in the present investigations are described in this chapter.

3.1 Details of experimental material

3.1.1 Experimental site

The experiments were carried out in survey number 59 of Department of Plant Pathology and Microbiology at Instructional Farm of the Post Graduate Institute, M.P.K.V., Rahuri, Dist. Ahmednagar (M.S.).

3.1.2 Soil

The topography of experimental field was uniform and leveled with well drained soil. A composite soil sample upto 30 cm soil depth from experimental area was collected prior to sowing and analysed for physical, chemical properties and also for nitrogen, phosphorus and potassium content.

The relevant data on the physical, chemical properties and the nitrogen, phosphorus, potassium content of the experimental site along with the analytical methods used are presented in Table 1.

Table 1. Pertinent physical, chemical properties and nitrogen, phosphorus and potassium content of the soil under investigation and method used

Sr. No.	Characteristics	Composition		Method adopted	Reference
		2000	2001		
A.	**Physical properties**				
1.	Gravelly (%)	51.8	51.8		
2.	Sand (%)	29.3	29.3	International pipette method	Piper (1966)
3.	Silt (%)	20.1	20.1	International pipette method	Piper (1966)
4.	Clay (%)	50.6	50.6	International pipette method	Piper (1966)
5.	Textural class	Gravelly clay	Gravelly clay	International pipette method	Piper (1966)
B.	**Chemical properties**				
1.	Available nitrogen (kg ha^{-1})	156.00	147.00	Alkaline permanganate method	Subhiya & Asija (1956)
2.	Available phosphorus (kg ha^{-1})	10.4	9.65	Olsen's method	Olsen *et al.* (1954)
3.	Available potassium (kg ha^{-1})	358.00	286.00	Flame photometer method	Hanway and Heidal (1967)
4.	Soil pH	8.29	8.31	Backman's glass electrode method	Piper (1966)

3.1.3 Climatic conditions

3.1.3.1 General

Geographically, the Instructional Farm of Post Graduate Institute, M.P.K.V., Rahuri is situated between 19°47' and 19° North latitude and between 74°32' and 74°47' East longitude. The altitude varied from 495 to 569 M above the mean sea level. This tract is on the Eastern side of Western Ghat and falls under rain shadow area.

Climatically, the area falls in semi-arid tropics with annual rainfall ranging between 307 and 619 mm, the average being 520 mm, which is erratic and unevenly distributed in 15 to 45 rainy days in different years. Out of the total annual rainfall, above 80 per cent is received from South West monsoon from June to September. The annual mean maximum temperature is 37.9° C with a range between 33° C and 45° C and annual mean minimum temperature is 17.2° C with a range between 3° C and 23° C. The mean relative humidity at 7.30 hours and at 14.30 hours is 59 and 35 per cent respectively. Agronomically the area falls in scarcity zone of Maharashtra.

3.1.3.2 Season during experimental period

The data on important weather parameters during the cropping period (1st experiment *kharif* 2000) recorded at the central meteorological observatory located in 'B' block of M.P.K.V., Rahuri are presented in Table 2A.

From the data presented in Table 2A, it was observed that the mean maximum temperature ranged between 24.6° C and 33.6° C, while the mean minimum temperature ranged between 13.6° C and 22.8° C. The relative humidity during morning and evening hours ranged between 71.3 and 93.3 per cent and between 28.9 and 76.9 per cent, respectively.

The mean weekly pan evaporation data showed that the minimum pan evaporation of 2.5 mm day^{-1} was recorded in the month of August, while maximum pan evaporation of 6.8 mm day^{-1} was recorded in the month of July.

The total rainfall received during the year 2000 was 632.2 mm in 52 rainy days. However, the total rainfall received from 1st July to 30th October 2000 was 465.9 mm in 35 rainy days.

The total rainfall received during the month of July, August, September and October 2000 was 49.8 mm, 254.0 mm, 62.2 mm and 99.9 mm, respectively.

Thus, climatic condition and rainfall distribution was quite favourable for groundnut crop under study.

The data on important weather parameters during cropping period (2nd experiment *Kharif* 20001) recorded are presented in Table 2B.

From the data presented in Table 2B, it was observed that the mean maximum temperature ranged between 31.9° and 27.9° C while the mean minimum temperature ranged between 21.9° C and 11.9° C. The relative humidity during morning and evening hours ranged between 97 and 81 per cent and between 82 and 30 per cent respectively. The minimum pan evaporation data showed that the maximum pan evaporation of 6.7 mm day^{-1} was recorded in the 27, 28 and 35 meteorological weeks while minimum pan evaporation of 2.5 mm day^{-1} was recorded in the month of October.

The total rainfall received during the year 2001 was 493.40 mm in 33 rainy days. However, the total rainfall received from July to October 2001 was 402.70 mm in 26 rainy days. Maximum rains were received during the month of August, September and October were 84.1, 164.6 and 129.4 mm respectively. While highest rainfall 164.6 mm received in the month of September which was not congenial for pod development stage of the groundnut crop.

Table 2 A. Meteorological data recorded during the experimental period (July to October, 2000)

Meteorological week	Date	Rainfall (mm)	Rainy days (No.)	Temperature (°C)		Humidity (%)		Mean evaporation (mm day^{-1})
				Max.	Min.	Morn.	Even.	
1	2	3	4	5	6	7	8	9
July								
27	02-08	6.6	1	29.7	22.0	84.4	63.7	4.0
28	09-15	42.0	4	28.8	22.8	88.6	75.4	4.1
29	16-22	0.0	0	24.6	19.2	71.3	50.4	4.0
30	23-29	1.2	1	31.7	20.0	82.6	46.1	5.8
31	30-05	0.0	0	33.3	19.7	81.4	42.1	6.8
August								
32	06-12	10.2	4	31.3	22.0	84.0	57.3	5.1
33	13-19	0.7	1	31.7	21.3	82.4	50.1	6.0
34	20-26	218.8	6	28.4	21.9	93.3	76.9	2.5
35	27-02	24.3	4	28.7	21.8	90.0	69.0	3.9
September								
36	03-09	1.5	1	29.0	20.0	84.6	59.0	4.6
37	10-16	0.0	0	31.3	18.6	85.4	50.1	4.6
38	17-23	10.6	3	32.3	19.9	88.3	51.9	5.5
39	24-30	50.1	4	32.0	20.6	91.1	49.7	4.7
October								
40	01-07	64.1	2	33.0	19.8	86.9	45.0	4.3
41	08-14	23.0	3	30.5	20.4	90.9	60.7	3.3
42	15-21	12.8	1	32.7	17.0	88.4	32.6	4.6
43	22-28	0.0	0	33.6	15.7	87.6	28.9	4.8
44	29-04	0.0	0	32.4	13.6	83.9	28.9	3.8

Table 2 B. Meteorological data recorded during the experimental period (July to October, 2001)

Meteorological week	Date	Rainfall (mm)	Rainy days (No.)	Temperature (°C)		Humidity (%)		Mean evaporation (mm day^{-1})
				Max.	Min.	Morn.	Even.	
1	2	3	4	5	6	7	8	9
July								
27	02-08	2.2	-	30.3	21.8	83	61	6.7
28	09-15	3.0	1	30.5	21.9	81	57	6.7
29	16-22	2.6	1	29.1	21.3	84	66	4.9
30	23-29	0.0	-	31.4	21.7	82	54	6.4
31	30-05	16.8	2	31.4	21.3	82	58	5.6
August								
32	06-12	69.8	4	27.9	21.3	94	82	3.0
33	13-19	9.8	1	29.2	20.8	88	67	3.8
34	20-26	4.5	1	29.8	20.4	89	58	4.6
35	27-02	0.0	-	31.0	20.9	83	53	6.7
September								
36	03-09	19.0	2	31.6	19.9	88	56	5.9
37	10-16	3.2	1	31.7	20.1	89	51	5.8
38	17-23	67.7	3	31.0	20.3	92	65	3.5
39	24-30	74.7	3	31.8	20.4	94	58	3.9
October								
40	01-07	24.2	2	31.1	21.0	95	69	3.8
41	08-14	97.5	4	29.7	20.6	97	69	2.5
42	15-21	7.7	1	31.1	18.2	90	48	4.3
43	22-28	0.0	-	31.3	12.5	90	33	4.7
44	29-04	0.0	-	31.9	11.9	86	30	4.4

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3.1.3.3 Cropping history of the experimental field

The cropping history of the experimental field for the previous three years is presented in Table 3.

Table 3. Cropping history of the experimental site for previous three years

Year	Crops grown in previous three years	
	Kharif	***Rabi***
1997	Groundnut	Gram
1998	Tomato	Onion/Sunflower
1999	Pigeonpea	Wheat
2000	Present investigation (Groundnut)	Gram
2001	Present investigation (Groundnut)	-

3.2 Details of experimental method

3.2.1 Experimental details

Design : Split-Split plot

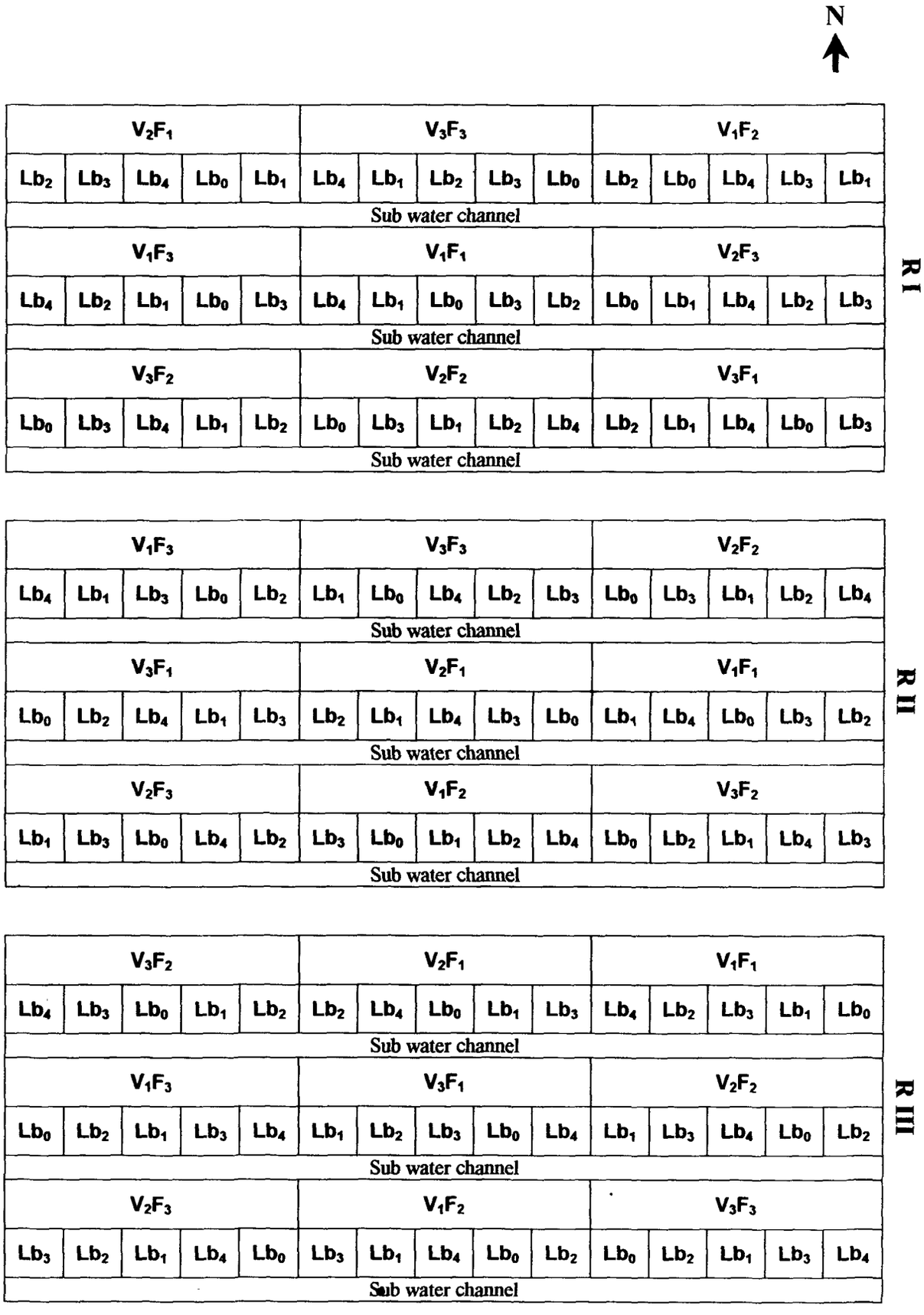
Main plot treatment

A) Varieties (3)

1. ICGV-86590, 2. JL-24, 3. SB-XI

B) Fertilizer levels (3)

1. Recommended dose of fertilizer (RDF)
2. 75 % of RDF
3. 50 % of RDF



Design : Split Plot Gross plot size : 3.0 x 3.0 m

Spacing : 30 x 10 cm Net plot size : 2.80 x 2.40 m

Fig. 1 : Plan of Layout (*Kharif* 2000)

N

V_1F_3					V_2F_2					V_3F_1				
Lb_4	Lb_2	Lb_1	Lb_0	Lb_3	Lb_0	Lb_3	Lb_1	Lb_2	Lb_4	Lb_2	Lb_1	Lb_4	Lb_0	Lb_3
Sub water channel														
V_3F_2					V_1F_1					V_2F_3				
Lb_0	Lb_3	Lb_4	Lb_1	Lb_2	Lb_4	Lb_1	Lb_0	Lb_3	Lb_2	Lb_0	Lb_1	Lb_4	Lb_2	Lb_3
Sub water channel														
V_2F_1					V_3F_3					V_1F_2				
Lb_2	Lb_3	Lb_4	Lb_0	Lb_1	Lb_4	Lb_1	Lb_2	Lb_3	Lb_0	Lb_2	Lb_0	Lb_4	Lb_3	Lb_1
Sub water channel														

R I

V_3F_1					V_2F_1					V_1F_3				
Lb_4	Lb_1	Lb_3	Lb_0	Lb_2	Lb_0	Lb_1	Lb_2	Lb_4	Lb_3	Lb_3	Lb_0	Lb_1	Lb_2	Lb_4
Sub water channel														
V_1F_2					V_3F_3					V_2F_2				
Lb_2	Lb_0	Lb_4	Lb_1	Lb_3	Lb_1	Lb_2	Lb_4	Lb_0	Lb_3	Lb_4	Lb_1	Lb_0	Lb_3	Lb_2
Sub water channel														
V_2F_3					V_1F_1					V_3F_2				
Lb_3	Lb_1	Lb_0	Lb_2	Lb_4	Lb_3	Lb_1	Lb_0	Lb_2	Lb_4	Lb_0	Lb_1	Lb_2	Lb_4	Lb_3
Sub water channel														

R II

V_1F_3					V_2F_1					V_1F_1				
Lb_0	Lb_4	Lb_2	Lb_1	Lb_3	Lb_2	Lb_4	Lb_0	Lb_1	Lb_3	Lb_4	Lb_2	Lb_3	Lb_1	Lb_0
Sub water channel														
V_3F_2					V_1F_2					V_2F_2				
Lb_4	Lb_3	Lb_0	Lb_1	Lb_2	Lb_1	Lb_2	Lb_3	Lb_0	Lb_4	Lb_1	Lb_3	Lb_4	Lb_0	Lb_2
Sub water channel														
V_2F_3					V_3F_1					V_3F_3				
Lb_3	Lb_0	Lb_2	Lb_1	Lb_4	Lb_3	Lb_1	Lb_4	Lb_0	Lb_2	Lb_0	Lb_2	Lb_1	Lb_3	Lb_4
Sub water channel														

R III

Design : Split Plot Gross plot size : 3.0 x 3.0 m

Spacing : 30 x 10 cm Net plot size : 2.80 x 2.40 m

Fig. 2 : Plan of Layout (*Kharif* 2001)

Subplot treatments

Liquid biofertilizers (5)

1. Control
2. Bioplin
3. Phosfert
4. Vitormone
5. Rhizobium

Replication	-	3	
Plot size	-	Gross :	3.00 x 3.00 m
		Net :	2.80 x 2.40 m
Spacing	-	30 x 10 cm	

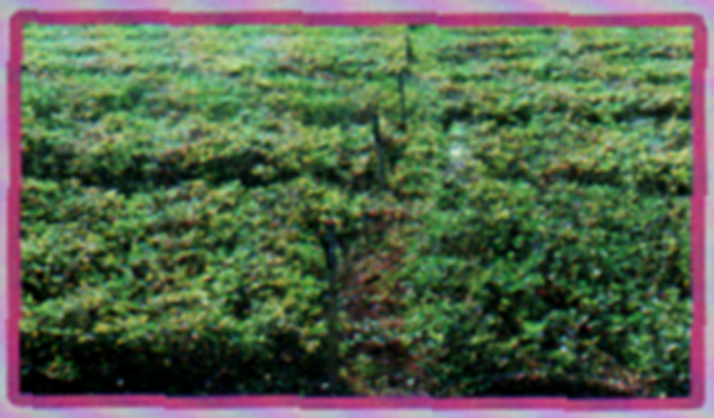
Forty five treatment combinations formed from three varieties, three fertilizer levels as main plot treatment and five liquid biofertilizers as subplot treatments. The allocation of main and subplot treatments to the representative plots was done by random method. The details of treatments along with the symbols used are given in Table 4.

Table 4. Details of the treatments and symbol used

Sr. No.	Treatment details	Symbols
	Main plot treatment	
A.	**Varieties (3)**	
1.	ICGV-86590	V_1
2.	JL-24	V_2
3.	SB-XI	V_3
B.	**Fertilizer levels (3)**	
1.	Recommended dose of fertilizer (RDF)	F_1
2.	75 per cent of RDF	F_2
3.	50 per cent of RDF	F_3
	Sub plot treatments	
	Liquid bio-fertilizers (5)	
1.	Control	Lb_0
2.	Bioplin	Lb_1
3.	Phosfert	Lb_2
4.	Vitormone	Lb_3
5.	*Rhizobium*	Lb_4

3.2.2 Cultural operations

The datewise detail operations carried out in the experimental plot are given in Table 5.





(*Kharif* 2000)





(*Kharif* 2001)

Plate 1: Field view of the experimental plot.

Table 5. The schedule of cultural operations carried out for groundnut during *kharif* 2000 and 2001

Sr. No.	Particulars of operation	*Kharif* 2000		*Kharif* 2001	
		Frequency	Date	Frequency	Date
A.	Pre-sowing operations				
1.	Ploughing	1	23/5/2000	1	15/6/2001
2.	Disking	1	29/5/2000	1	24/6/2001
3.	Harrowing	1	30/6/2000	1	1/7/2001
4.	Collection of stubble	1	2/7/2000	1	5/7/2001
5.	Preparation of experimental layout	1	2/6/2000	1	5/7/2001
B.	Sowing				
1.	Application of fertilizers	1	8/7/2000	1	19/7/2001
2.	Sowing by dibbling	1	8/7/2000	1	19/7/2001
C.	Post sowing operations				
1.	Gap filling	1	17/7/2000	1	30/7/2001
2.	Hand weeding	2	27/7/2000 11/8/2000	2	20/8/2001 15/9/2001
D.	Irrigation		8/7/2000 17/7/2000 3/8/2000 22/8/2000		19/7/2001 20/7/2001 31/7/2001 9/9/2001
E.	Plant protection	1	14/8/2000	1	27/8/2001
F.	Harvesting JL-24 & SB-XI ICGV-86590	1	 14/10/2000 23/10/2000	1	 29/10/2001 5/11/2001

3.2.3 Fertilizer application

Application of fertilizers to all the plots as per the treatments. Recommended dose of fertilizer (RDF) 25:50:00 kg N and P_2O_5 ha^{-1} (F_1) 75 per cent of RDF (F_2), 50 per cent of RDF (F_3) was given just before sowing i.e. 8th July 2000 and 19th July 2001 for 1st and 2nd experiment, respectively. Nitrogen was applied through urea, while phosphorus was provided through single super phosphate.

3.2.4 Seeds and sowing

3.2.4.1 Variety

The groundnut variety SB-XI and JL-24 widely cultivated by the farmers in Maharashtra and ICGV-86590 recently released by the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) was used in present investigation.

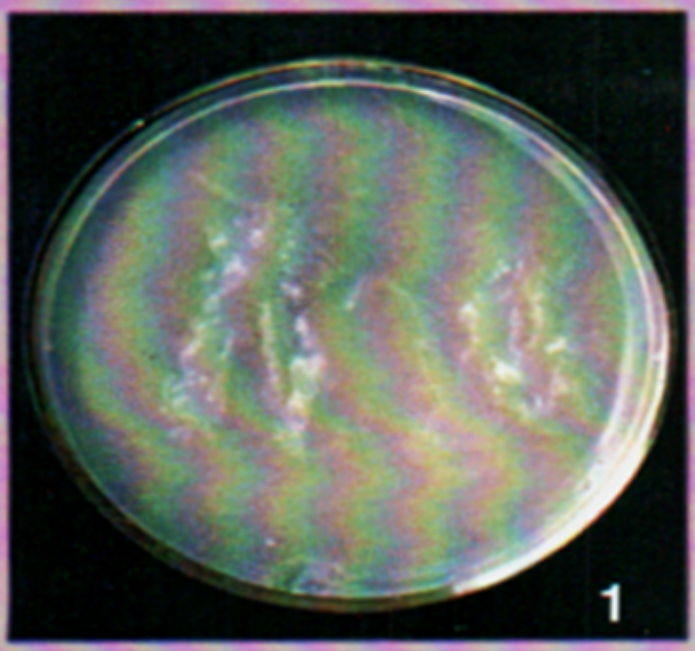
3.2.4.2 Seed

Seed of above mentioned varieties of groundnut was obtained from the Groundnut Breeder, Mahatma Phule Krishi Vidyapeeth, Rahuri.

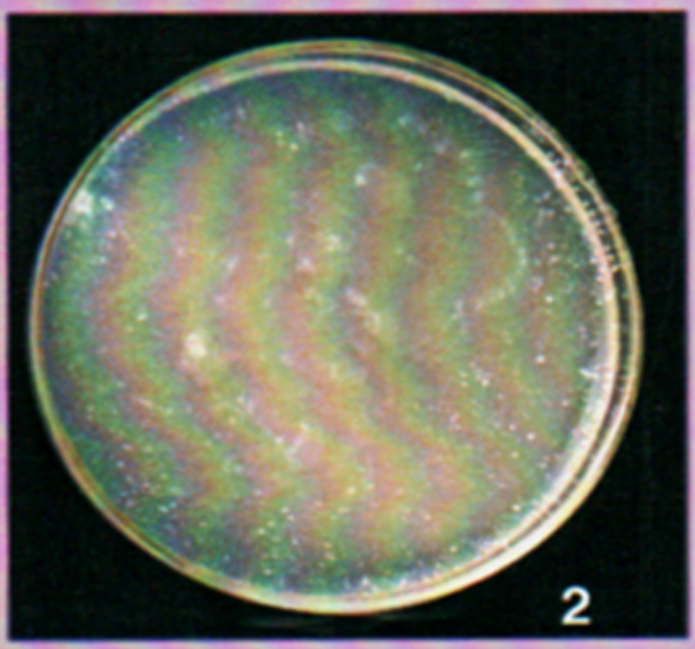
3.2.4.3 Seed treatment

Liquid biofertilizers *viz.*, Bioplin, Phosfert and Vitormone were brought from the M/s Kumar Krishi mitra Pvt. Ltd. Shivajinagar, Pune-5 through Head, Department of Plant Pathology and Microbiology, MPKV, Rahuri. *Rhizobium* (MPKV) culture was obtained from Agricultural Bacteriologist, College of Agriculture, Pune and used for the present field experiment.

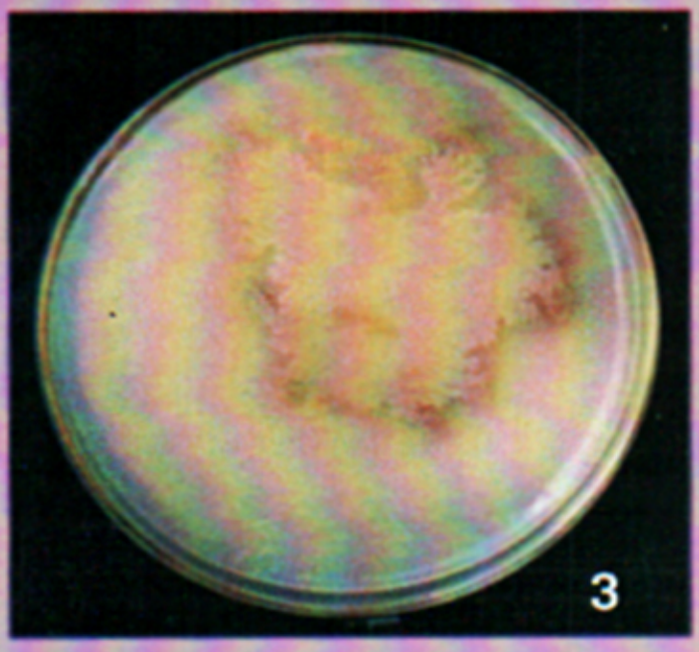
There were five biofertilizer treatments (Control-Lb_0, Bioplin-Lb_1, Phosfert Lb_2, Vitormone-Lb_3 and *Rhizobium* Lb_4) assigned to the subplot. Total 45 treatment combinations were tested in split plot design with 3 replications.



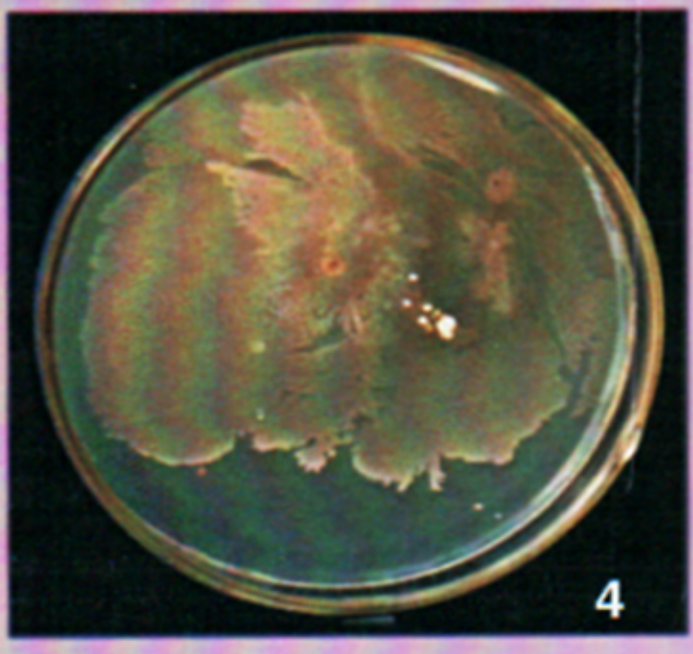
1: Pure cultures of *Azotobacter Chroococcum* isolated from Bioplin (MCLF).



2: Pure cultures of *Azotobacter Chroococcum* isolated from Vitormone (MCLF).



3: Pure cultures of *Bacillus polymixa* isolated from phosfert.



4: Pure cultures of *Rhizobium spp.* isolated from MPKV, Biofertilizer.

Plate 2 : Pure cultures of N fixing and P solubilizing micro-organisms isolated from different biofertilizers.

3.2.4.3.1 Control (Lb_0)

No application of bio-fertilizer.

3.2.4.3.2 Bioplin (Lb_1) (Seed pelleting)

100 ml Bioplin in one litre water and mixed thoroughly with 2 kg of sieved soil, kept for overnight and used for pelleting of seeds. Pelleted seeds were dried in shade before sowing.

3.2.4.3.3 Phosfert (Lb_2) (soil application)

The soil application of phosfert @ 250 ml ha^{-1} mixed with 5 kg of rock phosphate and broadcasted.

3.2.4.3.4 Vitormone (Lb_3) (Foliar spray)

The foliar spray of Vitormone @ 1 ml lit^{-1} of water were used for spraying at 30 days after sowing.

3.2.4.3.5 *Rhizobium* (Lb_4) (Seed pelleting)

The seeds of respective treatments (LB_4) were treated with *Rhizobium* culture @ 250 g carrier based inoculum per 10 kg of seed, by preparing its slurry with soil and cow dung and then air dried in shade before sowing.

Content of the product

Sr. No.	Name of product	Content
1.	Bioplin	Microorganisms of the genus *Azotobacter* (mixed culture liquid formulation – MCLF)
2.	Phosfert	Phosphate solubilizing microorganisms of genus *Bacillus*
3.	Vitormone	Microorganism of the genus Azotobacter (mixed culture liquid formulation – MCLF)
4.	*Rhizobium*	*Rhizobium* spp. (MPKV)

3.2.4.4 Sowing

The sowing of 1st experiment was done on 8th July 2000 and 2nd experiment on 19th July 2001, by dibbling one kernel per hill. Dibbling was done by maintaining the spacing of 30 cm between two rows and 10 cm between two plants.

3.2.5 Weeding and inter cultivation

The crop was kept free from weeds by one hoeing and two hand weeding. The first weeding and hoeing was done 20 days after sowing, followed by second weeding on 30 days after sowing.

This pattern of weeding and inter cultivation were same for both of the experiments.

3.2.6 Plant protection measure

A slight incidence of leaf miner was noticed when the crop was 25 days old, which was effectively controlled by spraying of Endosulfan 35 EC @ 600 ml in 400 liters of water per hectare on 14/8/2000 and 27/8/2001.

3.2.7 Application of irrigation

For first experiment irrigation was given immediately after sowing and three more irrigations (8/7, 17/7, 3/8, 22/8/2000) were given at critical growth stages of the crop.

For second experiment four irrigations were given starting from sowing upto 15 September i.e. on 19/7, 20/7, 31/7 and 9/9/2001. Sufficient rainfall was received in the month of August and September.

3.2.8 Growth observations

3.2.8.1 Sampling technique

For recording various growth observations three plants from each net plot were selected at random. The growth observations were recorded on 30th, 60th, 90th day after sowing and at harvest.

Characters studied

The characters studied are broadly divided into two groups.

i) Pre-harvest observations

ii) Post-harvest observations

3.2.8.2 Pre-harvest observations

3.2.8.2.1 Plant height (cm)

The plant height was measured from cotyledonary axil to base of the terminal bud on the main stem.

3.2.8.2.2 Number of primary branches

Branches arising from main stem (determined on n + 1 cotyledonary lateral branches) were considered as primary branches and number was recorded at an interval of 30 days of sowing starting from 30 DAS upto 90 DAS and at harvest.

3.2.8.2.3 Number of secondary branches

The number of secondary branches born on primary branches (determine on n + 2 cotyledonary lateral branches) were recorded at an interval of 30 days starting from 30 days after sowing upto 90 DAS and at harvest.

3.2.8.2.4 Number of leaves

Total number of leaves per plant were recorded periodically.

3.2.8.2.5 Number of flowers

The number of flowers per plant was counted daily starting from initiation of flowering upto the termination of flowering and total number of flowers per plant were calculated.

3.2.8.2.6 Number of pegs

The number of pegs per plant was counted from the sampled plant and the value was averaged out.

3.2.8.2.7 Flower to peg ratio

Flower to peg ratio was calculated from total number of flowers divided by the total number of pegs.

3.2.9 Biochemical parameters

3.2.9.1 Chlorophyll content (mg/g)

The chlorophyll content in leaves was determined using 80 % acetone and spectrophotometer recording absorbance at 645 and 663 nm wavelength by using following formula.

$$\text{Chlorophyll 'a'} = 12.7\,(A_{663}) - 2.69\,(A_{645}) \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll 'b'} = 22.9\,(A_{645}) - 4.68\,(A_{663}) \times \frac{V}{1000 \times W}$$

$$\text{Total chlorophyll} = 20.2\,(A_{645}) + 8.02\,(A_{663}) \times \frac{V}{1000 \times W}$$

in mg/g fresh weight of leaves.

where,

A = Absorption spectrophotometer in their respective wavelength

V = Volume prepared

W = Weight of the sample taken

3.2.9.2 Leghaemoglobin content (mg/g)

The leghaemoglobin content at 30th, 60th, 90th days after sowing and at harvest was estimated by Jorden and Garrad (1951) method. One gram of fresh nodules were crushed in a mortar with sodium hyposulphate and cold pyridine. The final volume was made to 10 ml and centrifuged at 2000 RPM to discard any contaminating particles and the clear supernatant was collected. The absorbance of leghaemoglobin was recorded on spectronic 20 at 550 nm wavelength.

3.2.10 Nodulation studies

3.2.10.1 Root length (cm)

The sampled plants were gently uprooted along with intact roots from the soil. The root length was measured from base of terminal bud on the main stem to the tip of the main root.

3.2.10.2 Number of root nodules

The plants were gently uprooted from the soil. The roots were washed in water and nodules were separated from roots and counted, on 30th, 60th, 90th day of sowing and at harvest.

3.2.10.3 Dry matter of nodules (mg)

After counting, the same nodules were kept in hot air oven in paper bags for drying (at 60° C temperature) and dry weight was recorded.

3.2.11 Dry matter studies

Three plants were randomly selected from each net plot for dry matter studies from these plants leaves, stem, pegs and pods were separated and air dried and then kept in hot air oven in paper bags for drying (at 60° C temperature) and dry weight was recorded. For total dry weight sum of weight of leaves, stem pegs and pods was made.

3.2.12 Phenological studies

3.2.12.1 Days required for initiation of flowering

The dates of appearance of first flower in net plot was recorded and then days required for initiation of flowering were calculated.

3.2.12.2 Days required for 50 per cent flowering

Number of days from sowing to the flowering in 50 per cent plants per plot in each replications were recorded to represent as days to 50 per cent flowering.

3.2.12.3 Days required for physiological maturity

The number of days required for physiological maturity of groundnut crop was recorded.

3.2.13 Growth functions

From the data of leaf area and dry matter collected at different samplings such as Absolute Growth Rate (AGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Crop Growth Rate (CGR) were estimated by using appropriate formulae.

3.2.13.1 Absolute Growth Rate (AGR) (g day^{-1})

Absolute growth rate for total dry matter accumulation was calculated by the following formula given by Briggs *et al.* (1920) and expressed in g day^{-1}

$$AGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 and W_2 refer to weights of total dry matter per plant at time t_1 and t_2 days respectively.

3.2.13.2 Relative Growth Rate (RGR) (g g^{-1} day^{-1})

The rate at which plant incorporates material into its substances i.e. RGR was calculated by using formula given by Briggs *et al.* (1920) and expressed as g g^{-1} day^{-1}.

$$RGR = \frac{Log_e W_2 - Log_e W_1}{(t_2 - t_1)}$$

Where,

W_1 and W_2 represent total dry matter per plant (g) at time t_1 and t_2 (days), respectively.

3.2.13.3 Net Assimilation Rate (NAR) (g dm^{-2} day^{-1})

The NAR is an increase in dry weight of plant per unit leaf area per unit time. It is calculated by the formula suggested by Gregory (1926) and expressed as g dm^{-2} day^{-1}.

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{Log_e L_2 - Log_e L_1}{L_2 - L_1}$$

Where,

W_1 and W_2 represent total dry matter, L_1 and L_2 denote the leaf area (dm^2) per plant at time t_1 and t_2 (days), respectively.

3.2.13.4 Crop Growth Rate (CGR) (g m^2 d^{-1})

CGR was calculated by the formula given by Duncan *et al.* (1978) as follows

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{\text{Land area per plant}}$$

Where,

W_2, W_1 represents total dry matter (g) per plant at times t_2 and t_1, respectively.

3.2.14 Post-harvest observations

3.2.14.1 Number of pegs

The number of pegs per plant was counted from the sampled plants and the value was averaged out.

3.2.14.2 Number of pods (mature and immature pods)

Total number of pods per plant were counted from the sampled plants and mature and immature pods then separated and counted.

3.2.14.3 Peg to pod ratio

Peg to pod ratio was calculated by dividing the total number of pegs by total number of pods.

3.2.14.4 Dry weight of pod (g)

Pods were separated from the three randomly selected plants after uprooting. The pods were dried and cleaned. The weight of pods per plant was recorded and averaged.

3.2.14.5 Hundred pod weight (g)

From the produce of each net plot, the hundred randomly selected pods were dried and cleaned and their weight was recorded.

3.2.14.6 Hundred kernel weight (g)

Randomly selected sample of hundred kernels from each net plot was obtained from shelling the pods and its weight was recorded.

3.2.14.7 Sound mature kernel (SMK) percentage

A half kg sample of dry pods was taken from each net plot and they were shelled out and sound mature kernels were selected. On the basis of this, sound mature kernel (SMK) percentage was calculated by using the following formula.

$$\text{Sound mature kernel (\%)} = \frac{\text{Number of sound mature kernels}}{\text{Total number of kernels}} \times 100$$

3.2.14.8 Shelling percentage

A representative sample of 500 g dry pods was taken from the total produce of each net plot and was shelled out. The shelling percentage was calculated from the weight of kernels and shells by using the formula as given below.

$$\text{Shelling (\%)} = \frac{\text{Weight of kernel}}{\text{Weight of pods}} \times 100$$

3.2.14.9 Dry pod yield (kg ha^{-1})

Pods were separated from the plants after uprooting from each net plot. Pods were cleaned and sundried yield of dry pods per net plot (kg/plot) was recorded and computed to dry yield (kg ha^{-1}).

3.2.14.10 Haulm yield (kg ha^{-1})

After removing the pods from plants, the haulm was sundried till a constant weight was obtained. The haulm yield from each net plot (kg/plot) was recorded and computed to kg ha^{-1}.

3.2.14.11 Oil yield (kg ha^{-1})

The oil percentage was estimated on Nuclear magnetic Resonance (NMR) in each plot from each replication and computed to kg ha^{-1}.

3.2.14.12 Harvest index

The harvest index was calculated by using formula given by Donald (1962).

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

3.2.15 Soil analysis

3.2.15.1 Initial nitrogen, phosphorus and potassium (NPK) content of soil

(a) Available nitrogen (N)

Available nitrogen from soil was determined by modified alkaline permanganate method (Subiya& Asija 1956)

(b) Available phosphorus (P)

Available phosphorus from soil was estimated by calorimetric method by using $NaHCO_3$ as extractant Olsen *et al.* (1954).

(c) Available potassium (K)

Available potassium from soil was estimated by flame photometer method (Hanway and Heidal, 1967).

3.2.15.2 Nitrogen, phosphorus and potassium content of the soil after harvest

The soil from respective plots were analysed for NPK content after harvest by methods denoted as above in 3.2.15.1.

3.2.16 Chemical analysis

3.2.16.1 Oil content (%)

The oil content (%) of the kernels were estimated with the help of NMR at harvest.

3.2.16.2 Protein content of kernels

The nitrogen content of kernels at harvest was determined by Micro-Kjeldahl's digestion and distillation method (Jackson, 1968). The crude protein content was worked out by multiplying the nitrogen content by the factor 6.25.

3.2.17 Statistical analysis and interpretation of data

A standard method of 'Analysis of variance (ANOVA) was used for analysis of the data for split plot design (Panse and Sukhatme, 1985). The 'F' test of significance was used for testing the null hypothesis and appropriate standard error (SE) for each treatment effect was worked out. The critical difference (CD) at 5 % probability levels was computed at appropriate places, for testing the significance of treatment differences, where the treatment effects were significant. Suitable graphical illustrations of the data have been given at appropriate places.

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The results obtained in the "Studies on Effect of liquid bio-fertilizers on morpho-physiological and biochemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) during *kharif* season" of the years (2000-2001) are presented in this chapter, by using tables, graphs and photographs.

4.1 Growth studies

4.1.1 Mean plant height (cm)

The data regarding mean plant height in groundnut as affected periodically by different treatments during the year 2000 and 2001 are presented in Table 6 and graphically depicted in Fig. 3. The differences due to different varieties, fertilizers levels and liquid biofertilizers on plant height of groundnut were statistically significant at 30, 60, 90 DAS and at harvest for both the years. The mean plant height increased from 30 DAS to 90 DAS and thereafter increase was marginal.

4.1.1.1 Effect of Varieties (2000)

It is seen from the data presented in Table 6 that the mean plant height for varieties V_2 (11.04 cm) and V_1 (9.00 cm) was recorded significantly the highest and lowest at 30 DAS.

At 60 DAS the variety V_2 (26.35 cm) which was at par with V_3 (26.06 cm) recorded significantly higher mean plant height than the variety V_1 (25.15 cm).

The highest and the lowest mean plant height at 90 DAS was recorded by the variety V_1 (31.88 cm) and V_2 (26.48 cm) respectively.

Similarly, these varieties also showed similar trend in plant height at harvest [V_1 (32.48 cm) and V_2 (27.13 cm)].

Table 6. Periodical mean plant height (cm) per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	9.00	25.15	31.88	32.48	11.47	20.78	31.60	32.33
V_2	11.04	26.35	26.48	27.13	12.27	23.60	25.69	26.11
V_3	9.66	26.06	30.48	30.77	11.84	19.97	25.40	26.33
SE ±	0.16	0.22	0.21	0.18	0.12	0.17	0.24	0.27
CD 5%	0.49	0.66	0.63	0.54	0.35	0.52	0.72	0.82
Ferti. Levels								
F_1	10.84	28.57	31.28	31.77	12.62	23.18	29.71	30.20
F_2	9.73	25.86	29.68	29.95	11.84	21.64	27.53	28.69
F_3	9.13	23.13	27.88	28.66	11.11	19.53	25.44	25.89
SE ±	0.16	0.22	0.21	0.18	0.12	0.17	0.24	0.27
CD 5%	0.49	0.66	0.63	0.54	0.35	0.52	0.72	0.82
Liq. Bioferti.								
Lb_0	8.18	22.14	28.81	28.98	9.00	16.03	22.30	22.93
Lb_1	12.00	27.51	32.44	33.00	14.44	24.93	30.93	31.40
Lb_2	8.96	25.70	28.92	29.33	11.81	19.96	26.52	27.03
Lb_3	7.70	25.29	26.74	27.66	8.67	19.92	25.93	26.89
Lb_4	12.67	28.63	33.18	33.48	15.37	26.41	32.15	33.04
SE ±	0.14	0.22	0.25	0.21	0.15	0.28	0.36	0.35
CD 5%	0.39	0.63	0.72	0.60	0.41	0.78	1.02	0.99
Interactions								
V x F	NS	Sig.	Sig.	Sig.	NS	NS	Sig.	Sig.
V x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
F x Lb	NS	Sig.	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	Sig.	NS	Sig.	NS	NS	NS	NS

4.1.1.2 Effect of Fertilizer Levels

The mean plant height in groundnut due to fertilizer level F_1 at 30, 60, 90 DAS and at harvest were significantly highest (10.84, 28.57, 31.28 and 31.77 cm, respectively) and it was significantly the lowest under F_3 (9.13, 23.13, 27.88 and 28.66 cm, respectively).

4.1.1.3 Effect of Liquid Biofertilizers

The mean plant height recorded due to liquid biofertilizer application was significantly higher due to Lb_1 (12.00 cm), Lb_2 (8.96 cm) and Lb_4 (12.67 cm) at 30 DAS while it was at par due to Lb_3 (7.70 cm) over control Lb_0 (8.18 cm).

At 60 DAS the mean plant height was significantly higher due to the treatments Lb_1 (27.51 cm), Lb_2 (25.70 cm), Lb_3 (25.29 cm) and Lb_4 (28.63 cm) over control Lb_0 (22.14 cm).

At 90 DAS the mean plant height recorded was significantly higher due to Lb_1 (32.44 cm), Lb_2 (28.92 cm), Lb_4 (33.18 cm) except Lb_3 (26.74 cm) which was at par over control Lb_0 (28.81 cm).

At harvest the mean plant height recorded was significantly higher due to Lb_1 (33.00 cm) and Lb_4 (33.48 cm) and it was significantly the lowest due to Lb_3 (27.66 cm) and at par due to Lb_2 (29.33 cm) over control Lb_0 (28.98 cm).

4.1.1.4 Interaction Effects

The interaction effect due to variety x fertilizer levels and F x Lb at 30 DAS was found to be non-significant.

Interaction effect due to fertilizer x liquid biofertilizer at 90 DAS was found to be non-significant.

Interactions of variety x fertilizer x liquid bio-fertilizer were found to be non-significant at 30 and 90 DAS. Interaction F x Lb was non-significant at harvest.

4.1.1.4.1 Interaction effect of varieties x fertilizer for mean plant height (cm) at 60 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	27.80	25.13	22.53
V_2	30.00	26.40	22.66
V_3	27.93	26.07	24.20
SE ±	0.38		
CD at 5 %	1.14		

The interaction between varieties and fertilizer levels revealed that the variety V_2 with fertilizer F_1 recorded significantly the highest (30.00 cm) mean plant height at 60 DAS over rest of the infractions. While V_1F_3 recorded the lowest (22.53 cm) plant height over rest of the interactions.

4.1.1.4.2 Interaction effect of varieties x fertilizer for mean plant height (cm) at 90 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	34.40	32.267	29.00
V_2	27.93	26.33	25.20
V_3	31.53	30.46	29.47
SE ±	0.36		
CD at 5 %	1.10		

The interaction due to varieties and fertilizer indicated that the V_1 with F_1 and V_2 with F_3 recorded significantly the highest (34.40 cm) and the lowest (25.20 cm) mean plant height respectively at 90 DAS.

4.1.1.4.3 Interaction effect of varieties x fertilizer for mean plant height (cm) at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	34.53	32.53	30.40
V_2	29.00	26.60	25.80
V_3	31.80	30.73	29.80
SE ±	0.31		
CD at 5 %	0.93		

The interaction due to varieties and fertilizer levels observed that the V_1 with F_1 recorded significantly the highest (34.53 cm) mean plant height. However V_2 with F_3 recorded significantly the lowest plant height (25.80 cm). Further V_2 with F_2 was at par (26.60 cm) with it.

4.1.1.4.4 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at 30 DAS (2000)

Var./ Liq. Bioferti.	**Lb_0**	**Lb_1**	**Lb_2**	**Lb_3**	**Lb_4**
V_1	7.67	10.55	8.33	7.55	10.88
V_2	9.56	13.11	10.11	7.88	14.55
V_3	7.33	12.33	8.44	7.66	12.55
SE ±	0.27				
CD at 5 %	0.77				

The interaction due to varieties and liquid biofertilizer indicated that V_2 with Lb_4 recorded significantly the highest plant height (14.55 cm) followed by V_2 Lb_1 (13.11 cm).

4.1.1.4.5 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at 60 DAS (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	21.00	26.88	26.22	23.89	27.78
V_2	22.44	28.11	26.11	25.56	29.55
V_3	23.00	27.55	24.78	26.44	28.55
SE ±	0.41				
CD at 5 %	1.16				

Differences in plant height within the varieties due to different treatments of liquid bio-fertilizer was found to be significant at 60 DAS only. Where plant height of all the three varieties under study was significantly increased from Lb_1 to Lb_4 over control Lb_0.

4.1.1.4.6 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at 90 DAS (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	30.00	34.55	31.00	28.66	35.22
V_2	21.33	30.66	25.11	23.55	31.77
V_3	29.11	32.11	30.66	28.00	32.55
SE ±	0.45				
CD at 5 %	1.28				

The mean plant height was significantly higher with interaction V_1 Lb_4 (35.22 cm) followed by V_1 Lb_1 (34.55 cm) while significantly the lowest plant height was observed in V_2 Lb_0 (21.33 cm) over rest of interactions.

4.1.1.4.7 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at harvest (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	30.66	34.55	31.33	30.55	35.33
V_2	21.77	32.00	25.55	24.22	32.11
V_3	29.11	32.44	31.11	28.22	33.00
SE ±	0.37				
CD at 5 %	1.07				

Interaction between varieties and liquid bio-fertilizer was found to be significant. The variety V_1 with Lb_4 recorded significantly the highest (35.33 cm) plant height followed by V_1 Lb_1 (34.55 cm). Significantly the lowest plant height was recorded by V_2 Lb_0 (21.77 cm) over all other remaining combinations.

4.1.1.4.8 Interaction effect of fertilizer x liquid biofertilizer for mean plant height (cm) at 60 DAS (2000)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	25.22	30.22	29.11	27.00	31.33
F_2	22.11	28.00	25.55	25.66	28.00
F_3	19.11	24.33	22.44	23.22	26.55
SE ±	0.41				
CD at 5 %	1.17				

Differences in plant height due to combined effect of fertilizer and liquid biofertilizer were found to be significant. The interaction F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (31.33 cm) and the lowest (19.11 cm) mean plant height respectively at 60 DAS.

4.1.1.4.9 Interaction effect of varieties x fertilizer levels x liquid biofertilizer for mean plant height (cm) at 60 DAS (2000)

Var. / Ferti. / Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	24.66	20.00	18.33	24.33	23.66	19.33	26.66	22.66	19.66
Lb_1	28.66	27.00	25.00	32.33	28.66	23.33	29.66	28.33	24.66
Lb_2	29.66	25.66	23.33	31.66	25.66	21.00	26.00	25.33	23.00
Lb_3	26.66	26.00	19.00	28.00	25.00	23.66	26.33	26.00	27.00
Lb_4	29.33	27.00	27.00	33.66	29.00	26.00	31.00	28.00	26.66
SE ±	0.67								
C.D at 5 %	1.88								

Interaction between varieties fertilizers and liquid bio-fertilizer for mean plant height at harvest was found to be significant. The treatment combination V_2 F_1 Lb_4 recorded significantly higher (33.66 cm) mean plant height followed by V_2 F_1 Lb_1 (32.33 cm), over rest of interaction. However significantly lower plant height was recorded by the interaction V_1 F_3 Lb_0 (18.33 cm), V_1 F_3 Lb_3 (19.00 cm), V_2 F_3 Lb_0 (19.33 cm) and V_3 F_3 Lb_0 (19.66 cm). It was also observed from the data that plant height of all the three varieties tried were higher under F_1 (RDF) with different liquid biofertilizers and it was reduced with reduced fertilizer level mostly due to 50 per cent of RDF (F_3).

4.1.1.4.10 Interaction effect of varieties x fertilizer levels x liquid biofertilizer for mean plant height (cm) at harvest (2000)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	33.33	32.33	26.33	23.66	21.00	20.66	31.00	29.00	27.33
Lb_1	36.66	34.33	32.66	34.00	31.33	30.66	33.33	32.33	31.66
Lb_2	32.66	31.00	30.33	28.66	24.66	23.33	31.66	31.00	30.66
Lb_3	31.33	30.33	30.00	25.00	24.33	23.33	29.00	28.33	27.33
Lb_4	38.66	34.66	32.66	33.66	31.66	31.00	34.00	33.00	32.00
SE ±	0.64								
C.D at 5 %	1.80								

Differences in plant height due to combined effect of varieties, fertilizer levels and liquid bio-fertilizer were found to be significant at harvest. The variety V_1 under fertilizer F_1 with liquid biofertilizer Lb_4 recorded significantly higher (38.66 cm) plant height. Also it was numerically higher with V_1 F_1 Lb_1 (36.66 cm). while significantly lower plant height was noticed due to treatment combination of V_2 F_3 Lb_0 (20.66 cm) and V_2 F_2 Lb_0 (21.00 cm) over rest of the combinations.

4.1.1.1 Effect of varieties (2001)

From the data presented in Table 6 revealed that the mean plant height in groundnut was recorded significantly higher by V_2 (12.27 cm) and V_3 (11.84 cm) at 30 DAS.

At 60 DAS the variety V_2 (23.60 cm) and V_1 (20.78 cm) recorded significantly higher mean plant height while V_3 (19.97 cm) recorded significantly the lowest.

At 90 DAS it was revealed that V_1 (31.60 cm) recorded significantly the highest mean plant height.

The mean plant height at harvest V_1 (32.33 cm) recorded significantly the highest value.

4.1.1.2 Effect of fertilizer levels

The mean plant height due to F_1 at 30, 60, 90 DAS and at harvest were significantly the highest (12.62, 23.18, 29.71 and 30.20 cm) respectively the lowest under F_3 (11.11, 19.53, 25.44 and 25.89 cm) respectively.

4.1.1.3 Effect of liquid biofertilizer

From the data presented in Table 6 it is observed that the mean plant height was significantly the highest at 30, 60, 90 DAS and at harvest due to different liquid biofertilizer treatment except due to Lb_3 (8.67 cm) on 30 DAS which was at par over the control.

4.1.1.4 Interaction effects

Interaction effect due to variety x fertilizer levels on plant height was found to be non-significant at 30 and 60 DAS.

Interaction effect due to fertilizer x liquid biofertilizer was found to be non-significant at 30, 60, 90 DAS and at harvest.

Interaction effect due to variety x fertilizer x liquid biofertilizer was found to be non-significant at all the stages.

4.1.1.4.1 Interaction effect of varieties x fertilizer for mean plant height (cm) at 90 DAS (2001)

Varieties/ Fertilizer levels	F_1	F_2	F_3
V_1	34.40	32.20	28.20
V_2	27.53	25.40	28.13
V_3	27.20	25.00	24.00
SE ±	0.41		
CD at 5 %	1.25		

The interaction between varieties and fertilizer levels revealed that variety V_1 with F_1 and V_3 with F_3 recorded significantly the highest (34.40 cm) and lowest (24.00 cm) mean plant height respectively at 90 DAS.

4.1.1.4.2 Interaction effect of varieties x fertilizer for mean plant height (cm) at harvest (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	35.20	33.33	28.46
V_2	27.73	26.00	24.60
V_3	27.66	26.73	24.60
SE ±	0.47		
CD at 5 %	1.41		

The interaction between varieties and fertilizer level indicated that variety V_1 with F_1 and V_2 and V_3 with F_3 was significantly the highest (35.20 cm) and lowest (24.60 cm) mean plant height respectively at harvest.

4.1.1.4.3 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at 30 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	9.22	12.88	12.00	8.44	14.77
V_2	8.55	15.33	13.22	8.44	15.77
V_3	9.22	15.11	10.22	9.11	15.55
SE ±	0.25				
CD at 5 %	0.72				

At 30 DAS interaction between varieties and liquid biofertilizers was found to be significant. Where variety V_2 with Lb_4 recorded significantly the highest mean plant height (15.77 cm) followed by V_3Lb_4 (15.55 cm), V_2Lb_1 (15.33 cm), V_3 Lb_1 (15.11 cm).

4.1.1.4.4 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at 60 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	15.11	23.44	19.44	20.88	25.00
V_2	19.22	27.77	20.88	20.88	29.22
V_3	13.77	23.55	19.55	18.00	25.00
SE ±	0.46				
CD at 5 %	1.31				

Variation for plant height due to combined effect of varieties and liquid biofertilizer was found to be significant. The treatment combination V_2 Lb_4 and V_3 Lb_0 recorded significantly the highest (29.22 cm) and the lowest (13.77 cm) mean plant height respectively at 60 DAS.

4.1.1.4.5 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at 90 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	25.11	36.55	30.22	28.11	38.00
V_2	20.66	28.22	24.88	24.66	30.00
V_3	21.11	28.00	24.44	25.00	28.44
SE ±	0.60				
CD at 5 %	1.72				

Differences in plant height due to combined effect of varieties and liquid biofertilizer was found to be significant at 90 DAS. The variety V_1 with Lb_4 recorded significantly the highest (38.00 cm) mean plant height followed by V_1 Lb_1 (36.55 cm) over rest of the interaction. However, V_3 Lb_0 observed significantly the lowest (21.11 cm) plant height over rest of interaction.

4.1.1.4.6 Interaction effect of varieties x liquid biofertilizer for mean plant height (cm) at harvest (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	26.00	37.78	30.22	29.00	38.66
V_2	21.11	28.44	25.33	24.88	30.77
V_3	21.66	28.00	25.55	26.77	29.66
SE ±	0.61				
CD at 5 %	1.73				

The combination of V_1 Lb_4 observed significantly the highest (38.66 cm) mean plant height followed by V_1 Lb_1 (37.78 cm) than other combination tried. Also V_2 Lb_0 recorded significantly the lowest (21.11 cm) mean plant height over rest of combination.

The interaction of F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (36.00 cm) and the lowest (20.88 cm) mean plant height over rest of interaction at harvest.

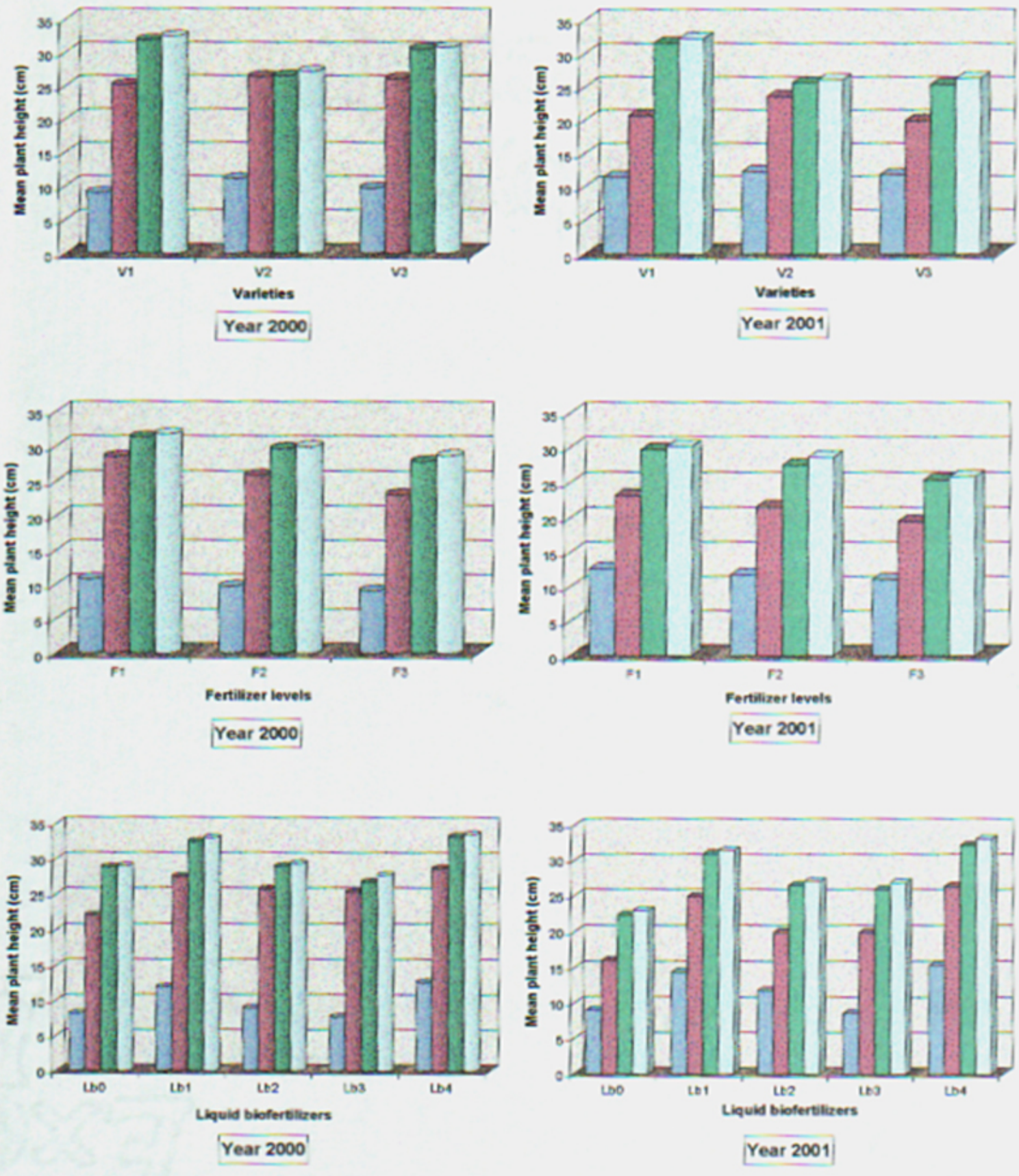


Fig. 3 : Mean plant height (cm) of groundnut as affected by different treatments

4.1.2 Mean number of primary branches per plant

Data on mean number of primary branches per plant of groundnut as affected by different treatments during 2000 and 2001 are presented in Table 7.

4.1.2.1 Effect of varieties (2000)

The mean number of primary branches were non-significant at 30, 60, 90 DAS and at harvest.

4.1.2.2. Effect of fertilizer levels

At 30 DAS mean number of primary branches, per plant due to application of different fertilizer levels F_1 was significantly the highest (4.46) and it was significantly the lowest due to F_3 (4.29).

At 60 DAS mean number of primary branches under F_1 was significantly the highest (4.50) and under F_2 it was at par (4.39) while it was significantly the lowest under F_3 (4.26).

Similarly, these fertilizer levels were also recorded similar trend at 90 DAS. F_1 (4.52), F_2 (4.39) and F_3 (4.20).

At harvest the mean number of primary branches per plant was significantly the highest in F_1 (4.54) while it was significantly the lowest in F_2 (4.38) and F_3 (4.23) treatments.

4.1.2.3. Effect of liquid biofertilizer

At 30 DAS the mean number of primary branches per plant recorded due to liquid biofertilizer application significantly higher due to Lb_1 (4.57) Lb_2 (4.20), Lb_3 (4.27) and Lb_4 (4.80) over control Lb_0 (4.00).

At 60 DAS the mean number of primary branches per plant recorded due to liquid biofertilizer application was significantly the highest due to Lb_4 (4.94) and Lb_1 (4.78) while it was at par due to Lb_3 (4.11) and Lb_2 (4.05) over control Lb_0 (4.03).

Table 7. Mean number of primary branches per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	4.34	4.38	4.34	4.33	4.47	4.79	5.57	4.76
V_2	4.42	4.43	4.39	4.40	4.64	5.77	5.40	4.67
V_3	4.33	4.34	4.38	4.41	4.73	4.71	4.55	4.63
SE ±	0.032	0.040	0.044	0.044	0.37	0.63	0.65	0.55
CD 5%	NS	NS	NS	NS	0.11	NS	NS	NS
Ferti. Levels								
F_1	4.46	4.50	4.52	4.54	4.66	4.70	6.22	4.66
F_2	4.34	4.39	4.39	4.38	4.56	4.71	4.58	4.65
F_3	4.29	4.26	4.20	4.23	4.62	5.86	4.72	4.75
SE ±	0.032	0.040	0.044	0.044	0.37	0.63	0.65	0.55
CD 5%	0.095	0.12	0.132	0.13	NS	NS	NS	NS
Liq. Bioferti.								
Lb_0	4.00	4.03	4.00	4.05	4.00	4.20	6.04	4.25
Lb_1	4.57	4.78	4.59	4.71	5.24	7.03	4.87	5.12
Lb_2	4.20	4.05	4.09	4.01	4.04	4 20	4.44	4.22
Lb_3	4.27	4.11	4.25	4.23	4.04	4.61	5.79	4.50
Lb_4	4.80	4.94	4.91	4.90	5.37	5.40	4.72	5.35
SE ±	0.058	0.041	0.055	0.063	0.058	0.80	0.84	0.13
CD 5%	0.16	0.11	0.15	0.17	0.16	NS	NS	0.36
Interactions								
V x F	NS	NS	NS	NS.	Sig.	NS	NS	NS.
V x Lb	NS	NS	NS	NS	Sig.	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	Sig.	NS	NS	NS

At 90 DAS mean number of primary branches per plant was recorded significantly the highest due to Lb_4 (4.91), Lb_1 (4.59) and Lb_3 (4.25) and it was at par due to Lb_2 (4.09) over control Lb_0 (4.00).

Further, the mean number of primary branches per plant at harvest was recorded significantly the highest due to treatments Lb_4 (4.90), Lb_1 (4.71) Lb_3 (4.23) and it was at par due to Lb_2 (4.01) over control Lb_0 (4.05).

4.1.2.4 Interaction effects

The interactions were found to be non-significant.

4.1.2.1 Effect of varieties (2001)

At 30 DAS variety V_3 recorded significantly the highest (4.73) mean number of primary branches, per plant, while V_1 recorded significantly the lowest (4.47) and V_2 was at par (4.64).

At 60, 90 DAS and at harvest the observations on mean number of primary branches recorded were found to be non-significant.

4.1.2.2 Effect of fertilizer levels

The data recorded on mean number of primary branches per plant at 30, 60, 90 DAS and at harvest due to application of different fertilizer levels were found to non-significant.

4.1.2.3 Effect of liquid biofertilizers

At 30 DAS the mean number of primary branches per plant recorded was significantly the highest due to Lb_4 (5.37), Lb_1 (5.24) and due to Lb_2, Lb_3 it was at par (4.04) over control Lb_0 (4.00).

At 60 and 90 DAS the data recorded on mean number of primary branches per plant due to different biofertilizer treatments were found to be non-significant.

At harvest due to Lb_4 and Lb_1 treatments the mean number of primary branches per plant was significantly the highest (5.35, 5.12) respectively. While treatment Lb_3 (4.50) and Lb_2 (4.22) were at par over control Lb_0 (4.25).

4.1.2.4 Interactions effects

Interactions due to V x F, V x Lb and V x F x Lb were found to be non-significant except F x Lb at 30 DAS.

4.1.2.4.1 Interaction effect of varieties x fertilizer for mean number of primary branches at 30 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	4.24	4.48	4.68
V_2	4.86	4 46	4.59
V_3	4.86	4.73	4.59
SE ±	0.065		
CD at 5 %	0.19		

The interaction effects due to varieties and fertilizer levels on mean number of primary branches per plant were found to be significant at 30 DAS. The mean number of primary branches per plant significantly the highest due to V_2 and V_3 with F_1 (4.86) followed by V_1F_3 (4.68) and V_3F_2 (4.73) while V_1 with F_1 recorded significantly the lowest (4.24) and rest of the combination was at par with it.

4.1.2.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of primary branches at 30 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	4.00	4.88	4.11	4.29	5.07
V_2	4.00	5.25	4.63	4.47	5.44
V_3	4.00	5.59	4.00	4.44	5.62
SE ±	0.097				
CD at 5 %	0.27				

Interaction between varieties and liquid biofertilizer was found to be significant where interaction V_3 Lb_4 produced significantly the highest (5.62) mean number of primary branches per plant followed by V_3 Lb_1 and V_2 Lb_4 (5.59, 5.44) respectively at 30 DAS.

4.1.2.4.3 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of primary branches at 30 DAS (2001)

Var. / Ferti. / Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Lb_1	4.44	4.99	5.22	5.66	4.66	5.44	5.55	5.66	5.55
Lb_2	4.00	4.00	4.33	4.00	4.11	4.00	4.00	4.00	4.00
Lb_3	4.11	4.33	4.44	4.99	4.33	4.11	4.88	4.22	4.22
Lb_4	4.66	5.11	5.44	5.66	5.21	5.44	5.88	5.77	5.22
SE ±	0.17								
C.D at 5 %	0.48								

Data relating to mean number of primary branches indicated that interaction V_3 F_1 Lb_4 recorded significantly higher (5.88) mean number of primary branches per plant followed by V_1F_3 Lb_4 (5.44), V_2 F_1 Lb_1 and Lb_4 (5.66), V_2 F_3 Lb_4 (5.44) V_3 F_1 Lb_1 (5.55), V_3 F_2 Lb_1 and Lb_4 (5.66 and 5.77), V_3 F_3 Lb_1 and Lb_4 (5.55, 5.22) respectively.

From these results it could be seen that the varieties tested with liquid biofertilizer treatments such as Lb_1 and Lb_4 produced higher number of mean primary branches over rest of liquid biofertilizer treatments.

4.1.3 Mean number of secondary branches per plant

Data regarding mean number of secondary branches per plant as affected by different treatments during the year 2000 and 2001 are presented in Table 8.

Table 8. Mean number of secondary branches per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	1.45	1.58	1.69	1.53	1.23	1.33	1.41	1.50
V_2	1.52	1.51	1.67	1.52	1.34	1.40	1.48	1.93
V_3	1.58	1.58	1.64	1.56	1.44	1.36	1.45	1.56
SE ±	0.038	0.034	0.061	0.034	0.64	0.35	0.036	0.24
CD 5%	NS	NS	NS	NS	NS	NS	NS	NS
Ferti. Levels								
F_1	1.62	1.69	1.83	1.64	1.36	1.43	1.48	1.97
F_2	1.51	1.56	1.65	1.54	1.30	1.36	1.45	1.54
F_3	1.42	1.41	1.51	1.44	1.36	1.31	1.41	1.49
SE ±	0.38	0.034	0.061	0.034	0.64	0.35	0.36	0.24
CD 5%	0.113	0.10	0.18	0.102	NS	NS	NS	NS
Liq Bioferti.								
Lb_0	1.06	1.07	1.21	1.20	1.28	1.00	1.03	1.34
Lb_1	2.13	1.16	2.30	1.99	1.38	1.69	1.80	2.30
Lb_2	1.07	1.14	1.15	1.23	1.86	1.16	1.16	1.54
Lb_3	1.06	1.12	1.21	1.10	1.38	1.13	1.26	1.34
Lb_4	2.26	2.28	2.45	2.17	1.58	1.86	1.98	1.81
SE ±	0.044	0.051	0.049	0.089	0.11	0.048	0.058	0.32
CD 5%	0.12	0.14	0.15	0.25	0.31	0.13	0.16	NS
Interactions								
V x F	NS	NS	NS	NS.	NS.	NS	NS	NS.
V x Lb	NS	NS	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.1.3.1 Effect of varieties (2000)

The observations recorded on mean number of secondary branches per plant at different varieties at 30, 60, 90 DAS and at harvest were statistically non-significant.

4.1.3.2 Effect of fertilizer levels

At 30 DAS under F_1 and F_3 recorded significantly the highest and the lowest mean number of secondary branches per plant (1.62, 1.42) respectively, however, it was at par under F_2 (1.51).

At 60 DAS under F_1 and F_3 recorded significantly the highest and lowest mean number of secondary branches per plant (1.69, 1.41) respectively. However under F_2 (1.56) recorded significantly highest mean secondary branches over F_3 (1.41).

At 90 DAS under F_1 and F_3 recorded significantly highest (1.83) and lowest (1.51) mean secondary branches per plant while it was at par under F_2 (1.65) over F_3 (1.51).

Similar results were also noticed at harvest where F_1 and F_3 recorded significantly the highest (1.64) and lowest (1.44) mean number of secondary branches.

4.1.3.3 Effect of liquid biofertilizers

At 30 DAS mean secondary branches per plant recorded was significantly higher due to Lb_4 (2.26) and Lb_1 (2.13) while it was at par due to Lb_2 (1.07) over control Lb_0 (1.06).

At 60 DAS Lb_4 (2.28) recorded significantly the highest mean number of secondary branches per plant and due to Lb_1 (1.16), Lb_2 (1.14) and Lb_3 (1.12) were at par over control Lb_0 (1.07).

At 90 DAS the mean number of secondary branches per plant were significantly highest due to Lb_4 (2.45) and Lb_1 (2.30) while Lb_2 (1.15) were at par with control Lb_0 (1.21).

At harvest the mean number of secondary branches per plant was significantly highest due to Lb_4 (2.17) and Lb_1 (1.99) while Lb_2 (1.23) and Lb_3 (1.10) were at par over control Lb_0 (1.20).

4.1.3.4 The interaction effects

The interactions were statistically found to be non-significant at all the stages.

4.1.3.1 Effect of varieties (2001)

The data recorded on mean number of secondary branches per plant of varieties at 30, 60, 90 DAS and at harvest were statistically non-significant.

4.1.3.2 Effect of fertilizer levels

The mean number of secondary branches per plant under fertilizer levels were not influenced significantly.

4.1.3.3 Effect of liquid biofertilizers

At 30 DAS mean number of secondary branches per plant was significantly the highest due to Lb_2 (1.86) while remaining treatments Lb_3 and Lb_1 (1.38) and Lb_4 (1.58) were at per over control Lb_0 (1.28).

At 60 DAS the mean number of secondary branches per plant was significantly higher with almost all treatments as Lb_1 (1.69), Lb_2 (1.16), Lb_4 (1.86) except Lb_3 (1.13) which was at par over control Lb_0 (1.00).

Further, at 90 DAS due to Lb_4 (1.98), Lb_1 (1.80) and Lb_3 (1.26) recorded significantly the highest mean number of secondary branches per plant except Lb_2 (1.16) which was at par over control Lb_0 (1.03).

However, the mean number of secondary branches per plant recorded at harvest were statistically non-significant.

4.1.3.4 The Interaction effects

Interactions were found to be non-significant at 30, 60, 90 DAS and at harvest.

4.1.4 Mean number of leaves per plant

The data on mean number of leaves per plant for the year 2000 and 2001 are given in Table 9 and graphically depicted in Fig. 4.

Table 9. Mean number of leaves per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	21.07	49.36	48.80	39.70	16.71	36.48	21.64	15.44
V_2	21.64	51.50	32.24	24.78	15.93	33.86	18.28	14.15
V_3	21.13	43.49	36.20	27.71	16.73	31.18	20.66	13.24
SE ±	0.32	0.30	0.31	0.48	0.15	0.25	0.32	0.22
CD 5%	Ns	0.91	0.94	1.43	0.44	0.74	0.95	0.67
Ferti. Levels								
F_1	23.36	51.40	40.71	33.24	17.44	36.24	23.64	16.00
F_2	21.50	48.56	39.40	30.93	16.48	34.15	20.28	14.20
F_3	19.00	44.38	37.13	28.00	15.48	31.13	16.66	12.64
SE ±	0.32	0.30	0.31	0.48	0.15	0.25	0.32	0.22
CD 5%	0.960	0.91	0.94	1.43	0.44	0.74	0.95	0.67
Liq. Bioferti.								
Lb_0	14.14	40.56	31.63	24.59	12.48	24.85	14.29	11.63
Lb_1	25.66	54.85	45.00	37.00	19.85	38.15	24.33	16.52
Lb_2	18.51	42.07	30.41	24.52	16.44	32.85	17.48	14.07
Lb_3	18.59	41.67	30.67	23.89	12.63	32.63	16.66	12.44
Lb_4	29.19	61.41	57.70	43.63	20.96	41.03	28.22	16.74
SE ±	0.45	0.47	0.45	0.68	0.21	0.39	0.32	0.26
CD 5%	1.24	1.33	1.20	1.87	0.60	1.07	0.91	0.73
Interactions								
V x F	NS	Sig.	NS	NS.	Sig.	NS	Sig.	Sig.
V x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
F x Lb	NS	NS	NS	NS	NS	NS	Sig.	NS
V x F x Lb	NS	NS	NS	NS	Sig.	NS	Sig.	NS

4.1.4.1 Effect of varieties (2000)

The data recorded on mean number of leaves per plant of varieties at 30 DAS was statistically non-significant.

At 60 DAS the variety V_2 reocrded significantly the highest mean number of leaves per plant (51.50) while V_3 recorded significantly the lowest (43.49).

At 90 DAS the mean number of leaves recorded by the V_1 was significantly highest (48.80). However, V_2 was recorded significantly lowest (32.24). Also V_3 recorded significantly higher leaves (36.20) over V_2 (32.24).

At harvest the mean number of leaves recorded by V_1 and V_2 were significantly highest and lowest (39.70, 24.78) respectively.

It is observed from the data that mean number of leaves per plant increased from 30 to 60 DAS while it was reduced at 90 DAS and upto at harvest.

4.1.4.2 Effect of fertilizer levels

The mean number of leaves per plant at 30 DAS was significantly highest under F_1 (23.36) and significantly lowest under F_3 (19.00) while F_2 recorded significantly highest (21.50) leaves over F_3.

At 60 DAS the mean number of leaves per plant under F_1 and F_3 were recorded significantly the highest and lowest (51.40, 44.38) respectively.

Further, at 90 DAS the mean leaf number per plant under F_1 and F_3 were significantly highest and lowest (40.71, 37.13) while F_2 gives significantly highest leaves (39.40) over F_3.

At harvest, similar results were recorded at 30, 60 and 90 DAS. However, F_1 and F_3 recorded significantly highest (33.24) and lowest (28.00) leaves respectively while F_2 recorded (30.93) leaves which was significantly higher over F_3.

Further, total number of leaves was reduced at 90 DAS and mostly upto harvest.

4.1.4.3 Effect of liquid biofertilizer

At 30 DAS the number of leaves per plant was significantly higher due to all the treatments of liquid biofertilizers Lb_4 (29.19), Lb_1 (25.66), Lb_3 (18.59) and Lb_2 (18.51) over control Lb_0 (14.14).

At 60 DAS the number of leaves per plant was significantly increase due to Lb_4 (61.41), Lb_1 (54.85), Lb_2 (42.07) except Lb_3 (41.67) which was at par with control Lb_0 (40.56).

At 90 DAS mean number of leaves per plant was significantly the highest due to Lb_4 (57.70) and Lb_1 (45.00) while it was significantly lowest due to Lb_2 (30.41) and at par due to Lb_3 (30.67) over control Lb_0 (31.63).

At harvest the number of leaves per plant was significantly highest due to Lb_4 (43.63) and Lb_1 (37.00) while it was at par due to Lb_2 (24.52) and Lb_3 (23.89) over control Lb_0 (24.59).

4.1.4.4 The interaction effects

Interaction due to V x F at 60 DAS and V x Lb at all the growth stages was statistically significant while rest of the interactions were found to be non-significant.

4.1.4.4.1 Interaction effect of varieties x fertilizer for mean number of leaves per plant at 60 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	53.27	48.07	46.73
V_2	55.60	54.00	44.87
V_3	45.33	43.60	41.52
SE ±	0.52		
CD at 5 %	1.57		

The interactive effects due to varieties and fertilizer levels on mean number of leaves per plant at 60 DAS was found to be significant. The variety V_2 with F_1 and V_3F_3 combination recorded significantly the highest (55.60) and the lowest (41.52) mean number of leaves per plant respectively.

4.1.4.4.2 Interaction effect of varieties x liquid biofertilizers for mean number of leaves per plant at 30 DAS (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	16.22	22.89	17.66	17.33	31.22
V_2	15.89	27.33	18.22	18.44	28.33
V_3	11.22	26.78	19.66	20.00	28.00
SE ±	0.76				
CD at 5 %	2.16				

The combined effects due to varieties and liquid bio-fertilizer were found to be significant at 30 DAS. Where V_1Lb_4 and V_3Lb_0 produced significantly the highest (31.22) and the lowest (11.22) mean number of leaves per plant respectively.

4.1.4.4.3 Interaction effect of varieties x liquid biofertilizers for mean number of leaves per plant at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	43.67	55.66	45.44	45.22	56.78
V_2	34.56	56.44	45.22	46.89	74.33
V_3	43.44	52.44	35.55	32.89	53.11
SE ±	0.79				
CD at 5 %	2.24				

At 60 DAS interaction between varieties and liquid biofertilizer were found to be significant. The combination V_2 Lb_4 recorded significantly the highest (74.33) number of leaves per plant while V_3 Lb_3 produced significantly the lowest (32.89) leaves followed by V_2 Lb_0 (34.56) over rest of the interaction.

4.1.4.4.4 Interaction effect of varieties x liquid biofertilizers for mean number of leaves per plant at 90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	45.78	56.88	35.22	36.00	70.11
V_2	26.56	38.11	22.67	28.66	45.22
V_3	22.75	40.00	33.33	27.33	57.78
SE ±	0.76				
CD at 5 %	2.17				

The interactive effects due to varieties and liquid biofertilizers on mean number of leaves per plant at 90 DAS were found to be significant. Among the treatment combination tried interaction V_1 Lb_4 produced significantly the highest (70.11) mean number of leaves while lowest was recorded by V_3 Lb_0 (22.75).

At 90 DAS under F_1 and F_3 recorded significantly the highest and lowest (23.64, 16.66) leaves per plant respectively while under F_2 it was significantly highest (20.28) over F_3 (16.66).

At harvest similar results was obtained under F_1 and F_3 recorded significantly highest and lowest leaves per plant (16.00, 12.64 respectively).

4.1.4.3 Effect of liquid biofertilizer

The mean number of leaves were significantly higher due to all the liquid biofertilizer treatments at 30, 60, 90 DAS and at harvest, as Lb_1 (19.85, 38.15, 24.33 and 16.52), Lb_2 (16.44, 32.85, 17.48 and 14.07), Lb_3 (32.63, 16.66, 12.44) and Lb_4 (20.96, 41.03, 28.22, 16.74) respectively except due to Lb_3 (12.63) which was at par over control Lb_0 (12.48, 24.85, 14.29, 11.63).

4.1.4.4 The interaction effects

Interaction due to V x F was non-significant at 60 DAS.

Interaction due to F x Lb was found to be non-significant at 30 and 60 DAS and at harvest.

Interaction due to V x F x Lb was statistically found to be non-significant at 60 DAS and at harvest.

4.1.4.4.1 Interaction effect of varieties x fertilizer for mean number of leaves per plant at 30 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	16.80	17.26	16.06
V_2	17.60	15.73	14.46
V_3	17.93	16.46	15.93
SE ±	0.25		
CD at 5 %	0.76		

The combination of V_3 and V_2 with F_1 and V_1 F_2 recorded significantly the highest number of leaves per plant (17.93, 17.60, 17.26) respectively. However V_2 F_3 noticed significantly lowest (14.46) leaves and rest of the combination was at par with it.

4.1.4.4.2 Interaction effect of varieties x fertilizer for mean number of leaves per plant at 90 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	24.73	21.33	18.66
V_2	20.53	18.20	16.13
V_3	25.66	21.33	15.00
SE ±	0.55		
CD at 5 %	1.65		

The significantly highest leaves was recorded by the combination V_3 F_1 (25.66) followed by V_1 F_1 (24.73) while V_3 F_3 recorded significantly the lowest (15.00) number of leaves per plant. However rest of the combination were at par with it.

4.1.4.4.3 Interaction effect of varieties x fertilizer for mean number of leaves per plant at harvest (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	17.40	15.13	13.80
V_2	16.46	14.06	11.93
V_3	14.13	13.40	12.20
SE ±	0.38		
CD at 5 %	1.15		

Variation for total number of leaves due to combined effect of varieties and fertilizers were found to be significant. The treatment combination of V_1 F_1 observed significantly the highest (17.40) leaves per plant followed by V_2 F_1 (16.46). However V_2 F_3 recorded significantly the lowest number of leaves per plant (11.93) and remaining combination were at par with it.

4.1.4.4.4 Interaction effect of varieties x liquid biofertilizer for mean number of leaves per plant at 30 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	12.11	19.77	18.22	12.77	20.66
V_2	12.55	18.88	16.11	12.00	20.11
V_3	12.77	20.00	15.00	13.11	22.11
SE ±	0.35				
CD at 5 %	1.01				

Differences in number of leaves per plant due to varieties and liquid bio-fertilizer were found to be significant at 30 DAS. Where V_3 Lb_4 produced significantly the highest (22.11) mean number of leaves per plant over rest of the intersection.

4.1.4.4.5 Interaction effect of varieties x liquid biofertilizer for mean number of leaves per plant at 60 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	24.88	43.22	33.88	35.22	45.22
V_2	24.88	36.66	35.66	32.33	39.77
V_3	23.88	34.55	29.00	30.33	38.11
SE ±	0.64				
CD at 5 %	1.84				

At 60 DAS interaction between varieties and liquid biofertilizer was found to be significant. The treatment combination V_1 Lb_4 produced significantly the highest (45.22) number of leaves per plant while with V_3 Lb_0 it was significantly lowest (23.88) followed by V_1 and V_2 Lb_0 (24.88).

4.1.4.4.6 Interaction effect of varieties x liquid biofertilizer for mean number of leaves per plant at 90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	16.44	26.88	18.33	19.11	27.44
V_2	13.22	21.88	16.66	16.44	23.22
V_3	13.22	24.22	17.44	14.44	34.00
SE ±	0.59				
CD at 5 %	1.69				

Interaction effect between varieties and liquid biofertilizer was found to be significant where, V_3 Lb_4 recorded significantly the highest (34.00) number of leaves per plant over rest of the interactions.

4.1.4.4.7 Interaction effect of varieties x liquid biofertilizer for mean number of leaves per plant at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	14.00	17.22	14.22	13.66	18.11
V_2	11.66	16.33	12.88	13.88	16.00
V_3	9.22	16.00	15.11	9.77	16.11
SE ±	0.46				
CD at 5 %	1.30				

At harvest interaction between varieties and liquid biofertilizer was found to be significant. The treatment combination V_1 Lb_4 produced significantly the highest (18.11) number of leaves followed by V_1 Lb_1 (17.22). While significantly lowest leaves per plant was observed in V_3 Lb_0 (9.22) followed by V_3 Lb_3 (9.77) respectively over rest of combination.

4.1.4.4.8 Interaction effect of fertilizer x liquid biofertilizer for mean number of leaves per plant at 90 DAS (2001)

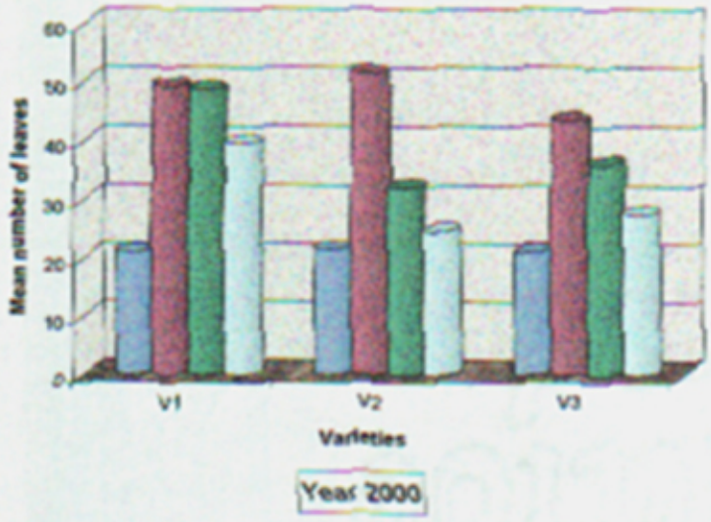
Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	17.11	28.22	21.77	18.55	32.55
F_2	13.44	24.88	16.11	16.77	30.22
F_3	12.33	19.88	14.55	14.66	21.88
SE ±	0.59				
CD at 5 %	1.69				

Variation in number of leaves due to combined effect of fertilizer and liquid bio-fertilizer was found to be significant. The treatment combination of F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (32.55) and the lowest (12.33) number of leaves per plant respectively over rest of the combinations at 90 DAS.

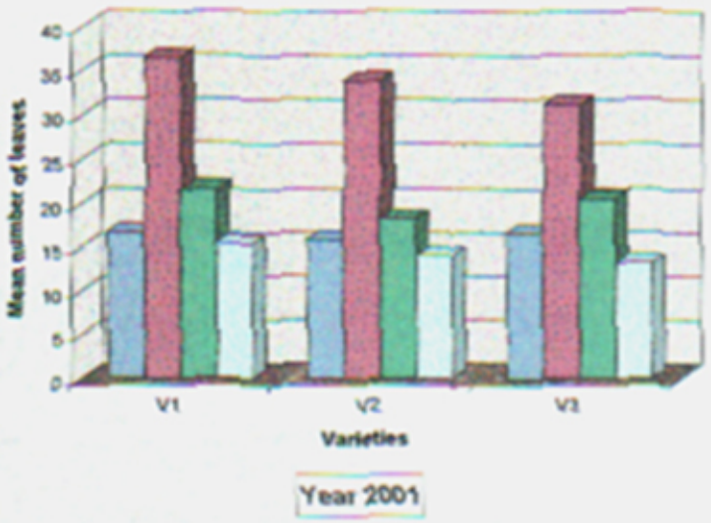
4.1.4.4.9 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of leaves per plant at 30 DAS (2001)

Var. / Ferti. / Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	11.66	12.33	12.33	13.66	12.66	11.33	15.33	12.00	11.00
Lb_1	19.00	20.66	19.66	21.66	18.33	17.00	21.66	20.00	20.33
Lb_2	18.00	19.33	17.33	17.00	16.66	14.66	16.00	14.66	14.00
Lb_3	14.66	12.66	11.00	14.00	11.33	10.66	13.33	13.33	12.66
Lb_4	20.66	21.33	20.00	22.00	19.66	18.66	23.33	21.66	21.33
SE ±	1.16								
C.D at 5 %	3.26								

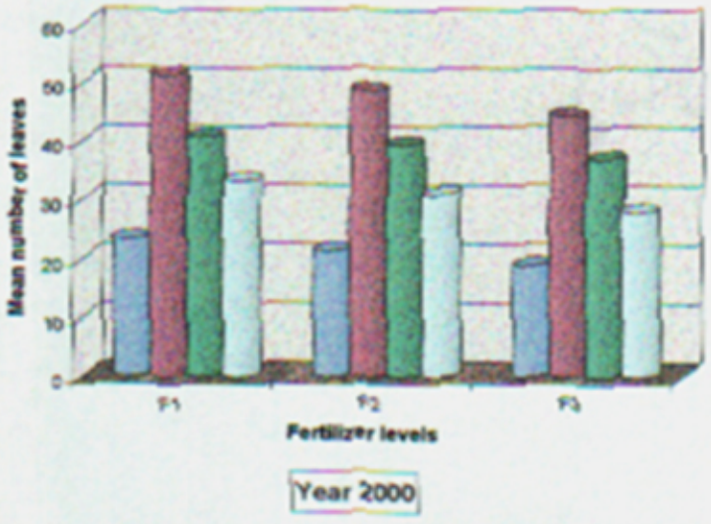
The combined effect due to varieties, fertilizer levels and liquid biofertilizer were found to be significant for number of leaves per plant produced at 30 DAS. The treatment combination V_3 F_1 Lb_4 produced significantly higher (23.33) number of leaves followed by V_1 F_2 Lb_1 and Lb_4 (20.66, 21.33 respectively).



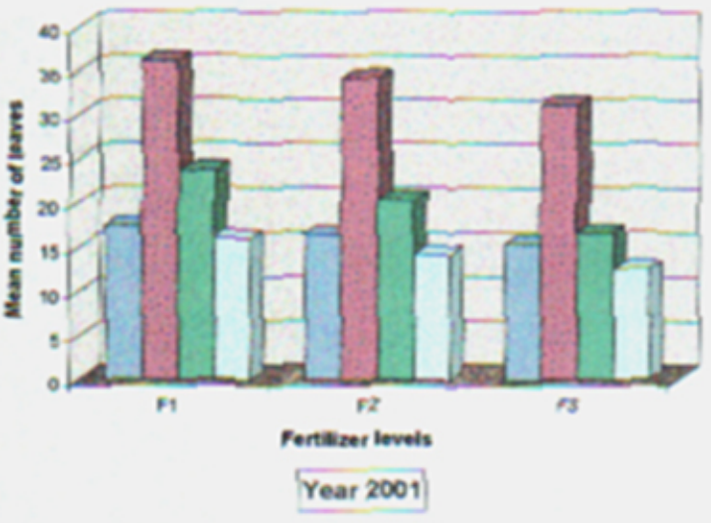
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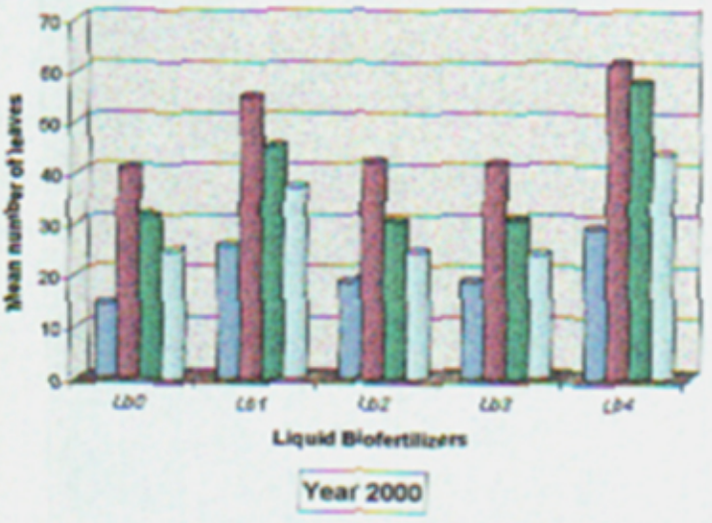
Year 2001



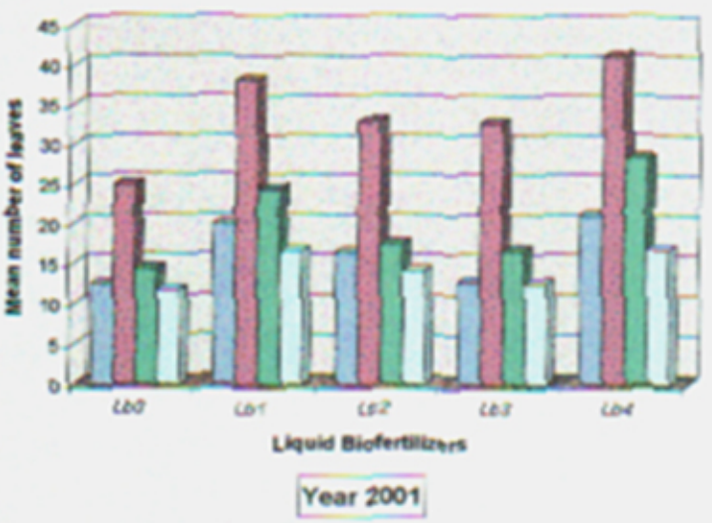
Year 2000



Year 2001



Year 2000



Year 2001



Fig. 4 : Mean number of leaves per plant of groundnut as affected by different treatments

4.1.4.4.10 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of leaves per plant at 90 DAS (2001)

Var. / Ferti. / Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	20.33	15.33	13.66	15.66	13.00	11.00	15.33	12.00	12.33
Lb_1	29.31	26.66	24.66	25.33	21.33	19.00	30.00	26.66	16.00
Lb_2	22.33	17.00	15.66	18.66	16.66	14.66	24.33	14.66	13.33
Lb_3	21.33	18.66	17.33	18.00	17.33	14.00	16.33	14.33	12.66
Lb_4	30.33	29.00	23.00	25.00	22.66	22.00	42.33	39.00	20.66
SE ±	2.73								
C.D at 5 %	10.97								

Significantly the highest number of leaves per plant was observed in the interaction V_3F_1 Lb_4 (42.33) while significantly lower number of leaves per plant observed with combination V_2 F_3 Lb_0 (11.00) and also with V_2 and V_3 F_2 Lb_0 (13.00, 12.00 respectively) at 90 DAS.

4.1.5 Mean number of flowers per plant

Data regarding mean number of flowers per plant in groundnut (2000 and 2001) are given in Table 10.

4.1.5.1 Effect of varieties (2000)

At 30 DAS the variety V_1 and V_3 recorded significantly the highest (30.49) and lowest (24.09) flowers while V_2 recorded (26.42) significantly the highest flowers per plant over V_3.

At 60 DAS V_2 and V_3 recorded significantly the highest mean number of flowers per pant (159.58 and 119.24) respectively. However, V_1 recorded significantly the highest mean number of flowers (151.49) over V_3. This was also observed from the data that maximum number of flowers were recorded by this time.

At 90 DAS V_1 and V_3 recorded significantly the highest and the lowest mean number of flowers per plant (79.58 and 54.40) respectively.

Table 10. Mean number of flowers per plant of groundnut as affected by different treatment

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	30.49	151.49	79.58	39.00	18.53	81.20	43.62	44.43
V_2	26.42	159.58	55.13	13.43	16.04	102.13	28.68	15.26
V_3	24.09	119.24	54.40	36.20	17.89	76.24	41.33	43.29
SE ±	0.46	2.33	0.73	0.49	0.31	1.76	0.67	0.63
CD 5%	1.37	6.98	2.18	1.46	0.93	5.27	2.01	1.82
Ferti. Levels								
F_1	30.22	159.86	71.04	31.92	18.44	91.46	39.91	36.76
F_2	27.00	142.96	62.00	30.08	17.71	87.40	38.73	34.11
F_3	23.79	127.49	56.06	26.66	16.31	80.71	35.00	32.09
SE ±	0.46	2.33	0.73	0.49	0.31	1.76	0.67	0.63
CD 5%	1.37	6.98	2.18	1.46	0.93	5.27	2.01	1.82
Liq. Bioferti.								
Lb_0	19.11	97.89	42.18	26.41	14.00	66.77	26.77	34.61
Lb_1	31.26	170.48	75.63	33.41	20.70	104.33	46.29	37.20
Lb_2	22.11	117.22	50.78	25.18	15.63	75.48	31.66	35.08
Lb_3	24.30	130.04	56.78	25.78	16.29	79.00	34.52	32.86
Lb_4	38.26	201.56	89.81	36.37	20.81	107.03	50.15	31.90
SE ±	0.59	2.77	1.55	0.64	0.35	1.82	0.72	0.65
CD 5%	1.64	7.67	4.36	1.77	0.98	2.28	1.99	1.79
Interactions								
V x F	NS	NS	Sig.	NS.	NS	NS	NS	NS
V x Lb	Sig.	Sig.	Sig.	NS	Sig.	NS	Sig.	NS
F x Lb	NS	NS	NS	NS	NS	Sig.	Sig.	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS



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Similarly over the period upto harvest V_1 and V_3 recorded significantly the highest and lowest mean number of flowers per plant (39.00 and 36.20) respectively over V_2 (13.43).

4.1.5.2 Effect of fertilizer levels

At 30 DAS the mean number of flowers recorded under F_1 and F_3 was significantly the highest and lowest (30.22 and 23.79) while under F_2 mean number of flowers per plant was significantly the highest (27.00) over F_3 (23.79).

At 60 DAS similar results were obtained under F_1 and F_3 which recorded significantly highest and lowest (159.86 and 127.49) mean number of flower per plant. However, under F_2 significantly highest flowers (142.96) was recorded over F_3.

At 90 DAS mean number of flowers under F_1 and F_3 was recorded significantly the highest and the lowest (71.04 and 56.06) while under F_2 significantly highest flowers per plant was recorded (62.00) as compared with F_3.

At harvest the similar observation were recorded at 30, 60, 90 DAS. Under F_1 and F_3 significantly highest and lowest flowers per plant were recorded (31.92, 26.66) over the period of starting of the flowering upto the cessation of the same. While under F_2 number of flowers recorded was significantly highest (30.08) over F_3.

4.1.5.3 Effect of liquid biofertilizer

From the data presented in Table 10 it was observed that mean number of flowers recorded significantly higher due to Lb_1 (31.26, 170.48, 75.63, 33.41) Lb_2 (22.11, 117.22, 50.78, 25.18) Lb_3 (24.30, 130.04, 56.78, 25.78) Lb_4 (38.26, 201.56, 89.81, 36.37) all the liquid bio-fertilizer treatments at 30, 60, 90 DAS and at harvest respectively over control Lb_0 (19.11, 97.89, 42.18, 26.41).

4.1.5.4 The interaction effects

Interaction due to V x F was found to be non-significant at 30, 60 DAS and at harvest. Interaction due to F x Lb and V x F x Lb were found to be statistically non-significant at all the stages.

4.1.5.4.1 Interaction effects of varieties x fertilizer for mean number of flowers per plant at 90 DAS (2000)

Varieties / Fertilizer levels	F_1	F_2	F_3
V_1	88.53	78.80	71.40
V_2	59.66	55.27	50.46
V_3	64.93	51.93	46.33
SE ±	1.26		
CD at 5 %	3.78		

Mean number of flowers per plant was found significantly higher in variety V_1 when coupled with F_1 level of fertilizer (88.53) while V_3 F_3 combination recorded significantly the lowest (46.33) flowers and rest of combination were significantly superior over it.

4.1.5.4.2 Interaction effects of varieties x liquid biofertilizer for mean number of flowers per plant at 30 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	21.88	36.77	22.11	26.77	44.89
V_2	17.00	30.89	23.00	24.22	37.00
V_3	18.44	26.11	21.22	21.77	32.88
SE ±	1.02				
CD at 5 %	2.91				

At 30 DAS significantly maximum mean number of flowers per plant was recorded by V_1 Lb_4 (44.89) while V_2 Lb_0 observed significantly the lowest (17.00) followed by V_3 Lb_0 (18.44) over rest of combination.

4.1.5.4.3 Interaction effects of varieties x liquid biofertilizer for mean number of flowers per plant at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	109.22	187.89	112.88	130.66	216.77
V_2	92.44	192.55	135.11	149.78	228.00
V_3	92.00	131.00	103.66	109.66	159.88
SE ±	4.88				
CD at 5 %	13.87				

Interaction between varieties and liquid bio-fertilizer was found to be significant where V_2 Lb_4 and V_1 Lb_4 produced significantly the highest (228.00, 216.77) mean number of flowers respectively over rest of the interaction.

4.1.5.4.4 Interaction effects of varieties x liquid biofertilizer for mean number of flowers per plant at 90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	50.44	105.00	59.44	70.33	112.66
V_2	33.11	63.77	46.66	51.22	80.88
V_3	43.00	58.11	46.22	48.77	75.88
SE ±	2.50				
CD at 5 %	7.08				

At 90 DAS significantly maximum number of flowers was produced by V_1 Lb_4 (112.66) while V_2 Lb_0 recorded (33.11) which was significantly the lowest over rest of interaction.

4.1.5.1 Effect of varieties (2001)

At 30 DAS the mean number of flowers in groundnut recorded by V_1 (18.53) was significantly highest followed by V_3 (17.89) while V_2 recorded significantly lowest (16.04) mean number of flowers per plant.

At 60 DAS V_2 recorded significantly the highest mean number of flowers per plant (102.13) and the lowest by V_1 (81.20) and V_3 (76.24) respectively.

At 90 DAS V_1 recorded significantly highest (43.62) mean number of flowers per plant followed by V_3 (41.33) while V_2 recorded significantly lowest (28.68).

At harvest V_2 recorded significantly the lowest mean number of flowers per plant (15.26) while V_1 was recorded significantly the highest mean number of flowers (44.43) followed by V_3 (43.29).

4.1.5.2 Effect of fertilizer levels

At 30 DAS the mean number of flowers under F_1 was significantly the highest (18.44) followed by F_2 (17.71) while F_3 recorded significantly the lowest (16.31).

Further, at 60 DAS F_1 was recorded significantly the highest flowers per plant (91.46) followed by F_2 (87.40) while under F_3 it was significantly the lowest (80.71).

At 90 DAS the mean number of flowers per plant recorded under F_1 was significantly the highest (39.91) while under F_3 it was significantly the lowest (35.00) and F_2 recorded (38.73) flowers which was significantly highest over F_3.

At harvest under F_1 and F_3 recorded significantly the highest and the lowest flowers (36.76, 32.07) while F_2 recorded (34.11) flowers which was significantly higher over F_3.

4.1.5.3 Effect of liquid biofertilizer

From the data it is revealed that mean number of flowers per plant recorded significantly higher due to Lb_1 (20.70, 104.33, 46.29, 37.20) Lb_2 (15.63, 75.48, 31.66, 35.08) Lb_3 (16.29, 79.00, 34.52, 32.86), Lb_4 (20.81, 107.03, 50.15, 31.90) at 30, 60, 90 DAS and at harvest respectively over control Lb_0 (14.00, 66.77, 26.77, 34.61).

4.1.5.4 The interaction effects

Interactions were found to be non significant except V x Lb at 30, 90 DAS and F x Lb at 60, 90 DAS.

4.1.5.4.1 Interaction effect of varieties x liquid biofertilizer for mean number of flowers per plant at 30 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	14.44	23.00	15.55	16.33	23.33
V_2	13.22	18.88	14.55	15.00	18.55
V_3	14.33	20.22	16.77	17.55	20.55
SE ±	0.63				
CD at 5 %	1.79				

Interaction between varieties and liquid bio-fertilizer was significant where V_1 Lb_4 recorded significantly the highest (23.33) mean number of flowers per plant followed by V_1 Lb_1 (23.00).

4.1.5.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of flowers per plant at 90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	31.44	56.11	34.33	37.11	59.11
V_2	20.00	34.11	23.44	26.00	39.88
V_3	28.88	48.66	37.22	40.44	51.44
SE ±	1.30				
CD at 5 %	3.71				

At 90 DAS the interaction between varieties and liquid bio-fertilizer was found to be significant. The treatment combination V_1 Lb_4 observed significantly the highest (59.11) mean number of flowers per plant followed by V_1 Lb_1 (56.11). However, V_2 Lb_0 (20.00) recorded significantly the lowest number of flowers.

4.1.5.4.3 Interaction effect of fertilizer x liquid biofertilizer for mean number of flowers per plant at 60 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	70.66	107.77	77.77	82.22	118.88
F_2	66.66	105.00	75.77	77.88	111.66
F_3	63.00	100.22	72.88	76.88	90.55
SE ±	3.33				
CD at 5 %	9.48				

From the data on number of flowers indicated that treatment combination F_1 Lb_4 recorded significantly the higher (118.88) number of flowers followed by F_2 Lb_4 (111.66) while all levels of fertilizer with Lb_0 recorded significantly lower mean number of flowers per plant F_3 Lb_0 (63.00) F_2 Lb_0 (66.66) and F_1 Lb_0 (70.66) at 60 DAS.

4.1.5.4.4 Interaction effect of fertilizer x liquid biofertilizer for mean number of flowers per plant at 90 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	28.77	47.88	33.00	35.55	54.33
F_2	26.44	46.55	31.00	34.88	54.66
F_3	25.11	44.44	30.88	33.11	41.44
SE ±	1.30				
CD at 5 %	3.70				

Interaction between fertilizer and liquid bio-fertilizer indicated that F_2 with Lb_4 recorded significantly higher (54.66) number of flowers followed by F_1 Lb_4 (54.33). However significantly lowest (25.11) mean number of flowers per plant were produced by F_3 Lb_0 over rest of interaction at 90 DAS.

4.1.6 Mean number of pegs/plant

Data on mean number of pegs per plant of groundnut as affected by different treatments during 2000 and 2001 are presented in Table 11.

4.1.6.1 Effect of varieties (2000)

At 60 DAS the variety V_2 and V_1 recorded significantly the highest (26.96) and the lowest (22.47) mean number of pegs per plant while V_3 recorded (23.20) which was at par with V_1.

At 90 DAS V_1 recorded significantly the highest (35.96) number of pegs per plant followed by V_2 (30.67).

At harvest similar results was obtained where V_1 recorded significantly the highest (37.22) followed by V_2 (30.50) and V_3 (26.38) mean number of pegs per plant.

Table 11. Mean number of pegs per plant of groundnut as affected by different treatments

Treatment	Year 2000			Year 2001		
	DAS			DAS		
	60	90	AH	60	90	AH
Varieties						
V_1	22.47	35.96	37.22	12.15	17.66	19.53
V_2	26.96	30.67	30.80	13.93	15.57	19.86
V_3	23.20	30.22	26.38	12.51	17.64	18.64
SE ±	0.34	0.32	0.40	0.24	0.43	0.22
CD 5%	1.013	0.97	1.20	0.71	1.28	0.66
Ferti. Levels						
F_1	27.49	38.06	36.13	14.46	18.95	21.80
F_2	24.42	32.71	30.60	12.93	16.84	19.48
F_3	20.71	26.07	27.67	11.20	15.08	16.75
SE ±	0.34	0.32	0.40	0.24	0.43	0.22
CD 5%	1.013	0.97	1.20	0.71	1.28	0.66
Liq. Bioferti.						
Lb_0	19.04	19.85	21.85	8.74	9.85	12.18
Lb_1	26.52	40.92	38.15	15.11	20 55	23.70
Lb_2	23.56	29.81	24.96	10.77	16.63	18.92
Lb_3	22.26	24.74	28.22	12.29	16.48	17.74
Lb_4	29.67	46.74	44.15	17.40	21.29	24.18
SE ±	0.43	0.33	0.40	0.24	0.38	0.39
CD 5%	1.22	0.92	1.12	0.66	1.04	1.08
Interactions						
V x F	Sig.	Sig.	NS	NS	NS	NS
V x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
F x Lb	NS	Sig.	Sig.	Sig.	NS	NS
V x F x Lb	NS	Sig.	Sig.	NS	NS	NS

4.1.6.2 Effect of fertilizer levels

At 60 DAS the mean number of pegs per plant under F_1 and F_3 were recorded significantly the highest and the lowest (27.49 and 20.71 respectively).

At 90 DAS the mean number of pegs per plant under F_1 and F_3 recorded significantly the highest (38.06) and lowest (26.07).

At harvest under F_1 and F_3 mean number of pegs per plant recorded significantly highest (36.13) and lowest (27.67) while under F_2 it was significantly the highest as compared with F_3.

4.1.6.3 Effect of liquid biofertilizers

The mean number of pegs due to all liquid biofertilizer treatments recorded significantly higher due to Lb_1 (26.52, 40.92, 38.15) Lb_2 (23.56, 29.81, 24.96), Lb_3 (22.26, 24.74, 28.22) and Lb_4 (29.67, 46.74, 44.15) at 60, 90 DAS and at harvest respectively over control Lb_0 (19.04, 19.85, 21.85).

4.1.6.4 The interaction effect

The interaction due to V x F was non-significant at harvest. The interaction due to F x Lb and V x F x Lb was not significant at 60 DAS.

4.1.6.4.1 Interaction effect of varieties x fertilizer for mean number of pegs per plant at 60 DAS (2000)

Varieties / Fertilizer levels	F_1	F_2	F_3
V_1	25.06	21.93	20.40
V_2	31.13	27.26	22.46
V_3	26.26	24.06	19.26
SE ±	0.58		
CD at 5 %	1.75		

The interaction between varieties and fertilizer levels was significant. Where combination V_2 F_1 and V_3 F_3 recorded significantly the highest (31.13) and lowest (19.26) mean number of pegs per plant respectively at 60 DAS.

4.1.6.4.2 Interaction effect of varieties x fertilizer for mean number of pegs per plant at 90 DAS (2000)

Varieties / Fertilizer levels	F_1	F_2	F_3
V_1	40.80	37.00	30.06
V_2	35.53	29.86	26.60
V_3	37.86	31.27	21.53
SE ±	0.56		
CD at 5 %	1.68		

At 90 DAS interaction between varieties and fertilizer was found to be significant in respect of mean number of pegs per plant. The variety V_1 with F_1 fertilizer levels noticed significantly the highest (40.80) number of pegs while V_3 F_3 recorded significantly lowest (21.53).

4.1.6.4.3 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	16.88	25.55	20.55	22.78	26.56
V_2	19.89	31.11	28.00	21.66	34.11
V_3	20.33	22.88	22.11	22.33	28.33
SE ±	0.75				
CD at 5 %	2.13				

Differences in mean number of pegs per plant due to combined effect of varieties and liquid biofertilizer were found to be significant at 60 DAS. The variety V_2 with Lb_4 produced significantly the highest (34.11) number of pegs while V_1 Lb_0 produced significantly the lowest (16.88), over rest of interaction.

4.1.6.4.4 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at 90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	18.44	50.77	33.33	23.66	53.55
V_2	20.00	37.33	29.33	24.33	42.33
V_3	19.11	34.67	26.78	26.22	44.33
SE ±	0.60				
CD at 5 %	1.71				

At 90 DAS V_1 Lb_4 produced significantly the highest (53.55) mean number of pegs per plant while V_1, V_2, V_3 with Lb_0 recorded significantly the lowest (18.44, 20.00, 19.11 respectively) over rest of interactions.

4.1.6.4.5 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	26.22	49.22	26.66	28.89	55.11
V_2	19.22	35.77	26.66	32.44	39.88
V_3	20.11	29.44	21.55	23.33	37.44
SE ±	0.74				
CD at 5 %	2.12				

Interaction between V_1 and Lb_4 recorded significantly the highest (55.11) mean number of pegs per plant while V_2 Lb_0 recorded significantly the lowest (19.22) and V_3 Lb_0 (20.11).

4.1.6.4.6 Interaction effect of fertilizer x liquid biofertilizer for mean number of pegs per plant at 90 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	21.55	50.44	32.33	28.00	58.00
F_2	18.88	39.66	30.77	25.88	48.33
F_3	17.11	32.66	26.33	20.33	33.88
SE ±	0.60				
CD at 5 %	1.71				

The treatment combination F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (58.00) and the lowest (17.11) mean number of pegs per plant over rest of interactions at 90 DAS.

4.1.6.4.7 Interaction effect of fertilizer x liquid biofertilizer for mean number of pegs per plant at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	23.44	43.66	28.77	32.66	52.11
F_2	21.66	36.66	25.00	27.66	42.00
F_3	20.44	34.11	21.11	24.33	38.33
SE ±	0.74				
CD at 5 %	2.11				

At harvest interaction F_1 Lb_4 produced significantly the highest (52.11) mean number of pegs per plant while F_3 Lb_0 (20.44) and F_2 Lb_0 (21.66) produced significantly the lowest pegs over rest of interaction.

4.1.6.4.8 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of pegs per plant at 90 DAS (2000)

Var. / Ferti. / Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	21.66	17.66	16.00	21.00	21.00	18.00	22.00	18.00	17.33
Lb_1	57.00	52.33	43.00	46.66	33.00	32.33	47.66	33.66	22.66
Lb_2	34.33	34.00	31.66	32.66	29.00	26.33	30.00	29.33	21.00
Lb_3	25.00	24.33	21.66	29.00	24.00	20.00	30.00	29.33	19.33
Lb_4	66.00	56.66	38.00	48.33	42.33	36.00	59.00	46.00	27.33
SE ±	0.97								
C.D at 5 %	2.75								

The mean number of pegs per plant was significantly the highest with interaction V_1 F_1 Lb_4 (66.00). From the data it was also observed that mean number pegs per plant was reduced under reduced levels of fertilizers F_1 to F_3 but it was significantly higher due to application of different liquid bio-fertilizer treatments from Lb_1 to Lb_4 over control Lb_0.

4.1.6.4.9 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean under of pegs per plant at harvest (2000)

Var. / Ferti. / Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	27.33	26.00	25.33	20.33	19.00	17.66	22.66	19.33	18.33
Lb_1	56.00	46.00	45.66	39.66	35.00	32.66	35.33	29.00	24.00
Lb_2	29.00	27.00	24.00	32.00	25.00	23.00	25.33	23.00	16.33
Lb_3	30.66	28.00	28.00	39.00	33.66	24.66	28.33	21.33	20.33
Lb_4	65.33	52.33	47.66	42.00	40.00	37.66	49.00	33.66	29.66
SE ±	1.73								
C.D at 5 %	3.40								

Similar results were obtained at 90 DAS where significantly the highest mean number of pegs per plant was recorded by the interaction V_1 F_1 Lb_4 (65.33) over rest of the interaction. It was also seen that all the varieties under different levels of fertilizers with Lb_0 recorded the lowest mean number of pegs per plant at harvest over rest of the combinations tried.

4.1.6.1 Effect of varieties (2001)

At 60 DAS V_2 and V_1 recorded significantly the highest (13.93) and the lowest (12.15) mean number of pegs per plant while V_3 recorded (12.51) pegs which was significantly lowest over V_2.

At 90 DAS V_1 and V_3 recorded significantly the highest mean number of pegs per plant (17.66 and 17.64) respectively while V_2 recorded significantly the lowest (15.57).

At harvest V_2 recorded significantly highest (19.86) mean number of pegs followed by V_1 (19.53) while V_3 recorded significantly lowest (18.64) pegs.

4.1.6.2 Effect of fertilizer levels

At 60 DAS the mean number of pegs per plant under F_1 was recorded significantly the highest (14.46) followed by F_2 (12.93) while under F_3 it was significantly the lowest (11.20).

At 90 DAS mean number of pegs per plant under F_1 was significantly highest (18.95) followed by F_2 (16.84) and F_3 it was significantly the lowest (15.08).

Further, at harvest mean number of pegs per plant under F_1 and F_3 was significantly the highest and the lowest (21.80, 16.75 respectively). However, under F_2 mean number of pegs recorded was significantly higher (19.48) as compared to F_3.

4.1.6.3 Effect of liquid biofertilizer

At 60, 90 DAS and at harvest the mean number of pegs per plant were significantly the highest due to liquid biofertilizer treatments as Lb_1 (15.11, 20.55, 23. 70), Lb_2 (10.77, 16.63, 18.92), Lb_3 (12.29, 16.48, 17.74) and Lb_4 (17.40, 21.29, 24.18) respectively over control Lb_0 (8.74, 9.85, 12.18).

4.1.6.4 The interaction effects

The interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant at 60, 90 DAS and at harvest.

4.1.6.4.1 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at 60 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.22	14.44	9.66	11.11	17.33
V_2	8.22	17.55	11.55	13.66	18.66
V_3	9.77	13.33	11.11	12.11	16.22
SE ±	0.43				
CD at 5 %	1.25				

The interactive effect due to varieties and liquid biofertilizer on production of number of pegs at 60 DAS was found to be significant. Where treatment combination V_2 Lb_4 and V_1 and V_2 Lb_0 produced significantly the highest (18.66) and the lowest (8.22) number of pegs respectively over rest of interactions.

4.1.6.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at 90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	9.22	22.88	17.77	16.00	22.44
V_2	9.88	17.66	15.00	15.88	19.44
V_3	10.44	21.11	17.11	17.55	22.00
SE ±	0.72				
CD at 5 %	2.06				

At 90 DAS significantly the highest mean number of pegs per plant was recorded by the treatment combination V_1 Lb_1 (22.88) followed by V_1 Lb_4 (22.44) V_3 Lb_4 and V_3 Lb_1 (22.00, 21.11) respectively over remaining combinations.

4.1.6.4.3 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	13.66	24.44	17.33	17.33	24.88
V_2	12.00	23.55	21.00	17.33	25.44
V_3	10.88	23.11	18.00	18.55	22.22
SE ±	0.64				
CD at 5 %	1.82				

At harvest interaction between varieties and liquid biofertilizer was found to be significant. The interaction V_2 Lb_4 recorded significantly the highest mean number of pegs per plant (25.44) followed by V_1 Lb_1 and Lb_4 (24.44 and 24.88) respectively over rest of the interactions. However V_3 Lb_0 and V_2 Lb_0 recorded significantly the lowest (10.88, 12.70) number of pegs per plant respectively.

4.1.6.4.4 Interaction effect of fertilizer x liquid biofertilizer for mean number of pegs per plant at 60 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	9.77	16.77	12.22	13.44	14.00
F_2	8.55	15.66	11.00	12.33	12.93
F_3	7.88	12.88	9.11	11.11	11.20
SE ±	0.43				
CD at 5 %	1.25				

Data pertaing to mean number of pegs per plant at 60 DAS indicated that interaction F_1 Lb_1 produced significantly the highest (16.77) number of pegs followed by F_2 Lb_1 (15.66) while F_3 Lb_0 and F_2 Lb_0 produced significantly the lowest (7.88, 8.55) mean number of pegs per plant respectively over rest of combinations.

4.1.7 Flower to peg ratio

Data regarding flower to peg ratio for the year 2000 and 2001 are presented in Table 12.

4.1.7.1 Effect of varieties (2000)

At 60 DAS V_3 and V_1 recorded the highest and the lowest (0.20 and 0.14) flower to peg ratio while V_2 recorded 0.17 which was significantly the highest over V_1.

At 90 DAS and at harvest the flower to peg ratio was observed to be statistically non-significant.

4.1.7.2 Effect of fertilizer levels

At 60 DAS the flower to peg ratio was significantly the highest (0.18) followed by F_2 (0.17) whereas for F_3 it was significantly the lowest (0.16).

At 90 DAS and at harvest the flower to peg ratio was found to be statistically non-signficant.

Table 12. Flower to peg ratio per plant of groundnut as affected by different treatments

Treatment	Year 2000			Year 2001		
	DAS			DAS		
	60	90	AH	60	90	AH
Varieties						
V_1	0.14	0.45	0.21	0.14	0.40	0.17
V_2	0.17	0.55	0.19	0.13	0.54	0.18
V_3	0.20	0.51	0.20	0.16	0.42	0.17
SE ±	0.004	0.55	0.003	0.005	0.22	0.004
CD 5%	0.011	NS	NS	0.015	0.066	NS
Ferti. Levels						
F_1	0.18	0.54	0.21	0.15	0.49	0.18
F_2	0.17	0.53	0.20	0.14	0.44	0.18
F_3	0.16	1.45	0.20	0.13	0.43	0.17
SE ±	0.004	0.55	0.003	0.005	0.022	0.004
CD 5%	0.011	NS	NS	0.015	NS	0.012
Liq. Bioferti.						
Lb_0	0.19	0.47	0.20	0.13	0.38	0.17
Lb_1	0.15	0.55	0.21	0.14	0.45	0.17
Lb_2	0.20	0.59	0.20	0.14	0.52	0.18
Lb_3	0.17	0.45	0.20	0.15	0.49	0.17
Lb_4	0.15	0.52	0.20	0.16	0.43	0.18
SE ±	0.005	0.72	0.004	0.004	0.016	0.004
CD 5%	0.014	NS	NS	0.011	0.04	NS
Interactions						
V x F	NS	NS	NS	NS	NS	NS
V x Lb	Sig.	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS

4.1.7.3 Effect of liquid biofertilizer

At 60 DAS the flower to peg ratio was at par due to liquid bio-fertilizers treatments Lb_1 (0.15), Lb_2 (0.20), Lb_3 (0.17) and Lb_4 (0.15).

At 90 DAS and at harvest it was statistically non-significant.

4.1.7.4 The interaction effects

Interactions were non-significant except V x Lb at 60 DAS.

4.1.7.4.1 Interaction effect of varieties x liquid biofertilizer for flower to peg ratio at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.14	0.13	0.17	0.16	0.12
V_2	0.21	0.16	0.20	0.14	0.15
V_3	0.21	0.17	0.21	0.21	0.18
SE ±	0.009				
CD at 5 %	0.024				

Interaction between varieties and liquid bio-fertilizer was found to be significant at 60 DAS. Flower to peg ratio was significantly the highest due to V_2 and V_3 Lb_0 (0.21) and V_2 and V_3 Lb_2 (0.20, 0.21) followed by V_3 Lb_4 (0.18) respectively.

4.1.7.1 Effect of varieties (2001)

At 60 DAS V_3 recorded significantly the highest flower to peg ratio (0.16) followed by V_1 (0.14) while V_2 recorded significantly the lowest (0.13).

At 90 DAS V_2 recorded significantly the highest (0.54) flower to peg ratio whereas V_3 and V_1 recorded significantly the lowest (0.42 and 0.40) over V_2.

At harvest the data on flower to peg ration was statistically non-significant.

4.1.7.2 Effect of fertilizer levels

At 60 DAS flower to peg ratio under F_1 was significantly the highest (0.15) followed by F_2 (0.14) and under F_3 recorded (0.13) which was significantly the lowest.

At 90 DAS the flower to peg ratio was found statistically non-significant.

At harvest the flower to peg ratio was not influenced statistically whereas it was at par with each other under F_1, F_2, F_3 flower to peg ratio were (0.18, 0.18, 0.17), respectively.

4.1.7.3 Effect of liquid biofertilizer

At 60 and 90 DAS the flower to peg ratio was significantly the highest due to Lb_1 (0.14, 0.45), Lb_2 (0.14, 0.52) Lb_3 (0.15, 0.49) and Lb_4 (0.16, 0.43) respectively over control Lb_0 (0.13, 0.38).

At harvest the data on flower to peg ratio was statistically found to be non-significant.

4.1.7.4 The interaction effects

Interactions were found to be non-significant.

4.2 Biochemical studies

4.2.1 Chlorophyll 'a' content (mg/g) in the leaves

Data regarding chlorophyll 'a' content in leaves for the year 2000 and 2001 are presented in Table 13.

Table 13. Chlorophyll 'a' content (mg/g) in the leaves of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	7.18	8.33	8.17	4.27	6.84	7.74	7.53	4.16
V_2	6.73	7.64	5.97	4.05	6.33	7.26	5.65	3.75
V_3	6.48	7.22	5.82	3.88	6.07	6.56	5.51	3.63
SE ±	0.070	0.075	0.064	0.039	0.093	0.049	0.10	0.065
CD 5%	0.21	0.23	0.19	0.12	0.28	0.15	0.31	NS
Ferti. Levels								
F_1	6.92	7.96	6.86	4.12	6.59	7.38	6.45	3.95
F_2	6.81	7.74	6.66	4.10	6.43	7.16	6.19	3.80
F_3	6.64	7.48	6.45	3.98	6.22	7.09	6.06	3.79
SE ±	0.070	0.075	0.064	0.039	0.093	0.049	0.10	0.065
CD 5%	0.21	0.23	0.19	0.12	0.28	0.15	NS	NS
Liq. Bioferti.								
Lb_0	5.68	6.55	5.63	3.37	5.32	6.21	5.09	3.18
Lb_1	7.77	8.19	7.24	4.65	7.31	7.25	6.68	4.35
Lb_2	6.67	7.74	6.56	4.02	6.39	7.23	6.17	3.86
Lb_3	5.88	7.59	6.28	3.49	5.40	6.99	5.95	3.25
Lb_4	7.94	8.58	7.56	4.80	7.66	8.26	7.26	4.59
SE ±	0.095	0.095	0.096	0.084	0.10	0.067	0.12	0.081
CD 5%	0.26	0.026	0.27	0.23	0.28	0.19	0.32	0.22
Interactions								
V x F	NS	NS	NS	NS	NS	NS	NS	NS
V x Lb	NS	Sig.	NS	NS	Sig.	Sig.	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.2.1.1 Effect of varieties (2000)

The results were statistically significant within the varieties.

At 30 DAS in variety V_1 the cholorophyll 'a' content in leaves was significantly the highest (7.18) followed by V_2 (6.73) while V_3 content (6.48) which was significantly the lowest.

At 60 DAS chlorophyll 'a' content in leaves recorded by V_1 (8.33) was significantly the highest and V_3 content (7.22) which was significantly the lowest.

At 90 DAS and at harvest in V_1 and V_3 the cholorphyll 'a' content in leaves was the significantly highest and lowest (8.17, 4.27) and (5.82, 3.88) respectively.

4.2.1.2 Effect of fertilizer levels

At 30 DAS in F_1 the cholorphyll 'a' content in leaves was significantly the highest (6.92) followed by F_2 (6.81) and F_3 (6.64) which was significantly the lowest.

At 60 DAS F_1 recorded significantly the highest chlorophyll 'a' (7.96) content in leaves followed by F_2 (7.74) while under F_3 (7.48) which was significantly lowest.

At 90 DAS in F_1 and F_3 chlorophyll 'a' content in leaves was significantly the highest and the lowest (6.86, 6.45).

At harvest chlorophyll 'a' content in leaves under F_1 and F_3 was significantly the highest and the lowest (4.12, 3.98) respectively.

4.2.1.3 Effect of liquid biofertilizer

The chlorophyll 'a' content in leaves at 30, 60, 90 DAS and at harvest was significantly higher due to almost all liquid biofertilizer treatments as Lb_1 (7.77, 8.19, 7.24 and 4.65), Lb_2 (6.67, 7.74, 6.56 and 4.02), Lb_3 (7.59, 6.28) Lb_4 (7.94, 8.58, 7.56 and 4.80) respectively except due to Lb_3 (5.88 and 3.49) at 30 DAS and at harvest which was at per with control Lb_0 (5.68, 6.55, 5.63 and 3.37).

4.2.1.4 The interaction effects

Interactions were found to be non-significant at all stages except V x Lb at 60 DAS.

4.2.1.4.1 Interaction effect of varieties x liquid biofertilizer for chlorophyll 'a' content (mg/g) in leaves at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	7.56	8.44	8.21	7.99	9.46
V_2	6.29	8.32	7.83	7.33	8.43
V_3	5.82	7.78	7.18	7.42	7.85
SE ±	0.16				
CD at 5 %	0.46				

Interaction between varieties and liquid biofertilizer was found to be significant. The treatment combination V_1 Lb_4 and V_3 Lb_0 recorded significantly the highest (9.46 mg/g) and the lowest (5.82 mg/g) chlorophyll 'a' content at 60 DAS.

4.2.1.1 Effect of varieties (2001)

At 30, 60, 90 DAS V_1 content significantly the highest chlorophyll 'a' content in leaves (6.84, 7.74, 7.53) respectively while V_3 recorded significantly the lowest (6.07, 6.56, 5.51). However, V_2 content significantly highest chlorophyll 'a' (7.26) at 60 DAS and at 30 and 90 DAS it was at par (6.33, 5.65) respectively over V_3.

At harvest the chlorophyll 'a' content in leaves was statistically found to be non-significant.

4.2.1.2 Effect of fertilizer levels

At 30 and 60 DAS under F_1 chlorophyll 'a' content was significantly the highest (6.59, 7.38) respectively followed by F_2 (6.43, 7.16) while under F_3 it was significantly the lowest (6.22, 7.09) respectively.

Further, the results regarding chlorophyll 'a' content in leaves at 90 DAS and at harvest was statistically non-significant.

4.2.1.3 Effect of liquid biofertilizer

The chlorophyll 'a' content at 30, 60, 90 DAS and at harvest was significantly higher due to Lb_1 (7.31, 7.25, 6.68 and 4.35), Lb_2 (6.39, 7.23, 6.17 and 3.86), Lb_3 (6.99) and Lb_4 (7.66, 8.26, 7.26, 4.59) except due to Lb_3 (5.40, 5.95, 3.25) at 30, 90 DAS and at harvest respectively over control Lb_0 (5.32, 6.21, 5.09 and 3.18).

4.2.1.4 The interaction effects

Interaction due to V x F, F x Lb and V x F x Lb were found to be non-significant at 30, 60, 90 DAS and at harvest and V x Lb at 90 DAS and at harvest.

4.2.1.4.1 Interaction effect of varieties x liquid biofertilizer for chlorophyll 'a' content (mg/g) in leaves at 30 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	5.68	7.39	7.30	5.86	7.99
V_2	5.30	7.23	6.26	5.32	7.54
V_3	4.98	7.31	5.61	5.02	7.46
SE ±	0.18				
CD at 5 %	0.52				

The combination of V_1 Lb_4 recorded significantly the highest chlorophyll 'a' content (7.99 mg/g) in leaves followed by V_2 Lb_4 (7.54 mg/g). While to significantly the lowest chlorophyll 'a' content in leaves was recorded by V_3 Lb_0 (4.98 mg/g).

4.2.1.4.2 Interaction effect of varieties x liquid biofertilizer for chlorophyll 'a' content (mg/g) in leaves at 60 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	7.14	7.74	7.66	7.48	8.70
V_2	5.93	7.50	7.40	7.18	8.29
V_3	5.56	6.53	6.63	6.31	7.79
SE ±	0.11				
CD at 5 %	0.32				

The interactive effects due to varieties and liquid biofertilizer on chlorophyll 'a' content in leaves at 60 DAS was found to be significant. Where V_1 Lb_4 and V_3 Lb_0 recorded significantly the highest (8.70 mg/g) and the lowest (5.56 mg/g) chlorophyll 'a' content in leaves.

4.2.2 Chlorophyll 'b' content (mg/g) in leaves

Data regarding chlorophyll 'b' content in leaves during 2000 and 2001 are presented in Table 14.

Table 14. Chlorophyll 'b' content (mg/g) in leaves of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	3.24	3.65	2.74	1.56	3.07	3.38	2.68	1.41
V_2	2.98	3.35	1.70	1.44	2.83	3.19	1.55	1.33
V_3	2.84	3.19	1.75	1.37	2.57	2.89	1.54	1.21
SE ±	0.087	0.048	0.043	0.028	0.043	0.061	0.023	0.039
CD 5%	0.26	0.14	0.129	0.085	NS	NS	0.068	NS
Ferti. Levels								
F_1	3.10	3.48	2.11	1.50	2.88	3.24	1.97	1.36
F_2	3.03	3.41	2.07	1.47	2.79	3.14	1.92	1.31
F_3	2.93	3.30	2.01	1.42	2.80	3.08	1.88	1.28
SE ±	0.087	0.048	0.043	0.028	0.043	0.061	0.023	0.039
CD 5%	NS	NS	NS	NS	NS	NS	NS	NS
Liq. Bioferti.								
Lb_0	2.54	2.86	1.76	1.23	2.41	2.72	1.68	1.13
Lb_1	3.20	3.60	2.16	1.54	2.85	3.21	1.95	1.34
Lb_2	3.05	3.43	2.08	1.47	2.81	3.16	1.92	1.32
Lb_3	2.95	3.32	2.01	1.42	2.72	3.06	1.87	1.27
Lb_4	3.37	3.77	2.31	1.63	3.33	3.62	2.21	1.51
SE ±	0.088	0.057	0.061	0.035	0.069	0.076	0.030	0.054
CD 5%	0.24	0.16	0.17	0.09	0.19	0.21	0.083	0.15
Interactions								
V x F	NS	NS	NS	NS	NS	NS	NS	NS
V x Lb	NS	NS	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.2.2.1 Effect of varieties (2000)

At 30 DAS V_1 recorded significantly highest (3.24 mg/g) chlorophyll 'b' followed by V_2 (2.98 mg/g) while V_3 recorded significantly the lowest (2.84 mg/g).

At 60 DAS V_1 and V_3 content significantly the highest (3.65 mg/g) and lowest (3.19 mg/g) chlorophyll 'b' while V_2 content significantly the highest value (3.35 mg/g) of chlorophyll 'b' over V_3.

At 90 DAS in V_1 cholorphyll 'b' content was significantly the highest in leaves (2.74 mg/g) while V_3 and V_2 recorded 1.75 and 1.70 mg/g respectively.

At harvest significantly highest and lowest chlorophyll 'b' was recorded by V_1 (1.56 mg/g) and V_3 (1.37 mg/g), while V_2 content (1.44 mg/g) which was at par over V_1 and V_3.

4.2.2.2 Effect of fertilizer levels

The effect due to various levels of fertilizer on chlorophyll 'b' content was not statistically significant at all the stages of observation.

4.2.2.3 Effect of liquid biofertilizer

The effect due to various liquid biofertilizer treatments on chlorophyll 'b' content (mg/g) in leaves was significantly higher as Lb_1 (3.20, 3.60, 2.16, 1.54), Lb_2 (3.05, 3.43, 2.08, 1.47), Lb_3 (2.95, 3.32, 2.01, 1.42) and Lb_4 (3.37, 3.77, 2.31, 1.61) at 30, 60, 90 DAS and at harvest respectively over control Lb_0 (2.54, 2.86, 1.76 and 1.23).

4.2.2.4 The interaction effects

The interaction effect on chlorophyll 'b' content in leaves was found to be non-significant at all the stages.

4.2.2.1 Effect of varieties (2001)

The data on chlorophyll 'b' content in leaves within the varieties was found to be non-significant at 30, 60 DAS and at harvest. While on 90 DAS it was significantly influenced. Where variety V_1 content significantly the highest (2.68 mg/g) chlorophyll 'b' in leaves while V_2 (1.55 mg/g) and V_3 (1.54 mg/g) recorded which was significantly the lowest.

4.2.2.2 Effect of fertilizer levels

The effect due to various levels of fertilizers on chlorophyll 'b' content in leaves was found to be non-significant at 30, 60, 90 DAS and at harvest.

4.2.2.3 Effect of liquid biofertilizer

It is revealed from the data at 30, 60, 90 DAS and at harvest that chlorophyll 'b' content (mg/g) in leaves was significantly higher due to various liquid biofertilizer treatments as Lb_1 (2.85, 3.21, 1.95, 1.34), Lb_2 (2.81, 3.16, 1.92, 1.32) Lb_3 (2.72, 3.06, 1.87), Lb_4 (3.33, 3.62, 2.21, 1.51) respectively except Lb_3 (1.27) at harvest which was at par over control Lb_0 (2.41, 2.72, 1.68, 1.13).

4.2.2.4 The interaction effects

The interaction effect on chlorophyll 'b' content in leaves was found to be non-significant at all the stages of observations.

4.2.3 Total chlorophyll content (mg/g)

Data on total chlorophyll content in leaves during 2000 and 2001 are presented in Table 15 and graphically depicted in Fig. 5.

Table 15. Total chlorophyll content (mg/g) in leaves of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	10.41	11.98	10.92	4.53	9.95	11.18	10.30	5.56
V_2	9.69	10.98	7.61	3.85	9.10	10.42	7.21	5.06
V_3	9.32	10.43	7.60	3.69	8.61	9.54	7.16	4.85
SE ±	0.093	0.082	0.072	0.18	0.073	0.085	0.12	0.084
CD 5%	0.28	0.25	0.22	0.54	0.22	0.26	0.36	NS
Ferti. Levels								
F_1	10.02	11.44	8.90	4.29	9.46	10.66	8.49	5.32
F_2	9.85	11.13	8.73	4.05	9.21	10.33	8.14	5.10
F_3	9.57	10.81	8.50	3.72	8.99	10.15	8.03	5.05
SE ±	0.093	0.082	0.072	0.18	0.073	0.085	0.12	0.084
CD 5%	0.28	0.25	0.22	NS	0.22	0.26	0.36	NS
Liq. Bioferti.								
Lb_0	8.22	9.39	7.30	3.51	7.65	9.28	6.80	4.32
Lb_1	10.98	11.78	9.41	4.65	9.59	10.35	8.97	5.72
Lb_2	9.72	11.21	8.63	3.94	8.53	10.35	8.11	5.15
Lb_3	8.83	10.91	8.28	3.41	8.45	10.08	7.82	4.49
Lb_4	11.29	12.35	9.92	4.59	9.60	11.85	9.41	6.11
SE ±	0.12	0.12	0.104	0.17	0.29	0.14	0.18	0.083
CD 5%	0.34	0.32	0.29	0.47	0.81	0.39	0.48	0.23
Interactions								
V x F	NS	NS	NS	NS	NS	NS	NS	NS
V x Lb	NS	Sig.	Sig.	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.2.3.1 Effect of varieties (2000)

The total chlorophyll content in leaves was significantly influenced due to different treatments within the varieties. At 30 DAS variety V_1 recorded significantly the highest total chlorophyll content in leaves (10.41 mg/g) while V_3 content significantly the lowest (9.32 mg/g) and V_2 content (9.69 mg/g) which was significantly higher over V_3.

At 60 DAS the variety V_1 and V_3 recorded significantly the highest and the lowest total chlorophyll content in leaves (11.98 mg/g, 10.43 mg/g) respectively while V_2 recorded (10.98 mg/g) which was significantly highest over V_3.

At 90 DAS the variety V_1 recorded significantly the highest (10.92 mg/g) total chlorophyll while V_2 and V_3 content (7.61 and 7.60 mg/g) which was significantly the lowest over V_1.

Data at harvest observed that variety V_1 and V_2 content significantly the highest and the lowest (4.53, 3.85 mg/g) total chlorophyll while V_3 content (3.69 mg/g) which was at par over V_2.

4.2.3.2 Effect of fertilizer levels

At 30 DAS the total chlorophyll content in leaves under F_1 was significantly the highest (10.02 mg/g) followed by V_2 (9.85 mg/g) and under F_3 (9.57 mg/g) which was significantly the lowest.

At 60 DAS under F_1 and F_3 it was significantly the highest and the lowest (11.44, 10.81 mg/g) respectively while under F_2 it was significantly highest (11.13 mg/g) as compared to F_3.

At 90 DAS under F_1 total chlorophyll content in leaves significantly the highest (8.90 mg/g) followed by F_2 (8.73 mg/g) and under F_3 (8.50 mg/g) which was significantly the lowest.

Total chlorophyll content at harvest was statistically found to be non-significant.

4.2.3.3 Effect of liquid biofertilizers

At 30, 60 and 90 DAS the total chlorophyll content (mg/g) in leaves was significantly the highest due to Lb_1 (10.98, 11.78, 9.41 mg/g) Lb_2 (9.72, 11.21, 8.63 mg/g), Lb_3 (8.83, 10.91, 8.28 mg/g), Lb_4 (11.29, 12.35, 9.92 mg/g) over control Lb_0 (8.22, 9.39, 7.30 mg/g).

At harvest due to Lb_1 and Lb_4 total chlorophyll in leaves was significanlty the highest (4.65 and 4.59 mg/g) respectively over control Lb_0 (3.51 mg/g), while it was at par due to Lb_2 (3.94 mg/g) and Lb_3 (3.41 mg/g) over control Lb_0 (3.51 mg/g).

4.2.3.4 The interaction effects

Interaction effects were found to be non-significant at all stages except V x Lb at 60 and 90 DAS.

4.2.3.4.1 Interaction effect of varieties x liquid biofertilizer for total chlorophyll content (mg/g) at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	10.85	12.14	11.81	11.49	13.58
V_2	8.93	11.98	11.27	10.55	12.12
V_3	8.37	11.20	10.54	10.67	11.13
SE ±	0.19				
CD at 5 %	0.56				

Variation for total chlorophyll content in leaves due to combined effect of varieties and fertilizers were found to be significant whereas V_1 Lb_4 and V_3 Lb_0 produced significantly the highest (13.58 mg/g) and the lowest (8.37 mg/g) total chlorophyll content at 60 DAS.

4.2.3.4.2 Interaction effect of varieties x liquid biofertilizer for total chlorophyll content (mg/g) at 90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	10.03	11.27	10.92	10.38	11.96
V_2	5.94	8.46	7.42	7.18	9.05
V_3	5.92	8.50	7.56	7.28	8.73
SE ±	0.17				
CD at 5 %	0.50				

At 90 DAS total chlorophyll content was signifiantly the highest due to interaction of V_1 Lb_4 (11.96 mg/g) while V_3 and V_2 Lb_0 recorded (5.92 and 5.94 mg/g) significantly the lowest total chlorophyll content respectively.

4.2.3.1 Effect of varieties (2001)

At 30 DAS the variety V_1 and V_3 recorded significantly the highest and lowest total chlorophyll content in leaves (9.95, 8.61 mg/g) respectively.

Similar results were obtained at 60 DAS also where variety V_1 and V_3 recorded significantly the highest and the lowest total chlorophyll content (11.18, 9.54 mg/g) respectively.

At 90 DAS variety V_1 content significantly highest total chlorophyll (10.30 mg/g) whereas V_2 and V_3 recorded (7.21, 7.16 mg/g) total chlorophyll which was significantly lowest over V_1.

At harvest total chlorophyll content within the varieties was non-significant.

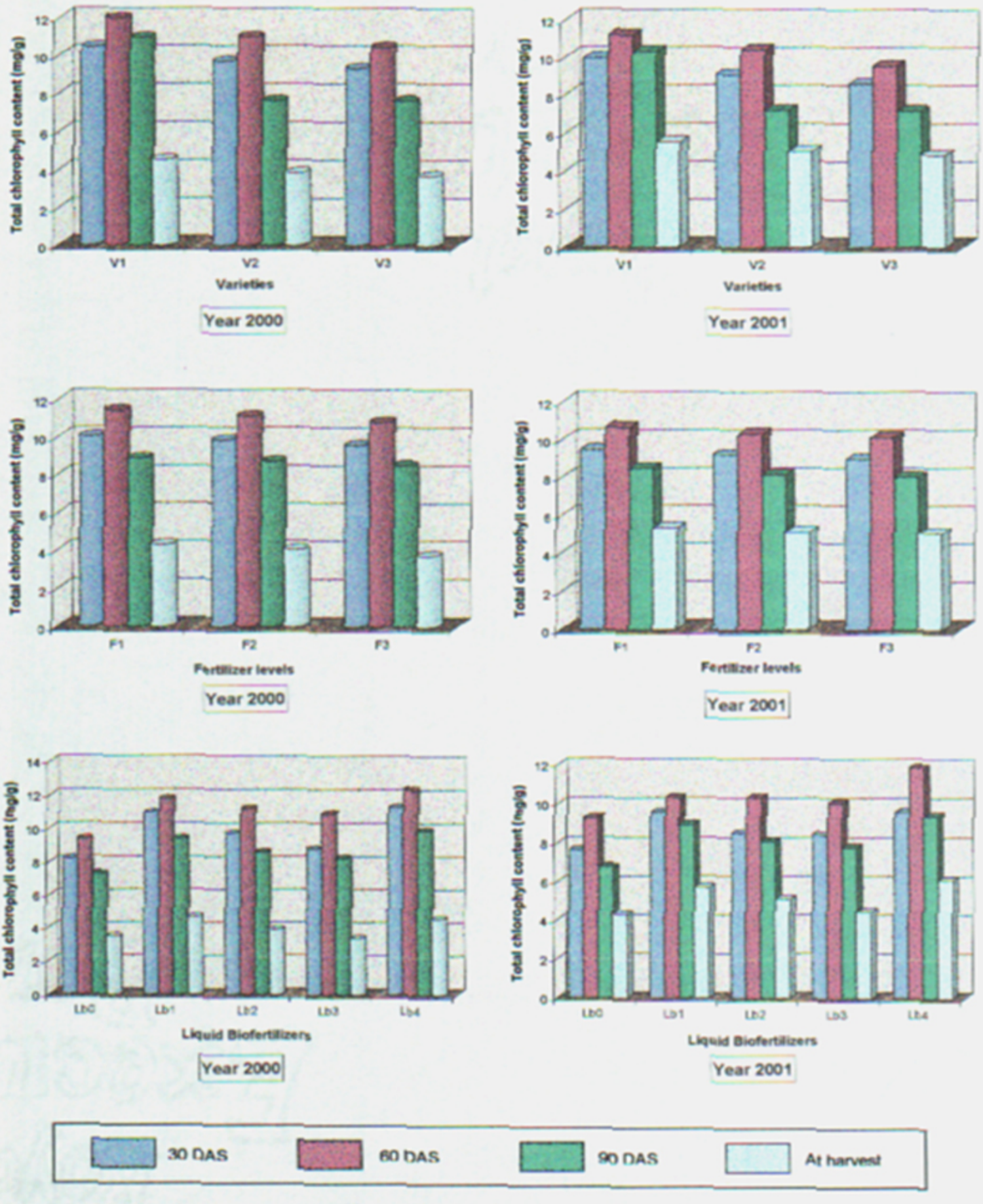


Fig. 5 : Total chlorophyll content (mg/g) in leaves of groundnut as affected by different treatments

4.2.3.2 Effect of fertilizer levels

At 30 DAS total chlorophyll content in leaves under F_1 and F_3 was significantly the highest and lowest (9.46, 8.99 mg/g) respectively.

At 60 DAS under F_1 total chlorophyll content in leaves was significanlty the highest (10.66 mg/g) followed by F_2 (10.33 mg/g) and F_3 (10.15 mg/g) which was significantly lowest.

At 90 DAS total chlorophyll content in leaves under F_1 was (8.49 mg/g) significantly highest followed by F_2 (8.14 mg/g) and under F_3 (8.03 mg/g) which was significantly the lowest.

At harvest the data recorded on total chlorophyll content was found to be non-significant.

4.2.3.3 Effect of liquid biofertilizer

The total chlorophyll content (mg/g) in leaves was significantly increased at 30, 60, 90 DAS and at harvest due Lb_1 (9.59, 10.35, 8.97, 5.72 mg/g) Lb_2 (8.53, 10.35, 8.11, 5.15 mg/g) Lb_3 (10.08, 7.82, 4.49 mg/g) Lb_4 (9.60, 11.85, 9.41, 6.11 mg/g) except Lb_3 (8.45 mg/g) at 30 DAS which was at par over control Lb_0 (7.65, 9.28, 6.80, 4.32 mg/g) respectively.

4.2.3.4 The interaction effects

Interaction effects were found to be non-significant at all the stages of observations.

4.2.4 Leghaemoglobin content (mg/g)

Data regarding leghaemoglobin content in the root nodules of the groundnut as affected by different treatments for the year 2000 and 2001 are given in Table 16.

Table 16. Leghaemoglobin content (mg/g) in the root nodules of the groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	0.431	0.490	0.387	0.250	0.435	0.492	0.390	0.232
V_2	0.413	0.488	0.341	0.227	0.402	0.483	0.331	0.201
V_3	0.392	0.479	0.462	0.204	0.380	0.471	0.350	0.186
SE ±	0.005	0.004	0.058	0.003	0.005	0.004	0.005	0.003
CD 5%	0.015	NS	NS	NS	0.016	NS	NS	NS
Ferti. Levels								
F_1	0.412	0.485	0.361	0.227	0.408	0.489	0.363	0.210
F_2	0.415	0.488	0.364	0.229	0.412	0.483	0.361	0.214
F_3	0.409	0.483	0.465	0.226	0.401	0.475	0.350	0.202
SE ±	0.005	0.004	0.058	0.003	0.005	0.004	0.005	0.003
CD 5%	NS	NS	NS	NS	0.016	NS	NS	NS
Liq. Bioferti.								
Lb_0	0.410	0.483	0.365	0.226	0.400	0.471	0.343	0.200
Lb_1	0.416	0.492	0.356	0.230	0.418	0.497	0.376	0.215
Lb_2	0.399	0.468	0.355	0.219	0.392	0.473	0.357	0.200
Lb_3	0.401	0.472	0.363	0.222	0.392	0.473	0.353	0.200
Lb_4	0.436	0.513	0.546	0.240	0.428	0.507	0.386	0.224
SE ±	0.006	0.005	0.077	0.004	0.006	0.004	0.008	0.004
CD 5%	0.016	0.014	NS	0.011	0.016	0.011	NS	0.011
Interactions								
V x F	NS	NS	NS	NS	NS	NS	NS	NS
V x Lb	NS	NS	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.2.4.1 Effect of varieties (2000)

At 30 DAS the variety V_1 and V_3 content significantly the highest and lowest leghaemoglobin (0.431 and 0.392 mg/g) while V_2 content (0.413 mg/g) which was significantly the highest over V_3.

Data on leghaemoglobin content at 60, 90 DAS and at harvest was found to be non-significant.

4.2.4.2 Effect of fertilizer levels

The effect due to different leaves of fertilizers on leghaemoglobin content were found to be non-significant at 30, 60, 90 DAS and at harvest.

4.2.4.3 Effect of liquid biofertilizers

At 30 DAS the leghaemoglobin content was significantly the highest due Lb_4 (0.436 mg/g) while it was at par with rest of the treatments Lb_1 (0.416 mg/g), Lb_2 (0.399 mg/g), Lb_3 (0.401 mg/g) over control Lb_0 (0.410 mg/g).

The leghaemoglobin content at 60 DAS was significantly highest due to Lb_4 (0.513 mg/g). While it was significantly the lowest due to Lb_2 (0.468 mg/g) and it was at par with Lb_1 (0.492 mg/g) and Lb_3 (0.472 mg/g) over control Lb_0 (0.483 mg/g).

At 90 DAS the results regarding leghaemoglobin content was non-significant.

At harvest the leghaemoglobin content was significantly the highest due to Lb_4 (0.240 mg/g) while it was at par with rest of the treatments Lb_1 (0.230 mg/g), Lb_2 (0.219 mg/g) Lb_3 (0.222 mg/g) over control Lb_0 (0.226 mg/g).

4.2.4.4 The interaction effects

The interaction effects were found to be non-significant.

4.2.4.1 Effect of varieties (2001)

At 30 DAS the variety V_1 and V_3 content significantly the highest leghaemoglobin (0.43, 0.380 mg/g) respectively while V_2 recorded (0.402 mg/g) leghaemoglobin content which was significntly the highest as compared to V_3.

As regards leghaemoglobin content at 60, 90 DAS and at harvest it was found to be statistically non-significant.

4.2.4.2 Effect of fertilizer levels

The leghaemoglobin content at 30 DAS under different fertilizer levels (F_1, F_2, F_3) (0.408, 0.412, 0.401 mg/g) was at par with each other. However, the results in respect of leghaemoglobin content at 60, 90 and at harvest were found to be non-significant.

4.2.4.3 Effect of liquid biofertilizers

At 30 DAS the leghaemoglobin content due to Lb_4 (0.428 mg/g) was significantly highest however, it was at par with rest of the treatments Lb_1 (0.418 mg/g) Lb_2 and Lb_3 (0.392 mg/g) over control Lb_0 (0.400 mg/g).

At 60 DAS the effect due to Lb_4 (0.507 mg/g) and Lb_1 (0.497 mg/g) on leghaemoglobin content significantly the highest while due to Lb_2 and Lb_3 (0.473 mg/g) equal value of leghaemoglobin content was recorded with control Lb_0 (0.471 mg/g).

At 90 DAS the data recorded on leghaemoglobin content was found to be non-significant.

At harvest the leghaemoglobin content due to Lb_4 (0.224 mg/g) and Lb_1 (0.215 mg/g) was significantly and numerically higher. While due to Lb_2 and Lb_3 (0.200 mg/g) equal value was recorded with control Lb_0 (0.200 mg/g).

4.2.4.4 The interaction effects

The interaction effects were found to be non-significant.

4.3 Nodulation studies

4.3.1 Root length (cm)

Data regarding root length (cm) of groundnut as affected by different treatments during 2000 and 2001 are presented Table 17.

Table 17. Root length (cm) of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	7.29	9.22	10.42	11.07	9.08	10.35	11.73	12.51
V_2	7.91	9.36	10.07	10.47	9.24	11.02	11.57	11.97
V_3	7.73	9.42	9.82	10.49	9.46	11.24	13.68	14.04
SE ±	0.15	0.12	0.16	0.17	0.094	0.095	0.10	0.14
CD 5%	0.45	NS	0.47	0.51	0.28	0.28	0.31	0.43
Ferti. Levels								
F_1	8.42	9.80	10.87	11.22	10.06	11.93	13.48	13.97
F_2	7.65	9.33	10.11	10.82	9.24	10.91	12.17	12.84
F_3	6.87	8.86	9.33	9.98	8.48	9.77	11.33	11.71
SE ±	0.15	0.12	0.16	0.17	0.094	0.095	0.10	0.14
CD 5%	0.45	0.37	0.47	0.51	0.28	0.28	0.31	0.43
Liq. Bioferti.								
Lb_0	6.63	8.26	8.82	9.33	7.77	8.25	9.96	10.48
Lb_1	8.96	10.37	11.15	11.15	10.48	12.70	13.85	14.37
Lb_2	6.42	8.67	9.63	10.04	8.63	9.74	11.33	11.63
Lb_3	6.52	9.03	9.67	10.37	8.14	9.63	12.11	12.66
Lb_4	9.70	10.33	11.26	12.48	11.29	14.03	14.40	15.07
SE ±	0.132	0.17	0.18	0.23	0.12	0.14	0.16	0.21
CD 5%	0.37	0.46	0.50	0.62	0.33	0.39	0.46	0.58
Interactions								
V x F	NS	NS	NS	NS	NS	NS	Sig.	NS
V x Lb	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	NS
F x Lb	NS	NS	Sig.	NS	NS	Sig.	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.3.1.1 Effect of varieties (2000)

At 30 DAS the variety V_2 and V_1 recorded significantly the highest (7.91) and the lowest (7.29) root length while V_3 recorded (7.73) which was at par over V_1 and V_2.

Data on root length at 60 DAS was found to be non-significant.

At 90 DAS V_1 recorded significantly the highest root length (10.42) followed by V_2 (10.07) while V_3 recorded significantly the lowest root length (9.82).

At harvest variety V_1 recorded significantly the highest (11.07) root length while V_2 and V_3 recorded (10.47, 10.49) respectively which was at par with each other.

4.3.1.2 Effect of fertilizer levels

At 30 DAS root length under F_1 was significantly highest (8.42) while under F_2 and F_3 (7.65, 6.87) it was significantly lowest over it.

At 60 DAS under F_1 significantly highest root length was recorded (9.80) while under F_3 it was significantly lowest (8.86) and under F_2 (9.33) which was significantly highest over F_3.

At harvest under F_1 root length was significantly the highest (11.22) followed by F_2 (10.82) and under F_3 (9.98) which was significantly the lowest with F_1 and F_2.

4.3.1.3 Effect of liquid biofertilizer

Root length was influenced significantly due to liquid biofertilizer treatments. At 30 DAS it was significantly the highest due to Lb_1 and Lb_4 (8.96, 9.70) while due to Lb_2 and Lb_3 (6.42, 6.52) it was at par over control Lb_0 (6.63).

At 60 DAS root length was recorded significantly the highest due to Lb_1 (10.37), Lb_3 (9.03) and Lb_4 (10.33) and due to Lb_2 (8.67) which was at par over control Lb_0 (8.26).

At 90 DAS and at harvest root length was significantly the highest due to all the treatments as Lb_1 (11.15, 11.15) Lb_2 (9.63, 10.04) Lb_3 (9.67, 10.37) and Lb_4 (11.26, 12.48) over control Lb_0 (8.82, 9.33), respectively.

4.3.1.4 The interaction effects

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant at 30, 60, 90 DAS and at harvest and also V x Lb was non-significant at 30 and 60 DAS.

4.3.1.4.1 Interaction effect of varieties x liquid biofertilizers for mean root length (cm) at 90 DAS (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.77	11.44	10.55	9.66	11.66
V_2	8.66	11.33	9.00	9.22	12.00
V_3	9.00	10.66	9.33	10.11	10.00
SE ±	0.32				
CD at 5 %	0.91				

Interaction between varieties and liquid bio-fertilizer was found to be significant. The treatment combination V_2 Lb_4 observed significantly the highest (12.00 cm) root length followed by V_1 with Lb_4 (11.44, 11.66 cm) and V_2 Lb_1 (11.33 cm) respectively at 90 DAS.

4.3.1.4.2 Interaction effect of varieties x liquid biofertilizers for mean root length (cm) at harvest (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	9.55	11.44	10.66	11.33	12.33
V_2	8.88	11.33	9.33	9.44	13.33
V_3	9.55	10.66	10.11	10.33	11.77
SE ±	0.38				
CD at 5 %	1.10				

The interaction due to V_2 Lb_4 at harvest recorded significantly the highest (13.33 cm) mean root length followed by V_1 Lb_4 (12.33 cm). While the combination V_3 Lb_0, V_2 Lb_2 and V_2 Lb_3 recorded significantly the lowest (9.55, 9.33, 9.44 cm) mean root length respectively at harvest.

4.3.1.4.3 Interaction effect of fertilizer x liquid biofertilizers for mean root length (cm) at 90 DAS (2000)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	9.11	11.88	10.11	10.22	13.00
F_2	8.88	11.00	9.66	9.77	11.22
F_3	8.44	10.55	9.11	9.00	9.55
SE ±	0.32				
CD at 5 %	0.91				

At 90 DAS the interaction F_1 Lb_4 observed significantly the highest (13.00 cm) root length. However significanlty lower root length was recorded by the interaction F_3 Lb_0 (8.44 cm) F_2 Lb_0 (8.88) F_3 Lb_3 (9.00 cm) and F_3 Lb_2 (9.11 cm) respectively over rest of interactions.

4.3.1.1 Effect of varieties (2001)

At 30 DAS variety V_3 recorded significantly the highest root length (9.46) followed by V_2 (9.24) and V_1 recorded (9.08) which was significantly the lowest.

At 60 DAS V_3 recorded significantly the highest (11.24) followed by V_2 (11.02) while V_1 recorded significantly the lowest (10.35) root length.

At 90 DAS variety V_3 recorded significantly the highest root length (13.68) while V_2 and V_1 recorded (11.57, 11.73) respectively, which was significantly the lowest over V_3.

At harvest variety V_3 and V_2 recorded significantly the highest (14.04) and the lowest (11.970 root length while V_1 recorded (12.51) which was significantly higher over V_2.

4.3.1.2 Effect of fertilizer levels

At 30, 60, 90 DAS and at harvest significantly the highest root length was recorded under F_1 (10.06, 11.93, 13.48, 13.97) followed by F_2 (9.24, 10.91, 12.17, 12.84) while F_3 recorded (8.48, 9.77, 11.33, 11.71) which was significantly the lowest over F_1 and F_2 respectively.

4.3.1.3 Effect of liquid biofertilizer

From the data at 30, 60, 90 DAS and at harvest significantly the highest root length was recorded due to Lb_1 (10.48, 12.70, 13.85, 14.37), Lb_2 (8.63, 9.74, 11.33, 11.63), Lb_3 (8.14, 9.63, 12.11, 12.66) and Lb_4 (11.29, 14.03, 14.40, 15.07) over control Lb_0 (7.77, 8.25, 9.96, 10.48) respectively.

4.3.1.4 The interaction effect

Interaction due to V x F was found to be non-significant at 30, 60 DAS and at harvest.

Interaction due to V x Lb was non-significant at harvest. Interaction due to F x Lb and V x F x Lb was found to be non-significant at 30, 60, 90 DAS and at harvest except F x Lb at 60 DAS.

4.3.1.4.1 Interaction effect of varieties x fertilizer for mean root length (cm) per plant at 90 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	12.60	11.60	11.00
V_2	12.66	11.26	10.80
V_3	15.20	13.00	12.00
SE ±	0.18		
CD at 5 %	0.54		

As regards root length interaction between varieties and fertilizer levels was significant. The combination V_3 F_1 and V_1 F_3 recorded significantly the highest (15.20 cm) and lowest (11.00 cm) mean root length.

4.3.1.4.2 Interaction effect of varieties x liquid biofertilizer for mean root length (cm) per plant at 30 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.22	10.11	8.55	7.88	10.66
V_2	7.33	10.66	8.44	8.11	11.66
V_3	7.77	10.66	8.88	8.44	11.55
SE ±	0.20				
CD at 5 %	0.59				

At 30 DAS root length was influenced significantly due to varieties and liquid bio-fertilizer. It was significantly the highest due to interaction V_2 Lb_4 (11.66 cm) followed by V_3 Lb_4 (11.55 cm) while significantly the lowest root length was observed due to combination of V_2 Lb_0 (7.33 cm) and V_3 Lb_0 (7.77 cm).

4.3.1.4.3 Interaction effect of varieties x liquid biofertilizer for mean root length (cm) per plant at 60 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.00	11.66	8.77	9.00	14.33
V_2	7.44	13.11	10.00	10.66	13.88
V_3	9.33	13.33	10.44	9.22	13.88
SE ±	0.23				
CD at 5 %	0.67				

Differences in root length due to combined effect of varieties and liquid biofertilizer were found to be significant at 60 DAS. The root length of all the varieties under study was significantly the highest with Lb_4 i.e. V_1 Lb_4 (14.33 cm) V_2 Lb_4 (13.88 cm) V_3 Lb_4 (13.88 cm). However, it was significantly the lowest with control (Lb_0) i.e. V_1 Lb_0 (8.00 cm), V_2 Lb_0 (7.44) and V_3 Lb_0 (9.33 cm).

4.3.1.4.4 Interaction effect of varieties x liquid biofertilizer for mean root length (cm) per plant at 90 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	10.22	13.11	10.55	11.11	13.66
V_2	9.00	13.33	10.44	11.33	13.77
V_3	10.66	15.11	13.00	13.88	15.77
SE ±	0.27				
CD at 5 %	0.77				

At 90 DAS the interaction between varieties and liquid biofertilizer was significant where treatment combination V_3 Lb_4 recorded significantly the highest (15.77 cm) mean root length followed by V_3 Lb_1 (15.11 cm), V_2 Lb_4 (13.77 cm) and V_1 Lb_4 (13.66 cm) while V_2 Lb_0 recorded significantly the lowest (9.00 cm) mean root length over rest of interaction.

4.3.1.4.5 Interaction effect of fertilizer x liquid biofertilizer for mean root length (cm) per plant at 60 DAS (2001)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	8.66	14.00	10.77	10.77	15.44
F_2	8.22	13.22	9.55	9.66	13.88
F_3	7.88	10.88	8.88	8.44	12.77
SE ±	0.23				
CD at 5 %	0.67				

Interaction between fertilizer and liquid bio-fertilizer was found to be significant. The interaction of F_1 with Lb_4 recorded significantly the highest (15.44 cm) mean root length over rest of interaction at 60 DAS.

4.3.2 Mean number of root nodules

Data regarding mean number of root nodules per plant of groundnut as affected by different treatments for the year 2000 and 2001 are presented in Table 18 and graphically depicted in Fig. 6.

Table 18. Mean number of root nodules per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	9.00	37.95	106.04	108.24	15.46	35.13	124.08	125.08
V_2	25.82	82.86	96.62	95.77	15.62	31.02	105.20	105.86
V_3	11.64	38.11	93.82	92.11	16.02	29.11	75.26	79.04
SE ±	8.99	1.04	1.85	1.59	0.45	0.32	0.77	0.58
CD 5%	NS	3.13	5.55	4.77	NS	0.96	2.30	1.72
Ferti. Levels								
F_1	27.70	60.47	117.22	115.69	16.73	35.51	110.95	111.53
F_2	10.48	53.46	99.04	99.53	15.71	31.93	100.82	104.04
F_3	8.31	45.00	80.22	80.91	14.66	27.82	90.87	94.42
SE ±	8.99	1.04	1.85	1.59	0.25	0.32	0.77	0.58
CD 5%	NS	3.13	5.55	4.77	NS	0.96	2.30	1.72
Liq. Bioferti.								
Lb_0	7.33	39.37	46.25	44.85	9.59	19.96	41.48	42.44
Lb_1	13.18	65.07	137.26	139.63	20.85	37.33	137.22	140.11
Lb_2	8.04	45.40	71.96	71.33	14.70	28.00	84.18	88.18
Lb_3	7.22	47.37	70.55	68.22	9.77	31.11	94.40	96.66
Lb_4	41.66	67.66	168.11	169.52	23.59	42.37	146.96	149.25
SE ±	11.53	2.99	2.89	1.75	0.34	0.46	0.893	0.79
CD 5%	NS	8.45	8.20	4.84	NS	1.26	2.52	2.23
Interactions								
V x F	NS	Sig.	NS	NS	NS	NS	Sig.	Sig.
V x Lb	NS	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.
F x Lb	NS	NS	NS	Sig.	NS	NS	Sig.	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.3.2.1 Effect of varieties (2000)

Data on mean number of root nodules at 30 DAS was found to be non significant.

At 60 DAS variety V_2 recorded significantly the highest (82.86) root nodules while V_3 and V_4 recorded (38.11 and 37.95) lower root nodules respectively.

At 90 DAS significantly the highest rood ndules was recorded by variety V_1 (106.04) while V_3 recorded (93.82) which was significantly the lowest and V_2 observed (96.62) which was at par with V_3.

At harvest significantly the highest and the lowest mean number of root nodules was recorded by the variety V_1 (108.24) and V_3 (92.11) respectively.

4.3.2.2 Effect of fertilizer levels

The results on mean number of root nodules under different levels of fertilizer at 30 DAS was found to be non-significant.

At 60, 90 DAS and at harvest mean number of nodules recorded under F_1 was significantly the highest (60.47, 117.22, 115.69) followed by F_2 (53.46, 99.04, 99.53) respectively while under F_3 (45.00, 80.22, 80.91) which was significantly the lowest.

4.3.2.3 Effect of liquid biofertilizer

Mean number of root nodules at 30 DAS was found to be non-significant.

At 60 DAS root nodule was significantly the highest due to Lb_1 (65.07) and Lb_4 (67.66) while Lb_2 and Lb_3 recorded (45.40, 47.37) respectively which was at par over control Lb_0 (39.37).

At 90 DAS and at harvest nodule number was significantly higher due to all the treatments of liquid bio-fertilizer over control as Lb_1 (137.26, 139.63), Lb_2 (71.96, 71.33) Lb_3 (70.55, 68.22) Lb_4 (168.11, 169.52) respectively over control Lb_0 (46.25, 44.85).

4.3.2.4 The interaction effects

Interaction due to V x F, V x Lb, F x Lb and V x F x Lb were found to be non-significant except V x F at 60 DAS V x Lb at 60, 90 DAS and at harvest and F x Lb at harvest.

4.3.2.4.1 Interaction effect of varieties x fertilizer for mean number of root nodules per plant at 60 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	43.06	39.33	31.46
V_2	94.66	83.40	70.53
V_3	43.66	37.66	33.00
SE ±	1.80		
CD at 5 %	5.41		

The interaction between varieties and fertilizer levels was found to be significant. V_2 with F_1 recorded significantly the highest (94.66) while V_1 F_3 (31.46) the lowest number of root nodules at 60 DAS.

4.3.2.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of root nodules per plant at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	34.11	40.22	31.78	33.55	50.11
V_2	45.00	115.11	77.22	70.77	113.22
V_3	39.00	39.88	34.22	37.77	39.66
SE ±	4.75				
CD at 5 %	13.44				

The variety V_2 with Lb_1 recorded significantly highest (115.11) number of root nodules followed by V_2 Lb_4 (113.22) at 60 DAS.

4.3.2.4.3 Interaction effect of varieties x liquid biofertilizer for mean number of root nodules per plant at 90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	48.00	156.66	77.66	72.88	175.00
V_2	39.88	120.88	83.00	77.66	161.66
V_3	50.88	134.22	55.22	61.11	167.66
SE ±	4.85				
CD at 5 %	13.74				

The interaction effect due to varieties and liquid biofertilizer was found to be significant at 90 DAS. Mean number of root nodules recorded by all the varieties under study was significantly highest with Lb_4 i.e. V_1 Lb_4 (175.00), V_2 Lb_4 (161.66) and V_3 Lb_4 (167.66) followed by Lb_1 i.e. V_1 Lb_1 (156.66) V_2 Lb_1 (120.88) and V_3 Lb_1 (134.22).

4.3.2.4.4 Interaction effect of varieties x liquid biofertilizer for mean number of root nodules per plant at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	48.88	162.88	78.33	73.66	177.44
V_2	36.11	121.66	79.33	78.77	163.00
V_3	49.55	134.33	56.33	52.22	168.11
SE ±	3.13				
CD at 5 %	8.92				

At harvest the interaction between varieties and liquid biofertilizer was found to be significant whereas V_1 Lb_4 recorded significantly the highest (177.44) root nodules while V_2 Lb_0 recorded (36.11) number of root nodules which was significantly the lowest.

4.3.2.4.5 Interaction effect of fertilizer x liquid biofertilizer for mean number of root nodules per plant at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	58.44	153.55	92.22	84.11	190.11
F_2	44.33	137.77	68.00	68.77	178.77
F_3	31.77	127.55	53.77	51.77	139.66
SE ±	3.13				
CD at 5 %	8.92				

At harvest the interaction F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (190.11) and the lowest (31.77) number of nodules per plant over rest of the interaction.

4.3.2.1 Effect of varieties (2001)

Data on mean number of root nodules at 30 DAS was found statistically non-significant.

At 60 DAS the variety V_1 recorded significantly the highest number of root nodules (35.13) followed by V_2 (31.02) while V_3 recorded (29.11) which was significantly the lowest over V_1 and V_2.

At 90 DAS the root nodule number was significantly the highest with variety V_1 (124.08) followed by V_2 (105.20) and V_3 (75.26) which was significantly the lowest over V_1 and V_2.

Nodule numbers was significantly affected within the varieties at harvest where variety V_1 recorded significantly the highest root nodules (125.08) followed by V_2 (105.86) and V_3 (79.04) which was significantly the lowest.

4.3.2.2 Effect of fertilizers

At 30 DAS data on mean root nodule number was found to be non-significant.

At 60 DAS under F_1 significantly the highest root nodule number (35.51) followed by F_2 (31.93) and under F_3 it was (27.82) which was significantly the lowest, with F_1 and F_2.

At 90 DAS and at harvest under F_1 the root nodule number was significantly the highest (110.95, 111.53) followed by F_2 (100.82, 104.04) respectively whereas under F_3 recorded (90.87, 94.92) which was significantly the lowest.

4.3.2.3 Effect of liquid biofertilizer

Data on nodule number at 30 DAS was statistically non-significant.

At 60, 90 DAS and at harvest number of nodules was significantly the highest due to all the liquid biofertilizer treatments as Lb_1 (37.33, 137.22, 140.11) Lb_2 (28.00, 84.18, 88.14) Lb_3 (31.11, 94.40, 96.66), Lb_4 (42.37, 146.96, 149.25) respectively over control Lb_0 (19.96, 41.48, 42.44).

4.3.2.4 The interaction effects

Interaction due to V x F at 30 and 60 DAS, V x Lb at 30 DAS, F x Lb at 30, 60 DAS and at harvest and V x F x Lb at 30, 60, 90 DAS and at harvest was statistically found to be non-significant.

4.3.2.4.1 Interaction effect of varieties x fertilizer for mean number of root nodules per plant at 90 DAS (2001)

Varieties / Fertilizer levels	F_1	F_2	F_3
V_1	82.33	76.80	60.66
V_2	116.66	102.20	96.33
V_3	133.86	123.46	114.93
SE ±	1.33		
CD at 5 %	3.98		

Differences in number of root nodules due to combined effect of varieties and fertilizer levels were found to be significant at 90 DAS. The combination V_3 F_1 and V_1 F_3 recorded significantly the highest (133.86) and lowest (60.66) mean number of root nodules. In the remaining combinations the mean number of root nodules was in between these two combinations.

4.3.2.4.2 Interaction effect of varieties x fertilizer for mean number of root nodules per plant at harvest (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	82.33	83.13	71.26
V_2	117.33	102.33	97.93
V_3	134.53	126.66	114.07
SE ±	0.99		
CD at 5 %	2.98		

The interaction due to varieties and fertilizer was found to be significant at harvest. Where V_3 F_1 and V_1 F_3 combination were recorded significantly the highest (134.53) and lowest (71.26) mean number of root nodules.

4.3.2.4.3 Interaction effect of varieties x liquid biofertilizer for mean number of root nodules per plant at 60 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	17.77	42.88	33.11	33.88	48.00
V_2	21.55	34.00	28.00	30.77	40.77
V_3	20.55	35.11	22.88	28.66	38.33
SE ±	0.77				
CD at 5 %	2.20				

The combined effect due to varieties and liquid biofertilizer was found to be significant at 60 DAS where V_1 Lb_4 produced significantly higher (48.00) number of root nodules while V_1 Lb_0 recorded (17.77) which was significantly the lowest.

4.3.2.4.4 Interaction effect of varieties x liquid biofertilizer for mean number of root nodules per plant at 90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	24.66	101.55	59.55	75.33	105.22
V_2	37.44	144.66	88.44	90.00	165.44
V_3	62.33	165.44	104.55	117.88	170.22
SE ±	1.58				
CD at 5 %	4.49				

The combination of V_3 Lb_4 and V_1 Lb_0 produced significantly the highest (170.22) and the lowest (24.66) number of root nodules per plant respectively at 90 DAS.

4.3.2.4.5 Interaction effect of varieties x liquid biofertilizer for mean number of root nodules per plant at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	25.66	108.22	68.88	80.22	112.22
V_2	38.00	145.11	88.88	90.22	167.11
V_3	63.66	167.00	106.77	119.55	168.44
SE ±	1.35				
CD at 5 %	3.83				

At harvest number of nodules due to varieties and liquid biofertilizer was found to be significant. The treatment combination V_3 Lb_4 recorded significantly higher (168.44) number of root nodules followed by V_2 Lb_4 and V_3 Lb_1 (167.11 and 167.00) respectively. However V_1 Lb_0 produced significantly the lowest (25.66) number of nodules over rest of interaction.

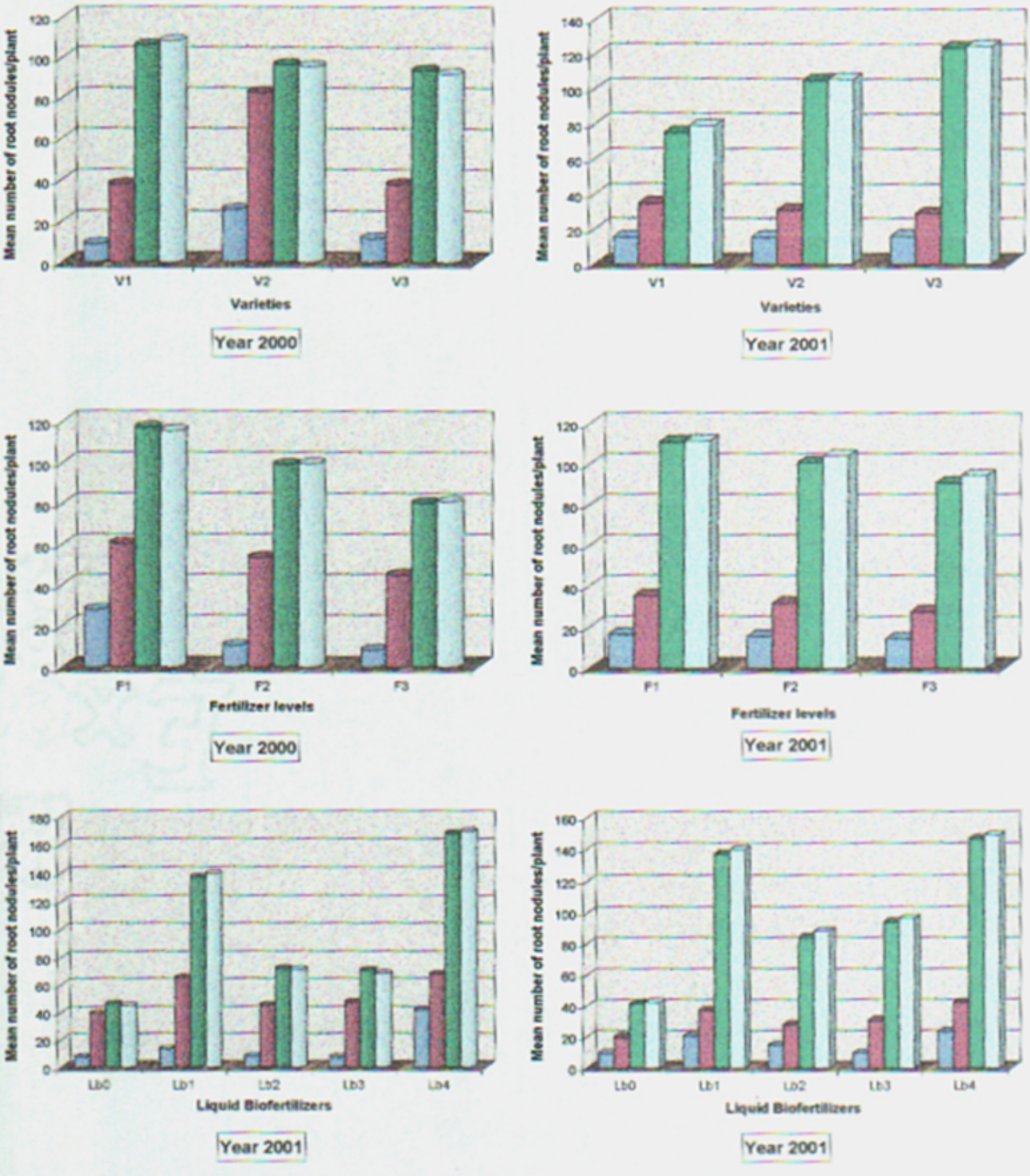


Fig. 6 : Mean number of root nodules per plant of groundnut as affected by different treatments

4.3.2.4.6 Interaction effect of fertilizer x liquid biofertilizer for mean number of root nodules per plant at 90 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	50.22	149.00	93.88	103.22	158.44
F_2	40.66	138.22	80.22	96.66	148.33
F_3	33.55	124.44	78.44	83.33	134.11
SE ±	1.58				
CD at 5 %	4.50				

From the data on mean number of root nodules at 90 DAS observed that F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (158.44) and the lowest (33.55) mean number of nodules over rest of the treatment combinations.

4.3.3 Mean dry weight of root nodules (mg)

Data pertaining to dry weight of root nodules (mg) for the year 2000 and 2001 are presented in Table 19.

4.3.3.1 Effect of varieties (2000)

At 30 DAS data on dry weight of nodules were statistically found to be non-significant.

At 60 DAS variety V_2 recorded significantly the highest (82.88) dry weight of nodules while V_3 and V_1 recorded (40.95, 38.85) which was significantly the lowest over V_2.

At 90 DAS variety V_1 recorded significantly the highest mean dry weight (111.28) followed by V_2 (101.08) while V_3 recorded (96.16) which was significantly the lowest.

4.3.2.4.6 Interaction effect of fertilizer x liquid biofertilizer for mean number of root nodules per plant at 90 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	50.22	149.00	93.88	103.22	158.44
F_2	40.66	138.22	80.22	96.66	148.33
F_3	33.55	124.44	78.44	83.33	134.11
SE ±	1.58				
CD at 5 %	4.50				

From the data on mean number of root nodules at 90 DAS observed that F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (158.44) and the lowest (33.55) mean number of nodules over rest of the treatment combinations.

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At 90 DAS variety V_1 recorded significantly the highest mean dry weight (111.28) followed by V_2 (101.08) while V_3 recorded (96.16) which was significantly the lowest.

Table 19. Mean dry weight of root nodules (mg) per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	6.75	38.85	111.28	114.65	11.29	35.81	127.73	132.54
V_2	7.40	82.88	101.08	102.17	11.12	31.33	110.62	112.20
V_3	30.14	40.95	96.16	97.71	11.21	31.62	77.70	83.69
SE ±	12.67	2.58	1.68	1.51	0.18	1.39	1.52	0.64
CD 5%	NS	7.72	5.05	4.53	NS	NS	4.55	1.93
Ferti. Levels								
F_1	8.90	62.76	120.94	122.63	11.98	35.99	116.66	118.15
F_2	29.46	53.93	103.99	105.45	11.18	32.35	104.00	110.19
F_3	5.92	45.98	84.10	86.44	10.46	30.42	95.38	100.09
SE ±	12.67	2.58	1.68	1.51	0.18	1.39	1.52	0.64
CD 5%	NS	7.72	5.05	4.53	NS	4.17	4.55	1.93
Liq. Bioferti.								
Lb_0	5.28	45.93	48.79	48.72	6.87	20.22	43.55	44.98
Lb_1	45.84	59.54	144.10	147.63	14.89	37.85	139.92	148.51
Lb_2	5.92	50.64	75.56	75.61	10.48	32.09	89.00	93.31
Lb_3	5.17	44.66	70.19	72.31	6.98	31.53	99.40	102.44
Lb_4	11.58	70.34	176.40	179.95	16.80	42.91	154.31	158.14
SE ±	16.26	3.93	2.50	1.83	0.24	1.74	1.96	0.84
CD 5%	NS	10.88	6.97	5.07	NS	4.83	5.53	2.37
Interactions								
V x F	NS	NS	NS	NS	NS	NS	Sig.	NS
V x Lb	NS	NS	Sig.	Sig.	NS	NS	Sig.	Sig.
F x Lb	NS	NS	NS	Sig.	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

Similar results were obtained at harvest where V_1 recorded significantly the highest dry weight of nodules (114.65) followed by V_2 (102.17) and V_3 (97.71) which was significantly the lowest.

4.3.3.2 Effect of fertilizer levels

Data pertaining to nodule dry weight at 30 DAS was found to be non-significant.

At 60 DAS under F_1 dry weight of nodules was significantly the highest (62.76) followed by F_2 (53.93) and under F_3 it was (45.98) significantly the lowest.

At 90 DAS and at harvest under F_1 dry weight of nodules was significantly the highest (120.94, 122.63) followed by F_2 (103.99, 105.45) respectively while under F_3 it was (84.10, 86.44) significantly the lowest.

4.3.3.3 Effect of liquid biofertilizer

The results on dry weight of nodules at 30 DAS was found to be non-significant.

At 60 DAS dry weight of nodules was significantly the highest due to Lb_1 (59.54) Lb_4 (70.34) while due to Lb_2 and Lb_3 (50.64, 44.66) it was at par with control Lb_0 (45.93).

At 90 DAS and at harvest the dry weight of nodules was significantly the highest due to all the treatments as Lb_1 (144.10, 147.63), Lb_2 (75.56, 75.61), Lb_3 (70.19, 72.31) Lb_4 (176.40, 179.95) over control Lb_0 (48.79, 48.72).

4.3.3.4 The interaction effects

Interaction effect due to V x F V x Lb, F x Lb, V x F x Lb was found to be non-significant at all the stages of observation except V x Lb at 90 DAS and at harvest and F x Lb at harvest.

4.3.3.4.3 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of root nodules (mg) per plant at harvest (2000)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	61.95	162.76	97.75	89.16	201.52
F_2	47.11	144.90	72.06	72.90	190.28
F_3	37.10	135.22	57.00	54.86	148.05
SE ±	3.21				
CD at 5 %	9.13				

From the data relating to dry weight of nodules noticed that treatment combination F_1 Lb_4 and F_3 Lb_0 produced significantly the highest (201.52 mg) and lowest (37.10 mg) dry weight of nodules at harvest as compared to other combination.

4.3.3.1 Effect of varieties (2001)

Data regarding dry weight of nodules at 30 and 60 DAS found to be non-significant.

From the data on mean dry weight of root nodules at 90 DAS and at harvest it was observed that variety V_1 and V_3 recorded significantly the highest (127.73, 132.54) and the lowest (77.70, 83.69) values respectively. However, variety V_2 recorded (110.62, 112.20) nodules dry weight which was significantly the highest over V_3 and the lowest over V_1.

4.3.3.2 Effect of fertilizer levels

Data on dry weight of root nodules at 30 DAS was found to be non-significant.

At 60 DAS under F_1 significantly highest root nodule dry weight (35.99) was recorded followed by F_2 (32.35) while under F_3 it was significantly lowest (30.42).

At 90 DAS and at harvest under F_1 and F_3 significantly the highest and the lowest dry weight of root nodules (116.66, 118.15) and (95.38, 100.09) was recorded. While under F_2 it was (104.00, 110.19) which was significantly the lowest over F_3.

4.3.3.3 Effect of liquid biofertilizers

Data recorded on mean dry weight of root nodules was found to be non-significant at 30 DAS.

At 60, 90 DAS and at harvest mean dry weight of root nodules was significantly the highest due to Lb_1 (37.85, 139.92, 148.51), Lb_2 (32.09, 89.00, 93.31), Lb_3 (31.53, 99.40, 102.44) and Lb_4 (42.91, 154.31, 158.14) respectively over control Lb_0 (20.22, 43.55, 44.98).

4.3.3.4 The interaction effects

Interaction due to V x F, V x Lb, F x Lb and V x F x Lb was found to be non-significant at all the stages of observation except V x F at 90 DAS and V x Lb at 90 DAS and at harvest.

4.3.3.4.1 Interaction effect of varieties x fertilizer for mean dry weight of root nodules (mg) per plant at 90 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	86.45	82.74	63.91
V_2	122.99	107.31	101.57
V_3	140.56	121.95	120.68
SE ±	2.63		
CD at 5 %	7.88		

Variation for dry weight of nodules due to combined effect of varieties and fertilizer were found to be significant at 90 DAS. Significantly the highest and the lowest dry weight of root nodules was observed under the combination of V_3 F_1 and V_1 F_3 (140.56, 63.91 mg) respectively.

4.3.3.4.2 Interaction effect of varieties x liquid biofertilizer for mean dry weight of root nodules (mg) per plant at 90 DAS (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	25.90	106.98	66.03	79.10	110.48
V_2	39.31	151.90	92.86	95.31	173.71
V_3	65.45	160.89	109.78	123.78	178.33
SE ±	3.39				
CD at 5 %	9.64				

The interaction between varieties and liquid bio-fertilizer was found to be significant. The variety V_3 with Lb_4 recorded significantly higher (178.33 mg) dry weight of nodules followed by V_2 Lb_4 (173.71 mg) while V_1 Lb_0 recorded significantly the lowest (25.90) dry weight of nodules at 90 DAS.

4.3.3.4.3 Interaction effect of varieties x liquid biofertilizer for mean dry weight of root nodules (mg) per plant at harvest (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	27.21	114.71	72.55	85.03	118.96
V_2	40.25	153.81	94.22	95.56	177.13
V_3	67.48	177.02	113.18	126.72	178.31
SE ±	1.45				
CD at 5 %	4.12				

At harvest interaction between varieties and liquid biofertilizer was found to be significant. The interaction V_3 Lb_4 recorded significantly higher (178.31) dry weight of root nodules followed by V_2 Lb_4 (177.13) and V_3 Lb_1 (177.02) while V_1 Lb_0 recorded (27.21) significantly the lowest dry weight of root nodules.

4.4 Dry matter studies

Data relating to dry matter of leaves per plant of groundnut as affected by different treatments for the year 2000 and 2001 are given in Table 20.

Dry matter accumulation of leaves increased with advancement in age of the crop.

4.4.1 Mean dry weight of leaves (g) per plant

4.4.1.1 Effect of varieties (2000)

The varietal differences in respect of dry weight of leaves at 30 DAS was found to be non-significant.

At 60 DAS significantly the highest dry matter of leaves was recorded by variety V_2 (7.52) followed by V_1 (7.30) and V_3 recorded (6.91) which was significantly the lowest.

At 90 DAS V_3 recorded significantly highest dry weight of leaves (11.04) while V_2 was significantly lowest (4.67) and V_1 accumulate (7.88) which was significantly highest over V_2 and lowest over V_3.

Similar results was also recorded at harvest where significantly the highest and lowest dry weight of leaves was observed by variety V_3 (10.02) and V_2 (4.31) respectively. However V_1 recorded (7.71) dry weight of leaves which was significantly highest over V_3 and lowest over V_2.

Table 20. Mean dry weight of leaves (g) per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	0.855	7.30	7.88	7.71	1.64	2.821	2.529	2.690
V_2	0.834	7.52	4.67	4.31	0.793	3.209	2.090	1.406
V_3	0.955	6.91	11.04	10.02	0.731	2.352	3.871	1.881
SE ±	0.018	0.088	0.16	0.081	0.507	0.007	0.017	0.005
CD 5%	NS	0.264	0.48	0.24	NS	0.022	0.052	0.014
Ferti. Levels								
F_1	1.01	8.31	9.12	8.55	0.820	2.944	3.282	2.196
F_2	0.890	7.24	7.49	7.21	0.764	2.812	2.906	1.956
F_3	0.753	6.19	6.98	6.28	1.587	2.626	2.301	1.825
SE ±	0.018	0.088	0.16	0.081	0.507	0.007	0.017	0.005
CD 5%	NS	0.264	0.48	0.24	NS	NS	0.052	0.014
Liq. Bioferti.								
Lb_0	0.505	4.74	4.95	4.54	0.764	2.087	1.978	1.750
Lb_1	1.156	9.02	9.42	9.02	2.158	3.050	3.690	2.186
Lb_2	0.764	7.27	8.25	7.43	0.846	2.398	2.658	1.989
Lb_3	0.502	5.39	6.26	5.74	0.727	2.504	1.917	1.597
Lb_4	1.480	9.79	10.45	9.99	0.791	3.931	3.907	2.439
SE ±	0.023	0.12	0.20	0.12	0.67	0.009	0.022	0.005
CD 5%	NS	0.33	0.57	0.34	NS	0.025	0.061	0.014
Interactions								
V x F	NS	Sig.	NS	Sig.	NS	NS	NS	Sig.
V x Lb	Sig.	NS	NS	Sig.	NS	Sig.	Sig.	Sig.
F x Lb	NS	NS	NS	NS	NS	NS	Sig.	Sig.
V x F x Lb	NS	NS	Sig.	NS	NS	NS	Sig.	NS

4.4.1.2 Effect of fertilizer levels

Data regarding dry weight of leaves under different fertilizer levels at 30 DAS was found to be non-significant.

Data in respect of dry weight of leaves at 60, 90 DAS and at harvest indicated significant differences under different levels of fertilizers. Where under F_1 and F_3 it was significantly the highest and lowest dry weight of leaves was recorded (8.31, 9.12, 8.55 and 6.19, 6.98, 6.28) respectively. While F_2 recorded (7.24, 7.49, 7.21) which was significantly highest under F_3 and lowest under F_1.

4.4.1.3 Effect of liquid biofertilizers

The differences due to liquid biofertilizers on dry weight of leaves at 30 DAS was found to be non-significant.

At 60, 90 DAS and at harvest significantly higher dry weight of leaves was observed due to Lb_1 (9.02, 9.42, 9.02) Lb_2 (7.27, 8.25, 7.43), Lb_3 (5.39, 6.26, 5.74) Lb_4 (9.79, 10.45, 9.99) over control Lb_0 (4.74, 4.95, 4.54).

4.4.1.4 The interaction effects

The interaction effects were found to be non-significant at all stages except V x F at 60 DAS and at harvest, V x Lb at 30 DAS and at harvest and V x F x Lb at 90 DAS.

4.4.1.4.1 Interaction effect of varieties x fertilizer for mean dry weight of leaves (g) per plant at 60 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	8.06	7.30	6.53
V_2	9.03	7.39	6.12
V_3	7.82	7.01	5.91
SE ±	0.15		
CD at 5 %	0.46		

Dry weight of leaves due to interaction between varieties and fertilizer levels was significant at 60 DAS. Variety V_2 with F_1 and V_3 with F_3 was recorded significantly the highest (9.03) and lowest (5.91) dry weight of leaves respectively.

4.4.1.4.2 Interaction effect of varieties x fertilizer for mean dry weight of leaves (g) per plant at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	8.93	7.99	6.19
V_2	6.11	3.68	3.13
V_3	10.60	9.94	9.50
SE ±	0.14		
CD at 5 %	0.41		

Differences in dry weight of leaves due to combined effect of varieties and fertilizer levels were found to be significant at harvest. Where V_3 F_1 and V_2 F_3 noticed significantly the highest (10.60 g) and the lowest (3.13 g) dry weight of leaves.

4.4.1.4.3 Interaction effect of varieties x liquid biofertilizer for mean dry weight of leaves (g) per plant at 30 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.43	1.14	0.69	0.43	1.57
V_2	0.55	1.11	0.68	0.46	1.35
V_3	0.53	1.22	0.90	0.60	1.50
SE ±	0.04				
CD at 5 %	0.11				

The interactive effects due to varieties and liquid bio-fertilizer on production of dry matter of leaves at 30 DAS were found to be significant. The interaction V_1 Lb_4 produced significantly the highest dry weight (1.57 g) followed by V_3 Lb_4 (1.50 g) over rest of the interactions. While V_1 Lb_0 and V_1 Lb_3 produced significantly the lowest (0.43 g) dry weight of leaves followed by V_3 Lb_0 (0.53 g) respectively.

4.4.1.4.4 Interaction effect of varieties x liquid biofertilizer for mean dry weight of leaves (g) per plant at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	4.46	10.34	7.20	5.83	10.70
V_2	2.81	5.65	3.90	3.11	6.06
V_3	6.35	11.06	11.19	8.27	13.20
SE ±	0.21				
CD at 5 %	0.58				

Interaction between varieties and liquid bio-fertilizer were found to be significant. The interaction V_3 Lb_4 recorded significantly highest (13.20 g) dry weight of leaves over rest of interaction at harvest. While V_2 Lb_0 and V_2 Lb_3 recorded significantly lower (2.81, 3.11 g) mean dry weight of leaves respectively.

4.4.1.4.5 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean dry weight of leaves (g) per plant at 90 DAS (2000)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	5.78	5.58	3.12	4.10	2.55	2.15	7.30	6.93	6.45
Lb_1	12.28	9.13	8.89	8.36	5.32	4.83	12.24	11.78	11.71
Lb_2	8.12	8.27	6.33	6.87	3.20	2.47	12.99	12.93	12.47
Lb_3	7.90	5.74	5.03	3.93	3.43	2.89	9.26	9.13	9.03
Lb_4	13.27	8.11	9.23	9.14	5.66	5.19	14.68	14.44	14.28
SE ±	0.60								
C.D at 5 %	1.71								

Significantly the highest mean dry weight of leaves was recorded by the treatment combination V_3 F_1 Lb_4 (14.68) followed by V_3 F_1 Lb_2 (12.99), V_1 F_1 Lb_4 (13.27) and V_3 F_2 and F_3 Lb_4 (14.44, 14.28) respectively. However significantly the lowest mean dry weight was observed in V_2 F_3 Lb_0 (2.15) V_2 F_2 Lb_0 (2.55) and V_1 F_3 Lb_0 (3.12) interaction as compared to remaining combination.

4.4.1.1 Effect of varieties (2001)

At 30 DAS varietal differences for dry weight of leaves was found to be non-significant.

At 60 DAS significantly the highest dry weight was recorded by the variety V_2 (3.209) followed by V_1 (2.821) and V_3 (2.352) which was significantly the lowest over V_1 and V_2.

At 90 DAS V_3 recorded significantly the highest dry weight of leaves (3.871) followed by V_1 (2.529) and V_2 recorded (2.090) which was significantly lowest over V_3 and V_1.

At harvest significantly highest and lowest dry weight of leaves was noticed by V_1 (2.690) and V_3 (1.881) respectively.

4.4.1.2 Effect of fertilizer levels

Data relating to dry weight of leaves at 30 and 60 DAS was found to be statistically non-significant.

At 90 DAS and at harvest significantly highest and lowest dry matter accumulation of leaves was observed under F_1 and F_3 (3.282, 2.196) respectively and (2.301, 1.825) while under F_2 it was noticed (2.906, 1.956) which was significantly highest with F_3 and lowest with F_1.

4.4.1.3 Effect of liquid biofertilizer

Liquid biofertilizers had non-significant effect on dry weight of leaves at 30 DAS.

It was evident that dry weight of leaves at 60 DAS was significantly highest due to Lb_1 (3.050), Lb_2 (2.398), Lb_3 (2.504) Lb_4 (3.931) respectively over control Lb_0 (2.087).

At 90 DAS and at harvest significantly highest dry weight was observed due to almost all liquid bio-fertilizer treatments i.e. Lb_1 (3.690, 2.186) Lb_2 (2.658, 1.989) Lb_4 (3.907, 2.439) respectively except Lb_3 (1.917, 1.597) over control Lb_0 (1.978, 1.750).

4.4.1.4 The interaction effects

Interaction was found to be non-significant at all the stages except V x F at harvest, V x Lb at 60, 90 DAS and at harvest, F x Lb at 90 DAS and at harvest, V x F x Lb at 90 DAS.

4.4.1.4.1 Interaction effect of varieties x fertilizer for mean dry weight of leaves (g) per plant at harvest (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	2.98	2.64	2.44
V_2	1.58	1.33	1.30
V_3	2.02	1.89	1.73
SE ±	0.008		
CD at 5 %	0.025		

Interaction effects between varieties and fertilizer leavels in respect of dry weight of leaves at harvest was found to be significant. Where treatment combination V_1 F_1 and V_2 F_3 recorded significantly the highest (2.98 g) and lowest (1.30 g) dry weight of leaves at harvest.

4.4.1.4.2 Interaction effect of varieties x liquid biofertilizer for mean dry weight of leaves (g) per plant at 60 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	1.81	3.21	2.04	2.58	4.45
V_2	2.55	3.10	2.38	3.35	4.64
V_3	1.89	2.83	2.77	1.56	2.69
SE ±	0.016				
CD at 5 %	0.044				

Significantly the highest (4.64 g) dry weight of leaves was recorded by the interaction V_2 Lb_4 while significantly the lowest dry weight of leaves (1.56 g) was recorded by V_3 Lb_3 over rest of the interaction at 60 DAS.

4.4.1.4.3 Interaction effect of varieties x liquid biofertilizer for mean dry weight of leaves (g) per plant at 90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	2.47	2.73	2.28	2.32	2.83
V_2	0.940	2.76	1.85	1.56	3.33
V_3	2.52	5.57	3.83	1.87	5.55
SE ±	0.038				
CD at 5 %	0.11				

Interaction effect due to varieties and liquid bio-fertilizer was found to be significant at 90 DAS. The combination V_3 Lb_4 recorded significantly the highest (5.55 g) and V_2 Lb_0 (0.940 g) the lowest dry weight of leaves was recorded respectively.

4.4.1.4.4 Interaction effect of varieties x liquid biofertilizer for mean dry weight of leaves (g) per plant at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	2.62	2.79	2.46	2.67	2.88
V_2	1.10	1.61	0.972	1.04	2.31
V_3	1.52	2.14	2.53	1.08	2.12
SE ±	0.009				
CD at 5 %	0.026				

At harvest dry weight of leaves was significant due to varieties and liquid biofertilizer. The interaction V_1 Lb_4 and V_2 Lb_2 produced significantly the highest (2.88 g) and the lowest (0.972 g) mean dry weight of leaves respectively.

4.4.1.4.5 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of leaves (g) per plant at 90 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	2.16	4.72	2.93	2.06	4.52
F_2	1.98	3.67	2.76	1.98	4.12
F_3	1.79	2.67	2.26	1.69	3.07
SE ±	0.038				
CD at 5 %	0.11				

Data relating to dry weight of leaves noticed that interaction F_1 Lb_1 and F_3 Lb_3 recorded significantly the highest (4.72 g) and the lowest (1.69 g) dry weight of leaves as compared to other interaction at 90 DAS.

4.4.1.4.6 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of leaves (g) per plant at harvest (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	1.86	2.28	2.26	1.91	2.65
F_2	1.78	2.18	1.94	1.50	2.36
F_3	1.59	2.09	1.75	1.37	2.29
SE ±	0.009				
CD at 5 %	0.026				

Significantly the highest and the lowest dry weight of leaves was recorded by the interaction F_1 Lb_4 (2.65 g) F_3 Lb_3 (1.37 g) respectively over rest of the interaction at harvest.

4.4.1.4.7 Interaction effect of V x F x Lb for mean dry weight of leaves (g) per plant at 90 DAS (2001)

Var. / Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	2.59	2.50	2.31	1.23	0.84	0.74	2.65	2.60	2.31
Lb_1	2.82	2.79	2.57	3.75	2.38	2.15	7.58	5.84	3.30
Lb_2	2.43	2.30	2.12	2.06	1.86	1.63	4.31	4.14	3.05
Lb_3	2.42	2.41	2.13	1.60	1.58	1.49	2.17	1.97	1.46
Lb_4	2.92	2.83	2.75	3.83	3.67	2.48	6.82	5.85	3.98
SE ±	0.065								
C.D at 5 %	0.18								

From the data it was revealed that the interaction V_3 F_1 Lb_1 recorded significantly the highest (7.58 g) mean dry weight of leaves at 90 DAS over rest of the interaction. While interaction V_2 F_3 Lb_0 and V_2 F_2 Lb_0 recorded significantly the lowest (0.743, 0.840 g) dry weight of leaves respectively.

4.4.2 Mean dry weight of stem (g)

Data regarding mean dry weight of stem per plant of groundnut as affected by different treatments for the year 2000 and 2001 are presented in Table 21.

4.4.2.1 Effect of varieties (2000)

The varietal differences was found to be significant due to different treatments where variety V_1 and V_2 recorded significantly the highest and lowest (0.715, 4.76) and (0.582, 4.03) mean dry weight of stem at 30 and 60 DAS respectively.

At 90 DAS and at harvest significantly the highest dry weight of stem was recorded by the variety V_3 (7.85, 7.78) followed by V_1 (6.75, 6.90) while V_2 recorded (4.42, 4.57) dry weight of stem which was significantly the lowest over rest of the varieties.

Table 21. Mean dry weight of stem (g) per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	0.715	4.76	6.75	6.90	0.570	1.651	3.002	3.915
V_2	0.582	4.03	4.42	4.57	0.477	2.365	2.690	1.384
V_3	0.613	4.51	7.85	7.78	0.419	1.967	4.206	4.182
SE ±	0.015	0.042	0.053	0.13	0.003	0.007	0.007	0.015
CD 5%	0.043	0.16	0.16	0.38	0.010	0.020	0.20	0.044
Ferti. Levels								
F_1	0.796	5.20	7.24	7.37	0.522	2.185	4.128	3.650
F_2	0.602	4.42	6.32	6.24	0.521	1.979	3.195	3.324
F_3	0.512	3.68	5.46	5.63	0.423	1.818	2.574	2.507
SE ±	0.015	0.042	0.053	0.13	0.003	0.007	0.007	0.015
CD 5%	0.043	0.16	0.16	0.38	0.10	0.20	0.020	0.044
Liq. Bioferti.								
Lb_0	0.350	2.82	3.86	3.98	0.266	1.510	1.925	2.486
Lb_1	0.892	5.11	7.48	7.61	0.617	2.274	3.609	3.638
Lb_2	0.523	3.78	6.05	6.23	0.449	1.694	3.166	3.012
Lb_3	0.393	3.91	5.12	5.26	0.386	1.941	3.136	2.696
Lb_4	1.025	6.56	9.18	9.02	0.726	2.551	4.659	3.969
SE ±	0.016	0.054	0.095	0.201	0.004	0.009	0.010	0.031
CD 5%	0.046	0.15	0.27	0.56	0.012	0.26	0.029	0.086
Interactions								
V x F	NS	Sig.	Sig.	NS	NS	Sig.	Sig.	NS
V x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
F x Lb	NS	Sig.	Sig.	NS	NS	Sig.	Sig.	NS
V x F x Lb	NS	NS	Sig.	NS	NS	NS	Sig.	NS

4.4.2.2 Effect of fertilizer levels

The data on mean dry weight of stem was significantly affected at different levels of fertilizers at all the stages of observation. Under F_1 dry weight of stem was significantly highest (0.796, 5.20, 7.24, 7.37) at 30, 60, 90 DAS and at harvest while under F_3 it was significantly the lowest (0.512, 3.68, 5.46, 5.63) respectively and under F_2 it was (0.602, 4.42, 6.32, 6.24) which was significantly highest with F_3 and lowest as compared to F_1.

4.4.2.3 Effect of liquid biofertilizer

From the data on dry weight of stem at 30, 60, 90 DAS and at harvest found that it was significantly highest due Lb_1 (0.892, 5.11, 7.48, 7.61) Lb_2 (0.523, 3.78, 6.05, 6.23) Lb_3 (3.91, 5.12, 5.26) and Lb_4 (1.025, 6.56, 9.18. 9.02) over control Lb_0 (0.350, 2.82, 3.86, 3.98) respectively except due to Lb_3 (0.393) which was at par with it.

4.4.2.4 The interaction effect

Interaction due to V x F and F x Lb was found to be non-significant at 30 DAS and at harvest.

Interaction due to V x F x Lb was found to be non-significant at 30, 60 DAS and at harvest.

4.4.2.4.1 Interaction effect of varieties x fertilizer for mean dry weight of stem (g) per plant at 60 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	5.88	4.74	3.68
V_2	4.71	3.89	3.48
V_3	5.02	4.64	3.87
SE ±	0.07		
CD at 5 %	0.22		

Significantly the highest and the lowest dry weight of stem was recorded by the treatment combination V_1 F_1 (5.88) and V_2 F_3 (3.48) respectively at 60 DAS.

4.4.2.4.2 Interaction effect of varieties x fertilizer for mean dry weight of stem (g) per plant at 90 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	7.70	6.60	5.94
V_2	5.07	4.51	3.67
V_3	8.93	7.84	6.75
SE ±	0.09		
CD at 5 %	0.28		

The interactive effects due to varieties and fertilizer levels on production of dry matter of stem (g) per plant at 90 DAS were found to be significant.

Significantly the highest dry weight of stem was recorded by V_3 F_1 (8.93 g) while the lowest was recorded by V_2 F_3 (3.67 g).

4.4.2.4.3 Interaction effect of varieties x fertilizer for mean dry weight of stem (g) per plant at 30 DAS (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.38	1.08	0.58	0.41	1.11
V_2	0.34	0.80	0.47	0.32	0.97
V_3	0.32	0.79	0.51	0.44	0.95
SE ±	0.029				
CD at 5 %	0.083				

Interaction between varieties and liquid bio-fertilizer was significant where V_1 Lb_4 recorded significantly the highest (1.11 g) dry weight of stem at 30 DAS.

4.4.2.4.4 Interaction effect of varieties x liquid biofertilizer for mean dry weight of stem (g) per plant at 60 DAS (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	2.73	5.72	3.75	4.12	7.49
V_2	2.23	4.65	3.71	3.72	5.82
V_3	3.49	4.93	3.87	3.90	6.37
SE ±	0.093				
CD at 5 %	0.026				

At 60 DAS interaction between varieties and liquid biofertilizer found to be significant. The interaction V_1 Lb_4 and V_2 Lb_0 recorded significantly the highest (7.49 g) and lowest (2.23 g) dry weight of stem respectively.

4.4.2.4.5 Interaction effect of varieties x liquid biofertilizer for mean dry weight of stem (g) per plant at 90 DAS (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	4.28	7.78	6.12	5.02	10.55
V_2	2.46	5.05	4.52	3.81	6.26
V_3	4.84	9.62	7.51	6.53	10.73
SE ±	0.15				
CD at 5 %	0.44				

Significantly higher dry weight of stem (10.73 g) was recorded by V_3 Lb_4 followed by V_1 Lb_4 (10.55 g) while V_2 Lb_0 observed significantly the lowest (2.46 g) mean dry weight of stem at 90 DAS.

4.4.2.4.6 Interaction effect of varieties x liquid biofertilizer for mean dry weight of stem (g) per plant at harvest (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	4.35	7.97	6.28	5.21	10.72
V_2	2.57	5.18	4.63	3.90	6.57
V_3	5.04	9.69	7.77	6.66	9.74
SE ±	0.33				
CD at 5 %	0.95				

The interaction V_1 Lb_4 and V_2 Lb_0 was produced significantly the highest (10.72 g) and the lowest (2.57 g) mean dry weight of stem at harvest.

4.4.2.4.7 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of stem (g) per plant at 60 DAS (2000)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	3.21	6.09	4.15	4.48	8.09
F_2	2.88	5.14	3.85	3.94	6.29
F_3	2.34	4.09	3.33	3.32	5.30
SE ±	0.093				
CD at 5 %	0.26				

At 60 DAS significantly the highest and the lowest dry weight of stem was produced by the interaction F_1 Lb_4 (8.09) and F_3 Lb_0 (2.34) respectively over rest of interaction.

4.4.2.4.8 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of stem (g) per plant at 90 DAS (2000)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	4.49	8.49	6.34	5.41	11.45
F_2	4.01	7.49	6.12	5.05	8.93
F_3	3.08	6.48	5.69	4.09	7.15
SE ±	0.15				
CD at 5 %	0.44				

Data regarding dry weight of stem observed that interaction F_1 Lb_4 and F_3 Lb_1 produced significantly the highest (11.45 g) and the lowest (3.08 g) dry weight at stem at 90 DAS over rest of combination.

4.4.2.4.9 Interaction effect of V x F x Lb for mean dry weight of stem (g) per plant at 90 DAS (2000)

Var. / Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	5.22	4.72	2.91	2.81	2.51	2.07	5.46	4.79	4.26
Lb_1	8.04	7.79	7.51	5.59	5.38	4.19	11.83	9.30	7.73
Lb_2	6.44	6.42	5.51	4.80	4.51	4.25	7.79	7.43	7.31
Lb_3	5.48	4.85	4.72	3.94	3.85	3.64	6.79	6.45	6.33
Lb_4	12.34	9.24	9.07	8.23	6.30	4.23	12.80	11.25	8.15
SE ±	0.28								
C.D at 5 %	0.80								

The interactive effects due to varieties, fertilizer levels and liquid biofertilizer on production of dry matter of stem at 90 DAS were found to be significant. Significantly higher dry weight of stem was recorded by the interaction V_1 F_1 Lb_4 (13.34 g) followed by V_3 F_1 Lb_4 (12.80 g) while lower dry weight of stem was recorded by the interaction (V_2 F_3 Lb_0) (2.07) respectively over rest of the interaction tried.

4.4.2.1 Effect of varieties (2001)

At 30 DAS dry weight of stem was recorded significantly highest by variety V_1 (0.570) followed by V_2 (0.477) while V_3 (0.419) which was significantly the lowest.

At 60 DAS variety V_2 recorded significantly highest dry weight of stem (2.365) followed by V_3 (1.967) and V_1 given (1.651) which was significantly the lowest.

At 90 DAS variety V_3 observed significantly the highest dry weight of stem (4.206) followed by V_1 (3.002). However V_2 recorded (2.690) which was significantly the lowest.

At harvest similar results were obtained where significantly the highest dry weight of stem was recorded by V_3 (4.182) followed by V_1 (3.915) and by V_2 (1.384) which was significantly the lowest.

4.4.2.2 Effect of fertilizer levels

Data on dry weight of stem under different levels of fertilizer were found to be significant.

Dry weight of stem in F_1 and F_3 was significantly the highest and the lowest at 30, 60, 90 DAS at harvest (0.522, 2.185, 4.128, 3.650) and (0.423, 1.818, 2.574, 2.507) respectively while under F_2 (0.521, 1.979, 3.195, 3.324) which was significantly the highest in F_3 and the lowest in F_1.

4.4.2.3 Effect of liquid biofertilizer

Significanlty highest dry weight of stem was recorded due to all the treatment of the liquid biofertilizers at all the stages of observations i.e. due to Lb_1 (0.617, 2.274, 3.609, 3.638) Lb_2 (0.449, 1.694, 3.116, 3.012) Lb_3 (0.386, 1.941, 3.136, 2.696), Lb_4 (0.726, 2.551, 4.659, 3.969) respectively over control Lb_0 (0.266, 1.510, 1.925, 2.486).

4.4.2.4 The interaction effect

Interaction due to V x F and F x Lb was found to be non-significant at 30 DAS and at harvest. While V x F x Lb was non-significant as 30, 60 DAS and at harvest.

4.4.2.4.1 Interaction effect of varieties x fertilizer for mean dry weight of stem (g) per plant at 60 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	1.92	1.59	1.43
V_2	2.50	2.39	2.19
V_3	2.12	1.94	1.82
SE ±	0.012		
CD at 5 %	0.035		

Dry weight of stem was found to be significant due to interaction between varieties and fertilizer levels. The treatment combinations V_2 F_1 and V_1 and F_3 was recorded significantly the highest (2.50) and lowest (1.43) mean dry weight of stem respectively.

4.4.2.4.2 Interaction effect of varieties x fertilizer for mean dry weight of stem (g) per plant at 90 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	3.16	3.019	2.82
V_2	3.13	2.42	1.90
V_3	5.48	4.14	2.98
SE ±	0.013		
CD at 5 %	0.038		

The combination of V_3 F_1 and V_2 F_3 was produced significantly the highest (5.48) and the lowest (1.90) mean dry weight of stem respectively at 90 DAS.

4.4.2.4.3 Interaction effect of varieties x liquid biofertilizer for mean dry weight of stem (g) per plant at 30 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.28	0.80	0.56	0.45	0.74
V_2	0.19	0.60	0.52	0.39	0.67
V_3	0.31	0.45	0.25	0.30	0.76
SE ±	0.007				
CD at 5 %	0.021				

From the interaction it is revealed that V_1 Lb_1 and V_2 Lb_0 produced significantly the highest (0.80 and the lowest (0.19) mean dry weight of stem at 30 DAS.

4.4.2.4.4 Interaction effect of varieties x liquid biofertilizer for mean dry weight of stem (g) per plant at 60 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	1.44	1.67	0.70	1.91	2.51
V_2	1.82	2.76	2.19	2.24	2.79
V_3	1.26	2.38	2.18	1.66	2.33
SE ±	0.016				
CD at 5 %	0.045				

The treatment combination V_2 Lb_4 produced significantly the highest (2.79) mean dry weight of stem followed by V_2 Lb_1 (2.76) while V_1 Lb_2 recorded significantly the lowest (0.70) mean dry weight of stem.

4.4.2.4.5 Interaction effect of varieties x liquid biofertilizer for mean dry weight of stem (g) per plant at 90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	2.31	3.10	3.12	2.34	4.12
V_2	1.37	3.41	2.05	2.94	3.66
V_3	2.08	4.31	4.32	4.12	6.18
SE ±	0.017				
CD at 5 %	0.049				

At 90 DAS the combination V_3 Lb_4 recorded significantly the highest (6.18) mean dry weight of stem while it was significantly the lowest due to V_2 Lb_0 (1.37).

4.4.2.4.6 Interaction effect of varieties x liquid biofertilizer for mean dry weight of stem (g) per plant at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	3.29	4.11	4.14	3.02	5.00
V_2	1.10	1.47	1.00	1.03	2.30
V_3	3.06	5.32	3.89	4.03	4.60
SE ±	0.050				
CD at 5 %	0.14				

At harvest the interaction V_1 Lb_4 produced significantly the highest (5.00) mean dry weight of stem while it was significantly lower due to V_2 Lb_0 (1.10) and V_2 Lb_3 (1.03) over rest of the interaction.

4.4.2.4.7 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of stem (g) per plant at 60 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	1.59	2.39	1.81	2.26	2.86
F_2	1.50	2.27	1.68	1.84	2.59
F_3	1.43	2.15	1.60	1.71	2.20
SE ±	0.016				
CD at 5 %	0.045				

Data pertaining to mean dry weight of stem indicated that interaction F_1 Lb_4 and F_3 Lb_0 produced significantly the highest (2.86) and the lowest (1.43) mean dry weight of stem at 60 DAS over rest of the interaction.

4.4.2.4.8 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of stem (g) per plant at 90 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	2.16	3.86	4.00	3.71	5.90
F_2	1.87	3.31	3.08	2.92	4.79
F_3	1.75	2.65	2.41	2.78	3.29
SE ±	0.017				
CD at 5 %	0.049				

As regards dry weight of stem at 90 DAS the interaction F_1 Lb_4 and F_3 Lb_0 produced significantly the highest (5.90) and the lowest (1.75) mean dry weight of stem respectively over rest of combinations.

4.4.2.4.9 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean dry weight of stem (g) per plant at 90 DAS (2001)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	2.50	2.31	2.13	1.85	1.16	1.10	2.13	2.12	2.00
Lb_1	3.16	3.14	3.00	5.38	2.54	2.31	6.04	4.25	2.63
Lb_2	3.27	3.16	2.92	2.96	1.67	1.53	5.77	4.41	2.77
Lb_3	2.56	2.36	2.11	4.05	2.42	2.36	4.51	3.99	3.86
Lb_4	4.30	4.11	3.96	4.42	4.33	2.23	8.98	5.91	3.67
SE ±	0.031								
C.D at 5 %	0.088								

The data on dry weight of stem at 90 DAS indicated that interaction V_3 F_1 Lb_4 recorded significantly the highest (8.98) mean dry weight of stem over rest of the interactions. While significantly lower dry weight of stem was observed with treatment combination of V_2 F_3 Lb_0 (1.10) and V_2 F_2 Lb_0 (1.16) over rest of the interaction tried.

4.4.3 Mean dry weight of pods (g)

Data relating to mean dry weight of pods (g) per plant of groundnut as affected by different treatments during the year 2000 and 2001 are presented in Table 22.

Table 22. Mean dry weight of pods (g) per plant of groundnut as affected by different treatments

Treatment	Year 2000		Year 2001	
	90 DAS	AH	90 DAS	AH
Varieties				
V_1	13.14	14.16	6.71	8.90
V_2	10.65	11.19	5.87	6.66
V_3	10.35	11.10	5.25	5.77
SE ±	0.072	0.11	0.17	0.17
CD 5%	0.22	0.32	0.51	0.51
Ferti. Levels				
F_1	12.92	13.60	6.25	7.45
F_2	11.47	12.29	5.93	7.02
F_3	9.75	10.56	5.65	6.85
SE ±	0.072	0.11	0.17	0.17
CD 5%	0.22	NS	NS	NS
Liq. Bioferti.				
Lb_0	7.09	7.73	4.82	6.10
Lb_1	13.56	14.65	6.54	7.68
Lb_2	10.72	11.48	5.78	7.13
Lb_3	10.13	10.84	5.32	6.47
Lb_4	15.40	16.00	7.25	8.16
SE ±	0.13	0.15	0.21	0.19
CD 5%	0.37	0.41	0.57	0.53
Interactions				
V x F	Sig.	NS	NS	NS
V x Lb	Sig.	Sig.	NS	NS
F x Lb	Sig.	Sig.	NS	NS
V x F x Lb	NS	NS	NS	NS

4.4.3.1 Effect of varieties (2000)

Varietal differences in respect of dry weigh of pods at 90 DAS and at harvest was influenced significantly. Variety V_1 recorded significanly the highest (13.14, 14.16) dry weight of pods followed by V_2 (10.65, 11.19) while V_3 recorded significantly the lowest (10.35, 11.10) respectively.

4.4.3.2 Effect of fertilizer levels

At 90 DAS dry weight of pods under F_1 and F_3 was significantly highest (12.92) and lowest (9.75) while F_2 recorded (11.47) which was significantly highest with F_3 and lowest with F_1.

Differences in dry weight of pods under different levels of fertilizer was found to be non-significant.

4.4.3.3 Effect of liquid biofertilizer

It could be observed from the data on dry weight of pods at 90 DAS was statistically significant where it was significantly higher due to all the liquid bio-fertilizer treatments from Lb_1 to Lb_4 (13.56, 10.72, 10.13, 15.40) respectively over control Lb_0 (7.09).

Liquid biofertilizer had significant effect on mean dry weight of pods at harvest where it was higher with almost all the treatments i.e. Lb_1 to Lb_4 (14.65, 11.48, 10.84, 16.00) respectively over control Lb_0 (7.73).

4.4.3.4 The interaction effects

Interaction due to V x F was found to be non-significant at harvest and V x F x Lb at 90 DAS and at harvest.

4.4.3.4.1 Interaction effect of varieties x fertilizer for mean dry weight of pods (g) per plant at 90 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	14.62	13.25	11.52
V_2	11.99	10.41	9.56
V_3	12.13	10.75	8.16
SE ±	0.18		
CD at 5 %	0.55		

Variation for dry weight of pods due to interaction effect between varieties and fertilizer levels was found to be significant. Variety V_1 with F_1 and V_3 F_3 produced significantly the highest (14.62) and the lowest (8.16) mean dry weight of pods respectively at 90 DAS.

4.4.3.4.2 Interaction effect of varieties x liquid biofertilizer for mean dry weight of pods (g) per plant at 90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	7.57	15.30	13.46	12.43	16.90
V_2	6.28	13.71	9.27	8.92	15.07
V_3	7.42	11.67	9.42	9.03	14.22
SE ±	0.21				
CD at 5 %	0.60				

The interaction between variety and liquid bio-fertilizer was found to be significant where interaction V_1 Lb_4 and V_2 Lb_0 was produced significantly the highest (16.90) and the lowest (6.20) mean dry weight of pods respectively over rest of the interaction at 90 DAS.

4.4.3.4.3 Interaction effect of varieties x liquid biofertilizer for mean dry weight of pods (g) per plant at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.87	16.68	14.35	13.41	17.44
V_2	6.36	14.66	9.87	9.41	15.61
V_3	7.94	12.61	10.21	9.69	15.05
SE ±	0.24				
CD at 5 %	0.70				

The treatment combination V_1 Lb_4 and V_2 Lb_0 recorded significantly the highest (17.44) and the lowest (6.36) mean dry weight of pods over rest of interaction at harvest.

4.4.3.4.4 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of pods (g) per plant at 90 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	8.34	15.75	11.75	11.07	17.65
F_2	6.94	13.85	10.86	10.66	15.03
F_3	5.99	11.09	9.53	8.64	13.50
SE ±	0.21				
CD at 5 %	0.60				

The interaction effects due to fertilizer and liquid bio-fertilizer on production of dry weight of pods at 90 DAS found to be significant. Where treatment combination of F_1 Lb_4 and F_3 Lb_0 produced significantly the highest (17.65) and the lowest (5.99) dry weight of pods respectively as compared with remaining interactions.

4.4.3.4.5 Interaction effect of fertilizer x liquid biofertilizer for mean dry weight of pods (g) per plant at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	8.80	16.61	12.63	11.69	18.25
F_2	8.07	14.74	11.69	11.44	15.52
F_3	6.30	12.61	10.14	9.40	14.34
SE ±	0.24				
CD at 5 %	0.70				

At harvest data on dry weight of pods was found to be significant due to interaction of fertilizer and liquid bio-fertilizer. However the combination of F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (18.25) and the lowest (6.30) mean dry weight of pods over rest of interaction.

4.4.3.1 Effect of varieties (2001)

From the data it was observed that at 90 DAS and at harvest variety V_1 recorded significantly the highest (6.71, 8.90) dry weight of pods while V_3 observed significantly the lowest (5.25, 5.77).

4.4.3.2 Effect of fertilizer levels

At 90 DAS and at harvest mean dry pod weight was found to be non-significant under different levels of fertilizer.

4.4.3.3 Effect of liquid biofertilizers

Mean dry pod weight was significantly higher at 90 DAS and at harvest due to Lb_1 (6.54, 7.68) Lb_2 (5.78, 7.13) Lb_4 (7.25, 8.16) respectively over control Lb_0 (4.82, 6.10) except due to Lb_3 (5.32, 6.47) which was at par with control.

4.4.3.4 The interaction effect

Interaction effects were found to be non-significant at 90 DAS and at harvest.

4.4.4 Mean total dry weight (g)

The data on mean total dry weight (g) per plant of groundnut as affected by different treatments for the year 2000 and 2001 are presented in Table 23 and graphically depicted in Fig. 7.

4.4.4.1 Effect of varieties (2000)

At 30 DAS significantly highest mean total dry weight was recorded by V_1 (1.59) and V_2 (1.43) which was significantly the lowest.

At 60 DAS variety V_1 observed significantly the highest mean total dry weight (12.07) followed by V_2 (11.55) while V_3 (11.44) which was significantly lowest.

At 90 DAS and at harvest mean total dry weight was significantly the highest with V_3 (28.34, 29.25) followed by V_1 (28.17, 29.25) while V_2 (19.17, 20.10) which was significantly the lowest.

4.4.4.2 Effect of fertilizer levels

Significant differences were observed under different levels of fertilizer where under F_1 significantly the highest mean total dry weight was recorded at 30, 60, 90 DAS and at harvest (1.80, 13.52, 28.37, 29.74) respectively. However under F_3 it was significantly the lowest (1.31, 9.88, 21.81, 22.92).

Table 23. Mean total dry weight (g) per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	DAS				DAS			
	30	60	90	AH	30	60	90	AH
Varieties								
V_1	1.59	12.07	28.17	29.25	1.33	4.49	12.17	15.48
V_2	1.43	11.55	19.17	20.10	1.27	5.57	8.17	10.14
V_3	1.57	11.44	28.34	29.25	1.13	4.25	12.33	14.34
SE ±	0.039	0.094	0.38	0.21	0.012	0.042	0.18	0.17
CD 5%	0.12	0.28	1.13	0.62	0.035	0.126	0.56	0.52
Ferti. Levels								
F_1	1.80	13.52	28.37	29.74	1.35	5.07	11.82	15.14
F_2	1.49	11.66	25.49	25.95	1.27	4.81	10.75	13.33
F_3	1.31	9.88	21.81	22.92	1.10	4.44	10.10	11.49
SE ±	0.039	0.094	0.38	0.21	0.012	0.042	0.18	0.17
CD 5%	0.12	0.28	1.13	0.62	0.035	0.126	0.56	0.52
Liq. Bioferti.								
Lb_0	0.930	7.57	15.51	16.27	0.75	3.59	8.62	10.32
Lb_1	2.04	14.15	30.43	31.32	1.49	5.28	12.34	15.01
Lb_2	1.29	11.06	24.58	25.14	1.22	4.08	10.73	12.96
Lb_3	0.896	9.31	21.86	22.23	1.02	4.42	9.54	11.56
Lb_4	2.50	16.36	33.75	36.06	1.73	6.47	13.21	16.76
SE ±	0.044	0.13	0.49	0.24	0.012	0.037	0.27	0.18
CD 5%	0.13	0.36	1.370	0.55	0.034	0.104	0.75	0.51
Interactions								
V x F	Sig.	Sig.	NS	NS	NS	Sig.	NS	NS
V x Lb	NS	Sig.	NS	NS	Sig.	NS	NS	Sig.
F x Lb	Sig.	Sig.	NS	NS	Sig.	Sig.	NS	Sig.
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.4.4.3 Effect of liquid biofertilizer

Mean total dry weight was significantly the highest at 30 DAS due to Lb_1 (2.04), Lb_2 (1.29), Lb_4 (2.502) except due to Lb_3 (0.896) which was at par over control Lb_0 (0.930).

At 60, 90, DAS and at harvest mean total dry weight was recorded significantly the highest due to Lb_1 (14.15, 30.43, 31.32), Lb_2 (11.06, 24.58, 25.14) Lb_3 (9.31, 21.86, 22.23) and Lb_4 (16.36, 33.75, 36.06) respectively over control Lb_0 (7.57, 15.51, 16.27).

4.4.4.4 The interaction effect

Interaction due to V x F, V x Lb (30 DAS) F x Lb was found to be non-significant at 90 DAS and at harvest. While V x F x Lb was found to be non-significant at 30, 60, 90 DAS and at harvest.

4.4.4.4.1 Interaction effect of varieties x fertilizer for mean total dry weight (g) per plant at 30 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	1.73	1.62	1.42
V_2	1.86	1.28	1.15
V_3	1.79	1.57	1.35
SE ±	0.068		
CD at 5 %	0.20		

Mean total dry weight per plant was influenced significantly due to interaction between varieties and levels of fertilizer at 30 DAS. Significantly the highest mean total dry weight were produced by the combination V_2 F_1 (1.86) followed by V_3 F_1 (1.79) and V_1 F_1 (1.73) while V_2 F_3 produced (1.15) which was significantly the lowest.

4.4.4.4.2 Interaction effect of varieties x fertilizer for mean total dry weight (g) per plant at 60 DAS (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	13.96	12.04	10.21
V_2	13.75	11.29	9.61
V_3	12.84	11.65	9.83
SE ±	0.16		
CD at 5 %	0.48		

Interaction between varieties and fertilizer was found to be significant at 60 DAS. Where treatment combination V_1 F_1 produced significantly the highest (13.96) followed by V_2 F_1 (13.75) mean total dry weight. However V_2 F_3 produced significantly the lowest (9.61) mean total dry weight.

4.4.4.4.3 Interaction effect of varieties x liquid biofertilizer for mean total dry weight (g) per plant at 60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.07	14.02	11.01	10.31	16.95
V_2	6.81	14.83	11.01	8.47	16.64
V_3	7.84	13.61	11.16	9.14	15.47
SE ±	0.21				
CD at 5 %	0.62				

Interaction between varieties and liquid biofertilizer was found to be significant. Where V_1 Lb_4 produced significantly the highest (16.95) total dry weight followed by V_2 Lb_4 (16.64) while significantly the lowest dry weight was recorded by V_2 Lb_0 (6.81).

4.4.4.4.4 Interaction effect of fertilizer x liquid biofertilizer for mean total dry weight (g) per plant at 30 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	1.06	2.16	1.71	1.13	2.94
F_2	0.84	2.04	1.21	0.87	2.48
F_3	0.89	1.93	0.94	0.69	2.08
SE ±	0.079				
CD at 5 %	0.22				

From the data it was noticed that interaction F_1 Lb_4 produced significantly the highest (2.94) mean total dry weight at 30 DAS over rest of the interaction. While F_2 Lb_0 and F_3 Lb_0 produced significantly lower (0.84 and 0.89) mean total dry weight of stem respectively.

4.4.4.4.5 Interaction effect of fertilizer x liquid biofertilizer for mean total dry weight (g) per plant at 60 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	8.85	16.16	12.15	10.90	19.24
F_2	7.73	14.07	11.17	9.38	15.97
F_3	6.14	11.93	9.86	7.65	13.85
SE ±	0.21				
CD at 5 %	0.62				

At 60 DAS total dry weight was significantly the highest due to F_1 Lb_4 (19.24) and the lowest due to F_3 Lb_0 (6.14) respectively over rest of the interaction.

4.4.4.1 Effect of varieties (2001)

At 30 DAS variety V_1 and V_3 recorded significantly the highest (1.33) and lowest (1.13) total dry weight and V_2 recorded (1.27) which was significantly the lowest over V_1.

At 60 DAS mean total dry weight of variety V_2 was significantly the highest (5.57) followed by V_1 (4.49) and V_3 (4.25) which was significantly the lowest.

At 90 DAS significantly the highest mean total dry weight was recorded by V_3 (12.33) followed by V_1 (12.17) while V_2 (8.17) recorded significantly the lowest total dry weight.

At harvest variety V_1 recorded significantly the highest (15.48) total dry weight followed by V_3 (14.34) while V_2 recorded (10.14) which was significantly the lowest.

4.4.4.2 Effect of fertilizer levels

Significant effect of fertilizer levels on total dry matter accumulation per plant was noticed. The fertilizer level F_1 significantly recorded the highest value at 30, 60, 90 DAS and at harvest (1.35, 5.07, 11.82, 15.14) respectively while under F_3 (1.10, 4.44, 10.10, 11.49) it was significantly the lowest further under F_2 mean total dry weight was recorded (1.27, 4.81, 10.75, 13.33) which was significantly highest over F_3.

4.4.4.3 Effect of liquid biofertilizer

Significantly highest total dry matter accumulation per plant at 30, 60, 90 DAS and at harvest was observed with application of liquid biofertilizer i.e. due to Lb_1 (1.49, 5.28, 12.34, 15.01) Lb_2 (1.22, 4.08, 10.73, 12.96), Lb_3 (1.02, 4.42, 9.54, 11.56) Lb_4 (1.73, 6.47, 13.21, 16.76) respectively over control Lb_0 (0.75, 3.59, 8.62, 10.32).

4.4.4.4 The interaction effect

Interaction due to V x F was found to be non-significant at 30, 90 DAS and at harvest. Interaction due to V x Lb was non-significant at 60 and 90 DAS. Interaction due to F x Lb was non-significant at 90 DAS and V x F x Lb was found to be non-significant at 30, 60, 90 DAS and at harvest.

4.4.4.4.1 Interaction effect of varieties x fertilizer for mean total dry weight (g) per plant at 60 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	4.95	4.46	4.06
V_2	5.88	5.65	5.17
V_3	4.37	4.31	4.08
SE ±	0.07		
CD at 5 %	0.22		

Mean total dry weight was influcnced significantly due to interaction effect between varieties and fertilizer levels. Where V_2 F_1 and V_1 F_3 produced significantly the highest (5.88) and the lowest (4.06) mean total dry weight respectively.

4.4.4.4.2 Interaction effect of varieties x liquid biofertilizer for mean total dry weight (g) per plant at 30 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.73	1.66	1.38	1.19	1.68
V_2	0.61	1.53	1.41	1.11	1.70
V_3	0.91	1.29	0.86	0.78	1.80
SE ±	0.022				
CD at 5 %	0.062				

At 30 DAS the interaction V_3 Lb_4 and V_2 Lb_0 produced significantly the highest (1.80) and the lowest (0.61) total dry weight over rest of the interaction.

4.4.4.4.3 Interaction effect of varieties x liquid biofertilizer for mean total dry weight (g) per plant at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	13.75	16.20	15.53	13.86	18.07
V_2	7.08	11.71	9.29	9.13	13.30
V_3	10.14	17.12	14.07	11.49	18.91
SE ±	0.33				
CD at 5 %	0.95				

The interactive effects due to varieties and liquid bio-fertilizers on production of dry matter per plant at harvest was found to be significant. The interaction V_3 Lb_4 produced significantly highest total dry matter (18.91) followed by V_1 Lb_4 (18.07) while V_2 Lb_0 recorded significantly the lowest (7.08) total dry weight over rest of the interactions.

4.4.4.4.4 Interaction effect of fertilizer x liquid biofertilizer for mean total dry weight (g) per plant at 30 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.80	1.62	1.29	1.17	1.87
F_2	0.75	1.51	1.24	1.06	1.81
F_3	0.69	1.36	1.12	0.85	1.50
SE ±	0.022				
CD at 5 %	0.062				

From the data it was observed that the interaction F_1 Lb_4 (1.87) recorded significantly higher total dry weight followed by F_2 Lb_4 (1.81). While F_3 Lb_0 (0.69) recorded significantly the lowest over rest of combinations.

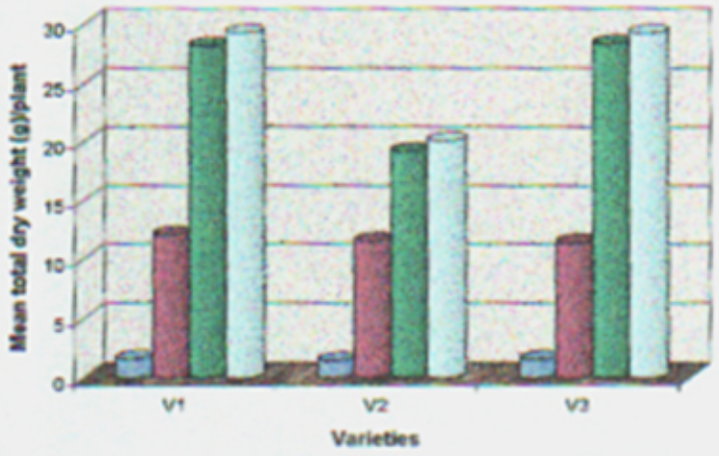
4.4.4.4.5 Interaction effect of Fertilizer x liquid biofertilizer for mean total dry weight (g) per plant at 60 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	3.77	5.38	4.30	4.86	7.02
F_2	3.61	5.45	4.07	4.37	6.54
F_3	3.40	5.02	3.88	4.019	5.86
SE ±	0.071				
CD at 5 %	0.20				

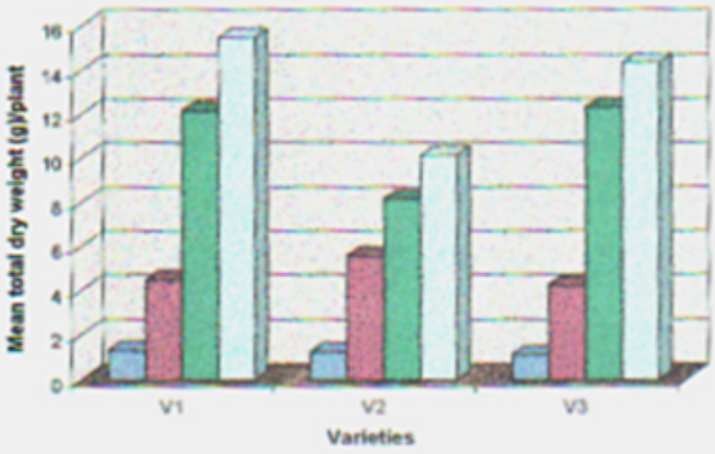
Mean total dry weight at 60 DAS observed that interaction F_1 Lb_4 and F_3 Lb_0 produced significantly the highest (7.02) and the lowest (3.40) mean total dry weight respectively over rest of combinations.

4.4.4.4.6 Interaction effect of fertilizer x liquid biofertilizer for mean total dry weight (g) per plant at harvest (2001)

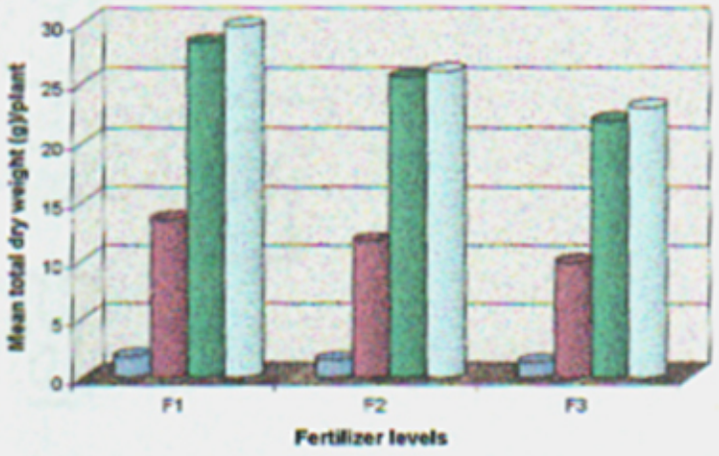
Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	11.13	17.66	14.65	12.85	19.41
F_2	10.38	14.67	13.07	11.26	17.28
F_3	9.45	12.69	11.17	10.57	13.59
SE ±	0.33				
CD at 5 %	0.95				



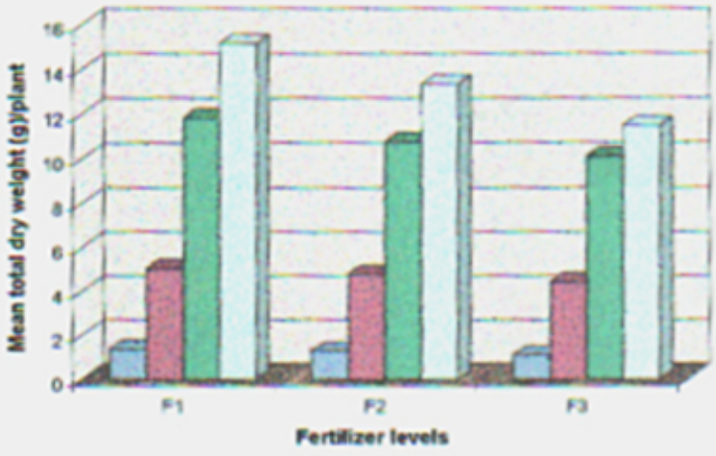
Year 2000



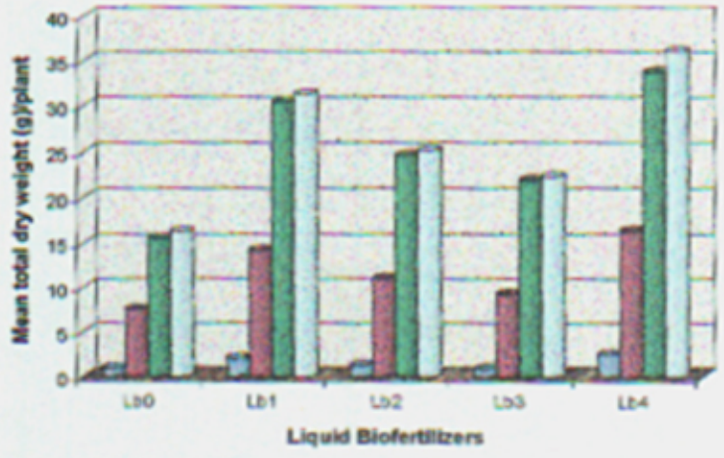
Year 2001



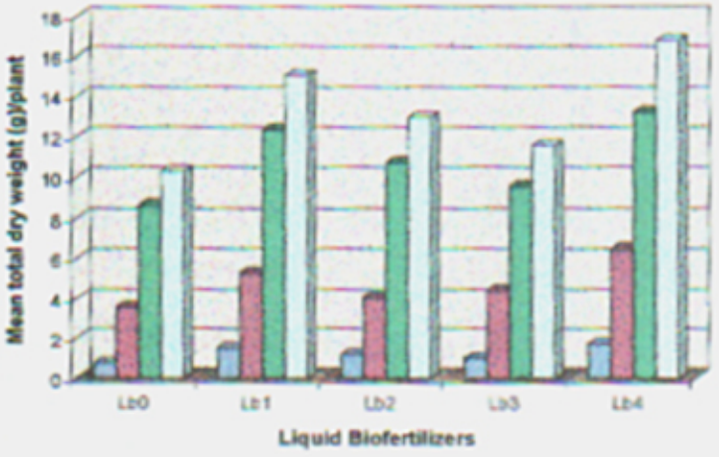
Year 2000



Year 2001



Year 2000



Year 2001



Fig. 7 : Mean total dry weight (g) per plant of groundnut as affected by different treatments

At harvest significantly the highest and the lowest mean total dry weight was produced by the combination F_1 Lb_4 (19.41) and F_3 Lb_0 (9.45) respectively over rest of interaction.

4.5 Phenological studies

Data on phenological parameters such as days required for initiation of flowering, days required for 50 per cent flowering and days required for physiological maturity of the groundnut as affected by different treatments for the year 2000 and 2001 are presented in Table 24.

4.5.1 Days required for initiation of flowering

Significant effect on days required for initiation of flowering within the varieties was noticed. Variety V_1 required (29.06) days for initiation of flowering, which was significantly the highest over V_2 and V_3. Significantly the lowest days were required for initiation of flowering by V_2 (23.47). While initiation of flowering was observed within (24.53) days by V_3 which was significantly the highest over V_2.

4.5.1.1 Effect of varieties (2000)

Significant effect on days requird for initiation of flowering within the varieties was noticed. Variety V_1 required (29.06) days for initiation of flowering which was significantly the highest over V2 and V_3 significantly the lowest days were required for initiation of lowering by V_2 (23.47). While initiation of flowering took place within (24.53) days by V_3 which was significantly the highest over V_2.

Table 24. The data on phenological studies on initiation of flowering, 50 % flowering and days to maturity of groundnut as affected by different treatments

Treatment	Year 2000			Year 2001 DAS		
	DAS			DAS		
	Initiation of flowering	50 % flowering	Days to maturity	Initiation of flowering	50 % flowering	Day to maturity
Varieties						
V_1	29.06	36.40	109.35	29.51	36.48	113.33
V_2	23.47	28.80	92.13	24.20	29.51	94.46
V_3	24.53	31.89	100.11	24.91	32.33	104.91
SE ±	0.27	0.24	0.53	0.31	0.29	0.80
CD 5%	0.80	0.73	1.58	0.92	0.89	2.40
Ferti. Levels						
F_1	26.40	33.16	102.18	26.57	33.26	106.04
F_2	25.47	32.20	100.33	26.22	32.73	104.04
F_3	25.20	31.73	99.09	25.82	32.33	102.62
SE ±	0.27	0.24	0.53	0.31	0.29	0.80
CD 5%	0.80	0.73	1.58	NS	NS	2.40
Liq. Bioferti.						
Lb_0	25.78	32.59	97.59	26.11	32.44	101.92
Lb_1	25.78	32.33	101.78	26.88	33.51	105.74
Lb_2	25.11	31.89	100.63	25.85	32.29	103.96
Lb_3	25.78	32.44	99.48	26.00	32.66	102.85
Lb_4	26.00	32.56	103.18	26.18	32.96	106.70
SE ±	0.33	0.34	0.72	0.27	0.22	0.76
CD 5%	NS	NS	1.987	NS	0.61	2.09
Interactions						
V x F	NS	NS	NS	NS	NS	NS
V x Lb	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS

4.5.1.2 Effect of fertilizer levels

Fertilizer levels had significant influence on days required for initiation of flowering. The F_1 required 26.49 days for initiation of flowering which was significantly the highest. However, under F_2 and F_3 initiation of flowering took place on (25.47 and 25.20) respectively which was at par with each other.

4.5.1.3 Effect of liquid biofertilizer

Data on days required for initiation of flowering was found to be non-significant.

4.5.1.4 The interaction effects

Interaction effects were found to be non-significant.

4.5.1.1 Effect of varieties (2001)

Data on days required for initiation of flowering was influenced significantly. Variety V_1 required significantly highest days (29.51) for initiation of flowering. While variety V_2 and V_3 required (24.20, 24.91) days respectively which was at par with each other.

4.5.1.2 Effect of fertilizer levels

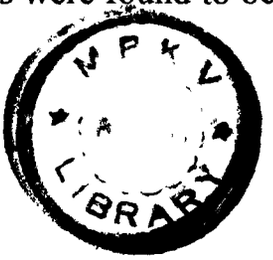
Data on days required for initiation of flowering under different levels of fertilizer was found to be non-significant.

4.5.1.3 Effect of liquid biofertilizer

The effect on days required for initiation of flowering due to different liquid biofertilizer treatments was statistically non-significant.

4.5.1.4 The interaction effect

Interaction effects were found to be non-significant at all the stages of crop growth.



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4.5.2 Days required of 50 % flowering

4.5.2.1 Effect of varieties (2000)

Varital differences for days to 50 % flowering was found to be significant. Variety V_1 required (36.40) days for 50 % flowering which was significantly the highest. Significantly lowest days were required by the variety V_2 (28.80). while V_3 required (31.89) days for 50 % flowering which was significantly the highest over V_2 and lowest over V_1.

4.5.2.2 Effect of fertilizer levels

Differences on days required for 50 per cent flowering due to different levels of fertilizer was affected significantly. Significantly highest and lowest days required for 50 per cent flowering under F_1 (33.16) and F_3 (31.73) was observed while under F_2 (32.20) which was significantly highest over F_3 and lowest over F_1.

4.5.2.3 Effect of liquid biofertilizer

Data on days required for 50 per cent flowering due to different liquid biofertilizer treatments was found to be non-significant.

4.5.2.4 The interaction effect

Interaction effects were found to be non-significant.

4.5.2.1 Effect of varieties (2001)

Variety V_1 and V_2 recorded significantly the highest and the lowest (36.48, 29.51) days respectively for 50 per cent flowering while 50 per cent flowering was took place in V_3 (32.33) which was significantly highest over V_2 and lowest over V_1.

4.5.2.2 Effect of fertilizer levels

The effect on days required for 50 per cent flowering under different levels of fertilizer were found to be non-significant.

4.5.2.3 Effect of liquid biofertilizer

Days required for 50 per cent flowering were significantly the highest due to Lb_1 (33.51) while due to Lb_2 (32.29) Lb_3 (32.66), Lb_4 (32.96) which was at par over control Lb_0 (32.44).

4.5.2.4 The interaction effect

Interaction effects were found to be non-significant.

4.5.3 Days to maturity

4.5.3.1 Effect of varieties (2000)

Variety V_1 required (109.35) days for maturity which was significantly the highest followed by V_3 (100.11). However V_2 matured within (93.13) days which was significantly lowest over V_1 and V_3.

4.5.3.2 Effect of fertilizer levels

Under different fertilizer levels days to maturity was affected significantly. Significantly the maximum days were required for maturity under F_1 (102.18) followed by F_2 (100.33) while under F_3 (99.09) which was significantly the minimum.

4.5.3.3 Effect of liquid biofertilizer

Days required for maturity under different treatments of liquid biofertilizer was significantly higher i.e. due to Lb_1 (101.78), Lb_2 (100.63), Lb_4 (103.18) except Lb_3 (99.48) which was at par over control Lb_0 (97.59).

4.5.3.4 The interaction effect

Interaction effects were found to be non-significant.

4.5.3.1 Effect of varieties (2001)

Variety V_1 recorded (113.33) days for maturity which was significantly the highest followed by V_3 (104.91). While V_2 required (94.46) days for maturity which was significantly highest over V_2 and lowest over V_1.

4.5.3.2 Effect of fertilizer levels

Days required for maturity under F_1 was significantly the highest (106.04). While under F_3 it was significantly the lowest (102.62) and under F_2 (104.04) it was at par under F_1 and F_3.

4.5.3.3 Effect of liquid biofertilizer

Days required for maturity due to Lb_1 and Lb_4 (105.74, 106.70) respectively was significantly the highest while due to Lb_2, Lb_3 (103.96, 102.85) it was at par over control Lb_0 (101.92).

4.5.3.4 The interaction effect

Interaction effects were found to be non-significant.

4.6 Growth functions

Data on absolute growth rate (AGR) as affected by different treatments during 2000 and 2001 are presented in Table 25.

4.6.1 Absolute Growth Rate (AGR) (g day^{-1})

4.6.1.1 Effect of varieties (2000)

Significant effect on AGR within the varieties was noticed. The variety V_1 and V_2 recorded significantly the highest (0.400) and the lowest (0.318) AGR during 30-60 days after sowing.

Table 25. The data on absolute growth rate (g day $^{-1}$) of groundnut as affected by different treatments

Treatment	Year 2000			Year 2001		
	DAS			DAS		
	30-60	60-90	90- Ah	30-60	60-90	90-Ah
Varieties						
V_1	0.400	0.530	0.351	0.324	0.428	0.280
V_2	0.337	0.370	0.224	0.217	0.301	0.178
V_3	0.318	0.350	0.259	0.211	0.285	0.187
SE ±	0.004	0.008	0.004	0.003	0.003	0.005
CD 5%	0.011	0.023	0.013	0.008	0.008	0.014
Ferti. Levels						
F_1	0.388	0.467	0.326	0.263	0.374	0.264
F_2	0.336	0.419	0.296	0.236	0.341	0.234
F_3	0.280	0.364	0.261	0.212	0.299	0.196
SE ±	0.004	0.008	0.004	0.003	0.003	0.005
CD 5%	0.011	0.023	0.011	0.008	0.008	0.014
Liq. Bioferti.						
Lb_0	0.218	0.268	0.189	0.159	0.221	0.155
Lb_1	0.403	0.502	0.352	0.277	0.406	0.271
Lb_2	0.324	0.411	0.290	0.234	0.331	0.216
Lb_3	0.274	0.349	0.247	0.202	0.281	0.184
Lb_4	0.457	0.552	0.395	0.329	0.451	0.304
SE ±	0.005	0.009	0.007	0.004	0.004	0.007
CD 5%	0.016	0.029	0.022	0.010	0.011	0.021
Interactions						
V x F	NS	NS	NS	Sig.	Sig.	NS
V x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
F x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
V x F x Lb	Sig.	NS	NS	Sig.	Sig.	NS

From the data it is observed that maximum AGR is noticed during the period of 60-90 days after sowing where significantly the highest (0.530) and the lowest (0.350) AGR was recorded by the variety V_1 and V_3 respectively. Absolute growth rate was slowly increased during the period from 90 DAS to harvest. However AGR in the variety (V_1) is higher as it required more days for physological maturity while significantly the lowest AGR was shown by the variety V_2 (0.224) as it was matured earlier which reduces the growth at later stages of the crop.

4.6.1.2 Effect of fertilizer levels

Absolute growth rate is significantly affected due to different levels of fertilizers. It was significantly the highest under recommended dose of fertilizer at 30-60, 60-90, and 90 to at harvest (0.388, 0.467, 0.326), respectively. It is observed from the data that it is goes on increasing from 30-60 days the rate of increasing was maximum during 60-90 and then the rate was lower.

4.6.1.3 Effect of liquid biofertilizer

The absolute growth rate is significantly higher due to different treatments of liquid bio-fertilizer during 30-60, Lb_1 (0.403), Lb_2 (0.324) Lb_3 (0.274) and Lb_4 (0.457) over control Lb_0 (0.218).

Similar results is obtained during 60-90 Lb_1 (0.502), Lb_2 (0.411), Lb_3 (0.349), Lb_4 (0.552) over control Lb_0 (0.268) and 90 to at harvest Lb_1 (0.352) Lb_2 (0.290), Lb_3 (0.247), Lb_4 (0.395) over control Lb_0 (0.189).

4.6.1.4 The interaction effects

Interaction effect due to variety x fertilizer levels was found to be non-significant at all the stages of the crop growth and interaction effect of variety x fertilizer x liquid bio-fertilizer at 60-90 and 90 to at harvest was found to be non-significant.

4.6.1.4.1 Interaction effect of varieties x liquid biofertilizer for absolute growth rate (g day $^{-1}$) at 30-60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.0241	0.396	0.324	0.315	0.476
V_2	0.197	0.425	0.329	0.256	0.477
V_3	0.215	0.386	0.318	0.250	0.418
SE ±	0.009				
CD at 5 %	0.024				

Variation for absolute growth rate due to interaction effect between varieties and liquid bio-fertilizer treatments was found to be significant. Variety V_2 with Lb_4 (0.477) recorded significantly the highest value of AGR whereas variety V_2 with Lb_0 recorded significantly lower values of AGR (0.197).

4.6.1.4.2 Interaction effect of fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 30-60 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.261	0.475	0.350	0.314	0.543
F_2	0.226	0.401	0.331	0.276	0.449
F_3	0.167	0.333	0.290	0.231	0.379
SE ±	0.009				
CD at 5 %	0.024				

Significant differences in respect of AGR was observed due to interaction effect of fertilizer and different treatments of liquid bio-fertilizer. The F_1 with Lb_4 and F_3 with Lb_0 recorded significantly the highest (0.543) and the lowest (0.167) values of AGR.

4.6.1.4.3 Interaction effect of varieties x fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) at 30-60 DAS (2000)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	0.273	0.228	0.224	0.237	0.213	0.140	0.272	0.236	0.138
Lb_1	0.480	0.389	0.321	0.510	0.420	0.346	0.435	0.393	0.332
Lb_2	0.379	0.326	0.267	0.338	0.336	0.314	0.332	0.332	0.289
Lb_3	0.377	0.313	0.256	0.284	0.257	0.226	0.281	0.256	0.212
Lb_4	0.527	0.480	0.420	0.633	0.438	0.359	0.469	0.430	0.357
SE ±	0.018								
C.D at 5 %	0.052								

Significantly the highest AGR was recorded by the interaction V_2 F_1 Lb_4 (0.633) while significantly the lowest AGR was observed due to interaction of V_3 F_3 Lb_0 (0.138) and V_2 F_3 Lb_0 (0.140) over rest of the interactions.

4.6.1.4.4 Interaction effect of varieties x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 60-90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.325	0.640	0.546	0.444	0.696
V_2	0.232	0.466	0.363	0.283	0.504
V_3	0.248	0.402	0.323	0.320	0.455
SE ±	0.016				
CD at 5 %	0.046				

The interaction effect of V_1 Lb_4 recorded significantly the highest AGR (0.696) while significantly lowest AGR was observed due to V_2 Lb_0 (0.232) followed by V_3 Lb_3 (0.248).

4.6.1.4.5 Interaction effect of fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 60-90 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.304	0.562	0.414	0.383	0.669
F_2	0.267	0.504	0.429	0.341	0.553
F_3	0.234	0.439	0.389	0.323	0.433
SE ±	0.016				
CD at 5 %	0.046				

The interaction F_1 Lb_4 recorded significantly the highest (0.669) and F_3 Lb_0 significantly the lowest (0.234) values at 60 to 90 DAS.

4.6.1.4.6 Interaction effect of varieties x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 90 DAS to at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.244	0.479	0.409	0.332	0.539
V_2	0.140	0.282	0.223	0.180	0.304
V_3	0.182	0.295	0.237	0.238	0.342
SE ±	0.011				
CD at 5 %	0.032				

The treatment combination V_1 Lb_4 and V_2 Lb_0 recorded significantly the highest (0.539) and the lowest (0.140) values of AGR.

4.6.1.4.7 Interaction effect of fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 90 DAS at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.211	0.390	0.288	0.270	0.469
F_2	0.198	0.356	0.306	0.241	0.389
F_3	0.165	0.310	0.275	0.229	0.326
SE ±	0.011				
CD at 5 %	0.032				

The interaction F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (0.469) and the lowest (0.165) AGR values.

4.6.1.1 Effect of varieties (2001)

Varietal differences in respect of absolute growth rate is observed during 30-60, 60-90 and 90 to at harvest. The variety V_1 recorded significantly the highest AGR (0.324, 0.428, 0.280) during 30-60, 60-90 and 90 to at harvest respectively while significantly the lowest AGR is recorded by the variety V_3 (0.211, 0.285, 0.187) during 30-60, 60-90 and 90 to at harvest respectively.

4.6.1.2 Effect of fertilizer levels

Different fertilizer levels had significant impact on absolute growth rate. Where under F_1 it is significantly the highest (0.263, 0.374, 0.264) and significantly the lowest (0.212, 0.299, 0.196) under F_3 during 30-60, 60-90, and 90 to at harvest respectively.

4.6.1.3 Effect of liquid biofertilizer

The absolute growth rate was significantly higher due to different treatments i.e. Lb_1 (0.277, 0.406, 0.271) Lb_2 (0.234, 0.331, 0.216), Lb_3 (0.282, 0.281, 0.184) and Lb_4 (0.329, 0.451, 0.304) during 30-60, 60-90 and 90 to at harvest respectively over control. Lb_0 (0.159, 0.221, 0.155).

4.6.1.4 The interaction effects

Interaction effect of variety x fertilizer and variety x fertilizer x liquid biofertilizer was found to be non-significant at 90 DAS to at harvest.

4.6.1.4.1 Interaction effect of varieties x fertilizer for absolute growth rate (g day $^{-1}$) at 30-60 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	0.325	0.278	0.237
V_2	0.256	0.207	0.187
V_3	0.208	0.187	0.165
SE ±	0.005		
CD at 5 %	0.014		

The interaction effect of varieties and fertilizer levels was found to be significant where treatment combination V_1 F_1 and V_3 F_3 recorded significantly the highest (0.325) and the lowest (0.165) AGR respectively.

4.6.1.4.2 Interaction effect of varieties x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 30-60 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.192	0.317	0.259	0.252	0.380
V_2	0.142	0.272	0.210	0.154	0.354
V_3	0.143	0.225	0.178	0.145	0.242
SE ±	0.006				
CD at 5 %	0.017				

Significantly the highest AGR was recorded by the interaction V_1 Lb_4 (0.380) while treatment combination i.e. V_2 Lb_0 (0.142), V_3 Lb_0 (0.143), V_3 Lb_3 (0.145) and V_2 Lb_3 (0.154) recorded lower AGR values.

4.6.1.4.3 Interaction effect of fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 30-60 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.176	0.320	0.238	0.215	0.366
F_2	0.152	0.269	0.216	0.179	0.304
F_3	0.149	0.223	0.194	0.157	0.257
SE ±	0.006				
CD at 5 %	0.017				

Treatment combination F_1 Lb_4 recorded significantly the highest (0.366) AGR while the interaction F_3 Lb_0 (0.149), F_2 Lb_0 (0.152) and F_3 Lb_3 (0.157) have recorded significantly lower AGR values.

4.6.1.4.4 Interaction effect of varieties x fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) at 30-60 DAS (2001)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	0.218	0.182	0.176	0.152	0.137	0.136	0.157	0.138	0.135
Lb_1	0.383	0.311	0.256	0.325	0.269	0.221	0.253	0.228	0.193
Lb_2	0.303	0.261	0.214	0.216	0.214	0.201	0.194	0.173	0.168
Lb_3	0.301	0.250	0.204	0.181	0.137	0.145	0.164	0.149	0.123
Lb_4	0.422	0.384	0.334	0.405	0.280	0.230	0.271	0.249	0.207
SE ±	0.001								
C.D at 5 %	NS								

The interaction effect due to varieties x fertilizer levels liquid biofertilizer were found to be non-significant.

4.6.1.4.5 Interaction effect of varieties x fertilizer for absolute growth rate (g day $^{-1}$) at 60-90 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	0.478	0.421	0.384
V_2	0.335	0.310	0.259
V_3	0.311	0.292	0.254
SE ±	0.005		
CD at 5 %	0.015		

Significantly the highest AGR was recorded by the interaction V_1 F_1 (0.478) while the lowest AGR was recorded by the treatment combination V_3 F_3 (0.254) and V_2 F_3 (0.259).

4.6.1.4.6 Interaction effect of varieties x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 60-90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.260	0.511	0.436	0.355	0.577
V_2	0.200	0.376	0.294	0.228	0.407
V_3	0.204	0.330	0.263	0.260	0.370
SE ±	0.007				
CD at 5 %	0.019				

The interaction of V_1 Lb_4 and V_2 Lb_0 recorded significantly the highest (0.577) and the lowest (0.200) AGR over rest of the interactions.

4.6.1.4.7 Interaction effect of fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 60-90 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.243	0.453	0.333	0.306	0.537
F_2	0.229	0.409	0.346	0.275	0.446
F_3	0.192	0.355	0.314	0.262	0.371
SE ±	0.007				
CD at 5 %	0.019				

Significantly the highest and the lowest AGR was recorded by the interaction F_1 Lb_4 (0.537) and F_3 Lb_0 (0.192) respectively over rest of the interaction.

4.6.1.4.8 Interaction effect of varieties x fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) at 60-90 DAS (2001)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	0.302	0.263	0.214	0.202	0.218	0.181	0.226	0.206	0.181
Lb_1	0.556	0.509	0.469	0.415	0.395	0.317	0.387	0.323	0.279
Lb_2	0.448	0.447	0.413	0.276	0.318	0.289	0.276	0.273	0.241
Lb_3	0.390	0.349	0.326	0.264	0.215	0.205	0.264	0.261	0.254
Lb_4	0.694	0.538	0.499	0.516	0.402	0.302	0.400	0.398	0.313
SE ±	0.001								
C.D at 5 %	NS								

The interaction effect due to varieties x fertilizer levels x liquid bio-fertilizer were found to be non-significant.

4.6.1.4.9 Interaction effect of varieties x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 90 DAS to at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.199	0.387	0.331	0.270	0.435
V_2	0.116	0.204	0.180	0.141	0.249
V_3	0.149	0.240	0.192	0.195	0.277
SE ±	0.012				
CD at 5 %	0.033				

Significantly the highest and the lowest AGR was recorded by the treatment combination V_1 Lb_4 (0.435) and V_2 Lb_0 (0.116) respectively over rest of combinations.

4.6.1.4.10 Interaction effect of fertilizer x liquid biofertilizer for absolute growth rate (g day $^{-1}$) per plant at 90 DAS to at harvest (2001).

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.173	0.316	0.234	0.219	0.379
F_2	0.156	0.267	0.246	0.197	0.316
F_3	0.135	0.247	0.223	0.189	0.266
SE ±	0.012				
CD at 5 %	0.033				

Significantly the highest AGR was recorded by the treatment combination F_1 Lb_4 (0.379) while F_3 Lb_0 (0.135) and F_2 Lb_0 (0.156) showed lower values of AGR over rest of the combinations.

4.6.2 Relative growth rate (RGR) (g g $^{-1}$ day $^{-1}$)

The data on RGR as affected by different treatments during 2000 and 2001 are presented in Table 26.

4.6.2.1 Effect of varieties (2000 and 2001)

The observation recorded on RGR at 30-60, 60-90 and 90 to at harvest were statistically non-significant during both the years except at 30-60 DAS variety V_1 recorded significantly the highest (0.022) and V_2 the lowest (0.011) value of RGR during 2001.

4.6.2.2 Effect of fertilizer levels

At all the growth stages RGR were found to be non-significant during both the years except during 30-60 DAS RGR was significantly the highest under F_1 (0.022) and the lowest under F_3 (0.010) during the year 2001.

Table 26. The data on relative growth rate (g. g^{-1}.day^{-1}) of groundnut as affected by different treatments

Treatment	Year 2000			Year 2001		
	DAS			DAS		
	30-60	60-90	90- Ah	30-60	60-90	90-Ah
Varieties						
V_1	0.013	0.040	0.007	0.022	0.031	0.006
V_2	0.012	0.039	0.006	0.011	0.031	0.005
V_3	0.013	0.036	0.007	0.013	0.028	0.006
SE ±	0.001	0.001	0.001	0.002	0.001	0.001
CD 5%	NS	NS	NS	0.007	NS	NS
Ferti. Levels						
F_1	0.013	0.039	0.007	0.022	0.029	0.006
F_2	0.013	0.038	0.007	0.014	0.029	0.006
F_3	0.011	0.037	0.006	0.010	0.028	0.005
SE ±	0.001	0.001	0.001	0.002	0.001	0.001
CD 5%	NS	NS	NS	0.007	NS	NS
Liq. Bioferti.						
Lb_0	0.011	0.031	0.006	0.021	0.025	0.005
Lb_1	0.013	0.042	0.007	0.019	0.033	0.006
Lb_2	0.013	0.037	0.007	0.010	0.029	0.005
Lb_3	0.011	0.035	0.006	0.014	0.027	0.005
Lb_4	0.015	0.044	0.008	0.012	0.035	0.006
SE ±	0.001	0.002	0.001	0.004	0.001	0.001
CD 5%	NS	NS	NS	NS	NS	NS
Interactions						
V x F	NS	NS	NS	Sig.	NS	NS
V x Lb	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS

4.6.2.3 Effect of liquid biofertilizer

The data on RGR due to liquid biofertilizer were found to be non-significant at all the growth stages during both the years.

4.6.2.4 The interaction effect

Interaction effects were found to be non-significant during both the years except due to V x F at 30-60 DAS during 2001.

4.6.2.4.1 Interaction effect of varieties x fertilizer for RGR (g dm^{-2} day^{-1}) at 30-60 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	0.040	0.017	0.010
V_2	0.010	0.015	0.009
V_3	0.018	0.011	0.010
SE ±	0.004		
CD at 5 %	NS		

The interaction effect due to varieties and fertilizer levels were found to be non-significant.

4.6.3 Net assimilation rate (NAR) (g dm^{-2} day^{-1})

Data pertaining to NAR for the year 2000 and 2001 are presented in Table 27.

4.6.3.1 Effect of varieties (2000 and 2001)

The effect of different varieties on NAR was found to be non-significant at all stages during both the years except during 60-90 and 90 to harvest during 2000.

Where significantly the highest NAR was recorded by the variety V_1 (0.045) while variety V_2 and V_3 are at par with each other, at 60-90 DAS. While at 90 DAS to at harvest variety V_1 recorded significantly the highest NAR (0.022).

Table 27. The data on net assimilation rate (g. dm^{-2}.day^{-1}) of groundnut as affected by different treatments

Treatment	Year 2000			Year 2001		
	DAS			DAS		
	30-60	60-90	90- Ah	30-60	60-90	90-Ah
Varieties						
V_1	0.026	0.045	0.022	0.021	0.034	0.017
V_2	0.021	0.037	0.017	0.016	0.028	0.013
V_3	0.020	0.035	0.017	0.018	0.025	0.013
SE ±	0.001	0.001	0.001	0.002	0.001	0.001
CD 5%	NS	0.003	0.003	NS	NS	NS
Ferti. Levels						
F_1	0.024	0.043	0.020	0.023	0.031	0.015
F_2	0.022	0.039	0.019	0.017	0.030	0.014
F_3	0.021	0.036	0.017	0.016	0.027	0.013
SE ±	0.001	0.001	0.001	0.002	0.001	0.001
CD 5%	NS	0.003	0.003	NS	NS	NS
Liq. Bioferti.						
Lb_0	0.018	0.031	0.015	0.014	0.023	0.011
Lb_1	0.025	0.043	0.020	0.019	0.033	0.017
Lb_2	0.022	0.038	0.018	0.017	0.028	0.014
Lb_3	0.020	0.036	0.018	0.020	0.024	0.012
Lb_4	0.027	0.047	0.023	0.023	0.036	0.017
SE ±	0.002	0.002	0.002	0.003	0.002	0.001
CD 5%	0.005	0.005	0.006	NS	0.006	0.004
Interactions						
V x F	NS	NS	NS	NS	NS	NS
V x Lb	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS

4.6.3.2 Effect fertilizer levels

The data on NAR due to different levels of fertilizer were found to be non-significant at all the stages during both the years except at 30-60 and 90 to at harvest during 2000 it was significantly the highest under F_1 (0.043) and the lowest under F_3 (0.036) at 30-60 DAS. Whereas during 90 to at harvest it was significantly the highest under F_1 (0.020) and was at par with F_2 and F_3.

4.6.3.3 Effect of liquid biofertilizer

During 30-60 DAS NAR were significantly higher with the liquid biofertilizer treatments Lb_1 (0.018) and Lb_4 (0.027) while it was at par with rest of the treatments over control Lb_0 (0.018).

Significantly higher NAR were recorded due to all the liquid biofertilizer treatment Lb_1 (0.043) Lb_2 (0.038), Lb_3 (0.036) and Lb_4 (0.047) over the control Lb_0 (0.031) at 60 to 90 DAS. Similar results were observed during the year 2001 i.e. Lb_1 (0.033) and Lb_4 (0.036) over the control Lb_0 (0.023).

At 90 to at harvest during 2000 NAR was significantly the highest due to Lb_4 (0.023) while it was at par with rest of the treatments over control Lb_0 (0.015). Also during the year 2001 it was significantly the highest due to Lb_1, Lb_4 (0.017) over the control Lb_0 (0.011).

4.6.4.4 The interaction effect

Interaction effect was found to be non-significant.

4.6.4 Crop growth rate (CGR) (g m^{-2} day^{-1})

The data on CGR during the year 2000 and 2001 are presented in Table 28.

Table 28. The data on crop growth rate (g. m^{-2}.day $^{-1}$) of groundnut as affected by different treatments

Treatment	Year 2000			Year 2001		
	DAS			DAS		
	30-60	60-90	90- Ah	30-60	60-90	90-Ah
Varieties						
V_1	13.34	17.75	11.67	10.80	14.32	9.32
V_2	11.05	12.30	7.47	7.30	10.04	6.07
V_3	10.57	11.63	8.16	7.15	9.48	6.05
SE ±	0.13	0.26	0.14	0.08	0.010	0.16
CD 5%	0.40	0.78	0.43	0.25	0.32	0.49
Ferti. Levels						
F_1	12.78	15.52	10.85	8.80	12.47	8.76
F_2	11.21	13.94	9.87	7.85	11.42	7.51
F_3	9.31	12.21	8.71	7.21	9.94	6.46
SE ±	0.13	0.26	0.14	0.08	0.010	0.16
CD 5%	0.40	0.78	0.43	0.25	0.32	0.49
Liq. Bioferti.						
Lb_0	7.24	8.94	6.27	5.36	7.40	5.18
Lb_1	13.15	16.73	11.72	9.21	13.51	8.91
Lb_2	10.78	13.62	9.68	7.99	11.14	7.26
Lb_3	9.11	11.55	8.21	6.74	9.32	6.11
Lb_4	15.22	18.63	13.15	10.67	15.03	10.30
SE ±	0.19	0.28	0.22	0.12	0.13	0.23
CD 5%	0.59	0.83	0.67	0.36	0.38	0.71
Interactions						
V x F	NS	NS	NS	Sig.	Sig.	NS
V x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
F x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
V x F x Lb	Sig.	NS	NS	NS	NS	NS

4.6.4.1 Effect of varieties (2000)

Significantly the highest CGR was recorded by the variety V_1 (13.34 and 17.75) at 30-60 and 60-90 DAS respectively.

At 90 to at harvest significantly the highest CGR was recorded by the variety V_1 (11.67) and the lowest by the variety V_2 (7.47).

4.6.4.2 Effect of fertilizer levels

Significant differences in CGR were observed due to different levels of fertilizer. Significantly the highest CGR was recorded under the F_1 (12.78, 15.52, 10.85) and the lowest under F_3 (9.31, 12.21, 8.71) at 30-60, 60-90 and 90 to at harvest respectively.

4.6.4.3 Effect of biofertilizer

Significantly higher CGR was recorded due to all the treatments of liquid biofertilizer i.e. Lb_1 (13.15, 16.73, 11.72) Lb_2 (10.78, 13.62, 9.68), Lb_3 (9.11, 11.55, 8.21) and Lb_4 (15.22, 18.23, 13.15) at 30-60, 60-90 and 90 to at harvest respectively over control Lb_0 (7.24, 8.94, 6.27).

4.6.4.4 The interaction effect

The interaction effect due to V x F found to be non-significant at all the stages and V x F x Lb at 60-90 and 90 to at harvest.

4.6.4.4.1 Interaction effect of varieties x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) at 30-60 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.05	13.20	10.79	10.50	15.84
V_2	6.12	13.39	10.97	8.52	15.88
V_3	7.17	12.87	10.57	8.31	13.94
SE ±	0.32				
CD at 5 %	0.92				

Significantly higher CGR was recorded by the treatment combination V_2 Lb_4 (15.88) and V_1 Lb_4 (15.84) while V_2 Lb_0 recorded significantly the lowest (6.12) CGR.

4.6.4.4.2 Interaction effect of fertilizer x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) at 30-60 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	8.68	15.03	11.65	10.45	18.09
F_2	7.53	13.34	11.03	9.17	14.97
F_3	5.52	11.09	9.65	7.70	12.60
SE ±	0.32				
CD at 5 %	0.92				

Significantly the highest and the lowest CGR was recorded by the interaction F_1 Lb_4 (18.09) and F_3 Lb_0 (5.52) respectively.

4.6.4.4.3 Interaction effect of varieties x fertilizer x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) at 30-60 DAS (2000)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	9.08	7.62	7.45	7.89	7.10	4.53	9.07	7.86	4.59
Lb_1	15.98	12.96	10.68	14.64	13.99	11.13	14.48	13.08	11.05
Lb_2	12.62	10.86	8.89	11.27	11.18	10.46	11.07	11.04	9.61
Lb_3	12.55	10.44	8.51	9.45	8.57.	7.53	9.37	8.52	7.05
Lb_4	17.57	15.99	13.94	21.08	14.59	11.97	15.61	14.31	11.89
SE ±	0.57								
C.D at 5 %	1.58								

The treatment combination V_1F_1 Lb_4 recorded significantly the highest CGR (17.57) while $V_2F_3Lb_0$ recorded significantly the lowest (4.53) value of CGR at 30-60 DAS.

4.6.4.4.4 Interaction effect of varieties x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) at 60-90 DAS (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	10.83	21.31	18.07	14.64	23.92
V_2	7.73	15.51	12.10	9.34	16.79
V_3	8.26	13.38	10.68	10.66	15.16
SE ±	0.51				
CD at 5 %	1.47				

The interaction V_1 Lb_4 recorded significantly the highest (23.92) while V_2 Lb_0 (7.73) and V_3 Lb_0 (8.26) recorded the lowest CGR respectively.

4.6.4.4.5 Interaction effect of fertilizer x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) at 60-90 DAS (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	10.11	18.78	13.80	12.65	22.28
F_2	8.91	16.80	14.28	11.30	18.43
F_3	7.79	14.62	12.76	10.71	15.17
SE ±	0.51				
CD at 5 %	1.47				

Significantly the highest CGR was recorded in the treatment combination F_1 Lb_4 (22.28) while lower CGR was recorded due to the interaction of F_2 Lb_3 (7.79) and F_2 Lb_0 (8.91).

4.6.4.4.6 Interaction effect of varieties x liquid biofertilizer for crop growth rate (g m^{-2} day $^{-1}$) at 90 DAS to at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.11	15.94	13.63	11.06	17.94
V_2	4.67	9.38	7.54	5.65	10.11
V_3	6.04	9.83	7.87	7.93	11.39
SE ±	0.37				
CD at 5 %	1.05				

There is significant impact on CGR due to interaction of variety and liquid biofertilizer where V_1 Lb_4 recorded significantly the highest (17.94) and the lowest by CGR was recorded the combination V_3 Lb_0 (6.04).

4.6.4.4.7 Interaction effect of fertilizer x liquid biofertilizer for crop growth rate (g m^{-2} day $^{-1}$) at 90 DAS to at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	7.026	12.993	9.604	15.639	10.85
F_2	6.314	11.860	8.038	12.97	9.87
F_3	5.492	10.314	7.626	10.84	8.71
SE ±	0.37				
CD at 5 %	1.05				

Significantly the highest CGR was recorded by the interaction F_1 Lb_3 (15.63) while it was lowest in the interaction F_3 Lb_0 (5.492) followed by F_2 Lb_0 (6.314).

4.6.4.1 Effect of varieties (2001)

Significantly the highest value of CGR are recorded by the variety V_1 (10.80 and 9.32) at 30-60 and 90 to at harvest respectively. However at 60-90 DAS significantly the highest CGR recorded by the variety V_1 (14.32) and the lowest by the variety V_3 (9.48).

4.6.4.2 Effect of fertilizers

Significant differences in CGR were observed due to different levels of fertilizer. Significantly the highest CGR was recorded under F_1 (8.80) at 30 to 60 DAS.

At 60-90 DAS significantly the highest and the lowest CGR was recorded under F_1 and F_3 (12.47 and 9.94) respectively.

Similarly under F_1 CGR was significantly the highest (8.76) at 90 to at harvest.

4.6.4.3 Effect of liquid biofertilizer

From the data it is observed that significantly higher CGR was recorded due to different treatments of liquid biofertilizer i.e. Lb_1 (9.21, 13.51, 8.91), Lb_2 (7.99. 11.14, 7.26), Lb_3 (6.74, 9.32, 6.11), Lb_4 (10.67, 15.03, 10.30) at 30-60, 60-90 and 90 DAS to at harvest respectively over the control Lb_0 (5.36, 7.40, 5.18). The magnitude of increase was more due to the treatments Lb_4 and Lb_1.

4.6.4.4 The interaction effect

The interaction of V x F at 90 DAS to at harvest and V x F x Lb at all the stages was found to be non-significant.

4.6.4.4.3 Interaction effect of fertilizer x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) at 30-60 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	5.84	10.67	7.91	7.16	12.19
F_2	5.29	8.97	7.41	5.94	10.16
F_3	4.96	7.10	6.47	5.23	8.56
SE ±	0.21				
CD at 5 %	0.61				

The crop growth rate was significantly the highest due to interaction of F_1 Lb_4 (12.19) while it was lower due to F_3 Lb_0 (4.96), F_3 Lb_3 (5.23) and F_2 Lb_0 (5.29).

4.6.4.4.4 Interaction effect of varieties x fertilizer for crop growth rate (g m^{-2} day^{-1}) at 60-90 DAS (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	15.92	14.23	12.79
V_2	11.14	10.31	8.66
V_3	10.34	9.73	8.38
SE ±	0.18		
CD at 5 %	0.55		

Significantly the highest CGR was recorded by the interaction V_1 F_1 (15.92) while the lowest was recorded by the V_3 F_3 and V_2 F_3 (8.38, 8.66) respectively.

4.6.4.4.5 Interaction effect of varieties x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) at 60-90 DAS (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	8.64	17.03	14.85	11.82	19.22
V_2	6.74	12.51	9.80	7.59	13.54
V_3	6.80	10.98	8.77	8.53	12.33
SE ±	0.23				
CD at 5 %	0.66				

The treatment combination V_1 Lb_4 showed significantly the highest (19.22) CGR while V_2 Lb_0 and V_3 Lb_0 recorded lower (6.74, 6.80) CGR respectively.

4.6.4.4.6 Interaction effect of fertilizer x liquid biofertilizer for crop growth rate (g m^{-2} day^{-1}) per plant at 60-90 DAS (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	8.10	15.08	11.10	10.19	17.88
F_2	7.62	13.62	11.65	9.16	14.86
F_3	6.46	11.82	10.47	8.60	12.37
SE ±	0.23				
CD at 5 %	0.66				

Significantly the highest and the lowest CGR was observed in the treatment combination F_1 Lb_4 (17.88) and F_3 Lb_0 (6.46) respectively.

4.6.4.4.7 Interaction effect of varieties x liquid biofertilizer for crop growth rate (g m^{-2} day $^{-1}$) at 90 DAS to at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	6.63	12.89	11.02	8.98	14.48
V_2	3.97	6.78	6.32	4.75	8.30
V_3	4.95	7.98	6.62	6.48	9.23
SE ±	0.39				
CD at 5 %	1.12				

The variety V_1 with liquid biofertilizer treatment Lb_4 recorded significantly the highest CGR (14.48) while the combination V_2 Lb_0, V_2 Lb_3 and V_3 Lb_0 recorded significantly lower values of CGR i.e. (3.97, 4.75 and 4.95) respectively.

4.6.4.4.8 Interaction effect of fertilizer x liquid biofertilizer for crop growth rate (g m^{-2} day $^{-1}$) at 90 DAS to at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	5.74	10.53	7.78	7.30	12.63
F_2	5.19	8.88	8.20	6.57	10.51
F_3	4.61	8.23	7.99	6.34	8.87
SE ±	0.39				
CD at 5 %	1.26				

The interaction F_1 Lb_4, F_3 Lb_0 and F_2 Lb_0 recorded significantly the highest (12.63[illegible] and lower (4.61, 5.19) CGR respectively over rest of the interactions.

4.7 Post harvest studies

Data on post harvest observation such as number of pegs, number of pods, number of mature and immature pods of groundnut as affected by different treatments during the year 2000 and 2001 are presented in Table 29 and graphically depicted in Fig. 8.

Table 29. The data on post harvest observations on number of pegs, number of pods, number of mature and immature pods per plant of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	At harvest				At harvest			
	No. of pegs	No. of pods	No. of mature pods	No. of immature pods	No. of pegs	No. of pods	No. of mature pods	No. of immature pods.
Varieties								
V_1	36.78	26.04	18.67	9.42	20.22	14.71	8.77	5.57
V_2	31.04	20.71	13.78	6.91	17.51	14.31	9.02	4.33
V_3	31.62	20.11	14.33	7.16	17.66	13.15	10.82	3.77
SE ±	0.34	0.33	0.31	0.21	0.12	0.16	0.18	0.13
CD 5%	1.01	0.99	0.92	0.63	0.35	0.46	0.52	0.39
Ferti. Levels								
F_1	38.64	25.89	17.53	9.24	20.28	15.64	10.82	5.11
F_2	33.60	22.13	15.35	7.49	18.77	14.33	9.71	4.55
F_3	27.20	19.84	13.89	6.76	16.33	12.20	8.08	4.02
SE ±	0.34	0.33	0.31	0.21	0.12	0.16	0.18	0.13
CD 5%	1.01	0.99	0.92	0.63	0.35	0.46	0.52	0.39
Liq. Bioferti.								
Lb_0	19.89	15.85	9.92	5.82	15.07	10.92	6.37	4.37
Lb_1	41.93	27.25	19.63	7.85	21.33	16.22	11.92	4.51
Lb_2	30.70	19.41	13.11	7.55	16.85	12.59	8.03	4.63
Lb_3	25.07	18.18	13.00	7.59	16.59	11.88	8.07	4.07
Lb_4	48.15	32.41	22.29	10.29	22.48	18.66	13.29	5.22
SE ±	0.37	0.32	0.31	0.39	0.17	0.19	0.16	0.18
CD 5%	1.05	0.89	0.85	1.09	0.46	0.52	0.46	0.49
Interactions								
V x F	Sig.	NS	NS	Sig.	Sig.	NS	Sig.	Sig.
V x Lb	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
F x Lb	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.	Sig.
V x F x Lb	Sig.	Sig.	NS	NS	Sig.	Sig.	Sig.	Sig.

4.7.1 Mean number of pegs

4.7.1.1 Effect of varieties (2000)

Varietal differences on mean number of pegs was influenced significantly. Variety V_1 recorded significantly the highest (36.78) mean number of pegs while V_2 and V_3 recorded (31.04, 31.62) which was at par with each other.

4.7.1.2 Effect of fertilizer levels

Mean number of pegs was affected significantly due to different levels of fertilizer. Under F_1 mean number of pegs was significantly the highest (38.64) followed by F_2 (33.60) while under F_3 it was significantly the lowest (27.20).

4.7.1.3 Effect of liquid biofertilizer

Mean number of pegs was significantly highest due to all treatments of liquid biofertilizer. Over control i.e. Lb_1 (41.93), Lb_2 (30.70), Lb_3 (25.07) and Lb_4 (48.15) over Lb_0 (19.89).

4.7.1.4 The interaction effects

Interaction due to V x F, V x Lb, F x Lb and V x F x Lb was found to be significant and results of the same has been explained separately.

4.7.1.4.1 Interaction effect of varieties x fertilizer for mean number of pegs per plant at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	41.26	37.93	31.13
V_2	35.80	30.33	27.00
V_3	38.86	32.53	23.46
SE ±	0.58		
CD at 5 %	1.75		

Differences in mean number of pegs due to combined effect of varieties and fertilizer levels were found to be significant at harvest. The treatment combination V_1 F_1 and V_3 F_3 produced significantly the highest (41.26) and the lowest (23.46) mean number of pegs per plant respectively.

4.7.1.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	17.88	33.00	22.00	20.77	36.55
V_2	13.44	24.55	18.55	15.33	31.66
V_3	16.22	24.22	17.66	18.44	29.00
SE ±	0.67				
CD at 5 %	1.90				

Interaction between varieties and liquid bio-fertilizer was found to be significant. The interaction V_1 Lb_4 and V_2 Lb_0 produced significantly the highest (36.55) and the lowest (13.44) number of pegs respectively at harvest.

4.7.1.4.3 Interaction effect of fertilizer x liquid biofertilizer for mean number of pegs per plant at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	18.22	32.11	22.11	20.22	36.77
F_2	16.33	26.33	18.77	18.33	30.88
F_3	13.00	23.33	17.33	16.00	29.55
SE ± mean	0.67				
CD at 5 %	1.90				

The treatment combination F_1 Lb_4 and F_3 Lb_0 observed significantly the highest (36.77) and the lowest (13.00) number of pegs at harvest over rest of combinations.

4.7.1.4.4 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of pegs per plant at harvest (2000)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	21.00	20.00	12.66	16.00	12.66	11.66	17.66	16.33	14.66
Lb_1	39.00	30.00	30.00	30.00	23.33	20.33	27.33	25.66	19.66
Lb_2	24.00	22.33	19.66	20.66	17.66	17.33	21.66	16.33	15.00
Lb_3	23.33	21.33	17.66	17.00	15.33	13.66	20.33	18.33	16.66
Lb_4	44.66	33.00	32.00	33.66	32.00	29.33	32.00	27.66	27.33
SE ±	1.11								
C.D at 5 %	3.15								

The interaction between varieties, fertilizer levels and liquid bio-fertilizer on mean number of pegs at harvest was found to be significant. Where treatment combination V_1 F_1 Lb_4 recorded significantly the highest (44.66) number of pegs over rest of combinations. However, significantly lower number of pegs was observed with interaction V_2 F_3 Lb_0 (11.66), V_1 F_3 Lb_0 (12.66) and V_2 F_2 Lb_0 (12.66) over rest of interaction.

4.7.1.1 Effect of varieties (2001)

Differences within the varieties on mean number of pegs was found to be statistically significant. Variety V_1 recorded significantly the highest mean number of pegs (20.22) while V_2 and V_3 recorded (17.51, 17.66) mean number of pegs which was at par with each other.

4.7.1.2 Effect of fertilizer levels

Significant differences was observed on mean number of pegs under different levels of fertilizer. Where under F_1 recorded (20.28) which was significantly the highest followed by F_2 (18.77) and under F_3 it was significantly the lowest (16.33).

4.7.1.3 Effect of liquid biofertilizer

Mean number of peg was significantly higher due to all the treatments as Lb_1 to Lb_4 (21.33, 16.85, 16.59, 22.48) respectively over control Lb_0 (15.07).

4.7.1.4 The interaction effects

The interaction effects were statistically significant.

4.7.1.4.1 Interaction effect of varieties x fertilizer for mean number of pegs per plant at harvest (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	22.20	20.60	17.86
V_2	18.80	18.06	15.66
V_3	19.86	17.66	15.46
SE ±	0.20		
CD at 5 %	0.59		

The combined effect due to varieties and fertilizer levels were found to be significant for mean number of pegs at harvest. Where V_1 F_1 and V_2 F_3 recorded significantly the highest (22.20) and lowest (15.66) mean number of pegs respectively.

4.7.1.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of pegs per plant at harvest (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	16.22	23.88	18.33	16.66	26.00
V_2	15.00	19.22	16.44	16.66	20.22
V_3	14.00	20.88	15.77	16.44	21.22
SE ±	0.28				
CD at 5 %	0.80				

The interaction effects due to varieties and liquid bio-fertilizer for mean number of pegs per plant at harvest were found to be significant. The combination V_1 Lb_4 and V_2 Lb_0 recorded significantly the highest (26.00) and the lowest (15.00) number of pegs respectively.

4.7.1.4.3 Interaction effect of fertilizer x liquid biofertilizer for mean number of pegs per plant at harvest (2001)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	16.44	23.33	18.55	18.11	25.00
F_2	15.22	22.00	16.66	16.44	23.55
F_3	13.55	18.66	15.33	15.22	18.88
SE ±	0.28				
CD at 5 %	0.80				

The interaction F_1 Lb_4 and F_3 Lb_0 recorded significantly the highest (25.00) and the lowest (13.55) mean number of pegs respectively over rest of interaction at harvest.

4.7.1.4.4 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of pegs per plant at harvest (2001)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	17.00	16.66	15.00	16.00	15.00	14.00	16.33	14.00	11.66
Lb_1	26.33	25.00	20.33	20.66	19.66	17.33	23.00	21.33	18.33
Lb_2	20.00	18.66	16.33	18.33	16.00	15.00	17.33	15.33	14.66
Lb_3	19.00	16.00	15.00	17.33	17.33	15.33	18.00	16.00	15.33
Lb_4	28.66	26.66	22.66	21.66	22.33	16.66	24.66	21.66	17.33
SE ±	0.49								
C.D at 5 %	1.37								

The interaction V_1 F_1 Lb_4 and V_3 F_3 Lb_0 recorded significantly the highest (28.66) and the lowest (11.66) mean number of pegs respectively over rest of the interaction.

4.7.2 Mean number of pods per plant

4.7.2.1 Effect of varieties (2000)

In variety V_1 significantly the highest mean number of pods (26.04) were observed. Variety V_2 and V_3 recorded (20.71, 21.11) mean number of pods respectively which was at par with each other.

4.7.2.2 Effect of fertilizer levels

Mean number of pods under F_1 was significantly the highest (25.89). While under F_3 it was significantly lowest (19.84) and under F_2 (22.13) it was observed significantly the highest over F_3 and lowest over F_1.

4.7.2.3 Effect of liquid biofertilizer

Effect of liquid biofertilizer on mean number of pods was significantly higher due to Lb_1 to Lb_4 (27.25, 19.41, 18.18, 32.41) respectively over control Lb_0 (15.85).

4.7.2.4 The interaction effect

Interaction due to V x F was found to be non-significant.

4.7.2.4.1 Interaction effect of varieties x liquid biofertilizer for mean number of pods per plant at harvest (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	17.88	33.00	22.00	20.77	36.55
V_2	13.44	24.55	18.55	15.33	31.66
V_3	16.22	24.22	17.66	18.44	29.00
SE ±	0.60				
CD at 5 %	1.71				

The interaction V_1 Lb_4 and V_2 Lb_0 produced significantly the highest (36.55) and the lowest (13.44) number of pods per plant respectively at harvest over rest of the interactions.

4.7.2.4.2 Interaction effect of fertilizer x liquid biofertilizer for mean number of pods per plant at harvest (2000)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	18.22	32.11	22.11	20.22	36.77
F_2	16.33	26.33	18.33	18.33	30.88
F_3	13.00	23.33	17.33	16.00	29.55
SE ±	0.60				
CD at 5 %	1.71				

The data on mean number of pods per plant at harvest indicated that the interaction F_1 Lb_4 and F_3 Lb_0 produced significantly the highest (36.77) and the lowest (13.00) mean number of pods respectively at harvest over rest of interactions.

4.7.2.4.3 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of pods per plant at harvest (2000)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	21.00	20.00	12.66	16.00	12.00	11.66	17.66	16.33	14.66
Lb_1	39.00	30.00	30.00	30.00	23.33	20.33	27.33	25.66	19.66
Lb_2	24.00	22.33	19.66	20.66	17.66	17.33	21.66	16.33	15.00
Lb_3	23.33	21.33	17.66	17.00	15.33	13.66	20.33	18.33	16.66
Lb_4	44.66	33.00	32.00	33.00	32.00	29.33	32.00	27.66	27.33
SE ±	0.96								
C.D at 5 %	2.72								

Data on mean number of pods per plant found that the interaction V_1 F_1 Lb_4 recorded significantly the highest (44.66) mean number of pods over rest of the interaction. However, it was significantly lower with interaction V_2 F_3 Lb_0 (11.66), V_2 F_2 Lb_0 (12.00) and V_1 F_3 Lb_0 (12.66) over rest of the interaction at harvest.

4.7.2.1 Effect of varieties (2001)

Variety V_1 recorded significantly the highest mean number of pods per plant (14.71) while V_3 recorded (13.15) which was significantly lowest.

4.7.2.2 Effect of fertilizer levels

Mean number of pods was significantly influenced due to different levels of fertilizer where as under F_1 significantly the highest number of pods, were recorded (15.64) followed by F_2 (14.33) and under F_3 (12.20) it was significantly lowest.

4.7.2.3 Effect of liquid biofertilizer

The mean number of pods under different liquid biofertilizer treatments was significantly higher due to Lb_1 to Lb_4 (16.22, 12.59, 11.88, 18.66) respectively over control Lb_0 (10.92).

4.7.2.4 The interaction effect

Interaction due to V x F was found to be non-significant.

4.7.2.4.1 Interaction effect of varieties x liquid biofertilizer for mean number of pods per plant at harvest (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	12.00	16.22	12.11	10.33	20.88
V_2	10.00	15.22	12.66	11.88	16.00
V_3	10.77	17.22	13.00	13.44	19.11
SE ±	0.32				
CD at 5 %	0.92				

From the data it is observed that significantly the highest and the lowest mean number of pods per plant were recorded by the interaction V_1 Lb_4 (20.88) and V_2 Lb_0 (10.00) respectively over rest of the intersections.

4.7.2.4.2 Interaction effect of fertilizer x liquid biofertilizer for mean number of pods per plant at harvest (2001)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	12.33	18.00	14.00	12.77	21.11
F_2	11.11	16.55	13.00	12.00	19.00
F_3	9.33	14.11	10.77	10.88	15.88
SE ±	0.32				
CD at 5 %	0.92				

Interaction between fertilizer and liquid bio-fertilizer was found to be significant at harvest where interaction F_1 Lb_4 and F_3 Lb_0 produced significantly the highest (21.11) and the lowest (9.33) mean number of pods over rest of the interactions.

4.7.2.4.3 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of pods per plant at harvest (2001)

Var./ Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	13.33	13.00	9.66	10.66	10.00	9.33	13.00	10.33	9.00
Lb_1	19.33	16.33	13.00	16.00	15.66	14.00	18.66	17.66	15.33
Lb_2	12.66	12.33	11.33	14.66	13.33	10.00	14.00	13.33	11.00
Lb_3	11.00	10.00	10.00	13.00	12.33	10.33	14.33	13.66	12.33
Lb_4	24.66	20.66	17.33	18.00	17.00	12.66	20.33	19.33	17.66
SE ±	0.55								
C.D at 5 %	1.56								

Interaction on mean number of pods revealed that V_1 F_1 Lb_4 produced significantly the highest (24.66) mean number of pods over rest of interaction at harvest.

4.7.3 Mean number of mature pods

4.7.3.1 Effect of varieties (2000)

Significantly highest mature pods was recorded by the variety V_1 (18.67) followed by V_3 (14.33) while V_2 recorded (13.78) mature pods which was significantly the lowest.

4.7.3.2 Effect of fertilizer levels

Under different levels of fertilizers mean number of mature pods was influenced significantly. It was significantly highest (17.53) under F_1 followed by F_2 (15.35) while under F_3 it was significantly the lowest (13.89).

4.7.3.3 Effect of liquid biofertilizers

Mean number of mature pods was significantly superior due to Lb_1 to Lb_4 (19.63, 13.11, 13.00, 22.29) respectively over Lb_0 (9.92).

4.7.3.4 The interaction effect

Interaction due to V x F was found to be non-significant.

4.7.3.4.1 Interaction effect of varieties x liquid biofertilizer for mean number of mature pods per plant at harvest (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	10.88	23.33	15.00	17.33	26.77
V_2	7.77	19.11	11.88	9.66	20.44
V_3	11.11	16.44	12.44	12.00	19.66
SE ±	0.56				
CD at 5 %	1.60				

Data on mature pods revealed that interaction V_1 Lb_4 and V_2 Lb_0 recorded significantly the highest (26.77) and the lowest (7.77) mature pods respectively over rest of interaction at harvest.

4.7.3.4.2 Interaction effect of fertilizer x liquid biofertilizer for mean number of mature pods per plant at harvest (2000)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	10.66	22.66	15.00	13.22	26.11
F_2	10.11	18.77	13.11	13.44	21.33
F_3	9.00	17.44	11.22	12.33	19.44
SE ±	0.56				
CD at 5 %	1.60				

Data on mature pods indicated that treatments combination of F_1 Lb_4 recorded significantly the highest mature pods (26.11) while F_3 Lb_0 and F_2 Lb_0 (9.00, 10.11) observed lowest mature pods respectively over rest of interaction.

4.7.3.1 Effect of varieties (2001)

Variety V_3 (10.82) recorded significantly the highest mature pods followed by V_2 (9.02) while V_1 recorded (8.77) mature pods which was significantly the lowest.

4.7.3.2 Effect of fertilizer levels

Under different levels of fertilizer mean number of mature pods was influenced significantly where under F_1 and F_3 it was significantly the highest (10.82) and lowest (8.08) and under F_2 it was (9.71) which was superior over F_3.

4.7.3.3 Effect of liquid biofertilizer

Mean number of mature pods was also influenced due to different treatments with Lb_1 to Lb_4 (11.92, 8.03, 8.07, 13.29) respectively which was significantly higher over control Lb_0 (6.37).

4.7.3.4 The interaction effect

4.7.3.4.1 Interaction effect of varieties x fertilizer for mean number of mature pods per plant at harvest (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	9.53	8.86	7.93
V_2	10.20	9.26	7.60
V_3	12.73	11.00	8.73
SE ±	0.30		
CD at 5 %	0.90		

The interaction effects due to varieties and fertilizer levels were found to be significant at harvest. The variety V_3 with F_1 and V_2 F_3 recorded significantly the highest (12.73) and the lowest (7.60) mean number of mature pods respectively.

4.7.3.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of mature pods per plant at harvest (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	6.33	11.11	6.66	6.55	13.22
V_2	5.44	10.55	8.88	7.88	12.33
V_3	7.33	14.11	8.55	9.77	14.33
SE ±	0.30				
CD at 5 %	0.87				

As regards mature pods at harvest it was significantly the highest and the lowest values were recorded by the interaction V_3 Lb_4 (14.33) and V_2 Lb_0 (5.44) respectively over rest of interaction.

4.7.3.4.3 Interaction effect of fertilizer x liquid biofertilizer for mean number of mature pods per plant at harvest (2001)

Ferti./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	7.44	12.66	9.77	9.00	15.22
F_2	6.11	12.33	7.55	8.11	14.44
F_3	5.55	10.77	6.77	7.11	10.22
SE ±	0.30				
CD at 5 %	0.87				

At harvest mature pods observed due to treatment combination F_1 Lb_4 significantly the highest (15.22) while F_3 Lb_0 and F_2 Lb_0 recorded (5.55, 6.11) matured pods which was significantly lower over rest of the combinations.

4.7.3.4.4 Interaction effect of varieties x fertilizer x liquid biofertilizer for mean number of mature pods per plant at harvest (2001)

Var./ Ferti./	V_1			V_2			V_3		
Liq. Bioferti.	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	7.66	6.00	5.33	5.33	5.33	5.66	9.33	7.00	5.66
Lb_1	13.00	10.33	10.00	10.00	11.66	10.00	15.00	15.00	12.33
Lb_2	6.66	6.66	6.66	11.66	8.33	6.66	11.00	7.66	7.00
Lb_3	7.00	6.00	6.66	8.33	9.00	6.33	11.66	9.33	8.33
Lb_4	13.33	15.33	11.00	15.66	12.00	9.33	16.66	16.00	10.33
SE ±	0.48								
C.D at 5 %	1.37								

The interaction V_3 F_1 Lb_4 recorded significantly higher (16.66) mature pods followed by V_2 F_1 Lb_4 and V_1 F_2 Lb_4 (15.66, 15.33) respectively over rest of interaction at harvest.

4.7.4 Mean number of immature pods

4.7.4.1 Effect of varieties (2000)

Significantly the highest and the lowest immature pods by the variety V_1 (9.42) and V_2 (6.91) was recorded while variety V_3 recorded (7.16) immature pods which was significantly the highest over V_2.

4.7.4.2 Effect of fertilizer levels

The immature pods due to different levels of fertilizer was influenced significantly. Under F_1 (9.24) and F_3 (6.76) significantly the highest and the lowest immature pods was recorded while under F_2 (7.49) immature pods was observed which was significantly highest over F_3 and lowest with F_1.

4.7.4.3 Effect of liquid biofertilizer

From the data it was observed that immature pods was increased with liquid biofertilizer treatments from Lb_1 to Lb_4 (7.85, 7.55, 7.59, 10.29) respectively over control Lb_0 (5.82).

4.7.4.4 The interaction effect

Interaction due to F x Lb and V x F x Lb was found to be non-significant.

4.7.4.4.1 Interaction effect of varieties x fertilizer for immature pods at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	12.00	8.60	7.66
V_2	7.66	6.60	6.46
V_3	8.06	7.26	6.13
SE ±	0.36		
CD at 5 %	1.08		

The interaction between varieties and fertilizer levels indicated that variety V_1 with fertilizer level F_1 recorded significantly the highest (12.00) immature pods while significantly the lowest immature pods were observed in V_3 F_3 (6.13) followed by V_2 F_3 (6.46) and V_2 F_2 (6.60) respectively at harvest.

4.7.4.4.2 Interaction effect of varieties x liquid biofertilizer for immature pods at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	7.00	9.66	10.11	10.55	9.77
V_2	5.44	5.44	6.66	5.77	11.22
V_3	5.11	8.44	5.88	6.44	9.88
SE ±	0.83				
CD at 5 %	1.80				

The interaction between varieties and liquid bio-fertilizer was found to be significant at harvest. The interaction V_3 Lb_0 recorded lowest immature pods (5.11) followed by V_2 and V_1 Lb_0 (5.44, 7.00) respectively while V_2 Lb_4 recorded highest immature pods (11.22) followed by V_1 Lb_3 and Lb_2 (10.55 and 10.11) respectively.

4.7.4.1 Effect of varieties (2001)

Significantly the highest immature pods was recorded by the variety V_1 (5.57) followed by variety V_2 (4.33) while significantly the lowest immature pods was recorded by V_3 (3.77)

4.7.4.2 Effect of fertilizer levels

Significantly highest and lowest immature pods was recorded under F_1 and F_3 (5.11, 4.02) respectively while under F_2 it was (4.55) which was significantly lowest over F_1 and highest over F_3.

4.7.4.3 Effect of liquid biofertilizer

Mean number of immature pods due to Lb_4 (5.22) was recorded significantly highest while due to remaining treatments it was at par i.e. Lb_1 to Lb_3 (4.51, 4.63, 4.07) respectively over control Lb_0 (4.37).

4.7.4.4 The interaction effect

4.7.4.4.1 Interaction effect of varieties x fertilizer for mean number of immature pods per plant at harvest (2001)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	6.80	5.33	4.40
V_2	4.86	4.26	3.86
V_3	3.66	3.86	3.80
SE ±	0.22		
CD at 5 %	0.68		

Variation for number of immature pods due to combined effect of varieties and fertilizer levels was found to be significant at harvest. The variety V_1 with F_1 fertilizer levels produced significantly the highest (6.80) immature pods. However, significantly lowest immature pods was produced by V_3 F_1 (3.66) followed by V_2 and V_3 with F_2 and F_3 (4.26, 3.86, 3.86, 3.80) respectively.

4.7.4.4.2 Interaction effect of varieties x liquid biofertilizer for mean number of immature pods per plant at harvest (2001)

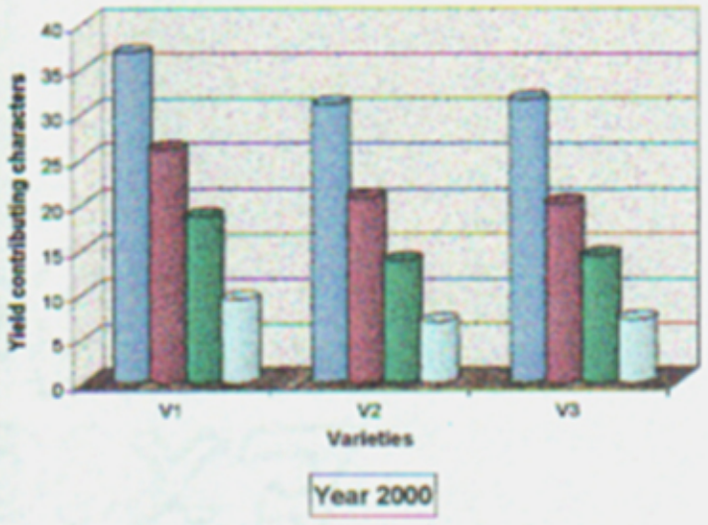
Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	4.88	5.44	5.33	4.33	7.88
V_2	4.66	4.88	4.00	3.88	4.22
V_3	3.55	3.22	4.55	4.00	3.55
SE ±	0.30				
CD at 5 %	0.85				

The interaction V_1 Lb_4 recorded significantly highest immature pods (7.88) at harvest over rest of the interactions. While V_3 Lb_1 observed lowest immature pods (3.22) also by V_3 Lb_0 and V_3 Lb_4 (3.55).

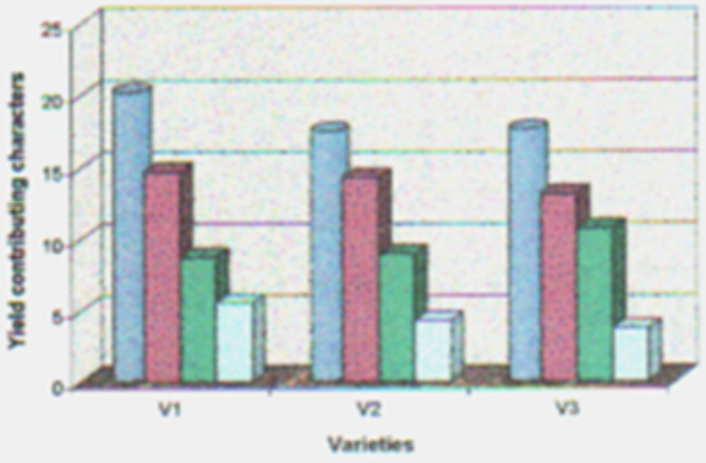
4.7.4.4.3 Interaction effect of fertilizer x liquid biofertilizer for mean number of immature pods per plant at harvest (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	4.88	5.66	4.11	4.44	6.44
F_2	4.33	4.44	5.44	3.88	4.66
F_3	3.88	3.44	4.33	3.88	4.55
SE ±	0.30				
CD at 5 %	0.85				

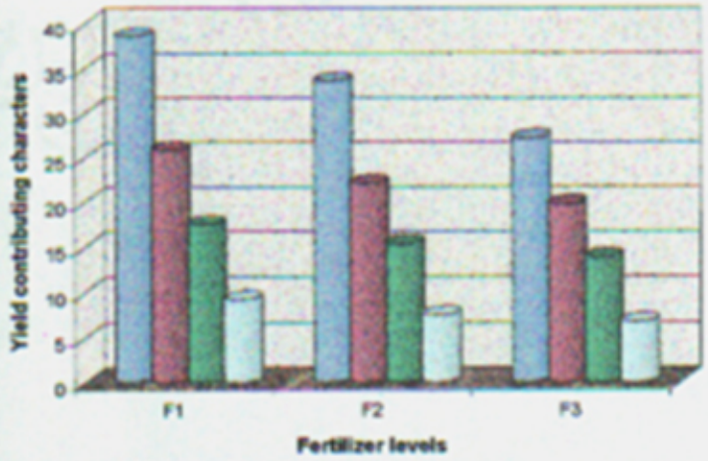
From the data on immature pods it was observed that significantly lowest immature pods was recorded by the combination F_3 Lb_1 (3.44) while significantly the highest (6.44) immature pods was recorded by F_1 Lb_4.



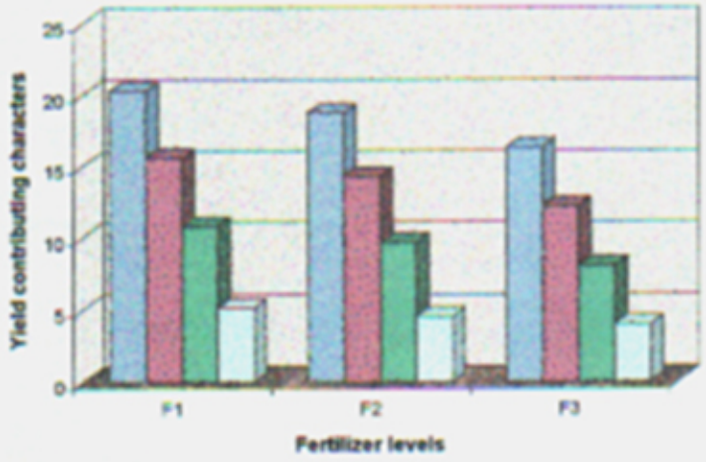
Year 2000



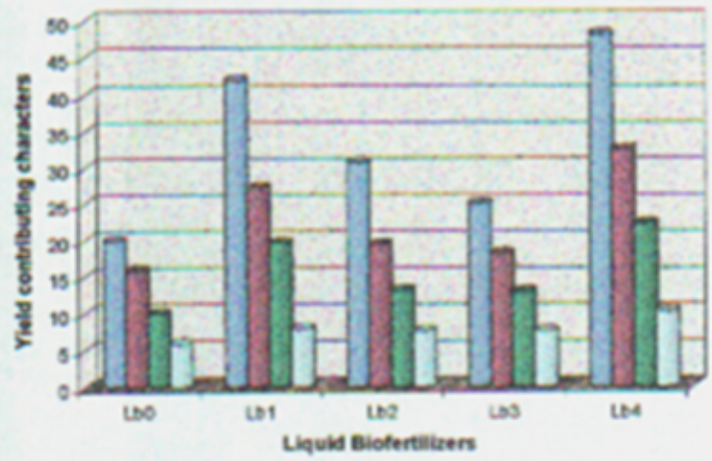
Year 2001



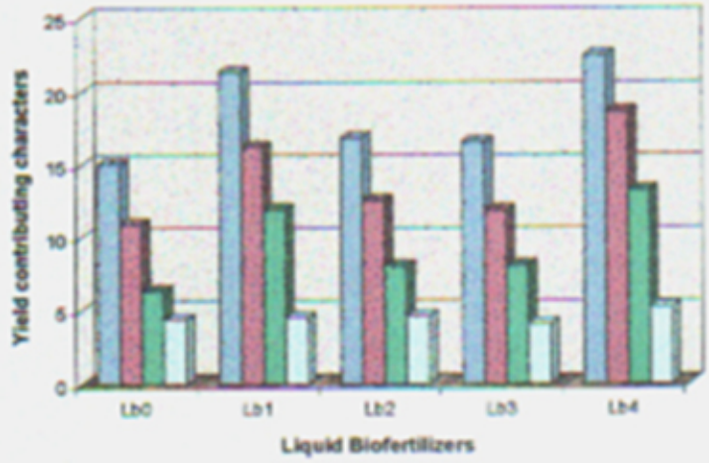
Year 2000



Year 2001



Year 2000



Year 2001

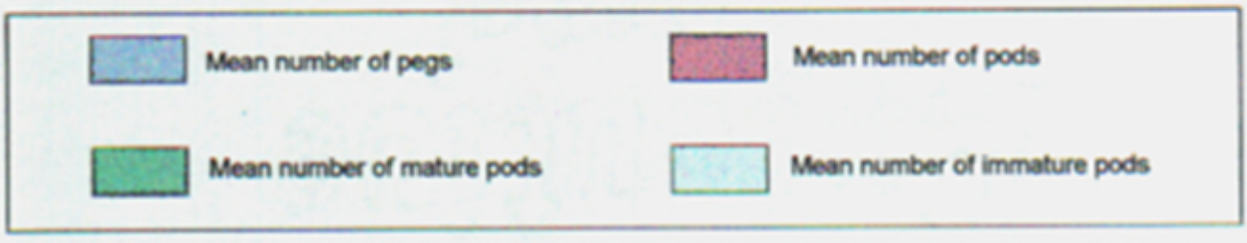


Fig. 8 : Mean number of pegs, mean number of pods, mean number of mature and immature pods per plant of groundnut as affected by different treatments at harvest

4.7.4.4.4 Interaction effect of V x F x Lb for mean number of immature pods per plant at harvest (2001)

Var. /Ferti./ Liq. Bioferti.	V_1			V_2			V_3		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Lb_0	5.66	4.66	4.33	5.66	4.66	3.66	3.33	3.66	3.66
Lb_1	6.33	6.66	3.33	6.66	4.00	4.00	4.00	2.66	3.00
Lb_2	5.33	6.00	4.66	3.00	5.00	4.00	4.00	5.33	4.33
Lb_3	5.33	4.00	3.66	4.66	3.00	4.00	3.33	4.66	4.00
Lb_4	11.33	6.33	6.00	4.33	4.66	3.66	3.66	3.00	4.00
SE ±	0.52								
C.D at 5 %	1.47								

Variation for number of immature pods due to combined effect of varieties, fertilizer levels and liquid biofertilizer was found to be significant at harvest. Where significantly the lowest immatured pods were produced by the interaction V_3 F_2 Lb_1 (2.66) and significantly the highest by $V_1F_1Lb_4$ (11.33).

Post harvest studies such as peg to pod ratio, dry weight of pods, 100 pod weight, 100 kernel weight per plant of groundnut as affected by different treatments for the year 2000 and 2001 are presented in Table 30 and graphically depicted in Fig.9.

4.7.5 Peg to pod ratio

4.7.5.1 Effect of varieties (2000)

Peg to pod ratio within the varieties was not significantly influenced statistically.

4.7.5.2 Effect of fertilizer levels

The differences due to different levels of fertilizers on peg to pod ratio was found to be non-significant.

Table 30. Data on peg to pod ratio, dry weight of pods, 100 pod weight, 100 kernel weight per plant of groundnut as affected by different treatment

Treatment	Year 2000				Year 2001			
	At harvest				At harvest			
	Peg to pod ratio	Dry weight of pods (g)	100 pod weight (g)	100 kernel weight (g)	Pet to pod ratio	Dry weight of pods (g)	100 pod weight (g)	100 kernel weight (g)
Varieties								
V_1	0.74	15.19	114.93	30.50	0.69	8.89	112.35	29.70
V_2	0.67	11.70	101.47	36.52	0.74	6.70	99.31	33.77
V_3	0.82	11.43	81.87	29.53	0.81	5.48	78.05	31.36
SE ±	0.10	0.18	0.61	0.38	0.008	0.090	0.53	0.72
CD 5%	NS	0.53	1.82	1.13	NS	0.27	1.59	NS
Ferti. Levels								
F_1	0.74	14.08	101.62	33.61	0.76	7.21	99.29	32.43
F_2	0.76	12.77	99.64	32.15	0.75	7.02	96.37	31.18
F_3	.74	11.47	96.41	30.80	0.73	6.85	94.05	31.22
SE ±	0.10	0.18	0.61	0.38	0.008	0.09	0.53	0.72
CD 5%	NS	0.53	1.82	1.13	NS	0.27	1.59	NS
Liq. Bioferti.								
Lb_0	0.72	8.69	90.85	29.30	0.70	6.04	88.95	28.23
Lb_1	0.72	15.07	102.18	33.68	0.76	7.50	99.01	32.34
Lb_2	0.81	12.26	99.37	32.14	0.71	7.03	97.13	30.78
Lb_3	0.72	11.29	97.50	31.46	0.75	6.60	94.33	30.69
Lb_4	0.75	16.54	106.22	34.34	0.80	7.95	103.44	36.01
SE ±	0.011	0.31	0.57	0.47	0.008	0.089	0.63	0.84
CD 5%	NS	0.86	1.57	1.30	NS	0.25	1.63	2.31
Interactions								
V x F	Sig.	Sig.	NS	NS	NS	NS	NS	NS
V x Lb	Sig.	Sig.	Sig.	NS	Sig.	NS	Sig.	NS
F x Lb	Sig.	NS	NS	NS	Sig.	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.7.5.3 Effect of liquid biofertilizer

Non-significant effect was observed on peg to pod ratio due to application of liquid biofertilizer.

4.7.5.4 The interaction effect

Interaction due to V x F x Lb was non-significant

4.7.5.4.1 Interaction effect of varieties x fertilizer for peg to pod ratio at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	0.77	0.76	0.69
V_2	0.70	0.65	0.66
V_3	0.75	0.85	0.85
SE ±	0.017		
CD at 5 %	0.051		

Interaction effect between varieties and fertilizer levels was found to be significant at harvest.

Treatment combination V_3 F_2 recorded significantly the highest (0.85) peg to pod ratio. While V_2 F_2 recorded significantly the lowest (0.65) peg to pod ratio.

4.7.5.4.2 Interaction effect of varieties x liquid biofertilizer for peg to pod ratio at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.68	0.66	0.82	0.88	0.66
V_2	0.69	0.67	0.74	0.48	0.78
V_3	0.80	0.82	0.88	0.80	0.79
SE ±	0.019				
CD at 5 %	0.055				

From the data on peg to pod ratio at harvest it was found that interaction V_1 Lb_3 and V_3 Lb_2 recorded higher peg to pod ratio (0.88) while it was lower with interaction V_2 Lb_3 (0.48).

4.7.5.4.3 Interaction effect of fertilizer x liquid biofertilizer for peg to pod ratio at harvest (2000)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.76	0.74	0.81	0.67	0.70
F_2	0.75	0.73	0.80	0.74	0.75
F_3	0.65	0.69	0.82	0.74	0.78
SE ±	0.019				
CD at 5 %	0.055				

From the data it can be seen that peg to pod ratio was higher under all the fertilizer level with Lb_2 i.e. F_1 Lb_2 (0.81), F_2 Lb_2 (0.80) and F_3 Lb_2 (0.82) over rest of the interaction. While significantly lower peg to pod ratio was recorded by F_3 Lb_0 (0.65) and F_1 Lb_3 (0.67).

4.7.5.1 Effect of varieties (2001)

Varietal differences on peg to pod ratio was found to be non-significant.

4.7.5.2 Effect of fertilizer levels

Data on peg to pod ratio under different levels of fertilizer was found to be non-significant.

4.7.5.3 Effect of liquid biofertilizer

Effect of liquid biofertilizer on peg to pod ratio was non-significant.

4.7.5.4 The interaction effect

Interaction effect due to V x F and V x F x Lb was found to be non-significant.

4.7.5.4.1 Interaction effect of varieties x liquid biofertilizer for peg to pod ratio at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	0.68	0.67	0.56	0.73	0.79
V_2	0.66	0.78	0.76	0.70	0.78
V_3	0.77	0.82	0.81	0.81	0.84
SE ±	0.015				
CD at 5 %	0.043				

The interaction V_3 Lb_4 recorded higher peg to pod ratio (0.84) followed by V_3 Lb_1 (0.82) and V_3 Lb_2 and V_3 Lb_3 (0.81) while lowest peg to pod ratio was recorded by the interaction V_1 Lb_2 (0.56).

4.7.5.4.2 Interaction effect of fertilizer x liquid biofertilizer for peg to pod ratio at harvest (2001)

Ferti. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
F_1	0.74	0.77	0.72	0.73	0.83
F_2	0.67	0.75	0.74	0.77	0.80
F_3	0.69	0.76	0.67	0.74	0.78
SE ±	0.015				
CD at 5 %	0.043				

Peg of pod ratio was significantly the highest with F_1 Lb_4 (0.83) followed by F_2 Lb_4 (0.80) and F_3 Lb_4 (0.78) while significantly the lowest peg to pod ratio was observed by the interaction F_2 Lb_0 (0.67) over rest in interaction.

4.7.6 Dry weight of pods (g)/plant

4.7.6.1 Effect of varieties (2000)

Varietal differences on dry weight of pods was observed significantly.

Varity V_1 (15.19) and V_3 (11.43) was recorded significantly the highest and the lowest dry pod weight per plant.

4.7.6.2 Effect of fertilizer levels

Fertilizer had significant effect on dry weight of pods. Under F_1 (14.08) and F_3 (11.47) dry pod weight was observed which was significantly the highest and the lowest. However, under F_2 it was (12.77) significantly higher under F_3 and lowest under F_1.

4.7.6.3 Effect of liquid biofertilizer

Dry weight of pods was significantly higher due to different treatments of liquid biofertilizer i.e. from Lb_1 to Lb_4 (15.07, 12.26, 11.29, 16.54) respectively over control Lb_0 (8.69).

4.7.6.4 The interaction effect

Interaction due to F x Lb and V x F x Lb was found to be non-significant.

4.7.6.4.1 Interaction effect of varieties x fertilizer for mean dry weight of pods (g) per plant at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	15.90	15.17	14.49
V_2	13.00	11.72	10.40
V_3	13.34	11.42	9.52
SE ±	0.30		
CD at 5 %	0.92		

Interaction due to varieties and fertilizer noticed that V_1 F_1 and V_3 F_3 combination recorded significantly the highest (15.90) and the lowest (9.52) dry weight of pods at harvest.

4.7.6.4.2 Interaction effect of varieties x liquid biofertilizer for mean dry weight of pods (g) per plant at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	10.27	17.38	15.64	14.44	18.21
V_2	7.41	15.12	10.21	9.72	16.06
V_3	8.40	12.73	10.92	9.72	15.35
SE ±	0.50				
CD at 5 %	1.42				

The interaction V_1 Lb_4 and V_2 Lb_0 recorded significantly the highest (18.21) and the lowest (7.41) dry weight of pods over rest of interactions at harvest.

4.7.6.1 Effect of varieties (2001)

Significantly the highest and the lowest dry pod weight was recorded by variety V_1 (8.89) and V_2 (5.48) respectively while V_3 recorded (6.70) dry pod weight which was significantly the highest over V_2 and lowest over V_1.

4.7.6.2 Effect of fertilizer levels

Dry pod weight under F_1 was observed significantly the highest (7.21) and in F_3 it was significantly the lowest (6.85). While in F_2 (7.02) it was significantly highest over F_3.

4.7.6.3 Effect of liquid biofertilizer

From the data it was observed that dry pod weight was significantly the highest due to Lb_1 to Lb_4 (7.50, 7.03, 6.60, 7.95) respectively over control Lb_0 (6.04).

4.7.6.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.7 100 pod weight

4.7.7.1 Effect of varieties (2000)

Significantly the highest and the lowest 100 pod weight was recorded by the variety V_1 (144.93) and V_3 (81.87) respectively while variety V_2 recorded (101.47) 100 pod weight which was significantly the highest over V_3 and the lowest over V_1.

4.7.7.2 Effect of fertilizer levels

Differences in 100 pod weight was recorded due to different levels of fertilizer. Significantly the highest and the lowest 100 pod weight was observed under F_1 (101.62) and F_3 (96.41) respectively while F_2 recorded (99.64) 100 pod weight which was significantly the highest over F_3 and the lowest over F_1.

4.7.7.3 Effect of liquid biofertilizer

Significant differences were observed in 100 pod weight due to Lb_1 to Lb_4 (102.18, 99.37, 97.50, 106.22) respectively over control Lb_0 (90.85).

4.7.7.4 The interaction effect

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant.

4.7.7.4.1 Interaction effect of varieties x liquid biofertilizer for 100 pod weight (g) at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	107.90	119.00	114.60	111.43	122.01
V_2	90.16	103.67	101.85	100.35	111.32
V_3	74.90	83.72	81.67	80.73	85.34
SE ±	1.06				
CD at 5 %	3.039				

Data on 100 pod weight at harvest indicated that the interaction V_1 Lb_4 recorded significantly higher (122.01) 100 pod weight followed by V_1 Lb_1 (119.00) while the lowest was recorded by the interaction V_3 Lb_0 (74.99) over rest of the interaction.

4.7.7.1 Effect of varieties (2001)

Significantly the highest and the lowest 100 pod weight was recorded by V_1 (112.35) and V_3 (78.05) respectively.

4.7.7.2 Effect of fertilizer levels

Further, the differences due to fertilizer levels was affected significantly. Where under F_1 and F_3 100 pod weight was significantly the highest (99.29) and lowest (94.05).

4.7.7.3 Effect of liquid biofertilizer

From the data it is revealed that 100 pod weight was significantly the highest due to all the treatments of liquid biofertilizer from Lb_1 to Lb_4 (99.01, 97.13, 94.33, 103.44) respectively over control Lb_0 (88.95).

4.7.7.4 The interaction effect

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant.

4.7.7.4.1 Interaction effect of varieties x liquid biofertilizer for 100 pod weight (g) per plant at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	105.03	116.63	112.70	107.24	120.15
V_2	89.13	101.33	99.61	97.63	108.84
V_3	72.68	79.06	79.07	78.12	81.33
SE ±	1.11				
CD at 5 %	3.18				

At harvest significantly the highest and the lowest 100 pod weight was recorded by V_1 Lb_4 and V_3 Lb_0 (120.15, 72.68) respectively over rest of interactions.

4.7.8 100 Kernel weight

4.7.8.1 Effect of varieties (2000)

The differences on 100 kernel weight within the varieties were observed. Variety V_2 recorded significantly the highest kernel weight (36.52) over rest of the varieties. Where V_1 and V_3 recorded (30.50, 29.53) respectively which was at par with each other.

4.7.8.2 Effect of fertilizer levels

Significant differences were observed on 100 kernel weight due to different levels of fertilizer. Under F_1 (33.61) 100 kernel weight was recorded which was significantly the highest followed by F_2 (32.15) and under F_3 (30.80) which was significantly the lowest.

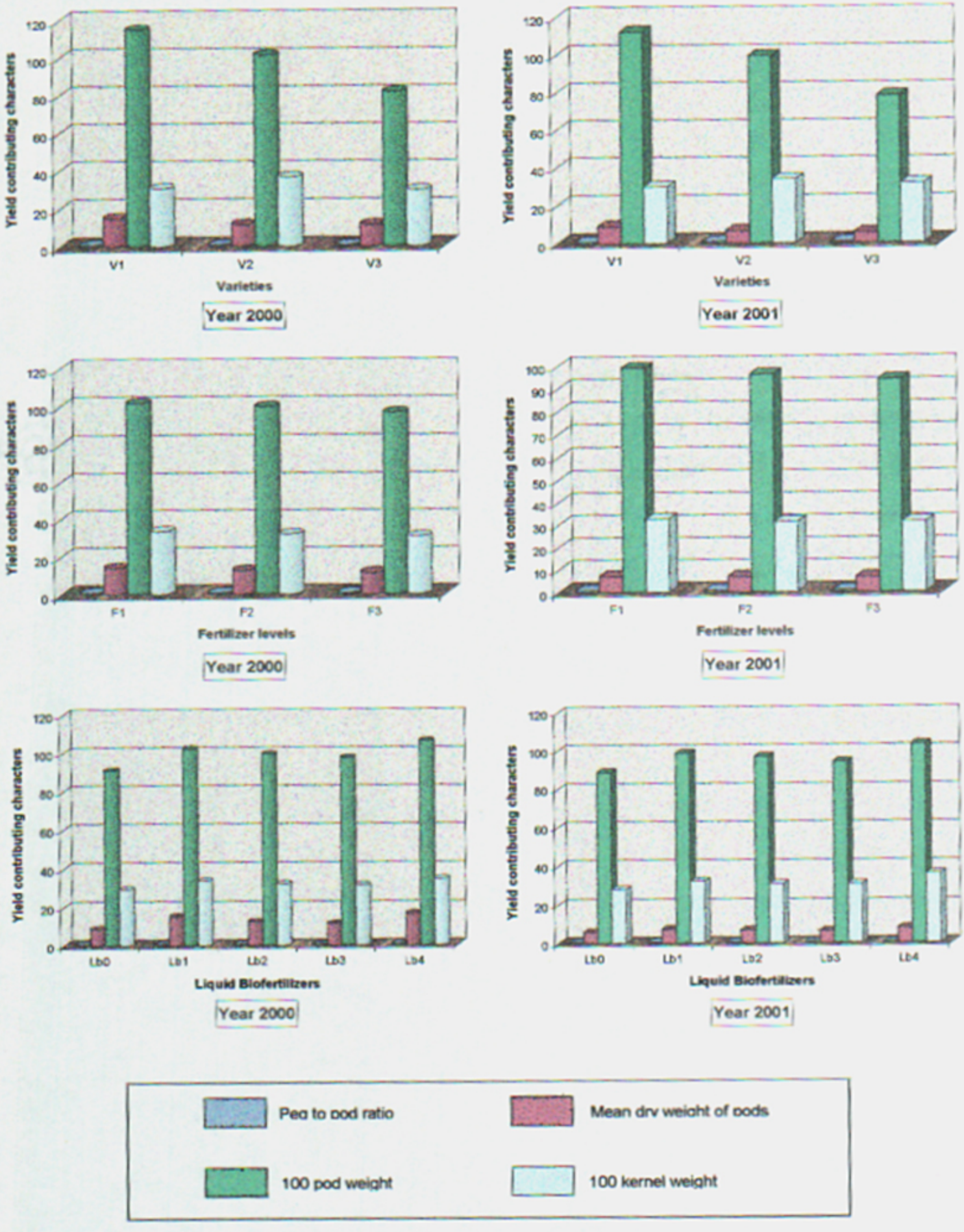


Fig. 9 : Peg to pod ratio, mean dry weight of pods, 100 pod weight, 100 kernel weight per plant of groundnut as affected by different treatments at harvest

4.7.8.3 Effect of liquid biofertilizer

Weight of 100 kernels was recorded significantly the highest due to Lb_1 to Lb_4 (33.68, 32.14, 31.46, 34.34) respectively over control Lb_0 (29.30).

4.7.8.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.8.1 Effect of varieties (2001)

The varietal differences on 100 kernel weight was found to be non-significant.

4.7.8.2 Effect of fertilizer levels

Data on 100 kernel weight under different levels of fertilizer was found to be non-significant.

4.7.8.3 Effect of liquid biofertilizer

The 100 kernel weight was significantly the highest due to the liquid biofertilizer treatments from Lb_1 to Lb_4 (32.34, 30.78, 30.69, 36.01) respectively over control Lb_0 (28.23).

4.7.8.4 The interaction effect

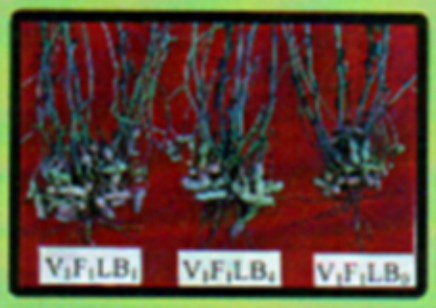
Interaction effects were found to be non-significant.

Data on post harvest studies such as dry pod yield, dry haulm yield, oil yield and harvest index during the year 2000 and 2001 are presented in Table 31 and graphically depicted in Fig. 10.

4.7.9 Dry pod yield (kg/ha)

4.7.9.1 Effect of varieties (2000)

Dry pod yield was significantly affected within the varieties due to different treatments. Variety V_1 recorded significantly the highest dry pod yield (2407.05) followed by variety V_2 (2087.86). However, significantly the lowest dry pod yield (1848.98) was recorded by V_3.

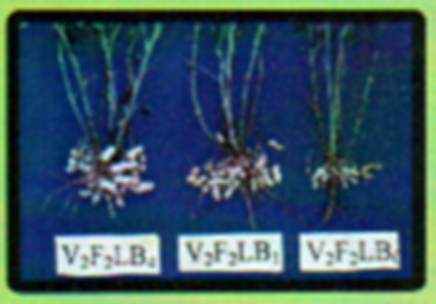






V_1: ICGV - 86590







V_2: JL - 24







V_3: SB - XI

F_1: Recommended dose of fertilizer (RDF)
F_2: 75% of RDF F_3 : 50% of RDF

LB_4: *Rhizobium* LB_1: Bioplin LB_0: No Biofertilizer (Control)

Plate 3: Effect of treatment combination on pod yield in groundnut during *Kharif* 2000

Table 31. Data on dry pod yield, dry haulm yield, oil yield and harvest index of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	At harvest				At harvest			
	Dry pod yield (kg/ha)	Dry Haulm yield (kg/ha)	Oil yield (kg/ha)	HI %	Dry pod yield (kg/ha)	Dry Haulm yield (kg/ha)	Oil yield (kg/ha)	HI %
Varieties								
V_1	2407.05	3931.24	774.81	41.02	2078.92	3390.55	648.41	40.60
V_2	2087.86	4043.27	795.96	39.06	1553.71	2496.98	486.46	28.16
V_3	1848.98	4781.25	670.11	28.25	1450.12	4024.35	556.52	26.32
SE ±	10.95	17.95	7.13	0.19	20.15	36.36	7.85	0.15
CD 5%	32.82	53.78	21.37	0.56	60.37	108.96	23.54	0.45
Ferti. Levels								
F_1	2221.55	4476.27	793.14	36.33	1680.40	3550.69	579.21	36.09
F_2	2110.80	4248.09	745.16	36.13	1638.74	3367.41	570.43	35.94
F_3	2011.55	4031.39	702.59	35.87	1603.61	3293.78	541.74	35.59
SE ±	10.95	17.95	7.13	0.19	20.15	36.36	7.85	0.15
CD 5%	32.82	53.78	21.37	NS	60.37	108.96	23.54	NS
Liq. Bioferti.								
Lb_0	1785.14	3547.12	614.64	35.54	1397.44	2839.85	460.17	35.11
Lb_1	2241.35	4501.19	798.49	36.37	1752.96	3539.99	623.80	36.30
Lb_2	2111.64	4275.76	744.78	36.01	1652.26	3291.17	560.64	35.84
Lb_3	2050.25	4135.21	710.59	35.91	1541.64	3112.23	519.03	35.61
Lb_4	2384.78	4800.30	866.29	36.72	1860.27	3736.55	655.35	36.52
SE ±	14.98	26.89	8.66	0.21	19.44	35.62	12.45	0.19
CD 5%	40.90	75.86	24.00	0.57	53.88	98.72	34.53	0.51
Interactions								
V x F	Sig.	Sig.	NS	NS	NS	NS	NS	NS
V x Lb	Sig.	Sig.	NS	NS	Sig.	Sig.	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS



V_1: ICGV - 86590



V_2: JL - 24



V_3 : SB XI

F_1: *Recommended dose of fertilizer* (RDF)
F_2: 75% of RDF **F_3 : 5% of RDF**

LB_4: *Rhizobium* **LB_1: Bioplin** **LB_0: No Biofertilizer (Control)**

Plate 4 : Effect of treatment combination on pod yield in groundnut during *Kharif* 2001

4.7.9.2 Effect of fertilizer levels

Significant differences were observed in dry pod yield due to different levels of fertilizer. Under F_1 significantly the highest dry pod yield was recorded (2221.55), followed by F_2 (2110.80). However, significantly the lowest dry pod yield (2011.55) was recorded under F_3.

4.7.9.3 Effect of liquid biofertilizer

Dry pod yield was significantly highest due to liquid biofertilizer Lb_1 (2241.35), Lb_2 (2111.64), Lb_3 (2050.25) and Lb_4 (2384.78) over control Lb_0 (1785.14).

4.7.9.4 The interaction effects

Interaction due to F x Lb and V x F x Lb was found to be non-significant.

4.7.9.4.1 Interaction effect of varieties x fertilizer for mean dry pod yield (kg/ha) at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	2477.16	2410.67	2333.32
V_2	2181.54	2108.83	1973.20
V_3	2005.94	1812.87	1728.13
SE ±	18.96		
CD at 5 %	56.83		

Interaction between varieties and fertilizer was found to be significant at harvest. The treatment combination V_1 F_1 and V_3 F_3 produced significantly the highest (2477.16) and the lowest (1728.13) dry pod yield respectively.

4.7.9.4.2 Interaction effect of varieties x liquid biofertilizer for mean dry pod yield (kg/ha) at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	2160.98	2516.52	2400.78	2261.89	2695.09
V_2	1746.02	2223.40	2093.24	2058.52	2318.11
V_3	1448.40	1984.11	1840.91	1830.35	2141.14
SE ±	24.98				
CD at 5 %	70.91				

Variation for dry pod yield due to combined effect of varieties and liquid biofertilizer at harvest was found to be significant. Where interaction V_1 Lb_4 recorded significantly the highest (2695.09) dry pod yield while significantly the lowest was recorded by V_3 Lb_0 (1448.40) over rest of the interaction.

4.7.9.1 Effect of varieties (2001)

Varietal differences on dry pod yield were affected significantly. Variety V_1 recorded significantly the highest dry pod yield (2078.92) followed by V_2 (1553.71). While significantly lowest dry pod yield was recorded by V_3 (1450.12).

4.7.9.2 Effect of fertilizer levels

Under F_1 dry pod yield was significantly the highest (1680.40) followed by F_2 (1638.74) and significantly the lowest dry pod yield was recorded under F_3 (1603.62).

4.7.9.3 Effect of liquid biofertilizer

Dry pod yield was significantly affected due to different treatments of liquid biofertilizers from Lb_1 to Lb_4 (1752.96, 1652.26, 1541.64, 1860.27) respectively over control Lb_0 (1397.44).

4.7.9.4 The interaction effect

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant.

4.7.9.4.1 Interaction effect of varieties x liquid biofertilizer for mean dry pod yield (kg/ha) at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	1828.68	2168.21	2078.68	1941.66	2377.35
V_2	1056.85	1392.61	1357.72	1199.20	1444.21
V_3	1306.80	1698.07	1520.39	1484.05	1759.24
SE ±	36.23				
CD at 5 %	103.28				

Data on dry pod yield found that interaction V_1 Lb_4 and V_2 Lb_0 produced significantly the highest (2377.35) and the lowest (1056.85) dry pod yield respectively over rest of interaction at harvest.

4.7.10 Dry haulm yield (kg/ha)

4.7.10.1 Effect of varieties (2000)

Varietal differences on dry haulm yield were observed. Significantly the highest dry haulm yield (4781.25) followed by V_2 (4043.27) while V_1 recorded (3931.24) which was significantly the lowest.

4.7.10.2 Effect of fertilizer levels

It was observed from the data that dry haulm yield was significantly the highest under F_1 (4476.27) followed by F_2 (4248.09) while under F_3 it was significantly the lowest (4031.39).

4.7.10.3 Effect of liquid biofertilizer

Dry haulm yield was significantly affected due to different liquid biofertilizer treatments it was significantly the highest due to Lb_1 to Lb_4 (4501.19, 4275.76, 4135.21, 4800.30) respectively over control Lb_0 (3547.12).

4.7.10.4 The interaction effect

Interaction effect due to F x Lb and V x F x Lb was found to be non-significant.

4.7.10.4.1 Interaction effect of varieties x fertilizer for mean dry haulm yield (kg/ha) at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	4047.41	3938.57	3807.72
V_2	4223.27	4076.13	3830.38
V_3	5158.12	4729.55	4456.06
SE ±	31.08		
CD at 5 %	93.16		

The effects of interaction on dry haulm yield was found to be significant at harvest. The variety V_3 with F_1 and V_1 F_3 produced significantly the highest (5158.12) and the lowest (3807.72) dry haulm yield respectively.

4.7.10.4.2 Interaction effect of varieties x liquid biofertilizer for mean dry haulm yield (kg/ha) at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	3534.89	4107.12	3916.94	3700.00	4397.22
V_2	3382.00	4296.44	4063.43	3995.71	4480.74
V_3	3724.46	5102.00	4846.90	4709.93	5522.94
SE ±	45.35				
CD at 5 %	128.57				

The interaction V_3 Lb_4 and V_2 Lb_0 produced significantly the highest (5522.94) and the lowest (3382.00) dry haulm yield respectively over rest of the interaction at harvest.

4.7.10.1 Effect of varieties (2001)

Significantly the highest dry haulm yield was recorded by variety V_3 (4024.35) followed by V_1 (3390.55), while it was significantly the lowest by V_2 (2496.98).

4.7.10.2 Effect of fertilizer levels

The dry haulm yield under F_1 was signfiicantly the highest (3550.69) while it was significantly the lowest under F_3 (3293.78) over F_1.

4.7.10.3 Effect of liquid biofertilizer

Dry haulm yield was significantly the highest due to different liquid biofertilizer treatments i.e. from Lb_1 to Lb_4 (3539.99, 3291.17, 3112.23, 3736.55) respectively over control Lb_0 (2839.85).

4.7.10.4 The interaction effect

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant.

4.7.10.4.1 Interaction effect of varieties x liquid biofertilizer for mean dry haulm yield (kg/ha) at harvest (2001)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	2983.63	3537.61	3387.09	3169.70	3874.70
V_2	2085.03	2703.30	2576.88	2327.64	2792.04
V_3	3450.90	4379.06	3909.54	3839.36	4542.90
SE ±	66.08				
CD at 5 %	188.32				

The interaction V_3 Lb_4 recorded significantly the highest (4542.90) dry haulm yield followed by V_3 Lb_1 (4379.06) while it was significantly the lowest due to V_2 Lb_0 (2085.03) over rest of combination at harvest.

4.7.11. Oil yield (kg/ha)

4.7.11.1 Effect of varieties (2000)

Variety V_2 recorded significantly the highest oil yield (795.96) followed by V_1 (774.81) while V_3 recorded significantly lowest oil yield (670.11).

4.7.11.2 Effect of fertilizer levels

Significantly the highest oil yield was recorded under F_1 (793.14) followed by F_2 (745.16) while under F_3 it was significantly the lowest (702.59).

4.7.11.3 Effect of liquid biofertilizer

The oil yield was significantly higher due to Lb_1 to Lb_4 (798.49, 744.78, 710.59, 866.29) respectively over control Lb_0 (614.64).

4.7.11.4 The interaction effects

Interaction effects were found to be non-significant.

4.7.11.1 Effect of varieties (2001)

Variety V_1 recorded significantly the highest oil yield (648.41) followed by V_3 (556.52) while V_2 recorded (486.46) oil yield which was significantly the lowest.

4.7.11.2 Effect of fertilizer levels

Due to different levels of fertilizer oil yield was significantly affected. Where it was significantly the highest under F_1 (579.21) followed by F_2 (570.43) and under F_3 (541.74) it was significantly the lowest.

4.7.11.3 Effect of liquid biofertilizer

Oil yield was significantly the highest due to Lb_1 to Lb_4 (623.80, 560.64, 519.03, 655.35) respectively over control Lb_0 (460.17).

4.7.11.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.12 Harvest index (%)

4.7.12.1 Effect of varieties (2000)

Harvest index recorded by V_1 was significantly the highest (41.02) while significantly the lowest V_3 (28.25).

4.7.12.2 Effect of fertilizer levels

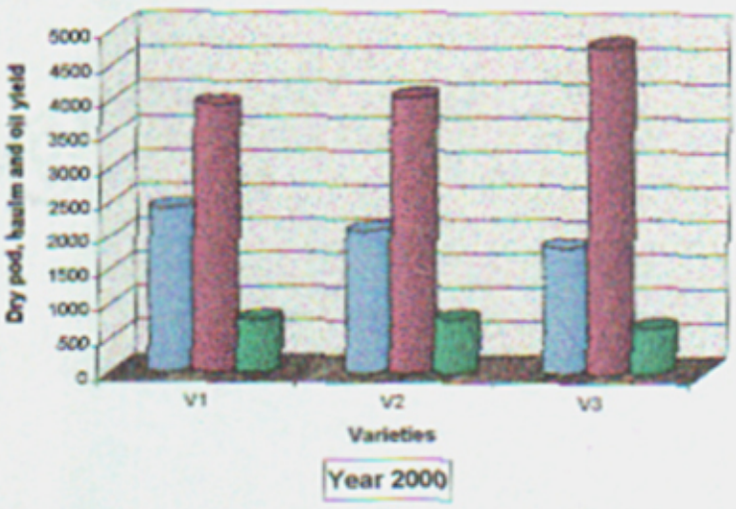
Effect of different levels of fertilizer on harvest index was found to be non-significant.

4.7.12.3 Effect of liquid biofertilizer

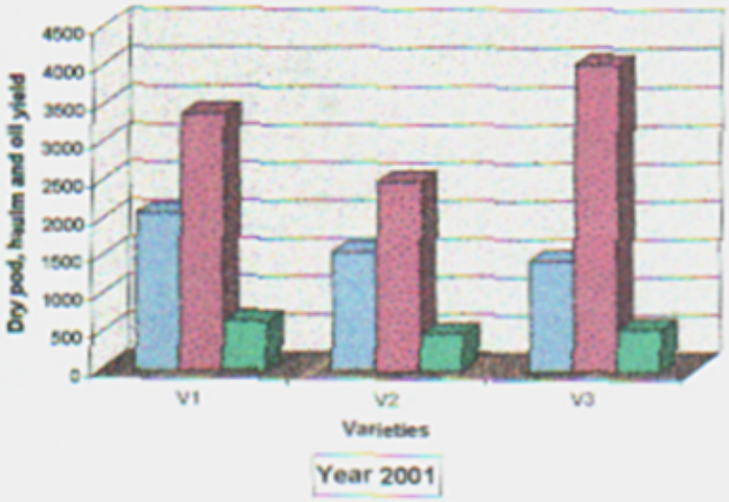
The harvest index was significantly the highest due to different treatments of liquid biofertilizers i.e. from Lb_1 to Lb_4 (36.37, 36.01, 35.91, 36.72) respectively over control Lb_0 (35.54) except Lb_2 (36.01).

4.7.12.4 The interaction effect

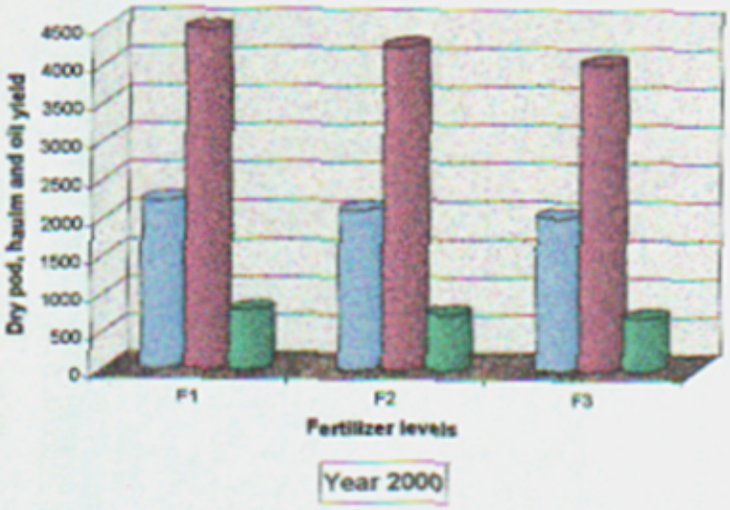
Interaction effects were found to be non-significant.



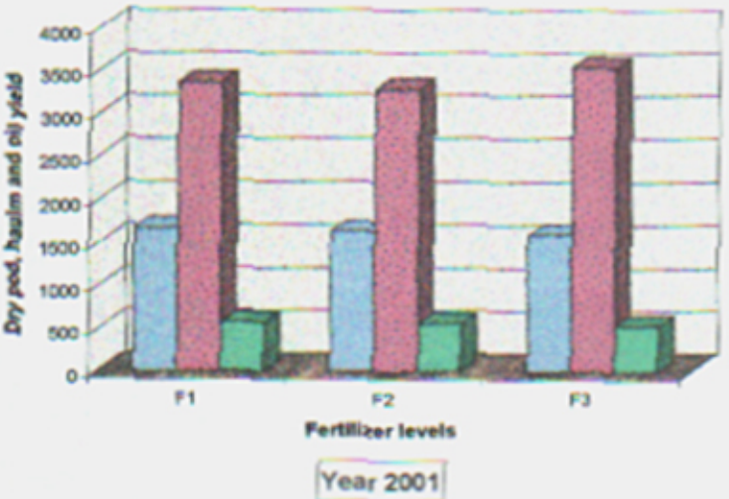
Year 2000



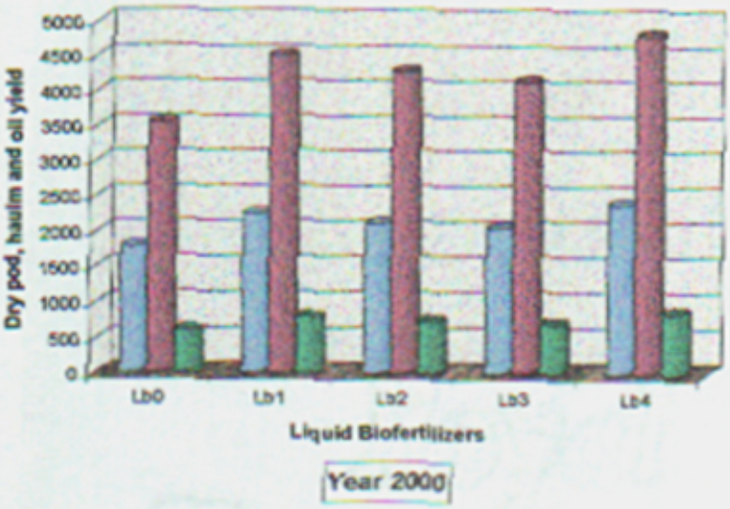
Year 2001



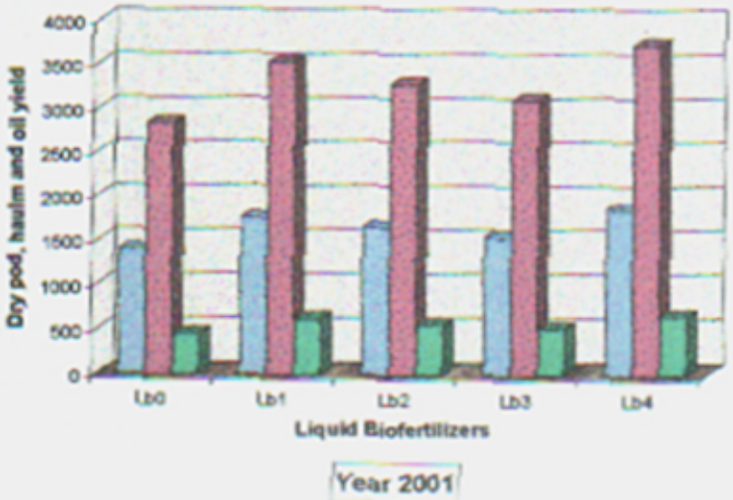
Year 2000



Year 2001



Year 2000



Year 2001

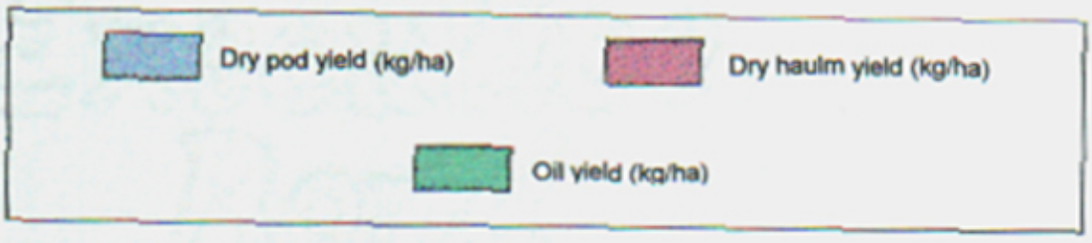


Fig. 10: Dry pod, haulm and oil yield of groundnut as affected by *different treatments at harvest*

4.7.12.1 Effect of varieties (2001)

Variety V_1 recorded significantly the highest (40.60) harvest index followed by V_3 (28.16) while V_2 recorded (26.32) it was significantly the lowest.

4.7.12.2 Effect of fertilizer levels

Harvest index had not affected significantly under different levels of fertilizer

4.7.12.3 Effect of liquid biofertilizer

Harvest index was significantly the highest due to Lb_1 (36.30), Lb_2 (35.84), Lb_4 (36.52) over control Lb_0 (35.11) while it was at par with Lb_3 (35.61).

4.712.4 The interaction effect

Interaction effects were found to be non-significant.

Data pertaining to sound mature kernel percentage, shelling percentage, oil and protein content as affected by different treatments during 2000 and 2001 are presented in Table 32 and graphically depicted in Fig. 11.

4.7.13 Sound mature kernel (SMK) percentage

4.7.13.1 Effect of varieties (2000)

Significantly highest SMK percentage was recorded by variety V_3 (85.27) followed by V_2 (84.49). While significantly the lowest SMK percentage was recorded by V_1 (76.02).

4.7.13.2 Effect of fertilizer levels

SMK percentage was recorded significantly the highest and the lowest under F_1 (85.06) and F_3 (78.80) respectively.

Table 32. Data on sound mature kernel percentage, shelling percentage oil and protein percentage of groundnut as affected by different treatments

Treatment	Year 2000				Year 2001			
	At harvest				At harvest			
	SMK %	Shelling %	Oil %	Protein %	SMK %	Shelling %	Oil %	Protein %
Varieties								
V_1	76.02	67.01	47.94	24.63	72.64	66.25	47.22	23.53
V_2	84.49	74.84	49.96	20.85	83.13	75.58	48.79	20.46
V_3	85.27	72.71	49.50	22.67	81.73	72.88	48.68	22.50
SE ±	0.52	0.72	0.20	0 19	0.49	0.30	0.37	0.11
CD 5%	1.56	2.14	0.60	0.58	1.48	0.90	1.11	0.34
Ferti. Levels								
F_1	85.06	72.25	49.48	22.96	81.00	71.92	48.65	22.43
F_2	81.91	71.00	49.12	22.77	79.40	71.55	47.97	22.24
F_3	78.80	71.31	48.81	22.50	77.11	71.24	48.06	21.82
SE ±	0.52	0.72	0.20	0.19	0.49	0.30	0.37	0.11
CD 5%	1.56	NS	NS	NS	1.48	NS	NS	NS
Liq. Bioferti.								
Lb_0	77.70	70.61	48.47	21.53	75.22	70.46	47.33	20.89
Lb_1	83.78	72.39	49.53	23.45	80.66	72.17	48.81	22.83
Lb_2	81.30	70.16	49.11	22.37	78.74	71.38	48.36	22.11
Lb_3	79.96	71.46	48.68	21.98	78.00	71.00	48.05	21.47
Lb_4	86.89	72.99	49.88	24.26	83.22	72.87	48.58	23.52
SE ±	0.67	0.80	0.24	0.23	0.76	0.38	0.43	0.25
CD 5%	1.60	NS	0.65	0.64	2.09	NS	NS	0.70
Interactions								
V x F	NS	NS	NS	NS	NS	NS	NS	NS
V x Lb	Sig.	NS	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS	NS	NS

4.7.13.3 Effect of liquid biofertilizer

Significantly the highest SMK percentage was recorded due to Lb_1 to Lb_4 (83.78, 81.30, 79.96, 86.89) respectively over control Lb_0 (77.70).

4.7.13.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.13.4.1 Interaction effect of varieties x liquid biofertilizer for SMK (%) at harvest (2000)

Var. / Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	69.11	77.66	76.00	74.33	83.00
V_2	81.33	87.66	82.22	81.22	90.00
V_3	82.66	86.00	85.66	84.33	87.00
SE ±	1.16				
CD at 5 %	3.30				

The combination of V_2 Lb_4 observed significantly higher (90.00) sound mature kernel percentage (SMK) followed by V_3 Lb_4 (87.00) and V_2 Lb_1 (87.66). However combination of V_1 Lb_0 found to be significantly lowest (69.11) SMK % over rest of interaction at harvest.

4.7.13.1 Effect of varieties (2001)

Significantly highest SMK percentage was recorded by variety V_2 (83.13) followed by V_3 (81.73). While V_1 recorded (72.64) SMK which was significantly the lowest.

4.7.13.2 Effect of fertilizer levels

Under F_1 SMK percentage was significantly the highest (81.00) followed by F_2 (79.40) and under F_3 (77.11) it was significantly the lowest.

4.7.13.3 Effect of liquid biofertilizer

The SMK percentage was significantly the lowest due to Lb_1 to Lb_4 (80.66, 78.74, 78.00, 83.22) respectively over control Lb_0 (75.22).

4.7.13.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.14 Shelling percentage

4.7.14.1 Effect of varieties (2000)

Variety V_2 recorded significantly the highest shelling percentage (74.84) followed by V_3 (72.71) while V_1 recorded (67.01) which was significantly the lowest.

4.7.14.2 Effect of fertilizer levels

The shelling percentage under different levels of fertilizer was found to be non-significant.

4.6.14.3 Effect of liquid biofertilizer

Shelling percentage had non-significant effect due to different treatments of liquid biofertilizers

4.7.14.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.14.1 Effect of varieties (2001)

Variety V_2 recorded significantly the highest shelling percentage (75.58) followed by V_3 (72.88) and significantly the lowest shelling percentage was recorded by V_1 (66.25).

4.7.14.2 Effect of fertilizer levels

Data on shelling percentage was found to be non-significant due to different levels of fertilizers.

4.7.14.3 Effect of liquid biofertilizer

Liquid biofertilizer had non-significant effect on shelling percentage.

4.7.14.4 The interaction effects

Interaction effects were found to be non-significant.

4.7.15 Oil content (%)

4.7.15.1 Effect of varieties (2000)

Oil content by the variety V_2 was recorded significantly the highest (49.96) followed by V_3 (49.50) and significantly the lowest oil content was recorded by V_1 (47.94).

4.7.15.2 Effect of fertilizer levels

Under different levels of fertilizer oil content was found to be non-significant.

4.7.15.3 Effect of liquid biofertilizer

Significantly highest oil content was observed due to Lb_1 (49.53) and Lb_4 (49.88) while it was at par due to Lb_2 and Lb_3 (49.11, 48.68) respectively over control Lb_0 (48.47).

4.7.15.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.15.1 Effect of varieties (2001)

Variety V_2 recorded significantly the highest oil content (48.79) followed by V_3 (48.68) and by V_1 (47.22) which was significantly the lowest.

4.7.15.2 Effect of fertilizer levels

Data pertaining to oil content due to different levels of fertilizer was found to be non-significant.

4.7.15.3 Effect of liquid biofertilizer

Oil content had non-significant effect due to different treatments of liquid biofertilizers.

4.7.15.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.16 Protein content (%)

4.7.16.1 Effect of varieties (2000)

Protein content by V_1 (24.63) was significantly the highest followed by V_3 (22.67) while significantly the lowest protein content was recorded by V_2 (20.85).

4.7.16.2 Effect of fertilizer levels

The data on protein content under different levels of fertilizer was found to be non-significant.

4.7.16.3 Effect of liquid biofertilizer

Protein content was significantly increased due to Lb_1 (23.45) Lb_2 (22.37) and Lb_4 (24.26) while due to Lb_3 (21.98) it was at par over control Lb_0 (21.53).

4.7.16.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.16.1 Effect of varieties (2001)

Variety V_1 recorded (23.53) protein which was significantly the highest followed by V_3 (22.50) while V_2 recorded (20.46) protein which was significantly the lowest.

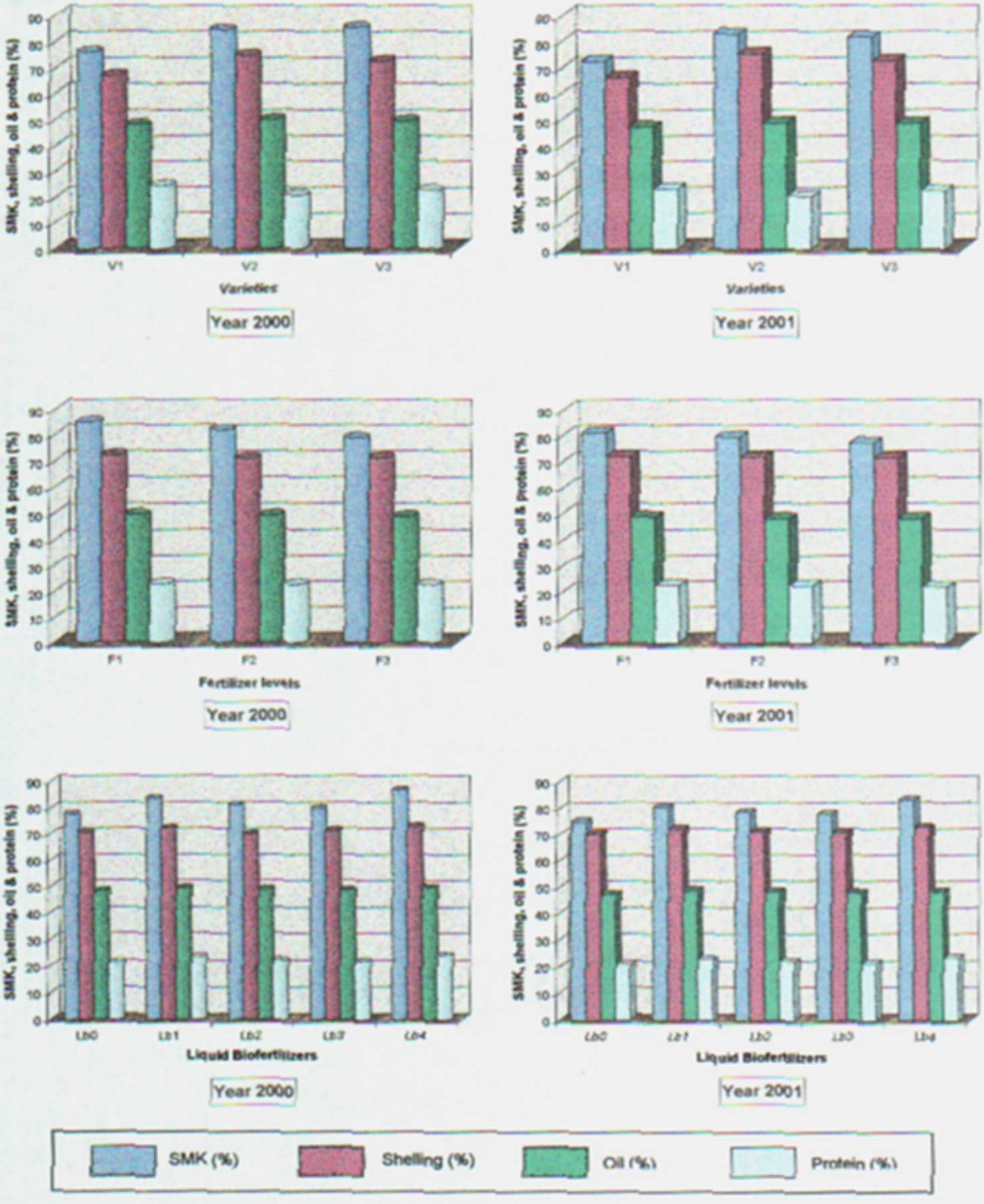


Fig. 11 : Sound mature kernel (SMK) and shelling percentage, oil and protein percentage of groundnut as affected by different treatments at harvest

4.7.16.2 Effect of fertilizer levels

The effect due to different levels of fertilizer on protein content was found to be non-significant.

4.7.16.3 Effect of liquid biofertilizer

Protein content was significantly higher due to Lb_1 (22.83), Lb_2 (22.11), Lb_4 (23.52) and due to Lb_3 (21.47) which was at par over control Lb_0 (20.89).

4.7.16.4 The interaction effect

Interaction effects were found to be non-significant.

4.7.17 Pooled results

4.7.17.1 Pooled results on yield contributing characters

Pooled data of two years (2000-2001) on yield contributing characters viz., No. of pegs /plant, No. of pods/plant, Dry wt. of pods (g/plant), SMK per cent, 100 pod wt. and 100 Kernel wt. are presented in Table 33.

The pooled data on number of pegs per plant, number of pod per plant, mean dry weight of pods due to different treatments that is within the varieties, fertilizers levels and liquid biofertilizers were found to be non-significant.

Pooled data of both the years on SMK (%) observed that variety V_2 (83.81) and V_3 (83.50) recorded significantly the highest SMK (%) over variety V_1 (74.33).

From the pooled data it is observed that significantly the highest 100 kernels weight is recorded by the variety V_2 (35.14).

Table 33. Pooled data on yield contributing characters of groundnut at harvest as influenced by different treatments

Treatment	No. of pegs / plant	No. of pods/ plant	Dry wt. of pods (g/plant)	SMK per cent	100 pod wt. (g)	100 kernel wt. (g)
Varieties						
V_1	28.50	20.37	12.04	74.33	113.64	30.10
V_2	24.27	17.71	8.59	83.81	130.39	35.14
V_3	24.64	16.93	9.06	83.50	79.66	30.44
S.E.±	2.28	2.19	1.37	1.63	17.10	1.29
C.D. @ 5 %	NS	NS	NS	4.76	NS	3.66
Fertilizer levels						
F_1	29.46	20.76	10.64	83.03	100.45	33.02
F_2	26.18	18.23	9.89	80.65	98.00	31.66
F_3	21.76	16.02	9.16	77.95	95.23	31.01
S.E.±	4.18	3.45	3.69	3.17	3.13	2.73
C.D. @ 5 %	NS	NS	NS	NS	NS	NS
Liq. Biofertilizer						
Lb_0	17.48	13.38	7.36	76.46	49.40	28.76
Lb_1	31.63	21.73	11.28	82.22	100.59	33.01
Lb_2	23.77	16.00	9.64	80.02	98.25	31.46
Lb_3	20.83	15.03	8.94	78.98	95.91	31.07
Lb_4	35.31	25.53	12.24	85.05	104.83	35.17
S.E.±	4.81	3.15	2.93	3.08	18.32	2.67
C.D. @ 5 %	NS	NS	NS	NS	NS	NS
Interactions						
V x F	-	-	-	-	-	-
V x Lb	-	-	-	-	-	-
F x Lb	-	-	-	-	-	-
V x F x Lb	-	-	-	-	-	-

4.7.17.2 Pooled results on dry pod and dry haulm yield

Pooled data on dry pod yield, dry haulm yield, harvest index, shelling percentage and oil content in kernel are presented in Table 34.

Pooled data of both the years showed that variety V_1 (2242.98) recorded the highest dry pod yield followed by the variety V_2 (1820.48) and the lowest dry pod yield was recorded by the variety V_3 (1649.55).

From the pooled data on dry pod, dry haulm yield, harvest index, shelling percentage and oil content were not influenced significantly due to fertilizer levels.

Pooled data on dry pod and haulm yield influenced significantly where higher dry pod yield due to Lb_4 (2122.52) and Lb_1 (1997.15) were recorded. As regards dry haulm yield the liquid biofertilizer treatment recorded higher values as Lb_1 (4020.59), Lb_2 (3783.46), Lb_3 (3623.72) and Lb_4 (4268.42) over control Lb_0 (3193.48).

Pooled data on harvest index were found to be non-significant within the varieties, different fertilizer levels and liquid biofertilizer treatments.

From the pooled data of both the years on shelling percentage it is observed that variety V_2 (74.99) recorded significantly the highest shelling percentage while V_1 recorded (66.63) which was significantly the lowest.

Data on shelling percentage due to fertilizer levels and liquid biofertilizer treatments it was found to be non-significant.

Pooled data on oil content per cent due to varieties, fertilizer levels and different treatments of liquid biofertilizers were found to be non-significant.

Table 34. Pooled data on dry pod, haulm yield, harvest index, shelling percentage and oil content of groundnut at harvest as influence by different treatments

Treatment	Dry pod yield (kg/ha)	Dry haulm yield (kg/ha)	Harvest index (%)	Shelling (%)	Oil content (%)
Varieties					
V_1	2242.98	3660.89	40.81	66.63	47.58
V_2	1820.48	3270.12	32.69	74.99	49.37
V_3	1649.55	4402.80	28.20	72.79	49.09
S.E.±	63.42	86.36	3.60	2.67	1.21
C.D. @ 5 %	385.70	NS	NS	8.03	NS
Fertilizer levels					
F_1	1953.97	3921.84	36.21	72.08	49.06
F_2	1874.77	3770.93	36.03	71.12	48.54
F_3	1807.58	3791.04	35.73	71.27	48.43
S.E.±	31.80	86.36	2.54	5.11	2.54
C.D. @ 5 %	NS	NS	NS	NS	NS
Liq. Biofertilizer					
Lb_0	1891.20	3193.48	35.32	70.53	47.90
Lb_1	1997.15	4020.59	36.33	72.28	49.17
Lb_2	1881.93	3783.46	35.92	70.77	48.73
Lb_3	1795.94	3623.72	35.76	71.23	48.36
Lb_4	2122.52	4268.42	36.62	72.90	49.23
S.E.±	26.91	70.04	2.06	4.66	2.36
C.D. @ 5 %	105.82	275.37	NS	NS	NS
Interactions					
V x F	-	-	-	-	-
V x Lb	-	-	-	-	-
F x Lb	-	-	-	-	-
V x F x Lb	-	-	-	-	-

4.7.18 Results on per cent increase of yield and yield contributing characters (2000 and 2001)

The data on per cent increase of yield and yield contributing characters is presented in Table 35 and 36 while per cent increase of yield is graphically depicted in Fig. 12.

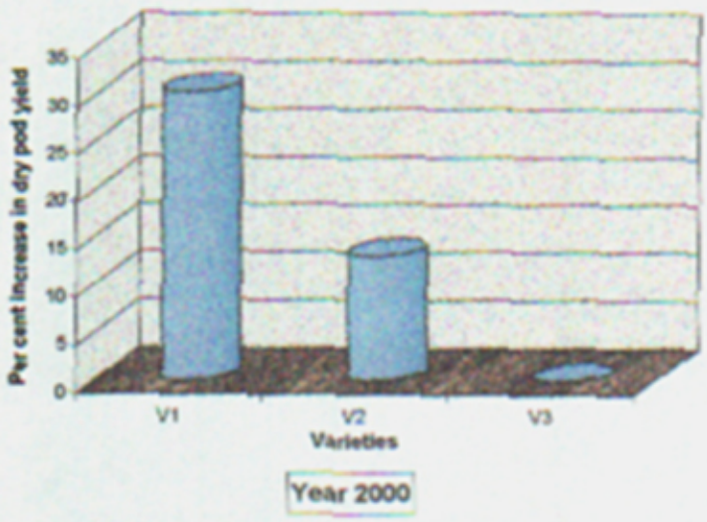
Data on per cent increase in yield and yield contributing characters presented in Table 35 for the year 2000 revealed that, the variety ICGV-86590 (V_1) recorded 30.18 per cent and JL-24 (V_2) 12.91 per cent higher yield than variety SB-XI (V_3). While recommended dose of fertilizer (F_1) and 75 % RDF (F_2) showed 10.43 per cent and 4.93 per cent increase in pod yield respectively over 50 % RDF (F_3). Liquid biofertilizer treatment had significant impact on pod yield. It is observed from the present study that *Rhizobium* (Lb_4) recorded higher yield 33.50 per cent followed by Bioplin (Lb_1) 25.55 per cent, Phosfert (Lb_2) 18.28 per cent and Vitormone (Lb_3) 14.85 per cent over control. Similar trend in yield contributing characters have been observed.

Table 35. Data on per cent increase on yield and yield contributing characters of groundnut (2000)

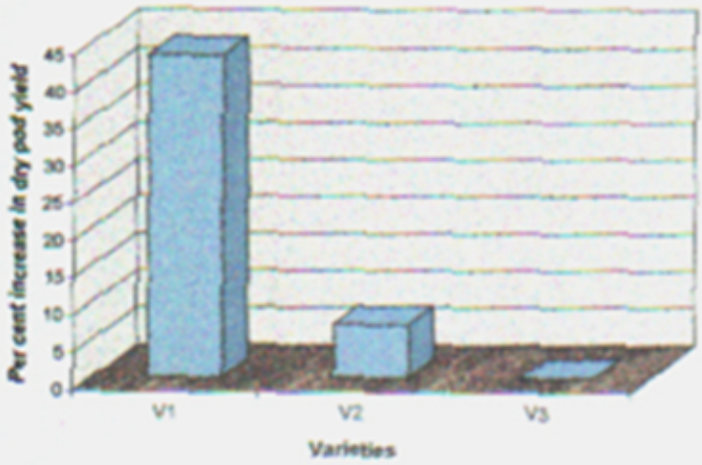
Treatments	Yield kg/ha	Yield contributing traits							
		% increase	No. of pegs/ plant	No. of pods/ plant	Dry weight of pods (g)/plant	100 pod weight (g)	100 kernel weight (g)	Shelling %	Harvest index (%)
Varieties									
V_1	2407.05	30.18	36.78	26.04	15.19	114.93	30.50	67.01	41.02
V_2	2087.86	12.91	31.04	20.71	11.70	101.47	36.52	74.84	39.06
V_3	1848.98	-	31.62	20.11	11.43	81.27	29.53	72.71	28.25
Ferti. levels									
F_1	2211.55	10.43	38.64	25.89	14.08	101.62	33.61	72.25	36.33
F_2	2110.80	4.93	33.60	22.13	12.77	99.64	32.15	71.00	36.13
F_3	2011.55	-	27.20	19.84	11.47	96.41	30.80	71.31	35.87
Liq. Bioferti.									
Lb_0	1785.14	-	19.89	15.85	8.69	90.85	29.30	70.61	35.54
Lb_1	2241.35	25.55	41.93	27.25	15.07	102.18	33.68	72.39	36.37
Lb_2	2111.64	18.28	30.70	19.41	12.26	99.37	32.14	70.16	36.01
Lb_3	2050.25	14.85	25.07	18.18	11.29	97.50	31.46	71.46	35.91
Lb_4	2384.78	33.59	48.15	32.41	16.54	106.22	34.34	72.99	36.72

Table 36. Data on per cent increase on yield and yield contributing characters of groundnut (2001)

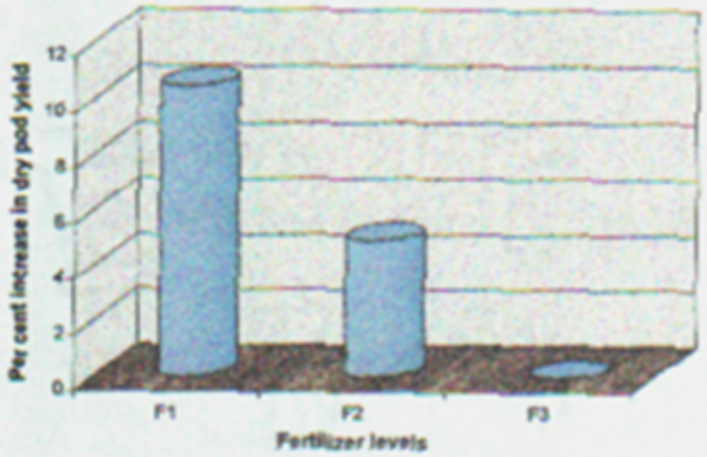
Treatments	Yield kg/ha	Yield contributing traits							
		% increase	No. of pegs/ plant	No. of pods/ plant	Dry weight of pods (g)/plant	100 pod weight (g)	100 kernel weight (g)	Shelling %	Harvest index (%)
Varieties									
V_1	2087.92	43.36	20.22	14.71	8.89	112.35	29.70	66.25	40.60
V_2	1553.71	7.14	17.51	14.31	6.70	99.31	33.77	75.58	28.16
V_3	1450.12	-	17.66	13.15	5.48	78.05	31.36	72.88	26.32
Ferti. Levels									
F_1	1680.40	4.78	20.28	15.64	7.21	99.29	32.43	71.92	36.09
F_2	1638.74	2.19	18.77	14.33	7.02	96.37	31.18	71.55	35.94
F_3	1603.61	-	16.33	12.20	6.85	94.05	31.22	71.24	35.59
Liq. Bioferti.									
Lb_0	1397.44	-	15.07	10.92	6.04	88.95	28.23	70.46	35.11
Lb_1	1752.96	25.44	21.33	16.22	7.50	99.01	32.34	72.17	36.30
Lb_2	1652.26	15.42	16.85	12.59	7.03	97.13	30.78	71.38	35.84
Lb_3	1541.64	10.31	16.59	11.88	6.60	94.33	30.67	71.01	35.61
Lb_4	1860.27	33.11	22.48	18.66	7.95	103.44	34.01	72.82	36.52



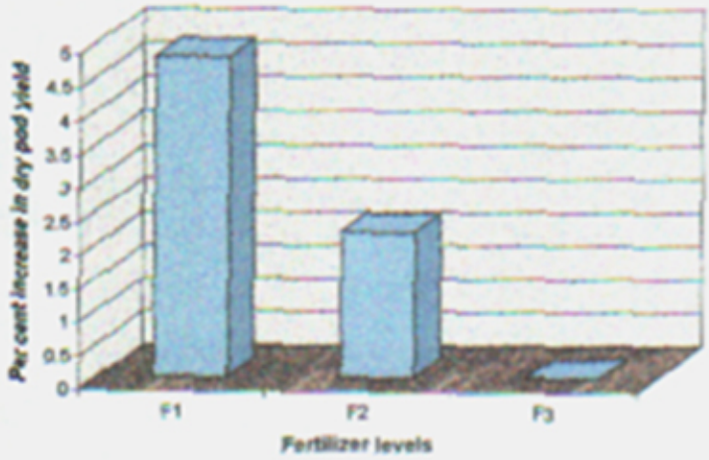
Year 2000



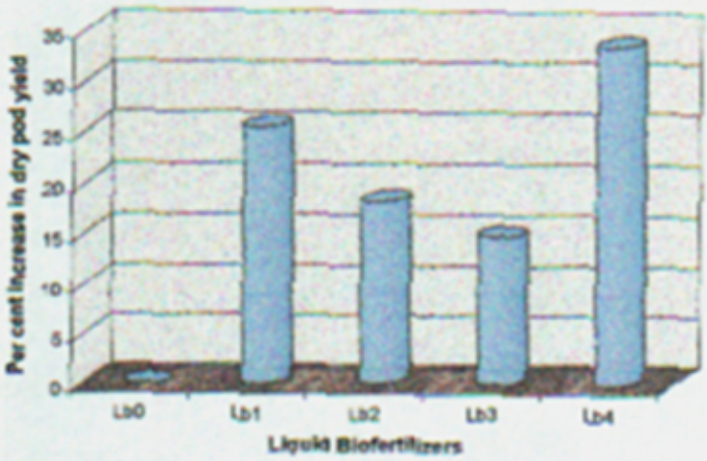
Year 2001



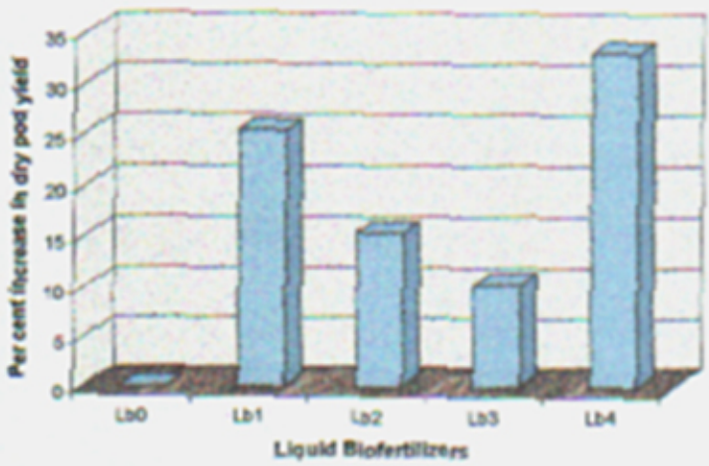
Year 2000



Year 2001



Year 2000



Year 2001

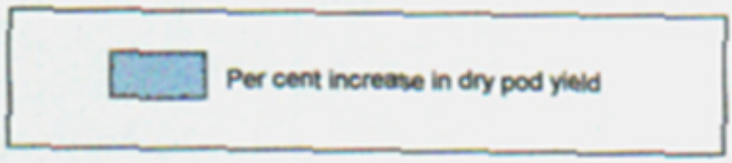


Fig. 12 : Per cent increase in dry pod yield of groundnut during 2000 & 2001

From the data presented in Table 36 for the year 2001 observed that, the variety ICGV-86590 (V_1) recorded 43.36 per cent and JL-24 (V_2) 7.14 per cent higher yield than variety SB-XI (V_3).

However, recommended dose of fertilizer (F_1) and 75 % RDF (F_2) recorded 4.78 and 2.19 per cent increase in dry pod yield respectively over 50 % RDF (F_3).

From the present study it is observed that liquid biofertilizer treatment increased the dry pod yield where *Rhizobium* (Lb_4) recorded higher yield 33.11 per cent, Bioplin (Lb_1) 25.44 per cent, Phosfert (Lb_2) 15.42 per cent and Vitormone (Lb_3) 10.31 per cent over control.

4.8 Soil analysis

Data regarding nitrogen, phosphorus and potassium content in the soil after harvest as affected by different treatments during the years 2000 and 2001 are presented in Table 37.

4.8.1 Nitrogen content in the soil after harvest (kg/ha)

4.8.1.1 Effect of varieties (2000)

Nitrogen content in the soil after harvest of the groundnut crop was affected significantly. Variety V_1 recorded significantly the highest 'N' content in the soil (127.35) followed by V_2 (126.53) while significantly lowest 'N' was content in soil due variety V_3 (122.40) after harvest.

4.8.1.2 Effect of fertilizer levels

Significantly the highest 'N' was content by the soil after harvest under F_1 (127.20) followed by F_2 (125.55) while under F_3 it was significantly lowest (123.53).

Table 37. Data on nitrogen, phosphorus and potassium content (kg/ha) in the soil after harvest of groundnut as affected by different treatments

Treatments	Year 2000			Year 2001		
	After harvest			After harvest		
	N	P	K	N	P	K
Varieties						
V_1	127.35	10.25	229.73	117.46	8.35	219.13
V_2	126.53	11.53	227.60	116.93	9.60	217.20
V_3	122.40	12.46	230.27	113.06	10.39	219.93
SE ±	0.76	0.24	1.06	1.04	0.22	1.33
CD 5%	2.30	0.71	NS	3.13	0.66	NS
Ferti. Levels						
F_1	127.20	11.60	226.80	117.40	9.64	216.80
F_2	125.55	11.69	229.13	114.93	9.80	218.93
F_3	123.53	10.94	231.66	115.13	8.91	220.53
SE ±	0.76	0.24	1.06	1.04	0.22	1.33
CD 5%	2.30	NS	3.18	NS	0.66	NS
Liq. Bioferti.						
Lb_0	141.44	13.33	237.77	132.55	11.52	227.88
Lb_1	122.55	10.53	222.22	112.44	8.56	212.55
Lb_2	124.33	12.05	231.11	114.00	10.13	220.11
Lb_3	121.33	11.80	234.44	112.88	9.67	224.111
Lb_4	117.48	9.36	220.44	107.22	7.36	209.11
SE ±	0.97	0.28	1.17	1.26	0.23	1.88
CD 5%	2.68	0.76	3.25	3.48	0.65	5.22
Interactions						
V x F	NS	NS	NS	NS	NS	NS
V x Lb	NS	NS	NS	NS	NS	NS
F x Lb	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS

4.8.1.3 Effect of liquid biofertilizer

From the data it was observed that nitrogen content in the soil after harvest was significantly the lowest due to different treatments of the liquid biofertilizer i.e. due to Lb_1 (122.55), Lb_2 (124.33), Lb_3 (121.33), Lb_4 (117.48) over control Lb_0 (141.44).

4.8.1.4 The interaction effect

Interaction effects were found to be non-significant.

4.8.1.1 Effect of varieties (2001)

Significantly the highest nitrogen was content in the soil after harvest due to V_1 (117.46) followed by V_2 (116.93) while it was significantly the lowest due to V_3 (113.06).

4.8.1.2 Effect of fertilizer levels

The nitrogen content in the soil after harvest of the groundnut crop under different levels of fertilizer was found to be non-significant.

4.8.1.3 Effect of liquid biofertilizer

Liquid biofertilizer had significant effect on nitrogen content in the soil after harvest of the crop. Where all the liquid biofertilizer treatments Lb_1 to Lb_4 recorded significantly lower N content in the soil after harvest over control Lb_0 (132.55).

4.8.1.4 The interaction effect

Interaction effects were found to be non-significant.

4.8.2 Phosphorus content in the soil after harvest (kg/ha)

4.8.2.1 Effect of varieties (2000)

Data related to phosphorus content in the soil after harvest within the varieties was found to be statistically significant. Varieties V_3 and V_1 recorded significantly the highest and lowest 'P' content in the soil after harvest (12.46, 10.25) respectively.

4.8.2.2 Effect of fertilizer levels

Data in respect of 'P' content in the soil after harvest under different levels of fertilizer was found to be non-significant.

4.8.2.3 Effect of liquid biofertilizer

Due to different treatments of the liquid biofertilizer 'P' content in the soil after harvest was significantly the lowest i.e. Lb_1 (10.53), Lb_2 (12.05), Lb_3 (11.80), Lb_4 (9.36) over content Lb_0 (13.33).

4.8.2.4 The interaction effect

Interaction effects were found to be non-significant.

4.8.2.1 Effect of varieties (2001)

Phosphorus content in the soil after harvest was significantly the highest and the lowest due to V_3 (10.39) and V_1 (8.35).

4.8.2.2 Effect of fertilize levels

Significantly lowest 'P' content was observed under F_3 (8.91) after harvest while under F_2 and F_1 it was significantly the highest (9.80, 9.64) 'P' content over F_3.

4.8.2.3 Effect of liquid biofertilizers

From the data it is revealed that 'P' content in the soil after harvest due to liquid biofertilizer was significantly the lowest from Lb_1 to Lb_4 (8.56, 10.13, 9.67, 7.36) over control Lb_0 (11.52).

4.8.2.4 The interaction effect

Interaction effects were found to be non-significant.

4.8.3 Potassium content in the soil after harvest (kg/ha)

4.8.3.1 Effect of varieties (2000)

Differences due to varieties on 'K' content in the soil after harvest was found to be non-significant.

4.8.3.2 Effect of fertilizer levels

Significant differences was observed 'K' content in the soil after harvest under different levels of fertilizer, Under F_3 significantly the maximum 'P' content in the soil after harvest was observed (231.66) followed by F_2 (229.13) while under F_1 it was significantly the maximum (226.80).

4.8.3.3 Effect of liquid biofertilizer

Significantly lowest 'K' content was recorded after harvest of the crop due to Lb_1 to Lb_4 (222.22, 231.44, 234.44, 220.44) respectively over control Lb_0 (237.77).

4.8.3.4 The interaction effects

Interaction effects were found to be non-significant.

4.8.3.1 Effect of varieties (2001)

Varietal differences on 'K' content in the soil after harvest was non-significant.

4.8.3.2 Effect of fertilizer levels

Potassium content in the soil after harvest under different levels of fertilizer was found to be non-significant.

4.8.3.3 Effect of liquid biofertilizer

Under different treatments of liquid biofertilizer 'K' content in the soil after harvest was significantly the lowest due to Lb_1 (212.55) Lb_2 (220.11), Lb_4 (209.11) while due to Lb_3 (224.11) which was at par over control Lb_0 (227.88).

4.8.3.4 The interaction effect

Interaction effects were found to be non-significant.

Data pertaining to total uptake of nitrogen, phosphorus and potassium by groundnut as affected by different treatments during the year 2000 and 2001 are presented in Table 38.

Table 38. Data on total uptake of nitrogen, phosphorus and potassium (kg/ha) of groundnut at harvest as affected by different treatments

Treatment	Year 2000			Year 2001		
	At harvest			At harvest		
	N	P	K	N	P	K
Varieties						
V_1	172.00	19.85	138.12	148.78	17.43	120.30
V_2	160.00	19.26	129.61	105.91	12.34	82.85
V_3	165.96	20.38	132.46	137.28	17.03	111.79
SE ±	1.21	0.23	1.42	1.78	0.17	1.09
CD 5%	3.64	0.68	4.25	5.33	0.50	3.29
Ferti. Levels						
F_1	174.10	20.69	141.36	134.98	15.98	107.85
F_2	165.96	20.04	131.36	129.87	15.57	105.47
F_3	158.25	18.76	127.13	127.12	15.25	101.63
SE ±	1.21	0.23	1.42	1.78	0.17	1.09
CD 5%	3.64	0.68	4.25	5.33	0.50	NS
Liq. Bioferti.						
Lb_0	139.86	20.11	109.12	111.66	13.23	89.25
Lb_1	175.65	18.37	141.42	142.40	16.89	115.70
Lb_2	167.07	20.18	134.77	125.66	15.28	99.93
Lb_3	159.78	19.82	129.92	119.79	14.41	97.57
Lb_4	188.17	20.67	151.73	153.78	18.19	122.46
SE ±	1.28	0.52	2.02	1.76	0.15	1.74
CD 5%	3.69	1.45	5.61	4.87	0.42	NS
Interactions						
V x F	Sig.	NS	NS	NS	NS	NS
V x Lb	Sig.	NS	Sig.	Sig.	Sig.	NS
F x Lb	NS	NS	NS	NS	NS	NS
V x F x Lb	NS	NS	NS	NS	NS	NS

4.8.4 Total uptake of nitrogen (kg/ha)

4.8.4.1 Effect of varieties (2000)

Significantly the highest 'N' uptake recorded by V_1 (172.00) followed by V_3 (165.96) and V_2 (160.00) which was significantly the lowest.

4.8.4.2 Effect of fertilizer levels

Significantly the highest total uptake of 'N' was observed under F_1 (174.10) followed by F_2 (165.96) while under F_3 (158.25) it was significantly the lowest.

4.8.4.3 Effect of liquid biofertilizer

Total nitrogen uptake by the groundnut under different liquid biofertilizer treatment was significantly the highest i.e. from Lb_1 to Lb_4 (175.65, 167.07, 159.78, 188.17) respectively over control Lb_0 (139.86).

4.8.4.4 The interaction effect

Interaction effects were found to be non-significant.

4.8.4.4.1 Interaction effect of varieties x fertilizer for mean total uptake of 'N' (kg/ha) at harvest (2000)

Varieties/Fertilizer levels	F_1	F_2	F_3
V_1	177.85	170.88	167.26
V_2	165.36	162.80	152.89
V_3	179.07	164.18	154.62
SE ±	2.11		
CD at 5 %	6.31		

The interaction between varieties and fertilizer was found to be significant at harvest where V_3 F_1 recorded significantly the highest (179.07) total uptake of 'N' followed by V_1 F_1 (177.85). However, significantly the lowest 'N' uptake was recorded by V_2 F_3 (152.89) followed by V_3 F_3 (154.62).

4.8.4.4.2 Interaction effect of varieties x liquid biofertilizer for mean total uptake of 'N' (kg/ha) at harvest (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	155.13	178.39	170.76	162.21	193.50
V_2	135.16	171.42	162.19	153.73	179.26
V_3	129.30	177.12	168.26	163.39	191.73
SE ±	2.33				
CD at 5 %	6.62				

From the data on total 'N' uptake it was observed that the combination of V_1 Lb_4 recorded significantly the highest (193.50) total 'N' uptake followed by V_3 Lb_4 (191.73). However significantly lowest 'N' uptake was observed by V_3 Lb_0 (129.30) over rest of interactions at harvest.

4.8.4.1 Effect of varieties (2001)

Varietal differences was observed on total 'N' uptake. Variety V_1 recorded significantly the highest 'N' uptake (148.78) followed V_3 (137.28) while V_2 was recorded significantly the lowest (105.91).

4.9.4.2 Effect of fertilizer levels

Under F_1 total 'N' uptake was recorded significantly the highest (134.98) followed by F_2 (129.87) while under F_3 (127.12) it was significantly lowest.

4.8.4.3 Effect of liquid biofertilizer

Significantly highest 'N' uptake was recorded due to liquid biofertilizer treatments from Lb_1 to Lb_4 (142.40, 125.66, 119.79, 153.78) over control Lb_0 (111.66).

4.8.4.4 The interaction effect

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant.

4.8.4.4.1 Interaction effect of varieties x liquid biofertilizer for mean total 'N' uptake (kg/ha) at harvest (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	131.10	155.45	150.17	135.94	171.24
V_2	87.68	121.31	99.36	88.52	132.69
V_3	116.19	150.44	127.44	134.91	157.40
SE ±	3.25				
CD at 5 %	9.26				

It was found that total 'N' uptake was significantly the highest due to combination of V_1 Lb_4 (171.24) and it was lowest due to V_2 Lb_0 (87.68) and V_2 Lb_3 (88.52) respectively over rest of interactions.

4.8.5 Total uptake of phosphorus (kg/ha)

4.8.5.1 Effect of varieties (2000)

Total uptake of 'P' recorded by V_3 (20.38) which was significantly the highest followed by V_1 (19.85) while V_2 observed (19.26) 'P' uptake which was significantly lowest.

4.8.5.2 Effect of fertilizer levels

Total 'P' uptake was significantly the highest under F_1 (20.69) followed by F_2 (20.04) while significantly lowest 'P' uptake was observed under F_3 (18.76).

4.8.5.3 Effect of liquid biofertilizer

Significantly lowest 'P' uptake was observed due to Lb_1 (18.37) while it was at par due to rest of the treatments Lb_2 (20.18), Lb_3 (19.82), Lb_4 (20.67) over control Lb_0 (20.11).

4.8.5.4 The interaction effect

Interaction effects were found to be non-significant.

4.8.5.1 Effect of varieties (2001)

Variety V_1 recorded significantly highest 'P' uptake (17.43) followed by V_3 (17.03). However, V_2 recorded significantly the lowest 'P' uptake (12.34).

4.8.5.2 Effect of fertilizer levels

Due to different levels of fertilizer 'P' uptake was influenced significantly. Under F_1 significantly the highest 'P' uptake was recorded (15.98) followed by F_2 (15.57) and under F_3 (15.25) it was significantly the lowest.

4.8.5.3 Effect of liquid biofertilizer

Significantly highest 'P' uptake was noticed due to Lb_1 to Lb_4 (16.89, 15.28, 14.41, 18.19) respectively over control Lb_0 (13.23).

4.8.5.4 The interaction effect

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant.

4.8.5.4.1 Interaction effect of varieties x liquid biofertilizer for mean total 'P' uptake (kg/ha) at harvest (2001)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	15.29	18.13	17.54	16.24	19.95
V_2	9.78	13.84	12.21	10.65	15.23
V_3	14.61	18.70	16.09	16.34	19.39
SE ±	0.29				
CD at 5 %	0.82				

Total 'P' uptake was significantly highest due to combination of V_1 Lb_4 (19.95) followed by V_3 Lb_4 (19.39). However significantly the lowest 'P' uptake was recorded by V_2 Lb_0 (9.78) over rest of interaction at harvest.

4.8.6 Total uptake of potassium (kg/ha)

4.8.6.1 Effect of varieties (2000)

Varietal differences on total 'K' uptake was statistically significant variety V_1 observed significantly the highest 'K' uptake (138.12) followed by V_3 (132.46) while V_3 recorded (129.61) 'K' uptake which was significantly the lowest.

4.8.6.2 Effect of fertilizer levels

Under F_1 (141.36) 'K' uptake was significantly the highest followed by F_2 (131.36) while under F_3 (127.13) it was significantly the lowest.

4.8.6.3 Effect of liquid biofertilizer

Total 'K' uptake was significantly highest due to application of liquid biofertilizer i.e. at Lb_1 to Lb_4 (141.42, 134.77, 129.72, 151.73) respectively over control Lb_0 (109.12).

4.8.6.4 The interaction effect

Interaction due to V x F, F x Lb and V x F x Lb was found to be non-significant.

4.8.6.4.1 Interaction effect of varieties x liquid biofertilizer for mean total 'K' uptake (kg/ha) at harvest (2000)

Var./ Liq. Bioferti.	Lb_0	Lb_1	Lb_2	Lb_3	Lb_4
V_1	124.47	142.39	138.20	130.36	155.15
V_2	108.93	138.17	129.62	126.80	144.48
V_3	93.97	143.68	136.49	132.59	155.53
SE ±	3.44				
CD at 5 %	9.75				

Total 'N' uptake was significantly higher due to combination of V_3 Lb_4 (155.53) followed by V_1 Lb_1 (155.15) while it was significantly lowest due to V_3 Lb_0 (93.97) over rest of the combination of harvest.

4.8.6.1 Effect of varieties (2001)

Total uptake of 'K' by the variety V_1 was significantly higher (120.30) followed by V_3 (111.79), while V_2 recorded lowest 'K' uptake (82.85).

4.8.6.2 Effect of fertilizer levels

The differences on 'K' uptake under different levels of fertilizer was found to be non-significant.

4.8.6.3 Effect of liquid biofertilizers

Total 'K' uptake due to different treatments of the liquid bio-fertilizer was found to be non-significant.

4.3.6.4 The interaction effect

Interaction effects were found to be non-significant.

DISCUSSION

5. DISCUSSION

The experiment entitled "Studies on effect of liquid biofertilizers on morphophysiological and biochemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) varieties during *kharif* season" was conducted at Post Graduate Instructional Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri during the *kharif* seasons of 2000 and 2001. The results obtained in the present investigation are discussed in this chapter.

5.1 Growth studies

Growth is an effect of metabolic activities of the plant, when anabolic processes are more than catabolic processes there is synthesis and accumulation of various organic substances which results into the growth and development (Dhumal *et al.* 1997).

The plant height differed significantly due to different treatments at all growth stages of crop (Table 6). There was varied response of groundnut varieties to different fertilizer and liquid biofertilizer treatments. The variety ICGV – 86590 (V_1) recorded higher plant height (31.88, 32.48 and 31.60, 32.33) at 90 DAS and at harvest during the years 2000 and 2001, respectively than JL – 24 (V_2) and SB XI (V_3).

The increase in plant height with optimum levels of nitrogen (25 kg/ha) and phosphorus (50 kg/ha) application at all the growth stages i.e. 30, 60, 90 DAS and at harvest during both the years, this might be due to enhancement of vegetative growth caused by more nutrient uptake. The increase in plant height following

by more nutrient uptake. The increase in plant height following nitrogen fertilization may also be attributed to an increase in the availability of cytokinins to shoot which in turn play a role in elongation processes either through cell division or cell elongation (Goodwin and Erwee, 1983). Similar results have been reported by Sardhi, *et al.* (1990).

The availability of phosphorus might have helped in uptake of other nutrients needed by the crop. The biofertilizer inoculation helps in nitrogen fixation in legumes. Therefore, it might had combined effect on increased vegetative growth of plant. These results are in conformity with those obtained by Tomar *et al.* (1992) and Dey *et al.* (2000).

The data presented in Table 7 and 8 revealed that fertilizer and liquid biofertilizer treatments increased the number of primary and secondary branches per plant. In the present investigation, increase in the plant height, primary and secondary branches per plant due to different treatments resulted into subsequent increase in pod yield.

However, the treatment LB_4 recorded higher primary branches (4.90, 5.35), secondary branches (2.17, 1.81) at harvest during the years 2000 and 2001, respectively.

The increase in mean number of branches per plant was due to more absorption of plant nutrients under phosphorus level 50 kg P_2O_5 ha^{-1} which appeared to be the optimum dose for sufficient vegetative growth of plant as evident from the more number of branches. These results are in accordance with the findings of Sable and Khuspe (1986) and Chauhan (1988).

Rasal *et al.* (1998) reported that *Rhizobium* inoculation helped in nitrogen fixation and P Solubilizer organisms enhanced the microbial activity which might had effect on increased vegetative growth of the plant and mean number of branches per plant.

The data in respect of mean number of leaves per plant (Table 9) revealed that higher leaf number resulted in higher leaf area which played an important role in increasing the pod yield.

The variety V_1 recorded higher number of leaves (48.80, 21.64) at 90 DAS. While, recommended dose of fertilizer showed higher leaf numbers (40.71 and 16.00) during 2000 and 2001, respectively.

As regards, liquid biofertilizers the treatment LB_4 produced higher number of leaves (57.70 and 28.22) at 90 DAS during 2000 and 2001, respectively.

Enhancement of vegetative growth due to additional nitrogen and phosphorus uptake might have increased the number of leaves. These results are in conformity with the findings of Sable and Khuspe (1986) in groundnut and Dubey (1998) in soybean.

In the present investigation the high yielding variety ICGV – 86590 (V_1) recorded significantly higher leaf number at all the crop growth stages and simultaneously produced higher total dry matter and significantly higher pod yield than variety JL – 24 (V_2) and SB XI (V_3). Thus, the variety ICGV – 86590 showed a better relationship between the source and sink. The higher leaf number of variety ICGV – 86590 indicated that not only its higher leaf area and LAI, but also its persistence for longer time during the pod filling period played an important role in supplying sufficient food material for the development of sink i.e. pod. The high assimilating surface of

the variety ICGV – 86590 (V_1) during reproductive phase might had intercepted more solar energy enhancing their photosynthetic rate which ultimately resulted in higher dry matter production and hence higher pod yield.

The data presented in Table 10 revealed that variety V_2 produced significantly highest number of flowers at 60 DAS. This is the varietal character. However, under recommended dose of fertilizer produced higher number of flowers at all the growth stages particularly at 60 DAS it was (159.86 and 91.46) during the years 2000 and 2001 respectively.

While, liquid biofertilizer treatment LB_4 recorded highest number of flowers (201.56 and 107.03) at 60 DAS during 2000 and 2001 respectively.

Flowering is basically being controlled by environmental factors particularly the duration of light periods also is being influenced by other factors such as plant nutrition. Application of nitrogen significantly increased the total number of flowers. The increase in number of flowers due to nitrogen application could be attributed to an increase in plant height, which in turn provides more space by increasing the number of nodes per plant. Since groundnut bears flowers in the leaf axis of nodal junctions, the increase in the number of nodes could as well contribute to increased number of flowers per plant. Antony *et al.* (2000). The results of the present investigations are in agreement with these findings.

Nautiyal (2000) reviewed the literature concerning the microbial processes in the rhizosphere of plants which are crucial to plant and soil health. Not much is known at present about the effect of rhizosphere microbial community on plant yield and soil quality.

Processes in the rhizosphere influence plant disease, plant nutrition and root architecture by affecting the dynamics of microbial populations and communities. Therefore, there is interest to manipulate the rhizosphere microflora, which could in turn improve soil health plant health, yield and sustainability.

The role of different nutrients for growth in groundnut is presumed to be similar to other plants, serving as constituents of protoplasm regulating the osmotic pressure in plant cells and influencing the pH of the cell sap and buffer systems.

The nitrogen requirement of the crop is much higher than cereals as the protein content of its kernels is one and half times more than cereals. Nitrogen is known to be required in 3 major aspects of yield determination (i) formation of vegetative structure for nutrient absorption and photosynthesis (ii) formation of reproductive structures and determination of sink strength and (iii) production of assimilates to fill the economically important sink.

In groundnut application of both the sources of nitrogen amonical (urea) and nitrate (calcium nitrate) increased nitrogen in vegetative and reproductive parts. The nitrogen content was maximum in the vegetative parts with the application of urea in pegging stage and it was maximum in the reproductive parts with the application of calcium nitrate at flowering.

Phosphorus plays a key role in various physiological processes *viz.*, cell metabolism, root production, nodulation N_2 fixation. Deficiency of phosphorus would have a wide range of effects on cell function. It is an essential element participating in the skeleton of plasma membrane, nucleic acids, many coenzymes and organic molecules such as ATP and other phosphorelated products. It

plays important role in the energy transfer reactions and in oxidation reduction processes.

Potassium is essential for photosynthesis and pod development. It is readily mobile within the plant tissues. Its utilization in plant is concerned with the formation of carbohydrate and proteins, photosynthesis transpiration, enzyme action, synthesis of nucleic acid and chlorophyll, oxidative and photo phosphorelation, translocation etc.

Fertilizer is one of the important production factors for groundnut. It is known fact that plant utilize 30-50 per cent, 15-20 per cent and 40-60 per cent applied N, P and K respectively. The remaining goes as a loss in the form of leaching or volatilization or fixation because of hormones and enzymes naturally produced in the plants are insufficient for the mobilization and conversion of nutrients into basic plant tissues for optimum plant growth. Ghosh and Naik (1999).

Microorganisms have long been used to improve plant growth. A large number of microorganisms are commonly found in the soil including bacteria, fungi protozoa and algae. Of these, bacteria are by far the most common type of soil microorganisms, possibly because they can grow rapidly and have the ability to utilise a wide range of substances an either carbon or nitrogen sources. Bacteria have great potential for biocontrol, plant growth promotion, formation of soil aggregates and hence in the stabilization of soil structure and bioremediation. The heightened interest in the use of bacteria as bioinoculants has been incited by several events including the increased awareness and concern over the potential hazards of the chemical fertilizers and pesticides to the environment and public

health. Use of bioinoculants is highly compatible with the sustainable agricultural practices that are required for conserving natural resources in agriculture. Furthermore, with the population growing, land is going out of agriculture all the time. Therefore, there is no way except to produce more, through vertical growth in productivity not the horizontal growth in area in such way that we ensure sustainability of production process.

Root associated microorganisms may compete with other soil microbes for sources of carbon nitrogen, and or energy. The ability to utilise these nutritional resources present in the rhizosphere contributes to the survival and competitiveness of root associated bacteria. The rhizobacteria once considered as passive by stands of the root environment are now known to affect plant health, development and environment adaptation both beneficially and detrimental. Biological and metabolic activity of the root soil interface is among the most critical factors contributing to the support of life on our planet.

Direct influence include production of phytohormones, liberation of phosphates and micronutrients, symbiotic nitrogen fixation and stimulation of disease resistance mechanisms. An understanding to the mechanism to action of these factors can therefore, be exploited to enhance the beneficial effects (Nautiyal 2000).

The new approach in agriculture may involve the successful management of natural and renewable resources in crop production to satisfy changing human needs, simultaneously conserving the quality of environment. Now the developed countries have intensified the efforts to reduce the use of chemical fertilizers

and at the same time stabilise the productivity at current levels in such a scenario, integrated supply system has emerged as an important tool to stabilize the productivity at current levels and conserve the equality of environment. This includes use of bio-fertilizers, green / organic manures, crop rotation biopesticides and chemical fertilizers in judicious manner (Dubey, 1998).

5.2 Biochemical studies

Leaves being a photosynthetic organ for growth and development of plant which plays an important role in deciding the final yield. It is recognized that chlorophyll plays vital role in the biosynthesis of carbohydrates ultimately repercussive on yield. Low levels of chlorophyll content in leaves affect synthesis of carbohydrates and whole cellular metabolism.

There was increase in leaf number and ultimately the leaf area during the period between 30 and 60 days after sowing. Towards maturity, the leaf number and leaf area decreased substantially. The decrease of leaf number at maturity might be due to senescence in early formed leaves. The leaf senescence events often associated with translocation of nutrients formerly assimilated in leaves into developing pods

Significant differences within the varieties fertilizer levels and biofertilizers were observed on chlorophyll content of leaves both in terms of total chlorophyll as well as its components 'a' and 'b'. The total chlorophyll and its components were higher in the variety ICGV – 86590 (V_1) under the recommended dose of fertilizer and biofertilizer treatments *Rhizobium* (Lb_4) and Bioplin (Lb_1) respectively.



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The data presented in Table 13 indicated that chlorophyll 'a' content in leaves was higher in the variety V_1 (8.33, 7.74 mg/g) at 60 DAS during the years 2000 and 2001 respectively. This is a pick period for higher metabolic activities in terms of development of source and sink structures. Similarly, recommended dose of fertilizer (F_1) produced significantly highest chlorophyll 'a' content (7.96 and 7.38 mg/g) at 60 DAS during the years 2000 and 2001 respectively. As regards liquid biofertilizer treatment Lb_4 produced higher chlorophyll 'a' content (8.58, 8.26 mg/g) at 60 DAS during the years 2000 and 2001 respectively.

Similar results (Table 14) have been recorded on chlorophyll 'b' content.

The data on total chlorophyll content presented in Table 15 revealed that the total chlorophyll content was highest at 60 DAS. Where, variety V_1 produced highest chlorophyll content (11.98 and 11.18 mg/g) at 60 DAS during the years 2000 and 2001 respectively. Under F_1 it was higher (11.44 and 10.60 mg/g) during the years 2000 and 2001 respectively. While, the liquid biofertilizer treatment Lb_4 produced higher total chlorophyll content (12.35 and 11.85 mg/g) at 60 DAS during the years 2000 and 2001 respectively.

It was also noticed that towards maturity, the pigment content decreased conspicuously. Over the stage the maximum value was recorded between the 30-60 days after sowing. The ratio of chlorophyll a : b remained nearly the same at all the growth stages. Similar results have been reported by the Ghosh and Naik(1999).

The first indication that leghaemoglobin (Lb) apoprotein might be a plant product came from the observations that the pattern of Lb isomers produced in root nodules was controlled by the plant host and not the *Rhizobium* symbiont (Appleby 1984).

In present studies significant effect on leghaemoglobin content in root nodules of groundnut by different treatments have been recorded (Table 16).

The variety ICGV – 86590 (V_1) recorded higher leghaemoglobin content in root nodules during both the years. Also it is observed that liquid biofertilizer treatments (0.513, 0.483 mg/g) at 60 DAS during the years 2000 while same treatments have recorded higher values during 2001 have increased the leghaemoglobin content.

Sairam *et al.* (1989) indicated that application upto 90 kg phosphorus per hectare and inoculation with *Rhizobium* resulted in improved nodulation and higher leghaemoglobin content of root nodules alongwith an increase in nitrogen uptake available soil nitrogen content and dry matter production. Present results are on the similar line as reported by the Bal and Siddeque (1991) and Malewar *et al.* (1992).

5.3 Nodulation studies

Groundnut plays an important role in the economy of the country as an oilseed crop. One of the reason for a low yield of groundnut is the inadequate input of manures and fertilizers. Nitrogen is a major limiting factor in the proper growth and productivity of groundnut and major part of the nitrogen requirement is met through the symbiotic 'N' fixation. Considering the highest cost and less

availability of nitrogenous fertilizers in our country, efficient utilization of nitrogen in groundnut has to be worked out (Naidu, 2000).

Biological nitrogen fixation by legumes in association with *Rhizobium* is one of the most important means of converting large quantities of nitrogen gas from air and make it available to plants. The bacteria infect the legume roots and form root nodules. The legume *Rhizobium* association can fix 50-300 kg of nitrogen per hectare in one crop season and can leave behind substantial quantities of nitrogen in soil for succeeding crop. The quantity of nitrogen fixed varies with the kind of legume and agro ecological conditions available. In order to derive greater benefit from legumes grown in rotation and as intrercrops with non-legumes, it is necessary that legume seeds be inoculated with specific *Rhizobium* (Anandan, 2000).

The most widely used biofertilizer is *Rhizobium* consisting of specific bacterium *Rhizobium* which when applied to soil through seed or otherwise enter the roots of host plants and form nodules in the root surface. The bacteria depends on the host plant for food and in turn supply nitrogen to host. This is an unique phenomenon of entrapping atmospheric N by legumes through their nodular system and is termed as Biological Nitrogen Fixation (BNF). The quantity of N fixed by different legumes through the symbiotic activity of *Rhizobium* depends upon the type of legumes. Rhizobial strains, soil moisture, nutritional conditions of the soil and microbial association etc. Inoculation with efficient *Rhizobium* strain specific to each crop is very essential for the N gain and better crop yields.

Next to nitrogen, phosphorus plays an important role in plant nutrition. Soil contains both organic and inorganic forms of phosphorus. In soil large quantity of inorganic phosphorus is present in the form insoluble phosphate compounds of calcium, iron and aluminium. Number of Indian soils are deficient in available phosphorus. Efficiency of added phosphate fertilizers is also low because of its tendency to turn into unavailable forms. Large deposits (about 140 million tonnes) of low grade (10.87 per cent P) rock phosphate are distributed in different states of India. Their proper utilization as phosphates fertilizers is possible in conjunction with inoculants of phosphate solubilizing micro organisms. Several soil bacteria belonging to the genera *Pseudomonas* and *Bacillus* and fungi belonging to the genera *Penicillium* and *Aspirgillus* possess the ability to bring insoluble phosphate in soil and rock phosphates into soluble forms by secreting organic acids such as malice, citric, acetic, propionic, lactic, glycolic, fumaric and succinic acids (Singh, 1991).

The mode of action of P-solubilising biofertilizers is very interesting. The process is completely biotic. The biofertilizer containing microorganisms when applied in the rhizosphere soil of plants, the organisms multiply and increase population. These highly populated microbes produce significant quantities of organic acids as metabolic by products depending on various carbon substrates. These acids are formic, citric, acetic, propionic, malic, succinic, fumaric, glycolic, gluconic acids etc. These organic acids are sources of biologically generated H+ ion dissolves mineral phosphate and make it available to plant. The degree of solubilisation is influenced by pH, O_2 and CO_2 concentration and by the presence of organic material. Sometimes these acids form unionised association with metal

(chelation) and increase the concentration of soluble phosphate. Aliphatic acids are more effective than phenolic acids in many occasion the production of inorganic acids by Nitrifying bacteria and *Thiobacillus* convert insoluble phosphate to soluble form. Even some organisms produce H_2S, which in turn reduces the insoluble compounds and release available phosphate. Besides, their role in mineralisation of phosphate and phosphates enzyme activities can proved available P to plants as per requirement (Bhattacharyya and Jain, 2000).

Application of phosphorus increased the nodule number and their dry weight significantly, which was expected since phosphorus is reported to enhance multiplication and activity of nodule bacteria in legume rhizosphere and stimulate root production in terms of length and volume.

By way of inoculation treatments atmospheric nitrogen is fixed symbiotically in addition to the NO_3 assimilation to fulfill the N requirement of the crop. The nodulation and thereby nitrogen fixation rates increase as the groundnut plants moves from vegetative stage to reproductive stage (Nagre *et al.* 1991).

Additional uptake of nitrogen and phosphorus increased the root length of the plant. This caused the increase in nodulation. Anbusezhiyan (1994) observed that *Aspergillus awamori*, *Penicillium* spp. and VAM along with phosphorus significantly increased the number and dry weight of groundnut nodules.

The biofertilizer inoculation in combination with nitrogen and phosphorus might be responsible for maximum nodule number and dry weight. These results are supported by Joshi *et al.* (1990) and Rahman *et al.* (1992).

The data regarding nodulation studies revealed that number of nodules and its dry weight were affected significantly at all the growth stages due to different treatments. The variety ICGV – 86590 (V_1) produced significantly higher root nodules and its dry weight than the variety JL – 24 (V_2) and SB XI (V_3) during both the years. The data presented in Table 18 revealed that the variety V_1 recorded higher number of root nodules (106.04 and 124.08) at 90 DAS during the years 2000 and 2001 respectively. While, under fertilizer levels (RDF) F_1 recorded higher root nodules at all the growth stages during both the years.

As regards liquid biofertilizer treatments *Rhizobium* (Lb_4) followed by Bioplin (Lb_1) produced higher number of root nodules at all the growth stages during both the years.

Similar results have been obtained regarding dry weight of nodules at all the growth stages during both the years.

The enhanced number of nodules, their dry weight and dry weight of roots due to *Rhizobium* inoculation alone has been reported by Nagre *et al.* (1991) and Rahman *et al.* (1992).

From results pertaining to the total number and dry weight of nodules recorded at different stages of crop growth. It is seen (Table 18 and 19) that seed inoculation with *Rhizobium* has given more number and dry weight of nodules by the variety ICGV-86590 (V_1) than variety JL – 24 (V_2) and SB-XI (V_3) over rest of the biofertilizers tried. These results are in agreement with the results reported by Rahman *et al.* (1992).

Huang (1991) reported that nodule number and nodule weight increased with increase in the nitrogen levels, but it was only upto 25 kg N ha^{-1} in all the genotypes studied under inoculated and uninoculated conditions.

More *et al.* (1981) observed that application of 25 Kg N/ha showed better results of nodule numbers and its dry weight. They reported that 40 kg N/ha significantly reduced the number of nodules/plant as compared to control and further attributed that it may be due to the fact that the nitrogen need of the plant was fulfilled through increased supply of nitrogen from the fertilizer, and therefore, the plant tended to bear less number of nodules.

It may be possible to integrate the use of more than one biofertilizer and organic manure for increasing crop yields. *Rhizobium*, *Azotobacter*, *mycorrhizae*, phosphate solubilizers etc. could be used together or separately. In India where mixed cropping and double cropping is followed, the combined application of more than one biofertilizer holds great promise. Combined use of biofertilizers, organic manures and small doses of chemical fertilizers would not only give higher yields but help to maintain soil health and reduce pollution problems created by continuous application of high doses of chemical fertilizers (Anandan, 2000).

The increase in number of root nodules and dry weight of root nodules might be due to the growth regulating substances produced by *Rhizobium*. Thakre *et al.* (1999), have reported that inoculation of *Bradyrhizobium* of soybean, significantly produced more number of roots nodules/plant and dry weight of root nodules/plant. The present results are on the similar line of these reports.

5.4 Dry matter studies

The dry matter accumulation is a result of catabolic and anabolic processes while the partitioning of dry matter depends upon the source to sink relationship. The efficiency of groundnut is based on dry matter accumulation. The source of dry matter production for development of pod is green part of the plant such as leaves. Thus, the differential role of these plant parts might add to the differences in yield among the varieties. The differences in the yield is determined by the efficiency of plant parts in which the dry matter is synthesised and diverted to the economic yield.

The dry matter production and its partitioning into different plant parts played an important role in obtaining better yield. The dry matter produced is the result of the net accumulation of photosynthates after meeting the requirements for respiration. The data regarding dry matter accumulation in leaves, stem, pods and the total dry matter per plant (Table 20 - 23) revealed that higher mean total dry matter and mean dry weight of pods were accumulated in the variety ICGV – 86590 (V_1) than the variety JL – 24 (V_2) and SBXI (V_3).

Norman and Chongo (1992) reported that dry matter accumulation in the vegetative organs continued upto 69 day after anthesis, necessitating sharing of photosynthates between the vegetative and reproductive sinks. However, there was a preferential distribution of assimilates from current photosynthesis of the leaves and stems to the reproductive organs. The results of present investigation are similar to above reports.

In the present investigations the differences in the dry matter production within the varieties and among the treatments of fertilizer and liquid biofertilizer were observed. Where variety ICGV-86590 (V_1) produced higher dry matter (29.25 g) than the variety JL-24 (V_2) at harvest while, recommended dose of fertilizer (F_1) produced higher dry matter (29.74 g) as compared with rest of the fertilizer levels. As regards liquid biofertilizer treatments it was higher with almost all the treatments over control. While, extent of increase was more in Lb_4 (36.06) and Lb_1 (31.32) during 2000. The increase in total dry matter due to *Rhizobium* inoculation has been reported by More *et al.* (1981) and Rahman *et al.* (1992) in groundnut.

The increase in plant vigour in terms of plant height, leaf number and leaf area per plant due to different treatments were found to be useful in increasing photosynthetic activities and thereby accumulation of more carbohydrates and consequently higher dry matter. These results are in agreement with the findings of Sable (1980) and Sardhi *et al.* (1990).

Due to the biofertilizer *viz.*, P. solubilizer micro-organisms and nitrifying bacteria enhanced the plant vegetative growth due to additional nutrient uptake which ultimately reflected in increasing in plant vigour in terms of plant height, leaf number, leaf area might have been useful in increasing photosynthetic activity and thereby accumulation of more carbohydrates and consequently increased dry matter of groundnut.

Fertilizer in combination with biofertilizers enhanced the plant vegetative growth and this might have increased number of branches per plant and dry matter per plant. The results of present study are in similar line with the reports of More *et al.* (1981).

The differences in dry matter accumulation to the varieties under study, in relation to dry matter accumulation could be related to differences in phenologies and towards the later stages it might also be related to differing patterns of assimilate partitioning between vegetative and reproductive components Bell *et al.* (1991).

5.5 Phenological studies

Flowering, the photobiological process is the most radical change in the physiology of the plants. Induction of flowering in the plant is the most charming and challenging physiological phenomenon. It is partly dependent on the indogenous biochemical changes at shoot apex. The formation of flower is a cardinal point in the development of the plant (Dhumal *et al.* 1997).

A close look at the data in Table 24 indicate that wide variations in phenology. It revealed that a wide variability was exhibited by the different genotypes in their requirement for flowering. This could accounted for the differential response of those genotypes and their requirement of photoperiod, as the process of flowering is governed by the photoperiod apart from influence of other growing condition like temperature radiant energy, nutritional and soil moisture conditions (Antony, 2000).

In the present investigations the less number of days were required by both the varieties JL-24 (V_2) and SBXI (V_3) for initiation of flowering 50 % flowering and physiological maturity

under different treatments of fertilizers and liquid biofertilizers than the variety ICGV – 86590 (V_1). This may be due to the varietal characters. The variety ICGV – 86590 (V_1) required more number of days for initiation of flowering (29.06), 50 % flowering (36.40) and physiological maturity (109.35) during the year 2000. While during the year 2001 the days required for initiation of flowering, 50 % flowering and physiological maturity were 29.51, 36.48 and 113.33, respectively. Which may be correlated with more pod yield as the source sink relationship was better in this variety.

Chen (1989) noticed in the field trial that groundnut seeds inoculated with *Rhizobium* containing 200 million bacteria/ g. prolonged the growing period by 14 days.

5.6 Growth functions

The high pod yield of groundnut genotype was not only contributed by one or more components but also complimented by physiological components like AGR, RGR, NAR and CGR during the period of flowering and pod development.

The production of high groundnut yields is highly dependent on adequate growth rate and nutrient uptake. Three physiological processes responsible for yield variation in groundnut are (i) Partitioning of assimilates between vegetative and reproductive parts (ii) Duration of pod filling and (iii) Rate of pod development. Among these, most of the yield variations in groundnut cultivars were due to the differences in the partitioning of assimilates between vegetative and reproductive parts (Ghosh *et al.* 1998).

Genotypic differences with respect to total dry matter, and their partitioning into different plant parts of groundnut are reported. The cultivar ICGV – 86590 (V_1) accumulated significantly higher dry matter compared to JL – 24 (V_2) and SB XI (V_3). Among the different plant parts, the highest per cent of dry matter were accumulated in pods and negligible amount of dry matter were partitioned into the roots. The cultivar ICGV – 86590 (V_1) showed higher dry matter accumulation in pods.

The data on growth functions like AGR, RGR, NAR and CGR revealed significant differences within the varieties, fertilizer levels and different treatments of liquid biofertilizers.

AGR is an important parameter indicating the assimilate capacity of each genotype. In the present study the AGR (Table 25) was less during the early vegetative stage upto 30 DAS and increased with the onset of reproductive phase and showed maximum value during 60-90 DAS. This is a peak period for metabolic activities in terms of development of source and sink structures.

Significantly higher AGR was observed in the variety ICGV –86590 (V_1) (0.530 $g.day^{-1}$) followed by JL – 24 (V_2) (0.370 $g.day^{-1}$) and the lowest was recorded by the variety SB XI (V_3) (0.350 $g.day^{-1}$) at 60-90 DAS. While it was higher under recommended dose of fertilizer (0.467 $g.day^{-1}$) at 60-90 DAS and different liquid biofertilizer treatments. While, the extent of increase was higher with the treatments Lb_4 followed by Lb_1 (0.552, 0.502 $g.day^{-1}$) at 60-90 DAS during the year 2000. The similar results in respect of AGR was reported during the year 2001.

The results obtained on RGR (Table 26) showed that the RGR was increased during 60 to 90 DAS and declined thereafter.

The NAR expresses photosynthetic efficiency of plant. The data on NAR in the present study (Table 27) showed that higher value between 60-90 DAS for all the varieties. An increasing NAR during this period was associated with increased leaf area increased light absorption, which helped to improve pod yield in the groundnut.

The CGR is an important index of agricultural productivity on rate of dry matter accumulation. The dry matter increase in plant is a continuous process, where an increment at any interval is added to the capital for subsequent growth. The data on CGR (Table 28) indicated that CGR was increased during 60-90 DAS and was declined at 90 DAS to harvest.

The variety ICGV – 86590 (V_1) have showed higher CGR values (17.75, 14.32 $g.m^{-2}.day^{-1}$) during the year 2000 and 2001 respectively than rest of the varieties. While recommended dose of fertilizer have also recorded higher CGR (15.52, 12.47 $g.m^{-2}.day^{-1}$) at 60-90 DAS during 2000 and 2001 respectively. As regards the effect of liquid biofertilizer treatments it was significantly higher with almost all the treatments over control Lb_4 (18.63), Lb_1 (16.73) during the year 2000. Similar results have been obtained during second experiment.

The pattern of change in the AGR, RGR, NAR and CGR values at different crop growth stages of groundnut are in general in conformity with those reported by Pachpute (1984) and Deshmukh (1986).

5.7 Post harvest studies

The pod yield is complex biological process understanding of various physiological parameters, reflection of these metabolic processes in relation to ultimate yield is imperative towards efficient development of crop.

The study of yield and yield contributing components indicated significant differences between the three varieties (Table 29, 30, 31). The variety ICGV –86590 (V_1) recorded significantly the highest dry pod yield (2407.05, 2078.92 kg/ha) during 2000 and 2001, respectively than variety JL – 24 (V_2) and SB-XI (V_3) (Table 26). Also the recommended dose of fertilizer recorded higher yields (2221.55 and 1680.40 kg/ha) during the years 2000 and 2001 respectively. As application of liquid biofertilizer is considered the dry pod yield was higher with almost all the treatments over control. However, the extent of increase was more with Lb_4 followed by Lb_1 (2384.78, 2241.35 kg/ha) respectively during 2000 and (1860.27, 1752.96 kg/ha) during 2001.

The major yield contributing components in groundnut are number of pods per plant, 100 pod and kernel weight, harvest index etc. The variety ICGV – 86590 (V_1) showed superiority in some of the yield contributing components. This may be due to the varietal or genotypical characters. The variation in yield component among the groundnut varieties were also reported by Ahmed (1992).

The pooled data presented in Table 34 revealed that the variety V_1 recorded highest dry pod yield (2242.98 kg/ha). While under different fertilizer levels recommended dose of fertilizer (F_1) produced highest dry pod yield (1953.97 kg/ha). As regards liquid biofertilizer treatments dry pod yield was increased with almost all

the treatments over control Lb_0 (1891.20) while the extent of increase was higher with Lb_4 (2122.52), Lb_1 (1997.15), Lb_2 (1881.93).

The pod yield and yield contributing components indicated significant differences within the varieties, fertilizer levels and liquid biofertilizer treatments in groundnut (Table 35, 36) during both the years of the experiment.

From the data presented in Table 35 for the year 2000 observed that, the variety ICGV 86590 (V_1) recorded 30.18 per cent and JL - 24 (V_2) 12.91 per cent higher yield than variety SB-XI (V_3) while recommended dose of fertilizer (F_1) and 75 per cent RDF (F_2) showed 10.43 per cent and 4.93 per cent increase in pod yield, respectively over 50 per cent RDF (F_3). Biofertilizer treatments had significant impact on pod yield. It is observed from the present study that *Rhizobium* (Lb_4) recorded higher yield 33.50 per cent followed by Bioplin (Lb_1) 25.55 per cent, Phosfert (Lb_2) 18.28 per cent and Vitormone (Lb_3) 14.85 per cent over control during the year 2000.

From the data presented in Table 36 for the year 2001 observed that, the variety ICGV-86590 (V_1) recorded 43.36 per cent and JL-24 (V_2) 7.14 per cent higher yield than variety SB-XI (V_3). However, recommended dose of fertilizer (F_1) and 75 % RDF (F_2) recorded 4.78 and 2.19 per cent increase in dry pod yield respectively over 50 % RDF (F_3). From the present study it is observed that liquid biofertilizer treatment increased the dry pod yield where *Rhizobium* (Lb_4) recorded higher yield 33.11 per cent, Bioplin (Lb_1) 25.44 per cent, Phosfert (Lb_2) 15.42 per cent and Vitormone (Lb_3) 10.31 per cent over control.

The major yield contributing components in groundnut are number of pegs, number of pods, dry weight of pods, 100 pod and kernel weight, harvest index etc. The high yielding variety ICGV – 86590 (V_1) recorded higher values of these components which leads to higher yield followed by JL – 24 (V_2) and lowest values were observed in the variety SB-XI (V_3) which resulted in lowest yield than V_1 and V_2 during both the years.

Similarly, Geethalakshmi *et al.* (1993) reported that interaction of all the sources of nutrient (NPK + FYM + *Rhizobium*) recorded the highest groundnut pod yield recording 52% increased yield than NPK fertilization alone. The increased yield could be attributed to the synergistic effect of different nutrient sources, which affected the groundnut growth, yield and quality characters positively.

Observations recorded on number of pegs per plant number of pods per plant, 100 pod and kernel weight, sound mature kernel percentage, root length per plant followed similar trend. These results are in agreement with Geethalakshmi *et al.* (1993).

The higher yield of the variety ICGV – 86590 (V_1) was not only attributed by one or more yield contributing components but was also complimented by the physiological parameters like plant height, number of leaves per plant, total chlorophyll content in leaves, number of root nodules per plant at all the crop growth stages. This resulted in higher total dry matter production during the later crop growth stages.

Harvest index represents capacity (often termed sink power or sink capacity) to mobilise photosynthates and translocate it to the plant organ having economic value. Harvest index is good measure of the efficiency of genotype for converting the biological

yield into economic yield. Genotypes with high biomass coupled with high harvest index would be desirable for improving yield. In the present investigation the variety ICGV – 86590 (V_1) recorded the highest harvest index. The higher pod yield in this variety mainly contributed to the efficient translocation of assimilates to organ having economic importance (pod).

Thirumalaisamy and Ramanathan (1988) observed a significantly positive correlation of total biomass and harvest index with pod yield in groundnut and stressed the importance of these physiological characters in getting higher yield. The findings of the present investigation are on the line with the above principles.

Different fertilizer treatments had a significant impact on dry pod yield. It was maximum and significantly higher under recommended dose of fertilizer (RDF) (F_1) than 75 % of RDF (F_2) and 50 % of RDF (F_3). Optimum yield was realized with the level of recommended dose of fertilizer (25 kg N + 50 kg P_2O_5 kg/ha). This might be because of the fact that the important yield contributing characters viz., number of pegs per plant, number of pods per plant and dry weight of pods and 100 kernel weight, plant height etc. were significantly increased which resulted in increased dry pod yield with that level of fertilizer. Similar results were reported by Deshmukh *et al.* (1995) and Talashilkar *et al.* (1997).

Application of nitrogen @ 25 kg/ha and phosphorus @ 50 kg/ha with biofertilizer inoculation recorded the maximum values of all yield contributing characters. The increase in yield with N and P application with biofertilizers can be attributed to productivity level of individual plant. Similarly growth parameters such as plant height, number of branches per plant, number of root nodules per plant etc.

have recorded higher values which led to better growth and resulted into higher pod yield. Combined application of these chemical fertilizers and biofertilizers caused perceptible increase in these parameters over their individual applications.

Favourable effects of P on yield attributes and seed yield may be ascribed to its role in the constitution of ribonucleic acid, deoxyribonucleic acid and ATP which regulate vital metabolic processes in the plant helping in crop root formation, nitrogen fixation and finally in crop yield. Similar results have also been reported by Mishra and Baboo (1999).

Application of P @ 50 kg/ha at basal favourably influenced all the growth parameters and increased the number of mature pods, pod weight, shelling percentage test weight which led to increase in dry pod and haulm yield.

The increase in pod yield might be due to efficient diversion of photosynthates towards pod formation and development especially with nitrogen, phosphorus application which imparts better growth of the crop and better pod formation and filling leading to higher pod yield. These results are in conformity with Singh *et al.* (1994).

Different biofertilizer treatments differed significantly in respect of their influence on dry pod yield. The maximum dry pod yield was recorded due to different treatments of biofertilizers over control. Treatment of *Rhizobium* (Lb_4) was found to be superior followed by Bioplin (Lb_1) over rest of the treatments.

The data on yield attributes viz., number of mature pods per plant, 100 pod weight, number of pods per plant and dry pod yield of groundnut revealed that the response to biofertilizer treatments was highly significant.

Further, the significantly increased nitrogen fixation by the specific strains of biofertilizers might have resulted in better growth and yield parameters and yield of groundnut. Similar results were reported by Christopher *et al.* (1996).

Among different yield components number of pods per plant, dry weight of pods per plant, 100 pod weight were found to be most important which determined the pod yield of groundnut during *kharif* season.

There was significant beneficial effect of biofertilizer inoculation on nodule number dry weight of nodules dry pod and haulm yield. Plants receiving inoculation with N and P fertilizers produced higher values of these characters. This conforms the results obtained by Rahman *et al.* (1992).

Biofertilizers contain living cells of different types of microorganisms which have an ability to mobilize nutritionally important elements from non usable form through biological process.

Microorganisms, which could be used as biofertilizer including bacteria, fungi and blue green algae. The inoculum carrying these organisms need to be applied to enhance their activity in the rhizosphere (Anandan, 2000).

It may be possible to integrate the use of more than one biofertilizer and organic manure for increasing crop yields. *Rhizobium*, *Azotobactor*, micorrhizae, phosphate solubilizers etc. could be used together or separately. In India where mixed cropping and double cropping is followed, combined application of more than

one biofertilizer holds great promise. Combined use of biofertilizers, organic manures and small doses of chemical fertilizers would not only give higher yield but help to maintain soil health and reduce pollution problems created by continuous application of high doses of chemical fertilizers (Anandan, 2000).

The important yield contributing characters were significantly higher with the application of biofertilizer treatments due to nitrogen and phosphorus uptake, resulting in increased dry pod yield. Increase in root nodules due to different biofertilizer treatments and nitrifying bacteria also helped in increasing dry pod yield by fixing more nitrogen and consequently increasing its absorption. Similar findings have been reported by Ghosh and Poish (1995).

Among the biological sources due consideration should be given to the use of biofertilizers as supplementary or alternative and renewable sources of fertilizers, especially the *Bradyrhizobium* and the phosphate solubilizing micro organisms (Bandopadhyay *et al.*, 2000).

5.8 Soil analysis

The requirement of various nutrients for groundnut is high. High yields of groundnut can be obtained only by maintaining optimum levels of nutrients in the soil.

Groundnut is a leguminous plant which fixes atmospheric N in the root nodules and thereby the demand for applied nitrogen reduces. The contribution of biologically fixed N to the total N requirement of the plant has not been completely quantified but there are indications that under optimum conditions groundnut plant can fix atmospheric N to an extent of 200 to 260 kg N/ha, eliminating or reducing the need for application of fertilizer N. But, the amount of

nitrogen fixed symbiotically depends upon 3 major factors, *viz.*, the rhizobial strain, the genotype of the host plant and elements of the external environment which includes soil moisture, and temperature, light intensity, day length and availability of N.P.K. Groundnut is a member of the cowpea cross-inoculation group and is nodulated by bacteria from a large group of diverse legumes. However no tall rhizobial strains are efficient in fixing N through symbiosis. This also explains why the response to applied N is not consistent. Therefore, the question whether rhizobia can fix adequate N for groundnut production remains unsettled as some workers have found increase in yield by N fertilization.

The N requirement of groundnut plants is influenced by the amount of other nutrients available. A number of workers have found that the pod yield of groundnut in creased only with judicious combination of N and P rather than application of one nutrient only.

The total amount of P taken up by the groundnut plant is relatively small. Though the amount of P required is small, large quantity of fertilizer has to be applied as the efficiency of uptake of P from fertilizer is low. Because of the very low P requirement of groundnut, responses to application of P fertilizers has not been conspicuous.

Groundnut can use P at the lowest levels than most crops. The groundnut plant is also able to grow normally with low levels of soil available P probably because of the formation of mycorrhizal association of the roots with soil fungi or due to phosphobacteria in the rhizosphere of the plant making unavailable P available to the groundnut plant.

Potassium is needed by the groundnut crop from early stage of its growth to maturity. Considerable amount of K is taken up by the groundnut crop but most of the Indian soils are rich in K. Response to application of K can be expected only when available K in the soil is less. There is a mutual antagonistic effect on the uptake of K, Ca and Mg is more important than total amount of any of them. Response to applied K is not often obtained on Indian soils as they are medium to high in K content and also due to antagonistic effects or deficiencies of other plant nutrients.

The data on nitrogen, phosphorus, potassium content in the soil after harvest as affected by different treatments are presented in Table 37. From this data, it is indicated that nitrogen content in the soil after harvest of groundnut crop was affected significantly. Variety ICGV – 86590 (V) recorded significantly the highest 'N' content in the soil (127.35 and 117.46 kg/ha) during 2000 and 2001 respectively, followed by JL – 24 (V_2). While significantly the lowest N was content in the soil due to variety SB XI (V_3). The similar results were observed during both the years.

Further, it is noticed that higher 'N' content in the soil after harvest with recommended dose of nitrogen was observed.

It is indicated that the N status of the soil after harvest was improved by the variety ICGV – 86590 (V_1), recommended dose of fertilizer (F_1) (127.20 and 117.40 kg/ha) during the year 2000 and 2001 respectively. While the minimum N content in soil was evident under variety SB XI (V_3) and 50 % RDF (F_3). Gulati (1989) noticed that N content in soil was increased due to different cultivars and application of fertilizers.

Gaury *et al.* (1982) reported that there was increase in nitrogen fixation by 31 per cent by the inoculation with *Rhizobium* inoculation. Similar results were obtained in the present studies.

More and Jadhav (1997) reported that nodule number, plant height, N content and uptake in soybean were significantly increased due to application of cobalt. Application through soil, seed and alongwith *Rhizobium* inoculation was more effective in enhancing the nodulation, yield and uptake of nitrogen in the crop.

It has been reported that groundnut removes fairly large quantities of nutrients from the soil. Cultivation of groundnut will therefore, deplete the soil rapidly unless the soil is adequately manured. Increasing the levels of K particularly in low K soils showed prominent increase in yield under different soil types and agroclimatic condition in India. Organic manures addition results in various favourable changes in the soil like building up of organic matter, good soil aggregation, improvement in soil, physical properties, long lasting supply of macro and micro nutrients etc.

Rajendran and Veeraputhiran (2001) in his review indicated that phosphorus application increased the uptake of N, P, K nutrients. Application of P with organic manures or biofertilizers like phosphobacteria showed good response. The results of the present study are on the similar lines.

Phosphorus content in the soil after harvest was influenced significantly where variety SB-XI (V_3) observed highest P content followed by JL-24 (V_2) regarding potassium content the trend was almost similar during both the years.

The NPK uptake was influenced significantly in present investigation (Table 38). Nitrogen uptake was significantly higher by

the variety ICGV-86590 (V_1) (172.00, 148.78 kg/ha) during the years 2000 and 2001 respectively followed by SB-XI and lowest N uptake was observed by the variety JL-24. Similarly, the N uptake was significantly the highest under recommended dose of fertilizers (174.10, 134.98 kg/ha) during both the years respectively. Whereas liquid biofertilizers had significant impact on uptake of N by the groundnut. However, P uptake varied within the varieties and it was higher due to application of recommended dose of fertilizer and in combination of biofertilizer also. Similar results were reported by Gaury *et al.* (1982).

The K uptake revealed that the variety ICGV-86590 (V_1) utilized maximum K (138.12, 120.30 kg/ha) during the years 2000 and 2001 respectively followed by variety SB-XI (V_3). While K uptake from the soil was maximum under recommended dose of fertilizer RDF (F_1) (141.36, 107.85 kg/ha) during 2000 and 2001 respectively and different treatments of liquid biofertilizers, the treatment Lb_4 followed by Lb_1 (141.42 and 115.70 kg/ha) during 2000 and 2001 respectively.

The comparison of varieties revealed that the high yielding variety ICGV-86590 (V_1) utilized significantly more K from the soil than SB-XI (V_3) and JL-24 (V_2). The decrease in K status of soil after harvest, as observed in the present investigation, is a general trend in case of legume crops. All the liquid biofertilizer treatments utilized more K from the soil. Obviously, there are no reports on such effect of biofertilizers on available K status of the soil after harvest.

SUMMARY AND CONCLUSIONS

6. SUMMARY AND CONCLUSIONS

A field experiment entitled "Studies on effect of liquid biofertilizers on morphophysiological and biochemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) varieties during *kharif* season" at Post Graduate Instructional Farm, Department of Plant Pathology and Microbiology, MPKV, Rahuri (M.S.) during *kharif* season of the years 2000 and 2001.

The experiment with three varieties *viz.*, ICGV-86590 (V_1), JL-24 (V_2) and SB-XI (V_3) and three fertilizer levels i.e. recommended dose of fertilizers (RDF) (F_1), 75 per cent of RDF (F_2) and 50 per cent of RDF (F_3) as main plot treatments and five biofertilizer treatments such as, Bioplin (Lb_1), Phosfert (Lb_2), Vitormone (Lb_3), *Rhizobium* (Lb_4) and control (Lb_0) as subplot treatments were studied in split plot design with 3 replications. Thus, in all 45 combinations were studied during both the years.

The spacing adopted was 30 x 10 cm.

The experiment was carried out with following objectives,

1. To study the effect of liquid biofertilizers on yield and yield contributing characters of groundnut.
2. To study the effect of liquid biofertilizers on physiological parameters of groundnut.
3. To study the dry matter production and partitioning as influenced by the liquid biofertilizers.
4. To study the influence of liquid biofertilizers on oil and protein content of groundnut kernels.
5. To study the effect of liquid biofertilizers on biochemical characters *viz.*, chlorophyll content in leaves and leghaemoglobin content in root nodules.

The various observations were recorded at an interval of 30 DAS after sowing until harvest. The data collected for dry matter studies were used for estimation of growth function.

The following broad conclusions could be drawn from the results.

6.1 Growth studies

1. The varieties differed significantly in respect of growth parameters such as plant height, number of leaves per plant, primary and secondary branches per plant, number of flowers and pegs per plant etc. The variety ICGV-86590 (V_1) recorded higher values of the above parameters as compared to the variety JL-24 (V_2) and SB-XI (V_3).
2. Application of different levels of fertilizers had significant influence on growth characters of groundnut. Recommended dose of fertilizers (RDF) (F_1) resulted in significantly higher values of growth characters than 75 per cent RDF (F_2) and 50 per cent RDF (F_3).
3. Different treatments of liquid biofertilizers had significant effect on growth observations. Among the treatments *Rhizobium* (Lb_4) and Bioplin (Lb_1) (seed pelleting) resulted in higher plant height per plant, number of leaves per plant, number of primary and secondary branches per plant, total number of flowers and pegs per plant than rest of the treatments.

6.2 Biochemical parameters

1. Significant differences within the varieties fertilizer levels and biofertilizers were observed on chlorophyll content of leaves both in terms of total chlorophyll content as well as its components 'a' and 'b'. The total chlorophyll and its components were higher in the variety ICGV-86590 (V_1) in the recommended dose of fertilizers and biofertilizer treatments *Rhizobium* (Lb_4) and Bioplin (Lb_1).
2. The variety ICGV-86590 (V_1) have recorded higher leghaemoglobin in root nodules during both the years. Also it was observed that liquid biofertilizer treatments have increased the leghaemoglobin content in root nodules the extent of increase is higher in the *Rhizobium* (Lb_4).

6.3 Nodulation studies

1. As regards the nodulation studies the number of root nodules and its dry weight were affected significantly at all the growth stages due to different treatments. The variety ICGV-86590 (V_1) produced higher root nodules and its dry weight than the variety JL-24 (V_2) and SB-XI (V_3) during the year 2000. While JL-24 (V_2) recorded higher number and dry weight of root nodules during the year 2001. It was also observed that recommended dose of fertilizer produced higher number of root nodules and its dry weight.
2. Application of different liquid biofertilizer treatments had significant impact on the nodulation studies of the groundnut

where *Rhizobium* (Lb_4) followed by Bioplin (Lb_1) recorded higher number of root nodules and its dry weight over rest of the treatments.

3. The higher root length was observed by the variety ICGV-86590 and it was also influenced by different levels of fertilizer and liquid biofertilizer treatments. It was higher in recommended dose of fertilizer (F_1) and among the treatments *Rhizobium* (Lb_4) recorded higher root length.

6.4 Dry matter studies

1. The dry matter accumulation in leaves, stems, pods and total dry matter accumulated were higher in the variety ICGV-86590 (V_1) than the variety JL-24 (V_2) and SB-XI (V_3).
2. The differences in the dry matter production due to different levels of fertilizers and liquid biofertilizer treatments were observed where recommended dose of fertilizer (F_1) produced higher dry matter as compared with rest of the fertilizer levels.
3. As regards liquid biofertilizer it was higher with almost all the liquid biofertilizer treatments while extent of increase was higher due to *Rhizobium* (Lb_4) and Bioplin (Lb_1) over rest of the treatments.
4. The total dry matter production of the variety ICGV-86590 (V_1) was higher in combination of recommended dose of fertilizer (F_1) and liquid biofertilizer treatment *Rhizobium* (Lb_4) followed by Bioplin (Lb_1).

6.5 Phenological studies

1. A wide variability was exhibited by the different genotypes in their requirement for flowering. The lesser number of days were required by both the varieties JL-24 (V_2) and SB-XI (V_3) for initiation of flowering 50 per cent flowering and physiological maturity under different levels of fertilizers and liquid biofertilizer treatments.
2. The variety ICGV-86590 (V_1) required more number of days for initiation of flowering, 50 per cent flowering and physiological maturity.
3. Application of recommended dose of fertilizer increased the total number of flowers in all the varieties studied but extent of increase was more in variety ICGV-86590 (V_1) than JL-24 (V_2) and SB-XI (V_3).

6.6 Growth functions

1. The higher dry pod yielding variety ICGV-86590 recorded higher values for the mean AGR, RGR, NAR, CGR at most of the growth stages as compared to the low yielding varieties.
2. Among the fertilizer levels recommended dose of fertilizers (F_1) and liquid biofertilizer treatments *viz.*, *Rhizobium* (Lb_4) and Bioplin (Lb_1) (seed pelleting) recorded higher values of these growth functions over rest of the treatments.

6.7 Post harvest studies

1. The variety ICGV-86590 (V_1) produced the highest dry pod yield than variety JL-24 (V_1) and SB-XI (V_3) during both the years.

2. The high dry pod yield of the variety V_1 was not only attributed by one or more yield components but also was complimented by the physiological parameters like plant height, number of leaves, chlorophyll content in leaves, number of primary and secondary branches, root length, number of root nodules at all the growth stages.
3. Different fertilizer treatments had a significant impact on dry pod yield. It was the maximum and significantly the highest in recommended dose of fertilizer (F_1) than 75 per cent of RDF (F_2) and 50 per cent of RDF (F_3).
4. The liquid biofertilizer treatments differed significantly in respect of their influence on dry pod yield. The significantly highest dry pod yield was recorded due to different treatments of liquid biofertilizer over control. The treatment *Rhizobium* (Lb_4) was found to be superior followed by Bioplin (Lb_1) over rest of the treatments.
5. The increase in dry pod yield showed a close relationship with yield attributes *viz.*, number of pegs per plant, number of pods per plant, dry weight of pods per plant, 100 pod and kernel weight, harvest index etc. as all these components were increased by application of RDF (F_1) and liquid biofertilizer treatment *Rhizobium* (Lb_4) and Bioplin (Lb_1) over rest of the treatments.
6. The variety ICGV-86590 (V_1) recorded 30.18 per cent higher dry pod yield and JL-24 (V_2) 12.91 per cent than variety SB-XI (V_3) while recommended dose of fertilizer (F_1) and 75 per cent of RDF (F_2) showed 10.43 per cent and 4.93 per cent increase in dry pod yield, respectively over 50 per cent of RDF (F_3).

Biofertilizer treatments had significant impact on dry pod yield. It is observed from the present study that *Rhizobium* (Lb_4) recorded higher yield 33.50 per cent followed by Bioplin (Lb_1) 25.55 per cent, Phosfert (Lb_2) 18.28 per cent and Vitormone (Lb_3) 14.85 per cent over control (Lb_0) during the year 2000. Similar trend in per cent increase in dry pod yield within the varieties, fertilizer levels and liquid biofertilizer treatments were same during the year 2001.

7. The major yield contributing components in groundnut are number of pegs, number of pods per plant, dry weight of pods per plant 100 pod and kernel weight, harvest index etc. The high yielding variety ICGV – 86590 (V_1) recorded higher values of these components which leads to higher yield followed by JL – 24 (V_2) and lowest values were observed in the variety SB XI (V_3) which resulted in lowest dry pod yield than V_1 and V_2 during both the years.

8. The variety JL – 24 (V_2) recorded higher sound mature kernel (SMK) percentage over rest of the varieties. While fertilizer levels *viz.*, recommended dose of fertilizer (F_1) recorded highest SMK (%). However in biofertilizer treatment *Rhizobium* (Lb_4) and Bioplin (Lb_1) produced higher SMK percentage over rest of the treatments.

9. As regards to the shelling percentage the variety JL – 24 (V_2) recorded higher shelling percentage followed by the variety SB XI (V_3) while lowest values was recorded by the variety ICGV 86590 (V_1) during both the years. This is genotypical character and it was not influenced by the fertilizer levels and different biofertilizer treatments in the present study.

10. Harvest index is good measure of the efficiency of genotype for converting the biological yield into economic yield. Genotypes with high biomass coupled with high harvest index would be desirable for improving yield. In the present investigation the variety ICGV-86590 (V_1) recorded the highest harvest index. The higher pod yield in this variety mainly contributed to the efficient translocation of assimilates to organ having economic value i.e. pod in groundnut.

6.8 Soil analysis

1. The nitrogen status of the soil after harvest was improved by the variety ICGV - 86590 (V_1). It was also improved due to different levels of fertilizers and liquid biofertilizer treatments where RDF (F_1) and *Rhizobium* (Lb_4) recorded higher 'N' content in the soil after harvest.
2. Phosphorus content in the soil after harvest was influenced significantly where variety SB XI (V_3) observed highest P content followed by JL – 24 (V_2) regarding potassium content the trend was almost similar during both the years.
3.. The NPK uptake was influenced significantly where N uptake was higher by the variety ICGV – 86590 (V_1) followed by SB-XI (V_3) and the lowest N uptake was observed by the variety JL – 24 (V_2). Similarly the N uptake was significantly the highest under recommended dose of fertilizers. Whereas liquid biofertilizers had significant impact on uptake of N by groundnut.

4. Phosphorus uptake was varied within the varieties and it was higher under recommended dose of fertilizers and in combination of biofertilizers also.
5. The variety ICGV-86590 (V_1) utilized maximum K followed by variety SB-XI (V_3). While K uptake from the soil was maximum under recommended dose of fertilizer RDF (F_1) and different treatments of liquid biofertilizers.
6. Application of recommended dose of fertilizers and seed inoculation with biofertilizers (*Rhizobium* or Bioplin) culture would be a better proposition for *kharif* groundnut.

LITERATURE CITED

7. LITERATURE CITED

Ahmed, N. 1992. Effect of inoculation with P solubilizing organism on yield and P uptake of gram. J. Indian Soc. Soil Sci. 25 (4) : 391-393.

Anabusezhiyan. 1994. Dual activities of fungi in sulphur oxidation and phosphate solubilization. M.Sc. (Agri.) Thesis, submitted to MPKV, Rahuri.

Anandan, M. 2000. An Integrated approach of biofertilizers for sustainable agriculture, Intensive Agriculture, March-April 2000 : 9-11.

Anonymous. 2002. Agricultural statistics at a glance 2002. Directorate of Economics and Statistics, Deptt. of Agril. & Co-op. Ministry of Agril. Govt. of India, New Delhi.

Antony, E.; Doddamani, M.B.; Alagavadi, A.R. and Chetti, M.B. 2000. Response of groundnut genotypes to nitrogen levels and inoculation. Ann. agric. Res. 21 (2): 311-313.

Appleby, C.A. 1984. Leghaemoglobin and *Rhizobium* respiration. Ann. Rev. Pl. Physiol. 35 : 443-478.

Arunachalam, V.; Rao, P.S.K. and Mehta, S.L. 1993. Seed nitrogen and fatty acids reflecting yield variations in groundnut (*Arachis hypogaea* L.). Indian J. Agric. Sci. 63 (5): 289-291.

Bal, A.K. and Siddique, A.B.M. 1991. Fine structure of peanut root nodules induced by nod $^{+}$ fix $^{-}$ strains of *Brady rhizobium* with special reference to lipid bodies. Annals of Botany. 67 (4): 309-315.

Balasubramaniyan, A. 1995. Role of Biofertilizers in integrated nument management. National symposium on agriculture in reaction to environment. Held at IARI, New Delhi, on Jan. 16-18 Souvenir and abstracts. Indian Society of Agricultural Sciences. pp. 129.

Bandopadhyay, A.; Ghosh, P.K. and Mathur, R.K. 2000. Groundnut situation in India – The present scenario and future strategies. Indian Farming. May-2000. pp. 13-20.

Baronia, A.K. 2000. Effect of biofertilizers alone and in combination with fertilizers on yield and yield attributes of French bean (*Phaseolus vulgaris* L.). J. Soil and Crops. 10 (2): 206-209.

Baskar, M.; Solaimalal, A.; Sivakumar, C.; Sankaranarayanan, K. and Sudhakar, G. 2000. Role of phosphorus, zinc and phosphobacteria on soybean – A Review. Agric. Rev. 21 (1): 60-65.

Bell, M.J.; Shooter, R. and Mayer, R. 1991. Cultivar and environmental effects on growth and development of peanuts (*Arachis hypogaea* L.). Field Crop Res. 27 : 35-49.

Bell, M.J.; Wright, G.C. and Harch, G. 1993. Environmental and agronomic effects on the growth of four peanut cultivars in a sub-tropical environment, II. Dry matter partitioning. Experimental Agriculture. 29 (4): 491-501.

Bhattacharyya, P and R.K. Jain 2000. Phosphorus solubilising biofertilizers in the whirlpool of Rock phosphate – challenge and opportunities. Fertilizer News. Oct. Vol. 45 (10) : 45-49 & 51-52.

Briggs, G.E.; Kidd, F. and West, C. 1920. Quantitative analysis of growth. Ann. Appl. Biol. 7 : 103-202.

Champawat, R.S. 1991. Effect of micorhizal inoculation and phosphorus fertilizer on growth and nutrient uptake of groundnut (*Arachis hypogaea* L.). Indian J. of Agric. Sci. 60 (6): 425-427.

Chanway, C.P.; Turkington, R. and Holl, F.B. 1991. Ecological implications of specificity between plants and rhizosphere micro-organisms. Adv. in Ecol. Res. 21 : 121-169.

Chauhan, Y.S.; Jain, V.K.; Khandekar, M.P. and Jain, P.C. 1988. Response of groundnut (*Arachis hypogaea* L.) varieties to phosphorus fertilization. Indian J. of Agric. Sci. 58 (5): 359-361.

Chen, J.R. 1989. A trial on yield increasing effects of *Rhizobium* strain 1046 on groundnut. Zhejiang Agric. Sci. No. 2 : 74-75.

Christopher Lourduraj, A. Geethalakshmi, V. Devasenapathy, P., Nagarajan, P and Myilswami, V. 1996. Performance of different *Rehzobial* cultures in groundnut Madras Agric. J. 83 : 163-165.

Christopher, L.A. 1999. Nument mana pement in groundnut (*Arachis hypogaea* L.) cultivation. Agric. Rev. 20 (1): 14-20.

Das, S.N. and Bhaduri, P.N. 1975. Host *Rhizobium* interaction between *Phaseolus vulgaris* L. and *Rhizobium phaseoli*. Proceedings of the Indian National Science Academy. Part B. 40 : 554-561.

Deshmukh, D.D. and Dev, D.V. 1993. Nodulation in groundnut under different packages of practices during winter. Legume Res. 16 (4): 127-130.

Deshmukh, O.N. 1986. Investigation on physiological parameters associated with adaptability of groundnut genotypes to summer cultivation. M.Sc. (Agri.) Thesis submitted to MPKV, Rahuri (M.S.).

Deshumkh, V.N., Bhoyar, S.M. and Parlikar, A.D. 1995. Response of groundnut (*Arachis hypogaea* L.) to levels of FYM N and P fertilization. J. Soils and Crops. 5 (1) : 53-56.

Detroja, K.S.; Malvia, D.D.; Kaneria, B.B.; Khanpara, V.D. and Patel, R.K. 1997. Response of summer groundnut (*Arachis hypogaea* L.) to phosphorus, biofertilizers and seed size. Indian J. Agron. 42 (1): 165-168.

Dey, R.; Pal, K.K.; Chauhan, S. and Bhatt, P.M. 1999. Deleterious rhizobacterai associated with groundnut. International Arachis Newsletter (19): 48-49.

Dey, R.; Pal, K.K.; Chauhan, S.M. and Bhatt, D.M. 2000. Field evaluation of plant growth promoting Rhizobacteria of groundnut. International Arachis Newsletter (12): 77-79.

Dhumal, K.N., More, T.N. and Munnoli, M.A. 1997. Plant growth. A text book of Plant Physiology. First Edn. pp. 90-101.

Donald, C.M. 1962. In search of yield. J. Australian Inst. Agril. Sci. 28 : 171-178.

Dubey, S.K. 1997. Efficacy of phosphate solubilizing microorganisms and *Brady Rhizobium japonium* on yield of soybean (*Glycine max* L. Merill) in vertisol. Agric. Sci. Dig. 17 (4): 247-249.

Dubey, S.K. 1998. Response of soybean (*Glycine max* L.) to biofertilizers with and without nitrogen, phosphorus and potassium on swell-shrink soil. Indian J. of Agron. 43 (3): 546-549.

Dubey, S.K.; Ray, N. and Sharma, J.K. 1986. Effect of P and K doses on the yield attributes, yield and N content of kernels in groundnut (*Arachis hypogaea* L.). Indian Agriculturist. 30 (4): 269-273.

Dubey, Y.P. 2000. Biofertilizer – A component of plant nutrient supply system. Intensive Agriculture, March – April, 2000 : 13-14.

Duncan, W.G.; Cloud, D.S.; Mc Graw, R.L. and Boote, K.G. 1978. The physiological aspects of peanut yield improvement. Crop Science. 18 : 1015-1020.

Dutta, M.; Rao, B.S.; Nambiar, P.T.C.; Williams, J.H. and Dart, P.J. 1988. Ontogenic Nariation in nitrogen assimilation, nodulation and nitrogen fixation in groundnut (*Arachis hypogaea* L.) genotypes. Annals of Applied Biol. 112 (3): 537-545.

Gaur, Y.D., Sen, A.N. and Subba Rao, N.S. 1974. Use of *Rhizobium* strains to improve groundnut yield. Proc. Indian Nat. Sci. Acad., B 40 : 562.

Gaury, F.; Diem, H.G. and Dommergues, Y.R. 1982. Effect of inoculation with glomus mosseae on nitrogen fixation by field grown soybean. Pl. Soil. 68 (3) : 321-329.

Geethalakshmi, V.; Christopher, A.L.; John, A.J. and Rajamanickam, K. 1993. Nutrient management in groundnut. Madras Agric. J. 80 (7): 412-414.

Ghosh, G. and Pois, C. 1998. Response of *Rhizobium*, phosphate solubilizing bacteria and microrhizal organisms on some legume crops. Envir. Ecol. 16 (3) : 607-611.

Ghosh, P.K. and Naik, P.R. 1999. Effect of biozyme on fertilizer use efficiency and yields of summer groundnut (*Arachis hypogaea* L.). Fertilizer News. 44 (7): 53-54.

Gillber, K.E.; Nambiar, P.T.C.; Rao, B.S.; Dart, P.J. and Day, J.M. 1987. A comparison of nitrogen fixation in genotypes of groundnut (*Arachis hypogaea* L.) using ^{15}N – isotope dilution. Biology and Fertility of Soils. 5 (1): 23-25.

Glick, R.B. 1995. The enhancement of plant growth promotion by free living bacteria. Canadian J. of Microbiol. 41 : 109-117.

Goodwin, P.B. and Erwee, M.B. 1983. The growth and functioning of leaves (Eds. J.E. Dale and F.L. Milthrope). Cambridge University Press, New York, pp. 207.

Gowri, K.V.; Subrahmanyam, M.V.R. and Bheemaiah, G. 2000. Influence of leguminous and non-leguminous tree species on yield and economics of rainfed groundnut under nitrogen and phosphorus fertilization. Indian J. of Agric. Sci. 70 (6): 413-415.

Gregory, D.J. 1926. The effect of climatic conditions on the growth of barley. Ann. Bot. 40 : 1-26.

Grewal, H.S.; Bains, D.S. and Brar, S.S. 1989. Effect of N, P, K and Zn application on nodulation and uptake of N, P and K by groundnut grown in rotation after wheat. Annals of Biology. 5 (1): 69-76.

Gulati, S.L. 1989. Effect of inoculum concentration of *Rhizobium* japonicum on *Glycine max*. Indian J. agric. Res. 59 (1) : 59-60.

Gupta, A.; Gopal, M. and Tilak, K.V. 2001. Rhizobacteria from field grown mungbean : Plant growth promoting potential. Indian J. agric. Res. 35 (1): 31-35.

Hanway, J. and Heidal, H.S. 1967. Soil analysis methods as used in Iowa State College. Soil Testing Lab., Iowa Agric. Univ. 57 : 1-31.

Hasan, H.R.; Delowara, K. and Maqbul Hossain, A.K. 1992. Effect of inoculation and fertilization on growth and yield of some varieties of groundnut. Legume Res. 15 (3): 137-140.

Hegde, S.V. 2000. Liquid *Rhizobium* fertilizer for improved quality and performance. Bioferti. Newslett. Dec. 2000, pp. 7-8.

Huang, X.Z. 1991. The effects of different nitrogen levels on nodulation, nitrogen supply and yield of groundnuts. J. of South China Agric. Univ. 12 (1): 68-72.

Jackson, M.L. 1968. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi. pp. 498.

Jain, N.K., Jain, H.C. and Khandkar, U.R. 1988. Response of *kharif* legumes to fertilizer and Rhizobium inoculation. India J. Agron. 33 (4) 347-350.

Jena, P.K., Barik, A., Ghatak, S., Mukherjee, A.K. and Sounda, G. 1990. Effect of nitrogen, phosphorus and potassium on yield and yield attributes of rainfed groundnut (*Arachis hypogaea* L.). Indian J. of Agric. Sci. 60 (1) : 49.51.

Jeyabal, A.S., Palaniappan and Chellian, S. 1999. Response of groundnut to fertilizer and bio-fertilizer application. The Andhra Agric. J. 46 (1 and 2) : 11-14.

Jorden, D.C. and Garrad, E.H. 1951. Estimation of leghaemoglobin from nodules. Canadian J. Bot. 29 : 360-371.

Joshi, P.K., Kulkarni, J.H. and Bhatt, D.M. 1990. Interaction between strains of Bradyrhizobium groundnut (*Arachis hypogaea* L.) cultivars. Tropical Agriculture. 67 (2) : 115-118.

Joshi, P.K., Kulkarni, J.H., Chauhan, S. and Sojitra, V.K. 1987. A comparison of rhizosphere microflora in two varietal forms of groundnut (*Arachis hypogaea* L.). Zentralblatt for mikrobiologie. 142 (7) : 515-519.

Joshi, S.S., Thorve, P.V., and Nagre, K.T. 1981. Effect of *Rhizobium* inoculation and nitrogen application on root nodulation of groundnut and soybean. PKV Res. J. 15 (2-2) : 157-158.

Kalaiselven, P., Subrahmaniyan, K. and Arulmozhi, N. 2000. Evaluation of different Rhizobium strains for groundnut (*Arachis hypogaea* L.) Res. on Crops. 1 (2) : 156-158.

Kene, D.R., Pathey, M.K., Thakare, K.K. 1988. Effect of graded levels of nitrogen and molybdenum on root nodulation and nitrogen fixation by Rhizobium in groundnut grown in vertisol. PKV Res. J. 12 (2) : 155-157.

Khan, B.H., Mahajan, S.V. and Sonar, K.R. 1989. Relative importance of soil and fertilizer nutrients for groundnut yield. J. Maharashtra Agric. Univ. 16 (2) : 139-241.

Kloepper, J.W., Hume, D.J., Scher, F.M., Singleton, C., Tipping, B., Laliberte, M., Frawley, K., Kutchaw, T., Simonson, C., Lifshitz, R., Zalesna, I. and Lee, L. 1988. Plant growth promoting bacteria on Canola (rapseed). Plant Disease. 72 : 42-46.

Kloepper, J.W.; Zablotowicz, R.M., Tipping, E.M. and Lifshitz, R. 1991. Plant growth promotion mediated by bacterial rhizosphere colonizers. Bettsville Symposia in Agric. Res. held at Beltsville, Maryland, USA on May, 8-11, No. 14, pp. 315-326.

Kshirasagar, C.R., Mandhare, V.K., Kalbhor, H.B. and Patil, P.L. 1994. Field response of French bean to single and composite Rhizobium inoculation. J. Maharashtra Agric. Univ. 19 (3) : 461-462.

Kucey, R.M.N. and Toomsan B. 1988. Peanal cultivar responses to Bradyhizobium inoculation. In Northease Thailand. Peannut, Sci. 15 : 63-90.

Kulkarni, J.H., Joshi, P.K. and Sojitra, V.K. 1984. Response of groundnut varieties to inoculation with Rhizobium strain India J. Agric. Sci. 54 (7) : 586-589.

Kulkarni, J.H., Joshi, P.K. and Sojitra, V.K. 1986. Influence of phosphorus and potassium application on nodulation, nitrogen accumulation and yield of groundnut. Legume Res. 9 (1) : 34-38.

Kulkarni. J.H. 1989. Growth and nodulation of peanut as influenced by cotyledon removal. Annals of Pl. Physol. 3 (1) : 91-94.

Kune, N.N., Kolte, S.O., Chitriv, A.J. and Wangikar, P.D. 1989. Bio-fertilizer in Vidarbha present and prospects. PKV. Res. J. 13 (2) : 168-169.

Lee, J.S., Cho, K.J., Nam, M.H. and Kang, V.G. 1990. Influence of gypsum and microelement fertilization on groundnuts with inoculation of Rhizobium sp. Research Report of the Rural Development Administration Soil and Fertility. 32 (1) : 47-51.

Mahale, S.S., Singh O.P., Sawant, C.V. 1991. Effects of different levels of nitrogen and phosphorus on different varieties of groundnut of Maharashtra Agric. Univ. 16 (1) : 137-138.

Malewar, G.U., Indulkar, B.S. and Malewar, V. 1992. Involvement of zinc in nodulation and N fixing indices in peanut. Annals of Pl. Physiol. 6 (2) : 232-237.

Mane, S.S., Raut, S.S. and Kohire, O.D. 1993. Comparative performance of VAM fungus and Rhizobium inoculation with groundnut. Annals. Pl. Physiol. 7 (1) : 116-118.

Martinez, V.R., Esquivel, M., Casanova, I., Walon, L. 1988. The potential of establishing symbiotic nitrogen fixation in peanut germplasm. Ciencias-de-la-Agriculture No. 33 : 5-10.

Mc Lachlan, K.D. and Norman, B.W. 1991. Symbiotic nitrogen fixation in subterrvanean clever. J. Aust. Inst. Agric. Sci. 27 : 244-245.

Melli, M. 1990. Effect of nitrogen fixation and mineral fertilizer applications in the semiarid environment of India. rivista de Agricultura Subtropicalle Tropical. 84 (3) : 457-472.

Mishra, S.K. and Baboo, R. 1999. Effect of nitrogen, phsophorus and seed incoulation on cowpea (*Vigna unguiculata*). J. Agron. 44 (2) : 373-376.

More, B.B., Patil, S.L. and Konde, B.K. 1981. Effect of Rhizobium inoculants under various levels of Nitrogen on nodulation and yield of peanut (*Arachis hypogaea* L.) J. of Maharashtra Agric. Univ. 6 (1) : 13-16.

More, S.D. and Jadhav, V.D. 1997. Effect of cobalt application and Rhizobium inoculation on nodulation, yield and nitrogen uptake in soybean. J. Maharashtra Agric. Univ. 22 (1) : 106-108.

Muhammed, S.V., Ramchandran, M.R. and Ramanathan, T.R. 1973. Fertilizer response and yield potential of TMV – 7 groundnut. Inidan J. Agric. Sci. 43 (1) : 67-69.

Nagaraj, G and Kumar, K. 1986. Nutrient uptake and partitioning in two Virginia varieties of groundnut (*Arachis hypogaea* L). Legume Res. 9 (1) : 50-54.

Nagre, K.T., Joshi, S.S. and Thorve, P.V. 1991. Effect of Rhizobium inoculation and nitrogen application on root nodulation of groundnut and soybean. PKV, Res. J. 15 (2) : 157-159.

Naidu, P. H. 2000. Response of bunch varieties of groundnut to Rhizobium inoculation. Legume Res. 23 (2) : 130-132.

Narayanan, A., Babu, V.B. and Reddy, G.L. 1991. Comparison of food legumes during their early vegetative phase for growth characterisitics and fertilizer response. Indian J. of Pl. Physiol. 34 (1) : 42-47.

Nautiyal, C.S. 2000. Plant beneficial Rhizosphere competent bacteria. Proc. Nat. Acad. Sci. India. 70 (13), II : 107-123.

Normon, J.C. and Chongo, W.C. 1992. Dry matter accumulation and partitioning in bambara groundnut [*Vigna subtervanea* (L). Verde] after anthesis. Adv. in Hort. Sci. 6 (3) : 116-120.

Olsen, S.R. Cole, C.G., Watanabe, F.S. and Dean, F.A. 1954. Estimation of available P in soil by extraction with $NaHCO_3$ USDA Cir : 919-939.

Pachpute, S.K. 1984. The influence of environment on the growth and yield of groundnut (*Arachis hypogaea* L.) varieties. M.Sc. (Agri.) Thesis submitted to MPKV, Rahuri (M.S.).

Pal, K.K. Dey, R., Bhatt, D.M. and Chauhan, S. 1999. Enhancement of groundnut growth and yield by plant prowth promoting rhizobacteria. International Arachis Newsletter. (12) : 51-52.

Panse, V.G. and Sukhatme, P.V. 1985. Statistical methods for agricultural workers. ICAR, New Delhi, 4th radiation pp. 187-202.

Pant, L.M. and Katiyar, A.K. 1996. Response of groundnut to fertilizer nitrogen, farm yard manure and Brady rhizobium inoculation. Agric. Sci. Dig. 16 (1) : 52-54.

Pawar, N.B. and Ghulghule J.N. 1980. Preliminary observations on occurrence and subsequence of root nodules in some pluses. Tropical Grain Legume Bulletin 17 (8) : 3-5.

Piper, C.S. 1966. Soil and plant analysis. Indian Ed. Hans Publisher, Bombay.

Polara, K.B., Patel, C.L. and Yadav, B.S. 1991. Accumulation and partitioning of dry matter and nutrients in groundnut. Indian J. of Pl. Physiol. 34 (2) : 122-125.

Rahman, M.H., Khanam, D. and Hossain, A.K.M. 1992. Effect of inoculation and fertilization on growth and yield of some varieties of groundnut. Legume Res. 15 (3) : 137-140.

Rajendran, K. and Veeraputhiran, R. 2001. Phosphorus nutrients in sunflower – A Review. Agric. Rev. 22 (1) : 68-70.

Rajeswari, V.R. 1990. Effect of applied nitrogen and *rhizobial* inoculation traits in groundnut (*Arachis hypogaea* L.). Andhra agric. J. 37 (4) : 407-409.

Rajeswari, V.R. 1991a. Influence of applied nitrogen and *rhizobial* inoculation on nodulation, root nitrogenase and leaf nitrate reductase activity in groundnut [*Arachis hypogaea* (L.)]. Annals of Pl. Physiol. 5 (2) : 142-147.

Rajeswari, V.R. 1991b. Effect of applied nitrogen and *rhizobial* inoculation on the nutrient uptake in groundnut. Annals of Agric. Res. 12 (4) : 403-407.

Raju, M.S. and Verma, S.C. 1984. Response of Green gram (*Vigna radiata*) to *rhizobial* inoculation in relation to fertilizer nitrogen. Legume Res. 7 (2) : 60-73.

Rao, S.K. Katariya, V.P. Gupta, A.K.S. and Kushwaha, J.S. 1983. Factors influencing pod yield and oil production and their implications in selection of high yielding groundnuts. Legume Research 6 92) : 61-64.

Rasal, P.H., Patil, P.L. and Kalbhor, H.B. 1998. Effect of VA-mycorrhiza and *Rhizobium* inoculation on gram. J. Maharashtra agric. Univ. 13 (3) : 359-360.

Raut, R.S., Ghonsikar, C.P. and Musande, V.G. 1980. Effect of composite culture of *Rhizobium* on important legumes grown in Marathwada region. In aspects of biological nitrogen fixation: Proceedings of the Third Southern Regional Conference on Microbial Inoculants in Crop production, 1-2 April, 1977. Dharwad, UAS. Technical Series No. 28, Bangalore. pp 19-21.

Raverkar, K.P. 1995. Bio-fertilizers : A boon for sustainable production and safe environment. National symposium on agriculture in relation to environment. Held at IARI, New Delhi on Jan. 16-18. Souvenir and abstracts. Indian Society of Agricultural Sciences pp. 130.

Reddy, R.R., Moses, G.T., Rahman, M.A. 1990. Compatibility studies on seed treatment with fungicide and *Rhizobium* and fertilizer application in groundnut J. of Res. APAU. 18 91) : 87-89.

Rooge, R.B., Patil, V.C. and Ravikishan, P. 1998. Effect of phosphorus application with phosphate solubilizing organisms on the yield, quality and P uptake of soybean. Legume Res. 21 (2) : 85-90.

Sable, R.N. 1980. Response of summer groundnut (*Arachis hypogaea* L.) variety SB-XI to moisture regimes, phosphate, antitranspirants and their combination. Ph.D. Thesis submitted to MPKV, Rahuri (M.S.).

Sable, R.N. and Khuspe, V.S. 1986. Effect of moisture phosphate and antitranspirants on growth, dry matter and yield of summer groundnut. J. Maharashtra agric. Univ. 11 (1) : 13-16.

Sahrawat, K.L., Srinivasa Rao, R.B. and Nambira, P.T.C. 1988. Macro and micronutrient uptake by nodulating and non-nodulating peanut lines. Plant and Soil. 109 (2) : 291-293.

Sairam, R.K., Tomar, P.S., Harika, A.S. and Ganguly, T.K. 1989. Effect of phosphorus levels and inoculation with *Rhizobium* on nodulation, leghaemoglobin content and nitrogen uptake in fodder cowpea. Legume Research. 12 (1) : 27-30.

Samarasinghe, P.W.S.M. and Tanner, J.M. 1989. Dry matter partitioning and growth analysis of peanut. Tropical Agriculturist. 145 : 103-111.

Sankar, A.S., Reddy, P.R. and Subba Rao, I.V. 1984. Nodulation and nitrogen fixation in groundnut as affected by seed size and phosphorus. Legume Res. 7 (1) : 1-5.

Sanoria, C.L. and Prasad, J.L. 1984. Associative effect of *Rhizobium* and *Azotobacter* at different levels of phosphorus on yield and nutrient content of Bengal gram (*Cicer arietinum* L.. Legume Res. 7 91) 13-16.

Sardhi, K., Subhash, G. and Raghavelu, G.V. 1990. Effect of graded levels of nitrogen and phosphorus on growth and yield of groundnut on sandy soils. Andhra Agri. J. 37 (2) : 122-124.

Sekhon, H.S., Singh, G.B., Singh, N.T., Sharma, P.N. and Khurana, A.S. 1995. Influence of nitrogen fertilization and *Rhizobium* inoculation in field pea (*Pisum sativaum* L.). National Symposium on Agriculture in relation to environment held at IARI, New Delhi on January 16-18. Souvenir and Abstracts. Indian Society of Agril. Sciences. pp. 133.

Shaheen, A. and Rahmatullah, 1994. Differential growth nodulation and N fixation efficiency of groundnut cultivar inoculated with different *Rhizobium* strains. J. of Agron. and Crop. Sci. 173 (5) : 289-292.

Shridhar, R.; Ramalingam, R.S. and Sivaram, M.R. 1989. Studies on the use of some strains of *Rhizobium* to improve groundnut yield and quality of field pea (*Pisum sativum* L. var. Arvense poir). Legume Res. 7 (1) : 37-42.

Shrivastava, S.N.L. and Verma, S.C. 1984. Effect of nitrogen, *Rhizobium* and techniques of phosphorus application on yield and quality of field pea (*Pisum sativam* L. Var. Arvense Poir). Legume Res. 7 (1) : 37-42.

Singh, H.P. 1991. The friendly microorganisms. Intensive Agriculture, May-June No 5 & 6 Vol. XXIX, pp. 26-30.

Singh, K.K. and Mishra, J.P. 1998. Bio-fertilizer in pulses. Fertilizer News (Dec.) 43 (12) : 91-102.

Singh, O.B., Sharma, H.B. and Singh, V.K. 1999. Effect of nitrogen, phosphorus and *Rhizobium* culture on yield and yield attributes of lentil under dryland conditions. Indian J. of Pulses Res. 12 (2) : 260-262.

Singh, V.K., Paliwal, A.K. and Singh, R.N. 1994. Response of groundnut (*Arachis hypogaea* L.) to phosphorus and potassium. Indian J. Agron. 39 (4) : 694-695.

Soddi, R.R., Sreenivasa, M.N., Chittapur, B.M., Babalad H.B. 1994. Field response of cowpea to the dual inoculation of VAM and *Rhizobium* at different fertilizer levels.

Subhiya, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 25 : 259-260.

Talashilkar, S.C. Dosani, A.A.K., Mehta, V.B. and Pawar, A.G. 1997. Integrated use of fertilizers on poultry manures. J. Maharashtra agric. Univ. 22 (2) : 205-207.

Tang, W.H. 1994. Yield increasing bacteria (YIB) and biocontrol of sheath blight of rice. In improving plant productivity with *Rhizosphere* bacteria (Ryder, M.H., Stephens, P.M. and Bowen, G.D. eds.) Adelaide, Australia : Common Wealth Scientific and Industrial Research Organization. pp 267-278.

Thakare, C.S. and Rasal, P.H. 2000. Evaluation of efficient *Rhizobium* strains for groundnut. Legume Res. 23 (4) : 259-261.

Thakre, C.S.; Rasal, P.H. and Patil, P.L. 1999. Evaluation of *Bradyrhizobium* strains for soybean. Legume Res. 22 : 26-30.

Thirumalaisamy, K. and Ramanathan, T. 1988. Relationship of total biomass and harvest index with yield in groundnut. Madras agric. J. 75 (7-8) : 299-302.

Tomar, S.S., Pathan, M.A., Gupta, K.P. and Khandkar, U.R. 1993. Effect of phosphate solubilzing bacteria at different levels of phosphate on Blackgram (*Phaseolus mungo*) Indian J. Agron. 38 (1) : 157-158.

Tripathi S.D. and Sandria, C.L. 1993. Groundnut inoculation with *Rhizobial* strains in Entisol of Varanasi, Uttar Pradesh. Groundnut News. 5 (1) : 7.

Turner, J.T., Backman, P.A. 1991. Factor relating to peanut yield increases after seed treatment with *Bacillus subtilis*. Plant Disease. 75 (4) : 347-353.

Upadhyay, R.G., Sharma, S. and Daramwal, N.S. 1999. Effect of *Rhizobium* inoculation and graded levels of phosphorus on the growth and yield of summer green gram (*Phaseolus radiatus* L.) Legume Res. 22 (4) : 277-279.

Vaddoria, M.A. and Patel, V.J. 1992. Character association and path analysis in Virginia runner groundnut (*Arachis hypogaea* L.). Madras Agric. J. 79 (9) : 500-504.

Varshney, J.G. 1981. Inoculation and nitrogen requirement (Grow soybean in Maghalaya). ICAR Res. India Farming. 4 : 5-6.

Varshney, J.G. 1989. Effect of *Rhizobium* and nitrogen on the yield and quality of groundnut and soybean. P.K.V. Res. J. 13 (2) : 152-153.

Wange, S.S. 1990. Competition between inoculated and native *Rhizobi* for nodulation of groundnut. J. of Maharashtra Agric. Univ. 15 (1) : 114-116.

Wankhede, S.Z., Dabre, W.M., Lanjawar, B.K., Sontakey, P.Y. and Takzure, S.C. 1991. Seed inoculation studies with *Rhizobium* and molybdenum on growth functions and yield of groundnut. New Agriculturist. 1 (2) : 159.160.

Wankhede, S.Z., Dabre, W.M., Lanjewar, B.K., Sontakey, P.Y. and Takzure, S.C. 1992. Effect of seed inoculation with *Rhizobium* culture and molybdemum on yield of groundnut (*Arachis hypogaea* L.) Indian J. of Agron. 37 (2) : 384-385.

Yadav, R.P. and Shrivastava, U.K. 1997. Response of chickpea (*Cicer arietinum*) to phosphorus and bio-fertilizers. Legume Res. 20 (2) : 137-140.

Yashiki, T., Takatiashi, Y., Kiho, N. and Shibuya, M. 1991. Partitioning of fertilizer nitrogen and its contribution to total nitrogen accumulation in groundnut plants. Bulletin of the chiba prefectural Agricultural experiment Station No. 32 : 91-97.

Zablotowicz, R.N. and Focht, D.D. 1981. Nodulation and nitrogen fixation of field grown California cowpea as influenced by well irrigated and drought conditions. Agron. J. 73 (1) : 9-12.

* Originals not seen

VITA

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SUKDEV KISANRAO RANSING

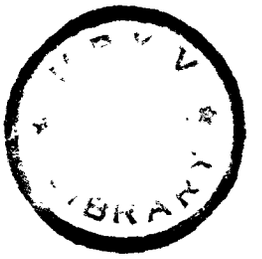
A candidate for the degree

of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

PLANT PHYSIOLOGY



Title of the thesis : "Studies on effect of liquid bio-fertilizers on morpho-physiological and bio-chemical parameters influencing yield of groundnut (*Arachis hypogaea* L.) during *Kharif* season"

Major field : Plant Physiology

Biographical information :

Personal :
- ❖ Born on August 1st, 1962 at village Arendoli, Tal. Shrigonda, Dist. Ahmednagar.
- ❖ Son of Shri. Kisanrao Bajirao Ransing

Educational :
- ❖ Attended Primary and Secondary School at Wadgaon (Tandali), Tal. Nagar, Dist. Ahmednagar and Higher Secondary education from Residential Jr. College, Ahmednagar.
- ❖ Received B.Sc. (Agri.) degree in first class with Distinction (1985) and M.Sc. (Agri.) (1987) in Plant Physiology from Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar.
- ❖ Recipient of Merit Scholarship during undergraduate and post graduate studies.

Service details :
- ❖ Junior Research Assistant at All India Coordinated Cotton Improvement Project, MPKV, Rahuri (1988 to 1992) and Senior Research Assistant 1993 onwards.
- ❖ Published fifteen research papers in various journals and ten popular articles.
- ❖ Published one book entitled, "Morphological characters of field and forage crops".

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