# EFFECT OF LIME, FARMYARD MANURE AND FERTILIZERS ON GROWTH, YIELD AND QUALITY OF SOYBEAN (*Glycine max* L. Merril) IN ACID SOILS OF NAGALAND

Thesis

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DOCTOR OF PHILOSOPHY

in

AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

By


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*Dedicated to my Parents,*

*Pratsolie Mere & Vegwu Mere,*

*and my siblings*

*Athonuo,*

*Angunuo,*

*Neitso*

*&*

*Ahezo*

## STUDENT'S DECLARATION

I, Mr. Vibeilie Mere, hereby declare that the subject matter of this Thesis is the record of work done by me, that the contents of this Thesis did not form the basis of the award of any previous Degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree to any other University/ Institute.

This is submitted to SASRD, Nagaland University for the Degree of Doctor of Philosophy in Agricultural Chemistry and Soil Science.

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## CERTIFICATE - I

This is to certify that the Thesis entitled "Effect of lime, farmyard manure and fertilizers on growth, yield and quality of soybean (*Glycine max* L. Merril) in acid soils of Nagaland" submitted to Nagaland University in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in the discipline of Agricultural Chemistry and Soil Science, is a record of research work carried out by Mr. Vibeilie Mere, Registration No. 611/2014, under my personal supervision and guidance.

All help received by him have been duly acknowledged.

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## CERTIFICATE - II

This is to certify that the Thesis entitled "Effect of lime, farmyard manure and fertilizers on growth, yield and quality of soybean (*Glycine max* L. Merril) in acid soils of Nagaland" submitted by Mr. Vibeilie Mere, Admission No. Ph-128/12, Registration No.611/2014, to Nagaland University in partial fulfilment of the requirements for the DOCTOR OF PHILOSOPHY in the discipline of Agricultural Chemistry and Soil Science has been examined and approved by the student Advisory Committee and the External Examiner, after viva voce.

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## ABSTRACT

Field experiment was conducted with lime, farmyard manure and fertilizers for two consecutive years during 2014 and 2015. Treatments consisted of lime – Zero, 400 kg/ha (furrow application) & 10% of LR ($L_0$, $L_1$, $L_2$ respectively), FYM – Zero & 5 tonnes $ha^{-1}$ on dry weight basis ($O_0$, $O_1$ respectively) fertilizers – Zero, 50% RDF, 75% RDF & 100 % RDF ($I_0$, $I_1$, $I_2$, $I_3$ respectively).

Plant height was found to be significantly higher during the entire period of plant growth where treatments received lime, FYM and fertilizers in adequate amounts. The same trend was observed in case of number of nodules, fresh and dry weight of nodules. Treatment $L_2O_1I_3$ gave significantly higher biological yield (6848.40 kg $ha^{-1}$, 6852.50 kg $ha^{-1}$), seed yield (2300.50 kg $ha^{-1}$, 2302.17 kg $ha^{-1}$) and stover yield (4547.90 kg $ha^{-1}$, 4550.33 kg $ha^{-1}$) than rest of the treatments. The numbers of seeds per pod and seed index were found to be non-significant. However, number of pods per plant was higher in $L_2O_1I_3$. pH of the soil was not significantly affected by treatments. Organic carbon was found to be significantly higher in $L_2O_1I_3$ (1.76 %) compared to control in both the years. Exchangeable calcium and magnesium [8.51{cmol (p) $kg^{-1}$} and 8.52 {cmol (p) $kg^{-1}$}, 1.80 {cmol (p)$kg^{-1}$} and 1.83 {cmol (p)$kg^{-1}$} respectively] contents were significantly higher with $L_2O_1I_2$ in soil after harvest of crop, compared to the rest of the treatments during both the years. Highest NPKS (400.77 kg $ha^{-1}$ and 400.50 kg $ha^{-1}$, 24.45 kg $ha^{-1}$ and 25.11 kg $ha^{-1}$, 109.76 kg $ha^{-1}$ and 108.43 kg $ha^{-1}$, 0.44 mg $kg^{-1}$ and 0.46 mg $kg^{-1}$ respectively) content at harvest were associated with treatment of $L_2O_1I_3$. Uptake of NPKS in seed as well as stover followed the same trend as it was with soil. Oil content in seed was not significantly affected by the treatments. However, oil and protein yield were higher in $L_2O_1I_3$ treatment.

## CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF PLATES

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| @ | - | at a rate of |
| cm | - | Centimetre |
| CD | - | Critical Difference |
| DAS | - | Days after Sowing |
| ºC | - | Degree Celsius |
| Ca | - | Calcium |
| CEC | - | Cation exchange capacity |
| E | - | East |
| EC | - | Electrical conductivity |
| *et al.* | - | *et allia* (and others/co-workers) |
| Fig. | - | Figure |
| FYM | - | Farmyard manure |
| g | - | Gram |
| ha | - | Hectare |
| HIV | - | Human immunodeficiency virus |
| ICAR | - | Indian Council of Agricultural Research |
| i.e. | - | Id est (that is) |
| kg | - | Kilogram |
| Max. | - | Maximum |
| m | - | Metre |
| $m^2$ | - | Metre square |
| msl | - | Mean sea level |
| MT | - | Metric Tonnes |
| Mg | - | Magnesium |
| mg | - | Milligram |
| Min. | - | Minimum |
| N | - | North |
| NEHR | - | North Eastern Hill Region |
| NPK | - | Nitrogen Phosphorus Potassium |
| NPKS | - | Nitrogen Phosphorus Potassium Sulphur |
| NU | - | Nagaland University |
| No. | - | Number |

| | | |
|---|---|---|
| $^{-1}$ or / | - | Per |
| % | - | Per cent |
| RDF | - | Recommended Dose of Fertilizers |
| SASRD | - | School of Agricultural Sciences and Rural Development |
| Sl. No. | - | Serial number |
| S | - | South |
| SSPD | - | Split split plot design |
| SEm± | - | Standard error of mean |
| var. | - | Variety |
| *viz.* | - | Videlicet (Namely) |
| W | - | West |

# *CHAPTER - I*

# *INTRODUCTION*

# INTRODUCTION

Soybean (*Glycine max* L. Merril) is a leguminous crop and it belongs to the family Leguminosae. It is rich in high quality protein (40-42%), oil (18-20%) and other nutrients like calcium, iron and glycine and also a good source of isoflavones. Soybean helps in preventing heart diseases, cancer, HIV etc (Kumar, 2007). Soybean protein is rich in lysine (5%), a valuable amino acid in which most of the cereals are deficient. In addition, it contains good amount of minerals, salts and vitamins (thiamine and riboflavin). Its sprouting grains contain a considerable amount of vitamin C, minerals, salt, thiamine and riboflavin (Singh *et al.*, 2003). Soybean being a good source of best quality protein and fat and hence called as vegetarian meat and also as wonder crop.

Eastern Asia or China is reported to be the origin of soybean. Globally, soybean has ranked first amongst various oilseed crops, contributing approximately 25% to the world's total oil and fat production. The world's soybean area, production and productivity are 120.78 million ha, 320.51 million tonnes and 2654 kg $ha^{-1}$ respectively (Anonymous, 2015-16). In India, area under soybean cultivation is 11.07 million hectares with a production of 8.64 million tonnes (Anonymous, 2015-16). Nearly 80% of the total soybean is produced in the states of Madhya Pradesh while Maharashtra, Rajasthan and Andhra Pradesh are also major producers.

Soybean has a very good adaptability towards a wide range of soils and climate. Soybean requires an optimum temperature of $26^oC$ to $30^oC$ and the crop does not grow if the temperature falls below $10^oC$ and above $40^oC$. The growth, flowering and seed formation are also effected by temperature. It is a short day plant and sensitive to photoperiods. The best type of soil is sandy loam having good organic manure content. Soils with a normal pH of 7 and a fair degree of water retention capacity are however better suited for its cultivation. The north eastern region of India is one of the soybean producing belts of India. It is grown on slopes, jhum land, terraces and plains. It is a potential crop of the region and grown primarily as a pulse crop as well as intercrop with maize, Italian finger millet, pigeon pea etc. The farmers of NEH region give very little priority for its cultivation at large scale. Like other leguminous crops, requirement of nitrogen is substantially fulfilled by symbiotic nitrogen fixation through *Rhizobium*.

It is one of the most popular food item for majority of the Nagas and is utilized as a fermented product as well as a pulse crop. Soybean is used for making high protein food for children. A large number of Indian and western dishes such as bread, `chapati', milk, sweets, pastries etc., can be prepared with soybean. It is widely used in the industrial production of different antibiotics. Soybean builds up the soil fertility by fixing adequaate amounts of atmospheric nitrogen through the root nodules, and also through leaf fall on the ground at maturity. It can be used as fodder; forage can be made into hay, silage etc. Its forage and cake are excellent nutritive foods for livestock and poultry. Approximately 85% of soybean produced is used for oil extraction, 10% for seed and 5% for food. Soybean contains less starch thus it is good for diabetic patients and its oil is used for human food, various pharmaceuticals, disinfectants, printing ink and soaps.

The agro-climatic conditions prevailing in Nagaland have been found to be highly favourable for soybean cultivation. Soil contains various nutrient that enables the plants to grow but these nutrient sources gets exhausted due to continuous extraction by plants. Hence, knowledge and information's about the physico-chemical properties of the soil is necessary to obtain optimum returns from the field and for proper nutrient management. The physico-chemical properties of soils in different parts of Nagaland still remain to be critically evaluated. There is widespread lack of basic information's and this becomes a hurdle in application of modern agricultural technologies, new farming practices and application of nutrient sources. The application and consumption of fertilizers in north east region of India in general and Nagaland in particular is still very low compared to the national average. Nagaland consumed 4.8 kg $ha^{-1}$ of NPK and NEH region consumed 51.75 kg $ha^{-1}$ of NPK, while the national average stood at 128.34 kg $ha^{-1}$ of NPK (Anonymous, 2013). The productivity and income from soybean has declined over the years because of nutrient depletion. Moreover, continuous imbalanced fertilization also has deteriorated soil health. Therefore, the situation warrants adoption of integrated nutrient management systems (Sikka *et. al.* 2013). Since no single source is enough to meet the needs of all the plant nutrients, integrated use of all the sources namely organic manures, fertilizers and Biofertilizers needs careful attention. Soybean responds well to both organic and inorganic fertilizers.

Keeping all the above facts in view, the present investigation entitled "Effect of lime, farmyard manure and fertilizers on growth, yield and quality of soybean (*Glycine max* L. Merril) in acid soils of Nagaland" is being undertaken with the following objectives,

- To study the effect of lime, FYM and fertilizers on growth and yield of soybean.
- To study the effect of different levels of lime, FYM and fertilizers on nutrient uptake and nutrient use efficiency.

- To study the crude protein and oil content of soybean as affected by lime, FYM and fertilizers
- To study the effect of lime, FYM and fertilizers on soil fertility status at harvest of the crop.

# *CHAPTER - II*

# *LITERATURE REVIEW*

# LITERATURE REVIEW

## 2.1. Effect on growth attributes

The effect of various organic amendments to soil on the yield, nodulation and nitrogen fixation by soybean variety Bragg was studied by Dev and Tilak (1976). Soil amended with manures recorded better nodulation, more leghaemoglobin synthesis and consequently higher nitrogen fixation than the unammended soils and the cakes amended soils. Application of cakes beyond 2.5 tonnes $ha^{-1}$ to the soil impaired the nitrogen fixation because of poor nodulation.

Sharma and Dixit (1987) reported that the effect of N fertilizer in general caused significant increase in growth and yield of soybean but highest seed yield (23 q $ha^{-1}$) and uptake of N, P, K, Ca and Mg. Protein and oil yield were increased by the combined use of fertilizer and FYM.

The growth attributes of soybean were greater in summer and higher doses of nitrogen and phosphorus increased the dry matter production (Singh and Gopalaswamy, 1991).

A field experiment to study the effect of N and P application on productivity of soybean was conducted by Jat and Nepalia (1995) and they reported that the yield attributing characters like pods $plant^{-1}$, seeds $pod^{-1}$ and test weight increase significantly by the application of 60 kg N $ha^{-1}$.

The profitability of conventional and mixed organic farming on Soybean crop was studied by Rajput *et al.* (1995) and results showed that soybean yield increased by 53% under mixed organic farming and the cost benefit ratio of soybean was double in the mixed organic farming area than conventional farming.

Sharma (1996) reported that the level of sulphur from 0-50 kg $ha^{-1}$ and sources of sulphur significantly influenced seed yield, quality and economics of soybean. The highest seed yield, oil, protein content and net return were obtained at 50 kg S $ha^{-1}$ through gypsum.

The combined use of FYM and N produced the highest yield of seed (23 q $ha^{-1}$), water use efficiency, uptake of N, P, K, S and Mg in soybean (Sharma and Mishra, 1997).

Hanumanthapa *et al.* (1998) reported significant influence of phosphorus in soybean seed yield.

The effect of lime and phosphorus on yield, nitrogen fixation and nutrient uptake by soybean on Ultisols of Manipur hills and reported that liming and phosphorus application increased grain yield, nodule weight, N and P uptake by grains and N content of the soil at harvest of the crop (Raychaudhuri *et al.*, 1998).

Appavu and Saravanan (1999) reported that the of all the organic treatments i.e., FYM, poultry manure and compost coir pith to soybean improved the yield as compared to control, but the plots which received FYM significantly recorded higher yield than other treatments.

Babhulkar *et al.* (2000) carried out a trial to study the residual effect of long term application of fertilizer alone and in combination with FYM on soil properties and yield of soybean. The results revealed a significant improvement in soil properties and the highest yield of soybean was recorded with the application of 7.5 tonnes FYM $ha^{-1}$ with half dose of recommended N and P which registered 26.81 % and 20.10 % increase over control and full dose of fertilizer.

Navale *et al.* (2000) noted the significant response on application of FYM in increasing the yield of soybean and showed that FYM treatment resulted in higher soil nutrient content, seed yield, N, P, K uptake and increase in seed yield by 24 %.

A field experiment to study the response of soybean cv. JS 335 to farmers' level (10:40 N: P per ha) and RDF (40:80:20 kg N:P:K per ha) and bio-fertilizers was carried out by Shrivastava *et al.* (2000). It was observed that RDF produced higher yields than farmers' fertilizer levels. Seed inoculation with PSB and *Rhizobium* increased the yields of Soybean over RDF alone.

Kumar *et al.* (2006) carried out experiments for two years to study the effect of INM (integrated nutrient management) on nutrients uptake, availability and seed yield of soybean under rainfed condition of Karnataka, India. The results indicated that application of 50% N + 10 t FYM $ha^{-1}$ recorded higher nutrient uptake (122.0, 37 and 110 kg of NPK $ha^{-1}$, respectively) and availability (248, 50 and 245 kg of NPK $ha^{-1}$, respectively) which was at par with 50% N + 50% N through PM + FYM + BS + PM. Higher seed yield was recorded with 100% N + 10 t FYM (1835 kg $ha^{-1}$) followed by 50% N + 50% N through PM + FYM + BS + CRC (1793 kg $ha^{-1}$). The lowest seed yield was recorded with absolute control (823 kg $ha^{-1}$).

Singh (2011) studied the effect of weed and nutrient management on nutrient dynamic, productivity and quality of soybean in Vertisols. Nutrient application at 100% and 125 % significantly improved weed dry weight and nutrients (N,P and K) uptake by weeds, but simultaneously enhanced crop nutrient uptake, yield attributes; protein, oil content and seed yield (17.52 q $ha^{-1}$) as compared to 75 % of RDF (1569 kg $ha^{-1}$).

Multilocation trial in diverse agro-climatic zones of India to optimize the sulphur requirements of soybean crop was conducted by Billore and Vyas (2012). The region-wise pooled results revealed that the highest soybean yield was recorded with 20 kg sulphur $ha^{-1}$ in north plain (1644 kg $ha^{-1}$), 35 kg sulphur $ha^{-1}$ n north eastern (1873 kg $ha^{-1}$) and 30 kg sulphur $ha^{-1}$ in central (2064 kg $ha^{-1}$) and southern zone (2500 kg $ha^{-1}$). The relationship between soybean yield and sulphur levels were found to be curvilinear. The economic optimum level of sulphur was worked out for soybean to be 24.39, 51.27, 33.83 and 32.28 kg sulphur $ha^{-1}$ for north plain, north eastern, central and southern zones respectively.

On farm trial for two consecutive years (2008 and 2009) during *kharif* seasons was carried out by Singh *et al.* (2012). The three treatments comprised of farmers practice (12:30:0 kg NPK $ha^{-1}$), general RDF (40:40:0 kg NPK $ha^{-1}$) and INM based on soil test value (25:40:10 kg NPK/ha in which 50 % N was applied through vermicompost and remaning NPK through chemical fertilizers along with seed treatment with use of *Bradyrhizobium japonicum* and PSB cultures). The highest seed yield of soybean (950 kg $ha^{-1}$) was recorded when crop was grown through INM while the lowest seed yield (600 kg $ha^{-1}$) was obtained with farmers practice of nutrient management.

### 2.2. Effect on yield attributes

An experiment during rainy season (*kharif*) was carried out by Patel and Chandravanshi (1996) and reported that application of nitrogen and phosphorus increased the number of pods per plant, test weight, seed and straw yields and concentration of N and P in soybean. Maximum straw yields was recorded with the application of 45 kg N $ha^{-1}$ and 90 kg $P_2O_5$ $ha^{-1}$.

Ramamurthy and Shivashankar (1996) studied the response of soybean (*Glycine max*) to organic matter (FYM + rice straw in the proportion of 1:1 at 0, 5 and 10 tonnes $ha^{-1}$) and phosphorus (37.5 and 56.25 kg $P_2O_5$ $ha^{-1}$). At the peak growth of 60 DAS, the leaf area index (LAI) was significantly increased from 2.57 in the control to 3.41 and 4.05 with 5 and 10 tonnes $ha^{-1}$ of organic matter. Similarly, grain yield increased significantly from 20.7 to 23.0

and 26.9 q ha$^{-1}$ with an increase of organic matter from 0 to 5 and 10 tonnes ha$^{-1}$ and 22.7 to 24.1 q ha$^{-1}$ with 37.5 to 56.25 kg $P_2O_5$ ha$^{-1}$ as a result of increased dry matter production at various growth stages.

In a field experiment, seeds of c.v. JSS 335 were inoculated with *Rhizobium* which resulted in highest nodule number and in turn highest yield (Dubey, 1999).

Panneerselvam *et al.* (1999) studied the influence of organic and inorganic fertilizers on nodulation in soybean and observed that the number of nodules at 60 DAS was favourably influenced by the combined application of organic manure and inorganic fertilizer in all the seasons and highest number of nodule per plant was observed under bio-digested slurry + 30:120:40 kg NPK ha$^{-1}$.

Field experiment to study the effect of combination of NPK and FYM on growth, yield and agronomic efficiency of soybean was done by Mandal *et al.* (2000) and reported the application of 100% recommended NPK + 10 t FYM per ha gave significantly superior seed yield (95.48%) to 100 % NPK (80.83 % seed yield) or no fertilizer per ha in respect of dry matter accumulation, crop growth rate, pods per plant, seed and stover yield.

Ramaswamy *et al.* (2001) reported that among the different treatments, the enriched FYM resulted in a significant increase in plant height, branches plant$^{-1}$ and number of pods plant$^{-1}$ in soybean. They also observed that the enriched FYM application recorded the highest grain yield of 1259 kg ha$^{-1}$ in summer and 1499 kg ha$^{-1}$ in Kharif.

The effect of farmyard manure ( 0 & 10 t ha$^{-1}$) and S fertilizer (0, 20, 40 & 60 kg ha$^{-1}$) on the growth and yield of soybean cultivars JS-335 and NRC-12 was studied by Gupta *et al.* (2003). All parameters increased with the increasing rates of FYM and S fertilizer. However, S at 40 kg/ha recorded the highest seed (15.59 q ha$^{-1}$) and straw yield (20.81 q ha$^{-1}$).

Galeshi *et al.* (2004) studied and examined the effect of various $KNO_3$ concentrations (0, 1, 3 and 5 gm) on nodulation, nodule growth, biological nitrogen fixation (BNF) and dry matter production. Results showed that nodule number and nodule fresh weight declined with increasing nitrate concentration but shoot and total dry weight, nitrogen percentage and nitrogen yield increased.

Application of recommended doses of N,P and K fertilizers (20:60:20 kg ha$^{-1}$) to soybean variety JS-335 along with 20 kg S ha$^{-1}$ and 10 tonnes FYM ha$^{-1}$ resulted in tallest plants (43 cm) and highest number of branches plant$^{-1}$, number of pods plant$^{-1}$ (32), 100 seed weight (14.9 g), root length (13.1 cm), root weight (1.2 gm plant$^{-1}$), number of root nodules (67 plant$^{-1}$), nodule weight (10.34 gm plant$^{-1}$) and seed yield (1497 kg ha$^{-1}$) (Paradkar and Deshmuk, 2004).

Sriramachandrasekharan and Muthukkaruppan (2004) conducted a pot culture experiment with four levels of S (0, 7.5. 15 and 30 kg ha$^{-1}$) in the presence and absence of *Bradyrhizobium* woth soybean as test crop. Results revealed that the highest nodule number plant$^{-1}$ (40.7), nitrogenase activity, number of pods plant$^{-1}$ (51.7), seed yield (22.95 g pot$^{-1}$), uptake of N (13 g plant$^{-1}$) and sulphur (0.46 g plant$^{-1}$) were recorded with 30 kg S ha$^{-1}$.

NPK fertilizer applied at 100% (30:70:00 kg ha$^{-1}$) recorded the maximum number of branches plant$^{-1}$, dry matter accumulation plant$^{-1}$, leaf area index, grain yield (17.95 q ha$^{-1}$) and stover yield (27.62 q ha$^{-1}$) (Khutate *et al.*, 2005).

The effect of micronutrients on the growth characters of soybean was studied by Shirpurkar *et al.* (2005). The result indicated that application of recommended dose of N:P:K @ 30:60:90 kg ha$^{-1}$ with Zn at 10 kg ha$^{-1}$ and farmyard manure(FYM) at 10 tonnes ha$^{-1}$ increased the growth characters (plant height, leaf number, leaf area, leaf area index, branch number and total dry matter), ultimately increasing the productivity of soybean.

The effect of graded $P_2O_5$ (0, 30, 60 and 90 kg ha$^{-1}$) and $K_2O$ (0, 30, 60 and 90 kg ha$^{-1}$) on yield and uptake of secondary and micronutrients by soybean was conducted in a trial by Tewari and Pal (2005). $P_2O_5$ significantly increased the grain and straw yield and uptake of N, P, K and S but decreased the uptake of Ca, Mg, Fe, Zn, Cu and Mn. $K_2O$ significantly increased the grain and straw yield and the uptake of major, secondary and micronutrients.

Imkongtoshi and Gohain (2009) conducted a field experiment during *kharif* to evaluate INM on soybean under the terraced cultivation of Nagaland. The trail was carried out in RBD with 10 different treatments. Highest plant height (63 cm) was recorded with the application of RDF. Highest number of seeds per pod (2.13) was recorded with the application of RDF (100%) + Lime (100%) followed by application of FYM alone (24.74 q ha$^{-1}$).

Lime application and integrated nutrient management is often recommended to increase crop production on acidic soils. Liming along with integrated nutrient management practices, if adopted properly, can lead to more than three-fold increase in maize productivity on an acidic soils (Kumar *et al.*, 2012).

### 2.3. Effect on quality attributes

Nutrient content and yield of grain and straw in soybean were increased with application of FYM (Jain *et al.*, 1995).

Haider *et al.* (1995) conducted a field trial to study the response of soybean to *Rhizobium* inoculation and urea fertilization and reported that the highest number and weight of nodules per plant and seed yield were obtained with a combination of *Rhizobium* inoculation and application of 20 kg N $ha^{-1}$.

Bachham and Sabale (1996) conducted an experiment of soybean cv 'Macs 124' to study the quality of seed yield, protein content and oil content with 50 kg N $ha^{-1}$ through urea, FYM, compost, vermicompost and observed that highest seed yield, seed protein content and seed oil content were obtained with 50% each of urea and FYM.

The root growth, seasonal evapo-transpiration and productivity of soybean and sorghum as sole and intercrop in 6 nutrient combinations was studied by Bandyopadhyay *et al.* (2004). Integrated use of farmyard manure @ 5 tonnes $ha^{-1}$ or phosphocompost @ 5 tonnes $ha^{-1}$ or poultry manure @ 1.5 tonnes $ha^{-1}$ along with 75% NPK improved the root length density (42.4 %), root mass density (95.9%) and root volume density (80.8%) registered higher seasonal evapo-transpiration (4.4%), total dry matter yield (12.9%) and seed yield (12.7%) over application of 100% NPK irrespective of the cropping systems.

Application of 100% LR was beneficial for maximizing the yield of groundnut and improvement of quality and uptake of nutrients and fertility status of lateritic soils (Chatterjee *et al.*, 2005).

Brar *et. al.* (2010) conducted a field experiment to study the response of soybean to different levels of phosphorus (P) and sulphur (S). Phosphorus application resulted in additional grain yield to the tune of 1.8 and 4.2 q ha-1 at research farm and farmers' field, respectively. Addition of S further improved grain yield of soybean. Phosphorus and sulphur uptake and apparent recovery efficiency increased significantly with P and S application. Response of soybean to P and S application was higher when sulphated phosphate was applied.

Experiments were conducted with Twelve treatments consisting 50% NPK, 100% NPK, FYM @ 10 tonnes $ha^{-1}$, vermicompost @ 5 t $ha^{-1}$, foliar spray of 10 % vermiwash at 30 and 45 days and their combinations with soybean as the test crop (var. PS-1347) in Mollisols of Tarai region. The combined application of treatments performed significantly better than their lone applications for most of the parameters. The treatments having FYM @ 5 t $ha^{-1}$ + vermicompost @ 2.5 t $ha^{-1}$ + vermiwash @ 10 % + 50 % NPK gave maximum nodule number (49 & 53 $plant^{-1}$), highest nodule dry weight (384 & 372 mg $plant^{-1}$) and plant dry weight (30.33 & 40.33 g $plant^{-1}$) at 60 DAS with grain yields (3210 & 3231 kg $ha^{-1}$) in the year 2006 and 2007 respectively (Singh and Kumar, 2012).

### 2.4. Effect on nutrient uptake

Application of lime, FYM and fertilizers resulted in increased uptakes of N and P by wheat and soybean (Mishra *et al.*, 1999). It was reported that the breaking up of Fe and Al phosphate complexes and the mineralization of organic P leads to increased P content in the soil.

Combined treatment of N and S was reported to enhance root activity leading to more S uptake in rice (Wani *et al.*, 2000).

N uptake by soybean increased by applying 100% RDF in combination with FYM (Singh and Rai, 2004). There was significant P and K uptake by the application of NPK, FYM and bio-fertilizers.

Application of lime along with NPK increased the N uptake in groundnut varieties. It was also reported that the lime amended soils showed increased uptake of N, P, Ca and Mg owing to their better availability. Chaterjee *et al.* (2005).

Increased phosphorus and potassium uptake by maize and wheat in treatment involving lime and NPK was observed by Singh *et al.* (2009). In an acidic soil treatment, NPK + lime resulted in better K uptake.

Application of P fertilizers has been reported to influence S uptake. Also, the uptake of P and S increased with the increased application of P and S fertilizers alone or in combination with other nutrient sources (Dhage *et al.*, 2014).

Saxena *et al.* (2013) reported that high level of P was directly proportional to the uptake of N, P and K.

Sharma *et al.* (2014) reported that with the enhanced nutrient S availability by supplying fertilizers, the S uptake increases.

## 2.5. Effect of soil fertility

Application of 40 kg $P_2O_5$ $ha^{-1}$ recorded marked increase in grain yield over control (Vyas *et al.*, 1987). However, the optimum dose of $P_2O_5$ on the basis of pooled data was 66 kg $ha^{-1}$

Higher grain yield was obtained with 40 kg N $ha^{-1}$ which was comparable with 20 kg N $ha^{-1}$ (Jayapaul and Ganesarya, 1990).

Mishra *et al.* (1994) conducted a field experiment during kharif season to study the influence of fertility levels on growth and yield of soybean and the result revealed that the yield attributes and yield of Soybean increased significantly due to application of 20 kg N + 60 kg $P_2O_5$ + 20 kg $K_2O$ $ha^{-1}$.

The nutrient management of soybean and soybean-based cropping system was studied by Bobde *et al.* (1998). Application of 7.5 tonnes FYM $ha^{-1}$ along with reduced dose of fertilizer to 50% gave significantly more grain yield of soybean as well as more monetary returns than the absolute control and recommended dose of fertilizer only.

Halvankar *et al.* (1999) conducted a field experiment during kharif season to study the effects of fertility levels on seed yield and related parameters. Fertility levels exerted significant effects on yield components, oil and seed yield of soybean. The F3 level of fertility (30 kg N + 120 kg $P_2O_5$ + 60 kg $K_2O$ $ha^{-1}$) was at par with F2 level (20 kg N + 80 kg $P_2O_5$ + 40 kg $K_2O$ $ha^{-1}$) but recorded significantly more seed yield than lower levels of fertility.

The combined of application of 60 kg $P_2O_5$ $ha^{-1}$ in soybean through diammonium phosphate (DAP) separately and seed placement by drilling proved to be the best with respect to growth, yield, attributes, net return, seed protein and seed oil content (Goswami *et al.*, 1999).

Correa *et al.* (2004) conducted experiment that consisted of three cover crops residues namely pearl millet, oats and guinea sorghum at 8 tonnes $ha^{-1}$ interacting with 0, 50, 100 and 150 kg/ha of P applied over straw mulch as simple SSP and concluded that the efficiency of phosphate fertilizers can be affected by phosphate sources, soil properties, way of application and plant species.

The role of potassium and its management, particularly in terms of adequate application is critical for success in soybean cropping (Mascarenhas *et al.*, 2004).

Deshmukh *et al.* (2005) conducted studies on INM in soybean-chickpea cropping system and all the INM treatments were found to be significantly superior to the farmers' practice with respect to growth, yield attributes, yield and economics and the fertility status of the soil. Among the INM treatments, 100% RDF for + 2.5 tonnes farmyard (FYM) ha$^{-1}$ + drainage in soybean and soil mulch in chickpea proved the best in all these parameters. The total productivity from the soybean-chickpea sequence was 32.09 q ha$^{-1}$ with the net return up to 26273 ha$^{-1}$ and BC ratio up to 2.91. This INM treatment also improved the organic carbon, available N, P and K status of the sol over their initial values. Thus, considering the maximum gain of soybean-chickpea sequence under rainfed conditions, application of FYM and moisture conservation practices along with full recommended dose of fertilizers are essential.

Manna *et al.* (2007) reported a positive effect of balanced fertilizer (NPK + lime or NPK + FYM) on crop yields and soil C and N fractions and aggregate size distribution. Thus, in a legume-based cropping system, balanced fertilizer management is necessary to sustain productivity from a sufficient nutrient supply without deteriorating soil quality.

A field experiment was conducted during kharif 2007 and 2008 on Vertisols of Kota region to find out the effect of different levels of sulphur (0, 10, 20, 30 and 40 kg ha$^{-1}$) and boron (0.0, 0.5, 1, 1.5 and 2 kg ha$^{-1}$) on productivity, quality and profitability of (Meena *et al.*, 2011). Results showed that application of 30 kg sulphur ha$^{-1}$ and 1 kg boron ha$^{-1}$ was found to be suitable for obtaining higher productivity and quality of soybean.

Najar *et al.* (2011) conducted field experiment to study the influence of sulphur level on yield, uptake and quality of soybean (*Glycine max*) under temperate conditions of Kashmir valley. Maximum growth, nodulation, yield and quality of soybean was recorded with 40 kg s ha$^{-1}$ which was at par with 30 kg s ha$^{-1}$. Stover and grain yield of soybean increased to the tune of 66.0 and 53.4 % over the control due to addition of 40 kg s ha$^{-1}$, respectively.

Paliwal *et al.* (2011) conducted a field experiment to evaluate the response of soybean in soybean – wheat cropping system to vermicompost and NPK fertility levels. A conjunctive use of vermicompost @ 5 t ha$^{-1}$ along with 15:45:15 kg ha$^{-1}$ NPK in soybean followed by an application of 90:45:30 kg ha$^{-1}$ NPK in succeeding wheat crop recorded significantly higher plant population, dry matter accumulation and root nodulation thereby found to be more profitable and productive over RDF and control.

Sentimenla *et al.* (2012) suggested that in phosphorus and Boron deficient upland soils of Nagaland, application of 60 kg P and 1.5 kg B $ha^{-1}$ could be beneficial for higher productivity and quality of soybean.

# *CHAPTER - III*

# *MATERIALS AND METHODS*

# MATERIALS AND METHODS

## 3.1. Site of experiment

The present investigation entitled **"Effect of lime, farmyard manure and fertilizers on growth, yield and quality of soybean (*Glycine max* L. Merril) in acid soils of Nagaland"** was carried out in the experimental research farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, situated at 25°45′ 43″ N latitude and 93° 53′ 04″ E longitude at an elevation of 310 m above mean sea level.

## 3.2. Climatic condition

The experimental farm lies in the humid sub-tropical zone with rainfall ranging from 2000 to 2500 mm per annum. The mean temperature ranges from 21˚ to 32˚ C during summer and goes down to about 12˚C in winter season.

## 3.3. Soil condition

The soil of the experimental field was well drained and sandy loam in texture. The texture and fertility status of the soil were ascertained by taking soil samples from a depth of 15-20 cm from different locations of the experimental plots with the help of soil auger, which were processed and analysed for different parameters following standard procedures. The soil was acidic in reaction (pH 5.53) with 0.72 % organic carbon, 252.78 kg $ha^{-1}$ available nitrogen, 18.55 kg $ha^{-1}$ available phosphorus and 171.10 kg $ha^{-1}$ available potassium.

## 3.4. DETAILS OF THE EXPERIMENT

### 3.4.1. Experimental layout

The field trial was laid out in Split Split Plot Design (SSPD) with twenty four treatment combinations which were replicated thrice and the experiment was conducted for two consecutive years (2014 & 2015) on the same site. The whole experimental field was divided into three equal blocks and each block was again divided into twenty four equal sized plots measuring 2.5 m x 2.5 m in order to accommodate the treatments. All together there were 72 plots. The details of the plan and layout of the experimental field are given in figure no. 1. The treatments were randomly allocated within the plots of a block.

### 3.4.2. Layout plan of the experimental field

a. **Crop :** Soybean (*Glycine max*)
b. **Variety:** JS 335

c. **Initial analysis of experimental soil**

1. pH
2. Lime requirement
3. Available N
4. Available P
5. Available K
6. Available S

d. **Experimental design :** Split-Split plot design

The experimental field was equally divided into 24 equal plots per replication and three replications were carried out.

e. **Treatments details:**

| | **Treatment** | **Symbol assigned** |
|---|---|---|
| **Lime** | 0 | $L_0$ |
| | 400 kg $ha^{-1}$ (furrow application) | $L_1$ |
| | 10% of LR | $L_2$ |
| **FYM** | 0 | $O_0$ |
| | 5 tonnes $ha^{-1}$ (on dry weight basis) | $O_1$ |
| **Fertilizers** | 0 | $I_0$ |
| | 50% RDF, | $I_1$ |
| | 75% RDF | $I_2$ |
| | 100 % RDF | $I_3$ |

No. of replications - 3

*LR = Lime requirement

*RDF (Recommended dose of fertilizer) = 20 kg N, 80 kg $P_2O_5$, 40 kg $K_2O$ & 40 kg S

* Nutrient content in 5 $tonnes^{-1}$ FYM = 25 kg N, 7.5 kg P and 50 kg K

f. **Treatment distribution**

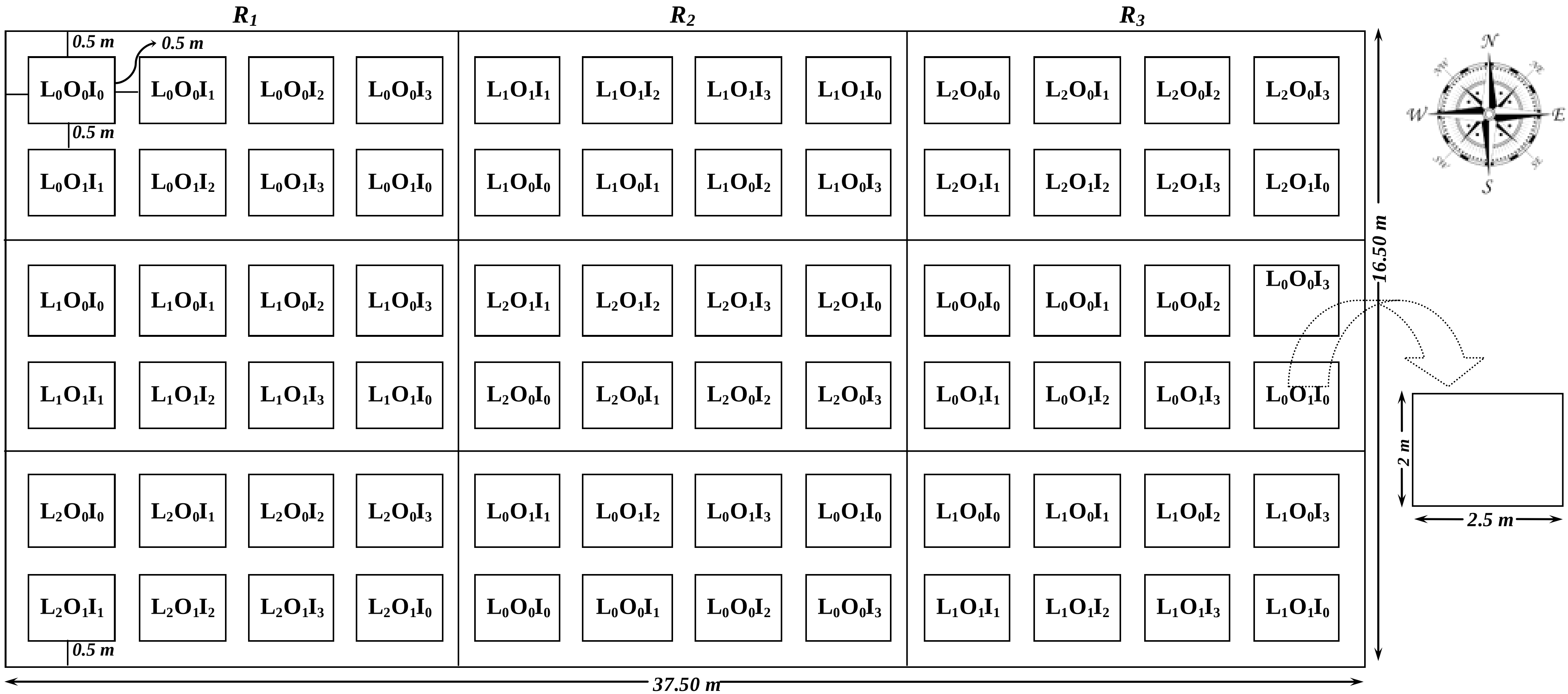
Main plot factor - Lime

Sub plot factor - FYM

Sub sub plot factor - Fertilizer

g. **Plot size** : 2.5 m x 2.5 m (length x breadth)

Net plot size = 2.0 m x 2.25 m = 4.5 $m^2$




**Lime level (Main plot factor)**

$L_0$= 0
$L_1$= 400 kg ha$^{-1}$ (Furrow application)
$L_2$= 10% LR

**Organic level (Sub plot factor)**

$O_0$= 0
$O_1$= 5 tonnes ha$^{-1}$

**Inorganic level (Sub-sub plot factor)**

$I_0$= 0
$I_1$= 50% RDF
$I_2$= 75% RDF
$I_3$= 100% RDF

**Fig 1: Layout of the experimental field (split-split plot design)**

**i. Spacing**

Plant to plant = 10 cm

Row to row = 45 cm

### 3.5. Agro-management

#### 3.5.1. Selection and preparation of field

A rectangular plot having uniform fertility and even topography was selected for conducting field trail. The experimental plot was ploughed in the first week of May 2014. The field was then harrowed and levelled properly. All the stubbles were removed and then the field was laid out according to the layout plan.

#### 3.5.2. Manure and fertilizer application

FYM and the inorganic fertilizers were applied to each plot as per the treatments. FYM was applied one month before the sowing so that decomposition of the organic manures would take place. Liming was done one month prior to sowing.

#### 3.5.3. Calculation of lime requirement (LR)

Lime requirement was calculated using the Buffer method (Shoemaker *et al.*, 1960). The initial soil samples from the field were determined for soil pH which resulted in a pH of 5.53. Therefore, the lime requirement as $CaCO_3$ will be 14.58 tonnes $ha^{-1}$ to raise the pH upto 6. Thus, 10% LR is 1458 kg $ha^{-1}$.

#### 3.5.4. Seed rate and sowing

The seed were sown directly to the plots by maintaining 10 cm plant to plant and 45 cm row to row spacing. The seeds were sown in the last week of June.

#### 3.5.5. After care

To maintain a uniform plant population, thinning and gap filling was done from time to time. Hand weeding was done firstly at 20 DAS and then later at every 15 days interval.

#### 3.5.6. Harvest and threshing

Harvesting was done in the month of October on regular interval depending on the maturity level of the pods. The crop was harvested at ground level and plot wise bundle of harvested crop were sun dried, threshed and cleaned manually.

### 3.6. Plant analysis

#### 3.6.1. Plant sampling

After threshing, the seed and stover were separated, air dried and finally oven dried at a temperature of 60 ºC to 70 ºC to attain a constant weight. The dried seed and stover samples were then grounded in a willy mill and kept in polythene bags for chemical analysis.

### 3.6.2. Seed and stover analysis

The seed and stover samples were separately collected after threshing from each plot and dried in oven. The oven-dried samples were ground to powder and analysed for N, P, K and S content.

Nitrogen content in both seed and stover was estimated by modified kjeldhal method as described by Black (1965). The protein content in seed was calculated by multiplying the seed N by a factor of 6.25. Phosphorous was determined by vanado-molybdate yellow colour method as outlined by Jackson (1973). Potassium was determined by flame photometry as described by Chapman and Pratt (1961). The plant samples were digested using HNO3-HClO4 and the sulphur content was determined turbimetrically as described for soil sulphur (Chesnin and Yien, 1950).

### 3.6.3. Oil content (%)

Seed samples of 5g each from all the treatments (plot wise) were taken for extraction of oil. The crushed samples were placed in a thimble and extracted with light petroleum ether for 6 hours in a soxhlet extraction unit as per method described by AOAC (1960). The extract was transferred to weight flask, the solvent distilled of and the last traces of solvent and moisture being removed by treating the flask at 100-150$^0$. Then, the flask was cooled and reweighed; the formula used for calculation of per cent oil in seed was as follows:

$$\text{Per cent oil} = \frac{(\text{W2} - \text{W1})\ \text{x}\ 100}{\text{X}}$$

Where,

$W_2$= weight of the empty flask (g)

$W_1$= weight of empty flask + weight of oil (g)

X = weight of sample taken for extraction (g)

## 3.7. Soil analysis

### 3.7.1. Soil sampling

Surface soil sample (0-15) cm was collected from the experimental field after harvest of crop. The samples were air dried, finely grounded and sieved through 2 mm sieve and then kept in polythene bags with proper labeling for analysis.

### 3.7.2. Analysis of soil samples for different parameters

The soil samples were analyzed for pH, organic carbon, available nitrogen, phosphorus, and potassium and sulphur contents.

**3.7.3. Soil Reaction (pH):** Glass electrode pH meter (Richards, 1954)

**3.7.4. Electrical Conductivity (EC):** Conductivity bridge (Richards, 1954)

**3.7.5. Mechanical Analysis:** International Pipette method using 1*N* sodium hydroxide (NaOH) (Piper, 1966)

**3.7.6. Soil Organic Carbon:** Rapid titration method outlined by Walkley and Black (1934) method and expressed in percentage as described by Jackson (1973).

**3.7.7. Cation Exchange Capacity (CEC):** 1 *N* $NH_4OAc$ at pH 7.0 (Chapman, 1965)

### 3.7.8. Available nitrogen

Available nitrogen was estimated by alkaline potassium permanganate method as outlined by Subbiah and Asija (1956) and the result was expressed in terms of percentage.

### 3.7.9. Available phosphorus

Available phosphorus was extracted with 0.03 NH4F in 0.025 HCl solutions. The procedure is primary meant for soils which are moderate to strongly acidic pH around 5.5 or less (Brays and Kurtz, 1945). The phosphorus content of the soil extract was then determined by calorimetric method of estimation.

### 3.7.10. Available potassium

The available potassium was determined by flame photometer after extracting the soil with neutral normal ammonium acetate (pH 7.0) (Jackson, 1973).

### 3.7.11. Available sulphur

The available sulphur was determined by turbidimetric method using 1:5 soil and extractant 0.15 % $CaCl_2$ solution and the intensity of turbidity formed was measured using UV spectrophotometer at a wave length of 440 nm **(**Chesnin and Yien, 1950).

### 3.7.12. Exchangeable Ca and Mg

1*N* ammonium acetate extracts of soil by titration against EDTA (Black, 1965).

**Plate 1: Experimental field at different days after sowing**

**Plate 2a: Picture showing germination**

**Plate 2b: Crops during the initial growth period**

**Plate 3a: Crops during the initial growth period**

**Plate 3b: At initial flowering stage**

**Plate 4a: Picture showing the nodule formations**

**Plate 4b: Pod formations**


**Plate 5: Experimental field at later growth stages**

### 3.8. Plant sampling for growth attributes

#### 3.8.1. Plant height (cm)

Three plants in each plot were selected and tagged for recording the plant height. The plant height was measured in cm from the ground level to the top of plants at 30 DAS, 45 DAS and 60 DAS. The average plant height was calculated for each treatment.

#### 3.8.2. Number of leaves per plant

The number of leaves per plant was counted from three selected plants from each plot or treatment at 30 DAS, 45 DAS, and 60 DAS and the average number of leaves per plant was calculated for each treatment.

#### 3.8.3. Nodule count

The nodule count was obtained by carefully removing sample plants from each plot, then washing the roots and nodules by gentle spray of water. After that, nodules were detached from roots. This was done at 30 DAS, 45 DAS and 60 DAS and average number of nodules per plant was calculated for each treatment.

#### 3.8.4. Fresh weight of nodules

After obtaining the nodules, they are weighed and their average was obtained to get the final nodule fresh weight. This was done at 30 DAS, 45 DAS, and 60 DAS and average number of nodules per plant was calculated for each treatment.

#### 3.8.5. Dry weight of nodules

After the nodule fresh weight is obtained, the nodules were dried to remove the moisture content in the nodule. The nodules are then weighed to obtain the nodule dry weight. This was done at 30 DAS, 45 DAS, and 60 DAS and average nodule dry weight per plant was calculated for each treatment.

#### 3.8.6. Dry weight of plant

The dry weight of the plants were taken from all the plots at 30 DAS, 45 DAS, 60 DAS, then the same samples were sun dried and later dried in hot air oven for about 24 hours at $60^0$C. When it was dried, weight of the sample was taken for recording.

### 3.9. Yield attributes

#### 3.9.1. Number of pods plant$^{-1}$

Total number of pods plant$^{-1}$ within 2 m$^2$ of each plot were counted and average were taken for each treatment.

### 3.9.2. Number of filled pods plant$^{-1}$

The number of filled pods plant$^{-1}$ was counted from three randomly selected pods and average was taken for each treatment.

### 3.9.3. Number of seeds pod$^{-1}$

Selected three plants were taken and the number of seeds pod$^{-1}$ was counted and the average was taken for each treatment.

### 3.9.4. Seed index (100 grain weight)

From the threshed grains, 100 grains were counted and their weight was recorded on plot-wise basis.

### 3.9.5. Seed yield (kg ha$^{-1}$)

The seed yield of all the plots were collected on treatment basis and the plot yield of each treatment were converted into kg ha$^{-1}$.

### 3.9.6. Stover yield (kg ha$^{-1}$)

After harvest, the straw were left in each respective plots for a week for sun drying, weight of the straw (plot-wise) were taken and recorded accordingly. The plot yield was converted into kg ha$^{-1}$.

## 3.10. Analysis of data

The data related to each character were analyzed statistically by applying the techniques of analysis of variance and the significant of different source of variations was tested by '*F*' test (Gomez and Gomez, 1984).

## 3.11. NPK use efficiency

The nitrogen use efficiency (NUE) is a term used to indicate the relative balance between the amount of fertilizer N taken up and used by the crop *versus* the amount of fertilizer N lost.

It is calculated using the formula as follows:

$$\text{Nutrient use efficiency (\%)} = \frac{\text{Nutrient uptake in fertilized plot} - \text{Nutrient uptake in control}}{\text{Fertlizer applied}} \text{x } 100$$

### 3.13. Analysis of physicochemical properties of soil from soybean growing areas of Kohima and Dimapur

A survey was conducted in order to collect the surface soil (0-15 cm) and soybean seed from thirteen different villages of Kohima and Dimapur district. Kohima district is situated at an elevation of 1444 above msl. The District has unique hill ranges which break into wide chaos and spurs and ridges with an elevation ranging from 600 msl to 3048 msl at Japfü Peak. It is situated at 25˚ 31' 03" N - 26˚ 00' 32" N and 93˚ 58' 58" E - 94˚ 15' 24" E. Dimapur district is located in the foothills of the Patkai mountain ranges. It is situated at 25˚ 58' 24.19" N - 25˚ 39' 49.05" N and 93˚ 59' 20.89" E - 93˚ 37' 18.43" E and the elevation ranges from 136 to 657 mts above MSL. The soils were mixed thoroughly and about 500 gm were retained from each field by following the quartering process. About 100 gm soybean seed samples were collected from each field for analysis purpose. Surface soil sample (0-15) cm was collected from the different fields at various locations. The samples were air dried, finely grounded and sieved through 2 mm sieve and then kept in polythene bags with proper labelling for chemical analysis.

# *CHAPTER - IV*

# *RESULTS AND DISCUSSIONS*

# RESULTS AND DISCUSSIONS

## 4.1. Analysis of physico-chemical properties of soil from soybean-growing areas of Kohima and Dimapur districts

### 4.1.1. Physical properties

It is evident from the table 1 that all the soil samples collected were high in sand content (46.0 to 80.0%). The lowest and highest sand content was recorded in the Murise and Diezephe soils of Dimapur district to the tune of 46.0 and 80.0% respectively. In general, the sand content tended to decrease with an increase in altitude. This is due to the fact that Water holding capacity (WHC) of sand is low which results in higher rate of leaching during heavy rainfall at higher altitudes.

As apparent from table 1, the silt content of all the soil samples collected were low and that ranges from 4.0 to 21.0%. The lowest silt content was recorded in Seithekiema soil of Dimapur district whereas it was highest in Murise soil of Dimapur district.

The clay content of the soil samples collected from different locations ranged from 8.0 to 38.0% (Table 1). The lowest clay content was recorded in Diezephe soil belonging to Dimapur district whereas it was highest in Tsiesema soil of Kohima district. The result is in conformity with the findings by Zende (1987) who reported that the clay content ranges between 4 to 35% in five districts of Nagaland.

### 4.1.2. Chemical properties

It is evident from the table 2, that all the soils samples collected were acidic in nature (pH 4.9 to pH 6.2). The maximum pH was recorded at New Chumukedima site of Dimapur district whereas the minimum was recorded in Kijumetouma of Kohima district. In general, the acidity of the soil increased with altitude. This is due to the fact that higher rate of leaching as a result of heavy rainfall at higher altitudes. The results were in accordance of the findings by several workers (Chakravorty and Chakravarti 1980; Zende 1987; Kumar and Rao, 1990) who reported that the pH of the soils ranged between 4.5 to 6.6 in the Eastern Himalayan region.

The organic carbon content increased with altitude (Table 2). This might be due to the change in altitude and formation of unhumified organic matter. Among the locations, the maximum organic carbon was recorded in Kijumetouma (0.98%) of Kohima district whereas the minimum was recorded in Tsithrongse (2.55%) of Dimapur district. The results were in conformity with the findings by several workers (Chakravorty and Chakravarti

1980; Zende 1987; Kumar and Roa 1990) who reported that the organic carbon of the soils ranged between 0.68 to 2.05% in the Eastern Himalayan region.

The EC of the soil samples collected from different locations ranged between 0.04 to 1.16 $dSm^{-1}$ (Table 2). The lowest EC was recorded for New Chumukedima soil in Dimapur district whereas it was highest in Nerhema soil in Kohima district. The result is in accordance with the findings of Misra and Saithantuaanga (2000) who reported that the EC ranged between 0.07 and 0.53 $dSm^{-1}$ in the soils of Mizoram.

The cation exchange capacity (CEC) of the soil samples collected from different locations ranged between 5.00 to 26.60 $cmol(P^+)kg^{-1}$ (Table 2). The lowest CEC was recorded in Murise soil of Dimapur district whereas it was highest in Kijumetouma soil of Kohima district. In general, the CEC of the soil increased with altitude. This may be due to low molecular weight of humus and intensive formation of new humus. The results were in accordance with the findings of Chenithung *et al.* (2014) who reported that the CEC of the soils ranged between 7.13 and 13.13 $cmol(P^+)kg^{-1}$ in the cultivated land use systems in Wokha district of Nagaland.

**4.1.3. Exchangeable Ca and Mg**

The exchangeable Ca of the soil samples varied from location to location (Table 2). Among the locations, the highest and lowest exchangeable Ca in the soil was recorded in Nerhema and Rusoma soils to the magnitude of 9.60 meq $100gm^{-1}$ and 2.20 meq $100gm^{-1}$ respectively in Kohima district. The result is in conformity with the findings by Kumar and Rao (1990) who reported that the exchangeable Ca of the soils in Manipur ranged between 0.60 and 10.40 meq $100gm^{-1}$.

The exchangeable Mg of the soil samples varied with location (Table 2). Among the locations, the highest exchangeable Mg was recorded in Dihoma soil of Kohima district of 6.40 meq $100gm^{-1}$ while the lowest was in Tsiesema of Kohima district and Tsithrongse of Dimapur district with 2.80 meq $100gm^{-1}$ each. The result is in accordance with the findings of Kumar and Rao (1990) who reported that the exchangeable Mg of the soils in Manipur ranges between 1.70 and 9.50 meq $100gm^{-1}$.

**4.1.4. Available N, P, K and S in soil**

The available N varied with location (Table 2). The highest available N in the soil was recorded in Rusoma soil of Kohima district (455.53 kg $ha^{-1}$) while the lowest (221.52 kg $ha^{-1}$) was in New Chumukedima of Dimapur. The result is in conformity with the

Table 1: Physical characteristics of collected soils from different locations in Nagaland

| Sl. No. | Location | District | Altitude in m above msl | Sand (%) | Silt (%) | Clay (%) | Textural class |
|---|---|---|---|---|---|---|---|
| 1 | Kezoma | Kohima | 1531 | 48.2 | 14.2 | 37.6 | sandy clay |
| 2 | Tsiesema | Kohima | 1470 | 51.6 | 10.4 | 38.0 | sandy clay |
| 3 | Nerhema | Kohima | 1390 | 51.0 | 14.0 | 35.0 | sandy clay loam |
| 4 | Kijumetouma | Kohima | 1134 | 50.0 | 12.8 | 37.2 | sandy clay |
| 5 | Kidima | Kohima | 1646 | 53.2 | 9.6 | 37.2 | sandy clay |
| 6 | Dihoma | Kohima | 1357 | 49.2 | 13.0 | 37.8 | sandy clay |
| 7 | Rusoma | Kohima | 1469 | 50.2 | 12.0 | 37.8 | sandy clay |
| 8 | Murise | Dimapur | 171 | 46.0 | 21.0 | 33.0 | sandy clay loam |
| 9 | Tsithrongse | Dimapur | 180 | 59.4 | 11.2 | 29.4 | sandy clay loam |
| 10 | Seithekiema | Dimapur | 190 | 76.0 | 4.0 | 20.0 | sandy loam |
| 11 | Diezephe | Dimapur | 140 | 80.0 | 12.0 | 8.0 | sandy loam |
| 12 | Bade | Dimapur | 162 | 60.6 | 10.2 | 29.2 | sandy clay loam |
| 13 | New Chumukedima | Dimapur | 221 | 60.4 | 11.8 | 27.8 | sandy clay loam |

Table 2: Chemical characteristics of collected soils from different locations in Nagaland

| Sl. No. | Location | District | Altitude (m) above msl | pH | OC (%) | EC ($dSm^{-1}$) | CEC [cmol (p+ $kg^{-1}$)] | Available nutrient in the soils | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Ca (meq $100gm^{-1}$) | Mg (meq $100gm^{-1}$) | N (kg $ha^{-1}$) | P (kg $ha^{-1}$) | K (kg $ha^{-1}$) | S (µg $g^{-1}$) |
| 1 | Kezoma | Kohima | 1531 | 6.03 | 2.18 | 0.13 | 15.4 | 8.8 | 3.4 | 386.55 | 8.13 | 156.60 | 0.27 |
| 2 | Tsiesema | Kohima | 1470 | 5.45 | 2.28 | 0.62 | 18.2 | 8.4 | 2.8 | 437.04 | 5.82 | 67.20 | 0.28 |
| 3 | Nerhema | Kohima | 1390 | 5.21 | 2.40 | 1.66 | 13.6 | 9.6 | 5.2 | 405.46 | 10.48 | 162.40 | 0.30 |
| 4 | Kijumetouma | Kohima | 1134 | 4.90 | 2.55 | 0.06 | 26.6 | 6.8 | 4.8 | 411.01 | 11.06 | 78.40 | 0.67 |
| 5 | Kidima | Kohima | 1646 | 6.01 | 2.40 | 0.15 | 12.0 | 8.6 | 5.6 | 448.58 | 8.82 | 184.00 | 0.33 |
| 6 | Dihoma | Kohima | 1357 | 5.11 | 1.45 | 0.10 | 10.8 | 6.6 | 6.4 | 449.94 | 8.59 | 167.20 | 0.34 |
| 7 | Rusoma | Kohima | 1469 | 5.70 | 1.10 | 0.32 | 12.2 | 2.2 | 3.1 | 455.53 | 10.12 | 123.30 | 0.26 |
| 8 | Murise | Dimapur | 171 | 6.10 | 1.65 | 0.17 | 5.0 | 6.8 | 3.6 | 229.70 | 22.02 | 184.80 | 0.24 |
| 9 | Tsithrongse | Dimapur | 180 | 6.05 | 0.98 | 0.30 | 13.0 | 8.2 | 2.8 | 229.88 | 28.50 | 179.20 | 1.15 |
| 10 | Seithekiema | Dimapur | 190 | 5.70 | 2.05 | 0.36 | 9.0 | 7.8 | 5.8 | 239.34 | 21.99 | 184.80 | 1.37 |
| 11 | Diezephe | Dimapur | 140 | 6.10 | 1.50 | 0.14 | 7.0 | 6.0 | 5.6 | 253.97 | 23.54 | 187.60 | 1.50 |
| 12 | Bade | Dimapur | 162 | 6.06 | 1.12 | 0.13 | 8.2 | 3.2 | 5.4 | 268.61 | 24.53 | 194.13 | 1.00 |
| 13 | New Chumukedima | Dimapur | 221 | 6.25 | 1.53 | 0.04 | 7.0 | 8.2 | 5.2 | 221.52 | 19.79 | 156.68 | 1.40 |

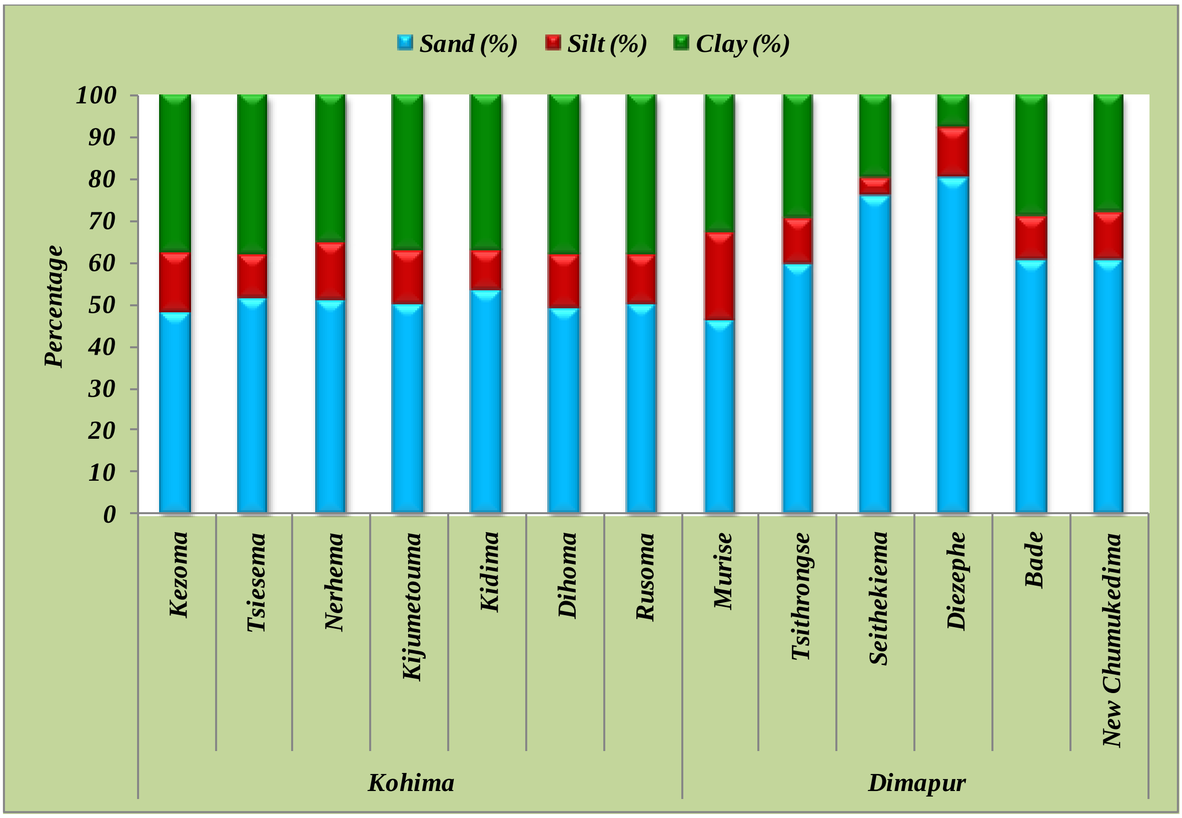



**Fig 2: Physical characteristics of soils collected from different locations in Nagaland**

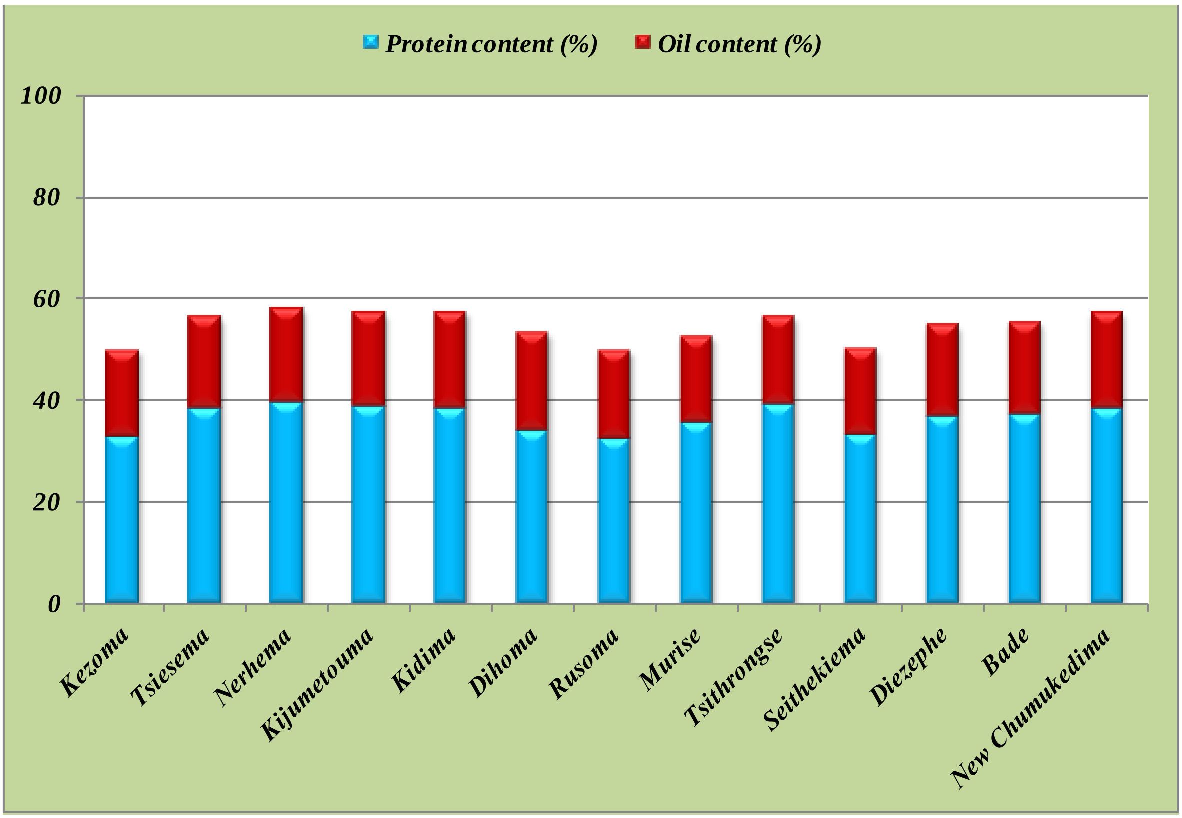



**Fig 3: Quality characteristics of soybean seed collected from different locations in Nagaland**

findings of Chenithung *et al.* (2014) who reported that the available nitrogen of the soils ranged between 290.60 and 386.70 kg ha$^{-1}$ in the cultivated land use systems in Wokha district of Nagaland.

The available $P_2O_5$ was medium to high status with an average value ranging between 5.82 to 24.53 kg ha$^{-1}$ respectively (Table 2). The highest available $P_2O_5$ in the soil was recorded in Bade soil of Dimapur district of 24.53 kg ha$^{-1}$ while the lowest was in Tsiesema of Kohima district (5.82 kg ha$^{-1}$).

The available $K_2O$ was medium to high with an average ranging between 67.20 to 194.13 kg ha$^{-1}$ (Table 2). The highest available $K_2O$ in the soil was recorded in Bade soil of Dimapur district (194.13 kg ha$^{-1}$) while the lowest (67.20 kg ha$^{-1}$) was at Tsiesema site of Kohima district.

The soluble S ranged between 0.24 to 1.50 µg g$^{-1}$ (Table 2). The highest and lowest soluble S in the soil was recorded in Diezephe and Murise soils in Dimapur district with 1.50 and 0.27 µg g$^{-1}$, respectively.

### 4.1.5. Correlation among the soils properties

The correlations amongst soil physical and chemical characteristics at different locations are presented in table 3. The sand content showed significant positive correlation with $P_2O_5$ and S but it had significant negative correlation with silt, clay and N. The silt content was positively correlated with clay, pH and N whereas with OC, $P_2O_5$, $K_2O$ and S it was negatively correlated. The clay content showed significant positive correlation with N but it had significant negative correlation with $P_2O_5$ and S. The pH showed significant positive correlation with $P_2O_5$ and $K_2O$ but it had significant negative correlation with N. The OC of the soils showed positive correlation with N but negative correlation with $P_2O_5$, $K_2O$ and S. The available N showed significant negative correlation with $P_2O_5$ and S whereas available $P_2O_5$ showed significant positive correlation with $K_2O$ and S. The results are in agreement with the findings of Chenithung *et al.* (2014).

### 4.1.6. N, P and K content in soybean seed

As apparent from the table 4, the percentage of nitrogen content in soybean seed showed significant difference among the growing sites. The highest nitrogen content was recorded at Nerhema site (6.33%) while the lowest was at Kezoma (5.24%) in Kohima district.

Table 3: Coefficients of correlation among the properties of soils collected from different locations in Nagaland

| | **Silt** | **Clay** | **$p^H$** | **OC** | **Available N** | **Available P** | **Available K** | **Available S** |
|---|---|---|---|---|---|---|---|---|
| **Sand** | -0.656* | -0.933** | 0.341 | -0.218 | -0.604* | 0.624* | 0.413 | 0.889** |
| **Silt** | | 0.339 | 0.037 | -0.054 | 0.008 | -0.074 | -0.011 | -0.490 |
| **Clay** | | | -0.443 | 0.297 | 0.748** | -0.742** | -0.509 | -0.874** |
| **$p^H$** | | | | -0.461 | -0.639* | 0.577* | 0.591* | 0.398 |
| **OC** | | | | | 0.442 | -0.606* | -0.412 | -0.353 |
| **Available N** | | | | | | -0.930** | -0.552 | -0.760** |
| **Available P** | | | | | | | 0.607* | 0.761** |
| **Available K** | | | | | | | | 0.360 |

***Note:*** ** Significant at the 0.01 level of significance

* Significant at the 0.05 level of significance

Table 4: Quality characteristics of soybean collected from different locations of Nagaland

| **Sl. No.** | **Location** | **District** | **Altitude (m) above msl** | **Nutrient content in seed** | | | **Protein content (%)** | **Oil content (%)** |
|---|---|---|---|---|---|---|---|---|
| | | | | **Total N in seed (%)** | **Total P in seed (%)** | **Total K in seed (%)** | | |
| 1 | Kezoma | Kohima | 1531 | 5.24 | 0.39 | 1.71 | 32.75 | 17.13 |
| 2 | Tsiesema | Kohima | 1470 | 6.12 | 0.40 | 1.95 | 38.25 | 18.04 |
| 3 | Nerhema | Kohima | 1390 | 6.33 | 0.42 | 2.23 | 39.56 | 18.37 |
| 4 | Kijumetouma | Kohima | 1134 | 6.20 | 0.43 | 2.33 | 38.75 | 18.35 |
| 5 | Kidima | Kohima | 1646 | 6.12 | 0.44 | 2.49 | 38.25 | 19.13 |
| 6 | Dihoma | Kohima | 1357 | 5.41 | 0.48 | 2.53 | 33.81 | 19.38 |
| 7 | Rusoma | Kohima | 1469 | 5.21 | 0.38 | 1.41 | 32.56 | 17.21 |
| 8 | Murise | Dimapur | 171 | 5.71 | 0.37 | 1.34 | 35.69 | 16.88 |
| 9 | Tsithrongse | Dimapur | 180 | 6.24 | 0.37 | 1.87 | 39.00 | 17.33 |
| 10 | Seithekiema | Dimapur | 190 | 5.31 | 0.40 | 2.09 | 33.19 | 16.90 |
| 11 | Diezephe | Dimapur | 140 | 5.87 | 0.41 | 1.96 | 36.69 | 18.02 |
| 12 | Bade | Dimapur | 162 | 5.97 | 0.42 | 2.03 | 37.31 | 18.10 |
| 13 | New Chumukedima | Dimapur | 221 | 6.14 | 0.33 | 2.11 | 38.38 | 18.82 |
| ***SEm±*** | | | | 0.016 | 0.0091 | 0.014 | 0.28 | 0.31 |
| ***CD (p=0.05)*** | | | | 0.046 | 0.027 | 0.042 | 0.82 | 0.92 |

The total phosphorus content in soybean seed ranged between 0.33 to 0.48% (Table 4). The highest phosphorus content was recorded in Dihoma soil of Kohima district (0.48%) while the lowest was in New Chumukedima of Dimapur district (5.24%).

The total potassium content in soybean seed ranged between 1.34 to 2.49% (Table 4). The highest potassium content was recorded in Kidima soil of Kohima district (2.49%) while the lowest was in Murise soil in Dimapur district (1.34 %).

### 4.1.7. Protein and oil content in soybean seed

The protein content in soybean seed collected from different locations showed significant difference ranging between 32.56 to 39.56% (Table 4). The highest protein content of 39.56% was recorded in Nerhema soil of Kohima district while the lowest was in Rusoma of Kohima district (32.56%). As apparent from the table 4, the oil content in soybean seed showed significant different among the growing locations ranging between 16.88 to 19.38%. The highest oil content of 19.38% was recorded in Dihoma soil of Kohima district while the lowest (16.88%) was at Murise site of Dimapur district.

### 4.1.8. Correlation between the quality characteristics of soybean seed and soil available nutrient content

The correlation between the quality characteristics of soybean seed (protein and oil) and available nutrient contents in soil is shown in table 5. The protein content showed positive correlation with oil content, Ca, Mg, P and S content and negative correlation with N and K. The oil content showed significant positive correlation with Mg whereas it showed negative correlation with P, K and S. The Ca content was positively correlated with Mg and negatively correlated with N, P, K and S. The Mg content showed positive correlation with P, K and S while it showed negative correlation with N. The soil-N showed significant negative correlation with P and S while it was negatively correlated with K content. P content showed significant positive correlation with K and S content. The K content showed positive correlation with S content.

It may be noted that the alkaline potassium permanganate method given by Subbiah and Asija (1956) was based on analysis of soil samples which were mostly alkaline in nature and included only one acidic soil from Northeast India. Hence, it may be assumed that the commonly used alkaline permanganate method may not be giving dependable and reliable results for soils of Northeast India or for that matter, acidic soils. The assumptions got support

Table 5: Coefficients of correlation between the quality characteristics of soybean seed and soil nutrient content

| | Oil content | Exchangeable Ca | Exchangeable Mg | Available N | Available P | Available K | Available S |
|---|---|---|---|---|---|---|---|
| **Protein content** | 0.430 | 0.380 | 0.019 | -0.115 | 0.150 | -0.147 | 0.169 |
| **Oil content** | | 0.163 | 0.602* | 0.398 | -0.366 | -0.073 | -0.053 |
| **Exchangeable Ca** | | | 0.018 | -0.010 | -0.190 | -0.023 | -0.050 |
| **Exchangeable Mg** | | | | -0.046 | 0.059 | 0.431 | 0.336 |
| **Available N** | | | | | -0.930** | -0.552 | -0.760** |
| **Available P** | | | | | | 0.607* | 0.761** |
| **Available K** | | | | | | | 0.360 |

***Note:*** ** Significant at the 0.01 level of significance
* Significant at the 0.05 level of significance

Table 6: Coefficient of correlation between the quality characteristics of soybean seeds

| | Protein content | Oil content |
|---|---|---|
| **N in the seed** | 1.00* | --- |
| **Soluble S in the soil** | | 0.339 |

***Note:*** ** Significant at the 0.01 level of significance
* Significant at the 0.05 level of significance

when many soil samples were collected from farmers field and analysed (Bordoloi *et al.*, 2013).

The mineralization of organic sulphur in soil depends primarily on the N: S ratio and $SO_4^{2-}$ formed might be fixed against extraction particularly if much Fe or Ba is present or the soil is very acidic (Baruah and Barthakur, 1997). Plants absorb S almost exclusively as $SO_4^{2-}$ but mobility of $SO_4^{2-}$ in soil may not always give satisfactory results in accordance with the time of sampling, while assessing $SO_4^{2-}$ availability. Also, turbidimetric method gives erroneous results in the soils containing high organic matter (Baruah and Barthakur, 1997). These reasons might have therefore resulted in negative correlations.

#### 4.1.9. Correlation coefficient study between the quality characteristics of soybean

The correlations amongst the quality characteristics of soybean are presented in table 6. The N content in the seeds showed significant positive correlation with protein content whereas the soluble S content in the soil showed significant positive correlation with oil content.

## 4.2. Effect of lime, farmyard manure and fertilizers on growth and yield of soybean

### 4.2.1. Effect on plant height

**Effect of lime on plant height**

The results on the plant height in different treatments have been presented in table 7. There was an appreciable increase in the height of the plant with the advancement of days and also significant difference among various treatments. It was apparent from the data, the maximum plant height was recorded in the treatment $L_2$ with corresponding value of 54.42 and 55.42 cm, 81.46 and 82.29 cm and 102.17 and 103.08 cm at 30, 45 and 60 DAS, respectively during 2014 and 2015 while in pooled data it was 54.92, 81.88 and 102.63 cm. The minimum plant height was recorded in the treatment $L_0$ i.e., 46.71 and 47.63 cm, 72.21 and 73.29 cm and 90.50 and 91.13 cm while in pooled data it was 47.17, 72.75 and 90.81 cm. In general, the application of lime was observed to boost the growth of the crop due to increase in the soil pH towards neutrality.

**Effect of farmyard manure on plant height**

Plant height at all the stages of crop growth was found higher in plots where organic matter was applied in higher amounts which might have attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. It was apparent from the table 7, the maximum plant height was recorded in treatment $O_1$ i.e., 54.22 and 54.78 cm, 79.83 and 80.61 cm and 97.97 and 98.75 cm at 30, 45 and 60 DAS, respectively during 2014 and 2015 while in pooled data it was 54.50, 80.22 and 98.36 cm. The minimum plant height was recorded in the treatment $O_0$ i.e., 46.83 and 48.00 cm, 71.97 and 72.89 cm and 94.36 and 95.14 cm while in pooled data it was 47.42, 72.43 and 94.75 cm.

**Effect of fertilizers on plant height**

From the data depicted in table 7, the results revealed that there was a significant difference among the treatments and maximum plant height was recorded in treatment $I_3$ i.e., 55.39 and 56.39 cm, 80.11 and 80.89 cm and 97.50 and 97.92 cm while pooled data had 55.89, 80.50 and 97.92 cm at 30, 45 and 60 DAS, respectively during 2014 and 2015. The minimum plant height was recorded in the treatment $I_0$ i.e., 45.67 and 46.33 cm, 72.06 and 72.94 cm and 94.83 and 95.44 cm while in pooled data it was 46.00, 72.50 and 95.14 cm.

**Effect of lime and farmyard manure on plant height**

At 30 DAS, the maximum and minimum plant heights were recorded in treatments $L_1O_1$ (55.25 and 55.58 cm) and $L_0O_0$ (40.75 and 41.92 cm) while in pooled data it was 55.42 and 41.33 cm during 2014 and 2015, respectively (Table 8). With the advancement of growth, the maximum plant height was associated with treatment $L_2O_1$ i.e., 83.83 and 84.75 cm and 104.50 and 105.42 cm while pooled data had 84.29 and 104.96 cm during 2014 and 2015, respectively at 45 and 60 DAS.

**Effect of lime and fertilizers on plant height**

The data (Table 8) revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum plant height i.e., 58.83 and 60.00 cm, 83.67 and 84.17 cm, 103.83 and 105 cm at 30, 45 and 60 DAS, respectively was associated with treatment $L_2I_3$ and pooled data had 59.42, 83.92 and 104.42 cm whereas the minimum plant height was recorded in the treatment $L_0I_0$ as 42.33 and 43.33 cm, 68.00 and 69.33 cm and 89.00 and 89.50 cm while in pooled data it was 42.83, 68.67 and 89.25 cm..

**Effect of farmyard manure and fertilizers on plant height**

The data presented in table 8 indicated that the maximum and minimum plant height was recorded in treatment $O_1I_3$ (58.11 and 58.89, 84.78 and 85.44, 99.33 and 100.11 cm) and $O_0I_0$ (41.22 and 42.33, 68.33 and 69.33, 93.00 and 93.67 cm) at 30, 45 and 60 DAS respectively and with pooled data as (58.50, 85.11 and 99.72 cm) and (41.78, 68.83 and 93.33 cm), respectively.

Table 7: Effect of lime, farmyard manure and fertilizers on height of soybean at different days after sowing (DAS)

| Treatments | Plant height (cm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| **$L_0$** | 46.71 | 47.63 | 47.17 | 72.21 | 73.29 | 72.75 | 90.50 | 91.13 | 90.81 |
| **$L_1$** | 50.46 | 51.13 | 50.79 | 74.04 | 74.67 | 74.35 | 95.83 | 96.63 | 96.23 |
| **$L_2$** | **54.42** | **55.42** | **54.92** | **81.46** | **82.29** | **81.88** | **102.17** | **103.08** | **102.63** |
| ***SEm±*** | ***1.18*** | ***1.01*** | ***0.78*** | ***1.17*** | ***2.41*** | ***1.34*** | ***3.24*** | ***3.64*** | ***2.44*** |
| ***CD(P=0.05)*** | ***4.64*** | ***3.98*** | ***2.54*** | ***4.61*** | ***9.47*** | ***4.37*** | ***12.71*** | ***14.31*** | ***7.95*** |
| **$O_0$** | 46.83 | 48.00 | 47.42 | 71.97 | 72.89 | 72.43 | 94.36 | 95.14 | 94.75 |
| **$O_1$** | **54.22** | **54.78** | **54.50** | **79.83** | **80.61** | **80.22** | **97.97** | **98.75** | **98.36** |
| ***SEm±*** | ***0.56*** | ***0.93*** | ***0.54*** | ***1.60*** | ***1.13*** | ***0.98*** | ***1.25*** | ***3.75*** | ***1.98*** |
| ***CD(P=0.05)*** | ***1.95*** | ***3.20*** | ***1.67*** | ***5.54*** | ***3.91*** | ***3.02*** | ***NS*** | ***NS*** | ***NS*** |
| **$I_0$** | 45.67 | 46.33 | 46.00 | 72.06 | 72.94 | 72.50 | 94.83 | 95.44 | 95.14 |
| **$I_1$** | 49.50 | 50.56 | 50.03 | 74.67 | 75.61 | 75.14 | 95.72 | 96.61 | 96.17 |
| **$I_2$** | 51.56 | 52.28 | 51.92 | 76.78 | 77.56 | 77.17 | 96.61 | 97.39 | 97.00 |
| **$I_3$** | **55.39** | **56.39** | **55.89** | **80.11** | **80.89** | **80.50** | **97.50** | **98.33** | **97.92** |
| ***SEm±*** | ***1.19*** | ***1.41*** | ***0.92*** | ***1.78*** | ***1.79*** | ***1.26*** | ***2.49*** | ***5.02*** | ***2.80*** |
| ***CD(P=0.05)*** | ***3.42*** | ***4.04*** | ***2.60*** | ***5.11*** | ***5.13*** | ***3.56*** | ***NS*** | ***NS*** | ***NS*** |

Table 8: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on height of soybean at different days after sowing (DAS)

| Treatments | Plant height (cm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0O_0$ | 40.75 | 41.92 | 41.33 | 67.67 | 68.83 | 68.25 | 88.33 | 89.00 | 88.67 |
| $L_0O_1$ | 52.67 | 53.33 | 53.00 | 76.75 | 77.75 | 77.25 | 92.67 | 93.25 | 92.96 |
| $L_1O_0$ | 45.67 | 46.67 | 46.17 | 69.17 | 70.00 | 69.58 | 94.92 | 95.67 | 95.29 |
| $L_1O_1$ | **55.25** | **55.58** | **55.42** | 78.92 | 79.33 | 79.13 | 96.75 | 97.58 | 97.17 |
| $L_2O_0$ | 54.08 | 55.42 | 54.75 | 79.08 | 79.83 | 79.46 | 99.83 | 100.75 | 100.29 |
| $L_2O_1$ | 54.75 | 55.42 | 55.08 | **83.83** | **84.75** | **84.29** | **104.50** | **105.42** | **104.96** |
| ***SEm±*** | ***0.97*** | ***1.60*** | ***0.94*** | ***2.77*** | ***1.96*** | ***1.70*** | ***2.16*** | ***6.49*** | ***3.42*** |
| ***CD(P=0.05)*** | ***3.37*** | ***5.55*** | ***2.89*** | ***9.59*** | ***6.78*** | ***5.23*** | ***7.47*** | ***22.47*** | ***10.54*** |
| $L_0I_0$ | 42.33 | 43.33 | 42.83 | 68.00 | 69.33 | 68.67 | 89.00 | 89.50 | 89.25 |
| $L_0I_1$ | 44.83 | 46.17 | 45.50 | 70.67 | 71.50 | 71.08 | 90.00 | 90.67 | 90.33 |
| $L_0I_2$ | 47.17 | 47.83 | 47.50 | 72.83 | 74.00 | 73.42 | 91.00 | 91.67 | 91.33 |
| $L_0I_3$ | 52.50 | 53.17 | 52.83 | 77.33 | 78.33 | 77.83 | 92.00 | 92.67 | 92.33 |
| $L_1I_0$ | 46.17 | 46.33 | 46.25 | 69.83 | 70.17 | 70.00 | 95.17 | 95.83 | 95.50 |
| $L_1I_1$ | 49.83 | 50.67 | 50.25 | 72.17 | 73.00 | 72.58 | 95.33 | 96.33 | 95.83 |
| $L_1I_2$ | 51.00 | 51.50 | 51.25 | 74.83 | 75.33 | 75.08 | 96.17 | 97.00 | 96.58 |
| $L_1I_3$ | 54.83 | 56.00 | 55.42 | 79.33 | 80.17 | 79.75 | 96.67 | 97.33 | 97.00 |
| $L_2I_0$ | 48.50 | 49.33 | 48.92 | 78.33 | 79.33 | 78.83 | 100.33 | 101.00 | 100.67 |
| $L_2I_1$ | 53.83 | 54.83 | 54.33 | 81.17 | 82.33 | 81.75 | 101.83 | 102.83 | 102.33 |
| $L_2I_2$ | 56.50 | 57.50 | 57.00 | 82.67 | 83.33 | 83.00 | 102.67 | 103.50 | 103.08 |
| $L_2I_3$ | **58.83** | **60.00** | **59.42** | **83.67** | **84.17** | **83.92** | **103.83** | **105.00** | **104.42** |
| ***SEm±*** | ***2.06*** | ***2.44*** | ***1.60*** | ***3.09*** | ***3.10*** | ***2.19*** | ***4.31*** | ***8.69*** | ***4.85*** |
| ***CD(P=0.05)*** | ***5.92*** | ***7.00*** | ***4.50*** | ***8.85*** | ***8.88*** | ***6.16*** | ***12.37*** | ***NS*** | ***13.67*** |
| $O_0I_0$ | 41.22 | 42.33 | 41.78 | 68.33 | 69.33 | 68.83 | 93.00 | 93.67 | 93.33 |
| $O_0I_1$ | 45.44 | 47.00 | 46.22 | 71.00 | 71.89 | 71.44 | 94.00 | 94.67 | 94.33 |
| $O_0I_2$ | 48.00 | 48.78 | 48.39 | 73.11 | 74.00 | 73.56 | 94.78 | 95.67 | 95.22 |
| $O_0I_3$ | 52.67 | 53.89 | 53.28 | 75.44 | 76.33 | 75.89 | 95.67 | 96.56 | 96.11 |
| $O_1I_0$ | 50.11 | 50.33 | 50.22 | 75.78 | 76.56 | 76.17 | 96.67 | 97.22 | 96.94 |
| $O_1I_1$ | 53.56 | 54.11 | 53.83 | 78.33 | 79.33 | 78.83 | 97.44 | 98.56 | 98.00 |
| $O_1I_2$ | 55.11 | 55.78 | 55.44 | 80.44 | 81.11 | 80.78 | 98.44 | 99.11 | 98.78 |
| $O_1I_3$ | **58.11** | **58.89** | **58.50** | **84.78** | **85.44** | **85.11** | **99.33** | **100.11** | **99.72** |
| ***SEm±*** | ***1.68*** | ***1.99*** | ***1.30*** | ***2.52*** | ***2.53*** | ***1.78*** | ***3.52*** | ***7.10*** | ***3.96*** |
| ***CD(P=0.05)*** | ***4.83*** | ***5.72*** | ***3.68*** | ***7.23*** | ***7.25*** | ***5.03*** | ***NS*** | ***NS*** | ***NS*** |

Table 9: Effect of lime, farmyard manure and fertilizers on plant height of soybean at different days after sowing (DAS)

| Treatments | Plant height (cm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0I_0$** | 36.67 | 38.00 | 37.33 | 63.00 | 64.33 | 63.67 | 86.33 | 87.00 | 86.67 |
| **$L_0O_0I_1$** | 37.33 | 39.33 | 38.33 | 65.67 | 66.33 | 66.00 | 87.67 | 88.33 | 88.00 |
| **$L_0O_0I_2$** | 40.33 | 41.00 | 40.67 | 68.00 | 69.33 | 68.67 | 89.00 | 89.67 | 89.33 |
| **$L_0O_0I_3$** | 48.67 | 49.33 | 49.00 | 74.00 | 75.33 | 74.67 | 90.33 | 91.00 | 90.67 |
| **$L_0O_1I_0$** | 48.00 | 48.67 | 48.33 | 73.00 | 74.33 | 73.67 | 91.67 | 92.00 | 91.83 |
| **$L_0O_1I_1$** | 52.33 | 53.00 | 52.67 | 75.67 | 76.67 | 76.17 | 92.33 | 93.00 | 92.67 |
| **$L_0O_1I_2$** | 54.00 | 54.67 | 54.33 | 77.67 | 78.67 | 78.17 | 93.00 | 93.67 | 93.33 |
| **$L_0O_1I_3$** | 56.33 | 57.00 | 56.67 | 80.67 | 81.33 | 81.00 | 93.67 | 94.33 | 94.00 |
| **$L_1O_0I_0$** | 40.67 | 41.33 | 41.00 | 65.67 | 66.67 | 66.17 | 94.33 | 95.00 | 94.67 |
| **$L_1O_0I_1$** | 44.33 | 45.67 | 45.00 | 68.00 | 69.00 | 68.50 | 94.67 | 95.33 | 95.00 |
| **$L_1O_0I_2$** | 46.33 | 46.67 | 46.50 | 70.67 | 71.33 | 71.00 | 95.00 | 96.00 | 95.50 |
| **$L_1O_0I_3$** | 51.33 | 53.00 | 52.17 | 72.33 | 73.00 | 72.67 | 95.67 | 96.33 | 96.00 |
| **$L_1O_1I_0$** | 51.67 | 51.33 | 51.50 | 74.00 | 73.67 | 73.83 | 96.00 | 96.67 | 96.33 |
| **$L_1O_1I_1$** | 55.33 | 55.67 | 55.50 | 76.33 | 77.00 | 76.67 | 96.00 | 97.33 | 96.67 |
| **$L_1O_1I_2$** | 55.67 | 56.33 | 56.00 | 79.00 | 79.33 | 79.17 | 97.33 | 98.00 | 97.67 |
| **$L_1O_1I_3$** | 58.33 | 59.00 | 58.67 | 86.33 | 87.33 | 86.83 | 97.67 | 98.33 | 98.00 |
| **$L_2O_0I_0$** | 46.33 | 47.67 | 47.00 | 76.33 | 77.00 | 76.67 | 98.33 | 99.00 | 98.67 |
| **$L_2O_0I_1$** | 54.67 | 56.00 | 55.33 | 79.33 | 80.33 | 79.83 | 99.67 | 100.33 | 100.00 |
| **$L_2O_0I_2$** | 57.33 | 58.67 | 58.00 | 80.67 | 81.33 | 81.00 | 100.33 | 101.33 | 100.83 |
| **$L_2O_0I_3$** | 58.00 | 59.33 | 58.67 | 80.00 | 80.67 | 80.33 | 101.00 | 102.33 | 101.67 |
| **$L_2O_1I_0$** | 50.67 | 51.00 | 50.83 | 80.33 | 81.67 | 81.00 | 102.33 | 103.00 | 102.67 |
| **$L_2O_1I_1$** | 53.00 | 53.67 | 53.33 | 83.00 | 84.33 | 83.67 | 104.00 | 105.33 | 104.67 |
| **$L_2O_1I_2$** | 55.67 | 56.33 | 56.00 | 84.67 | 85.33 | 85.00 | 105.00 | 105.67 | 105.33 |
| **$L_2O_1I_3$** | **59.67** | **60.67** | **60.17** | **87.33** | **87.67** | **87.50** | **106.67** | **107.67** | **107.17** |
| ***SEm±*** | ***2.92*** | ***3.45*** | ***2.26*** | ***4.36*** | ***4.38*** | ***3.09*** | ***6.10*** | ***12.29*** | ***6.86*** |
| ***CD(P=0.05)*** | ***8.37*** | ***9.90*** | ***6.37*** | ***12.52*** | ***12.55*** | ***8.71*** | ***NS*** | ***NS*** | ***19.34*** |

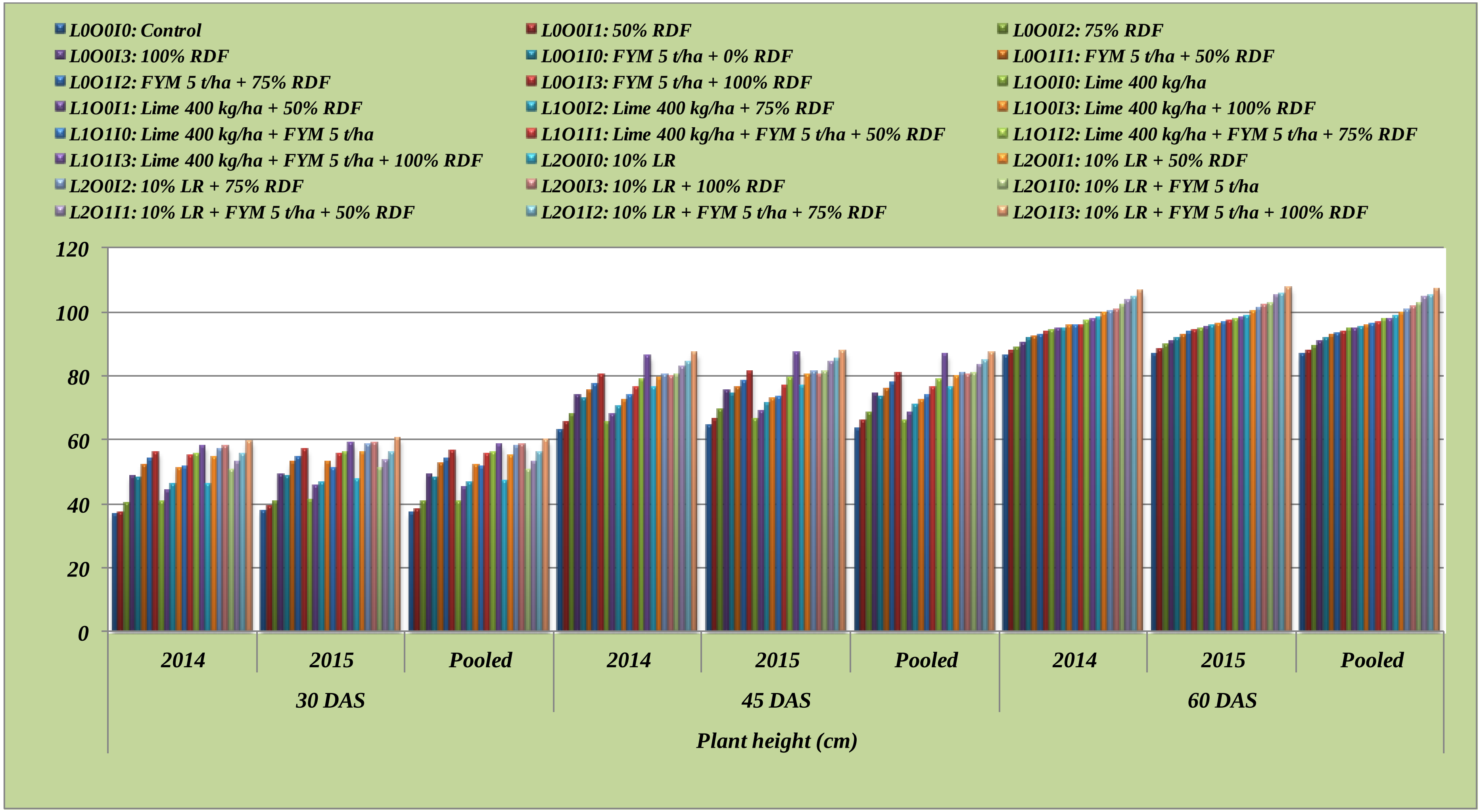



**Fig 4: Effect of lime, farmyard manure and fertilizers on plant height at different days after sowing (DAS) during 2014 and 2015**

**Effect of lime, farmyard manure and fertilizers on plant height**

The data indicated that the plant height at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM and lime (Table 9). Among the treatments, the maximum and minimum plant height was recorded in $L_2O_1I_3$ (59.67 and 60.67 cm, 87.33 and 87.67 cm and 106.67 and 107.67 cm) with pooled data as 60.17, 87.50 and 107.17 cm and $L_0O_0I_0$ (36.67 and 38.00 cm, 63.00 and 64.33 cm and 86.33 and 87.00 cm) with pooled data as 37.33, 63.67 and 86.67 cm at 30, 45 and 60 DAS, respectively during 2014 and 2015. The results revealed that $L_2O_1I_3$ enhanced plant growth significantly compared to the other treatments at 30, 45 and 60 DAS in both the years.

Combined effect of lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 100% RDF resulted in maximum plant height at 30, 45 and 60 DAS owing to increased metabolic activity. Application of nutrient sources viz., fertilizers and FYM led to increase availability of nutrients which may have aided favourable conditions for crop growth resulted in increased plant height along with increased nutrient input. Similar results with the increase on plant height along with input of NPK, lime and FYM have also been observed by Mishra *et al.* (1999).

**4.2.2. Effect on number of leaves**

**Effect of lime on number of leaves**

The results on the number of leaves in different treatments have been presented in table 10. There was an appreciable increase in plant height with the advancement of and in turn number of leaves which was significant among treatments. It was apparent from the data, the maximum number of leaves was recorded in the treatment $L_2$ with 6.17 and 6.46, 12.00 and 12.00, 23.63 and 24.00 cm at 30, 45 and 60 DAS, respectively during 2014 and 2015 while pooled data was 6.31, 12.00 and 23.81. Whereas, the minimum number of leaves was recorded in the treatment $L_0$ with 5.92 and 6.00, 11.13 and 11.17, 21.46 and 21.67 while pooled data was 5.96, 11.15 and 21.56. In general, the application of lime was observed to boost the growth of the crop due to increase in the soil pH towards neutral condition.

**Effect of farmyard manure on number of leaves**

The number of leaves at all the growth stages of crop was found higher in plots receiving higher amounts of organic matter which can be attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. It was apparent from the table 10, the maximum number of leaves was recorded in treatment $O_1$ as 6.17 and 6.31, 11.78 and 11.78, 23.25 and 23.36 at 30, 45 and 60 DAS, respectively during 2014 and 2015 while in pooled data it was 6.24, 11.78 and 23.31. The minimum number of leaves was recorded in the treatment $O_0$ as 5.92 and 6.08, 11.28 and 11.31, 21.92 and 22.19 while in pooled data it was 6.00, 11.29 and 22.06 at 30, 45 and 60 DAS, respectively during 2014 and 2015.

**Effect of fertilizers on number of leaves**

From the data (Table 10) it was inferred that there was a significant difference among the treatments and maximum number of leaves was recorded in treatment $I_3$ as 6.56 and 6.56, 12.28 and 12.17, 24.17 and 24.50 while pooled data had 6.56, 12.22 and 24.33 at 30, 45 and 60 DAS, respectively during 2014 and 2015. The minimum number of leaves was recorded in treatment $I_0$ as 5.78 and 5.83, 10.89 and 10.94, 21.33 and 21.33 while pooled had 5.81, 10.92 and 21.33 at 30, 45 and 60 DAS, respectively during 2014 and 2015.

**Effect of lime and farmyard manure on number of leaves**

The data indicated that the maximum and minimum number of leaves were recorded in treatment $L_2O_1$ (6.33 and 6.50) and $L_0O_0$ (5.58 and 5.58) while pooled data was 6.42 and 5.58 cm during 2014 and 2015, respectively at 30 DAS (Table 11). With the advancement of growth, the maximum number of leaves was recorded in $L_2O_1$ as 12.42 and 12.42, 25.00 and 25.17. The pooled data had 12.42 and 25.08 during 2014 and 2015, respectively at 45 and 60 DAS during 2014 and 2015.

**Effect of lime and fertilizers on number of leaves**

The results (Table 11) revealed that there was a significant difference among the treatments during 2014 and 2015; the maximum number of leaves was recorded as 7.00 and 6.83, 13.00 and 12.83, 24.50 and 25.33 at 30, 45 and 60 DAS, respectively in treatment $L_2I_3$ with pooled data as 6.92, 12.92 and 24.92 whereas the minimum plant height was recorded in treatment $L_0I_0$ as 5.83 and 5.67, 10.33 and 10.67, 19.83 and 19.83 while pooled data was 5.75, 10.50 and 19.83, respectively..

**Effect of farmyard manure and fertilizers on number of leaves**

The data (Table 11) indicated that the maximum and minimum number of leaves was recorded in treatment $O_1I_3$ (6.78 and 6.78, 12.56 and 12.56, 24.89 and 24.89) and $O_0I_0$ (5.56 and 5.56, 10.67 and 10.78, 20.67 and 20.56) at 30, 45 and 60 DAS respectively while pooled data had (6.78, 12.56 and 24.89) and (5.56, 10.78 and 20.61) at 30, 45 and 60 DAS during 2014 and 2015, respectively.

Table 10: Effect of lime, farmyard manure and fertilizers on number of leaves of soybean at different days after sowing (DAS)

| Treatments | Number of leaves | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0$** | 5.92 | 6.00 | 5.96 | 11.13 | 11.17 | 11.15 | 21.46 | 21.67 | 21.56 |
| **$L_1$** | 6.04 | 6.13 | 6.08 | 11.46 | 11.46 | 11.46 | 22.67 | 22.67 | 22.67 |
| **$L_2$** | **6.17** | **6.46** | **6.31** | **12.00** | **12.00** | **12.00** | **23.63** | **24.00** | **23.81** |
| ***SEm±*** | ***0.11*** | ***0.06*** | ***0.07*** | ***0.19*** | ***0.08*** | ***0.10*** | ***0.17*** | ***0.15*** | ***0.11*** |
| ***CD(P=0.05)*** | ***NS*** | ***0.25*** | ***0.21*** | ***0.73*** | ***0.31*** | ***0.33*** | ***0.65*** | ***0.57*** | ***0.36*** |
| **$O_0$** | 5.92 | 6.08 | 6.00 | 11.28 | 11.31 | 11.29 | 21.92 | 22.19 | 22.06 |
| **$O_1$** | **6.17** | **6.31** | **6.24** | **11.78** | **11.78** | **11.78** | **23.25** | **23.36** | **23.31** |
| ***SEm±*** | ***0.13*** | ***0.13*** | ***0.09*** | ***0.14*** | ***0.13*** | ***0.10*** | ***0.17*** | ***0.11*** | ***0.10*** |
| ***CD(P=0.05)*** | ***NS*** | ***NS*** | ***NS*** | ***0.50*** | ***0.44*** | ***0.29*** | ***0.60*** | ***0.37*** | ***0.31*** |
| **$I_0$** | 5.78 | 5.83 | 5.81 | 10.89 | 10.94 | 10.92 | 21.33 | 21.33 | 21.33 |
| **$I_1$** | 5.94 | 6.06 | 6.00 | 11.33 | 11.39 | 11.36 | 22.06 | 22.17 | 22.11 |
| **$I_2$** | 5.89 | 6.33 | 6.11 | 11.61 | 11.67 | 11.64 | 22.78 | 23.11 | 22.94 |
| **$I_3$** | **6.56** | **6.56** | **6.56** | **12.28** | **12.17** | **12.22** | **24.17** | **24.50** | **24.33** |
| ***SEm±*** | ***0.18*** | ***0.17*** | ***0.13*** | ***0.18*** | ***0.17*** | ***0.12*** | ***0.21*** | ***0.20*** | ***0.14*** |
| ***CD(P=0.05)*** | ***0.52*** | ***0.49*** | ***0.35*** | ***0.52*** | ***0.47*** | ***0.35*** | ***0.60*** | ***0.56*** | ***0.40*** |

Table 11: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on number of leaves of soybean at different days after sowing (DAS)

| Treatments | Number of leaves | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0O_0$ | 5.58 | 5.58 | 5.58 | 10.83 | 10.75 | 10.79 | 20.75 | 21.08 | 20.92 |
| $L_0O_1$ | 6.25 | 6.42 | 6.33 | 11.42 | 11.58 | 11.50 | 22.17 | 22.25 | 22.21 |
| $L_1O_0$ | 6.17 | 6.25 | 6.21 | 11.42 | 11.58 | 11.50 | 22.75 | 22.67 | 22.71 |
| $L_1O_1$ | 5.92 | 6.00 | 5.96 | 11.50 | 11.33 | 11.42 | 22.58 | 22.67 | 22.63 |
| $L_2O_0$ | 6.00 | 6.42 | 6.21 | 11.58 | 11.58 | 11.58 | 22.25 | 22.83 | 22.54 |
| $L_2O_1$ | **6.33** | **6.50** | **6.42** | **12.42** | **12.42** | **12.42** | **25.00** | **25.17** | **25.08** |
| ***SEm±*** | ***0.23*** | ***0.22*** | ***0.16*** | ***0.25*** | ***0.22*** | ***0.17*** | ***0.30*** | ***0.18*** | ***0.18*** |
| ***CD(P=0.05)*** | ***0.78*** | ***0.75*** | ***0.48*** | ***0.87*** | ***0.75*** | ***0.51*** | ***1.03*** | ***0.63*** | ***0.54*** |
| $L_0I_0$ | 5.83 | 5.67 | 5.75 | 10.33 | 10.67 | 10.50 | 19.83 | 19.83 | 19.83 |
| $L_0I_1$ | 6.00 | 5.83 | 5.92 | 11.00 | 11.00 | 11.00 | 20.83 | 20.83 | 20.83 |
| $L_0I_2$ | 5.67 | 6.17 | 5.92 | 11.33 | 11.33 | 11.33 | 21.67 | 22.33 | 22.00 |
| $L_0I_3$ | 6.17 | 6.33 | 6.25 | 11.83 | 11.67 | 11.75 | 23.50 | 23.67 | 23.58 |
| $L_1I_0$ | 5.67 | 5.67 | 5.67 | 11.00 | 10.67 | 10.83 | 21.50 | 21.67 | 21.58 |
| $L_1I_1$ | 6.00 | 6.00 | 6.00 | 11.33 | 11.67 | 11.50 | 22.00 | 22.00 | 22.00 |
| $L_1I_2$ | 6.00 | 6.33 | 6.17 | 11.50 | 11.50 | 11.50 | 22.67 | 22.50 | 22.58 |
| $L_1I_3$ | 6.50 | 6.50 | 6.50 | 12.00 | 12.00 | 12.00 | 24.50 | 24.50 | 24.50 |
| $L_2I_0$ | 5.83 | 6.17 | 6.00 | 11.33 | 11.50 | 11.42 | 22.67 | 22.50 | 22.58 |
| $L_2I_1$ | 5.83 | 6.33 | 6.08 | 11.67 | 11.50 | 11.58 | 23.33 | 23.67 | 23.50 |
| $L_2I_2$ | 6.00 | 6.50 | 6.25 | 12.00 | 12.17 | 12.08 | 24.00 | 24.50 | 24.25 |
| $L_2I_3$ | **7.00** | **6.83** | **6.92** | **13.00** | **12.83** | **12.92** | **24.50** | **25.33** | **24.92** |
| ***SEm±*** | ***0.32*** | ***0.30*** | ***0.22*** | ***0.32*** | ***0.29*** | ***0.21*** | ***0.36*** | ***0.34*** | ***0.25*** |
| ***CD(P=0.05)*** | ***0.91*** | ***0.85*** | ***0.61*** | ***0.90*** | ***0.82*** | ***0.60*** | ***1.03*** | ***0.97*** | ***0.70*** |
| $O_0I_0$ | 5.56 | 5.56 | 5.56 | 10.67 | 10.78 | 10.72 | 20.67 | 20.56 | 20.61 |
| $O_0I_1$ | 6.11 | 6.11 | 6.11 | 11.00 | 11.11 | 11.06 | 21.22 | 21.44 | 21.33 |
| $O_0I_2$ | 5.67 | 6.33 | 6.00 | 11.44 | 11.56 | 11.50 | 22.33 | 22.67 | 22.50 |
| $O_0I_3$ | 6.33 | 6.33 | 6.33 | 12.00 | 11.78 | 11.89 | 23.44 | 24.11 | 23.78 |
| $O_1I_0$ | 6.00 | 6.11 | 6.06 | 11.11 | 11.11 | 11.11 | 22.00 | 22.11 | 22.06 |
| $O_1I_1$ | 5.78 | 6.00 | 5.89 | 11.67 | 11.67 | 11.67 | 22.89 | 22.89 | 22.89 |
| $O_1I_2$ | 6.11 | 6.33 | 6.22 | 11.78 | 11.78 | 11.78 | 23.22 | 23.56 | 23.39 |
| $O_1I_3$ | **6.78** | **6.78** | **6.78** | **12.56** | **12.56** | **12.56** | **24.89** | **24.89** | **24.89** |
| ***SEm±*** | ***0.26*** | ***0.24*** | ***0.18*** | ***0.26*** | ***0.23*** | ***0.17*** | ***0.29*** | ***0.28*** | ***0.20*** |
| ***CD(P=0.05)*** | ***0.74*** | ***0.69*** | ***0.50*** | ***0.74*** | ***0.67*** | ***0.49*** | ***0.84*** | ***0.79*** | ***0.57*** |

Table 12: Effect of lime, farmyard manure and fertilizers on number of leaves of soybean at different days after sowing (DAS)

| Treatments | Number of leaves | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0O_0I_0$ | 5.33 | 4.67 | 5.00 | 10.00 | 10.33 | 10.17 | 19.00 | 18.67 | 18.83 |
| $L_0O_0I_1$ | 6.00 | 5.67 | 5.83 | 10.67 | 10.33 | 10.50 | 20.00 | 20.33 | 20.17 |
| $L_0O_0I_2$ | 5.33 | 6.00 | 5.67 | 11.00 | 11.33 | 11.17 | 21.00 | 21.67 | 21.33 |
| $L_0O_0I_3$ | 5.67 | 6.00 | 5.83 | 11.67 | 11.00 | 11.33 | 23.00 | 23.67 | 23.33 |
| $L_0O_1I_0$ | 6.33 | 6.67 | 6.50 | 10.67 | 11.00 | 10.83 | 20.67 | 21.00 | 20.83 |
| $L_0O_1I_1$ | 6.00 | 6.00 | 6.00 | 11.33 | 11.67 | 11.50 | 21.67 | 21.33 | 21.50 |
| $L_0O_1I_2$ | 6.00 | 6.33 | 6.17 | 11.67 | 11.33 | 11.50 | 22.33 | 23.00 | 22.67 |
| $L_0O_1I_3$ | 6.67 | 6.67 | 6.67 | 12.00 | 12.33 | 12.17 | 24.00 | 23.67 | 23.83 |
| $L_1O_0I_0$ | 5.67 | 5.67 | 5.67 | 11.00 | 10.67 | 10.83 | 21.67 | 22.00 | 21.83 |
| $L_1O_0I_1$ | 6.33 | 6.33 | 6.33 | 11.00 | 11.67 | 11.33 | 21.67 | 21.67 | 21.67 |
| $L_1O_0I_2$ | 6.00 | 6.33 | 6.17 | 11.67 | 11.67 | 11.67 | 23.00 | 22.67 | 22.83 |
| $L_1O_0I_3$ | 6.67 | 6.67 | 6.67 | 12.00 | 12.33 | 12.17 | 24.67 | 24.33 | 24.50 |
| $L_1O_1I_0$ | 5.67 | 5.67 | 5.67 | 11.00 | 10.67 | 10.83 | 21.33 | 21.33 | 21.33 |
| $L_1O_1I_1$ | 5.67 | 5.67 | 5.67 | 11.67 | 11.67 | 11.67 | 22.33 | 22.33 | 22.33 |
| $L_1O_1I_2$ | 6.00 | 6.33 | 6.17 | 11.33 | 11.33 | 11.33 | 22.33 | 22.33 | 22.33 |
| $L_1O_1I_3$ | 6.33 | 6.33 | 6.33 | 12.00 | 11.67 | 11.83 | 24.33 | 24.67 | 24.50 |
| $L_2O_0I_0$ | 5.67 | 6.33 | 6.00 | 11.00 | 11.33 | 11.17 | 21.33 | 21.00 | 21.17 |
| $L_2O_0I_1$ | 6.00 | 6.33 | 6.17 | 11.33 | 11.33 | 11.33 | 22.00 | 22.33 | 22.17 |
| $L_2O_0I_2$ | 5.67 | 6.67 | 6.17 | 11.67 | 11.67 | 11.67 | 23.00 | 23.67 | 23.33 |
| $L_2O_0I_3$ | 6.67 | 6.33 | 6.50 | 12.33 | 12.00 | 12.17 | 22.67 | 24.33 | 23.50 |
| $L_2O_1I_0$ | 6.00 | 6.00 | 6.00 | 11.67 | 11.67 | 11.67 | 24.00 | 24.00 | 24.00 |
| $L_2O_1I_1$ | 5.67 | 6.33 | 6.00 | 12.00 | 11.67 | 11.83 | 24.67 | 25.00 | 24.83 |
| $L_2O_1I_2$ | 6.33 | 6.33 | 6.33 | 12.33 | 12.67 | 12.50 | 25.00 | 25.33 | 25.17 |
| $L_2O_1I_3$ | **7.33** | **7.33** | **7.33** | **13.67** | **13.67** | **13.67** | **26.33** | **26.33** | **26.33** |
| ***Sem±*** | ***0.45*** | ***0.42*** | ***0.31*** | ***0.45*** | ***0.40*** | ***0.30*** | ***0.51*** | ***0.48*** | ***0.35*** |
| ***CD at 5%*** | ***1.28*** | ***1.20*** | ***0.86*** | ***1.28*** | ***1.16*** | ***0.85*** | ***1.46*** | ***1.37*** | ***0.98*** |

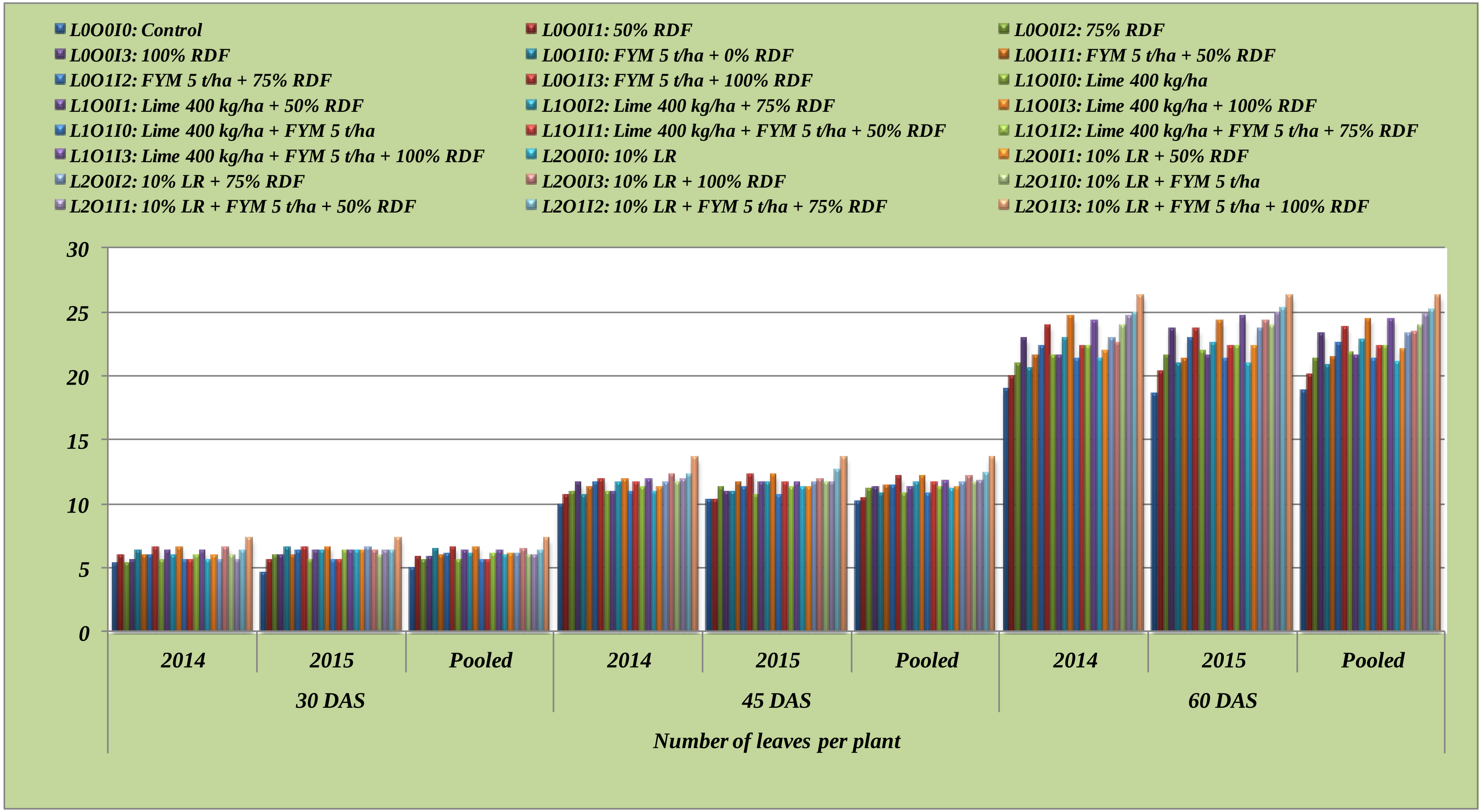



**Fig 5: Effect of lime, farmyard manure and fertilizers on number of leaves per plant at different days after sowing (DAS) during 2014 and 2015**

**Effect of lime, farmyard manure and fertilizers on number of leaves**

The data indicated that the number of leaves at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM and lime (Table 12). Among the treatments, the maximum number of leaves was recorded in $L_2O_1I_3$ (7.33 and 7.33, 13.67 and 13.67, 26.33 and 26.33) while pooled data had 7.33, 13.67 and 26.33 at 30, 45 and 60 DAS, respectively during 2014 and 2015. The minimum number of leaves was recorded at 30 DAS in treatment $L_0O_0I_0$ and $L_0O_0I_2$ as 5.33 in 2014 and in $L_0O_0I_0$ as 4.67 during 2015, whereas at 45 DAS, minimum number of leaves was recorded in $L_0O_0I_0$ (10.00) during 2014 and in $L_0O_0I_0$ and $L_0O_0I_1$ as 10.33 in 2015. At 45 DAS, minimum number of leaves was recorded in $L_0O_0I_0$ as 19.00 and 18.67, respectively during 2014 and 2015 with pooled data as 18.83. The results revealed that application of $L_2O_1I_3$ enhanced plant growth significantly as compared to the other treatments at 30, 45 and 60 DAS in both the years.

The combined effect of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100% RDF resulted in maximum number of leaves at 30, 45 and 60 DAS as 7.33, 13.67 and 26.33 leaves, respectively. Favourable conditions for crop growth could have been influenced by application of fertilizers and FYM, leading to increased availability of nutrients resulting in increasing number of leaves. Palve *et al.* (2011) also reported increase in number of leaves in soybean with input of 100 % RDF along with FYM @ 5 t $ha^{-1}$.

**4.2.3. Effect on number of nodules**

**Effect of lime on number of nodules**

The results on the number of nodules in different treatments have been presented in table 13. There was an appreciable increase in the number of nodules with the advancement of days which was significant difference among different treatments. It is apparent from the data, the maximum number of nodules was recorded in $L_2$ as 34.58 and 34.67, 44.25 and 44.67, 64.58 and 65.13 at 30, 45 and 60 DAS, respectively during 2014 and 2015 while pooled data had 34.63, 44.46 and 64.85 whereas the minimum number of nodules was recorded in $L_0$ as 24.25 and 24.21, 34.04 and 34.17, 53.04 and 53.04 while pooled data had 24.23, 34.10 and 53.04. In general, the application of lime was observed to boost the growth of the crop due to increase in the soil pH. The number of nodules increased with the increasing level of lime.

**Effect of farmyard manure on number of nodules**

The number of nodules at all the stages of crop growth was found higher in plots where FYM was applied in higher amounts which can be attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. It was apparent from the table 13, the maximum number of nodules was recorded in treatment $O_1$ as 32.17 and 32.25, 41.89 and 42.22, 61.39 and 61.61 at 30, 45 and 60 DAS, respectively during 2014 and 2015 while in pooled data it was 32.21, 42.06 and 61.50. The minimum number of nodules was recorded in the treatment $O_0$ as 28.89 and 29.11, 38.64 and 38.97, 58.94 and 59.17 while pooled data had 29, 38.81 and 59.06, respectively.

**Effect of fertilizers on number of nodules**

The data (Table 13) revealed that there was a significant difference among the treatments and the maximum number of nodules was recorded in treatment $I_3$ at 30 and 45 DAS as 33 and 33, 42.72 and 42.83 while pooled data had 33 and 42.78, respectively during 2014 and 2015. At 60 DAS, the maximum number of nodules was recorded in treatment $I_2$ as 61.50 and 61.61 respectively during 2014 and 2015, whereas the minimum number of nodules was recorded in the treatment $I_0$ as 27.78 and 28.11, 37.61 and 38.17, 57.83 and 58.06 while in the pooled data it had 27.94, 37.89 and 57.94.

**Effect of lime and farmyard manure on number of nodules**

The results showed that the maximum and minimum number of nodules were recorded in treatment $L_2O_1$ (35.42 and 35.42) and $L_0O_0$ (21.75 and 21.83) while pooled data had 35.42 and 21.79 during 2014 and 2015, respectively at 30 DAS (Table 14). With the advancement of growth, the maximum number of nodules was recorded in $L_2O_1$ as 45.08 and 45.42, 65.42 and 66.08 while pooled data had 45.25 and 65.75 cm during 2014 and 2015, respectively at 45 and 60 DAS.

**Effect of lime and fertilizers on number of nodules**

The data presented in table 14 revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum number of nodules was recorded as 36.17 and 36.17, 45.83 and 46.50, 66.17 and 66.83 at 30, 45 and 60 DAS, respectively in treatment $L_2I_3$ during 2014 and 2015, with pooled data as 36.17, 46.17 and 66.50. The minimum number of nodules was recorded in the treatment $L_0I_0$ as 20.00 and 20.50, 30.17 and 30.83, 50.17 and 50.17, respectively, during 2014 and 2015, while in the pooled data it was 20.25, 30.35 and 50.17.

**Effect of farmyard manure and fertilizers on number of nodules**

From the data (Table 14) it is inferred that the maximum number of nodules was

Table 13: Effect of lime, farmyard manure and fertilizers on number of nodules of soybean at different days after sowing (DAS)

| Treatments | Number of nodules | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0$ | 24.25 | 24.21 | 24.23 | 34.04 | 34.17 | 34.10 | 53.04 | 53.04 | 53.04 |
| $L_1$ | 32.75 | 33.17 | 32.96 | 42.50 | 42.96 | 42.73 | 62.88 | 63.00 | 62.94 |
| $L_2$ | **34.58** | **34.67** | **34.63** | **44.25** | **44.67** | **44.46** | **64.58** | **65.13** | **64.85** |
| ***SEm±*** | ***1.29*** | ***1.10*** | ***0.85*** | ***1.32*** | ***0.94*** | ***0.81*** | ***1.13*** | ***1.04*** | ***0.77*** |
| ***CD(P=0.05)*** | ***5.06*** | ***4.34*** | ***2.77*** | ***5.18*** | ***3.68*** | ***2.64*** | ***4.43*** | ***4.10*** | ***2.51*** |
| $O_0$ | 28.89 | 29.11 | 29.00 | 38.64 | 38.97 | 38.81 | 58.94 | 59.17 | 59.06 |
| $O_1$ | **32.17** | **32.25** | **32.21** | **41.89** | **42.22** | **42.06** | **61.39** | **61.61** | **61.50** |
| ***SEm±*** | ***1.00*** | ***0.70*** | ***0.61*** | ***0.81*** | ***0.34*** | ***0.44*** | ***1.01*** | ***0.99*** | ***0.71*** |
| ***CD(P=0.05)*** | ***NS*** | ***2.42*** | ***1.87*** | ***2.81*** | ***1.18*** | ***1.36*** | ***NS*** | ***NS*** | ***NS*** |
| $I_0$ | 27.78 | 28.11 | 27.94 | 37.61 | 38.17 | 37.89 | 57.83 | 58.06 | 57.94 |
| $I_1$ | 29.94 | 30.11 | 30.03 | 39.61 | 40.06 | 39.83 | 59.94 | 60.33 | 60.14 |
| $I_2$ | 31.39 | 31.50 | 31.44 | 41.11 | 41.33 | 41.22 | **61.50** | **61.61** | **61.56** |
| $I_3$ | **33.00** | **33.00** | **33.00** | **42.72** | **42.83** | **42.78** | 61.39 | 61.56 | 61.47 |
| ***SEm±*** | ***1.11*** | ***1.31*** | ***0.86*** | ***1.12*** | ***0.66*** | ***0.65*** | ***1.57*** | ***1.54*** | ***1.10*** |
| ***CD(P=0.05)*** | ***3.19*** | ***3.76*** | ***2.42*** | ***3.20*** | ***1.89*** | ***1.83*** | ***NS*** | ***NS*** | ***3.10*** |

Table 14: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on number of nodules of soybean at different days after sowing (DAS)

| Treatments | Number of nodules | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| **$L_0O_0$** | 21.75 | 21.83 | 21.79 | 31.67 | 31.58 | 31.63 | 51.83 | 51.83 | 51.83 |
| **$L_0O_1$** | 26.75 | 26.58 | 26.67 | 36.42 | 36.75 | 36.58 | 54.25 | 54.25 | 54.25 |
| **$L_1O_0$** | 31.17 | 31.58 | 31.38 | 40.83 | 41.42 | 41.13 | 61.25 | 61.50 | 61.38 |
| **$L_1O_1$** | 34.33 | 34.75 | 34.54 | 44.17 | 44.50 | 44.33 | 64.50 | 64.50 | 64.50 |
| **$L_2O_0$** | 33.75 | 33.92 | 33.83 | 43.42 | 43.92 | 43.67 | 63.75 | 64.17 | 63.96 |
| **$L_2O_1$** | **35.42** | **35.42** | **35.42** | **45.08** | **45.42** | **45.25** | **65.42** | **66.08** | **65.75** |
| ***SEm±*** | ***1.72*** | ***1.21*** | ***1.05*** | ***1.41*** | ***0.59*** | ***0.76*** | ***1.74*** | ***1.72*** | ***1.22*** |
| ***CD(P=0.05)*** | ***5.96*** | ***4.19*** | ***3.25*** | ***4.87*** | ***2.05*** | ***2.35*** | ***6.03*** | ***5.95*** | ***3.77*** |
| **$L_0I_0$** | 20.00 | 20.50 | 20.25 | 30.17 | 30.83 | 30.50 | 50.17 | 50.17 | 50.17 |
| **$L_0I_1$** | 23.67 | 23.83 | 23.75 | 33.33 | 33.83 | 33.58 | 53.67 | 53.83 | 53.75 |
| **$L_0I_2$** | 24.33 | 24.17 | 24.25 | 34.00 | 33.83 | 33.92 | 54.33 | 54.33 | 54.33 |
| **$L_0I_3$** | 29.00 | 28.33 | 28.67 | 38.67 | 38.17 | 38.42 | 54.00 | 53.83 | 53.92 |
| **$L_1I_0$** | 30.67 | 31.33 | 31.00 | 40.33 | 41.00 | 40.67 | 60.67 | 60.67 | 60.67 |
| **$L_1I_1$** | 31.83 | 32.00 | 31.92 | 41.50 | 42.17 | 41.83 | 61.83 | 62.17 | 62.00 |
| **$L_1I_2$** | 34.67 | 34.83 | 34.75 | 44.50 | 44.83 | 44.67 | 65.00 | 65.17 | 65.08 |
| **$L_1I_3$** | 33.83 | 34.50 | 34.17 | 43.67 | 43.83 | 43.75 | 64.00 | 64.00 | 64.00 |
| **$L_2I_0$** | 32.67 | 32.50 | 32.58 | 42.33 | 42.67 | 42.50 | 62.67 | 63.33 | 63.00 |
| **$L_2I_1$** | 34.33 | 34.50 | 34.42 | 44.00 | 44.17 | 44.08 | 64.33 | 65.00 | 64.67 |
| **$L_2I_2$** | 35.17 | 35.50 | 35.33 | 44.83 | 45.33 | 45.08 | 65.17 | 65.33 | 65.25 |
| **$L_2I_3$** | **36.17** | **36.17** | **36.17** | **45.83** | **46.50** | **46.17** | **66.17** | **66.83** | **66.50** |
| ***SEm±*** | ***1.93*** | ***2.27*** | ***1.49*** | ***1.93*** | ***1.14*** | ***1.12*** | ***2.72*** | ***2.67*** | ***1.91*** |
| ***CD(P=0.05)*** | ***5.52*** | ***6.51*** | ***4.20*** | ***5.54*** | ***3.28*** | ***3.16*** | ***7.81*** | ***7.66*** | ***5.38*** |
| **$O_0I_0$** | 27.00 | 27.22 | 27.11 | 37.00 | 37.56 | 37.28 | 57.11 | 57.89 | 57.50 |
| **$O_0I_1$** | 27.89 | 28.22 | 28.06 | 37.56 | 38.11 | 37.83 | 57.89 | 58.11 | 58.00 |
| **$O_0I_2$** | 29.67 | 29.89 | 29.78 | 39.33 | 39.33 | 39.33 | 59.78 | 59.33 | 59.56 |
| **$O_0I_3$** | 31.00 | 31.11 | 31.06 | 40.67 | 40.89 | 40.78 | 61.00 | 61.33 | 61.17 |
| **$O_1I_0$** | 28.56 | 29.00 | 28.78 | 38.22 | 38.78 | 38.50 | 58.56 | 58.22 | 58.39 |
| **$O_1I_1$** | 32.00 | 32.00 | 32.00 | 41.67 | 42.00 | 41.83 | 62.00 | 62.56 | 62.28 |
| **$O_1I_2$** | 33.11 | 33.11 | 33.11 | 42.89 | 43.33 | 43.11 | **63.22** | **63.89** | **63.56** |
| **$O_1I_3$** | **35.00** | **34.89** | **34.94** | **44.78** | **44.78** | **44.78** | 61.78 | 61.78 | 61.78 |
| ***SEm±*** | ***1.57*** | ***1.85*** | ***1.22*** | ***1.58*** | ***0.93*** | ***0.92*** | ***2.22*** | ***2.18*** | ***1.56*** |
| ***CD(P=0.05)*** | ***4.51*** | ***5.32*** | ***3.43*** | ***4.52*** | ***2.68*** | ***2.58*** | ***NS*** | ***NS*** | ***4.39*** |

Table 15: Effect of lime, farmyard manure and fertilizers on number of nodules of soybean at different days after sowing (DAS)

| Treatments | Number of nodules | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0I_0$** | 18.67 | 19.33 | 19.00 | 29.33 | 30.00 | 29.67 | 49.00 | 50.00 | 49.50 |
| **$L_0O_0I_1$** | 21.67 | 21.33 | 21.50 | 31.33 | 31.67 | 31.50 | 51.67 | 51.33 | 51.50 |
| **$L_0O_0I_2$** | 22.00 | 22.67 | 22.33 | 31.67 | 31.00 | 31.33 | 52.00 | 51.33 | 51.67 |
| **$L_0O_0I_3$** | 24.67 | 24.00 | 24.33 | 34.33 | 33.67 | 34.00 | 54.67 | 54.67 | 54.67 |
| **$L_0O_1I_0$** | 21.33 | 21.67 | 21.50 | 31.00 | 31.67 | 31.33 | 51.33 | 50.33 | 50.83 |
| **$L_0O_1I_1$** | 25.67 | 26.33 | 26.00 | 35.33 | 36.00 | 35.67 | 55.67 | 56.33 | 56.00 |
| **$L_0O_1I_2$** | 26.67 | 25.67 | 26.17 | 36.33 | 36.67 | 36.50 | 56.67 | 57.33 | 57.00 |
| **$L_0O_1I_3$** | 33.33 | 32.67 | 33.00 | 43.00 | 42.67 | 42.83 | 53.33 | 53.00 | 53.17 |
| **$L_1O_0I_0$** | 30.67 | 31.33 | 31.00 | 40.33 | 41.00 | 40.67 | 60.67 | 61.33 | 61.00 |
| **$L_1O_0I_1$** | 28.33 | 29.00 | 28.67 | 38.00 | 38.67 | 38.33 | 58.33 | 58.67 | 58.50 |
| **$L_1O_0I_2$** | 32.33 | 32.00 | 32.17 | 42.00 | 42.33 | 42.17 | 62.67 | 62.33 | 62.50 |
| **$L_1O_0I_3$** | 33.33 | 34.00 | 33.67 | 43.00 | 43.67 | 43.33 | 63.33 | 63.67 | 63.50 |
| **$L_1O_1I_0$** | 30.67 | 31.33 | 31.00 | 40.33 | 41.00 | 40.67 | 60.67 | 60.00 | 60.33 |
| **$L_1O_1I_1$** | 35.33 | 35.00 | 35.17 | 45.00 | 45.67 | 45.33 | 65.33 | 65.67 | 65.50 |
| **$L_1O_1I_2$** | 37.00 | 37.67 | 37.33 | 47.00 | 47.33 | 47.17 | **67.33** | **68.00** | **67.67** |
| **$L_1O_1I_3$** | 34.33 | 35.00 | 34.67 | 44.33 | 44.00 | 44.17 | 64.67 | 64.33 | 64.50 |
| **$L_2O_0I_0$** | 31.67 | 31.00 | 31.33 | 41.33 | 41.67 | 41.50 | 61.67 | 62.33 | 62.00 |
| **$L_2O_0I_1$** | 33.67 | 34.33 | 34.00 | 43.33 | 44.00 | 43.67 | 63.67 | 64.33 | 64.00 |
| **$L_2O_0I_2$** | 34.67 | 35.00 | 34.83 | 44.33 | 44.67 | 44.50 | 64.67 | 64.33 | 64.50 |
| **$L_2O_0I_3$** | 35.00 | 35.33 | 35.17 | 44.67 | 45.33 | 45.00 | 65.00 | 65.67 | 65.33 |
| **$L_2O_1I_0$** | 33.67 | 34.00 | 33.83 | 43.33 | 43.67 | 43.50 | 63.67 | 64.33 | 64.00 |
| **$L_2O_1I_1$** | 35.00 | 34.67 | 34.83 | 44.67 | 44.33 | 44.50 | 65.00 | 65.67 | 65.33 |
| **$L_2O_1I_2$** | 35.67 | 36.00 | 35.83 | 45.33 | 46.00 | 45.67 | 65.67 | 66.33 | 66.00 |
| **$L_2O_1I_3$** | **37.33** | **37.00** | **37.17** | **47.00** | **47.67** | **47.33** | 67.33 | 68.00 | 67.67 |
| ***SEm±*** | ***2.72*** | ***3.21*** | ***2.10*** | ***2.73*** | ***1.62*** | ***1.59*** | ***3.85*** | ***3.77*** | ***2.70*** |
| ***CD(P=0.05)*** | ***7.81*** | ***9.21*** | ***5.93*** | ***7.84*** | ***4.64*** | ***4.48*** | ***11.05*** | ***10.83*** | ***7.60*** |

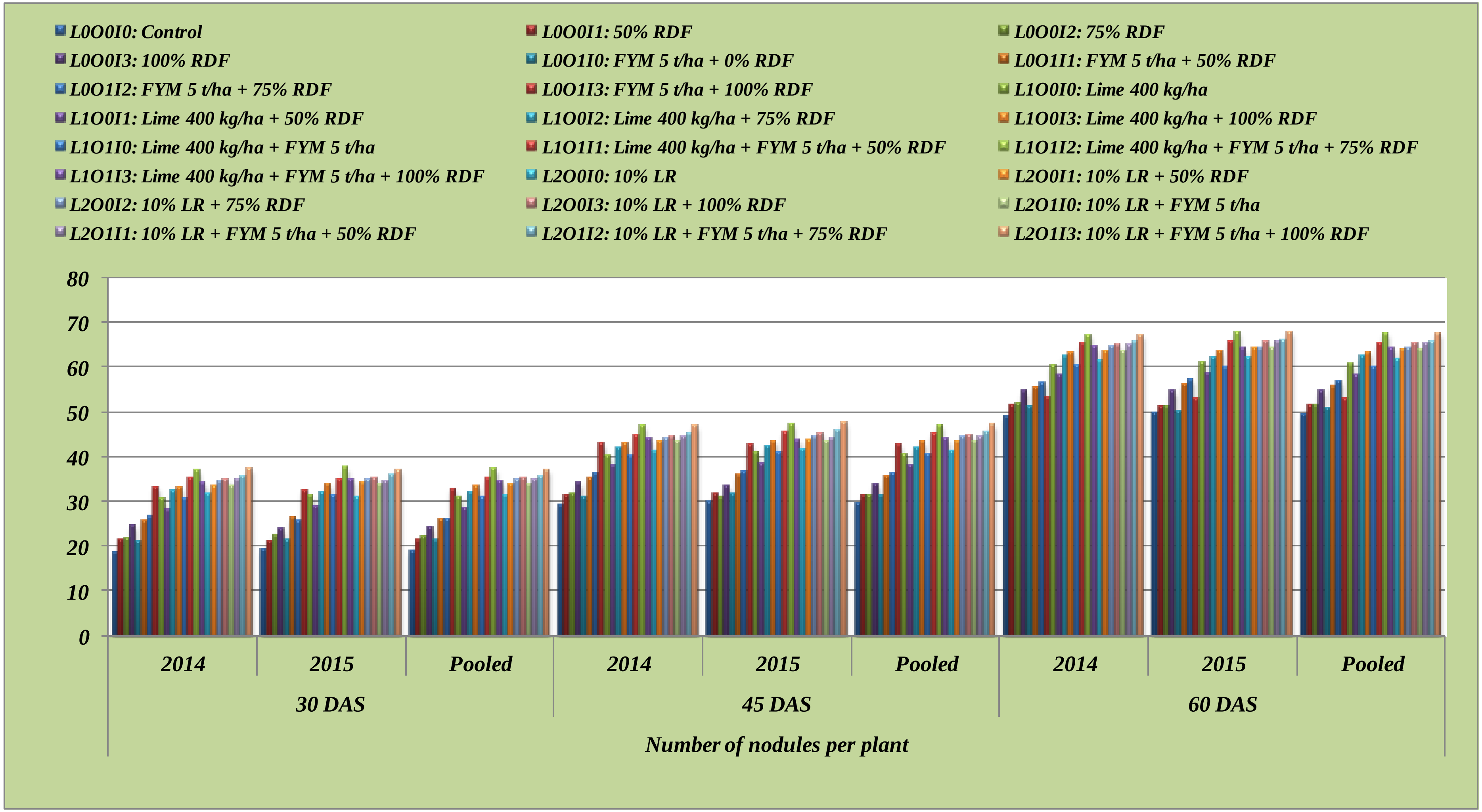



**Fig 6: Effect of lime, farmyard manure and fertilizers on number of nodules per plant at different days after sowing (DAS) during 2014 and 2015**

recorded in treatment $O_1I_3$ (35.00 and 34.89, 44.78 and 44.78) and $O_1I_2$ (63.22 and 63.89) and the minimum number of nodules in $O_0I_0$ (27.00 and 27.22, 37.00 and 37.56, 57.11 and 57.89) at 30, 45 and 60 DAS respectively with pooled data as (34.94, 44.78 and 63.56) and (27.11, 37.28 and 57.50), respectively..

**Effect of lime, farmyard manure and fertilizers on number of nodules**

The data indicated that the number of nodules at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM and lime (Table 15). Among the treatments, the maximum number of nodules was recorded in $L_2O_1I_3$ (37.33 and 37.00, 47.00 and 47.67) and $L_1O_1I_2$ (67.33 and 68.00) while in pooled data it was 37.17, 47.33 and 67.67 at 30, 45 and 60 DAS, respectively during 2014 and 2015. The minimum number of nodules was recorded in $L_0O_0I_0$ (18.67 and 19.33, 29.33 and 30.00, 49.00 and 50.00) while pooled data had 19.00, 29.67 and 49.50 at 30, 45 and 60 DAS, respectively during 2014 and 2015. The results revealed that application of $L_2O_1I_3$ enhanced nodulation significantly compared to the other treatments at 30, 45 DAS in both the years.

Overall, treatment with lime @ 400 kg $ha^{-1}$ in combination with FYM @ 5 t $ha^{-1}$ and 75% RDF showed the highest nodulation at 60 DAS while at 30 and 45 DAS, treatment with lime @ 10% LR in combination with FYM @ 5 t $ha^{-1}$ and 100% RDF showed highest nodulation which was at par with treatments where lime was incorporated. The increase nodulation could be due to the increase in pH as the treatments without lime did not show significant increase in nodulation. Increased nodulation further enhances fixation of atmospheric nitrogen by the nodules and this could be due to addition of nutrients through FYM and fertilizer nutrient sources. Similar results were reported by Najar *et al.* (2011). Increased production of nodules with the increased application of P was also observed by Vyas *et al.* (1987). Since no relevant literature or citations were available regarding the effect of lime, particularly for soybean growing areas of NEH region, therefore no further comparison could be conducted to corroborate or contradict with the present findings.

**4.2.4. Effect on fresh weight of nodule**

**Effect of lime on fresh weight of nodule**

The results on the fresh weight of nodule in different treatments have been presented in table 16. There was an appreciable increase in number of nodules and in turn fresh weight of nodules with the advancement of days. Further, significant difference was observed among various treatments. It was apparent from the data, the highest fresh weight of nodule was recorded in the treatment $L_2$ as 0.847 and 0.857 g, 1.09 and 1.10 g, 1.60 and 1.61 g at 30, 45 and 60 DAS, respectively during 2014 and 2015 while pooled data had 0.852 g, 1.10 g and 1.60 g. The minimum number of nodules was recorded in the treatment $L_0$ as 0.605 and 0.604 g, 0.848 and 0.852 g, 1.32 and 1.32 g, while in pooled data it was 0.604 g, 0.850 g and 1.32 g at 30, 45 and 60 DAS, respectively during 2014 and 2015. The fresh weight of nodule was observed to follow an increasing trend with the increase in application of lime owing to its effect on soil pH.

**Effect of farmyard manure on fresh weight of nodule**

The fresh weight of nodule during all the stages of crop growth was found higher in plots where FYM was applied in higher amounts which can be attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. It was apparent from the table 16, the maximum fresh weight of nodule was recorded in treatment $O_1$ as 0.807 and 0.815 g, 1.06 and 1.07 g, 1.55 and 1.56 g at 30, 45 and 60 DAS, respectively during 2014 and 2015 while pooled data had 0.811 g, 1.06 g and 1.56 g. The minimum fresh weight of nodule was recorded in the treatment $O_0$ as 0.692 and 0.697 g, 0.924 and 0.932 g, 1.41 and 1.41 g, while pooled data had 0.694 g, 0.928 g and 1.41 g at 30, 45 and 60 DAS, respectively during 2014 and 2015.

**Effect of fertilizers on fresh weight of nodule**

From the data presented in table 16, it could be inferred that there was a significant difference among the treatments. The highest fresh weight of nodule was recorded at 30 DAS in treatment $I_2$ as 0.786 g in 2014 and with treatment $I_3$ as 0.797 g in 2015. At 45 DAS the highest fresh weight of nodule was recorded with treatment $I_2$ and $I_3$ as 1.03 g each for both the treatments and for 2014 and 2015 while highest pooled data had 0.791 g and 1.03 g in treatment $I_3$ during 2014 and 2015, respectively. At 60 DAS, the highest fresh weight of nodule was recorded in treatment $I_2$ as 1.53 and 1.54 g respectively during 2014 and 2015, whereas the lowest fresh weight of nodule was recorded in the treatment $I_0$ as 0.693 and 0.702 g, 0.941 and 0.955 g, 1.45 and 1.45 g while pooled data had 0.697 g, 0.948 g and 1.45 g at 30, 45 and 60 DAS, respectively.

**Effect of lime and farmyard manure on fresh weight of nodule**

The results showed that the maximum and minimum fresh weight of nodule at 30 DAS were recorded in treatment $L_2O_1$ (0.859 and 0.876 g) and $L_0O_0$ (0.492 and 0.494 g) while pooled data had 0.867 g and 0.493 g during 2014 and 2015, respectively (Table 17).

With the advancement of growth, the maximum fresh weight of nodule was recorded in $L_2O_1$ as 1.11 g and 1.12 g, 1.62 and 1.63 g while pooled data had 1.12 g and 1.63 g during 2014 and 2015 at 45 and 60 DAS, respectively.

**Effect of lime and fertilizers on fresh weight of nodule**

The data (Table 17) pertaining on to fresh weight of nodules revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum fresh weight of nodule was recorded at 0.904 and 0.909 g, 1.16 and 1.17 g, 1.69 and 1.70 g at 30, 45 and 60 DAS, respectively in treatment $L_1I_2$ with pooled data as 0.906, 1.16 and 1.69 g. The minimum fresh weight of nodule was recorded at 30 DAS in the treatment $L_0I_0$ as 0.543 and 0.556 g; at 45 DAS in treatment $L_0I_2$ as 0.803 and 0.799 g; at 60 DAS with treatment $L_0I_3$ as 1.27 and 1.26 g during 2004 and 2015, respectively, while pooled data had 0.549, 0.80 and 1.27 g.

**Effect of farmyard manure and fertilizers on fresh weight of nodule**

From the data ascribed on table 17, it can be observed that the maximum fresh weight of nodule was recorded in treatment $O_1I_3$ (0.873 and 0.893 g, 1.15 and 1.15 g) and $O_1I_2$ (1.63 and 1.64 g) during 2014 and 2015 at 30, 45 and 60 DAS, respectively. The minimum number of nodules at 30 DAS was observed with treatment $O_0I_0$ and $O_0I_1$ (0.675 g) in 2014 while in 2015 it was minimum in treatment $O_0I_0$ (0.681 g) with pooled data as 0.678 g. At 45 DAS, minimum number of nodules was in $O_0I_1$ and $O_0I_3$ (0.91 and 0.92 g) for 2014 and 2015 while at 60 DAS, $O_0I_3$ recorded the minimum weight (1.37 g).

**Effect of lime, farmyard manure and fertilizers on fresh weight of nodule**

The data indicated that the number of nodules at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM, lime and organic matter (Table 18). Among the treatments, the maximum fresh weight of nodule was recorded in $L_1O_1I_2$ (0.999 and 1.017 g, 1.27 and 1.28 g, 1.82 and 1.84 g) with pooled data as 1.008, 1.27 and 1.83 at 30, 45 and 60 DAS, respectively during 2014 and 2015. The minimum number of nodules was recorded in $L_0O_0I_0$ (0.467 and 0.483 g) at 30 DAS with pooled data as 0.475 g and with treatment of $L_0O_0I_2$ (0.697 and 0.682 g, 1.14 and 1.13 g) with pooled data as 0.689 and 1.14 g at 45 and 60 DAS during 2014 and 2015, respectively.

The fresh weight of nodules was maximum with treatment of lime @ 400 kg $ha^{-1}$ along with FYM @ 5 t $ha^{-1}$ and 75% RDF at all the stages of growth. The nodules fresh weight per plant corresponds with the number of nodules obtained per plant.

Table 16: Effect of lime, farmyard manure and fertilizers on number of fresh weight of nodule at different days after sowing (DAS)

| Treatments | Fresh weight of nodule (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0$** | 0.605 | 0.604 | 0.604 | 0.848 | 0.852 | 0.850 | 1.32 | 1.32 | 1.32 |
| **$L_1$** | 0.796 | 0.807 | 0.802 | 1.03 | 1.04 | 1.04 | 1.53 | 1.53 | 1.53 |
| **$L_2$** | **0.847** | **0.857** | **0.852** | **1.09** | **1.10** | **1.10** | **1.60** | **1.61** | **1.60** |
| ***SEm±*** | ***0.040*** | ***0.026*** | ***0.026*** | ***0.031*** | ***0.023*** | ***0.019*** | ***0.026*** | ***0.024*** | ***0.018*** |
| ***CD(P=0.05)*** | ***0.157*** | ***0.101*** | ***0.078*** | ***0.122*** | ***0.090*** | ***0.063*** | ***0.103*** | ***0.095*** | ***0.058*** |
| **$O_0$** | 0.692 | 0.697 | 0.694 | 0.924 | 0.932 | 0.928 | 1.41 | 1.41 | 1.41 |
| **$O_1$** | **0.807** | **0.815** | **0.811** | **1.06** | **1.07** | **1.06** | **1.55** | **1.56** | **1.56** |
| ***SEm±*** | ***0.024*** | ***0.017*** | ***0.015*** | ***0.018*** | ***0.008*** | ***0.010*** | ***0.023*** | ***0.023*** | ***0.016*** |
| ***CD(P=0.05)*** | ***0.083*** | ***0.057*** | ***0.045*** | ***0.064*** | ***0.029*** | ***0.031*** | ***0.081*** | ***0.080*** | ***0.051*** |
| **$I_0$** | 0.693 | 0.702 | 0.697 | 0.941 | 0.955 | 0.948 | 1.45 | 1.45 | 1.45 |
| **$I_1$** | 0.733 | 0.737 | 0.735 | 0.970 | 0.980 | 0.975 | 1.47 | 1.48 | 1.47 |
| **$I_2$** | **0.786** | 0.789 | 0.787 | **1.03** | **1.03** | **1.03** | **1.53** | **1.54** | **1.54** |
| **$I_3$** | 0.785 | **0.797** | **0.791** | **1.03** | **1.03** | **1.03** | 1.47 | 1.48 | 1.48 |
| ***SEm±*** | ***0.030*** | ***0.031*** | ***0.021*** | ***0.025*** | ***0.016*** | ***0.015*** | ***0.037*** | ***0.036*** | ***0.026*** |
| ***CD(P=0.05)*** | ***0.086*** | ***0.088*** | ***0.061*** | ***0.072*** | ***0.046*** | ***0.042*** | ***0.11*** | ***0.10*** | ***0.07*** |

Table 17: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on fresh weight of nodule at different days after sowing (DAS)

| Treatments | Fresh weight of nodule (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0$** | 0.492 | 0.494 | 0.493 | 0.718 | 0.717 | 0.717 | 1.18 | 1.18 | 1.18 |
| **$L_0O_1$** | 0.718 | 0.714 | 0.716 | 0.979 | 0.988 | 0.983 | 1.46 | 1.46 | 1.46 |
| **$L_1O_0$** | 0.748 | 0.758 | 0.753 | 0.980 | 0.994 | 0.987 | 1.47 | 1.48 | 1.47 |
| **$L_1O_1$** | 0.844 | 0.855 | 0.850 | 1.09 | 1.09 | 1.09 | 1.58 | 1.58 | 1.58 |
| **$L_2O_0$** | 0.835 | 0.839 | 0.837 | 1.07 | 1.09 | 1.08 | 1.58 | 1.59 | 1.58 |
| **$L_2O_1$** | **0.859** | **0.876** | **0.867** | **1.11** | **1.12** | **1.12** | **1.62** | **1.63** | **1.63** |
| ***SEm±*** | ***0.041*** | ***0.029*** | ***0.025*** | ***0.032*** | ***0.015*** | ***0.018*** | ***0.041*** | ***0.040*** | ***0.029*** |
| ***CD(P=0.05)*** | ***0.143*** | ***0.099*** | ***0.077*** | ***0.110*** | ***0.051*** | ***0.054*** | ***0.14*** | ***0.14*** | ***0.088*** |
| **$L_0I_0$** | 0.543 | 0.556 | 0.549 | 0.816 | 0.834 | 0.825 | 1.36 | 1.35 | 1.36 |
| **$L_0I_1$** | 0.609 | 0.614 | 0.611 | 0.855 | 0.868 | 0.862 | 1.37 | 1.38 | 1.38 |
| **$L_0I_2$** | 0.575 | 0.570 | 0.573 | 0.803 | 0.799 | 0.801 | 1.28 | 1.28 | 1.28 |
| **$L_0I_3$** | 0.692 | 0.677 | 0.685 | 0.920 | 0.908 | 0.914 | 1.27 | 1.26 | 1.27 |
| **$L_1I_0$** | 0.721 | 0.736 | 0.729 | 0.948 | 0.964 | 0.956 | 1.43 | 1.43 | 1.43 |
| **$L_1I_1$** | 0.697 | 0.701 | 0.699 | 0.910 | 0.924 | 0.917 | 1.36 | 1.36 | 1.36 |
| **$L_1I_2$** | **0.904** | **0.909** | **0.906** | **1.16** | **1.17** | **1.16** | **1.69** | **1.70** | **1.69** |
| **$L_1I_3$** | 0.864 | 0.881 | 0.873 | 1.12 | 1.12 | 1.12 | 1.63 | 1.63 | 1.63 |
| **$L_2I_0$** | 0.817 | 0.813 | 0.815 | 1.06 | 1.07 | 1.06 | 1.57 | 1.58 | 1.58 |
| **$L_2I_1$** | 0.893 | 0.897 | 0.895 | 1.14 | 1.15 | 1.15 | 1.67 | 1.69 | 1.68 |
| **$L_2I_2$** | 0.879 | 0.888 | 0.883 | 1.12 | 1.13 | 1.13 | 1.63 | 1.63 | 1.63 |
| **$L_2I_3$** | 0.799 | 0.832 | 0.815 | 1.05 | 1.07 | 1.06 | 1.52 | 1.54 | 1.53 |
| ***SEm±*** | ***0.052*** | ***0.053*** | ***0.037*** | ***0.044*** | ***0.028*** | ***0.026*** | ***0.064*** | ***0.063*** | ***0.045*** |
| ***CD(P=0.05)*** | ***0.149*** | ***0.153*** | ***0.105*** | ***0.13*** | ***0.078*** | ***0.073*** | ***0.18*** | ***0.18*** | ***0.13*** |
| **$O_0I_0$** | 0.675 | 0.681 | 0.678 | 0.925 | 0.939 | 0.932 | 1.43 | 1.45 | 1.44 |
| **$O_0I_1$** | 0.675 | 0.683 | 0.679 | 0.907 | 0.921 | 0.914 | 1.40 | 1.40 | 1.40 |
| **$O_0I_2$** | 0.720 | 0.725 | 0.722 | 0.952 | 0.952 | 0.952 | 1.44 | 1.43 | 1.44 |
| **$O_0I_3$** | 0.697 | 0.700 | 0.698 | 0.912 | 0.918 | 0.915 | 1.37 | 1.37 | 1.37 |
| **$O_1I_0$** | 0.712 | 0.723 | 0.717 | 0.957 | 0.971 | 0.964 | 1.47 | 1.46 | 1.47 |
| **$O_1I_1$** | 0.790 | 0.791 | 0.791 | 1.03 | 1.04 | 1.04 | 1.54 | 1.55 | 1.55 |
| **$O_1I_2$** | 0.852 | 0.853 | 0.853 | 1.10 | 1.11 | 1.11 | **1.63** | **1.64** | **1.63** |
| **$O_1I_3$** | **0.873** | **0.893** | **0.883** | **1.15** | **1.15** | **1.15** | 1.58 | 1.58 | 1.58 |
| ***SEm±*** | ***0.042*** | ***0.044*** | ***0.030*** | ***0.036*** | ***0.023*** | ***0.021*** | ***0.052*** | ***0.051*** | ***0.037*** |
| ***CD(P=0.05)*** | ***0.121*** | ***0.125*** | ***0.086*** | ***0.102*** | ***0.065*** | ***0.059*** | ***0.15*** | ***0.15*** | ***0.10*** |

Table 18: Effect of lime, farmyard manure and fertilizers on fresh weight of nodule at different days after sowing (DAS)

| Treatments | Fresh weight of nodule (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0O_0I_0$ | 0.467 | 0.483 | 0.475 | 0.733 | 0.750 | 0.742 | 1.23 | 1.25 | 1.24 |
| $L_0O_0I_1$ | 0.498 | 0.491 | 0.495 | 0.721 | 0.728 | 0.725 | 1.19 | 1.18 | 1.18 |
| $L_0O_0I_2$ | 0.484 | 0.499 | 0.491 | 0.697 | 0.682 | 0.689 | 1.14 | 1.13 | 1.14 |
| $L_0O_0I_3$ | 0.518 | 0.504 | 0.511 | 0.721 | 0.707 | 0.714 | 1.15 | 1.15 | 1.15 |
| $L_0O_1I_0$ | 0.619 | 0.628 | 0.624 | 0.899 | 0.918 | 0.909 | 1.49 | 1.46 | 1.47 |
| $L_0O_1I_1$ | 0.719 | 0.737 | 0.728 | 0.989 | 1.01 | 1.00 | 1.56 | 1.58 | 1.57 |
| $L_0O_1I_2$ | 0.667 | 0.642 | 0.654 | 0.908 | 0.917 | 0.913 | 1.42 | 1.43 | 1.43 |
| $L_0O_1I_3$ | 0.867 | 0.849 | 0.858 | 1.12 | 1.11 | 1.11 | 1.39 | 1.38 | 1.38 |
| $L_1O_0I_0$ | 0.767 | 0.783 | 0.775 | 1.01 | 1.03 | 1.02 | 1.52 | 1.53 | 1.53 |
| $L_1O_0I_1$ | 0.652 | 0.667 | 0.659 | 0.874 | 0.889 | 0.882 | 1.34 | 1.35 | 1.35 |
| $L_1O_0I_2$ | 0.808 | 0.800 | 0.804 | 1.05 | 1.06 | 1.05 | 1.57 | 1.56 | 1.56 |
| $L_1O_0I_3$ | 0.767 | 0.782 | 0.774 | 0.989 | 1.00 | 1.00 | 1.46 | 1.46 | 1.46 |
| $L_1O_1I_0$ | 0.675 | 0.689 | 0.682 | 0.887 | 0.902 | 0.895 | 1.33 | 1.32 | 1.33 |
| $L_1O_1I_1$ | 0.742 | 0.735 | 0.739 | 0.945 | 0.959 | 0.952 | 1.37 | 1.38 | 1.38 |
| $L_1O_1I_2$ | **0.999** | **1.017** | **1.008** | **1.27** | **1.28** | **1.27** | **1.82** | **1.84** | **1.83** |
| $L_1O_1I_3$ | 0.961 | 0.980 | 0.971 | 1.24 | 1.23 | 1.24 | 1.81 | 1.80 | 1.81 |
| $L_2O_0I_0$ | 0.792 | 0.775 | 0.783 | 1.03 | 1.04 | 1.04 | 1.54 | 1.56 | 1.55 |
| $L_2O_0I_1$ | 0.875 | 0.893 | 0.884 | 1.13 | 1.14 | 1.14 | 1.66 | 1.67 | 1.66 |
| $L_2O_0I_2$ | 0.867 | 0.875 | 0.871 | 1.11 | 1.12 | 1.11 | 1.62 | 1.61 | 1.61 |
| $L_2O_0I_3$ | 0.805 | 0.813 | 0.809 | 1.03 | 1.04 | 1.04 | 1.50 | 1.51 | 1.50 |
| $L_2O_1I_0$ | 0.842 | 0.850 | 0.846 | 1.08 | 1.09 | 1.09 | 1.59 | 1.61 | 1.60 |
| $L_2O_1I_1$ | 0.910 | 0.901 | 0.906 | 1.16 | 1.15 | 1.16 | 1.69 | 1.71 | 1.70 |
| $L_2O_1I_2$ | 0.892 | 0.900 | 0.896 | 1.13 | 1.15 | 1.14 | 1.64 | 1.66 | 1.65 |
| $L_2O_1I_3$ | 0.792 | 0.851 | 0.822 | 1.08 | 1.10 | 1.09 | 1.55 | 1.56 | 1.56 |
| ***SEm±*** | ***0.073*** | ***0.075*** | ***0.053*** | ***0.062*** | ***0.039*** | ***0.037*** | ***0.091*** | ***0.089*** | ***0.063*** |
| ***CD(P=0.05)*** | ***0.210*** | ***0.216*** | ***0.148*** | ***0.18*** | ***0.11*** | ***0.10*** | ***0.26*** | ***0.25*** | ***0.18*** |

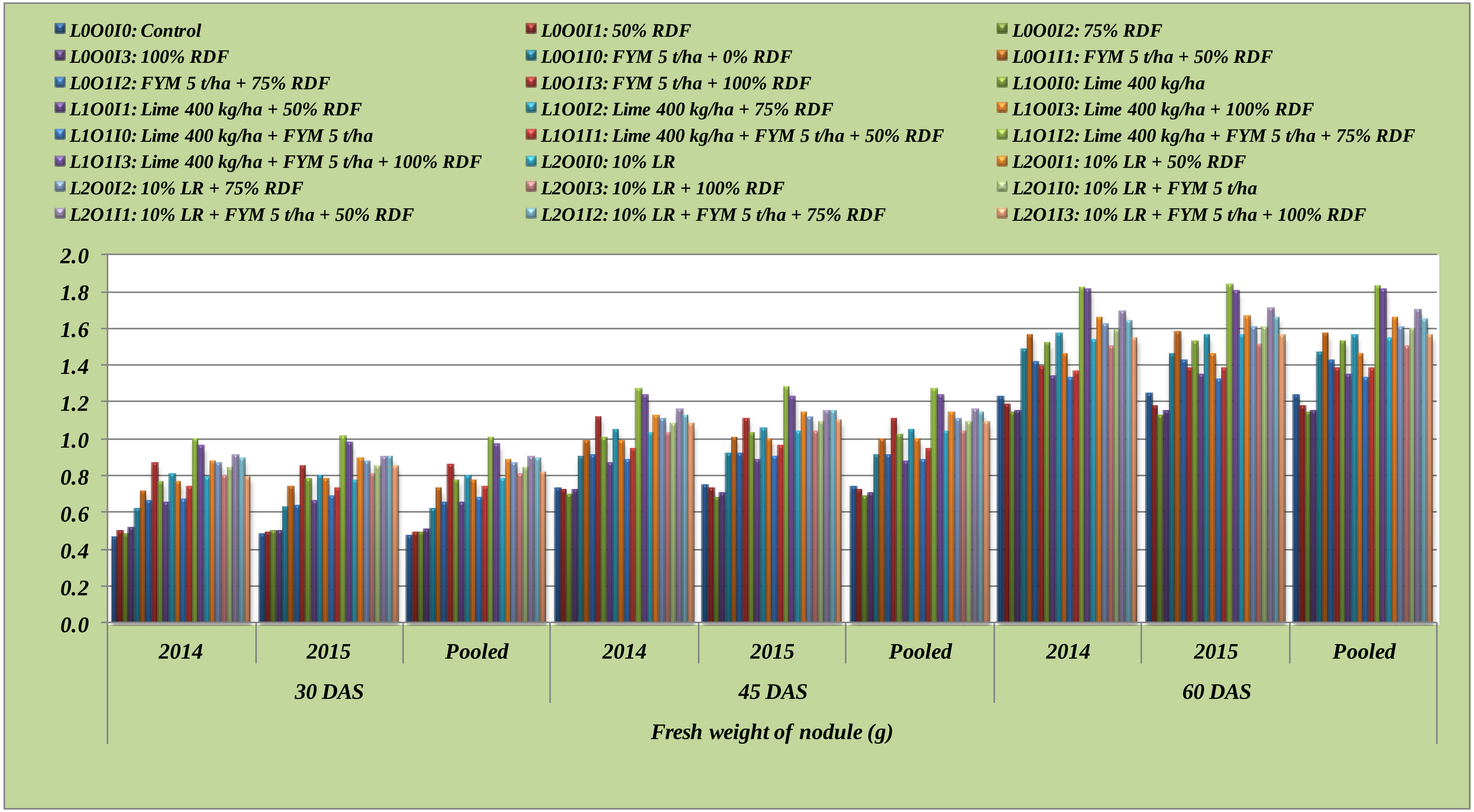



**Fig 7: Effect of lime, farmyard manure and fertilizers on fresh weight of nodule at different days after sowing (DAS) during 2014 and 2015**

### 4.2.5. Effect on dry weight of nodule

**Effect of lime on dry weight of nodule**

The results obtained on the dry weight of nodules in different treatments have been presented in table 19. There was an appreciable increase in dry weight of nodules with the advancement of days and it was significant among various treatments. It was apparent from the data, the highest dry weight of nodules was recorded in the treatment $L_2$ as 0.246 and 0.246 g, 0.315 and 0.318 g, 0.460 and 0.464 g at 30, 45 and 60 DAS, respectively during 2014 and 2015 while pooled data was 0.246, 0.316 and 0.462 g. The minimum dry weight of nodules was recorded in the treatment $L_0$ as 0.174 and 0.174 g, 0.244 and 0.245 g, 0.380 and 0.380 g, while pooled data were 0.174, 0.245 and 0.380 g at 30, 45 and 60 DAS, respectively during 2014 and 2015. In general, the application of lime was observed to increase the dry weight of nodules and in turn the dry weight of nodules. Dry weight of nodules was observed to follow an increasing trend with an increase in application of lime.

**Effect of farmyard manure on dry weight of nodule**

The dry weight of nodules during all the stages of crop growth was higher in plots where FYM was applied in higher amounts which can be attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. It was apparent from the table 19, the maximum dry weight of nodules was recorded in treatment $O_1$ as 0.239 and 0.238 g, 0.310 and 0.312 g, 0.454 and 0.455 g at 30, 45 and 60 DAS, respectively during 2014 and 2015 while pooled data were 0.238, 0.311 and 0.455 g. The minimum fresh weight of nodule was recorded in the treatment $O_0$ as 0.202 and 0.200 g, 0.268 and 0.270 g, 0.409 and 0.411 g, while pooled data were 0.201, 0.269 and 0.410 g at 30, 45 and 60 DAS, respectively during 2014 and 2015.

**Effect of fertilizers on dry weight of nodule**

The data (Table 19) indicated that there was a significant difference among the treatments. The highest dry weight of nodules was recorded in treatment $I_3$ as 0.244 and 0.244 g, 0.316 and 0.317 g, 0.453 and 0.454 g at 30, 45 and 60 DAS while pooled data were 0.244, 0.316 and 0.453 g in 2014 and 2015, respectively. The lowest dry weight of nodules was recorded at 30 DAS in the treatment $I_2$ as 0.210 g in 2014. However, it was 0.208 g in 2015 in treatment $I_0$ with pooled data of 0.210 and 0.209 g, respectively. At 45 and 60 DAS, the dry weight of nodules was recorded in treatment $I_2$ as 0.274 and 0.275 g, 0408 and 0.409 g with pooled data of 0.274 and 0.409 g during the year 2014 and 2015, respectively.

**Effect of lime and farmyard manure on dry weight of nodule**

From the data presented in table 20, the maximum and minimum dry weight of nodules were recorded in $L_2O_1$ (0.260 and 0.260 g, 0.331 and 0.334 g, 0.481 and 0.486 g) at 30 DAS while pooled data was 0.260, 0.332 and 0.483 g at 30, 45 and 60 DAS during 2014 and 2015, respectively. The minimum dry weight of nodules was recorded in $L_0O_0$ as 0.148 and 0.147 g, 0.215 and 0.214 g, 0.352 and 0.352 g with pooled data as 0.147, 0.215 and 0.352 g at 30, 45 and 60 DAS during 2014 and 2015, respectively.

**Effect of lime and fertilizers on dry weight of nodule**

The data (Table 20) revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum dry weight of nodules was recorded as 0.274 and 0.269 g, 0.347 and 0.348 g, 0.509 and 0.508 g at 30, 45 and 60 DAS, respectively in treatment $L_1I_3$ with pooled data as 0.272, 0.348 and 0.509 g. The minimum dry weight of nodules was recorded at 30, 45 and 60 DAS in the treatment $L_0I_2$ as 0.142 and 0.143 g, 0.200 and 0.199 g, 0.319 and 0.319 g during 2014 and 2015, respectively, while pooled data were 0.142, 0.199 and 0.319 g.

**Effect of farmyard manure and fertilizers on dry weight of nodule**

The results showed that the maximum dry weight of nodules was recorded in $O_1I_3$ (0.275 and 0.275 g, 0.353 and 0.352 g, 0.487 and 0.487 g) with pooled data of 0.275, 0.353 and 0.487 g during 2014 and 2015 at 30, 45 and 60 DAS, respectively (Table 20). The minimum dry weight of nodules at 30, 45 and 60 DAS was observed with treatment $O_0I_2$ (0.190 and 0.189 g, 0.251 and 0.251 g, 0.381 and 0.378 g) while the pooled data were 0.190, 0.251 and 0.379 g in 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on dry weight of nodule**

The data indicated that the number of nodules at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM, lime and organic matter (Table 21). Among the treatments, the maximum dry weight of nodules was recorded in $L_1O_1I_3$ (0.311 and 0.305 g, 0.394 and 0.391 g, 0.574 and 0.571 g) with pooled data as 0.308, 0.392 and 0.573 at 30, 45 and 60 DAS, respectively during 2014 and 2015. The minimum dry weight of nodules was recorded at 30 DAS in $L_0O_0I_2$ (0.139 g) during 2014 and in $L_0O_0I_0$ (0.135 g) and $L_0O_0I_2$ (0.135 g) during 2015. At 45 and 60 DAS, the minimum dry weight of nodules was recorded with treatment $L_0O_0I_2$ (0.194 and 0.190 g, 0.319 and 0.315 g) and pooled data as 0.192 and 0.317 g in 2014 and 2015, respectively.

Table 19: Effect of lime, farmyard manure and fertilizers on dry weight of nodule at different days after sowing (DAS)

| Treatments | Dry weight of nodule (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| **$L_0$** | 0.174 | 0.174 | 0.174 | 0.244 | 0.245 | 0.245 | 0.380 | 0.380 | 0.380 |
| **$L_1$** | 0.240 | 0.237 | 0.239 | 0.308 | 0.311 | 0.309 | 0.455 | 0.456 | 0.455 |
| **$L_2$** | **0.246** | **0.246** | **0.246** | **0.315** | **0.318** | **0.316** | **0.460** | **0.464** | **0.462** |
| ***SEm±*** | ***0.008*** | ***0.010*** | ***0.006*** | ***0.009*** | ***0.007*** | ***0.006*** | ***0.008*** | ***0.007*** | ***0.006*** |
| ***CD(P=0.05)*** | ***0.031*** | ***0.039*** | ***0.021*** | ***0.036*** | ***0.027*** | ***0.019*** | ***0.032*** | ***0.029*** | ***0.018*** |
| **$O_0$** | 0.202 | 0.200 | 0.201 | 0.268 | 0.270 | 0.269 | 0.409 | 0.411 | 0.410 |
| **$O_1$** | **0.239** | **0.238** | **0.238** | **0.310** | **0.312** | **0.311** | **0.454** | **0.455** | **0.455** |
| ***SEm±*** | ***0.005*** | ***0.007*** | ***0.004*** | ***0.005*** | ***0.003*** | ***0.003*** | ***0.007*** | ***0.007*** | ***0.005*** |
| ***CD(P=0.05)*** | ***0.017*** | ***0.024*** | ***0.013*** | ***0.019*** | ***0.009*** | ***0.009*** | ***0.024*** | ***0.024*** | ***0.015*** |
| **$I_0$** | 0.211 | 0.208 | 0.209 | 0.283 | 0.287 | 0.285 | 0.436 | 0.437 | 0.436 |
| **$I_1$** | 0.215 | 0.214 | 0.215 | 0.283 | 0.286 | 0.285 | 0.429 | 0.432 | 0.430 |
| **$I_2$** | 0.210 | 0.209 | 0.210 | 0.274 | 0.275 | 0.274 | 0.408 | 0.409 | 0.409 |
| **$I_3$** | **0.244** | **0.244** | **0.244** | **0.316** | **0.317** | **0.316** | **0.453** | **0.454** | **0.453** |
| ***SEm±*** | ***0.009*** | ***0.009*** | ***0.006*** | ***0.007*** | ***0.005*** | ***0.004*** | ***0.011*** | ***0.011*** | ***0.008*** |
| ***CD(P=0.05)*** | ***0.026*** | ***0.025*** | ***0.018*** | ***0.021*** | ***0.013*** | ***0.012*** | ***NS*** | ***NS*** | ***NS*** |

Table 20: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on dry weight of nodule at different days after sowing (DAS)

| Treatments | Dry weight of nodule (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0O_0$ | 0.148 | 0.147 | 0.147 | 0.215 | 0.214 | 0.215 | 0.352 | 0.352 | 0.352 |
| $L_0O_1$ | 0.200 | 0.201 | 0.200 | 0.274 | 0.276 | 0.275 | 0.408 | 0.407 | 0.408 |
| $L_1O_0$ | 0.225 | 0.222 | 0.224 | 0.291 | 0.295 | 0.293 | 0.437 | 0.438 | 0.438 |
| $L_1O_1$ | 0.255 | 0.252 | 0.254 | 0.324 | 0.326 | 0.325 | 0.473 | 0.473 | 0.473 |
| $L_2O_0$ | 0.233 | 0.232 | 0.232 | 0.298 | 0.302 | 0.300 | 0.438 | 0.441 | 0.440 |
| $L_2O_1$ | **0.260** | **0.260** | **0.260** | **0.331** | **0.334** | **0.332** | **0.481** | **0.486** | **0.483** |
| ***SEm±*** | ***0.009*** | ***0.012*** | ***0.007*** | ***0.009*** | ***0.004*** | ***0.005*** | ***0.012*** | ***0.012*** | ***0.009*** |
| ***CD(P=0.05)*** | ***0.030*** | ***0.041*** | ***0.023*** | ***0.032*** | ***0.015*** | ***0.016*** | ***0.042*** | ***0.042*** | ***0.026*** |
| $L_0I_0$ | 0.170 | 0.165 | 0.168 | 0.249 | 0.255 | 0.252 | 0.414 | 0.413 | 0.414 |
| $L_0I_1$ | 0.176 | 0.175 | 0.175 | 0.246 | 0.250 | 0.248 | 0.395 | 0.397 | 0.396 |
| $L_0I_2$ | 0.142 | 0.143 | 0.142 | 0.200 | 0.199 | 0.199 | 0.319 | 0.319 | 0.319 |
| $L_0I_3$ | 0.207 | 0.212 | 0.210 | 0.282 | 0.279 | 0.280 | 0.390 | 0.389 | 0.389 |
| $L_1I_0$ | 0.215 | 0.211 | 0.213 | 0.277 | 0.281 | 0.279 | 0.417 | 0.417 | 0.417 |
| $L_1I_1$ | 0.213 | 0.212 | 0.213 | 0.276 | 0.281 | 0.279 | 0.412 | 0.415 | 0.413 |
| $L_1I_2$ | 0.259 | 0.257 | 0.258 | 0.330 | 0.333 | 0.331 | 0.482 | 0.483 | 0.483 |
| $L_1I_3$ | **0.274** | **0.269** | **0.272** | **0.347** | **0.348** | **0.348** | **0.509** | **0.508** | **0.509** |
| $L_2I_0$ | 0.247 | 0.248 | 0.247 | 0.322 | 0.324 | 0.323 | 0.476 | 0.481 | 0.479 |
| $L_2I_1$ | 0.257 | 0.256 | 0.256 | 0.328 | 0.329 | 0.328 | 0.479 | 0.484 | 0.482 |
| $L_2I_2$ | 0.230 | 0.228 | 0.229 | 0.291 | 0.294 | 0.293 | 0.423 | 0.424 | 0.423 |
| $L_2I_3$ | 0.251 | 0.251 | 0.251 | 0.319 | 0.323 | 0.321 | 0.460 | 0.464 | 0.462 |
| ***SEm±*** | ***0.016*** | ***0.015*** | ***0.011*** | ***0.013*** | ***0.008*** | ***0.008*** | ***0.019*** | ***0.019*** | ***0.013*** |
| ***CD(P=0.05)*** | ***0.046*** | ***0.044*** | ***0.031*** | ***0.037*** | ***0.023*** | ***0.021*** | ***0.055*** | ***0.054*** | ***0.038*** |
| $O_0I_0$ | 0.205 | 0.203 | 0.204 | 0.279 | 0.283 | 0.281 | 0.429 | 0.435 | 0.432 |
| $O_0I_1$ | 0.198 | 0.196 | 0.197 | 0.264 | 0.268 | 0.266 | 0.407 | 0.408 | 0.407 |
| $O_0I_2$ | 0.190 | 0.189 | 0.190 | 0.251 | 0.251 | 0.251 | 0.381 | 0.378 | 0.379 |
| $O_0I_3$ | 0.214 | 0.213 | 0.213 | 0.279 | 0.281 | 0.280 | 0.419 | 0.421 | 0.420 |
| $O_1I_0$ | 0.216 | 0.213 | 0.214 | 0.287 | 0.291 | 0.289 | 0.442 | 0.439 | 0.440 |
| $O_1I_1$ | 0.233 | 0.232 | 0.232 | 0.303 | 0.305 | 0.304 | 0.451 | 0.456 | 0.453 |
| $O_1I_2$ | 0.230 | 0.230 | 0.230 | 0.297 | 0.300 | 0.298 | 0.436 | 0.440 | 0.438 |
| $O_1I_3$ | **0.275** | **0.275** | **0.275** | **0.353** | **0.352** | **0.353** | **0.487** | **0.487** | **0.487** |
| ***SEm±*** | ***0.013*** | ***0.013*** | ***0.009*** | ***0.010*** | ***0.007*** | ***0.006*** | ***0.016*** | ***0.015*** | ***0.011*** |
| ***CD(P=0.05)*** | ***0.037*** | ***0.036*** | ***0.026*** | ***0.030*** | ***0.019*** | ***0.017*** | ***0.045*** | ***0.044*** | ***0.031*** |

Table 21: Effect of lime, farmyard manure and fertilizers on dry weight of nodule at different days after sowing (DAS)

| Treatments | Dry weight of nodule (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| **$L_0O_0I_0$** | 0.141 | 0.135 | 0.138 | 0.214 | 0.219 | 0.217 | 0.358 | 0.365 | 0.361 |
| **$L_0O_0I_1$** | 0.151 | 0.153 | 0.152 | 0.222 | 0.224 | 0.223 | 0.366 | 0.363 | 0.364 |
| **$L_0O_0I_2$** | 0.139 | 0.135 | 0.137 | 0.194 | 0.190 | 0.192 | 0.319 | 0.315 | 0.317 |
| **$L_0O_0I_3$** | 0.160 | 0.164 | 0.162 | 0.229 | 0.224 | 0.227 | 0.364 | 0.364 | 0.364 |
| **$L_0O_1I_0$** | 0.199 | 0.196 | 0.197 | 0.284 | 0.290 | 0.287 | 0.471 | 0.461 | 0.466 |
| **$L_0O_1I_1$** | 0.201 | 0.196 | 0.199 | 0.270 | 0.275 | 0.272 | 0.425 | 0.430 | 0.428 |
| **$L_0O_1I_2$** | 0.145 | 0.151 | 0.148 | 0.205 | 0.207 | 0.206 | 0.320 | 0.324 | 0.322 |
| **$L_0O_1I_3$** | 0.255 | 0.260 | 0.257 | 0.335 | 0.333 | 0.334 | 0.416 | 0.413 | 0.415 |
| **$L_1O_0I_0$** | 0.229 | 0.224 | 0.227 | 0.295 | 0.300 | 0.297 | 0.443 | 0.448 | 0.446 |
| **$L_1O_0I_1$** | 0.200 | 0.196 | 0.198 | 0.262 | 0.267 | 0.265 | 0.403 | 0.405 | 0.404 |
| **$L_1O_0I_2$** | 0.234 | 0.236 | 0.235 | 0.307 | 0.309 | 0.308 | 0.458 | 0.456 | 0.457 |
| **$L_1O_0I_3$** | 0.238 | 0.233 | 0.236 | 0.301 | 0.305 | 0.303 | 0.443 | 0.445 | 0.444 |
| **$L_1O_1I_0$** | 0.201 | 0.197 | 0.199 | 0.259 | 0.263 | 0.261 | 0.390 | 0.385 | 0.388 |
| **$L_1O_1I_1$** | 0.226 | 0.228 | 0.227 | 0.291 | 0.295 | 0.293 | 0.422 | 0.424 | 0.423 |
| **$L_1O_1I_2$** | 0.283 | 0.278 | 0.281 | 0.354 | 0.356 | 0.355 | 0.506 | 0.511 | 0.509 |
| **$L_1O_1I_3$** | **0.311** | **0.305** | **0.308** | **0.394** | **0.391** | **0.392** | **0.574** | **0.571** | **0.573** |
| **$L_2O_0I_0$** | 0.245 | 0.250 | 0.248 | 0.327 | 0.329 | 0.328 | 0.487 | 0.493 | 0.490 |
| **$L_2O_0I_1$** | 0.243 | 0.239 | 0.241 | 0.307 | 0.312 | 0.310 | 0.451 | 0.456 | 0.454 |
| **$L_2O_0I_2$** | 0.198 | 0.196 | 0.197 | 0.251 | 0.252 | 0.252 | 0.366 | 0.364 | 0.365 |
| **$L_2O_0I_3$** | 0.244 | 0.242 | 0.243 | 0.308 | 0.313 | 0.311 | 0.449 | 0.453 | 0.451 |
| **$L_2O_1I_0$** | 0.248 | 0.246 | 0.247 | 0.317 | 0.319 | 0.318 | 0.465 | 0.470 | 0.468 |
| **$L_2O_1I_1$** | 0.270 | 0.273 | 0.272 | 0.348 | 0.346 | 0.347 | 0.507 | 0.512 | 0.510 |
| **$L_2O_1I_2$** | 0.263 | 0.261 | 0.262 | 0.331 | 0.336 | 0.334 | 0.480 | 0.485 | 0.482 |
| **$L_2O_1I_3$** | 0.259 | 0.261 | 0.260 | 0.329 | 0.333 | 0.331 | 0.471 | 0.476 | 0.473 |
| ***SEm±*** | ***0.023*** | ***0.022*** | ***0.016*** | ***0.018*** | ***0.012*** | ***0.011*** | ***0.027*** | ***0.027*** | ***0.019*** |
| ***CD(P=0.05)*** | ***0.065*** | ***0.062*** | ***0.044*** | ***0.052*** | ***0.033*** | ***0.030*** | ***0.078*** | ***0.077*** | ***0.054*** |

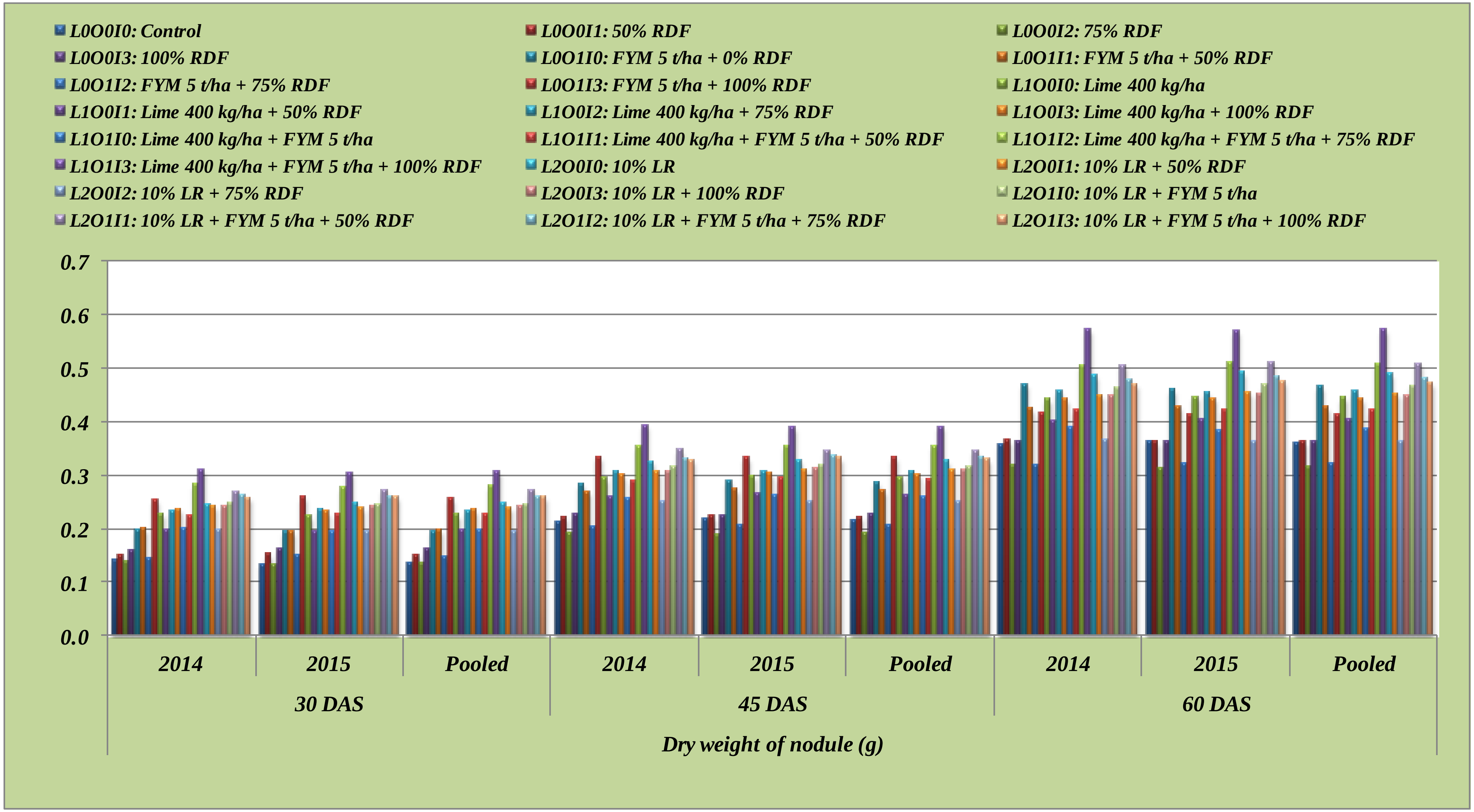



**Fig 8: Effect of lime, farmyard manure and fertilizers on dry weight of nodule at different days after sowing (DAS) during 2014 and 2015**

The dry weight of nodules was maximum with the treatment of lime @ 400 kg $ha^{-1}$ along with FYM @ 5 t $ha^{-1}$ and 100% RDF at 30, 45 and 60 DAS. The dry weight of nodules per plant corresponds with the number of nodules per plant. Similar dry weight of nodules at 45 and 60 DAS was also reported by Lakshman *et al.* (2015).

### 4.2.6. Effect on dry weight of plants

**Effect of lime on dry weight of plants**

The results on the dry weight of plants in different treatments have been presented in table 22. There was an appreciable increase in the dry weight of plants with the advancement of days which was significant among various treatments. It was apparent from the data, the highest dry weight of plants was recorded in the treatment $L_2$ as 2.73 and 2.70 g, 16.22 and 15.95 g, 20.24 and 20.25 g at 30, 45 and 60 DAS, respectively during 2014 and 2015 while in pooled data it was 2.72, 16.08 and 20.38 g. The minimum dry weight of plants was recorded in the treatment $L_0$ as 2.09 and 2.03 g, 10.31 and 10.23 g, 15.39 and 15.80 g, while pooled data had 2.06, 10.27 and 15.59 g at 30, 45 and 60 DAS, respectively during 2014 and 2015. In general, the application of lime significantly affected the weight of plant.

**Effect of farmyard manure on dry weight of plants**

The dry weight of plants during all the stages of crop growth was found to be higher in plots receiving organic matter in higher amounts which can be attributed to the higher supply of nutrients particularly NPK and their subsequent increase in uptake. It was apparent from the table 22, the maximum dry weight of plants was recorded in treatment $O_1$ as 2.45 and 2.44 g, 14.31 and 14.10 g, 18.38 and 18.61 g at 30, 45 and 60 DAS, respectively during 2014 and 2015 while pooled data had 2.44, 14.20 and 18.50 g. Whereas, the minimum dry weight of plants was recorded in the treatment $O_0$ as 2.32 and 2.34 g, 12.49 and 12.31 g, 16.79 and 17.01 g, while in pooled data it was 2.33, 12.40 and 16.90 g at 30, 45 and 60 DAS, respectively during 2014 and 2015.

**Effect of fertilizers on dry weight of plants**

The data indicated that there was a significant difference among the treatments the highest dry weight of plants was recorded in $I_3$ as 2.52 and 2.53 g, 14.20 and 14.07 g, 19.61 and 19.89 g at 30, 45 and 60 DAS while pooled data were 2.52, 14.13 and 19.75 g in 2014 and 2015, respectively (Table 22). The lowest dry weight of plants was recorded in the treatment $I_0$ as 2.20 and 2.22 g, 12.61 and 12.45 g, 16.35 and 16.61 g while in the pooled data it was 2.21, 12.53 and 16.48 g at 30, 45 and 60 DAS during the year 2014 and 2015, respectively.

**Effect of lime and farmyard manure on dry weight of plants**

The data (Table 23) showed that the maximum dry weight of plants was recorded in treatment $L_2O_1$ (2.85 and 2.83 g, 17.14 and 16.49 g, 21.29 and 21.49 g) at 30 DAS while pooled data was 2.84, 16.82 and 21.39 g at 30, 45 and 60 DAS during 2014 and 2015, respectively. The minimum dry weight of plants at 30 DAS was recorded in $L_0O_0$ (2.03 g) in 2014 and $L_0O_1$ (1.98 g) during 2015. The minimum dry weight of plants at 30 and 45 DAS was recorded in treatment $L_0O_0$ having 9.03 and 8.87 g, 14.28 and 14.72 g while pooled data had 8.95 and 14.50 during the year 2014 and 2015, respectively.

**Effect of lime and fertilizers on dry weight of plants**

From the data (Table 23), it revealed that there was a significant difference among the treatments and showed that during 2014 and 2015 the maximum dry weight of plants was recorded at 2.88 and 2.81 g, 16.92 and 16.71 g, 23.03 and 23.67 g at 30, 45 and 60 DAS, respectively in treatment $L_2I_3$ with pooled data as 2.84, 16.81 and 23.35 g. The minimum dry weight of plants was recorded at 30, 45 and 60 DAS in the treatment $L_0I_0$ with corresponding values as 1.77 and 1.77 g, 9.56 and 9.44 g, 14.12 and 14.98 g during 2014 and 2015, while in pooled data it was 1.77, 9.50 and 14.55 g, respectively.

**Effect of farmyard manure and fertilizers on dry weight of plants**

The results presented in table 23 showed that the maximum dry weight of plants was recorded in treatment $O_1I_3$ (2.58 and 2.63 g, 15.06 and 14.96 g, 20.12 and 20.43 g) and pooled data as 2.61, 15.01 and 20.28 g during 2014 and 2015 at 30, 45 and 60 DAS, respectively. The minimum dry weight of plants at 30, 45 and 60 DAS was observed with treatment $O_0I_0$ (2.14 and 2.14 g, 11.39 and 11.46 g, 15.54 and 15.62 g) while in pooled data it was 2.14, 11.42 and 15.58 g in 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on dry weight of plants**

The data indicated that the dry weight of plants at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM and lime (Table 24). Among the treatments, the maximum dry weight of plants was recorded in $L_2O_1I_3$ (3.04 and 3.04 g, 17.76 and 17.36 g, 24.44 and 24.37 g) at 30, 45 and 60 DAS, respectively with pooled data as 3.04, 17.56 and 24.41 during 2014 and 2015. The minimum dry weight of plants was recorded at 30 DAS in $L_0O_0I_0$ (1.70 g) during 2014 and in $L_0O_1I_2$ (1.66 g) during 2015. At 45

Table 22: Effect of lime, farmyard manure and fertilizers on dry weight of plants at different days after sowing (DAS)

| Treatments | Dry weight of plants (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| **$L_0$** | 2.09 | 2.03 | 2.06 | 10.31 | 10.23 | 10.27 | 15.39 | 15.80 | 15.59 |
| **$L_1$** | 2.34 | 2.44 | 2.39 | 13.67 | 13.44 | 13.55 | 17.13 | 17.12 | 17.12 |
| **$L_2$** | **2.73** | **2.70** | **2.72** | **16.22** | **15.95** | **16.08** | **20.24** | **20.52** | **20.38** |
| ***SEm±*** | ***0.075*** | ***0.039*** | ***0.042*** | ***0.39*** | ***0.23*** | ***0.23*** | ***0.55*** | ***0.24*** | ***0.30*** |
| ***CD(P=0.05)*** | ***0.30*** | ***0.15*** | ***0.14*** | ***1.55*** | ***0.92*** | ***0.75*** | ***2.15*** | ***0.96*** | ***0.98*** |
| **$O_0$** | 2.32 | 2.34 | 2.33 | 12.49 | 12.31 | 12.40 | 16.79 | 17.01 | 16.90 |
| **$O_1$** | **2.45** | **2.44** | **2.44** | **14.31** | **14.10** | **14.20** | **18.38** | **18.61** | **18.50** |
| ***SEm±*** | ***0.024*** | ***0.043*** | ***0.025*** | ***0.34*** | ***0.23*** | ***0.21*** | ***0.40*** | ***0.22*** | ***0.23*** |
| ***CD(P=0.05)*** | ***0.084*** | ***0.148*** | ***0.076*** | ***1.18*** | ***0.79*** | ***0.63*** | ***1.39*** | ***0.76*** | ***0.71*** |
| **$I_0$** | 2.20 | 2.22 | 2.21 | 12.61 | 12.45 | 12.53 | 16.35 | 16.61 | 16.48 |
| **$I_1$** | 2.38 | 2.39 | 2.39 | 13.27 | 13.05 | 13.16 | 16.70 | 16.95 | 16.82 |
| **$I_2$** | 2.45 | 2.42 | 2.43 | 13.51 | 13.26 | 13.39 | 17.68 | 17.80 | 17.74 |
| **$I_3$** | **2.52** | **2.53** | **2.52** | **14.20** | **14.07** | **14.13** | **19.61** | **19.89** | **19.75** |
| ***SEm±*** | ***0.051*** | ***0.057*** | ***0.038*** | ***0.43*** | ***0.22*** | ***0.24*** | ***0.48*** | ***0.35*** | ***0.30*** |
| ***CD(P=0.05)*** | ***0.15*** | ***0.16*** | ***0.11*** | ***1.24*** | ***0.62*** | ***0.68*** | ***1.38*** | ***1.00*** | ***0.84*** |

Table 23: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on dry weight of plants at different days after sowing (DAS)

| Treatments | Dry weight of plants (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| **$L_0O_0$** | 2.03 | 2.08 | 2.05 | 9.03 | 8.87 | 8.95 | 14.28 | 14.72 | 14.50 |
| **$L_0O_1$** | 2.15 | 1.98 | 2.06 | 11.59 | 11.60 | 11.60 | 16.50 | 16.88 | 16.69 |
| **$L_1O_0$** | 2.32 | 2.38 | 2.35 | 13.14 | 12.67 | 12.91 | 16.90 | 16.76 | 16.83 |
| **$L_1O_1$** | 2.36 | 2.50 | 2.43 | 14.19 | 14.21 | 14.20 | 17.37 | 17.47 | 17.42 |
| **$L_2O_0$** | 2.61 | 2.57 | 2.59 | 15.30 | 15.40 | 15.35 | 19.19 | 19.54 | 19.36 |
| **$L_2O_1$** | **2.85** | **2.83** | **2.84** | **17.14** | **16.49** | **16.82** | **21.29** | **21.49** | **21.39** |
| ***SEm±*** | ***0.042*** | ***0.074*** | ***0.043*** | ***0.59*** | ***0.40*** | ***0.36*** | ***0.70*** | ***0.38*** | ***0.40*** |
| ***CD(P=0.05)*** | ***0.15*** | ***0.26*** | ***0.13*** | ***2.05*** | ***1.37*** | ***1.10*** | ***2.41*** | ***1.31*** | ***1.22*** |
| **$L_0I_0$** | 1.77 | 1.77 | 1.77 | 9.56 | 9.44 | 9.50 | 14.12 | 14.98 | 14.55 |
| **$L_0I_1$** | 2.15 | 2.15 | 2.15 | 10.23 | 10.17 | 10.20 | 14.71 | 15.05 | 14.88 |
| **$L_0I_2$** | 2.21 | 2.00 | 2.10 | 10.05 | 9.86 | 9.95 | 15.73 | 15.85 | 15.79 |
| **$L_0I_3$** | 2.22 | 2.19 | 2.21 | 11.42 | 11.47 | 11.44 | 16.99 | 17.30 | 17.14 |
| **$L_1I_0$** | 2.25 | 2.25 | 2.25 | 12.71 | 12.69 | 12.70 | 16.67 | 16.58 | 16.62 |
| **$L_1I_1$** | 2.29 | 2.37 | 2.33 | 13.72 | 13.29 | 13.50 | 15.71 | 16.81 | 16.26 |
| **$L_1I_2$** | 2.39 | 2.54 | 2.47 | 13.97 | 13.77 | 13.87 | 17.34 | 16.39 | 16.86 |
| **$L_1I_3$** | 2.44 | 2.59 | 2.52 | 14.26 | 14.02 | 14.14 | 18.81 | 18.70 | 18.75 |
| **$L_2I_0$** | 2.58 | 2.64 | 2.61 | 15.56 | 15.22 | 15.39 | 18.26 | 18.26 | 18.26 |
| **$L_2I_1$** | 2.71 | 2.64 | 2.68 | 15.88 | 15.70 | 15.79 | 19.68 | 18.99 | 19.33 |
| **$L_2I_2$** | 2.75 | 2.72 | 2.73 | 16.52 | 16.16 | 16.34 | 19.99 | 21.15 | 20.57 |
| **$L_2I_3$** | **2.88** | **2.81** | **2.84** | **16.92** | **16.71** | **16.81** | **23.03** | **23.67** | **23.35** |
| ***SEm±*** | ***0.089*** | ***0.098*** | ***0.066*** | ***0.75*** | ***0.37*** | ***0.42*** | ***0.83*** | ***0.60*** | ***0.51*** |
| ***CD(P=0.05)*** | ***0.26*** | ***0.28*** | ***0.19*** | ***2.15*** | ***1.07*** | ***1.18*** | ***2.39*** | ***1.73*** | ***1.45*** |
| **$O_0I_0$** | 2.14 | 2.14 | 2.14 | 11.39 | 11.46 | 11.42 | 15.54 | 15.62 | 15.58 |
| **$O_0I_1$** | 2.31 | 2.32 | 2.32 | 12.37 | 12.12 | 12.25 | 15.84 | 16.06 | 15.95 |
| **$O_0I_2$** | 2.37 | 2.48 | 2.43 | 12.86 | 12.51 | 12.69 | 16.66 | 17.00 | 16.83 |
| **$O_0I_3$** | 2.45 | 2.43 | 2.44 | 13.34 | 13.17 | 13.26 | 19.09 | 19.34 | 19.22 |
| **$O_1I_0$** | 2.26 | 2.30 | 2.28 | 13.84 | 13.45 | 13.64 | 17.16 | 17.60 | 17.38 |
| **$O_1I_1$** | 2.45 | 2.45 | 2.45 | 14.17 | 13.99 | 14.08 | 17.56 | 17.83 | 17.70 |
| **$O_1I_2$** | 2.53 | 2.36 | 2.44 | 14.17 | 14.01 | 14.09 | 18.70 | 18.59 | 18.65 |
| **$O_1I_3$** | **2.58** | **2.63** | **2.61** | **15.06** | **14.96** | **15.01** | **20.12** | **20.43** | **20.28** |
| ***SEm±*** | ***0.073*** | ***0.080*** | ***0.054*** | ***0.61*** | ***0.30*** | ***0.34*** | ***0.68*** | ***0.49*** | ***0.42*** |
| ***CD(P=0.05)*** | ***0.21*** | ***0.23*** | ***0.15*** | ***1.75*** | ***0.87*** | ***0.96*** | ***1.95*** | ***1.41*** | ***1.18*** |

Table 24: Effect of lime, farmyard manure and fertilizers on dry weight of plants at different days after sowing (DAS)

| Treatments | Dry weight of plants (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 45 DAS | | | 60 DAS | | |
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| $L_0O_0I_0$ | 1.70 | 1.71 | 1.71 | 7.94 | 7.88 | 7.91 | 12.58 | 13.46 | 13.02 |
| $L_0O_0I_1$ | 2.10 | 2.12 | 2.11 | 8.82 | 8.78 | 8.80 | 13.48 | 13.39 | 13.44 |
| $L_0O_0I_2$ | 2.16 | 2.34 | 2.25 | 9.36 | 9.01 | 9.19 | 14.38 | 14.68 | 14.53 |
| $L_0O_0I_3$ | 2.15 | 2.14 | 2.15 | 10.02 | 9.79 | 9.90 | 16.66 | 17.34 | 17.00 |
| $L_0O_1I_0$ | 1.84 | 1.83 | 1.83 | 11.18 | 11.00 | 11.09 | 15.66 | 16.50 | 16.08 |
| $L_0O_1I_1$ | 2.20 | 2.19 | 2.20 | 11.65 | 11.55 | 11.60 | 15.93 | 16.71 | 16.32 |
| $L_0O_1I_2$ | 2.25 | 1.66 | 1.96 | 10.73 | 10.71 | 10.72 | 17.07 | 17.03 | 17.05 |
| $L_0O_1I_3$ | 2.29 | 2.24 | 2.27 | 12.82 | 13.15 | 12.98 | 17.31 | 17.25 | 17.28 |
| $L_1O_0I_0$ | 2.21 | 2.18 | 2.20 | 11.71 | 11.72 | 11.72 | 16.79 | 16.23 | 16.51 |
| $L_1O_0I_1$ | 2.27 | 2.24 | 2.26 | 13.38 | 12.63 | 13.01 | 15.29 | 16.96 | 16.12 |
| $L_1O_0I_2$ | 2.31 | 2.51 | 2.41 | 13.54 | 12.68 | 13.11 | 16.50 | 16.13 | 16.32 |
| $L_1O_0I_3$ | 2.47 | 2.57 | 2.52 | 13.93 | 13.66 | 13.80 | 19.01 | 17.73 | 18.37 |
| $L_1O_1I_0$ | 2.28 | 2.31 | 2.29 | 13.72 | 13.66 | 13.69 | 16.56 | 16.92 | 16.74 |
| $L_1O_1I_1$ | 2.30 | 2.49 | 2.40 | 14.05 | 13.95 | 14.00 | 16.13 | 16.66 | 16.39 |
| $L_1O_1I_2$ | 2.46 | 2.57 | 2.52 | 14.41 | 14.86 | 14.63 | 18.17 | 16.65 | 17.41 |
| $L_1O_1I_3$ | 2.41 | 2.62 | 2.52 | 14.60 | 14.37 | 14.49 | 18.61 | 19.66 | 19.13 |
| $L_2O_0I_0$ | 2.50 | 2.52 | 2.51 | 14.51 | 14.77 | 14.64 | 17.26 | 17.15 | 17.21 |
| $L_2O_0I_1$ | 2.57 | 2.61 | 2.59 | 14.92 | 14.94 | 14.93 | 18.76 | 17.84 | 18.30 |
| $L_2O_0I_2$ | 2.64 | 2.58 | 2.61 | 15.69 | 15.84 | 15.76 | 19.11 | 20.21 | 19.66 |
| $L_2O_0I_3$ | 2.72 | 2.57 | 2.65 | 16.08 | 16.06 | 16.07 | 21.61 | 22.96 | 22.29 |
| $L_2O_1I_0$ | 2.66 | 2.76 | 2.71 | 16.61 | 15.68 | 16.15 | 19.26 | 19.37 | 19.31 |
| $L_2O_1I_1$ | 2.85 | 2.67 | 2.76 | 16.83 | 16.46 | 16.65 | 20.61 | 20.13 | 20.37 |
| $L_2O_1I_2$ | 2.86 | 2.85 | 2.86 | 17.36 | 16.47 | 16.92 | 20.87 | 22.08 | 21.48 |
| $L_2O_1I_3$ | **3.04** | **3.04** | **3.04** | **17.76** | **17.36** | **17.56** | **24.44** | **24.37** | **24.41** |
| ***SEm±*** | ***0.126*** | ***0.138*** | ***0.093*** | ***1.06*** | ***0.53*** | ***0.59*** | ***1.18*** | ***0.85*** | ***0.73*** |
| ***CD(P=0.05)*** | ***0.36*** | ***0.40*** | ***0.26*** | ***3.04*** | ***1.51*** | ***1.67*** | ***3.38*** | ***2.44*** | ***2.05*** |

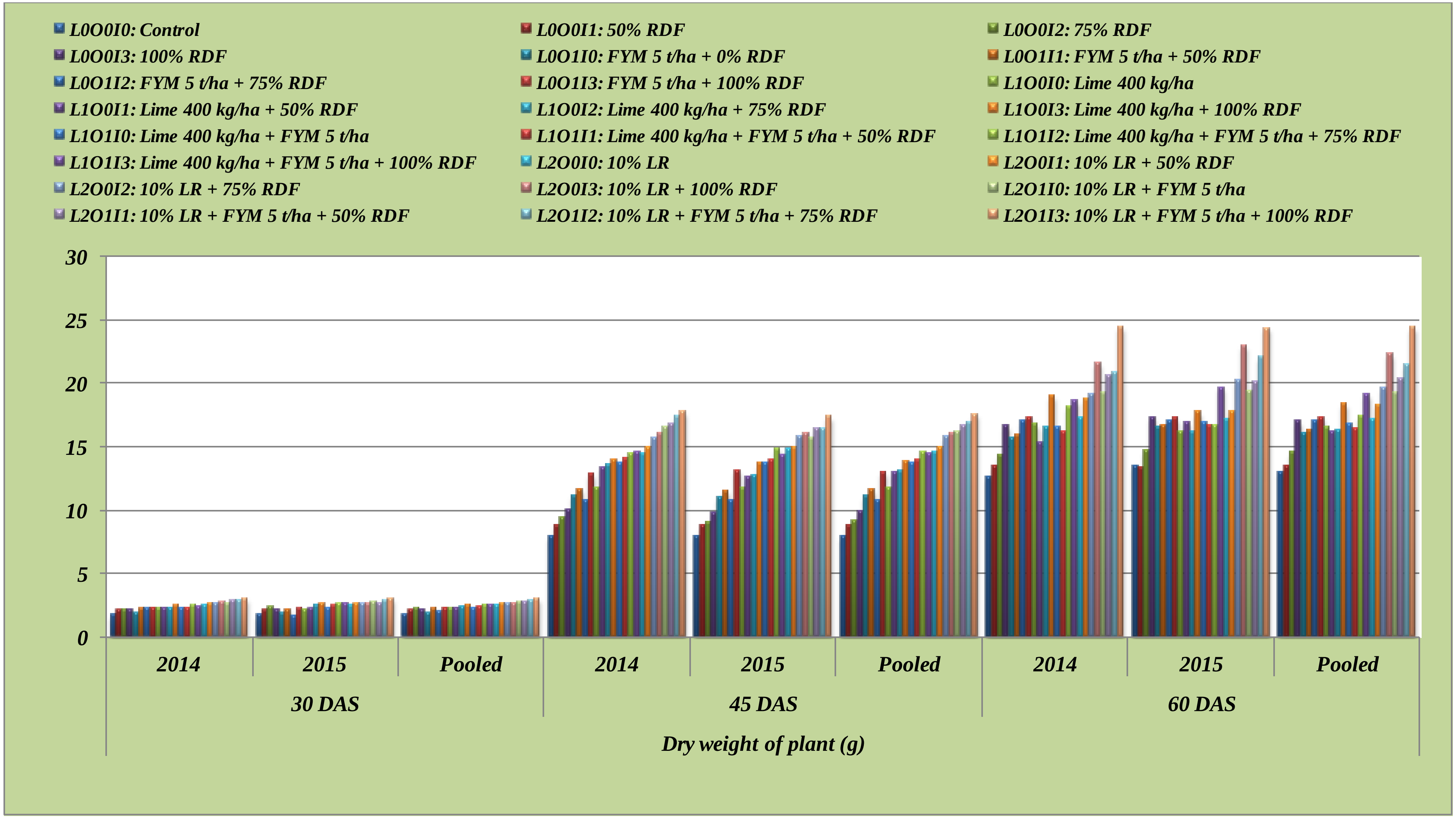



**Fig 9: Effect of lime, farmyard manure and fertilizers on dry weight of plant at different days after sowing (DAS) during 2014 and 2015**

DAS, the minimum dry weight of plants was recorded in $L_0O_0I_0$ (7.94 and 7.88 g) with pooled data as 7.91 g in 2014 and 2015, respectively. At 60 DAS, the minimum dry weight of plants was in $L_0O_0I_0$ (12.58 g) during 2014 and in $L_0O_0I_1$ (13.39 g) during 2015.

Increasing the quantity of nutrient input combined with application of lime resulted in higher dry weight of plants owing to increased availability of nutrients under favourable pH. Khutate *et al.* (2005) also reported that the plant weight at different stages of plant growth were also found higher with the application of 125% RDF + FYM @ 5t/ha at 30, 45 and 60 DAS.

The overall dry weight of plants was maximum in the treatment comprising of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100% RDF at 30 DAS which was at par with treatment of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 75% RDF. At 45 and 60 DAS, the maximum dry weight of plants was found in treatment having lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100% RDF. It was observed that treatment receiving higher amount of nutrients through fertilizers along with FYM and lime showed higher biomass which could be due to the vigorous growth due to increased availability of nutrients. Garud *et al.* (2014) also reported that application of 100% RDF gave higher plant weight.

**4.2.7. Effect on biological yield**

**Effect of lime on biological yield**

The results on the biological yield in different treatments have been presented in table 25. There was significant difference among various treatments towards biological yield. It was apparent from the data that the highest biological yield was recorded in the treatment $L_2$ as 6033.16 and 6034.65 kg $ha^{-1}$ while pooled data it was 6033.90 kg $ha^{-1}$ during 2014 and 2015, respectively. Whereas, the minimum biological yield was recorded in the treatment $L_0$ having yield of 4007.50 and 4009.62 kg $ha^{-1}$ while pooled data had 4008.56 kg $ha^{-1}$ during 2014 and 2015, respectively. The application of lime significantly affected the biological yield.

**Effect of farmyard manure on biological yield**

The biological yield was found higher in plots receiving higher amount of organic matter which can be attributed due to the mobilisation of nutrients and their uptakes. It was apparent from the table 25, the maximum biological yield was recorded in treatment $O_1$ as 5371.26 and 5371.41 kg $ha^{-1}$ while pooled data had 5371.34 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum biological yield was recorded in the treatment $O_0$ as 4759.74 and 4762.35 kg ha$^{-1}$ while in pooled data it was 4761.05 kg ha$^{-1}$ during 2014 and 2015, respectively.

**Effect of fertilizers on biological yield**

The data indicated that there was a significant difference among the treatments. The highest biological yield was recorded in treatment $I_3$ asto the tune of 5555.77 and 5554.38 kg ha$^{-1}$ while pooled data had 5555.07kg ha$^{-1}$ in 2014 and 2015, respectively (Table 25). The lowest biological yield was recorded in treatment $I_0$ as 4715.39 and 4719.05 kg ha$^{-1}$ while pooled data had 4717.22kg ha$^{-1}$ in 2014 and 2015, respectively.

**Effect of lime and farmyard manure on biological yield**

The maximum biological yield was recorded in treatment $L_2O_1$ (6454.41 and 6456.12 kg ha$^{-1}$) while pooled data had 6455.27 kg ha$^{-1}$ during 2014 and 2015, respectively (Table 26). Whereas, the minimum biological yield was realised in treatment $L_0O_0$ (3629.05 and 3633.98 kg ha$^{-1}$) while in pooled data it was 3631.51 kg ha$^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and fertilizers on biological yield**

Data pertaining to biological yield as affected by lime (Table 26) revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum biological yield was recorded as 6642.41 and 6646.25 kg ha$^{-1}$ in treatment $L_2I_3$ while pooled data had 6644.33kg ha$^{-1}$. The minimum biological yield was associated with $L_0I_0$ as 3771.16 and 3774.35kg ha$^{-1}$ during 2014 and 2015, respectively, while pooled data had 3772.75kg ha$^{-1}$.

**Effect of farmyard manure and fertilizers on biological yield**

The results from table 26 showed that the maximum biological yield was recorded in treatment $O_1I_3$ (5899.28 and 5897.77 kg ha$^{-1}$) with pooled data as 5898.53 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum biological yield was observed in treatment $O_0I_0$ (4484.31 and 4490.37 kg ha$^{-1}$) while the pooled data had 4487.34 kg ha$^{-1}$ in 2014 and 2015, respectively.

**Effect of lime, farmyard manure and inorganic fertilizers on biological yield**

The data indicated that the biological yield at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM and lime (Table 27). Among the treatments, the maximum biological yield was recorded in $L_2O_1I_3$ (6848.40 and 6852.50 kg ha$^{-1}$) with pooled data as 6850.45 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum biological yield was recorded in $L_0O_0I_1$ (3472.96 and 3480.63 kg ha$^{-1}$) with pooled data as 3476.80 kg ha$^{-1}$ in 2014 and 2015, respectively.

Biological yield with combined treatment of all three factors was found maximum in treatment comprising of lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 100% RDF which was at par with treatment of lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 75% RDF and the minimum was recorded in treatment with 50% RDF alone. Generally treatments receiving lime showed higher biological yield as compared to those without it. Liming increase the soil pH which results in better harvest of groundnut as reported by Chatterjee *et al.* (2005). In other studies by Saxena *et al.* (2013), application of 100% RDF along with FYM @ 5t ha$^{-1}$ was found to be significant over other treatment combinations in increasing the biological yield of soybean.

### 4.2.8. Effect on seed yield

**Effect of lime on seed yield**

The results on the seed yield in different treatments have been presented in table 25. There was significant increase and influence of treatment on seed yield and level of improvement was significant among various treatments. It was apparent from the data that the highest seed yield was recorded in the treatment $L_2$ as 2064.74 and 2065.45 kg ha$^{-1}$ while pooled data had 2065.09 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum seed yield was recorded in the treatment $L_0$ as 1428.86 and 1430.76 kg ha$^{-1}$ while in pooled data it was 1429.81 kg ha$^{-1}$ during 2014 and 2015, respectively. In general, the application of lime had significant affect on the seed yield.

**Effect of farmyard manure on seed yield**

The seed yield was found higher in plots receiving higher amounts of FYM due to its favourable influence on nutrient availability. It was apparent from the table 25 that the maximum seed yield was recorded in treatment $O_1$ as 1897.19 and 1897.18 kg ha$^{-1}$ while in pooled data it was 1897.19 kg ha$^{-1}$ during 2014 and 2015, respectively. Whereas, the minimum seed yield was recorded in $O_0$ as 1687.23 and 1688.93 kg ha$^{-1}$ while pooled data was 1688.08 kg ha$^{-1}$ during 2014 and 2015, respectively.

**Effect of fertilizers on seed yield**

The data pertaining to seed yield (Table 25) revealed that there was a significant difference among the treatments. The highest seed yield was recorded in treatment $I_3$ as 1911.53 and 1909.31 kg ha$^{-1}$ while pooled had 1910.42 kg ha$^{-1}$ in 2014 and 2015, respectively. The lowest seed yield was recorded in treatment $I_0$ as 1696.72 and 1699.58 kg ha$^{-1}$ while pooled data had 1698.15 kg ha$^{-1}$ in 2014 and 2015, respectively.

**Effect of lime and farmyard manure seed yield**

The data (Table 26) indicated that maximum seed yield was recorded in treatment $L_2O_1$ (2157.17 and 2157.26 kg ha$^{-1}$) while pooled data had 2157.22 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum seed yield was recorded in treatment $L_0O_0$ (1278.04 and 1281.33 kg ha$^{-1}$) while in pooled data it was 1279.68 kg ha$^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and fertilizers on seed yield**

The data pertaining to seed yield (Table 26) revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum seed yield was recorded as 2201.96 and 2203.96 kg ha$^{-1}$ respectively in $L_2I_3$ with pooled data as 2202.96 kg ha$^{-1}$. The minimum seed yield was recorded in $L_0I_0$ as 1360.53 and 1364.95 kg ha$^{-1}$ during 2014 and 2015, respectively, while pooled had 1362.74 kg ha$^{-1}$.

**Effect of farmyard manure and fertilizers on seed yield**

The results showed that the maximum seed yield was recorded in $O_1I_3$ (1978.24 and 1976.13 kg ha$^{-1}$) while pooled data had 1977.18 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum seed yield was observed in $O_0I_0$ (1588.48 and 1592.52 kg ha$^{-1}$) while in the pooled data it was 1590.50 kg ha$^{-1}$ in 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on seed yield**

The data indicated that the seed yield was found to be significantly affected by the application of fertilisers, FYM and lime (Table 27). Among the treatments, the maximum seed yield was recorded in $L_2O_1I_3$ (2300.50 and 2302.17 kg ha$^{-1}$) with pooled data as 2301.33 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum seed yield was in $L_0O_1I_0$ (1173.91 and 1178.77 kg ha$^{-1}$) while pooled data had 1176.34 kg ha$^{-1}$ in 2014 and 2015, respectively.

Palve *et al.* (2011) studied the different nutritional requirements of soybean and reported that application of 100% RDF with FYM @ 5 t ha$^{-1}$ gave the highest seed yield and was significantly higher than the other treatments. In the present investigation, application of lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 100% RDF gave the highest seed yield of 2301.33 kg ha$^{-1}$ which was significantly higher than the rest of the treatments. The treatments receiving lime @ 10% LR were at par with the highest yield. The individual effect of 100% RDF was significant over the other fertilizer doses. Higher application of nutrients from FYM and fertilizers had significant influence on seed yield which got improved with the inclusion of lime in the treatments. Mishra *et al.* (1999) reported that the lime, organic and inorganic combination gave significant higher yield in acidic red soils. Sarkar (2012) observed that soybean had a negative response to nitrogen in acid soils and that ameliorating the acid soils with FYM and lime resulted in better yield. Agarwal *et al.* (2007) found that the yield of pea in the plots treated with lime was 14.80% more than those unlimed plots.

### 4.2.9. Effect on stover yield

**Effect of lime on stover yield**

The results on the stover yield in different treatments have been presented in table 25. The treatment brought significant increase in the stover yield which was also significant among various treatments. The highest stover yield was realised in $L_2$ as 3968.42 and 3969.20 kg ha$^{-1}$ while pooled data had 3968.81 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum stover yield was in the treatment $L_0$ as 2578.64 and 2578.87 kg ha$^{-1}$ while in pooled data it was 2578.75 kg ha$^{-1}$ during 2014 and 2015, respectively. In general, the increasing level of lime enhanced stover yield.

**Effect of farmyard manure on stover yield**

The stover yield was found higher in plots receiving higher levels of FYM via increased uptake of nutrients. The maximum stover yield was recorded in treatment $O_1$ as 3474.08 and 3474.22 kg ha$^{-1}$ while pooled data had 3474.15 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum stover yield was associated with $O_0$ as 3072.51 and 3073.42 kg ha$^{-1}$ while in pooled data it was 3072.97 kg ha$^{-1}$ during 2014 and 2015, respectively (Table 25).

Table 25: Effect of lime, farmyard manure and fertilizers on biological yield (kg $ha^{-1}$), seed yield (kg $ha^{-1}$) and stover yield (kg $ha^{-1}$) of soybean at different days after sowing (DAS)

| Treatments | Biological yield (kg $ha^{-1}$) | | | Seed yield (kg $ha^{-1}$) | | | Stover yield (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| $L_0$ | 4007.50 | 4009.62 | 4008.56 | 1428.86 | 1430.76 | 1429.81 | 2578.64 | 2578.87 | 2578.75 |
| $L_1$ | 5155.86 | 5156.37 | 5156.11 | 1883.03 | 1882.96 | 1883.00 | 3272.83 | 3273.40 | 3273.11 |
| $L_2$ | **6033.16** | **6034.65** | **6033.90** | **2064.74** | **2065.45** | **2065.09** | **3968.42** | **3969.20** | **3968.81** |
| ***Sem±*** | ***66.42*** | ***103.43*** | ***61.46*** | ***48.20*** | ***39.95*** | ***31.30*** | ***53.03*** | ***85.13*** | ***50.15*** |
| ***CD at 5%*** | ***260.79*** | ***406.12*** | ***200.43*** | ***189.27*** | ***156.86*** | ***102.08*** | ***208.23*** | ***334.25*** | ***163.54*** |
| $O_0$ | 4759.74 | 4762.35 | 4761.05 | 1687.23 | 1688.93 | 1688.08 | 3072.51 | 3073.42 | 3072.97 |
| $O_1$ | **5371.26** | **5371.41** | **5371.34** | **1897.19** | **1897.18** | **1897.19** | **3474.08** | **3474.22** | **3474.15** |
| ***Sem±*** | ***78.55*** | ***41.45*** | ***44.41*** | ***42.33*** | ***35.75*** | ***27.70*** | ***41.88*** | ***28.69*** | ***25.38*** |
| ***CD at 5%*** | ***271.81*** | ***143.44*** | ***136.83*** | ***146.47*** | ***123.70*** | ***85.36*** | ***144.92*** | ***99.29*** | ***78.21*** |
| $I_0$ | 4715.39 | 4719.05 | 4717.22 | 1696.72 | 1699.58 | 1698.15 | 3018.67 | 3019.47 | 3019.07 |
| $I_1$ | 4878.25 | 4877.35 | 4877.80 | 1750.46 | 1750.07 | 1750.27 | 3127.79 | 3127.28 | 3127.53 |
| $I_2$ | 5112.61 | 5116.74 | 5114.67 | 1810.12 | 1813.27 | 1811.70 | 3302.49 | 3303.47 | 3302.98 |
| $I_3$ | **5555.77** | **5554.38** | **5555.07** | **1911.53** | **1909.31** | **1910.42** | **3644.23** | **3645.07** | **3644.65** |
| ***Sem±*** | ***90.41*** | ***74.87*** | ***58.69*** | ***46.31*** | ***47.85*** | ***33.29*** | ***72.27*** | ***56.32*** | ***45.81*** |
| ***CD at 5%*** | ***259.32*** | ***214.72*** | ***165.46*** | ***132.82*** | ***137.24*** | ***93.86*** | ***207.30*** | ***161.53*** | ***129.16*** |

Table 26: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on biological yield (kg ha$^{-1}$), seed yield (kg ha$^{-1}$) and stover yield (kg ha$^{-1}$) of soybean at different days after sowing (DAS)

| **Treatments** | **Biological yield (kg ha$^{-1}$)** | | | **Seed yield (kg ha$^{-1}$)** | | | **Stover yield (kg ha$^{-1}$)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0$** | 3629.05 | 3633.98 | 3631.51 | 1278.04 | 1281.33 | 1279.68 | 2351.01 | 2352.65 | 2351.83 |
| **$L_0O_1$** | 4385.95 | 4385.27 | 4385.61 | 1579.69 | 1580.18 | 1579.93 | 2806.26 | 2805.09 | 2805.67 |
| **$L_1O_0$** | 5038.28 | 5039.90 | 5039.09 | 1811.36 | 1811.81 | 1811.59 | 3226.92 | 3228.09 | 3227.51 |
| **$L_1O_1$** | 5273.43 | 5272.83 | 5273.13 | 1954.70 | 1954.12 | 1954.41 | 3318.73 | 3318.71 | 3318.72 |
| **$L_2O_0$** | 5611.90 | 5613.18 | 5612.54 | 1972.30 | 1973.65 | 1972.97 | 3639.60 | 3639.53 | 3639.57 |
| **$L_2O_1$** | **6454.41** | **6456.12** | **6455.27** | **2157.17** | **2157.26** | **2157.22** | **4297.24** | **4298.87** | **4298.05** |
| ***SEm±*** | ***136.05*** | ***71.79*** | ***76.91*** | ***73.31*** | ***61.92*** | ***47.98*** | ***72.54*** | ***49.70*** | ***43.96*** |
| ***CD(P=0.05)*** | ***470.79*** | ***248.44*** | ***237.00*** | ***253.69*** | ***214.26*** | ***147.84*** | ***251.00*** | ***171.98*** | ***135.47*** |
| **$L_0I_0$** | 3771.16 | 3774.35 | 3772.75 | 1360.53 | 1364.95 | 1362.74 | 2410.63 | 2409.40 | 2410.01 |
| **$L_0I_1$** | 3852.81 | 3852.63 | 3852.72 | 1377.10 | 1378.26 | 1377.68 | 2475.70 | 2474.37 | 2475.04 |
| **$L_0I_2$** | 3894.49 | 3903.55 | 3899.02 | 1417.32 | 1423.49 | 1420.40 | 2477.17 | 2480.06 | 2478.61 |
| **$L_0I_3$** | 4511.54 | 4507.96 | 4509.75 | 1560.49 | 1556.32 | 1558.41 | 2951.04 | 2951.64 | 2951.34 |
| **$L_1I_0$** | 4852.00 | 4857.90 | 4854.95 | 1757.18 | 1760.48 | 1758.83 | 3094.82 | 3097.42 | 3096.12 |
| **$L_1I_1$** | 4925.58 | 4923.58 | 4924.58 | 1857.21 | 1855.38 | 1856.30 | 3068.37 | 3068.20 | 3068.28 |
| **$L_1I_2$** | 5332.50 | 5335.06 | 5333.78 | 1945.58 | 1948.36 | 1946.97 | 3386.92 | 3386.71 | 3386.82 |
| **$L_1I_3$** | 5513.35 | 5508.92 | 5511.14 | 1972.15 | 1967.64 | 1969.90 | 3541.20 | 3541.28 | 3541.24 |
| **$L_2I_0$** | 5523.01 | 5524.89 | 5523.95 | 1972.46 | 1973.29 | 1972.88 | 3550.55 | 3551.60 | 3551.08 |
| **$L_2I_1$** | 5856.37 | 5855.84 | 5856.11 | 2017.08 | 2016.58 | 2016.83 | 3839.29 | 3839.26 | 3839.28 |
| **$L_2I_2$** | 6110.82 | 6111.62 | 6111.22 | 2067.45 | 2067.98 | 2067.72 | 4043.38 | 4043.64 | 4043.51 |
| **$L_2I_3$** | **6642.41** | **6646.25** | **6644.33** | **2201.96** | **2203.96** | **2202.96** | **4440.46** | **4442.29** | **4441.37** |
| ***SEm±*** | ***156.60*** | ***129.67*** | ***101.66*** | ***80.21*** | ***82.88*** | ***57.67*** | ***125.18*** | ***97.55*** | ***79.35*** |
| ***CD(P=0.05)*** | ***449.15*** | ***371.91*** | ***286.59*** | ***230.05*** | ***237.71*** | ***162.58*** | ***359.05*** | ***279.78*** | ***223.70*** |
| **$O_0I_0$** | 4484.31 | 4490.37 | 4487.34 | 1588.48 | 1592.52 | 1590.50 | 2895.83 | 2897.85 | 2896.84 |
| **$O_0I_1$** | 4560.89 | 4561.75 | 4561.32 | 1627.08 | 1628.19 | 1627.64 | 2933.81 | 2933.55 | 2933.68 |
| **$O_0I_2$** | 4781.53 | 4786.31 | 4783.92 | 1688.54 | 1692.52 | 1690.53 | 3092.99 | 3093.79 | 3093.39 |
| **$O_0I_3$** | 5212.25 | 5210.98 | 5211.62 | 1844.83 | 1842.48 | 1843.66 | 3367.42 | 3368.50 | 3367.96 |
| **$O_1I_0$** | 4946.47 | 4947.72 | 4947.10 | 1804.97 | 1806.63 | 1805.80 | 3141.50 | 3141.09 | 3141.30 |
| **$O_1I_1$** | 5195.62 | 5192.96 | 5194.29 | 1873.85 | 1871.95 | 1872.90 | 3321.77 | 3321.01 | 3321.39 |
| **$O_1I_2$** | 5443.68 | 5447.18 | 5445.43 | 1931.69 | 1934.03 | 1932.86 | 3511.99 | 3513.15 | 3512.57 |
| **$O_1I_3$** | **5899.28** | **5897.77** | **5898.53** | **1978.24** | **1976.13** | **1977.18** | **3921.04** | **3921.64** | **3921.34** |
| ***SEm±*** | ***127.86*** | ***105.88*** | ***83.00*** | ***65.49*** | ***67.67*** | ***47.09*** | ***102.21*** | ***79.65*** | ***64.79*** |
| ***CD(P=0.05)*** | ***366.73*** | ***303.67*** | ***234.00*** | ***187.83*** | ***194.09*** | ***132.74*** | ***293.16*** | ***228.44*** | ***182.65*** |

Table 27: Effect of lime, farmyard manure and fertilizers on biological yield (kg ha$^{-1}$), seed yield (kg ha$^{-1}$) and stover yield (kg ha$^{-1}$) of soybean at different days after sowing (DAS)

| Treatments | Biological yield (kg ha$^{-1}$) | | | Seed yield (kg ha$^{-1}$) | | | Stover yield (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0I_0$** | 3557.41 | 3563.94 | 3560.68 | 1173.91 | 1178.77 | 1176.34 | 2383.50 | 2385.17 | 2384.33 |
| **$L_0O_0I_1$** | 3472.96 | 3480.63 | 3476.80 | 1210.39 | 1218.72 | 1214.56 | 2262.57 | 2261.91 | 2262.24 |
| **$L_0O_0I_2$** | 3624.10 | 3631.77 | 3627.94 | 1277.26 | 1282.26 | 1279.76 | 2346.84 | 2349.51 | 2348.17 |
| **$L_0O_0I_3$** | 3861.71 | 3859.56 | 3860.64 | 1450.58 | 1445.56 | 1448.07 | 2411.13 | 2414.00 | 2412.57 |
| **$L_0O_1I_0$** | 3984.91 | 3984.76 | 3984.83 | 1547.15 | 1551.13 | 1549.14 | 2437.76 | 2433.63 | 2435.69 |
| **$L_0O_1I_1$** | 4232.65 | 4224.64 | 4228.64 | 1543.82 | 1537.80 | 1540.81 | 2688.84 | 2686.84 | 2687.84 |
| **$L_0O_1I_2$** | 4164.87 | 4175.32 | 4170.10 | 1557.38 | 1564.71 | 1561.04 | 2607.50 | 2610.61 | 2609.05 |
| **$L_0O_1I_3$** | 5161.36 | 5156.36 | 5158.86 | 1670.41 | 1667.07 | 1668.74 | 3490.95 | 3489.28 | 3490.12 |
| **$L_1O_0I_0$** | 4912.51 | 4919.58 | 4916.05 | 1677.19 | 1681.12 | 1679.15 | 3235.33 | 3238.46 | 3236.90 |
| **$L_1O_0I_1$** | 4881.74 | 4881.41 | 4881.58 | 1767.18 | 1765.51 | 1766.35 | 3114.56 | 3115.90 | 3115.23 |
| **$L_1O_0I_2$** | 5020.28 | 5025.23 | 5022.76 | 1820.60 | 1824.48 | 1822.54 | 3199.68 | 3200.75 | 3200.22 |
| **$L_1O_0I_3$** | 5338.60 | 5333.39 | 5335.99 | 1980.49 | 1976.14 | 1978.32 | 3358.11 | 3357.25 | 3357.68 |
| **$L_1O_1I_0$** | 4791.48 | 4796.21 | 4793.85 | 1837.17 | 1839.84 | 1838.51 | 2954.31 | 2956.37 | 2955.34 |
| **$L_1O_1I_1$** | 4969.42 | 4965.75 | 4967.58 | 1947.25 | 1945.25 | 1946.25 | 3022.17 | 3020.50 | 3021.34 |
| **$L_1O_1I_2$** | 5644.73 | 5644.89 | 5644.81 | 2070.56 | 2072.23 | 2071.40 | 3574.16 | 3572.66 | 3573.41 |
| **$L_1O_1I_3$** | 5688.10 | 5684.46 | 5686.28 | 1963.81 | 1959.15 | 1961.48 | 3724.28 | 3725.32 | 3724.80 |
| **$L_2O_0I_0$** | 4982.99 | 4987.59 | 4985.29 | 1914.33 | 1917.67 | 1916.00 | 3068.66 | 3069.93 | 3069.29 |
| **$L_2O_0I_1$** | 5327.96 | 5323.20 | 5325.58 | 1903.68 | 1900.35 | 1902.01 | 3424.28 | 3422.85 | 3423.57 |
| **$L_2O_0I_2$** | 5700.20 | 5701.94 | 5701.07 | 1967.76 | 1970.82 | 1969.29 | 3732.45 | 3731.11 | 3731.78 |
| **$L_2O_0I_3$** | 6436.43 | 6440.00 | 6438.21 | 2103.41 | 2105.75 | 2104.58 | 4333.02 | 4334.25 | 4333.63 |
| **$L_2O_1I_0$** | 6063.03 | 6062.20 | 6062.61 | 2030.58 | 2028.92 | 2029.75 | 4032.45 | 4033.28 | 4032.86 |
| **$L_2O_1I_1$** | 6384.78 | 6388.49 | 6386.63 | 2130.47 | 2132.81 | 2131.64 | 4254.31 | 4255.68 | 4254.99 |
| **$L_2O_1I_2$** | 6521.45 | 6521.31 | 6521.38 | 2167.14 | 2165.14 | 2166.14 | 4354.31 | 4356.17 | 4355.24 |
| **$L_2O_1I_3$** | **6848.40** | **6852.50** | **6850.45** | **2300.50** | **2302.17** | **2301.33** | **4547.90** | **4550.33** | **4549.11** |
| ***SEm±*** | ***221.46*** | ***183.38*** | ***143.77*** | ***113.43*** | ***117.21*** | ***81.55*** | ***177.04*** | ***137.95*** | ***112.22*** |
| ***CD(P=0.05)*** | ***635.19*** | ***525.97*** | ***405.30*** | ***325.34*** | ***336.18*** | ***229.92*** | ***507.77*** | ***395.67*** | ***316.37*** |

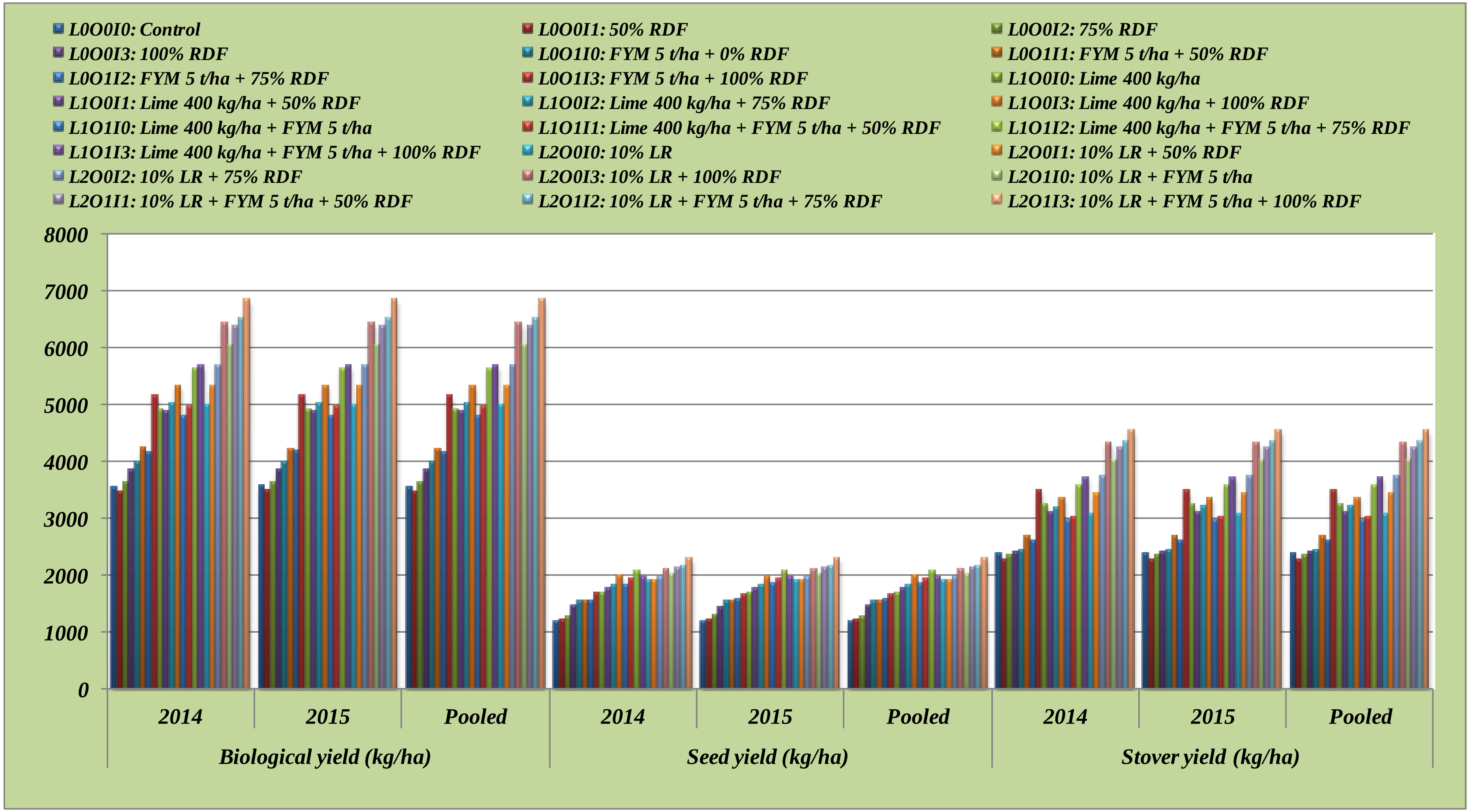



**Fig 10: Effect of lime, farmyard manure and fertilizers on biological yield, seed yield and stover yield during 2014 and 2015**

**Effect of fertilizers on stover yield**

The results revealed that there was a significant difference in stover yield among the treatments. The highest stover yield was recorded in treatment $I_3$ at 3644.23 and 3645.07 kg $ha^{-1}$ while pooled data had 3644.65 kg $ha^{-1}$ in 2014 and 2015, respectively. The lowest stover yield was recorded in treatment $I_0$ as 3018.67 and 30.19.4 kg $ha^{-1}$ while in pooled data it was 3019 kg $ha^{-1}$ in 2014 and 2015, respectively (Table 25).

**Effect of lime and farmyard manure on stover yield**

The data (Table 26) indicated that the maximum stover yield was recorded in treatment $L_2O_1$ (2497.24 and 4298 kg $ha^{-1}$) while pooled data had 4298.05 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum stover yield was recorded in treatment $L_0O_0$ (2351.01 and 2352.65 kg $ha^{-1}$) while pooled data had 2351.83 kg $ha^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and fertilizers on stover yield**

In general, the treatments significantly impacted the stover yield and it was also significant among themselves in both the years. The maximum stover yield was recorded as 4440.46 and 4442.29 kg $ha^{-1}$, respectively in treatment $L_2I_3$ with pooled data as 4441.37 kg $ha^{-1}$. The minimum stover yield was observed in the treatment $L_0I_0$ as 2410.63 and 2409.40 kg $ha^{-1}$ during 2014 and 2015, respectively, while pooled data was 2410.01 kg $ha^{-1}$.

**Effect of farmyard manure and fertilizers on stover yield**

The results showed that the maximum stover yield (Table 26) was recorded in $O_1I_3$ (3921.04 and 3921.64 kg $ha^{-1}$) with pooled data as 3921.34 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum stover yield was observed in treatment $O_0I_0$ (2895.83 and 2897.85 kg $ha^{-1}$) while the pooled data had 2896.84 kg $ha^{-1}$ in 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on stover yield**

The data indicated that stover yield at all the stages of crop growth was found to be significantly affected by the application of fertilisers, FYM and lime (Table 27). Among the treatments, the maximum stover yield was recorded in $L_2O_1I_3$ (4547.90 and 4550.33 kg $ha^{-1}$) with pooled data 4549.11 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum stover yield was in $L_0O_1I_0$ (1173.91 and 1178.77 kg $ha^{-1}$) with pooled data of 1176.34 kg $ha^{-1}$ in 2014 and 2015, respectively.

The combined application of lime @ 10 LR along with FYM @ 5 t $ha^{-1}$ and 100%

RDF gave the maximum stover yield and was significant over others and at par with treatment combination of lime @ 10 LR and 100% RDF, lime @ 10 LR along with FYM @ 5 t $ha^{-1}$ and 50% RDF and lime @ 10 LR along with FYM @ 5 t $ha^{-1}$ and 75% RDF. In treatments without lime, there was a marked decline in the stover yield. The vegetative growth was observed to be enhanced where nutrients were applied in higher amount and also lime was added to enhance soil pH making the nutrients more available for plant use. Obtaining higher significant stover yield by application of 100% RDF along with FYM @ 5 t $ha^{-1}$ was also reported by Saxena *et al.* (2013). Palve *et al.* (2011) also observed similar results with application of 100% RDF along with FYM @ 5 t $ha^{-1}$.

### 4.2.10. Effect on number of pods $plant^{-1}$

**Effect of lime on number of pods $plant^{-1}$**

The results on the number of pods $plant^{-1}$ in different treatments have been presented in table 28. There was an increase in the number of pods $plant^{-1}$ due to treatments and the influence was significant among the treatments. It was apparent from the data, the maximum number of pods $plant^{-1}$ was recorded in the treatment $L_2$ as 81.42 and 81.54 during 2014 and 2015, respectively while pooled data was 81.48. Whereas, the minimum number of pods $plant^{-1}$ was recorded in the treatment $L_0$ as 59.58 and 60.13 while pooled data was 59.85 during 2014 and 2015, respectively. The number of pods $plant^{-1}$ followed the levels of lime.

**Effect of farmyard manure on number of pods $plant^{-1}$**

The number of pods $plant^{-1}$ was found higher in plots having higher organic matter. It was apparent from the table 28, the maximum number of pods $plant^{-1}$ was recorded in treatment $O_1$ as 72.53 and 72.78 while pooled data had 72.65 during 2014 and 2015, respectively. The minimum number of pods $plant^{-1}$ was recorded in $O_0$ as 66.61 and 66.92 while pooled data had 66.76 during 2014 and 2015, respectively.

**Effect of fertilizers on number of pods $plant^{-1}$**

The data (Table 28) revealed that there was a significant difference among the treatments. The maximum number of pods $plant^{-1}$ was recorded in treatment $I_3$ as 76.94 and 77.44 while pooled data had 77.19 during 2014 and 2015, respectively. Whereas, the minimum number of pods $plant^{-1}$ was recorded in the treatment $I_0$ as 64.67 and 65.06 while in pooled data it was 64.86 during 2014 and 2015, respectively.

**Effect of lime and farmyard manure on number of pods $plant^{-1}$**

The maximum and minimum number of pods $plant^{-1}$ was recorded in $L_2O_1$ (86.92 and

87.00) and $L_0O_0$ (58.75 and 59.25) while pooled data had 86.96 and 59.00 during 2014 and 2015, respectively (Table 29).

**Effect of lime and fertilizers on number of pods plant$^{-1}$**

There was a significant difference among the treatments during 2014 and 2015. The maximum number of pods plant$^{-1}$ was recorded as 88.17 and 89.00 respectively in treatment $L_2I_3$ with pooled data as 88.58. The minimum number of pods plant$^{-1}$ was recorded as 54.17 and 54.67 respectively in treatment $L_0I_0$ with pooled data as 54.42 (Table 29).

**Effect of farmyard manure and fertilizers on number of pods plant$^{-1}$**

The results showed that the maximum number of pods plant$^{-1}$ was recorded in treatment $O_1I_3$ (82.67 and 83.44) with pooled data as 83.06 during 2014 and 2015, respectively. The minimum number of pods plant$^{-1}$ was recorded in $O_0I_0$ (62.78 and 63.33) with pooled data as 63.06 during 2014 and 2015, respectively (Table 29).

**Effect of lime, farmyard manure and fertilizers on number of pods plant$^{-1}$**

The data indicated that the number of pods plant$^{-1}$ was found to be significantly affected by the application of fertilisers, FYM and lime (Table 30). Among the treatments, the maximum number of pods plant$^{-1}$ was recorded in $L_2O_1I_3$ (95.33 and 96.33) with pooled data as 95.83, respectively during 2014 and 2015. The minimum number of pods plant$^{-1}$ was recorded in $L_0O_1I_0$ (52.00 and 52.33) with pooled data as 52.17 during 2014 and 2015, respectively.

Application of lime @ 10 LR along with FYM @ 5 t ha$^{-1}$ and 100% RDF gave the maximum number of pods plant$^{-1}$ and the control plot gave the minimum number of pods plant$^{-1}$ which is also the same case in all the treatment combinations of lime and FYM, lime and fertilizers, fertilizers and lime. The individual effect of lime @ 10% LR was found to give the maximum number of pods plant$^{-1}$ than other individual factors. Incorporation of lime provides favourable conditions for plant growth which results in better pod formation. Similar findings were reported by Mishra *et al.* (1999) using treatment combinations of lime, FYM and fertilizers. Saxena *et al.* (2013) also reported maximum pods plant$^{-1}$ in treatment combinations of 100% RDF with FYM @ 5 t ha$^{-1}$ and 125% RDF with FYM @ 5 t ha$^{-1}$.

**4.2.11. Effect on number of number of seeds pod$^{-1}$**

**Effect of lime on number of seeds pod$^{-1}$**

The results on the number of seeds pod$^{-1}$ in different treatments have been presented in table 28. The number of number of seeds pod$^{-1}$ had non-significant difference among various treatments. It was apparent from the data, the maximum number of number of seeds pod$^{-1}$ was recorded in the treatment $L_2$ as 2.75 and 2.75 during 2014 and 2015, respectively while pooled data was 2.75. Whereas, the minimum number of seeds pod$^{-1}$ was recorded in the treatment $L_0$ (2.63) in 2014 and treatment $L_1$ (2.67) in 2015 while pooled data had 2.67. The minimum pooled data is associated with $L_0$ as 2.67.

**Effect of farmyard manure on number of seeds pod$^{-1}$**

The results on the number of seeds pod$^{-1}$ as affected by different treatments have been presented in table 28. The number of seeds pod$^{-1}$ was found to be highest in treatment $O_1$ (2.72) in 2014 and treatment $O_0$ (2.72) in 2015. The minimum number of seeds pod$^{-1}$ was found to be lowest in treatment $O_0$ (2.67) in 2014 and $O_1$ (2.69) in 2015.

**Effect of fertilizers on number of seeds pod$^{-1}$**

The results on the number of seeds pod$^{-1}$ in different treatments have been presented in table 28. The maximum seeds pod$^{-1}$ was recorded at 2.83 in $I_2$ and $I_3$ in 2014 and $I_2$ (2.78) in 2015. Whereas, minimum seeds pod$^{-1}$ was recorded as 2.44 in $I_0$ during 2014 and in $I_1$ and $I_2$ and (2.67) during 2015.

**Effect of lime and farmyard manure on number of seeds pod$^{-1}$**

The perusal of data (Table 29) indicate that the maximum seeds pod$^{-1}$ was recorded as 2.75 in treatments $L_0O_0$, $L_2O_0$ and $L_2O_1$ during 2014 and 2.75 in treatments $L_1O_1$, $L_2O_0$ and $L_2O_1$ during 2015. The minimum seeds pod$^{-1}$ was recorded as 2.58 in treatment $L_0O_0$ during 2014 and 2.67 in treatments $L_0O_1$, $L_1O_0$ and $L_1O_1$ during 2015.

**Effect of lime and fertilizers on number of seeds pod$^{-1}$**

The results on the number of seeds pod$^{-1}$ in different treatments have been presented in table 29. During 2014, the maximum number of seeds pod$^{-1}$ was recorded as 3.00 in $L_2I_1$ and $L_2I_2$. The maximum seeds pod$^{-1}$ was recorded at 2.83 in treatment $L_0I_3$, $L_1I_2$, $L_2I_2$ and $L_2I_3$ during 2015. During 2014, the minimum seeds pod$^{-1}$ was recorded at 2.17 in treatment $L_2I_0$ while the minimum seeds pod$^{-1}$ was recorded at 2.50 in treatment $L_1I_3$ during 2015.

**Effect of farmyard manure and fertilizers on number of seeds pod$^{-1}$**

The results showed that the maximum number of seeds pod$^{-1}$ (2.89) was recorded in treatment $O_1I_3$ during 2014 and as 2.78 in treatment $O_0I_2$, $O_0I_3$ and $O_1I_2$ during 2015. The minimum number of seeds pod$^{-1}$ was recorded in treatment $O_0I_0$ (2.33) during 2014 and as 2.67 in treatment $O_0I_0$, $O_0I_1$, $O_1I_0$, $O_1I_1$ and $O_1I_3$ during 2015.

**Effect of lime, farmyard manure and fertilizers on number of seeds pod$^{-1}$**

The data (Table 30) indicated that the maximum number of seeds pod$^{-1}$ was recorded at 3.00 in treatments $L_0O_0I_2$, $L_0O_1I_3$, $L_1O_1I_3$, $L_2O_0I_1$, $L_2O_1I_2$, $L_2O_0I_3$, $L_2O_1I_1$ and $L_2O_1I_2$ during 2014. During 2015, the maximum number of seeds pod$^{-1}$ was recorded as 3.00 in treatments $L_0O_0I_3$, $L_1O_1I_2$, $L_2O_0I_2$ and $L_2O_1I_3$. The minimum number of seeds pod$^{-1}$ was recorded as 2.00 in treatments $L_2O_0I_0$ during 2014 and as 2.33 in treatment $L_1O_1I_3$ during 2015.

The number of seeds pods$^{-1}$ varied from 2.00 to 3.00 in different treatments and it was non-significant between them. Similar findings on number of seeds pod$^{-1}$ in soybean ranging from 2.10 to 2.30 was reported by Saxena *et al.* (2013). Mishra *et al.* (1999) also found that number of seeds pod$^{-1}$ ranged from 2.18 to 2.90 in soybean.

**4.2.12. Effect on seed index**

**Effect of lime on seed index**

The results on the seed index in different treatments have been presented in table 28. The maximum seed index was recorded in $L_2$ as 13.11 and 13.29 during 2014 and 2015, respectively while pooled data had 13.20. Whereas, the minimum seed index was recorded in $L_0$ as 10.94 and 10.93 while pooled data had 10.94 during 2014 and 2015, respectively.

**Effect of farmyard manure on seed index**

It is apparent from the table 28 that the maximum seed index was recorded in $O_1$ as 12.42 and 12.53, while pooled had value as 12.48 during 2014 and 2015, respectively. The minimum seed index was recorded in $O_0$ as 11.52 and 11.54 during 2014 and 2015, respectively while in pooled data it was 11.53.

**Effect of fertilizers on seed index**

The results revealed that the maximum seed index was recorded in $I_3$ as 12.59 and 12.69 while pooled data had 12.64 during 2014 and 2015, respectively. Whereas, the minimum seed index was recorded in $I_0$ as 11.31 and 11.25 while pooled data had 11.28 during 2014 and 2015, respectively (Table 28).

**Effect of lime and farmyard manure on seed index**

It is apparent from table 29 that the maximum and minimum seed index were recorded

Table 28: Effect of lime, farmyard manure and fertilizers on number of pods plant$^{-1}$, number of seeds pod$^{-1}$ and seed index of soybean at different days after sowing (DAS)

| Treatments | Number of pods plant$^{-1}$ | | | Number of seeds pod$^{-1}$ | | | Seed index (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0$** | 59.58 | 60.13 | 59.85 | 2.63 | 2.71 | 2.67 | 10.94 | 10.93 | 10.94 |
| **$L_1$** | 67.71 | 67.88 | 67.79 | 2.71 | 2.67 | 2.69 | 11.86 | 11.87 | 11.87 |
| **$L_2$** | **81.42** | **81.54** | **81.48** | **2.75** | **2.75** | **2.75** | **13.11** | **13.29** | **13.20** |
| ***SEm±*** | ***0.93*** | ***1.00*** | ***0.69*** | ***0.17*** | ***0.12*** | ***0.10*** | ***0.74*** | ***0.27*** | ***0.39*** |
| ***CD(P=0.05)*** | ***3.66*** | ***3.94*** | ***2.24*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** |
| **$O_0$** | 66.61 | 66.92 | 66.76 | 2.67 | **2.72** | 2.69 | 11.52 | 11.54 | 11.53 |
| **$O_1$** | **72.53** | **72.78** | **72.65** | **2.72** | 2.69 | **2.71** | **12.42** | **12.53** | **12.48** |
| ***SEm±*** | ***1.07*** | ***0.89*** | ***0.70*** | ***0.11*** | ***0.07*** | ***0.06*** | ***0.29*** | ***0.58*** | ***0.33*** |
| ***CD(P=0.05)*** | ***3.71*** | ***3.09*** | ***2.15*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** |
| **$I_0$** | 64.67 | 65.06 | 64.86 | 2.44 | 2.67 | 2.56 | 11.31 | 11.25 | 11.28 |
| **$I_1$** | 66.50 | 66.83 | 66.67 | 2.67 | 2.67 | 2.67 | 11.80 | 11.96 | 11.88 |
| **$I_2$** | 70.17 | 70.06 | 70.11 | **2.83** | **2.78** | **2.81** | 12.19 | 12.24 | 12.21 |
| **$I_3$** | **76.94** | **77.44** | **77.19** | **2.83** | 2.72 | 2.78 | **12.59** | **12.69** | **12.64** |
| ***SEm±*** | ***2.01*** | ***1.24*** | ***1.18*** | ***0.16*** | ***0.12*** | ***0.10*** | ***0.49*** | ***0.68*** | ***0.42*** |
| ***CD(P=0.05)*** | ***5.76*** | ***3.54*** | ***3.32*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** |

Table 29: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on number of pods plant$^{-1}$, number of seeds pod$^{-1}$ and seed index of soybean at different days after sowing (DAS)

| Treatments | Number of pods plant$^{-1}$ | | | Number of seeds pod$^{-1}$ | | | Seed index (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0$** | 58.75 | 59.25 | 59.00 | 2.58 | **2.75** | 2.67 | 10.46 | 10.32 | 10.39 |
| **$L_0O_1$** | 60.42 | 61.00 | 60.71 | 2.67 | 2.67 | 2.67 | 11.43 | 11.55 | 11.49 |
| **$L_1O_0$** | 65.17 | 65.42 | 65.29 | 2.67 | 2.67 | 2.67 | 11.49 | 11.54 | 11.52 |
| **$L_1O_1$** | 70.25 | 70.33 | 70.29 | **2.75** | 2.67 | 2.71 | 12.23 | 12.21 | 12.22 |
| **$L_2O_0$** | 75.92 | 76.08 | 76.00 | **2.75** | **2.75** | **2.75** | 12.63 | 12.75 | 12.69 |
| **$L_2O_1$** | **86.92** | **87.00** | **86.96** | **2.75** | **2.75** | **2.75** | **13.60** | **13.84** | **13.72** |
| ***SEm±*** | ***1.86*** | ***1.55*** | ***1.21*** | ***0.18*** | ***0.12*** | ***0.11*** | ***0.51*** | ***1.01*** | ***0.56*** |
| ***CD(P=0.05)*** | ***6.42*** | ***5.35*** | ***3.72*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** |
| **$L_0I_0$** | 54.17 | 54.67 | 54.42 | 2.50 | 2.67 | 2.58 | 10.26 | 10.29 | 10.28 |
| **$L_0I_1$** | 58.17 | 59.00 | 58.58 | 2.33 | 2.67 | 2.50 | 10.64 | 10.70 | 10.67 |
| **$L_0I_2$** | 59.33 | 59.50 | 59.42 | 2.83 | 2.67 | 2.75 | 11.31 | 11.17 | 11.24 |
| **$L_0I_3$** | 66.67 | 67.33 | 67.00 | 2.83 | **2.83** | 2.83 | 11.56 | 11.58 | 11.57 |
| **$L_1I_0$** | 65.33 | 65.50 | 65.42 | 2.67 | 2.67 | 2.67 | 11.27 | 11.10 | 11.18 |
| **$L_1I_1$** | 63.67 | 64.00 | 63.83 | 2.67 | 2.67 | 2.67 | 11.71 | 11.81 | 11.76 |
| **$L_1I_2$** | 65.83 | 66.00 | 65.92 | 2.67 | **2.83** | 2.75 | 11.85 | 11.90 | 11.87 |
| **$L_1I_3$** | 76.00 | 76.00 | 76.00 | 2.83 | 2.50 | 2.67 | 12.60 | 12.70 | 12.65 |
| **$L_2I_0$** | 74.50 | 75.00 | 74.75 | 2.17 | 2.67 | 2.42 | 12.40 | 12.36 | 12.38 |
| **$L_2I_1$** | 77.67 | 77.50 | 77.58 | 3.00 | 2.67 | 2.83 | 13.04 | 13.38 | 13.21 |
| **$L_2I_2$** | 85.33 | 84.67 | 85.00 | **3.00** | **2.83** | **2.92** | 13.40 | 13.66 | 13.53 |
| **$L_2I_3$** | **88.17** | **89.00** | **88.58** | 2.83 | **2.83** | 2.83 | **13.61** | **13.79** | **13.70** |
| ***SEm±*** | ***3.48*** | ***2.14*** | ***2.04*** | ***0.28*** | ***0.21*** | ***0.17*** | ***0.85*** | ***1.18*** | ***0.73*** |
| ***CD(P=0.05)*** | ***9.98*** | ***6.14*** | ***5.76*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** |
| **$O_0I_0$** | 62.78 | 63.33 | 63.06 | 2.33 | 2.67 | 2.50 | 10.85 | 10.79 | 10.82 |
| **$O_0I_1$** | 63.44 | 64.00 | 63.72 | 2.67 | 2.67 | 2.67 | 11.35 | 11.43 | 11.39 |
| **$O_0I_2$** | 69.00 | 68.89 | 68.94 | **2.89** | 2.78 | **2.83** | 11.72 | 11.77 | 11.74 |
| **$O_0I_3$** | 71.22 | 71.44 | 71.33 | 2.78 | 2.78 | 2.78 | 12.18 | 12.16 | 12.17 |
| **$O_1I_0$** | 66.56 | 66.78 | 66.67 | 2.56 | 2.67 | 2.61 | 11.77 | 11.71 | 11.74 |
| **$O_1I_1$** | 69.56 | 69.67 | 69.61 | 2.67 | 2.67 | 2.67 | 12.24 | 12.50 | 12.37 |
| **$O_1I_2$** | 71.33 | 71.22 | 71.28 | 2.78 | **2.78** | 2.78 | 12.66 | 12.71 | 12.68 |
| **$O_1I_3$** | **82.67** | **83.44** | **83.06** | **2.89** | 2.67 | 2.78 | **13.00** | **13.22** | **13.11** |
| ***SEm±*** | ***2.84*** | ***1.75*** | ***1.67*** | ***0.23*** | ***0.17*** | ***0.14*** | ***0.70*** | ***0.96*** | ***0.59*** |
| ***CD(P=0.05)*** | ***8.14*** | ***5.01*** | ***4.70*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** |

Table 30: Effect of lime, farmyard manure and fertilizers on number of pods plant$^{-1}$, number of seeds pod$^{-1}$ and seed index on of soybean at different days after sowing (DAS)

| Treatments | Number of pods plant$^{-1}$ | | | Number of seeds pod$^{-1}$ | | | Seed index (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0O_0I_0$ | 56.33 | 57.00 | 56.67 | 2.33 | 2.67 | 2.50 | 9.70 | 9.75 | 9.73 |
| $L_0O_0I_1$ | 59.33 | 60.33 | 59.83 | 2.33 | 2.67 | 2.50 | 9.98 | 10.10 | 10.04 |
| $L_0O_0I_2$ | 59.00 | 58.67 | 58.83 | **3.00** | 2.67 | 2.83 | 10.84 | 10.50 | 10.67 |
| $L_0O_0I_3$ | 60.33 | 61.00 | 60.67 | 2.67 | **3.00** | 2.83 | 11.31 | 10.94 | 11.13 |
| $L_0O_1I_0$ | 52.00 | 52.33 | 52.17 | 2.67 | 2.67 | 2.67 | 10.82 | 10.84 | 10.83 |
| $L_0O_1I_1$ | 57.00 | 57.67 | 57.33 | 2.33 | 2.67 | 2.50 | 11.30 | 11.31 | 11.30 |
| $L_0O_1I_2$ | 59.67 | 60.33 | 60.00 | 2.67 | 2.67 | 2.67 | 11.78 | 11.83 | 11.81 |
| $L_0O_1I_3$ | 73.00 | 73.67 | 73.33 | **3.00** | 2.67 | 2.83 | 11.81 | 12.21 | 12.01 |
| $L_1O_0I_0$ | 62.33 | 63.00 | 62.67 | 2.67 | 2.67 | 2.67 | 10.90 | 10.60 | 10.75 |
| $L_1O_0I_1$ | 63.00 | 63.33 | 63.17 | 2.67 | 2.67 | 2.67 | 11.45 | 11.56 | 11.51 |
| $L_1O_0I_2$ | 63.00 | 63.67 | 63.33 | 2.67 | 2.67 | 2.67 | 11.53 | 11.66 | 11.59 |
| $L_1O_0I_3$ | 72.33 | 71.67 | 72.00 | 2.67 | 2.67 | 2.67 | 12.08 | 12.35 | 12.22 |
| $L_1O_1I_0$ | 68.33 | 68.00 | 68.17 | 2.67 | 2.67 | 2.67 | 11.64 | 11.60 | 11.62 |
| $L_1O_1I_1$ | 64.33 | 64.67 | 64.50 | 2.67 | 2.67 | 2.67 | 11.98 | 12.05 | 12.02 |
| $L_1O_1I_2$ | 68.67 | 68.33 | 68.50 | 2.67 | **3.00** | 2.83 | 12.17 | 12.14 | 12.15 |
| $L_1O_1I_3$ | 79.67 | 80.33 | 80.00 | **3.00** | 2.33 | 2.67 | 13.12 | 13.05 | 13.09 |
| $L_2O_0I_0$ | 69.67 | 70.00 | 69.83 | 2.00 | 2.67 | 2.33 | 11.95 | 12.02 | 11.99 |
| $L_2O_0I_1$ | 68.00 | 68.33 | 68.17 | **3.00** | 2.67 | 2.83 | 12.63 | 12.63 | 12.63 |
| $L_2O_0I_2$ | 85.00 | 84.33 | 84.67 | **3.00** | **3.00** | **3.00** | 12.78 | 13.15 | 12.96 |
| $L_2O_0I_3$ | 81.00 | 81.67 | 81.33 | **3.00** | 2.67 | 2.83 | 13.14 | 13.19 | 13.16 |
| $L_2O_1I_0$ | 79.33 | 80.00 | 79.67 | 2.33 | 2.67 | 2.50 | 12.85 | 12.69 | 12.77 |
| $L_2O_1I_1$ | 87.33 | 86.67 | 87.00 | **3.00** | 2.67 | 2.83 | 13.45 | 14.13 | 13.79 |
| $L_2O_1I_2$ | 85.67 | 85.00 | 85.33 | **3.00** | 2.67 | 2.83 | 14.03 | 14.16 | 14.10 |
| $L_2O_1I_3$ | **95.33** | **96.33** | **95.83** | 2.67 | **3.00** | 2.83 | **14.08** | **14.39** | **14.24** |
| ***SEm±*** | ***4.92*** | ***3.03*** | ***2.89*** | ***0.39*** | ***0.29*** | ***0.24*** | ***1.21*** | ***1.67*** | ***1.03*** |
| ***CD(P=0.05)*** | ***14.11*** | ***8.68*** | ***8.14*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** |

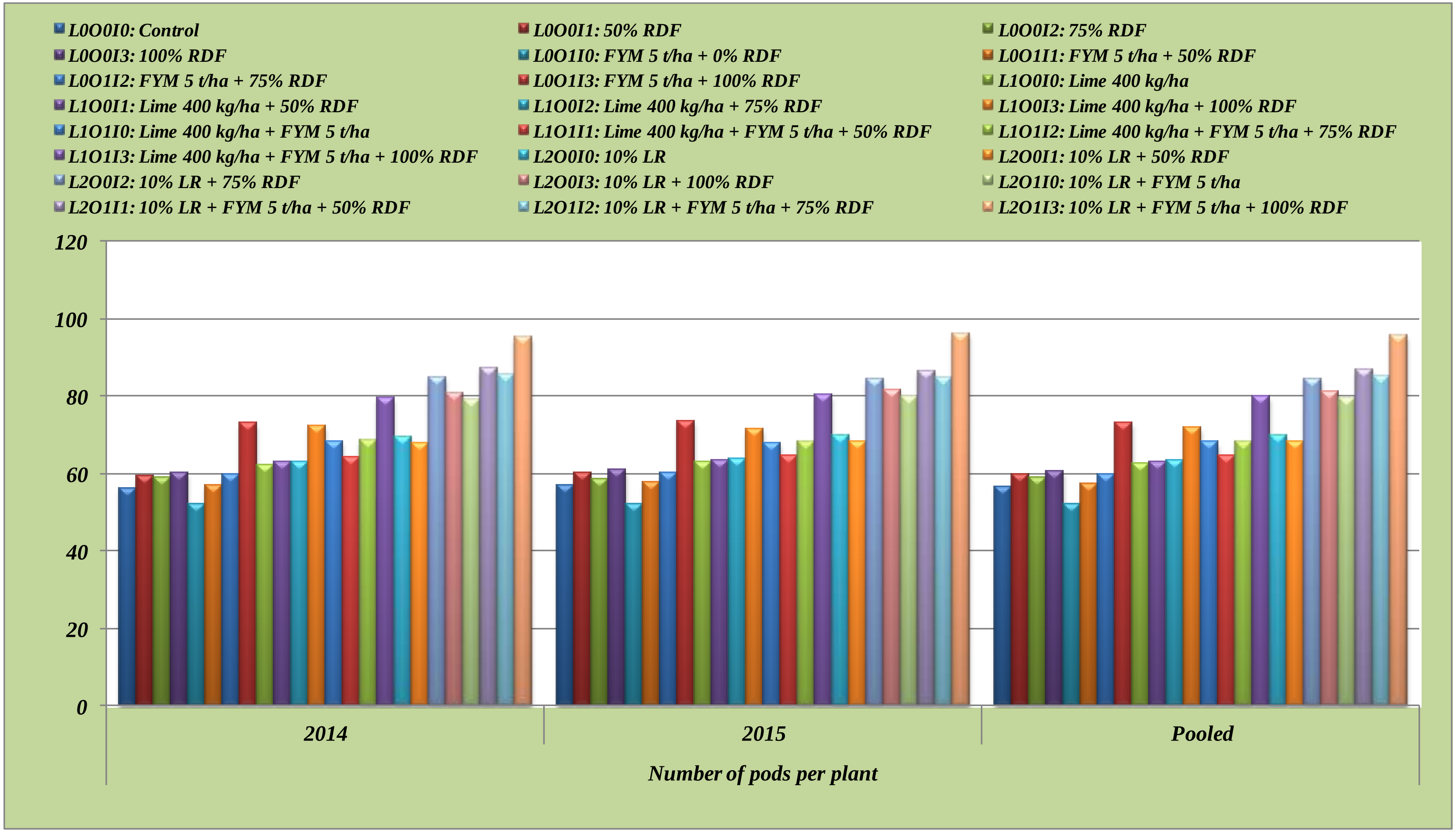



Fig 11: Effect of lime, farmyard manure and fertilizers on number of pods per plant during 2014 and 2015

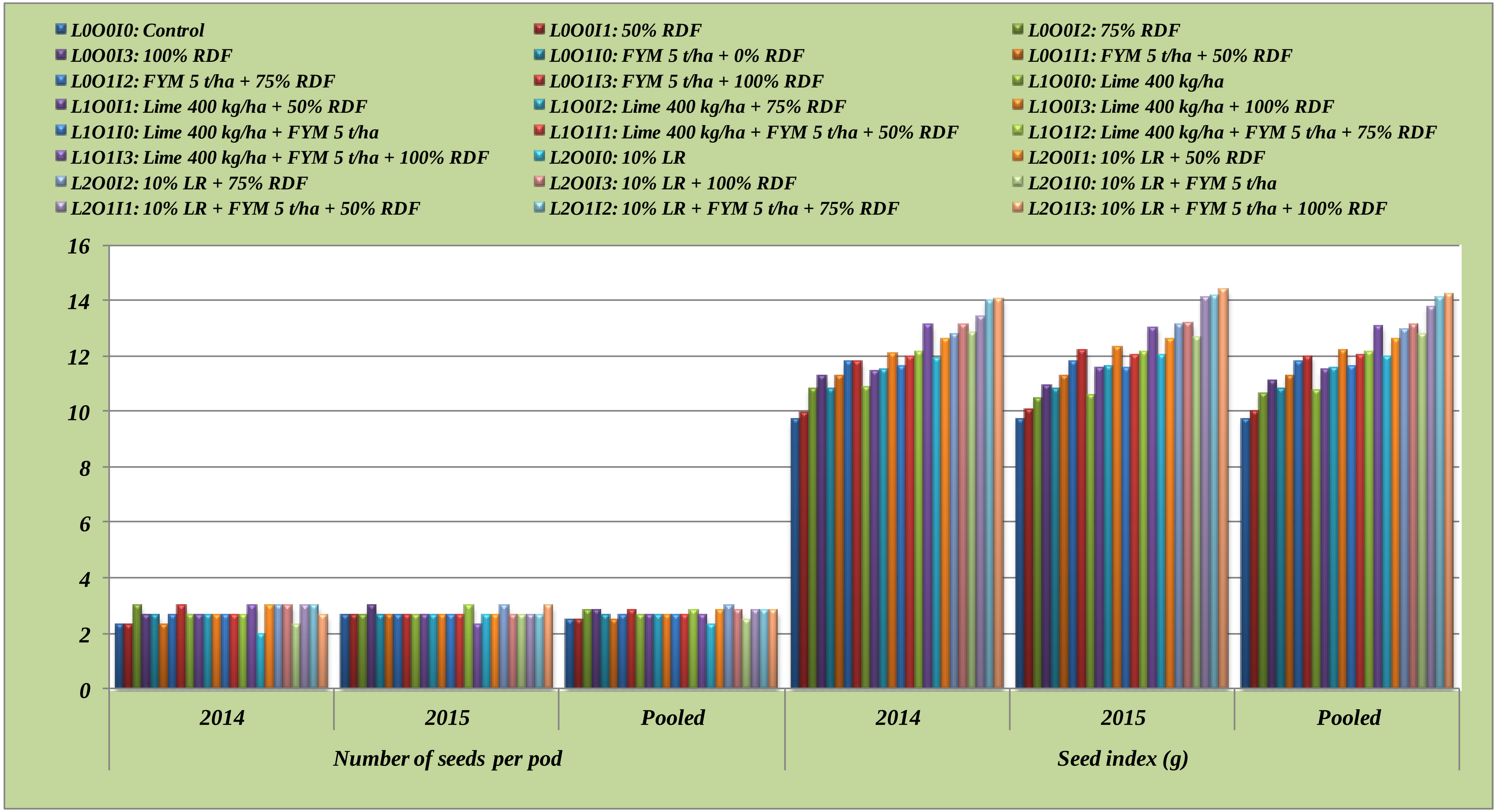



**Fig 12: Effect of lime, farmyard manure and fertilizers on number of seeds per pod and seed index during 2014 and 2015**

in treatment $L_2O_1$ (13.60 and 13.84) and $L_0O_0$ (10.46 and 10.32) during 2014 and 2015, respectively while in pooled data it was 13.72 and 10.39

**Effect of lime and fertilizers on seed index**

The results revealed that during 2014 and 2015, the maximum seed index was recorded at 13.61 and 13.79, respectively in $L_2I_3$ while in pooled data it was 13.70. The minimum seed index was recorded at 10.26 and 10.29 during 2014 and 2015, respectively in treatment $L_0I_0$ with pooled data as 10.28 (Table 29).

**Effect of farmyard manure and fertilizers on seed index**

The results showed that the maximum seed index was recorded in $O_1I_3$ (13.00 and 13.22) with pooled data as 13.11 during 2014 and 2015, respectively. The minimum seed index was recorded in $O_0I_0$ (10.85 and 10.79 g) with pooled data as 10.82 during 2014 and 2015, respectively (Table 29).

**Effect of lime, farmyard manure and fertilizers on seed index**

The perusal of data ascribed on table 30 indicate that the maximum seed index was recorded in $L_2O_1I_3$ (14.08 and 14.39 g) with pooled data as 14.24 g. The minimum seed index was associated with $L_0O_1I_0$ (9.70 and 9.75 g) with pooled data as 9.73 g during 2014 and 2015, respectively.

The maximum seed index from combined treatment of lime, FYM and fertilizers was found as 14.24 g with treatment of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100% RDF. However, it was found to be non-significant in different treatment combinations, with the values ranging from 9.73 to 14.24 g. Seed index ranging from 9.54 to 10.49 g was reported by Lakshman *et al.* (2015). Seed index was also reported by Saxena *et al.* (2013) as 8.40 to 9.30 g with the treatment using FYM and fertilizers at different doses on soybean.

## 4.3. To study the effect of different levels of lime, farmyard manure and fertilizers on nutrient uptake

### 4.3.1. Effect of lime on N, P, K and S uptake

**Effect of lime on N, P, K and S uptake**

The results on the N, P, K and S uptake (the nutrient concentrations of N, P, K and S in seed and stover has been presented in the appendices) in different treatments have been presented in table 31. The N, P, K and S uptake had shown significant difference among different treatments. It was apparent from the data, the maximum N, P, K and S uptake was recorded in $L_2$ as 185.53 and 191.00 kg ha$^{-1}$, 19.64 and 19.59 kg ha$^{-1}$, 153.10 and 154.93 kg ha$^{-1}$, 16.11 and 15.96 mg kg$^{-1}$ during 2014 and 2015, respectively while pooled data had 188.27, 19.61, 154.01 kg ha$^{-1}$ and 16.03 mg kg$^{-1}$. The minimum N, P, K and S uptake was recorded in $L_0$ as 108.35 and 112.58 kg ha$^{-1}$, 10.61 and 10.62 kg ha$^{-1}$, 75.16 and 76.27 kg ha$^{-1}$, 7.93 and 7.91 mg kg$^{-1}$ while pooled data had 110.27, 10.61, 75.72 kg ha$^{-1}$ and 7.92 mg kg$^{-1}$ during 2014 and 2015, respectively. The N, P, K and S uptake was observed to follow an increasing trend with the increase in application of lime.

**Effect of farmyard manure on N, P, K and S uptake**

The N, P, K and S uptake (the nutrient concentrations of N, P, K and S in seed and stover has been presented in the appendices) was found higher in plots receiving higher amounts of organic matter and that resulted in higher availability of nutrients and in turn the uptake. The maximum N, P, K and S uptake was recorded in $O_1$ as 160.88 and 165.60 kg ha$^{-1}$, 16.36 and 16.43 kg ha$^{-1}$, 125.68 and 129.14 kg ha$^{-1}$, 13.34 and 13.14 mg kg$^{-1}$ while pooled data had 163.24, 16.40, 127.41 kg ha$^{-1}$ and 13.24 mg kg$^{-1}$ during 2014 and 2015, respectively. The minimum N, P, K and S uptake by seeds were recorded in $O_0$ as 136.85 and 141.43 kg ha$^{-1}$, 13.55 and 13.73 kg ha$^{-1}$, 102.87 and 105.14 kg ha$^{-1}$, 10.66 and 10.86 mg kg$^{-1}$ while in pooled data it was 139.14, 13.64, 104.00 kg ha$^{-1}$ and 10.76 mg kg$^{-1}$ during 2014 and 2015, respectively.

**Effect of fertilizers on N, P, K and S uptake**

The results revealed that there was a significant difference among the treatments, however the maximum N, P, K and S uptake (the nutrient concentrations of N, P, K and S in seed and stover has been presented in the appendices) was recorded in $I_3$ as 166.37 and 169.64 kg ha$^{-1}$, 17.42 and 17.39 kg ha$^{-1}$, 131.88 and 135.13 kg ha$^{-1}$, 14.14 and 14.03 mg kg$^{-1}$ while pooled data had 168.01, 17.40, 133.51 kg ha$^{-1}$ and 14.09 mg kg$^{-1}$ during 2014 and 2015, respectively. The minimum N, P, K and S uptake were recorded in $I_0$ as 134.91 and 139.94 kg ha$^{-1}$, 12.80 and 12.98 kg ha$^{-1}$, 99.47 and 102.88 kg ha$^{-1}$, 10.20 and 10.01 mg kg$^{-1}$ while in pooled data it was 137.43, 12.89, 101.18 kg ha$^{-1}$ and 10.10 mg kg$^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and farmyard manure on N, P, K and S uptake**

It is apparent from table 32, the maximum N, P, K and S uptakes (the nutrient concentrations of N, P, K and S in seed and stover has been presented in the appendices) were recorded in $L_2O_1$ (201.48 and 206.61 kg ha$^{-1}$, 21.63 and 21.55 kg ha$^{-1}$, 172.16 and 173.65 kg ha$^{-1}$, 18.38 and 17.88 mg kg$^{-1}$) while pooled data had 204.04, 21.59, 172.90 kg ha$^{-1}$ and 18.13 mg kg$^{-1}$ during 2014 and 2015, respectively. The minimum N, P, K and S uptake was recorded in treatment $L_0O_0$ (69.87 and 99.00 kg ha$^{-1}$, 9.27 and 9.36 kg ha$^{-1}$, 65.21 and 64.38 kg ha$^{-1}$, 6.87 and 6.73 mg kg$^{-1}$) while pooled data was 97.94, 9.32, 64.79 kg ha$^{-1}$ and 6.80 mg kg$^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and fertilizers on N, P, K and S uptake**

The results revealed that there was a significant difference among the treatments. During 2014 and 2015, the maximum N, P, K and S uptake (the nutrient concentrations of N, P, K and S in seed and stover has been presented in the appendices) was recorded as 206.10 and 211.97 kg ha$^{-1}$, 22.73 and 22.66 kg ha$^{-1}$, 177.70 and 179.08 kg ha$^{-1}$, 19.07 and 18.82 mg kg$^{-1}$ in $L_2I_3$ with pooled data as 209.03, 22.69, 178.39 kg ha$^{-1}$ and 18.94 mg kg$^{-1}$, respectively. The minimum N, P, K and S uptake was recorded in $L_0O_0$ as 96.50 and 102.54 kg ha$^{-1}$, 9.44 and 9.47 kg ha$^{-1}$, 63.58 and 63.72 kg ha$^{-1}$, 6.85 and 6.71 mg kg$^{-1}$ while pooled data had 99.52, 9.45, 63.65 kg ha$^{-1}$ and 6.78 mg kg$^{-1}$ during 2014 and 2015, respectively.

**Effect of farmyard manure and fertilizers on N, P, K and S uptake**

The data (Table 32) showed that the maximum N, P, K and S uptake (the nutrient concentrations of N, P, K and S in seed and stover has been presented in the appendices) was recorded in $O_1I_3$ (176.61 and 181.10 kg ha$^{-1}$, 18.87 and 18.69 kg ha$^{-1}$, 146.85 and 150.56 kg ha$^{-1}$, 15.59 and 15.37 mg kg$^{-1}$) with pooled data had 178.86, 18.78, 148.70 kg ha$^{-1}$ and 15.48 mg kg$^{-1}$ during 2014 and 2015, respectively. The minimum N, P, K and S uptake was observed to be associated with $O_0I_0$ (125.11 and 129.10 kg ha$^{-1}$, 11.62 and 11.86 kg ha$^{-1}$, 90.32 and 94.41 kg ha$^{-1}$, 8.97 and 9.02 mg kg$^{-1}$) with pooled data as 127.10, 11.74, 92.36 kg ha$^{-1}$ and 8.99 mg kg$^{-1}$ during 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on N, P, K and S uptake**

The data indicated that the N, P, K and S uptake (the nutrient concentrations of N, P, K and S in seed and stover has been presented in the appendices) was found to be significantly affected by the application of fertilisers, FYM and lime (Table 33). Among the treatments, the maximum N, P, K and S uptake was recorded in $L_2O_1I_3$ (217.84 and 224.14 kg ha$^{-1}$, 24.56 and 24.26 kg ha$^{-1}$, 194.52 and 194.54 kg ha$^{-1}$, 20.81 and 20.31 mg kg$^{-1}$) with pooled data as 220.99, 24.41, 194.53 kg ha$^{-1}$ and 20.56 mg kg$^{-1}$ during 2014 and 2015, respectively. The minimum N, P, K and S uptake was recorded in $L_0O_1I_0$ (89.32 and 89.89 kg ha$^{-1}$, 8.15 and 8.20 kg ha$^{-1}$, 56.33 and 58.12 kg ha$^{-1}$, 6.27 and 6.01 mg kg$^{-1}$) with pooled data as 89.61, 8.17,

Table 31: Effect of lime, farmyard manure and fertilizers on N, P, K and S uptake

| Treatments | N uptake (kg ha$^{-1}$) | | | P uptake (kg ha$^{-1}$) | | | K uptake (kg ha$^{-1}$) | | | S uptake ( mg kg$^{-1}$ ) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| **$L_0$** | **108.35** | **112.58** | **110.47** | **10.61** | **10.62** | **10.61** | **75.16** | **76.27** | **75.72** | **7.93** | **7.91** | **7.92** |
| **$L_1$** | 152.72 | 156.97 | 154.84 | 14.62 | 15.04 | 14.83 | 114.57 | 120.23 | 117.40 | 11.98 | 12.15 | 12.06 |
| **$L_2$** | **185.53** | **191.00** | **188.27** | **19.64** | **19.59** | **19.61** | **153.10** | **154.93** | **154.01** | **16.11** | **15.96** | **16.03** |
| ***SEm±*** | ***2.91*** | ***3.17*** | ***2.15*** | ***0.26*** | ***0.32*** | ***0.21*** | ***3.69*** | ***3.41*** | ***2.51*** | ***0.32*** | ***0.30*** | ***0.22*** |
| ***CD(P=0.05)*** | ***11.43*** | ***12.47*** | ***7.02*** | ***1.00*** | ***1.27*** | ***0.67*** | ***14.47*** | ***13.39*** | ***8.19*** | ***1.25*** | ***1.17*** | ***0.71*** |
| **$O_0$** | 136.85 | 141.43 | 139.14 | 13.55 | 13.73 | 13.64 | 102.87 | 105.14 | 104.00 | 10.66 | 10.86 | 10.76 |
| **$O_1$** | **160.88** | **165.60** | **163.24** | **16.36** | **16.43** | **16.40** | **125.68** | **129.14** | **127.41** | **13.34** | **13.14** | **13.24** |
| ***SEm±*** | ***2.92*** | ***1.88*** | ***1.74*** | ***0.16*** | ***0.17*** | ***0.12*** | ***2.17*** | ***1.32*** | ***1.27*** | ***0.21*** | ***0.23*** | ***0.16*** |
| ***CD(P=0.05)*** | ***10.09*** | ***6.51*** | ***5.35*** | ***0.57*** | ***0.57*** | ***0.36*** | ***7.50*** | ***4.56*** | ***3.91*** | ***0.74*** | ***0.80*** | ***0.48*** |
| **$I_0$** | 134.91 | 139.94 | 137.43 | 12.80 | 12.98 | 12.89 | 99.47 | 102.88 | 101.18 | 10.20 | 10.01 | 10.10 |
| **$I_1$** | 141.88 | 147.81 | 144.85 | 14.13 | 14.36 | 14.25 | 108.43 | 111.18 | 109.81 | 11.19 | 11.28 | 11.24 |
| **$I_2$** | 152.30 | 156.66 | 154.48 | 15.47 | 15.60 | 15.53 | 117.32 | 119.37 | 118.35 | 12.48 | 12.70 | 12.59 |
| **$I_3$** | **166.37** | **169.64** | **168.01** | **17.42** | **17.39** | **17.40** | **131.88** | **135.13** | **133.51** | **14.14** | **14.03** | **14.09** |
| ***SEm±*** | ***3.03*** | ***2.66*** | ***2.02*** | ***0.25*** | ***0.25*** | ***0.18*** | ***1.75*** | ***1.74*** | ***1.23*** | ***0.23*** | ***0.23*** | ***0.16*** |
| ***CD(P=0.05)*** | ***8.69*** | ***7.62*** | ***5.68*** | ***0.72*** | ***0.73*** | ***0.50*** | ***5.01*** | ***5.00*** | ***3.48*** | ***0.66*** | ***0.65*** | ***0.46*** |

Table 32: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on N, P, K and S uptake

| Treatments | N uptake (kg ha$^{-1}$) | | | P uptake (kg ha$^{-1}$) | | | K uptake (kg ha$^{-1}$) | | | S uptake ( mg kg$^{-1}$ ) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0$** | 96.87 | 99.00 | 97.94 | 9.27 | 9.36 | 9.32 | 65.21 | 64.38 | 64.79 | 6.87 | 6.73 | 6.80 |
| **$L_0O_1$** | 119.84 | 126.16 | 123.00 | 11.94 | 11.87 | 11.91 | 85.11 | 88.16 | 86.64 | 8.99 | 9.08 | 9.04 |
| **$L_1O_0$** | 144.11 | 149.90 | 147.00 | 13.73 | 14.21 | 13.97 | 109.35 | 114.83 | 112.09 | 11.29 | 11.84 | 11.56 |
| **$L_1O_1$** | 161.33 | 164.03 | 162.68 | 15.52 | 15.88 | 15.70 | 119.78 | 125.62 | 122.70 | 12.66 | 12.46 | 12.56 |
| **$L_2O_0$** | 169.59 | 175.39 | 172.49 | 17.64 | 17.62 | 17.63 | 134.04 | 136.21 | 135.13 | 13.83 | 14.03 | 13.93 |
| **$L_2O_1$** | **201.48** | **206.61** | **204.04** | **21.63** | **21.55** | **21.59** | **172.16** | **173.65** | **172.90** | **18.38** | **17.88** | **18.13** |
| ***SEm±*** | ***5.05*** | ***3.26*** | ***3.01*** | ***0.28*** | ***0.29*** | ***0.20*** | ***3.76*** | ***2.28*** | ***2.20*** | ***0.37*** | ***0.40*** | ***0.27*** |
| ***CD(P=0.05)*** | ***17.47*** | ***11.28*** | ***9.26*** | ***0.98*** | ***0.99*** | ***0.62*** | ***12.99*** | ***7.91*** | ***6.77*** | ***1.28*** | ***1.38*** | ***0.84*** |
| **$L_0I_0$** | 96.50 | 102.54 | 99.52 | 9.44 | 9.47 | 9.45 | 63.58 | 63.72 | 63.65 | 6.85 | 6.71 | 6.78 |
| **$L_0I_1$** | 103.89 | 107.12 | 105.50 | 10.13 | 10.25 | 10.19 | 71.79 | 71.82 | 71.80 | 7.35 | 7.24 | 7.30 |
| **$L_0I_2$** | 108.42 | 112.50 | 110.46 | 10.12 | 10.20 | 10.16 | 75.11 | 75.10 | 75.10 | 7.71 | 8.05 | 7.88 |
| **$L_0I_3$** | 124.61 | 128.16 | 126.39 | 12.73 | 12.55 | 12.64 | 90.17 | 94.43 | 92.30 | 9.80 | 9.62 | 9.71 |
| **$L_1I_0$** | 139.30 | 142.87 | 141.08 | 12.19 | 12.62 | 12.41 | 103.87 | 110.32 | 107.09 | 10.41 | 10.29 | 10.35 |
| **$L_1I_1$** | 142.66 | 151.52 | 147.09 | 13.48 | 14.03 | 13.75 | 107.56 | 113.91 | 110.73 | 11.01 | 11.35 | 11.18 |
| **$L_1I_2$** | 160.50 | 164.67 | 162.59 | 16.03 | 16.55 | 16.29 | 119.07 | 124.80 | 121.94 | 12.92 | 13.30 | 13.11 |
| **$L_1I_3$** | 168.40 | 168.80 | 168.60 | 16.79 | 16.97 | 16.88 | 127.77 | 131.88 | 129.83 | 13.56 | 13.66 | 13.61 |
| **$L_2I_0$** | 168.94 | 174.42 | 171.68 | 16.78 | 16.84 | 16.81 | 130.97 | 134.59 | 132.78 | 13.33 | 13.02 | 13.18 |
| **$L_2I_1$** | 179.11 | 184.80 | 181.96 | 18.77 | 18.81 | 18.79 | 145.94 | 147.83 | 146.88 | 15.21 | 15.25 | 15.23 |
| **$L_2I_2$** | 187.98 | 192.81 | 190.39 | 20.26 | 20.03 | 20.14 | 157.78 | 158.21 | 158.00 | 16.81 | 16.74 | 16.77 |
| **$L_2I_3$** | **206.10** | **211.97** | **209.03** | **22.73** | **22.66** | **22.69** | **177.70** | **179.08** | **178.39** | **19.07** | **18.82** | **18.94** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***SEm±*** | ***5.25*** | ***4.60*** | ***3.49*** | ***0.44*** | ***0.44*** | ***0.31*** | ***3.03*** | ***3.02*** | ***2.14*** | ***0.40*** | ***0.39*** | ***0.28*** |
| ***CD(P=0.05)*** | ***15.05*** | ***13.20*** | ***9.84*** | ***1.25*** | ***1.26*** | ***0.87*** | ***8.68*** | ***8.66*** | ***6.02*** | ***1.15*** | ***1.13*** | ***0.79*** |
| **$O_0I_0$** | 125.11 | 129.10 | 127.10 | 11.62 | 11.86 | 11.74 | 90.32 | 94.41 | 92.36 | 8.97 | 9.02 | 8.99 |
| **$O_0I_1$** | 127.14 | 135.20 | 131.17 | 12.71 | 13.01 | 12.86 | 98.01 | 99.72 | 98.86 | 9.94 | 10.26 | 10.10 |
| **$O_0I_2$** | 139.03 | 143.23 | 141.13 | 13.89 | 13.96 | 13.93 | 106.23 | 106.73 | 106.48 | 11.05 | 11.49 | 11.27 |
| **$O_0I_3$** | 156.13 | 158.18 | 157.16 | 15.97 | 16.10 | 16.03 | 116.92 | 119.71 | 118.31 | 12.69 | 12.69 | 12.69 |
| **$O_1I_0$** | 144.72 | 150.79 | 147.75 | 13.99 | 14.09 | 14.04 | 108.63 | 111.35 | 109.99 | 11.42 | 11.00 | 11.21 |
| **$O_1I_1$** | 156.63 | 160.43 | 158.53 | 15.55 | 15.72 | 15.63 | 118.85 | 122.65 | 120.75 | 12.44 | 12.30 | 12.37 |
| **$O_1I_2$** | 165.57 | 170.09 | 167.83 | 17.05 | 17.23 | 17.14 | 128.41 | 132.02 | 130.22 | 13.92 | 13.90 | 13.91 |
| **$O_1I_3$** | **176.61** | **181.10** | **178.86** | **18.87** | **18.69** | **18.78** | **146.85** | **150.56** | **148.70** | **15.59** | **15.37** | **15.48** |
| ***SEm±*** | ***4.28*** | ***3.76*** | ***2.85*** | ***0.36*** | ***0.36*** | ***0.25*** | ***2.47*** | ***2.46*** | ***1.74*** | ***0.33*** | ***0.32*** | ***0.23*** |
| ***CD(P=0.05)*** | ***12.29*** | ***10.78*** | ***8.03*** | ***1.02*** | ***1.03*** | ***0.71*** | ***7.09*** | ***7.07*** | ***4.92*** | ***0.94*** | ***0.92*** | ***0.65*** |

Table 33: Effect of lime, farmyard manure and fertilizers on N, P, K and S uptake

| Treatments | N uptake (kg $ha^{-1}$) | | | P uptake (kg $ha^{-1}$) | | | K uptake (kg $ha^{-1}$) | | | S uptake ( mg $kg^{-1}$ ) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0I_0$** | 89.32 | 89.89 | 89.61 | 8.15 | 8.20 | 8.17 | 56.33 | 58.12 | 57.22 | 6.27 | 6.01 | 6.14 |
| **$L_0O_0I_1$** | 90.72 | 93.36 | 92.04 | 8.41 | 8.58 | 8.50 | 64.48 | 61.18 | 62.83 | 6.48 | 6.11 | 6.29 |
| **$L_0O_0I_2$** | 98.42 | 101.55 | 99.99 | 9.47 | 9.49 | 9.48 | 70.15 | 66.40 | 68.28 | 6.70 | 6.95 | 6.82 |
| **$L_0O_0I_3$** | 109.01 | 111.21 | 110.11 | 11.03 | 11.18 | 11.10 | 69.88 | 71.81 | 70.85 | 8.05 | 7.85 | 7.95 |
| **$L_0O_1I_0$** | 103.68 | 115.20 | 109.44 | 10.72 | 10.74 | 10.73 | 70.82 | 69.33 | 70.08 | 7.43 | 7.41 | 7.42 |
| **$L_0O_1I_1$** | 117.05 | 120.88 | 118.96 | 11.85 | 11.92 | 11.88 | 79.10 | 82.46 | 80.78 | 8.23 | 8.37 | 8.30 |
| **$L_0O_1I_2$** | 118.41 | 123.46 | 120.93 | 10.77 | 10.91 | 10.84 | 80.06 | 83.81 | 81.93 | 8.73 | 9.16 | 8.94 |
| **$L_0O_1I_3$** | 140.22 | 145.11 | 142.66 | 14.43 | 13.91 | 14.17 | 110.47 | 117.05 | 113.76 | 11.56 | 11.39 | 11.48 |
| **$L_1O_0I_0$** | 132.72 | 138.09 | 135.41 | 11.87 | 12.56 | 12.22 | 103.76 | 110.41 | 107.09 | 10.00 | 10.28 | 10.14 |
| **$L_1O_0I_1$** | 130.34 | 145.87 | 138.11 | 12.87 | 13.74 | 13.31 | 103.74 | 111.01 | 107.37 | 10.67 | 11.49 | 11.08 |
| **$L_1O_0I_2$** | 148.32 | 152.09 | 150.21 | 14.20 | 14.47 | 14.33 | 109.93 | 114.22 | 112.08 | 11.78 | 12.68 | 12.23 |
| **$L_1O_0I_3$** | 165.03 | 163.54 | 164.29 | 15.97 | 16.06 | 16.02 | 119.98 | 123.69 | 121.83 | 12.71 | 12.91 | 12.81 |
| **$L_1O_1I_0$** | 145.87 | 147.64 | 146.76 | 12.52 | 12.68 | 12.60 | 103.98 | 110.22 | 107.10 | 10.81 | 10.30 | 10.56 |
| **$L_1O_1I_1$** | 154.97 | 157.18 | 156.08 | 14.08 | 14.32 | 14.20 | 111.37 | 116.81 | 114.09 | 11.36 | 11.21 | 11.29 |
| **$L_1O_1I_2$** | 172.68 | 177.26 | 174.97 | 17.86 | 18.64 | 18.25 | 128.22 | 135.38 | 131.80 | 14.07 | 13.92 | 14.00 |
| **$L_1O_1I_3$** | 171.78 | 174.06 | 172.92 | 17.60 | 17.88 | 17.74 | 135.56 | 140.08 | 137.82 | 14.41 | 14.40 | 14.41 |
| **$L_2O_0I_0$** | 153.29 | 159.31 | 156.30 | 14.83 | 14.83 | 14.83 | 110.87 | 114.69 | 112.78 | 10.64 | 10.76 | 10.70 |
| **$L_2O_0I_1$** | 160.36 | 166.38 | 163.37 | 16.83 | 16.70 | 16.77 | 125.80 | 126.98 | 126.39 | 12.69 | 13.17 | 12.93 |
| **$L_2O_0I_2$** | 170.34 | 176.06 | 173.20 | 18.01 | 17.92 | 17.97 | 138.60 | 139.55 | 139.08 | 14.67 | 14.85 | 14.76 |
| **$L_2O_0I_3$** | 194.35 | 199.80 | 197.08 | 20.90 | 21.05 | 20.98 | 160.89 | 163.62 | 162.26 | 17.32 | 17.33 | 17.33 |
| **$L_2O_1I_0$** | 184.60 | 189.52 | 187.06 | 18.73 | 18.86 | 18.80 | 151.08 | 154.50 | 152.79 | 16.03 | 15.28 | 15.66 |
| **$L_2O_1I_1$** | 197.86 | 203.22 | 200.54 | 20.72 | 20.92 | 20.82 | 166.08 | 168.67 | 167.37 | 17.74 | 17.33 | 17.53 |
| **$L_2O_1I_2$** | 205.62 | 209.56 | 207.59 | 22.50 | 22.14 | 22.32 | 176.97 | 176.87 | 176.92 | 18.95 | 18.62 | 18.78 |
| **$L_2O_1I_3$** | **217.84** | **224.14** | **220.99** | **24.56** | **24.26** | **24.41** | **194.52** | **194.54** | **194.53** | **20.81** | **20.31** | **20.56** |
| ***SEm±*** | ***7.42*** | ***6.51*** | ***4.94*** | ***0.62*** | ***0.62*** | ***0.44*** | ***4.28*** | ***4.27*** | ***3.02*** | ***0.57*** | ***0.56*** | ***0.40*** |
| ***CD(P=0.05)*** | ***21.29*** | ***18.67*** | ***13.92*** | ***1.77*** | ***1.78*** | ***1.23*** | ***12.27*** | ***12.24*** | ***8.52*** | ***1.63*** | ***1.60*** | ***1.12*** |

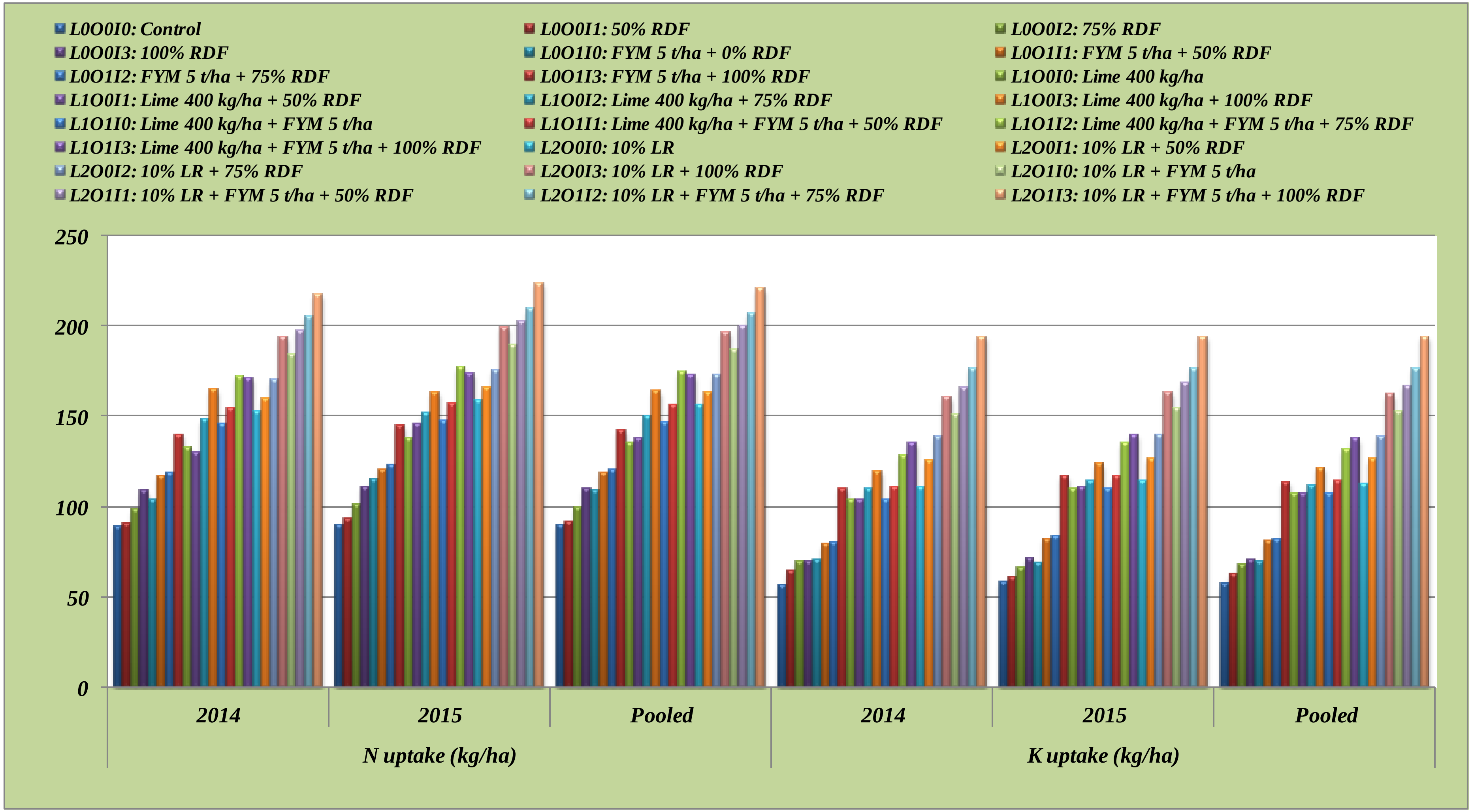



**Fig 13: Effect of lime, farmyard manure and fertilizers on nitrogen and potassium uptake during 2014 and 2015**

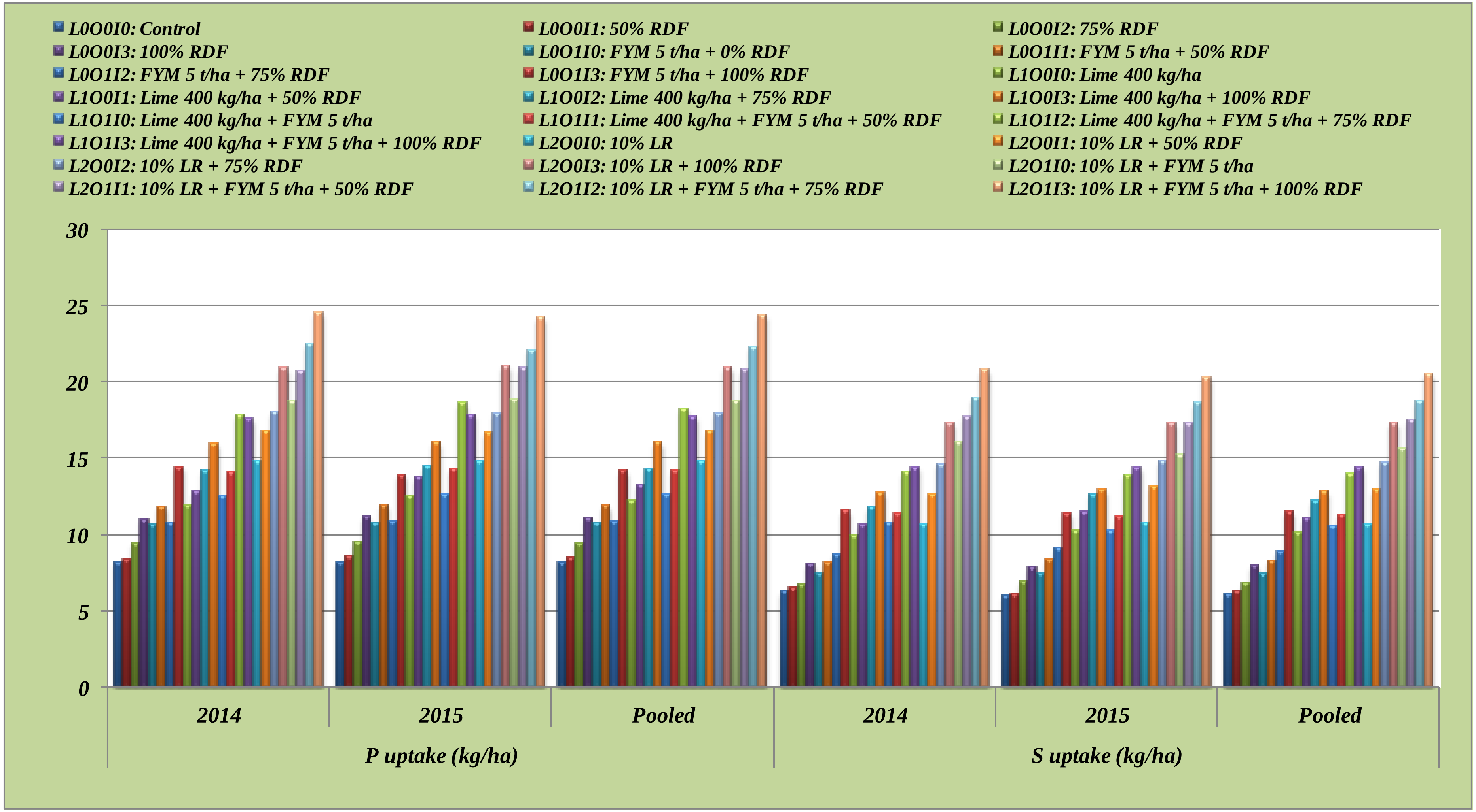



**Fig 14: Effect of lime, farmyard manure and fertilizers on phosphorus and sulphur uptake during 2014 and 2015**

57.22 kg $ha^{-1}$ and 6.14 mg $kg^{-1}$ during 2014 and 2015, respectively.

The maximum N uptake was observed as 220.99 kg $ha^{-1}$ having lime @ 10% LR along with FYM @ 5 $tha^{-1}$ and 100% RDF which was at par with lime @ 10% LR along with FYM @ 5 $tha^{-1}$ and 75% RDF. Supplying of more available nitrogen in the soil encourages vegetative growth and ultimately more stover production and in turn increased uptake. Nitrogen uptake was observed to follow an increasing trend in uptake with the level of lime. Supplying more nutrients and also raising the soil pH, making the nutrients in available form justifies the higher uptake. Higher nutrient uptake which is directly proportional to more nutrient input was reported by Saxena *et al.* (2013). Increased N uptake by soybean by applying 100% RDF in combination with FYM has also been reported by Singh and Rai (2004). Application of lime along with NPK increases the N uptake (Chaterjee *et al.*, 2005). Increase N uptake by application of lime, FYM and fertilizers was also reported by Mishra *et al.* (1999).

Phosphorus uptake in treatments having lime and NPK was observed to increase (Singh *et al.*, 2009). In the present investigation, phosphorus uptake was found to be maximum (24.21 kg $ha^{-1}$) in treatment with lime @ 10% LR, FYM @ 5 t $ha^{-1}$ and 100% RDF. In unlimed plots, the P uptake decreased drastically and this could be due to the unavailability of nutrients owing to high acidity and also poor utilisation of the supplemented nutrients. Mishra *et al.* (1999) and Singh and Rai (2004) also observed an increasing trend of P uptake with application of lime, FYM and fertilizers.

Potassium uptake was found to be maximum in treatment with lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100% RDF with the corresponding value as 194.53 kg $ha^{-1}$ and was significantly higher than other treatments. While treatments without lime had poorer K uptake. Similar results were also reported by researchers (Mishra *et al.*, 1999 and Saxena *et al.*, 2013). In acidic soils, NPK + lime resulted in higher K uptake as reported by Singh *et al.* (2009).

Sulphur uptake was maximum (20.56 mg $kg^{-1}$) with treatment of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100 % RDF which was at par with treatment with lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 75 % RDF . Availability of S in soil decreased with decrease in pH and vice versa, thus, amelioration of soil with lime increases the pH which leads to higher S availability in the soil and subsequently its uptake. In general, fertilizers treatments increased the biomass/grain yield thereby increasing the S-uptake. Sharma *et al.*

(2014) reported that with the enhanced S availability by supplying fertilizers, the S uptake increases. Combined treatment of N and S was reported to enhance root activity leading to more S uptake (Wani *et al.*, 2000). Application of P fertilizers has been reported to influence S uptake (Dhage *et al.*, 2014).

## 4.4. To study the crude protein and oil content of soybean as affected by Lime, Farmyard manure and fertilizers

### 4.4.1. Effect on protein and oil content

**Effect of lime on protein and oil content**

The results on the protein and oil content in different treatments have been presented in table 34. The protein and oil content had shown significant difference among various treatments. The maximum protein and oil content was recorded in $L_2$ as 35.99 and 37.56 %, 18.61 and 18.76 % during 2014 and 2015, respectively while pooled data had 36.78 and 18.69 %. The minimum protein and oil content was recorded in $L_0$ as 31.72 and 32.59 %, 17.08 and 17.14 % while pooled had 32.16 and 17.11 % during 2014 and 2015, respectively.

**Effect of farmyard manure on protein and oil content**

The protein and oil content was found higher in plots receiving higher amounts of FYM. Is was apparent from the table 34, the maximum protein and oil content was recorded in treatment $O_1$ as 34.47 and 35.65 %, 18.19 and 18.23 %, while pooled data had 35.06 and 18.21 % during 2014 and 2015, respectively. The minimum protein and oil content were recorded in $O_0$ as 33.27 and 34.29 %, 17.56 and 17.60 % while pooled data had 33.78 and 17.58 % during 2014 and 2015, respectively.

**Effect of fertilizers on protein and oil content**

The data (Table 34) revealed that there was a significant difference among the treatments. The maximum protein and oil content was recorded in treatment $I_3$ as 34.72 and 35.60 %, 18.26 and 18.31 % while pooled data had 35.16 and 18.29 % during 2014 and 2015, respectively. The minimum protein and oil content were recorded in the treatment $I_0$ as 33.15 and 34.13 %, 17.44 and 17.46 % while pooled data had 33.64 and 17.45 % during 2014 and 2015, respectively.

**Effect of lime and farmyard manure on protein and oil content**

The maximum protein and oil content were recorded in treatment $L_2O_1$ (37.19 and 38.55 %, 18.91 and 19.16 %) while pooled data was 37.87 and 19.04 % during 2014 and 2015, respectively. The minimum protein and oil content were recorded in treatment $L_0O_0$

(31.46 and 32.03 %, 16.64 and 16.79 %) while pooled data had 31.74 and 16.71 % during 2014 and 2015, respectively.

**Effect of lime and fertilizers on protein and oil content**

From the data presented in table 35, the results revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum protein and oil content was recorded at 36.82 and 38.44 %, 18.74 and 19.23 %, respectively in treatment $L_2I_3$ with pooled data as 37.63 and 18.98 %. During 2014 and 2015, the minimum protein and oil content was recorded at 31.21 and 31.77 %, 16.31 and 16.80 %, respectively in treatment $L_0I_0$ with pooled data as 54.42 and 10.28 %.

**Effect of farmyard manure and fertilizers on protein and oil content**

It is apparent from table 35 that the maximum protein and oil content was recorded in $O_1I_3$ (35.04 and 36.24 %, 18.31 and 18.54 %) with pooled data as 35.64 and 38.42 % during 2014 and 2015, respectively. The minimum protein and oil content was recorded in $O_0I_0$ (32.50 and 33.49 %, 17.09 and 17.19 %) with pooled data as 33.99 and 17.14 % during 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on protein and oil content**

The data indicated that the protein and oil content was found to be significantly affected by the application of fertilisers, FYM, lime and organic matter (Table 36). Among the treatments, the maximum protein content was recorded in $L_2O_1I_2$ (37.63 %) during 2014 and $L_2O_1I_3$ (39.13 %) during 2015. The maximum oil content was recorded in $L_2O_1I_1$ (19.14 %) in 2014 and $L_2O_1I_3$ (19.57 %) during 2015. The minimum protein content was recorded in $L_0O_0I_1$ (31.08 %) during 2014 and $L_0O_0I_0$ (31.19 %) during 2015 and the minimum oil content was recorded in $L_0O_0I_0$ (15.58 %) during 2014 and at16.36 % ($L_0O_0I_0$, $L_0O_0I_1$) during 2015.

The application of lime @ 10% LR along with FYM @ 5t ha$^{-1}$ and 100% RDF gave maximum protein content and was significantly higher than other treatments. Nitrogen is the most important factor for protein formation in soybean seeds and it has been observed that with the increase in nitrogen application, the protein content increased. Agarwal *et al.* (2007) also reported that protein content increased through liming when compared to unlimed treatments. Saxena *et al.* (2013) also reported increase in protein content by combined application of fertilizers along with FYM.

In general, oil content increased (19.20%) in treatment receiving lime @ 10% LR along with FYM @ 5t ha$^{-1}$ and 100% RDF over other treatments. The different treatments did not differ much with respect to their oil content but the control plot showed the lowest oil content. Slight increase in oil content could be due to the better nutrient management practices, viz., application of lime, FYM and fertilizers. Treatments where FYM and fertilizers were combined had a slightly better oil content as reported by Saxena *et al.* (2013). Singh and Rai (2004) also reported that application of recommended NPK with FYM resulted in higher oil content in soybean seeds. Higher percentage of protein and oil content with combined application of NPK and lime has also been documented by Chatterjee *et al.* (2005).

### 4.4.2. Effect on protein and oil yield

**Effect of lime on protein and oil yield**

The results on the protein and oil yield in different treatments have been presented in table 34. The protein and oil yield had shown significant difference among different treatments. It was apparent from the data, the maximum protein and oil yield was recorded in $L_2$ as 744.79 and 777.20 kg ha$^{-1}$, 387.28 and 389.06 kg ha$^{-1}$ during 2014 and 2015, respectively while pooled data had 761.00 and 388.17 kg ha$^{-1}$. The minimum protein and oil yield was recorded in $L_0$ as 454.00 and 467.57 kg ha$^{-1}$, 246.39 and 245.44 kg ha$^{-1}$ while pooled data had 460.79 and 245.91 kg ha$^{-1}$ during 2014 and 2015, respectively. The protein and oil yield increased with the increase in application of lime.

**Effect of farmyard manure on protein and oil yield**

The results on the protein and oil yield in different treatments have been presented in table 34. The protein and oil yield was found higher in plots having higher amounts of organic matter which can be attributed to the higher supply of nutrients. The maximum protein and oil yield was recorded in $O_1$ as 659.12 and 681.90 kg ha$^{-1}$, 347.73 and 348.11 kg ha$^{-1}$, while pooled data had 670.51 and 347.92 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum protein and oil yield were recorded in $O_0$ as 566.09 and 584.89 kg ha$^{-1}$, 300.17 and 299.06 kg ha$^{-1}$ while pooled data had 575.49 and 299.61 kg ha$^{-1}$ during 2014 and 2015, respectively.

**Effect of fertilizers on protein and oil yield**

The results revealed that there was a significant difference among the treatments (Table 34). The maximum protein and oil yield was recorded in $I_3$ as 668.80 and 685.97 kg ha$^{-1}$, 352.68 and 351.32 kg ha$^{-1}$ while pooled data had 677.38 and 352.00 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum protein and oil yield was recorded in $I_0$ as 567.02 and

585.85 kg $ha^{-1}$, 300.09 and 298.81 kg $ha^{-1}$ while in pooled data it was 576.44 and 299.45 kg $ha^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and farmyard manure on protein and oil yield**

It was apparent from table 35, that the maximum protein and oil yield were recorded in $L_2O_1$ (802.62 and 832.04 kg $ha^{-1}$, 411.66 and 415.32 kg $ha^{-1}$) and pooled data had 817.33 and 413.49 kg $ha^{-1}$ during 2014 and 2015, respectively. Whereas, the minimum protein and oil yield was recorded in $L_0O_0$ (402.62 and 411.03 kg $ha^{-1}$, 215.78 and 214.35 kg $ha^{-1}$) while pooled data had 406.82 and 215.06 kg $ha^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and fertilizers on protein and oil yield**

The results revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum protein and oil yield was recorded at 811.45 and 847.82 kg $ha^{-1}$, 420.08 and 424.08 kg $ha^{-1}$, respectively in $L_2I_3$ with pooled data as 829.64 and 422.08 kg $ha^{-1}$. Meanwhile, during 2014 and 2015, the minimum protein and oil yield was recorded at 425.12 and 435.18 kg $ha^{-1}$, 227.58 and 227.49 kg $ha^{-1}$, respectively in $L_0I_0$ with pooled data as 430.15 and 227.54 kg $ha^{-1}$.

**Effect of farmyard manure and fertilizers on protein and oil yield**

It is apparent from table 35, that the maximum protein and oil yield was recorded in $O_1I_3$ (698.08 and 722.05 kg $ha^{-1}$, 366.04 and 368.04 kg $ha^{-1}$) with pooled data as 710.06 and 367.18 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum protein and oil yield was recorded in $O_0I_0$ (519.77 and 539.18 kg $ha^{-1}$, 277.56 and 273.86 kg $ha^{-1}$) with pooled data as 529.48 and 275.71 kg $ha^{-1}$ during 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on protein and oil yield**

The data indicated that the protein and oil yield was found to be significantly affected by the application of fertilisers, FYM and lime (Table 36). Among the treatments, the maximum protein and oil yield was recorded in $L_2O_1I_3$ (861.73 and 900.73 kg $ha^{-1}$, 441.01 and 450.45 kg $ha^{-1}$) with pooled data as 881.23 and 445.73 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum protein and oil yield was recorded in $L_0O_0I_0$ (367.74 and 368.56 kg $ha^{-1}$, 191.41 and 187.46 kg $ha^{-1}$) with pooled data of 368.15 and 189.44 kg $ha^{-1}$ during 2014 and 2015, respectively.

Overall, the highest protein yield of 881.23 kg $ha^{-1}$ was recorded with treatment of

Table 34: Effect of lime, farmyard manure and fertilizers on protein content and oil content, protein yield and oil yield of soybean

| Treatments | Protein content (%) | | | Oil content (%) | | | Protein yield (kg ha$^{-1}$) | | | Oil yield (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0$ | 31.72 | 32.59 | 32.16 | 17.08 | 17.14 | 17.11 | 454.00 | 467.57 | 460.79 | 246.39 | 245.44 | 245.91 |
| $L_1$ | 33.89 | 34.76 | 34.33 | 17.94 | 17.84 | 17.89 | 639.03 | 655.41 | 647.22 | 338.19 | 336.26 | 337.23 |
| $L_2$ | **35.99** | **37.56** | **36.78** | **18.61** | **18.76** | **18.69** | **744.79** | **777.20** | **761.00** | **387.28** | **389.06** | **388.17** |
| ***SEm±*** | ***0.51*** | ***0.88*** | ***0.51*** | ***0.48*** | ***0.68*** | ***0.42*** | ***14.00*** | ***13.39*** | ***9.69*** | ***9.03*** | ***6.31*** | ***5.51*** |
| ***CD(P=0.05)*** | ***2.01*** | ***3.47*** | ***1.67*** | ***NS*** | ***NS*** | ***NS*** | ***54.98*** | ***52.57*** | ***31.59*** | ***35.44*** | ***24.78*** | ***17.96*** |
| $O_0$ | 33.27 | 34.29 | 33.78 | 17.56 | 17.60 | 17.58 | 566.09 | 584.89 | 575.49 | 300.17 | 299.06 | 299.61 |
| $O_1$ | **34.47** | **35.65** | **35.06** | **18.19** | **18.23** | **18.21** | **659.12** | **681.90** | **670.51** | **347.73** | **348.11** | **347.92** |
| ***SEm±*** | ***0.28*** | ***0.51*** | ***0.29*** | ***0.47*** | ***0.35*** | ***0.29*** | ***13.60*** | ***11.21*** | ***8.81*** | ***7.53*** | ***6.52*** | ***4.98*** |
| ***CD(P=0.05)*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***47.06*** | ***38.80*** | ***27.16*** | ***26.04*** | ***22.58*** | ***15.35*** |
| $I_0$ | 33.15 | 34.13 | 33.64 | 17.44 | 17.46 | 17.45 | 567.02 | 585.85 | 576.44 | 300.09 | 298.81 | 299.45 |
| $I_1$ | 33.52 | 34.77 | 34.15 | 17.89 | 17.91 | 17.90 | 592.21 | 614.57 | 603.39 | 315.57 | 315.97 | 315.77 |
| $I_2$ | 34.08 | 35.38 | 34.73 | 17.92 | 17.98 | 17.95 | 622.40 | 647.18 | 634.79 | 327.47 | 328.24 | 327.85 |
| $I_3$ | **34.72** | **35.60** | **35.16** | **18.26** | **18.31** | **18.29** | **668.80** | **685.97** | **677.38** | **352.68** | **351.32** | **352.00** |
| ***SEm±*** | ***0.62*** | ***0.46*** | ***0.38*** | ***0.54*** | ***0.49*** | ***0.37*** | ***15.26*** | ***15.36*** | ***10.83*** | ***8.15*** | ***7.89*** | ***5.67*** |
| ***CD(P=0.05)*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***NS*** | ***43.77*** | ***44.05*** | ***30.52*** | ***23.36*** | ***22.64*** | ***15.99*** |

Table 35: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on protein content and oil content, protein yield and oil yield of soybean

| Treatments | Protein content (%) | | | Oil content (%) | | | Protein yield (kg $ha^{-1}$) | | | Oil yield (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0$** | 31.46 | 32.03 | 31.74 | 16.64 | 16.79 | 16.71 | 402.62 | 411.03 | 406.82 | 215.78 | 214.35 | 215.06 |
| **$L_0O_1$** | 31.97 | 33.16 | 32.57 | 17.53 | 17.50 | 17.51 | 505.39 | 524.11 | 514.75 | 276.99 | 276.52 | 276.76 |
| **$L_1O_0$** | 33.55 | 34.27 | 33.91 | 17.75 | 17.66 | 17.70 | 608.70 | 621.28 | 614.99 | 321.85 | 320.02 | 320.93 |
| **$L_1O_1$** | 34.23 | 35.26 | 34.74 | 18.13 | 18.03 | 18.08 | 669.37 | 689.53 | 679.45 | 354.54 | 352.51 | 353.52 |
| **$L_2O_0$** | 34.80 | 36.57 | 35.68 | 18.30 | 18.37 | 18.34 | 686.96 | 722.36 | 704.66 | 362.89 | 362.81 | 362.85 |
| **$L_2O_1$** | **37.19** | **38.55** | **37.87** | **18.91** | **19.16** | **19.04** | **802.62** | **832.04** | **817.33** | **411.66** | **415.32** | **413.49** |
| ***SEm±*** | ***0.48*** | ***0.89*** | ***0.51*** | ***0.81*** | ***0.60*** | ***0.50*** | ***23.55*** | ***19.42*** | ***15.26*** | ***13.04*** | ***11.30*** | ***8.63*** |
| ***CD(P=0.05)*** | ***1.66*** | ***3.08*** | ***1.56*** | ***NS*** | ***NS*** | ***NS*** | ***81.51*** | ***67.21*** | ***47.03*** | ***45.11*** | ***39.11*** | ***26.58*** |
| **$L_0I_0$** | 31.21 | 31.77 | 31.49 | 16.31 | 16.80 | 16.56 | 425.12 | 435.18 | 430.15 | 227.58 | 227.49 | 227.54 |
| **$L_0I_1$** | 31.32 | 32.36 | 31.84 | 17.14 | 17.04 | 17.09 | 431.53 | 446.91 | 439.22 | 237.64 | 236.02 | 236.83 |
| **$L_0I_2$** | 31.96 | 33.23 | 32.59 | 17.17 | 17.09 | 17.13 | 453.48 | 473.87 | 463.67 | 243.88 | 243.71 | 243.79 |
| **$L_0I_3$** | 32.39 | 33.01 | 32.70 | 17.72 | 17.64 | 17.68 | 505.88 | 514.33 | 510.10 | 276.44 | 274.52 | 275.48 |
| **$L_1I_0$** | 33.02 | 33.90 | 33.46 | 17.60 | 17.34 | 17.47 | 580.64 | 597.02 | 588.83 | 309.10 | 305.23 | 307.17 |
| **$L_1I_1$** | 33.55 | 34.55 | 34.05 | 17.79 | 18.00 | 17.90 | 623.53 | 641.32 | 632.42 | 330.89 | 334.20 | 332.54 |
| **$L_1I_2$** | 34.04 | 35.24 | 34.64 | 18.05 | 17.97 | 18.01 | 662.91 | 687.54 | 675.22 | 351.26 | 350.25 | 350.76 |
| **$L_1I_3$** | 34.94 | 35.36 | 35.15 | 18.33 | 18.06 | 18.20 | 689.06 | 695.76 | 692.41 | 361.51 | 355.37 | 358.44 |
| **$L_2I_0$** | 35.21 | 36.73 | 35.97 | 18.42 | 18.25 | 18.34 | 695.30 | 725.35 | 710.33 | 363.58 | 363.71 | 363.65 |
| **$L_2I_1$** | 35.70 | 37.41 | 36.55 | 18.73 | 18.70 | 18.71 | 721.58 | 755.47 | 738.53 | 378.18 | 377.70 | 377.94 |
| **$L_2I_2$** | 36.25 | 37.67 | 36.96 | 18.54 | 18.88 | 18.71 | 750.82 | 780.15 | 765.49 | 387.27 | 390.76 | 389.02 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$L_2I_3$** | **36.82** | **38.44** | **37.63** | **18.74** | **19.23** | **18.98** | **811.45** | **847.82** | **829.64** | **420.08** | **424.08** | **422.08** |
| ***SEm±*** | ***1.07*** | ***0.79*** | ***0.66*** | ***0.94*** | ***0.84*** | ***0.63*** | ***26.43*** | ***26.60*** | ***18.75*** | ***14.11*** | ***13.67*** | ***9.82*** |
| ***CD(P=0.05)*** | ***3.06*** | ***2.26*** | ***1.87*** | ***NS*** | ***NS*** | ***NS*** | ***75.81*** | ***76.30*** | ***52.86*** | ***40.46*** | ***39.22*** | ***27.69*** |
| **$O_0I_0$** | 32.50 | 33.49 | 32.99 | 17.09 | 17.19 | 17.14 | 519.77 | 539.18 | 529.48 | 277.56 | 273.86 | 275.71 |
| **$O_0I_1$** | 32.85 | 34.17 | 33.51 | 17.36 | 17.42 | 17.39 | 538.23 | 561.70 | 549.96 | 284.83 | 286.01 | 285.42 |
| **$O_0I_2$** | 33.34 | 34.53 | 33.93 | 17.60 | 17.72 | 17.66 | 566.86 | 588.79 | 577.82 | 298.98 | 302.04 | 300.51 |
| **$O_0I_3$** | 34.39 | 34.97 | 34.68 | 18.21 | 18.08 | 18.15 | 639.51 | 649.90 | 644.70 | 339.31 | 334.32 | 336.81 |
| **$O_1I_0$** | 33.79 | 34.78 | 34.28 | 17.80 | 17.74 | 17.77 | 614.26 | 632.53 | 623.40 | 322.61 | 323.77 | 323.19 |
| **$O_1I_1$** | 34.20 | 35.38 | 34.79 | 18.41 | 18.40 | 18.41 | 646.20 | 667.44 | 656.82 | 346.30 | 345.93 | 346.12 |
| **$O_1I_2$** | 34.83 | 36.23 | 35.53 | 18.24 | 18.23 | 18.24 | 677.95 | 705.58 | 691.76 | 355.97 | 354.43 | 355.20 |
| **$O_1I_3$** | **35.04** | **36.24** | **35.64** | **18.31** | **18.54** | **18.42** | **698.08** | **722.05** | **710.06** | **366.04** | **368.33** | **367.18** |
| ***SEm±*** | ***0.87*** | ***0.64*** | ***0.54*** | ***0.77*** | ***0.69*** | ***0.52*** | ***21.58*** | ***21.72*** | ***15.31*** | ***11.52*** | ***11.16*** | ***8.02*** |
| ***CD(P=0.05)*** | ***12.29*** | ***10.78*** | ***8.03*** | ***1.02*** | ***1.03*** | ***0.71*** | ***7.09*** | ***7.07*** | ***4.92*** | ***0.94*** | ***0.92*** | ***0.65*** |

Table 36: Effect of lime, farmyard manure and fertilizers on protein content and oil content, protein yield and oil yield of soybean

| Treatments | Protein content (%) | | | Oil content (%) | | | Protein yield (kg ha$^{-1}$) | | | Oil yield (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0I_0$** | 31.23 | 31.19 | 31.21 | 15.58 | 16.36 | 15.97 | 367.74 | 368.56 | 368.15 | 191.41 | 187.46 | 189.44 |
| **$L_0O_0I_1$** | 31.08 | 31.77 | 31.43 | 16.50 | 16.36 | 16.43 | 375.74 | 386.91 | 381.32 | 200.64 | 199.65 | 200.15 |
| **$L_0O_0I_2$** | 31.60 | 32.60 | 32.10 | 16.73 | 16.80 | 16.76 | 403.67 | 418.09 | 410.88 | 213.63 | 215.40 | 214.52 |
| **$L_0O_0I_3$** | 31.94 | 32.54 | 32.24 | 17.74 | 17.64 | 17.69 | 463.31 | 470.56 | 466.93 | 257.43 | 254.88 | 256.16 |
| **$L_0O_1I_0$** | 31.19 | 32.35 | 31.77 | 17.04 | 17.24 | 17.14 | 482.50 | 501.80 | 492.15 | 263.76 | 267.52 | 265.64 |
| **$L_0O_1I_1$** | 31.56 | 32.96 | 32.26 | 17.78 | 17.71 | 17.75 | 487.32 | 506.90 | 497.11 | 274.63 | 272.39 | 273.51 |
| **$L_0O_1I_2$** | 32.31 | 33.85 | 33.08 | 17.60 | 17.38 | 17.49 | 503.28 | 529.65 | 516.46 | 274.12 | 272.01 | 273.06 |
| **$L_0O_1I_3$** | 32.83 | 33.48 | 33.16 | 17.69 | 17.65 | 17.67 | 548.44 | 558.10 | 553.27 | 295.46 | 294.16 | 294.81 |
| **$L_1O_0I_0$** | 32.48 | 33.56 | 33.02 | 17.66 | 17.26 | 17.46 | 544.70 | 564.19 | 554.44 | 296.13 | 290.16 | 293.14 |
| **$L_1O_0I_1$** | 33.13 | 34.33 | 33.73 | 17.28 | 17.72 | 17.50 | 585.38 | 606.15 | 595.76 | 305.28 | 312.77 | 309.03 |
| **$L_1O_0I_2$** | 33.54 | 34.56 | 34.05 | 17.83 | 17.91 | 17.87 | 610.68 | 630.59 | 620.63 | 324.63 | 326.77 | 325.70 |
| **$L_1O_0I_3$** | 35.04 | 34.63 | 34.83 | 18.25 | 17.73 | 17.99 | 694.05 | 684.21 | 689.13 | 361.35 | 350.37 | 355.86 |
| **$L_1O_1I_0$** | 33.56 | 34.23 | 33.90 | 17.53 | 17.41 | 17.47 | 616.57 | 629.85 | 623.21 | 322.08 | 320.31 | 321.19 |
| **$L_1O_1I_1$** | 33.98 | 34.77 | 34.38 | 18.30 | 18.28 | 18.29 | 661.68 | 676.49 | 669.09 | 356.51 | 355.62 | 356.06 |
| **$L_1O_1I_2$** | 34.54 | 35.92 | 35.23 | 18.26 | 18.03 | 18.15 | 715.14 | 744.48 | 729.81 | 377.90 | 373.73 | 375.82 |
| **$L_1O_1I_3$** | 34.83 | 36.10 | 35.47 | 18.42 | 18.39 | 18.41 | 684.07 | 707.31 | 695.69 | 361.67 | 360.37 | 361.02 |
| **$L_2O_0I_0$** | 33.79 | 35.71 | 34.75 | 18.03 | 17.94 | 17.98 | 646.88 | 684.78 | 665.83 | 345.16 | 343.96 | 344.56 |
| **$L_2O_0I_1$** | 34.33 | 36.42 | 35.38 | 18.31 | 18.19 | 18.25 | 653.57 | 692.03 | 672.80 | 348.58 | 345.61 | 347.09 |
| **$L_2O_0I_2$** | 34.88 | 36.42 | 35.65 | 18.23 | 18.47 | 18.35 | 686.22 | 717.69 | 701.96 | 358.67 | 363.96 | 361.31 |
| **$L_2O_0I_3$** | 36.19 | 37.75 | 36.97 | 18.64 | 18.89 | 18.77 | 761.18 | 794.92 | 778.05 | 399.15 | 397.70 | 398.43 |
| **$L_2O_1I_0$** | 36.63 | 37.75 | 37.19 | 18.81 | 18.57 | 18.69 | 743.72 | 765.93 | 754.82 | 382.00 | 383.47 | 382.73 |
| **$L_2O_1I_1$** | 37.06 | 38.40 | 37.73 | **19.14** | 19.21 | 19.18 | 789.59 | 818.91 | 804.25 | 407.78 | 409.79 | 408.78 |
| **$L_2O_1I_2$** | **37.63** | 38.92 | 38.27 | 18.86 | 19.29 | 19.07 | 815.43 | 842.61 | 829.02 | 415.88 | 417.56 | 416.72 |
| **$L_2O_1I_3$** | 37.46 | **39.13** | **38.29** | 18.84 | **19.57** | **19.20** | **861.73** | **900.73** | **881.23** | **441.01** | **450.45** | **445.73** |
| ***SEm±*** | ***1.51*** | ***1.12*** | ***0.94*** | ***1.33*** | ***1.19*** | ***0.90*** | ***37.38*** | ***37.62*** | ***26.52*** | ***19.95*** | ***19.34*** | ***13.89*** |
| ***CD(P=0.05)*** | ***4.32*** | ***3.20*** | ***2.64*** | ***NS*** | ***NS*** | ***NS*** | ***107.21*** | ***107.90*** | ***74.75*** | ***57.22*** | ***55.46*** | ***39.17*** |

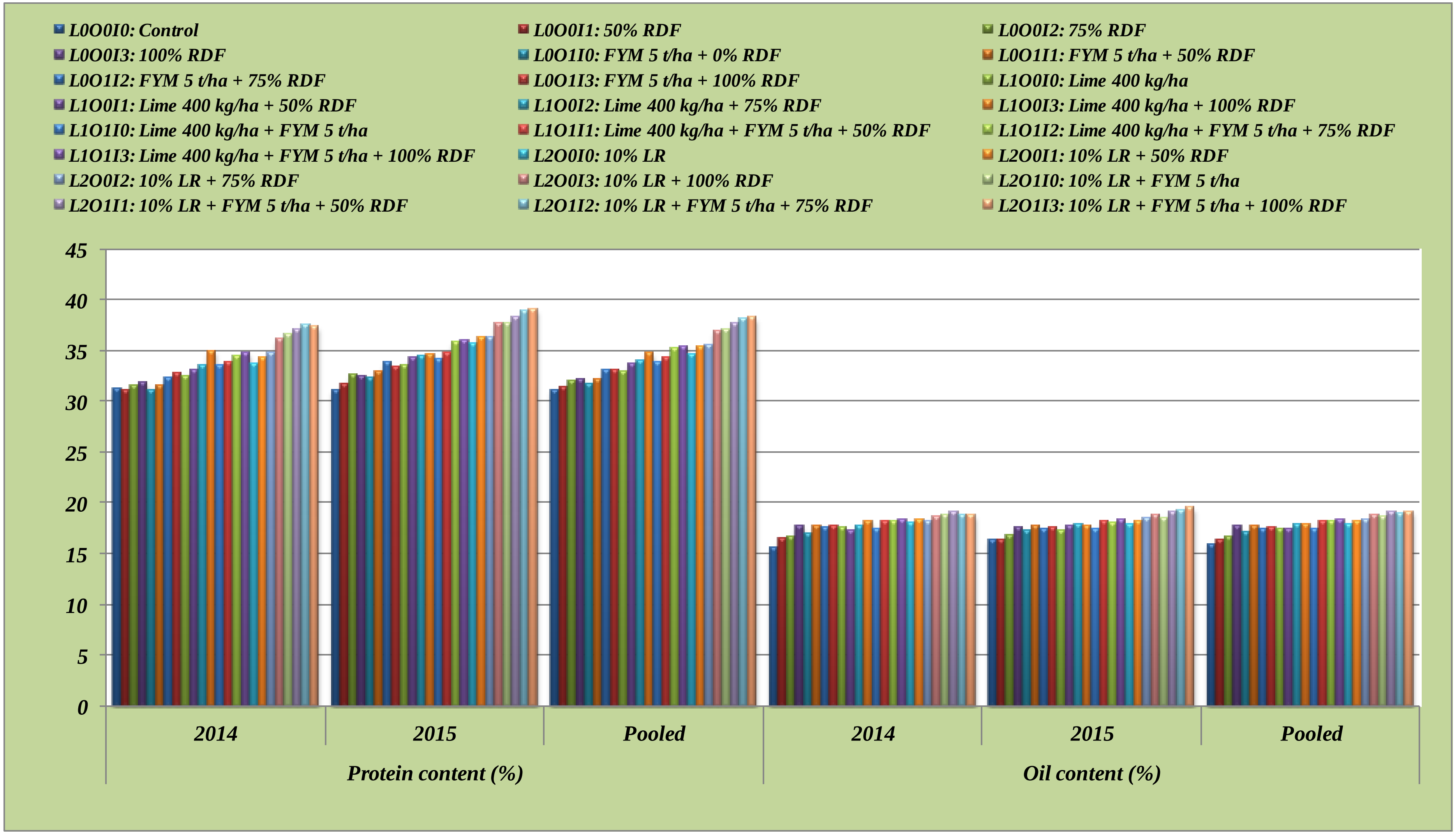



**Fig 15: Effect of lime, farmyard manure and fertilizers on protein and oil content of soybean seed during 2014 and 2015**

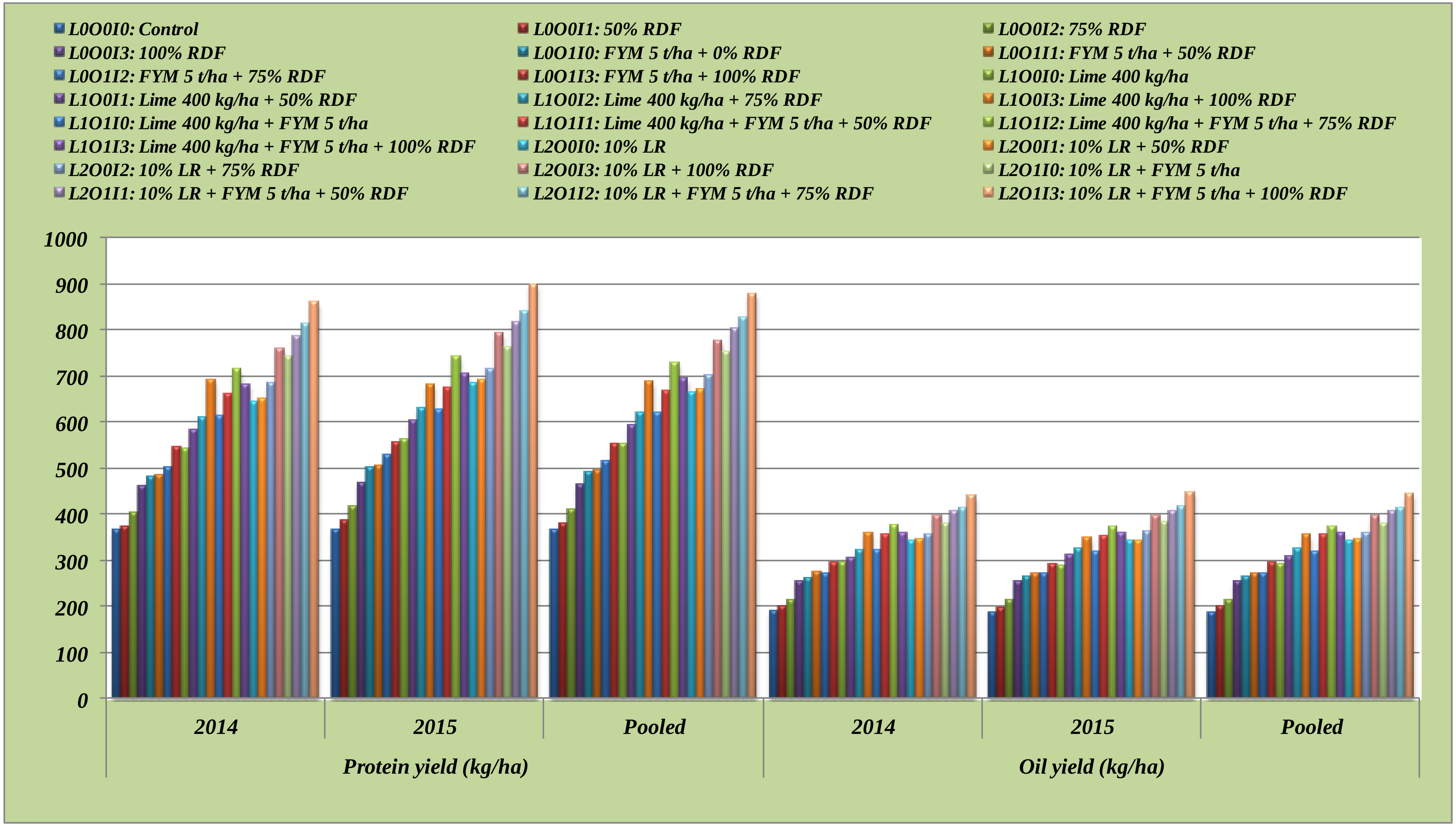



**Fig 16: Effect of lime, farmyard manure and fertilizers on protein and oil yield of soybean during 2014 and 2015**

lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 100% RDF which was at par with the treatment of lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 75% RDF and lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 50% RDF. Application of lime has been observed to enhance the total protein yield. The increased application of nitrogen have resulted in higher and nitrogen uptake which have translated into higher protein yield. Oil yield was found maximum (445.73 kg ha$^{-1}$) with treatment having lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 100% RDF which was at par with treatment comprising of lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 75% RDF and lime @ 10% LR along with FYM @ 5 t ha$^{-1}$ and 50% RDF. It was observed that liming creates favourable growing conditions for the crop by raising the pH and contributing to the overall oil yield. Addition of fertilizers also contributed to better yield. Higher protein and oil yield has been observed by application of 100% RDF and 125% RDF combined with FYM @ 5 t ha$^{-1}$ (Saxena *et al.*, 2013).

### 4.5. To study the effect of lime, farmyard manure and fertilizers on soil fertility status after harvest of crop

#### 4.5.1. Effect on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest

**Effect of lime on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest**

The results on pH, organic carbon, exchangeable Ca and Mg content in soil after harvest in different treatments have been presented in table 37. The pH, organic carbon, exchangeable Ca and Mg content in soil after harvest had shown significant difference among various treatments.

It was apparent from the data, the maximum pH and organic carbon content in soil after harvest was recorded in $L_2$ as 5.91 and 5.96, 1.459 and 1.435 during 2014 and 2015, respectively while pooled data had 5.94 and 1.447. Whereas, the minimum pH and organic carbon content in soil after harvest was recorded in $L_0$ as 5.61 and 5.61, 1.604 and 1.037, while pooled data had 5.61 and 1.051 during 2014 and 2015, respectively.

The exchangeable Ca in soil at harvest had shown significant difference among different treatments. It was apparent from the table 37, the maximum exchangeable Ca in soil was recorded in $L_2$ as 7.22 and 7.21{cmol (p$^+$) kg$^{-1}$} during 2014 and 2015, respectively while pooled data had 7.22 {cmol (p$^+$) kg$^{-1}$}. Whereas, the minimum exchangeable Ca in soil was recorded in $L_0$ as 3.10 and 3.10 {cmol (p$^+$) kg$^{-1}$} while pooled data had 3.10 {cmol (p$^+$) kg$^{-1}$} during 2014 and 2015, respectively. The exchangeable Mg in soil at harvest had significant difference among different treatments. The maximum exchangeable Mg content in soil at harvest was recorded in $L_0$ as 0.55 and 0.54{cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively while pooled data had 0.55 {cmol ($p^+$) $kg^{-1}$}. The minimum exchangeable Mg content in soil was recorded in the treatment $L_1$ as 0.51 and 0.52 {cmol ($p^+$) $kg^{-1}$} while pooled data had 0.51 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively.

**Effect of farmyard manure on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest**

The pH, organic carbon, exchangeable Ca and Mg content in soil at harvest was found to be higher in plots receiving higher organic matter.

It is apparent from the table 37, the maximum pH and organic carbon content in soil at harvest was recorded in $O_1$ as 5.79 and 5.84, 1.30 and 1.30 while pooled data had 5.81 and 1.30 during 2014 and 2015, respectively. The minimum pH and organic carbon content in soil at harvest were recorded in $O_0$ as 5.74 and 5.74, 1.20 and 1.17 while pooled data were 5.74 and 1.19 during 2014 and 2015, respectively.

The data presented on table 37 indicated that the maximum exchangeable Ca and Mg content in soil after harvest was recorded in $O_1$ as 5.77 and 5.77 {cmol ($p^+$) $kg^{-1}$}, 0.54 and 0.54 while pooled data had 5.77 and 0.54 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively. The minimum exchangeable Ca and Mg content in soil after harvest were recorded in the treatment $O_0$ as 4.48 and 4.48 {cmol ($p^+$) $kg^{-1}$}, 0.52 and 0.51 {cmol ($p^+$) $kg^{-1}$} while in pooled data it was 4.48 and 0.52 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively.

**Effect of fertilizers on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest**

The results revealed that there was a significant difference among the treatments (Table 37). The maximum pH and organic carbon in soil at harvest was recorded in $I_3$ as 5.81 and 5.90, 1.30 and 1.32 while pooled data had 5.85 and 1.309 during 2014 and 2015, respectively. The minimum pH and organic carbon content in soil at harvest was recorded in $I_0$ as 5.71 and 5.71, 1.24 and 1.20 in 2014 and 2015, respectively with pooled data of 5.71 and 1.221.

There was a significant difference among the treatments for exchangeable Ca and Mg. The maximum exchangeable Ca and Mg content in soil at harvest was recorded in $I_3$ as 5.76 and 5.76 {cmol ($p^+$) $kg^{-1}$}, 0.59 and 0.59 {cmol ($p^+$) $kg^{-1}$} while pooled data had 5.76 and 0.59 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively. The minimum exchangeable Ca and Mg content in soil at harvest was recorded in $I_0$ as 4.26 and 4.27 {cmol ($p^+$) $kg^{-1}$}, 0.44 and 0.45 {cmol ($p^+$) $kg^{-1}$} while pooled data had 4.26 and 0.45 during 2014 and 2015, respectively.

**Effect of lime and farmyard manure on pH, Organic carbon, exchangeable Ca and Mg content in soil at harvest**

From the data (Table 38) the maximum pH in soil at harvest was recorded in $L_2O_1$ (5.92 and 6.02) with pooled data as 5.97 during 2014 and 2015, respectively. Also, the maximum organic carbon content in soil at harvest was recorded at 1.48 in $L_2O_0$ during 2014 and $L_2O_1$ in 2015. The minimum pH and organic carbon content in soil at harvest were recorded in $L_0O_0$ (5.57 and 5.55, 0.88 and 0.87) while pooled data had 5.56 and 0.88 during 2014 and 2015, respectively.

It was apparent from table 38, the maximum and minimum exchangeable Ca content in soil at harvest were recorded in $L_2O_1$ (8.07 and 8.06 {cmol ($p^+$) $kg^{-1}$}) and $L_0I_0$ (2.70 and 2.69 {cmol ($p^+$) $kg^{-1}$}) while pooled data had 8.07 and 2.70 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively. The maximum exchangeable Mg content in soil at harvest was recorded in $L_0O_1$ (0.57 and 0.56 {cmol ($p^+$) $kg^{-1}$}) and minimum exchangeable Mg in soil at harvest were recorded at 0.51 {cmol ($p^+$) $kg^{-1}$} in $L_1I_0$ in 2014 and treatment $L_1I_0$ and $L_2I_0$ during 2015.

**Effect of lime and fertilizers on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest**

The results revealed that there was a significant difference among the treatments during 2014 and 2015. The maximum pH and organic carbon content in soil at harvest was recorded as 5.96 and 6.15, 1.60 and 1.61 in $L_2I_3$ with pooled data as 6.05 and 1.61, respectively. The minimum pH content in soil at harvest was recorded in $L_0I_0$ as 5.55 and 5.55 during 2014 and 2015, respectively. The minimum organic carbon content in soil at harvest was recorded in $L_0O_2$ as 0.92 in 2014 and 0.90 in 2015, respectively (Table 38).

During 2014 and 2015, the maximum exchangeable Ca in soil at harvest was recorded at 7.69 and 7.67 {cmol ($p^+$) $kg^{-1}$} in $L_2I_3$ with pooled data as 7.68 {cmol ($p^+$) $kg^{-1}$}, respectively. The minimum exchangeable Ca content in soil at harvest was recorded in $L_0I_0$ as 2.70 and 2.69 during 2014 and 2015, respectively. The maximum exchangeable Mg in soil at harvest was recorded at 0.63 and 0.63 {cmol ($p^+$) $kg^{-1}$} in treatment $L_0I_3$ with pooled data as 0.62 {cmol ($p^+$) $kg^{-1}$}, respectively. The minimum Mg content in soil at harvest was recorded in $L_2I_0$ as 0.44 and 0.45 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively.

**Effect of farmyard manure and fertilizers on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest**

The results showed that the maximum pH and organic carbon content in soil at harvest was recorded in $O_1I_3$ (5.84 and 6.00, 1.47 and 1.51) with pooled data as 5.92 and 1.49 during 2014 and 2015, respectively. The minimum pH and organic carbon content in soil at harvest was recorded in $O_0I_0$ (5.69 and 5.68, 1.28 and 1.20) with pooled data as 5.68 and 1.24 during 2014 and 2015, respectively (Table 38).

It was apparent from table 38, the maximum exchangeable Ca and Mg content in soil at harvest was recorded in $O_1I_3$ (6.25 and 6.27 {cmol ($p^+$) $kg^{-1}$}, 0.60 and 0.59 {cmol ($p^+$) $kg^{-1}$}) with pooled data as 6.29 and 0.59 during 2014 and 2015, respectively. The minimum exchangeable Ca and Mg content in soil after harvest was recorded in treatment $O_0I_0$ (3.72 and 3.74 {cmol ($p^+$) $kg^{-1}$}, 0.43 and 0.44 {cmol ($p^+$) $kg^{-1}$}) with pooled data as 3.73 and 0.44 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest**

The data indicated that the pH and organic carbon content in soil at harvest was found to be significantly affected by the application of fertilisers, FYM and lime (Table 39). Among the treatments, the maximum pH and organic carbon content in soil at harvest was recorded in $L_2O_1I_3$ (5.98 and 6.35, 1.76 and 1.76) with pooled data as 6.17 and 1.76 during 2014 and 2015, respectively. Also, the minimum pH and organic carbon content in soil at harvest was recorded in $L_0O_0I_0$ with 5.51 and 5.47, 0.90 and 0.87 with pooled data as 5.49 and 0.88 during 2014 and 2015, respectively.

The exchangeable Ca and Mg at harvest were found to be significantly affected by the application of fertilisers, FYM, lime and organic matter (Table 39). Among the treatments, the maximum exchangeable Ca content in soil at harvest was recorded in $L_2O_1I_2$ (8.53 and 8.51 {cmol ($p^+$) $kg^{-1}$}) with pooled data as 8.52 during 2014 and 2015, respectively. The minimum exchangeable Ca in soil at harvest was recorded in $L_0O_0I_0$ with 2.50 and 2.52 {cmol ($p^+$) $kg^{-1}$} with pooled data as 2.52 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively. The maximum exchangeable Mg in soil at harvest was recorded in $L_0O_1I_3$ (0.65 and 0.63 {cmol ($p^+$) $kg^{-1}$}) with pooled data as 0.64 {cmol ($p^+$) $kg^{-1}$} during 2014 and 2015, respectively. Also, the minimum exchangeable Mg in soil at harvest was recorded in $L_1O_0I_0$ and $L_2O_0I_0$ with 0.44 {cmol ($p^+$) $kg^{-1}$} in 2014 and in $L_1O_0I_0$ (0.43{cmol ($p^+$) $kg^{-1}$ }) during 2015.

Table 37: Effect of lime, farmyard manure and fertilizers on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest

| Treatments | pH | | | Organic carbon (%) | | | Exchangeable Ca {cmol $(p^+)kg^{-1}$} | | | Exchangeable Mg {cmol $(p^+)kg^{-1}$} | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0$ | 5.61 | 5.61 | 5.61 | 1.06 | 1.04 | 1.05 | 3.10 | 3.10 | 3.10 | 0.55 | 0.54 | 0.55 |
| $L_1$ | 5.77 | 5.80 | 5.78 | 1.23 | 1.24 | 1.23 | 5.07 | 5.06 | 5.07 | 0.51 | 0.52 | 0.51 |
| $L_2$ | 5.91 | 5.96 | 5.94 | 1.46 | 1.43 | 1.45 | 7.22 | 7.21 | 7.22 | 0.53 | 0.53 | 0.53 |
| SEm± | 0.21 | 0.22 | 0.15 | 0.16 | 0.04 | 0.08 | 0.09 | 0.11 | 0.07 | 0.01 | 0.01 | 0.00 |
| CD(P=0.05) | NS | NS | NS | NS | 0.16 | 0.28 | 0.34 | 0.42 | 0.22 | NS | 0.02 | 0.02 |
| $O_0$ | 5.74 | 5.74 | 5.74 | 1.20 | 1.17 | 1.19 | 4.48 | 4.48 | 4.48 | 0.52 | 0.51 | 0.52 |
| $O_1$ | 5.79 | 5.84 | 5.81 | 1.30 | 1.30 | 1.30 | 5.77 | 5.77 | 5.77 | 0.54 | 0.54 | 0.54 |
| SEm± | 0.08 | 0.10 | 0.06 | 0.08 | 0.08 | 0.06 | 0.09 | 0.10 | 0.07 | 0.01 | 0.01 | 0.00 |
| CD(P=0.05) | NS | NS | NS | NS | NS | NS | 0.31 | 0.33 | 0.20 | 0.02 | 0.02 | 0.01 |
| $I_0$ | 5.71 | 5.71 | 5.71 | 1.24 | 1.20 | 1.22 | 4.26 | 4.27 | 4.26 | 0.44 | 0.45 | 0.45 |
| $I_1$ | 5.74 | 5.76 | 5.75 | 1.26 | 1.20 | 1.23 | 5.10 | 5.08 | 5.09 | 0.54 | 0.54 | 0.54 |
| $I_2$ | 5.79 | 5.79 | 5.79 | 1.21 | 1.22 | 1.21 | 5.40 | 5.39 | 5.40 | 0.55 | 0.55 | 0.55 |
| $I_3$ | 5.81 | 5.90 | 5.85 | 1.29 | 1.32 | 1.31 | 5.76 | 5.76 | 5.76 | 0.59 | 0.59 | 0.59 |
| SEm± | 0.26 | 0.25 | 0.18 | 0.09 | 0.10 | 0.07 | 0.13 | 0.08 | 0.08 | 0.01 | 0.01 | 0.00 |
| CD(P=0.05) | NS | NS | NS | NS | NS | NS | 0.37 | 0.23 | 0.21 | 0.02 | 0.02 | 0.01 |

Table 38: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on pH, organic carbon, exchangeable Ca and Mg content in soil at harvest

| Treatments | pH | | | Organic carbon (%) | | | Exchangeable Ca {cmol $(p^+)kg^{-1}$} | | | Exchangeable Mg {cmol $(p^+)kg^{-1}$} | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0$** | **5.57** | **5.55** | **5.56** | 0.88 | 0.87 | 0.88 | **2.70** | **2.70** | **2.70** | 0.53 | 0.52 | 0.53 |
| **$L_0O_1$** | 5.65 | 5.67 | 5.66 | 1.24 | 1.20 | 1.22 | 3.50 | 3.50 | 3.50 | **0.57** | **0.56** | **0.57** |
| **$L_1O_0$** | 5.75 | 5.77 | 5.76 | 1.25 | 1.25 | 1.25 | 4.39 | 4.39 | 4.39 | 0.51 | 0.51 | 0.51 |
| **$L_1O_1$** | 5.79 | 5.83 | 5.81 | 1.20 | 1.22 | 1.21 | 5.75 | 5.74 | 5.75 | 0.52 | 0.52 | 0.52 |
| **$L_2O_0$** | 5.91 | 5.91 | 5.91 | **1.48** | 1.39 | 1.43 | 6.37 | 6.36 | 6.37 | 0.51 | 0.51 | 0.51 |
| **$L_2O_1$** | **5.92** | **6.02** | **5.97** | 1.44 | **1.48** | **1.46** | **8.07** | **8.06** | **8.07** | 0.54 | 0.54 | 0.54 |
| ***SEm±*** | ***0.13*** | ***0.18*** | ***0.11*** | ***0.13*** | ***0.14*** | ***0.10*** | ***0.16*** | ***0.17*** | ***0.11*** | ***0.01*** | ***0.01*** | ***0.01*** |
| ***CD(P=0.05)*** | ***NS*** | ***NS*** | ***NS*** | ***0.46*** | ***0.50*** | ***0.30*** | ***0.54*** | ***0.58*** | ***0.35*** | ***0.04*** | ***0.03*** | ***0.02*** |
| **$L_0I_0$** | 5.55 | 5.55 | 5.55 | 0.98 | 0.90 | 0.94 | 2.70 | 2.69 | 2.69 | 0.45 | 0.45 | 0.45 |
| **$L_0I_1$** | 5.58 | 5.60 | 5.59 | 1.27 | 1.23 | 1.25 | 3.06 | 3.06 | 3.06 | 0.55 | 0.53 | 0.54 |
| **$L_0I_2$** | 5.64 | 5.60 | 5.62 | 0.92 | 0.95 | 0.94 | 3.27 | 3.27 | 3.27 | 0.58 | 0.57 | 0.57 |
| **$L_0I_3$** | 5.68 | 5.69 | 5.68 | 1.09 | 1.07 | 1.08 | 3.38 | 3.38 | 3.38 | **0.63** | **0.62** | **0.62** |
| **$L_1I_0$** | 5.71 | 5.74 | 5.72 | 1.27 | 1.26 | 1.27 | 3.91 | 3.93 | 3.92 | 0.44 | 0.45 | 0.44 |
| **$L_1I_1$** | 5.75 | 5.80 | 5.78 | 1.18 | 1.14 | 1.16 | 4.81 | 4.78 | 4.79 | 0.54 | 0.53 | 0.54 |
| **$L_1I_2$** | 5.80 | 5.81 | 5.80 | 1.27 | 1.27 | 1.27 | 5.33 | 5.32 | 5.33 | 0.52 | 0.52 | 0.52 |
| **$L_1I_3$** | 5.81 | 5.85 | 5.83 | 1.19 | 1.28 | 1.24 | 6.23 | 6.23 | 6.23 | 0.56 | 0.56 | 0.56 |
| **$L_2I_0$** | 5.87 | 5.85 | 5.86 | 1.47 | 1.45 | 1.46 | 6.17 | 6.19 | 6.18 | 0.44 | 0.45 | 0.44 |
| **$L_2I_1$** | 5.89 | 5.89 | 5.89 | 1.33 | 1.25 | 1.29 | 7.43 | 7.40 | 7.42 | 0.54 | 0.54 | 0.54 |
| **$L_2I_2$** | 5.94 | 5.97 | 5.95 | 1.43 | 1.43 | 1.43 | 7.60 | 7.59 | 7.59 | 0.55 | 0.54 | 0.54 |
| **$L_2I_3$** | **5.96** | **6.15** | **6.05** | **1.60** | **1.61** | **1.61** | **7.69** | **7.67** | **7.68** | 0.59 | 0.58 | 0.59 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***SEm±*** | ***0.45*** | ***0.43*** | ***0.31*** | ***0.15*** | ***0.17*** | ***0.11*** | ***0.22*** | ***0.14*** | ***0.13*** | ***0.01*** | ***0.01*** | ***0.01*** |
| ***CD(P=0.05)*** | ***NS*** | ***NS*** | ***NS*** | ***0.44*** | ***0.48*** | ***0.32*** | ***0.64*** | ***0.40*** | ***0.37*** | ***0.03*** | ***0.03*** | ***0.02*** |
| **$O_0I_0$** | 5.69 | 5.68 | 5.68 | 1.28 | 1.20 | 1.24 | 3.72 | 3.74 | 3.73 | 0.43 | 0.44 | 0.44 |
| **$O_0I_1$** | 5.71 | 5.75 | 5.73 | 1.12 | 1.08 | 1.10 | 4.31 | 4.28 | 4.30 | 0.52 | 0.51 | 0.51 |
| **$O_0I_2$** | 5.77 | 5.75 | 5.76 | 1.29 | 1.26 | 1.27 | 4.64 | 4.65 | 4.64 | 0.53 | 0.53 | 0.53 |
| **$O_0I_3$** | 5.79 | 5.79 | 5.79 | 1.12 | 1.14 | 1.13 | 5.27 | 5.25 | 5.26 | 0.59 | 0.58 | 0.58 |
| **$O_1I_0$** | 5.73 | 5.75 | 5.74 | 1.20 | 1.20 | 1.20 | 4.79 | 4.80 | 4.80 | 0.45 | 0.46 | 0.46 |
| **$O_1I_1$** | 5.76 | 5.77 | 5.77 | 1.40 | 1.33 | 1.36 | 5.89 | 5.87 | 5.88 | 0.57 | 0.56 | 0.56 |
| **$O_1I_2$** | 5.82 | 5.83 | 5.82 | 1.12 | 1.18 | 1.15 | 6.16 | 6.13 | 6.15 | 0.56 | 0.56 | 0.56 |
| **$O_1I_3$** | **5.84** | **6.00** | **5.92** | **1.47** | **1.51** | **1.49** | **6.25** | **6.27** | **6.26** | **0.60** | **0.59** | **0.59** |
| ***SEm±*** | ***0.36*** | ***0.35*** | ***0.25*** | ***0.12*** | ***0.14*** | ***0.09*** | ***0.18*** | ***0.11*** | ***0.11*** | ***0.01*** | ***0.01*** | ***0.01*** |
| ***CD(P=0.05)*** | ***NS*** | ***NS*** | ***NS*** | ***0.36*** | ***0.39*** | ***0.26*** | ***0.52*** | ***0.33*** | ***0.30*** | ***0.02*** | ***0.02*** | ***0.02*** |

Table 39: Effect of lime, farmyard manure and fertilizers on pH, organic carbon, Ca and Mg content in soil at harvest

| Treatments | pH | | | Organic carbon (%) | | | Exchangeable Ca {cmol ($p^+$)$kg^{-1}$} | | | Exchangeable Mg {cmol ($p^+$)$kg^{-1}$} | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| $L_0O_0I_0$ | **5.51** | **5.47** | **5.49** | 0.90 | 0.87 | 0.88 | **2.50** | **2.52** | **2.51** | 0.44 | 0.45 | 0.45 |
| $L_0O_0I_1$ | 5.53 | 5.56 | 5.55 | 0.88 | 0.87 | 0.87 | 2.57 | 2.55 | 2.56 | 0.52 | 0.50 | 0.51 |
| $L_0O_0I_2$ | 5.61 | 5.55 | 5.58 | 0.88 | 0.91 | 0.90 | 2.67 | 2.69 | 2.68 | 0.54 | 0.55 | 0.54 |
| $L_0O_0I_3$ | 5.63 | 5.60 | 5.61 | 0.88 | 0.84 | 0.86 | 3.07 | 3.05 | 3.06 | 0.61 | 0.60 | 0.61 |
| $L_0O_1I_0$ | 5.59 | 5.62 | 5.61 | 1.06 | 0.92 | 0.99 | 2.89 | 2.87 | 2.88 | 0.45 | 0.46 | 0.45 |
| $L_0O_1I_1$ | 5.62 | 5.64 | 5.63 | 1.66 | 1.59 | 1.62 | 3.54 | 3.57 | 3.56 | 0.58 | 0.56 | 0.57 |
| $L_0O_1I_2$ | 5.67 | 5.64 | 5.66 | 0.96 | 0.99 | 0.98 | 3.87 | 3.85 | 3.86 | 0.61 | 0.60 | 0.61 |
| $L_0O_1I_3$ | 5.72 | 5.79 | 5.75 | 1.30 | 1.31 | 1.30 | 3.68 | 3.70 | 3.69 | **0.65** | **0.63** | **0.64** |
| $L_1O_0I_0$ | 5.68 | 5.71 | 5.70 | 1.26 | 1.24 | 1.25 | 3.11 | 3.14 | 3.12 | 0.42 | 0.44 | 0.43 |
| $L_1O_0I_1$ | 5.72 | 5.79 | 5.75 | 1.16 | 1.17 | 1.16 | 3.98 | 3.95 | 3.97 | 0.52 | 0.51 | 0.52 |
| $L_1O_0I_2$ | 5.77 | 5.75 | 5.76 | 1.54 | 1.49 | 1.52 | 4.58 | 4.60 | 4.59 | 0.53 | 0.52 | 0.53 |
| $L_1O_0I_3$ | 5.81 | 5.83 | 5.82 | 1.04 | 1.11 | 1.08 | 5.87 | 5.85 | 5.86 | 0.57 | 0.55 | 0.56 |
| $L_1O_1I_0$ | 5.73 | 5.77 | 5.75 | 1.29 | 1.29 | 1.29 | 4.71 | 4.72 | 4.71 | 0.45 | 0.47 | 0.46 |
| $L_1O_1I_1$ | 5.78 | 5.81 | 5.80 | 1.20 | 1.10 | 1.15 | 5.63 | 5.60 | 5.62 | 0.55 | 0.55 | 0.55 |
| $L_1O_1I_2$ | 5.82 | 5.86 | 5.84 | 0.99 | 1.06 | 1.03 | 6.08 | 6.04 | 6.06 | 0.51 | 0.52 | 0.51 |
| $L_1O_1I_3$ | 5.81 | 5.86 | 5.83 | 1.34 | 1.45 | 1.40 | 6.58 | 6.61 | 6.60 | 0.55 | 0.56 | 0.55 |
| $L_2O_0I_0$ | 5.88 | 5.85 | 5.86 | 1.69 | 1.50 | 1.60 | 5.55 | 5.57 | 5.56 | 0.43 | 0.44 | 0.43 |
| $L_2O_0I_1$ | 5.89 | 5.90 | 5.90 | 1.33 | 1.21 | 1.27 | 6.38 | 6.35 | 6.37 | 0.51 | 0.52 | 0.51 |
| $L_2O_0I_2$ | 5.92 | 5.94 | 5.93 | 1.44 | 1.37 | 1.41 | 6.66 | 6.67 | 6.66 | 0.52 | 0.52 | 0.52 |
| $L_2O_0I_3$ | 5.93 | 5.95 | 5.94 | 1.44 | 1.46 | 1.45 | 6.89 | 6.86 | 6.87 | 0.59 | 0.58 | 0.58 |
| $L_2O_1I_0$ | 5.86 | 5.85 | 5.86 | 1.25 | 1.40 | 1.32 | 6.79 | 6.81 | 6.80 | 0.45 | 0.46 | 0.46 |
| $L_2O_1I_1$ | 5.89 | 5.87 | 5.88 | 1.34 | 1.29 | 1.31 | 8.48 | 8.45 | 8.46 | 0.56 | 0.56 | 0.56 |
| $L_2O_1I_2$ | 5.96 | 5.99 | 5.98 | 1.42 | 1.49 | 1.45 | **8.53** | **8.51** | **8.52** | 0.57 | 0.56 | 0.57 |
| $L_2O_1I_3$ | **5.98** | **6.35** | **6.17** | **1.76** | **1.76** | **1.76** | 8.50 | 8.49 | 8.49 | 0.59 | 0.59 | 0.59 |
| ***SEm±*** | ***0.63*** | ***0.60*** | ***0.44*** | ***0.22*** | ***0.24*** | ***0.16*** | ***0.32*** | ***0.20*** | ***0.19*** | ***0.01*** | ***0.01*** | ***0.01*** |
| ***CD(P=0.05)*** | ***NS*** | ***NS*** | ***NS*** | ***0.62*** | ***0.68*** | ***0.45*** | ***0.91*** | ***0.57*** | ***0.53*** | ***0.04*** | ***0.04*** | ***0.03*** |

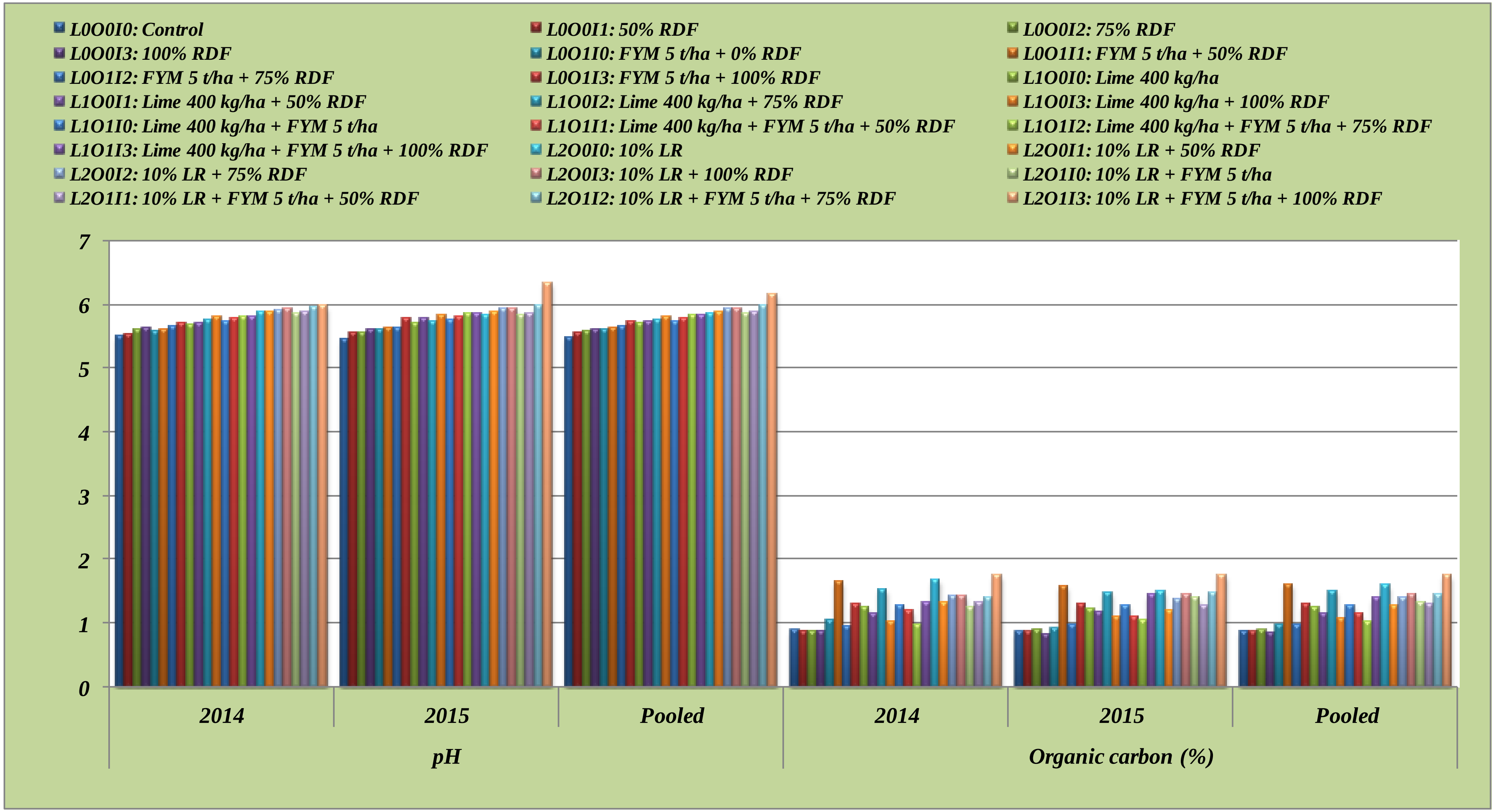



**Fig 17: Effect of lime, farmyard manure and fertilizers on pH and organic carbon content in soil at harvest during 2014 and 2015**

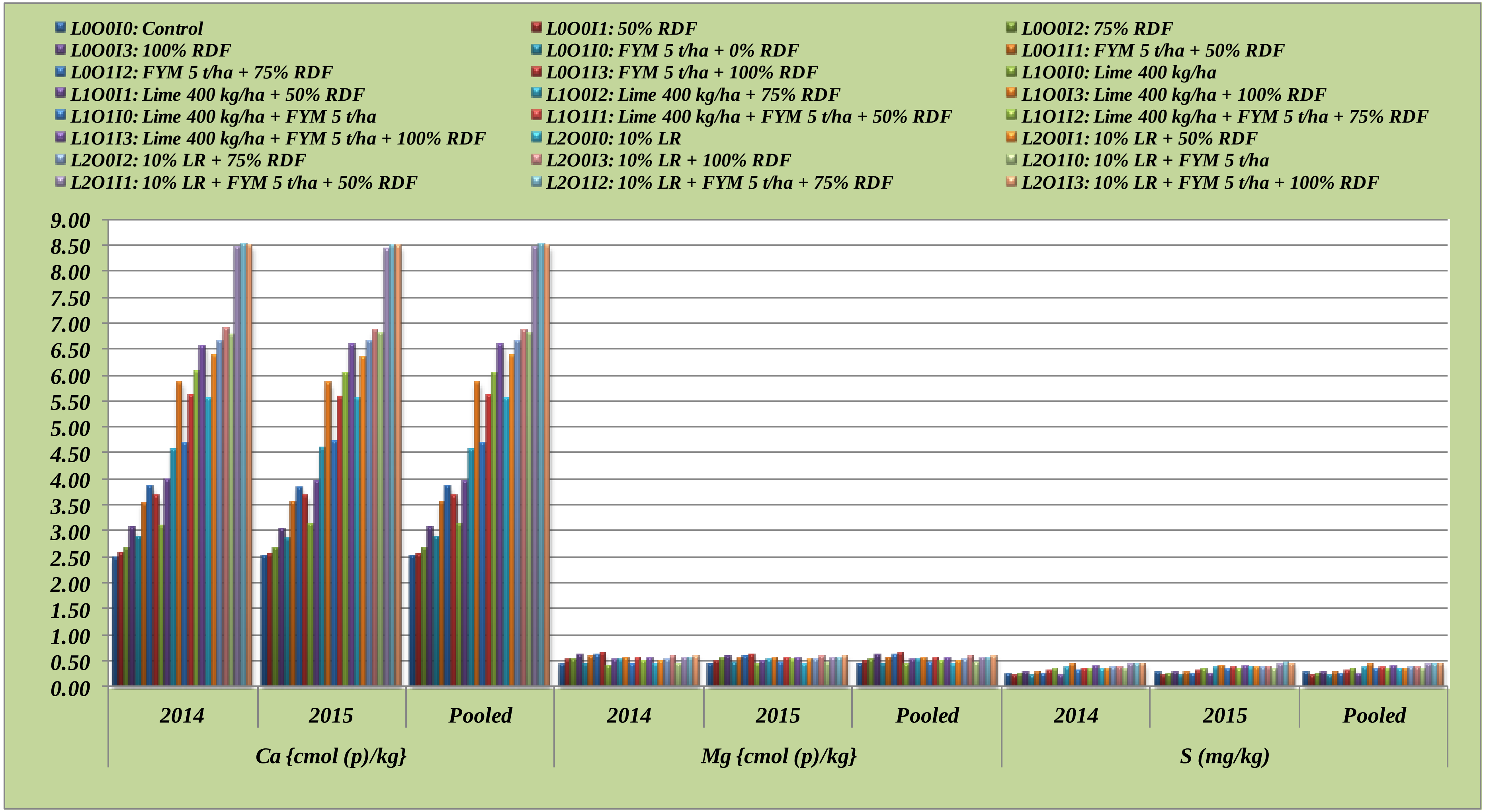



**Fig 18: Effect of lime, farmyard manure and fertilizers on calcium, magnesium and sulphur in soil at harvest during 2014 and 2015**

Incorporation of increasing doses of lime increased pH across the treatments. The highest pH was observed in treatment receiving lime @ 10% LR along with FYM @ 5 $tha^{-1}$ and 100% RDF but it was not significantly higher than the other treatments. Chatterjee *et al.* (2005) also reported that addition of lime shows significant decrease in exchangeable and total acidity and increase in soil reaction. The increase in pH with increasing doses of lime signified the effect of lime in the amelioration of soil acidity as reported by Singh *et al.* (2009).

Organic carbon was observed to be maximum in treatment by lime @ 10% LR along with FYM @ 5 $tha^{-1}$ and 100% RDF at 1.76 % which was at par with treatment of lime @ 10% LR and of lime @ 10% LR along with 100% RDF. Singh and Rai (2004) reported increase in organic carbon in the soil with application of FYM and fertilizers. Application of lime results in improving the soil conditions and incorporation of FYM with fertilizers also improves the soil aggregation which results in favouring root biomass growth and ultimately leads to higher organic carbon status in the soil. Similar findings have been reported by Singh *et al.* (2009).

The exchangeable calcium in the soil was highest with the application of lime @ 10% LR along with FYM @ 5 $tha^{-1}$ and 100% RDF. Increasing trend in exchangeable Ca was observed with increasing doses of lime. Sarkar (2012) also reported that liming along with balanced fertilization increases exchangeable calcium in soil.

The exchangeable Mg was observed to decrease across the treatments. In treatments where lime was incorporated, exchangeable Mg showed a steady decline compared to the unlimed treatments. The reaction between exchangeable Ca and Mg leads to the leaching of Mg due to the exchange reaction between the two and this could be the probable reason for the slight decrease in exchangeable Mg coupled with the addition of lime. Balanced fertilization with liming decreases exchangeable Mg in soil (Sarkar, 2012). Increase in pH has been reported to decrease the exchangeable Mg and also the exchange reaction between exchangeable Ca and Mg leads to Mg leaching in soil as reported by Miyazawa *et al.* (2001).

### 4.5.2. Effect on N, P, K and S content in soil at harvest

**Effect of lime on available N, P, K and S content in soil at harvest**

The results obtained on the available N, P, K and S content in soil at harvest in different treatments have been presented in table 40 and had resulted in significant difference among various treatments. It was apparent from the data, the maximum available N, P, K and

S content in soil was recorded in $L_2$ with 374.37 and 363.66 kg ha$^{-1}$, 23.07 and 23.44 kg ha$^{-1}$, 97.54 and 98.07 kg ha$^{-1}$, 0.391 and 0.401 mg kg$^{-1}$ during 2014 and 2015, respectively while pooled data had 369.02, 23.26, 97.81 kg ha$^{-1}$ and 0.396 mg kg$^{-1}$. The minimum available N, P, K and S content in soil was recorded in $L_0$ as 341.30 and 339.21 kg ha$^{-1}$, 16.18 and 16.15 kg ha$^{-1}$, 83.43 and 83.94 kg ha$^{-1}$, 0.262 and 0.262 mg kg$^{-1}$ while pooled data had 340.26, 16.17, 83.69 kg ha$^{-1}$ and 0.262 mg kg$^{-1}$ during 2014 and 2015, respectively. The available N, P, K and S content in soil at harvest was observed to follow an increasing trend with the increase in application of lime.

**Effect of farmyard manure on available N, P, K and S content in soil at harvest**

The available N, P, K and S content in soil at harvest was found to be higher in plots receiving higher amounts of organic matter. It was apparent from the table 40, the maximum N, P, K and S content in soil at harvest was recorded in $O_1$ as 371.61 and 357.75 kg ha$^{-1}$, 20.51 and 20.73 kg ha$^{-1}$, 92.56 and 92.95 kg ha$^{-1}$, 0.348 and 0.354 mg kg$^{-1}$ while pooled data had 364.68, 20.62, 92.76 kg ha$^{-1}$ and 0.351 mg kg$^{-1}$ during 2014 and 2015, respectively. The minimum available N, P, K and S content in soil at harvest were recorded in $O_0$ as 337.29 and 346.35 kg ha$^{-1}$, 18.81 and 19.03 kg ha$^{-1}$, 89.05 and 89.63 kg ha$^{-1}$, 0.323 and 0.329 mg kg$^{-1}$ while pooled data had 341.82 , 18.92, 89.34 kg ha$^{-1}$ and 0.326 mg kg$^{-1}$ during 2014 and 2015, respectively.

**Effect of fertilizers on available N, P, K and S content in soil at harvest**

The data presented in table 40 revealed that there was a significant difference among the treatments. The maximum available N, P, K and S content in soil at harvest was recorded in $I_3$ as 374.12 and 369.90 kg ha$^{-1}$, 20.52 and 20.68 kg ha$^{-1}$, 98.72 and 98.64 kg ha$^{-1}$, 0.379 and 0.374 mg kg$^{-1}$ while pooled data had 372.01, 20.60, 98.68 kg ha$^{-1}$ and 0.376 mg kg$^{-1}$ during 2014 and 2015, respectively. The minimum available N in soil at harvest was observed in $I_1$ as 343.03 kg ha$^{-1}$ during 2014 and in $I_0$ as 342.12 kg ha$^{-1}$ in 2015. The minimum available P and K content in soil after harvest was recorded in $O_0$ as 18.52 and 18.75 kg ha$^{-1}$, 81.01 and 81.68 kg ha$^{-1}$ while pooled data had 18.63 and 81.35 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum available S content in soil at harvest was recorded in $I_0$ as 0.311 mg kg$^{-1}$ in 2014 and in $I_1$ as 0.319 mg kg$^{-1}$ during 2015.

**Effect of lime and farmyard manure on available N, P, K and S content in soil at harvest**

From the data (Table 41), the maximum available N, P, K and S content in soil at harvest was recorded in $L_2O_1$ (384.97 and 367.73 kg ha$^{-1}$, 23.72 and 23.97 kg ha$^{-1}$, 98.76 and

98.78 kg $ha^{-1}$, 0.42 and 0.43 mg $kg^{-1}$) while pooled data had376.35, 23.84, 98.77 kg $ha^{-1}$ and 0.42 mg $kg^{-1}$ during 2014 and 2015, respectively. The minimum available N, P, K and S in soil at harvest was recorded in $L_0O_0$ (332.42 and 327.19 kg $ha^{-1}$, 15.46 and 15.18 kg $ha^{-1}$, 80.91 and 81.19 kg $ha^{-1}$, 0.25 and 0.26 mg $kg^{-1}$) while pooled data had 329.80, 15.32, 81.05 kg $ha^{-1}$ and 0.26 mg $kg^{-1}$ during 2014 and 2015, respectively.

**Effect of lime and fertilizers on available N, P, K and S content in soil at harvest**

The results (Table 41) revealed that there was a significant difference among the treatments. During 2014 and 2015, the maximum available N, P and K in soil at harvest was recorded at 384.36 and 390.50 kg $ha^{-1}$, 23.83 and 24.33 kg $ha^{-1}$, 106.40 and 106.43 kg $ha^{-1}$ in treatment $L_2I_3$ with pooled data as 387.43, 24.08 and 106.42 kg $ha^{-1}$, respectively. The maximum available S in soil at harvest was recorded at 0.42 mg $kg^{-1}$ in treatment $L_1I_3$ and $L_2I_3$ during 2014 and treatment $L_2I_2$ and $L_2I_3$ during 2015. The minimum available N content in soil at harvest was recorded in $L_0I_1$ as 313.60 kg $ha^{-1}$ in 2014 and in $L_0I_0$ as 328.23 kg $ha^{-1}$ in 2015. The minimum available P and K in soil at harvest were recorded in $L_0O_0$ as 15.24 and 15.24 kg $ha^{-1}$, 72.80 and 74.05 kg $ha^{-1}$ while pooled data had 15.24 and 73.43 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum available S in soil at harvest was recorded in $L_0I_0$ as 0.24 mg $kg^{-1}$ during 2014 and in $L_0I_1$ as 0.24 mg $kg^{-1}$ during 2015.

**Effect of farmyard manure and fertilizers on available N, P, K and S content in soil at harvest**

It was apparent from table 41 that the maximum available N, P, K and S content in soil at harvest was recorded in $O_1I_3$ (383.08 and 370.44 kg $ha^{-1}$, 21.59 and 21.81 kg $ha^{-1}$, 102.66 and 101.72 kg $ha^{-1}$, 0.39 and 0.39 mg $kg^{-1}$) with pooled data as 376.76, 21.70, 102.19 kg $ha^{-1}$ and 0.39 mg $kg^{-1}$ during 2014 and 2015, respectively. The minimum available N and S content in soil at harvest was recorded in $O_0I_1$ (314.99 and 331.72 kg $ha^{-1}$, 0.27 and 0.28 mg $kg^{-1}$) while pooled data had 323.36 kg $ha^{-1}$ and 0.27 mg $kg^{-1}$ during 2014 and 2015, respectively. The minimum available P and K content in soil at harvest was recorded in $O_0I_0$ (17.55 and 17.66 kg $ha^{-1}$, 81.39 and 82.24 kg $ha^{-1}$) with pooled data as 17.61 and 81.81 kg $ha^{-1}$ during 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on available N, P, K and S content in soil at harvest**

The data indicated that available N, P and K in soil at harvest was found to be significantly affected by the application of fertilisers, FYM, lime and organic matter (Table

Table 40: Effect of lime, farmyard manure and fertilizers on available N, P, K and S content in soil at harvest

| Treatments | Available N (kg ha$^{-1}$) | | | Available P (kg ha$^{-1}$) | | | Available K (kg ha$^{-1}$) | | | Available S ( mg kg$^{-1}$ ) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0$** | 341.30 | 339.21 | 340.26 | 16.18 | 16.15 | 16.17 | 83.43 | 83.94 | 83.69 | 0.262 | 0.262 | 0.262 |
| **$L_1$** | 347.68 | 353.28 | 350.48 | 19.73 | 20.05 | 19.89 | 91.44 | 91.87 | 91.65 | 0.355 | 0.361 | 0.358 |
| **$L_2$** | **374.37** | **363.66** | **369.02** | **23.07** | **23.44** | **23.26** | **97.54** | **98.07** | **97.81** | **0.391** | **0.401** | **0.396** |
| ***SEm±*** | ***4.47*** | ***4.36*** | ***3.12*** | ***0.35*** | ***0.40*** | ***0.27*** | ***1.42*** | ***1.75*** | ***1.13*** | ***0.012*** | ***0.009*** | ***0.008*** |
| ***CD(P=0.05)*** | ***17.55*** | ***17.13*** | ***10.18*** | ***1.39*** | ***1.58*** | ***0.88*** | ***5.58*** | ***6.88*** | ***3.68*** | ***0.048*** | ***0.035*** | ***0.025*** |
| **$O_0$** | 337.29 | 346.35 | 341.82 | 18.81 | 19.03 | 18.92 | 89.05 | 89.63 | 89.34 | 0.323 | 0.329 | 0.326 |
| **$O_1$** | **371.61** | **357.75** | **364.68** | **20.51** | **20.73** | **20.62** | **92.56** | **92.95** | **92.76** | **0.348** | **0.354** | **0.351** |
| ***SEm±*** | ***6.23*** | ***4.82*** | ***3.94*** | ***0.36*** | ***0.35*** | ***0.25*** | ***1.02*** | ***0.93*** | ***0.69*** | ***0.009*** | ***0.007*** | ***0.006*** |
| ***CD(P=0.05)*** | ***21.55*** | ***NS*** | ***12.13*** | ***1.24*** | ***1.22*** | ***0.77*** | ***NS*** | ***3.21*** | ***2.12*** | ***NS*** | ***NS*** | ***NS*** |
| **$I_0$** | 345.52 | 342.12 | 343.82 | 18.52 | 18.75 | 18.63 | 81.01 | 81.68 | 81.35 | 0.311 | 0.326 | 0.319 |
| **$I_1$** | 343.03 | 344.21 | 343.62 | 19.70 | 19.87 | 19.78 | 87.87 | 87.95 | 87.91 | 0.312 | 0.319 | 0.315 |
| **$I_2$** | 355.14 | 351.98 | 353.56 | 19.91 | 20.22 | 20.07 | 95.61 | 96.90 | 96.26 | 0.342 | 0.347 | 0.345 |
| **$I_3$** | **374.12** | **369.90** | **372.01** | **20.52** | **20.68** | **20.60** | **98.72** | **98.64** | **98.68** | **0.379** | **0.374** | **0.376** |
| ***SEm±*** | ***8.33*** | ***6.82*** | ***5.38*** | ***0.49*** | ***0.48*** | ***0.34*** | ***1.62*** | ***1.29*** | ***1.04*** | ***0.006*** | ***0.006*** | ***0.004*** |
| ***CD(P=0.05)*** | ***23.89*** | ***19.55*** | ***15.17*** | ***1.40*** | ***1.39*** | ***0.97*** | ***4.64*** | ***3.71*** | ***2.92*** | ***0.018*** | ***0.018*** | ***0.012*** |

Table 41: Effect of lime and farmyard manure; lime and fertilizers; farmyard manure and fertilizers on available N, P, K and S content in soil at harvest.

| Treatments | Available N (kg ha$^{-1}$) | | | Available P (kg ha$^{-1}$) | | | Available K (kg ha$^{-1}$) | | | Available S ( mg kg$^{-1}$ ) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** | **2014** | **2015** | **Pooled** |
| **$L_0O_0$** | **332.42** | **327.19** | **329.80** | **15.46** | **15.18** | **15.32** | **80.91** | **81.19** | **81.05** | **0.25** | **0.26** | **0.26** |
| **$L_0O_1$** | 350.19 | 351.23 | 350.71 | 16.91 | 17.12 | 17.01 | 85.95 | 86.69 | 86.32 | 0.27 | 0.27 | 0.27 |
| **$L_1O_0$** | 315.69 | 352.28 | 333.98 | 18.56 | 18.98 | 18.77 | 89.92 | 90.34 | 90.13 | 0.35 | 0.35 | 0.35 |
| **$L_1O_1$** | 379.67 | 354.28 | 366.98 | 20.90 | 21.12 | 21.01 | 92.96 | 93.40 | 93.18 | 0.36 | 0.37 | 0.36 |
| **$L_2O_0$** | 363.78 | 359.59 | 361.69 | 22.42 | 22.92 | 22.67 | 96.32 | 97.37 | 96.85 | 0.37 | 0.38 | 0.37 |
| **$L_2O_1$** | **384.97** | **367.73** | **376.35** | **23.72** | **23.97** | **23.84** | **98.76** | **98.78** | **98.77** | **0.42** | **0.43** | **0.42** |
| ***SEm±*** | ***10.79*** | ***8.35*** | ***6.82*** | ***0.62*** | ***0.61*** | ***0.43*** | ***1.76*** | ***1.60*** | ***1.19*** | ***0.016*** | ***0.013*** | ***0.010*** |
| ***CD(P=0.05)*** | ***37.32*** | ***28.91*** | ***21.02*** | ***2.15*** | ***2.11*** | ***1.34*** | ***6.09*** | ***5.55*** | ***3.67*** | ***0.056*** | ***0.045*** | ***0.032*** |
| **$L_0I_0$** | 332.42 | 328.23 | 330.33 | 15.24 | 15.24 | 15.24 | 72.80 | 74.05 | 73.43 | 0.24 | 0.26 | 0.25 |
| **$L_0I_1$** | 313.60 | 338.69 | 326.14 | 16.14 | 15.67 | 15.90 | 79.52 | 79.82 | 79.67 | 0.25 | 0.24 | 0.25 |
| **$L_0I_2$** | 347.05 | 336.60 | 341.82 | 16.23 | 16.56 | 16.40 | 89.60 | 90.62 | 90.11 | 0.26 | 0.26 | 0.26 |
| **$L_0I_3$** | 372.14 | 353.32 | 362.73 | 17.13 | 17.13 | 17.13 | 91.81 | 91.27 | 91.54 | 0.30 | 0.29 | 0.30 |
| **$L_1I_0$** | 334.08 | 342.70 | 338.39 | 18.26 | 18.59 | 18.43 | 82.88 | 82.88 | 82.88 | 0.34 | 0.36 | 0.35 |
| **$L_1I_1$** | 348.72 | 346.88 | 347.80 | 19.87 | 20.37 | 20.12 | 90.72 | 90.55 | 90.64 | 0.30 | 0.31 | 0.30 |
| **$L_1I_2$** | 342.05 | 357.67 | 349.86 | 20.20 | 20.64 | 20.42 | 94.20 | 95.82 | 95.01 | 0.36 | 0.37 | 0.36 |
| **$L_1I_3$** | 365.87 | 365.87 | 365.87 | 20.59 | 20.59 | 20.59 | 97.96 | 98.21 | 98.09 | **0.42** | 0.41 | 0.41 |
| **$L_2I_0$** | 370.05 | 355.41 | 362.73 | 22.07 | 22.40 | 22.24 | 87.36 | 88.11 | 87.74 | 0.35 | 0.36 | 0.36 |
| **$L_2I_1$** | 366.76 | 347.05 | 356.90 | 23.08 | 23.58 | 23.33 | 93.36 | 93.48 | 93.42 | 0.39 | 0.40 | 0.40 |
| **$L_2I_2$** | 376.32 | 361.69 | 369.00 | 23.30 | 23.46 | 23.38 | 103.04 | 104.27 | 103.66 | 0.41 | **0.42** | **0.42** |
| **$L_2I_3$** | **384.36** | **390.50** | **387.43** | **23.83** | **24.33** | **24.08** | **106.40** | **106.43** | **106.42** | **0.42** | **0.42** | **0.42** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***SEm±*** | ***14.43*** | ***11.81*** | ***9.32*** | ***0.84*** | ***0.84*** | ***0.59*** | ***2.80*** | ***2.24*** | ***1.79*** | ***0.011*** | ***0.011*** | ***0.008*** |
| ***CD(P=0.05)*** | ***41.38*** | ***33.87*** | ***26.28*** | ***2.42*** | ***2.40*** | ***1.67*** | ***8.03*** | ***6.43*** | ***5.05*** | ***0.031*** | ***0.031*** | ***0.021*** |
| **$O_0I_0$** | 321.96 | 334.40 | 328.18 | 17.55 | 17.66 | 17.61 | 81.39 | 82.24 | 81.81 | 0.32 | 0.34 | 0.33 |
| **$O_0I_1$** | 314.99 | 331.72 | 323.36 | 19.18 | 19.37 | 19.28 | 85.12 | 84.51 | 84.81 | 0.27 | 0.28 | 0.27 |
| **$O_0I_2$** | 347.05 | 349.95 | 348.50 | 19.08 | 19.52 | 19.30 | 94.91 | 96.22 | 95.56 | 0.34 | 0.34 | 0.34 |
| **$O_0I_3$** | 365.17 | 369.35 | 367.26 | 19.44 | 19.56 | 19.50 | 94.79 | 95.56 | 95.18 | 0.37 | 0.36 | 0.37 |
| **$O_1I_0$** | 369.07 | 349.84 | 359.45 | 19.50 | 19.83 | 19.66 | 80.64 | 81.12 | 80.88 | 0.30 | 0.32 | 0.31 |
| **$O_1I_1$** | 371.06 | 356.70 | 363.88 | 20.21 | 20.37 | 20.29 | 90.61 | 91.39 | 91.00 | 0.35 | 0.36 | 0.36 |
| **$O_1I_2$** | 363.23 | 354.02 | 358.62 | 20.74 | 20.92 | 20.83 | 96.32 | 97.59 | 96.95 | 0.35 | 0.36 | 0.35 |
| **$O_1I_3$** | **383.08** | **370.44** | **376.76** | **21.59** | **21.81** | **21.70** | **102.66** | **101.72** | **102.19** | **0.39** | **0.39** | **0.39** |
| ***SEm±*** | ***11.78*** | ***9.64*** | ***7.61*** | ***0.69*** | ***0.68*** | ***0.48*** | ***2.29*** | ***1.83*** | ***1.46*** | ***0.009*** | ***0.009*** | ***0.006*** |
| ***CD(P=0.05)*** | ***33.79*** | ***27.65*** | ***21.46*** | ***1.97*** | ***1.96*** | ***1.37*** | ***6.56*** | ***5.25*** | ***4.13*** | ***0.025*** | ***0.025*** | ***0.017*** |

Table 42: Effect of lime, farmyard manure and fertilizers on available N, P, K and S content in soil at harvest

| Treatments | Available N (kg $ha^{-1}$) | | | Available P (kg $ha^{-1}$) | | | Available K (kg $ha^{-1}$) | | | Available S ( mg $kg^{-1}$ ) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $L_0O_0I_0$ | **309.42** | **317.78** | **313.60** | **14.55** | **14.21** | **14.38** | **69.44** | **70.67** | **70.06** | **0.26** | **0.28** | **0.27** |
| $L_0O_0I_1$ | 301.06 | 305.24 | 303.15 | 15.75 | 14.98 | 15.36 | 80.64 | 79.57 | 80.11 | 0.22 | 0.22 | 0.22 |
| $L_0O_0I_2$ | 342.87 | 330.33 | 336.60 | 15.35 | 15.68 | 15.51 | 87.36 | 88.73 | 88.04 | 0.25 | 0.25 | 0.25 |
| $L_0O_0I_3$ | 376.32 | 355.41 | 365.87 | 16.19 | 15.85 | 16.02 | 86.21 | 85.80 | 86.01 | 0.28 | 0.28 | 0.28 |
| $L_0O_1I_0$ | 355.41 | 338.69 | 347.05 | 15.93 | 16.27 | 16.10 | 76.16 | 77.43 | 76.79 | 0.22 | 0.23 | 0.23 |
| $L_0O_1I_1$ | 326.14 | 372.14 | 349.14 | 16.52 | 16.36 | 16.44 | 78.40 | 80.07 | 79.23 | 0.28 | 0.27 | 0.27 |
| $L_0O_1I_2$ | 351.23 | 342.87 | 347.05 | 17.11 | 17.45 | 17.28 | 91.84 | 92.51 | 92.17 | 0.26 | 0.26 | 0.26 |
| $L_0O_1I_3$ | 367.96 | 351.23 | 359.59 | 18.07 | 18.40 | 18.23 | 97.41 | 96.75 | 97.08 | 0.32 | 0.31 | 0.31 |
| $L_1O_0I_0$ | 292.69 | 338.35 | 315.52 | 16.52 | 16.85 | 16.69 | 82.88 | 83.54 | 83.21 | 0.35 | 0.36 | 0.36 |
| $L_1O_0I_1$ | 301.06 | 338.69 | 319.87 | 19.40 | 20.07 | 19.73 | 87.36 | 85.69 | 86.53 | 0.23 | 0.25 | 0.24 |
| $L_1O_0I_2$ | 317.78 | 359.93 | 338.85 | 19.40 | 19.73 | 19.57 | 94.32 | 95.65 | 94.99 | 0.38 | 0.38 | 0.38 |
| $L_1O_0I_3$ | 351.23 | 372.14 | 361.69 | 18.93 | 19.27 | 19.10 | 95.12 | 96.45 | 95.79 | 0.43 | 0.42 | 0.43 |
| $L_1O_1I_0$ | 375.47 | 347.05 | 361.26 | 20.00 | 20.33 | 20.17 | 82.88 | 82.21 | 82.55 | 0.33 | 0.35 | 0.34 |
| $L_1O_1I_1$ | 396.38 | 355.08 | 375.73 | 20.34 | 20.67 | 20.51 | 94.08 | 95.41 | 94.75 | 0.36 | 0.38 | 0.37 |
| $L_1O_1I_2$ | 366.32 | 355.41 | 360.87 | 21.00 | 21.55 | 21.27 | 94.08 | 95.98 | 95.03 | 0.34 | 0.36 | 0.35 |
| $L_1O_1I_3$ | 380.50 | 359.59 | 370.05 | 22.25 | 21.92 | 22.09 | 100.80 | 99.97 | 100.39 | 0.41 | 0.40 | 0.40 |
| $L_2O_0I_0$ | 363.78 | 347.05 | 355.41 | 21.59 | 21.92 | 21.75 | 91.84 | 92.51 | 92.17 | 0.34 | 0.37 | 0.36 |
| $L_2O_0I_1$ | 342.87 | 351.23 | 347.05 | 22.40 | 23.07 | 22.73 | 87.36 | 88.26 | 87.81 | 0.35 | 0.37 | 0.36 |
| $L_2O_0I_2$ | 380.50 | 359.59 | 370.05 | 22.48 | 23.15 | 22.81 | 103.04 | 104.27 | 103.66 | 0.38 | 0.38 | 0.38 |
| $L_2O_0I_3$ | 367.96 | 380.50 | 374.23 | 23.21 | 23.55 | 23.38 | 103.04 | 104.44 | 103.74 | 0.39 | 0.39 | 0.39 |
| $L_2O_1I_0$ | 376.32 | 363.78 | 370.05 | 22.55 | 22.89 | 22.72 | 82.88 | 83.71 | 83.30 | 0.36 | 0.36 | 0.36 |
| $L_2O_1I_1$ | 390.65 | 342.87 | 366.76 | 23.76 | 24.09 | 23.93 | 99.36 | 98.69 | 99.03 | 0.43 | 0.43 | 0.43 |
| $L_2O_1I_2$ | 372.14 | 363.78 | 367.96 | 24.11 | 23.78 | 23.95 | 103.04 | 104.27 | 103.66 | **0.44** | **0.46** | **0.45** |
| $L_2O_1I_3$ | **400.77** | **400.50** | **400.63** | **24.45** | **25.11** | **24.78** | **109.76** | **108.43** | **109.09** | **0.44** | 0.45 | **0.45** |
| ***SEm±*** | ***20.40*** | ***16.70*** | ***13.18*** | ***1.19*** | ***1.18*** | ***0.84*** | ***3.96*** | ***3.17*** | ***2.54*** | ***0.015*** | ***0.015*** | ***0.011*** |
| ***CD(P=0.05)*** | ***58.52*** | ***47.89*** | ***37.16*** | ***3.42*** | ***3.39*** | ***2.37*** | ***11.36*** | ***9.09*** | ***7.15*** | ***0.043*** | ***0.043*** | ***0.030*** |

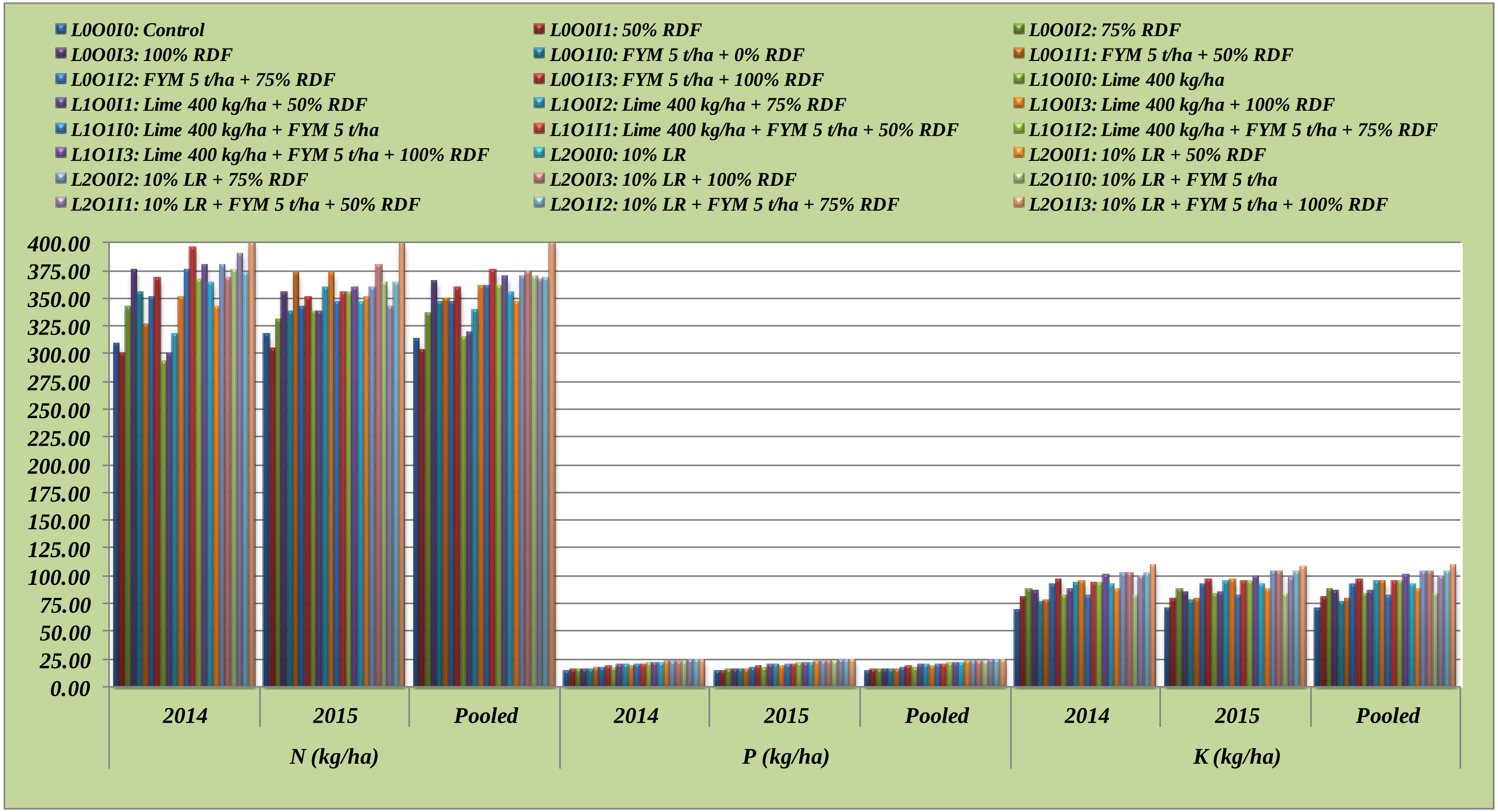



**Fig 19: Effect of lime, farmyard manure and fertilizers on available nitrogen, phosphorus and potassium in soil after harvest during 2014 and 2015**

42). Among the treatments, the maximum available N, P and K content in soil at harvest was recorded in $L_2O_1I_3$ (400.77 and 400.50 kg ha$^{-1}$, 24.45 and 25.11 kg ha$^{-1}$, 109.76 and 108.43 kg ha$^{-1}$) with pooled data as 400.63, 24.78 and 109.09 kg ha$^{-1}$ during 2014 and 2015, respectively. The maximum available S in soil at harvest was recorded at 0.44 mg kg$^{-1}$ in $L_2O_1I_2$ and $L_2O_1I_3$ in 2014 and at 0.46 mg kg$^{-1}$ during 2015. The minimum available N content in soil at harvest was recorded in $L_0O_0I_1$ with 301.06 and 305.24 kg ha$^{-1}$ during 2014 and 2015 respectively. The minimum available P and K content in soil at harvest was recorded in $L_0O_0I_0$ as 14.55 and 14.21 kg ha$^{-1}$, 69.44 and 70.67 kg ha$^{-1}$ with pooled data as 14.38 and 70.06 kg ha$^{-1}$ during 2014 and 2015, respectively. The minimum available S in soil at harvest was recorded at 0.22 mg kg$^{-1}$ in $L_0O_0I_1$ and $L_0O_1I_0$ during 2014 and in $L_0O_0I_1$ during 2015.

Maximum available N in soil at harvest was observed by application of lime @ 10% LR along with FYM @ 5 tha$^{-1}$ and 100% RDF. The increase in available N is attributed to the higher supply of nutrients through fertilizers and FYM. The organic matter acts as a source of nitrogen in the soil through the process of decomposition and mineralization of organic matter. The nitrogen could have been aided by the increased nodulation. Chatterjee *et al.* (2005) reported that available N in soil is more when the treatments of NPK are incorporated with various doses of lime.

Available P in soil was maximum with treatment of lime @ 10% LR along with FYM @ 5 tha$^{-1}$ and 100% RDF which was at par with all treatments receiving lime @ 10% LR in combination with FYM and fertilizers except with lime @ 10% LR alone. The increase in available P content in soil is due to the increase in pH due to application of lime. Chatterjee *et al.* (2005) reported increase in available P of soil with the application of lime over unlimed treatments. Increase in available P in soil with the combined application of FYM and NPK was also reported by Singh and Rai (2004).

Treatments receiving highest amount of lime, FYM and fertilizers have higher availability of K in the soil. Treatment with lime @ 10% LR along with FYM @ 5 tha$^{-1}$ and 100% RDF registered highest amount of available K in the soil (109.09 kg ha$^{-1}$) which was at par with all the treatments of lime @ 10% LR along 100% RDF and 75 % RDF. The higher availability of K in soil can be attributed to the conversion of non-exchangeable K fractions to available form. Similar increase of available K in soil through application of lime and fertilizers has been reported by Chatterjee *et al.* (2005).

Available S content in soil was maximum at 0.45 mg $kg^{-1}$ with treatment of lime @ 10% LR along with FYM @ 5 $tha^{-1}$ and 100% RDF which was at par with all treatments receiving lime @ 10% LR in combination with FYM and fertilizers except treatment with lime @ 10% LR alone. With decrease in soil pH, the S availability in soil has the tendency to get adsorbed, decreasing its availability and vice-versa. With the addition of lime, coupled with more addition of nutrients from fertilizers and FYM, the pH of the soil is raised, resulting in increased S availability. Higher amount of available S in soil has been reported by Arbad and Syed (2011) by applying NPK along with FYM.

### 4.5.3. Effect on nutrient use efficiency

**Effect of lime, farmyard manure and fertilizers on nitrogen use efficiency**

As shown in table 43, the highest nitrogen use efficiency by soybean was observed by the application of lime @ 10% LR along with 50 % RDF followed by lime @ 10% LR along with 75 % RDF and the lowest value was found in treatment comprising of 50 % RDF followed by 75 % RDF. The NUE varied from 0.24 to 7.38 kg $kg^{-1}$. This result indicates that application lime, farmyard manure and fertilizers decrease the losses of N, leading to efficient uptake and utilization of applied N.

**Effect of lime, farmyard manure and fertilizers on phosphorus use efficiency**

The highest phosphorus use efficiency by soybean was obtained by the application of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ followed by treatment having lime @ 400 kg $ha^{-1}$ along with FYM @ 5 t $ha^{-1}$. The lowest value was found in treatment with 50 % RDF followed by treatment of 75 % RDF. The NUE varied from 0.01 to 1.42 kg $kg^{-1}$.

**Effect of lime, farmyard manure and fertilizers on potassium use efficiency**

From the data pertained on table 43, the highest value potassium use efficiency by soybean was obtained by the application of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ followed by treatment of lime @ 10% LR along with 50 % RDF. The lowest value was found in treatment with 50 % RDF followed by treatment of 100 % RDF. The NUE varied from 0.28 to 3.82 kg $kg^{-1}$.

Among the treatments, $L_2O_0I_1$ reported highest nitrogen use efficiency while the highest P and K use efficiency was reported with treatment $L_2O_1I_1$ compared to the other treatments. The lowest N, P and K use efficiency was reported with $L_0O_0I_1$. Laharia *et al.* (2015) also reported increased use efficiency in soybean by increased NPK application.

Table 43: Effect of lime, farmyard manure and fertilizers on nutrient use efficiency

| Treatments | Nutrient use efficiency (kg $kg^{-1}$) | | |
|---|---|---|---|
| | **N** | **P** | **K** |
| **$L_0O_0I_0$** | 0.00 | 0.00 | 0.00 |
| **$L_0O_0I_1$** | 0.24 | 0.01 | 0.28 |
| **$L_0O_0I_2$** | 0.69 | 0.02 | 0.37 |
| **$L_0O_0I_3$** | 1.03 | 0.04 | 0.34 |
| **$L_0O_1I_0$** | 0.79 | 0.34 | 0.51 |
| **$L_0O_1I_1$** | 0.98 | 0.08 | 0.52 |
| **$L_0O_1I_2$** | 0.78 | 0.04 | 0.45 |
| **$L_0O_1I_3$** | 1.18 | 0.07 | 0.87 |
| **$L_1O_0I_0$** | 0.00 | 0.00 | 0.00 |
| **$L_1O_0I_1$** | 4.85 | 0.13 | 2.51 |
| **$L_1O_0I_2$** | 4.04 | 0.10 | 1.83 |
| **$L_1O_0I_3$** | 3.73 | 0.10 | 1.62 |
| **$L_1O_1I_0$** | 2.29 | 0.59 | 2.00 |
| **$L_1O_1I_1$** | 2.22 | 0.13 | 1.26 |
| **$L_1O_1I_2$** | 2.13 | 0.15 | 1.36 |
| **$L_1O_1I_3$** | 1.85 | 0.11 | 1.24 |
| **$L_2O_0I_0$** | 0.00 | 0.00 | 0.00 |
| **$L_2O_0I_1$** | 7.38 | 0.22 | 3.46 |
| **$L_2O_0I_2$** | 5.57 | 0.16 | 2.73 |
| **$L_2O_0I_3$** | 5.37 | 0.16 | 2.63 |
| **$L_2O_1I_0$** | 3.90 | 1.42 | 3.82 |
| **$L_2O_1I_1$** | 3.70 | 0.27 | 2.45 |
| **$L_2O_1I_2$** | 2.95 | 0.21 | 2.18 |
| **$L_2O_1I_3$** | 2.92 | 0.19 | 2.11 |

### 4.5.4. Effect of lime, farmyard manure and fertilizers on nutrient balance

**Effect of lime, farmyard manure and fertilizers on nitrogen balance in soil**

Lime, farmyard manure and fertilizers had positive effect on the nitrogen balance in the soil as showed in table 44. The maximum apparent gain of N was recorded with treatment combination of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100% RDF followed by treatment combination of lime @ 10% LR along with 100% RDF. The minimum N balance in soil was recorded with treatment of 50 % RDF only. All the treatment combinations showed positive nutrient balance when the difference between the initial and final nutrient status is taken into account. The actual difference between the initial and final nutrient status was found maximum with treatment of @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100 % RDF. This may be due to the supplement of nitrogen in the soil by the root nodules.

**Effect of lime, farmyard manure and fertilizers on phosphorus balance in soil**

Lime, farmyard manure and fertilizers had varied effect on the phosphorus balance in the soil as shown in table 45. The P balance in soil showed maximum apparent gain of P with treatment of lime @ 10% LR followed by treatment combination of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$. The actual difference between the initial and final nutrient status was found maximum in treatment with lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100 % RDF.

**Effect of lime, farmyard manure and fertilizers on potassium balance in soil**

The treatment combinations comprising of lime, farmyard manure and fertilizers had differential response on the potassium balance in the soil as showed in table 46. The maximum apparent gain of K was recorded in the treatment of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100 % RDF followed by treatment of lime @ 10% LR along with 75 % RDF. The maximum apparent K loss was recorded with treatment of FYM @ 5 t $ha^{-1}$ along with 50 % RDF followed by treatment of 100 % RDF only.

The nutrient balance in the soil for N showed significant gains in treatments where nutrients were supplied. The symbiotic nitrogen fixation by the crop could also be a factor for the apparent nutrient gain in the soil. The P balance in soil did not improve. Some treatments wherein low P was applied nutrient mining. K balance in soil was found to be positive in most of the treatments but low quantity of supplied nutrients resulted in apparent loss in some treatments. The integration of NPK and FYM helps in maintaining the soil health (Singh and Rai 2004; Mere *et al.,* 2013).

Table 44: Effect of lime, farmyard manure and fertilizers on nitrogen balance in soil

| Treatment | Initial stage (kg ha$^{-1}$) | Nutrient added (kg ha$^{-1}$) | Total nutrient uptake (kg ha$^{-1}$) | Expected nutrient balance (kg ha$^{-1}$) | Actual nutrient balance (kg ha$^{-1}$) | Apparent gain/loss (kg ha$^{-1}$) | Actual difference (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| | A | B | C | D = (A+B)-C | E | F=E-D | G=E-A |
| $L_0O_0I_0$ | 252.78 | 0 | 89.61 | 163.17 | 313.60 | 150.43 | 60.82 |
| $L_0O_0I_1$ | 252.78 | 10 | 92.04 | 170.74 | 303.15 | 132.41 | 50.37 |
| $L_0O_0I_2$ | 252.78 | 15 | 99.99 | 167.79 | 336.60 | 168.81 | 83.82 |
| $L_0O_0I_3$ | 252.78 | 20 | 110.11 | 162.67 | 365.87 | 203.20 | 113.09 |
| $L_0O_1I_0$ | 252.78 | 25 | 109.44 | 168.34 | 347.05 | 178.71 | 94.27 |
| $L_0O_1I_1$ | 252.78 | 30 | 118.96 | 163.82 | 349.14 | 185.32 | 96.36 |
| $L_0O_1I_2$ | 252.78 | 40 | 120.93 | 171.85 | 347.05 | 175.20 | 94.27 |
| $L_0O_1I_3$ | 252.78 | 45 | 142.66 | 155.12 | 359.59 | 204.47 | 106.81 |
| $L_1O_0I_0$ | 252.78 | 0 | 135.41 | 117.37 | 315.52 | 198.15 | 62.74 |
| $L_1O_0I_1$ | 252.78 | 10 | 138.11 | 124.67 | 319.87 | 195.20 | 67.09 |
| $L_1O_0I_2$ | 252.78 | 15 | 150.21 | 117.57 | 338.85 | 221.28 | 86.07 |
| $L_1O_0I_3$ | 252.78 | 20 | 164.29 | 108.49 | 361.69 | 253.20 | 108.91 |
| $L_1O_1I_0$ | 252.78 | 25 | 146.76 | 131.02 | 361.26 | 230.24 | 108.48 |
| $L_1O_1I_1$ | 252.78 | 30 | 156.08 | 126.70 | 375.73 | 249.03 | 122.95 |
| $L_1O_1I_2$ | 252.78 | 40 | 174.97 | 117.81 | 360.87 | 243.06 | 108.09 |
| $L_1O_1I_3$ | 252.78 | 45 | 172.92 | 124.86 | 370.05 | 245.19 | 117.27 |
| $L_2O_0I_0$ | 252.78 | 0 | 156.30 | 96.48 | 355.41 | 258.93 | 102.63 |
| $L_2O_0I_1$ | 252.78 | 10 | 163.37 | 99.41 | 347.05 | 247.64 | 94.27 |
| $L_2O_0I_2$ | 252.78 | 15 | 173.20 | 94.58 | 370.05 | 275.47 | 117.27 |
| $L_2O_0I_3$ | 252.78 | 20 | 197.08 | 75.70 | 374.23 | 298.53 | 121.45 |
| $L_2O_1I_0$ | 252.78 | 25 | 187.06 | 90.72 | 370.05 | 279.33 | 117.27 |
| $L_2O_1I_1$ | 252.78 | 30 | 200.54 | 82.24 | 366.76 | 284.52 | 113.98 |
| $L_2O_1I_2$ | 252.78 | 40 | 207.59 | 85.19 | 367.96 | 282.77 | 115.18 |
| $L_2O_1I_3$ | 252.78 | 45 | 220.99 | 76.79 | 400.63 | 323.84 | 147.85 |

Table 45: Effect of lime, farmyard manure and fertilizers on phosphorus balance in soil

| Treatment | Initial stage (kg ha$^{-1}$) | Nutrient added (kg ha$^{-1}$) | Total nutrient uptake (kg ha$^{-1}$) | Expected nutrient balance (kg ha$^{-1}$) | Actual nutrient balance (kg ha$^{-1}$) | Apparent gain/loss (kg ha$^{-1}$) | Actual difference (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| | A | B | C | D = (A+B)-C | E | F=E-D | G=E-A |
| **$L_0O_0I_0$** | 18.55 | 0 | 8.17 | 10.38 | 14.38 | 4.00 | -4.17 |
| **$L_0O_0I_1$** | 18.55 | 40 | 8.50 | 50.05 | 15.36 | -34.69 | -3.19 |
| **$L_0O_0I_2$** | 18.55 | 60 | 9.48 | 69.07 | 15.51 | -53.56 | -3.04 |
| **$L_0O_0I_3$** | 18.55 | 80 | 11.10 | 87.45 | 16.02 | -71.43 | -2.53 |
| **$L_0O_1I_0$** | 18.55 | 7.5 | 10.73 | 15.32 | 16.10 | 0.78 | -2.45 |
| **$L_0O_1I_1$** | 18.55 | 47.5 | 11.88 | 54.17 | 16.44 | -37.73 | -2.11 |
| **$L_0O_1I_2$** | 18.55 | 67.5 | 10.84 | 75.21 | 17.28 | -57.93 | -1.27 |
| **$L_0O_1I_3$** | 18.55 | 87.5 | 14.17 | 91.88 | 18.23 | -73.65 | -0.32 |
| **$L_1O_0I_0$** | 18.55 | 0 | 12.22 | 6.33 | 16.69 | 10.36 | -1.86 |
| **$L_1O_0I_1$** | 18.55 | 40 | 13.31 | 45.24 | 19.73 | -25.51 | 1.18 |
| **$L_1O_0I_2$** | 18.55 | 60 | 14.33 | 64.22 | 19.57 | -44.65 | 1.02 |
| **$L_1O_0I_3$** | 18.55 | 80 | 16.02 | 82.53 | 19.10 | -63.43 | 0.55 |
| **$L_1O_1I_0$** | 18.55 | 7.5 | 12.60 | 13.45 | 20.17 | 6.72 | 1.62 |
| **$L_1O_1I_1$** | 18.55 | 47.5 | 14.20 | 51.85 | 20.51 | -31.34 | 1.96 |
| **$L_1O_1I_2$** | 18.55 | 67.5 | 18.25 | 67.80 | 21.27 | -46.53 | 2.72 |
| **$L_1O_1I_3$** | 18.55 | 87.5 | 17.74 | 88.31 | 22.09 | -66.22 | 3.54 |
| **$L_2O_0I_0$** | 18.55 | 0 | 14.83 | 3.72 | 21.75 | 18.03 | 3.20 |
| **$L_2O_0I_1$** | 18.55 | 40 | 16.77 | 41.78 | 22.73 | -19.05 | 4.18 |
| **$L_2O_0I_2$** | 18.55 | 60 | 17.97 | 60.58 | 22.81 | -37.77 | 4.26 |
| **$L_2O_0I_3$** | 18.55 | 80 | 20.98 | 77.57 | 23.38 | -54.19 | 4.83 |
| **$L_2O_1I_0$** | 18.55 | 7.5 | 18.80 | 7.25 | 22.72 | 15.47 | 4.17 |
| **$L_2O_1I_1$** | 18.55 | 47.5 | 20.82 | 45.23 | 23.93 | -21.30 | 5.38 |
| **$L_2O_1I_2$** | 18.55 | 67.5 | 22.32 | 63.73 | 23.95 | -39.78 | 5.40 |
| **$L_2O_1I_3$** | 18.55 | 87.5 | 24.41 | 81.64 | 24.78 | -56.86 | 6.23 |

Table 46: Effect of lime, farmyard manure and fertilizers on potassium balance in soil

| Treatment | Initial stage (kg ha$^{-1}$) | Nutrient added (kg ha$^{-1}$) | Total nutrient uptake (kg ha$^{-1}$) | Expected nutrient balance (kg ha$^{-1}$) | Actual nutrient balance (kg ha$^{-1}$) | Apparent gain/loss (kg ha$^{-1}$) | Actual difference (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| | A | B | C | D = (A+B)-C | E | F=E-D | G=E-A |
| $L_0O_0I_0$ | 171.10 | 0 | 57.22 | 113.88 | 70.06 | -43.82 | -101.04 |
| $L_0O_0I_1$ | 171.10 | 20 | 62.83 | 128.27 | 80.11 | -48.16 | -90.99 |
| $L_0O_0I_2$ | 171.10 | 30 | 68.28 | 132.82 | 88.04 | -44.78 | -83.06 |
| $L_0O_0I_3$ | 171.10 | 40 | 70.85 | 140.25 | 86.01 | -54.24 | -85.09 |
| $L_0O_1I_0$ | 171.10 | 25 | 70.08 | 126.02 | 76.79 | -49.23 | -94.31 |
| $L_0O_1I_1$ | 171.10 | 45 | 80.78 | 135.32 | 79.23 | -56.09 | -91.87 |
| $L_0O_1I_2$ | 171.10 | 55 | 81.93 | 144.17 | 92.17 | -52.00 | -78.93 |
| $L_0O_1I_3$ | 171.10 | 65 | 113.76 | 122.34 | 97.08 | -25.26 | -74.02 |
| $L_1O_0I_0$ | 171.10 | 0 | 107.09 | 64.01 | 83.21 | 19.20 | -87.89 |
| $L_1O_0I_1$ | 171.10 | 20 | 107.37 | 83.73 | 86.53 | 2.80 | -84.57 |
| $L_1O_0I_2$ | 171.10 | 30 | 112.08 | 89.02 | 94.99 | 5.97 | -76.11 |
| $L_1O_0I_3$ | 171.10 | 40 | 121.83 | 89.27 | 95.79 | 6.52 | -75.31 |
| $L_1O_1I_0$ | 171.10 | 25 | 107.10 | 89.00 | 82.55 | -6.45 | -88.55 |
| $L_1O_1I_1$ | 171.10 | 45 | 114.09 | 102.01 | 94.75 | -7.26 | -76.35 |
| $L_1O_1I_2$ | 171.10 | 55 | 131.80 | 94.30 | 95.03 | 0.73 | -76.07 |
| $L_1O_1I_3$ | 171.10 | 65 | 137.82 | 98.28 | 100.39 | 2.11 | -70.71 |
| $L_2O_0I_0$ | 171.10 | 0 | 112.78 | 58.32 | 92.17 | 33.85 | -78.93 |
| $L_2O_0I_1$ | 171.10 | 20 | 126.39 | 64.71 | 87.81 | 23.10 | -83.29 |
| $L_2O_0I_2$ | 171.10 | 30 | 139.08 | 62.02 | 103.66 | 41.64 | -67.44 |
| $L_2O_0I_3$ | 171.10 | 40 | 162.26 | 48.84 | 103.74 | 54.90 | -67.36 |
| $L_2O_1I_0$ | 171.10 | 25 | 152.79 | 43.31 | 83.30 | 39.99 | -87.80 |
| $L_2O_1I_1$ | 171.10 | 45 | 167.37 | 48.73 | 99.03 | 50.30 | -72.07 |
| $L_2O_1I_2$ | 171.10 | 55 | 176.92 | 49.18 | 103.66 | 54.48 | -67.44 |
| $L_2O_1I_3$ | 171.10 | 65 | 194.53 | 41.57 | 109.09 | 67.52 | -62.01 |

# *CHAPTER - V*

# *SUMMARY AND CONCLUSION*

# SUMMARY AND CONCLUSION

## Physico-chemical properties of soil from soybean growing areas of Kohima and Dimapur districts

- In general, the sand content tended to decrease with an increase in altitude. This is due to the fact that WHC of sand is low which resulted in higher leaching during heavy rainfall at higher altitudes.

- The lowest and highest sand content was recorded in the Murise and Diezephe soils in Dimapur district as 46.00 and 80.00 % respectively.

- In general, the acidity of the soil tended to increase with altitude.

- The organic carbon increased with altitude. This might be due to the change in altitude and formation of unhumified organic matter.

- The highest available nitrogen, available phosphorus, available potassium and available sulphur in the soil was recorded in Rusoma soil in Kohima district as 455.53 kg $ha^{-1}$; Bade soil in Dimapur district as 24.53 kg $ha^{-1}$, Bade soil in Dimapur district as 194.13 kg $ha^{-1}$ and Diezephe soils in Dimapur district as 1.50 $\mu g$ $g^{-1}$ , respectively. The lowest available nitrogen, available phosphorus, available potassium and available sulphur was in New Chumukedima in Dimapur district as 221.52 kg $ha^{-1}$, Tsiesema soil in Kohima district as 5.82 kg $ha^{-1}$, Tsiesema soil in Kohima district as 67.20 kg $ha^{-1}$ and Murise soils in Dimapur district as 0.27 $\mu g$ $g^{-1}$, respectively.

- The highest total nitrogen content was recorded in soybean seed in Nerhema (6.33%) while the lowest was in Kezoma (5.24%) of Kohima district. The highest phosphorus content was recorded in soils of Dihoma in Kohima district (0.48%) while the lowest was in New Chumukedima of Dimapur district as 5.24%. The highest potassium content was recorded from soils of Kidima in Kohima district (2.49%) while the lowest was in Murise soil in Dimapur district as 1.41%.

- The highest protein content i.e., 39.56% was recorded in soybean seed of Nerhema site in Kohima district while the lowest was at Rusoma in Kohima district as 32.56%. The highest oil content of 19.38% was recorded in soybean seed at Dihoma site in Kohima district while the lowest was at Murise in Dimapur district as 16.88%.

**Effect of lime, farmyard manure and fertilizers on growth and yield of soybean**

- The maximum and minimum plant height was recorded in $L_2O_1I_3$ (59.67 and 60.67 cm, 87.33 and 87.67 cm and 106.67 and 107.67 cm) with pooled data as 60.17, 87.50 and 107.17 cm and $L_0O_0I_0$ (36.67 and 38.00 cm, 63.00 and 64.33 cm and 86.33 and 87.00 cm) with pooled data as 37.33, 63.67 and 86.67 cm at 30, 45 and 60 DAS, respectively during 2014 and 2015.

- The maximum number of leaves was recorded in $L_2O_1I_3$ (7.33 and 7.33, 13.67 and 13.67, 26.33 and 26.33) with pooled data as 7.33, 13.67 and 26.33 at 30, 45 and 60 DAS, respectively during 2014 and 2015.

- The maximum number of nodules was recorded in $L_2O_1I_3$ (37.33 and 37.00, 47.00 and 47.67) and $L_1O_1I_2$ (67.33 and 68.00) with pooled data as 37.17, 47.33 and 67.67 at 30, 45 and 60 DAS, respectively during 2014 and 2015.

- The maximum weight of plant was recorded in $L_2O_1I_3$ (3.04 and 3.04 g, 17.76 and 17.36 g, 24.44 and 24.37 g) with pooled data as 3.04, 17.56 and 24.41 at 30, 45 and 60 DAS, respectively during 2014 and 2015.

- Maximum biological yield was recorded under $L_2O_1I_3$ (6848.40 and 6852.50 kg $ha^{-1}$) with pooled data as 6850.45 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum biological yield was recorded in $L_0O_0I_1$ (3472.96 and 3480.63 kg $ha^{-1}$) with pooled data as 3476.80 kg $ha^{-1}$ in 2014 and 2015, respectively.

- The maximum seed yield was recorded in $L_2O_1I_3$ (2300.50 and 2302.17 kg $ha^{-1}$) with pooled data as 2301.33 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum seed yield was observed in $L_0O_1I_0$ (1173.91 and 1178.77 kg $ha^{-1}$) with pooled data as 1176.34 kg $ha^{-1}$ during 2014 and 2015, respectively.

- The maximum stover yield was recorded in $L_2O_1I_3$ (4547.90 and 4550.33 kg $ha^{-1}$) with pooled data as 4549.11 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum stover yield was associated with $L_0O_1I_0$ (1173.91 and 1178.77 kg $ha^{-1}$) with pooled data as 1176.34 kg $ha^{-1}$ during 2014 and 2015, respectively.

- The maximum number of pods $plant^{-1}$ was recorded in $L_2O_1I_3$ (95.33 and 96.33) with pooled data as 95.83, respectively during 2014 and 2015. The minimum number of pods plant$^{-1}$ was recorded in $L_0O_1I_0$ (52.00 and 52.33) with pooled data as 52.17 during 2014 and 2015, respectively

- The maximum seed index was recorded in $L_2O_1I_3$ (14.08 and 14.39 g) with pooled data as 14.24 g and the minimum seed index was recorded in $L_0O_1I_0$ (9.70 and 9.75 g) with pooled data as 9.73 g during 2014 and 2015, respectively

**Effect of different levels of lime, farmyard manure and fertilizers on nutrient uptake by soybean**

- The maximum N, P, K and S uptake in soybean was recorded in $L_2O_1I_3$ (217.84 and 224.14 kg ha$^{-1}$, 24.56 and 24.26 kg ha$^{-1}$, 194.52 and 194.54 kg ha$^{-1}$, 20.81 and 20.31 mg kg$^{-1}$) with pooled data as 220.99, 24.41, 194.53 kg ha$^{-1}$ and 20.56 mg kg$^{-1}$ during 2014 and 2015, respectively

- The minimum N, P, K and S uptake was recorded in $L_0O_1I_0$ (89.32 and 89.89 kg ha$^{-1}$, 8.15 and 8.20 kg ha$^{-1}$, 56.33 and 58.12 kg ha$^{-1}$, 6.27 and 6.01 mg kg$^{-1}$) with pooled data as 89.61, 8.17, 57.22 kg ha$^{-1}$ and 6.14 mg kg$^{-1}$ during 2014 and 2015, respectively.

**Crude protein and oil content of Soybean as affected by lime, farmyard manure and fertilizers**

- The maximum protein content in grain was recorded under $L_2O_1I_2$ (37.63 %) in 2014 and $L_2O_1I_3$ (39.13 %) in 2015 and the maximum oil content was recorded under $L_2O_1I_1$ (19.14 %) in 2014 and $L_2O_1I_3$ (19.57 %) in 2015.

- The minimum protein content was recorded under $L_0O_0I_1$ (31.08 %) in 2014 and $L_0O_0I_0$ (31.19 %) in 2015 and the minimum oil content was recorded under $L_0O_0I_0$ (15.58 %) in 2014 and at16.36 % ($L_0O_0I_0$, $L_0O_0I_1$) in 2015.

- The maximum protein yield and oil yield was recorded under $L_2O_1I_3$ (861.73 and 900.73 kg ha$^{-1}$, 441.01 and 450.45 kg ha$^{-1}$) with pooled data 881.23 and 445.73 kg ha$^{-1}$, during 2014 and 2015, respectively.

- The minimum protein yield and oil yield was recorded under $L_0O_0I_0$ (367.74 and 368.56 kg ha$^{-1}$, 191.41 and 187.46 kg ha$^{-1}$) with pooled data of 368.15 and 189.44 kg ha$^{-1}$ during 2014 and 2015, respectively.

**Effect of lime, farmyard manure and fertilizers on soil fertility status after harvest of crop**

- The maximum pH and organic carbon content in soil at harvest was recorded in $L_2O_1I_3$ (5.98 and 6.35, 1.76 and 1.76) with pooled data of 6.17 and 1.76 during 2014 and 2015, respectively.

- The minimum pH and organic carbon content in soil at harvest was recorded in $L_0O_0I_0$ as 5.51 and 5.47, 0.90 and 0.87 with pooled data as 5.49 and 0.88 during 2014 and 2015, respectively.

- The maximum exchangeable Ca at harvest was recorded in $L_2O_1I_2$ (8.53 and 8.51 {cmol ($p^+$) $kg^{-1}$}) with pooled data as 8.52 during 2014 and 2015, respectively. The minimum exchangeable Ca at harvest was recorded in treatment $L_0O_0I_0$ as 2.50 and 2.52 {cmol ($p^+$)$kg^{-1}$} with pooled data as 2.52 {cmol ($p^+$)$kg^{-1}$} during 2014 and 2015, respectively.

- The maximum exchangeable Mg at harvest was recorded in $L_0O_1I_3$ (0.65 and 0.63 {cmol ($p^+$) $kg^{-1}$}) with pooled data as 0.64 {cmol ($p^+$)$kg^{-1}$} during 2014 and 2015, respectively. The minimum exchangeable Mg at harvest was recorded in treatment $L_1O_0I_0$ and $L_2O_0I_0$ as 0.44 {cmol ($p^+$)$kg^{-1}$} in 2014 and in $L_1O_0I_0$ as 0.43{cmol ($p^+$) $kg^{-1}$} during 2015.

- The maximum available N, P and K in soil at harvest was recorded in $L_2O_1I_3$ (400.77 and 400.50 kg $ha^{-1}$, 24.45 and 25.11 kg $ha^{-1}$, 109.76 and 108.43 kg $ha^{-1}$) with pooled data as 400.63, 24.78 and 109.09 kg $ha^{-1}$ during 2014 and 2015, respectively. The maximum available S content in soil at harvest was recorded as 0.44 mg $kg^{-1}$ in treatment $L_2O_1I_2$ and $L_2O_1I_3$ during 2014 and as 0.46 mg $kg^{-1}$ in 2015.

- The minimum available N in soil at harvest was recorded in $L_0O_0I_1$ as 301.06 and 305.24 kg $ha^{-1}$ during 2014 and 2015 respectively. The minimum available P and K in soil at harvest was recorded in $L_0O_0I_0$ as 14.55 and 14.21 kg $ha^{-1}$, 69.44 and 70.67 kg $ha^{-1}$ with pooled data as 14.38 and 70.06 kg $ha^{-1}$ during 2014 and 2015, respectively. The minimum available S in soil at harvest was recorded as 0.22 mg $kg^{-1}$ in $L_0O_0I_1$ and $L_0O_1I_0$ during 2014 and in $L_0O_0I_1$ during 2015.

- The highest value NUE of nitrogen by soybean was obtained by the application of lime @ 10% LR along with 50 % RDF.

- The highest value NUE of phosphorus by soybean was received by the application of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$.

- The highest value NUE of potassium by soybean was realised by the application of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$.

**Conclusion**

Application of lime (10% LR), FYM @ 5 t $ha^{-1}$ and 100 % RDF was found to be the best combination among the treatments for achieving higher growth and yield of soybean in acidic soils of Nagaland. This may be due to the increase in pH and improvement of soil physico-chemical properties. Nutrient uptake was higher in treatments receiving higher amounts of added nutrients through organic and inorganic sources. This may probably be due to addition of nutrients and increased nutrient availability in the soil which probably led to higher growth and yield as observed from the outcome of the applied treatments in the experiment. The different treatments did not have any significant effect on the oil content of soybean. Residual nutrient in the soil were found to be directly proportional to the amount of nutrient applied. During the survey, it was observed that the commonly used alkaline permanganate method may not be giving dependable and reliable results as far as soils from Northeast India or for that matter, acidic soils are concerned, resulting in negative correlation when samples from various farmers field are collected, analysed and results studied. In the field experiment, the biological yield with combined treatment of all three factors was found maximum in treatment application of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 100% RDF which was at par with treatment of lime @ 10% LR along with FYM @ 5 t $ha^{-1}$ and 75% RDF. The minimum was recorded in treatment having 50% RDF alone. Generally, treatments receiving lime showed higher biological yield as compared to those without liming. NPK and S (400.77 kg $ha^{-1}$ and 400.50 kg $ha^{-1}$, 24.45 kg $ha^{-1}$ and 25.11 kg $ha^{-1}$, 109.76 kg $ha^{-1}$ and 108.43 kg $ha^{-1}$, 0.44 mg $kg^{-1}$ and 0.46 mg $kg^{-1}$ respectively) content in soil after harvest were higher in $L_2O_1I_3$. NPK and S uptake by seed and stover as well as nutrient uptake followed the same trend as in the case of soil. Oil content was not significantly affected by the treatments. However oil yield was higher in $L_2O_1I_3$. Protein yield was also higher in $L_2O_1I_3$. The nutrient balance in the soil for N showed significant gains in treatments where more amount of nutrients were supplied compared to those treatments where lesser amount was given. Among the treatments, $L_2O_0I_1$ reported highest nitrogen use efficiency while the highest P and K use efficiency was reported with treatment $L_2O_1I_1$ compared to the other treatments.

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# *APPENDICES*

# APPENDIX - I

| Treatment | | N content in seeds (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 4.91 | 4.97 | 5.11 | 5.01 | 4.91 | 5.05 |
| $T_2$ | $L_0O_0I_1$ | 4.95 | 4.95 | 5.02 | 5.12 | 4.95 | 5.18 |
| $T_3$ | $L_0O_0I_2$ | 5.19 | 4.95 | 5.03 | 5.19 | 5.19 | 5.27 |
| $T_4$ | $L_0O_0I_3$ | 5.20 | 5.09 | 5.04 | 5.28 | 5.20 | 5.14 |
| $T_5$ | $L_0O_1I_0$ | 4.97 | 4.99 | 5.01 | 5.29 | 4.97 | 5.27 |
| $T_6$ | $L_0O_1I_1$ | 5.10 | 5.08 | 4.97 | 5.31 | 5.10 | 5.41 |
| $T_7$ | $L_0O_1I_2$ | 5.21 | 5.18 | 5.12 | 5.40 | 5.21 | 5.64 |
| $T_8$ | $L_0O_1I_3$ | 5.30 | 5.27 | 5.19 | 5.35 | 5.30 | 5.42 |
| $T_9$ | $L_1O_0I_0$ | 5.17 | 5.14 | 5.28 | 5.51 | 5.17 | 5.43 |
| $T_{10}$ | $L_1O_0I_1$ | 5.34 | 5.27 | 5.29 | 5.59 | 5.34 | 5.55 |
| $T_{11}$ | $L_1O_0I_2$ | 5.38 | 5.41 | 5.31 | 5.62 | 5.38 | 5.59 |
| $T_{12}$ | $L_1O_0I_3$ | 5.78 | 5.64 | 5.40 | 5.43 | 5.78 | 5.41 |
| $T_{13}$ | $L_1O_1I_0$ | 5.34 | 5.42 | 5.35 | 5.67 | 5.34 | 5.42 |
| $T_{14}$ | $L_1O_1I_1$ | 5.37 | 5.43 | 5.51 | 5.71 | 5.37 | 5.61 |
| $T_{15}$ | $L_1O_1I_2$ | 5.59 | 5.44 | 5.55 | 6.02 | 5.59 | 5.63 |
| $T_{16}$ | $L_1O_1I_3$ | 5.62 | 5.51 | 5.59 | 6.12 | 5.62 | 5.59 |
| $T_{17}$ | $L_2O_0I_0$ | 5.43 | 5.38 | 5.41 | 5.92 | 5.43 | 5.79 |
| $T_{18}$ | $L_2O_0I_1$ | 5.67 | 5.39 | 5.42 | 5.95 | 5.67 | 5.86 |
| $T_{19}$ | $L_2O_0I_2$ | 5.71 | 5.42 | 5.61 | 5.97 | 5.71 | 5.80 |
| $T_{20}$ | $L_2O_0I_3$ | 6.02 | 5.72 | 5.63 | 6.01 | 6.02 | 6.09 |
| $T_{21}$ | $L_2O_1I_0$ | 6.12 | 5.87 | 5.59 | 5.99 | 6.12 | 6.01 |
| $T_{22}$ | $L_2O_1I_1$ | 6.20 | 5.98 | 5.61 | 6.12 | 6.20 | 6.11 |
| $T_{23}$ | $L_2O_1I_2$ | 6.32 | 5.87 | 5.87 | 6.21 | 6.32 | 6.15 |
| $T_{24}$ | $L_2O_1I_3$ | 6.33 | 5.68 | 5.97 | 6.25 | 6.33 | 6.20 |

## APPENDIX - II

| Treatment | | P content in seeds (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 0.31 | 0.31 | 0.33 | 0.33 | 0.31 | 0.31 |
| $T_2$ | $L_0O_0I_1$ | 0.32 | 0.33 | 0.34 | 0.32 | 0.33 | 0.33 |
| $T_3$ | $L_0O_0I_2$ | 0.35 | 0.34 | 0.36 | 0.33 | 0.34 | 0.34 |
| $T_4$ | $L_0O_0I_3$ | 0.38 | 0.39 | 0.38 | 0.38 | 0.39 | 0.38 |
| $T_5$ | $L_0O_1I_0$ | 0.34 | 0.33 | 0.34 | 0.32 | 0.33 | 0.33 |
| $T_6$ | $L_0O_1I_1$ | 0.34 | 0.35 | 0.36 | 0.36 | 0.35 | 0.34 |
| $T_7$ | $L_0O_1I_2$ | 0.32 | 0.31 | 0.38 | 0.37 | 0.31 | 0.33 |
| $T_8$ | $L_0O_1I_3$ | 0.37 | 0.38 | 0.40 | 0.36 | 0.38 | 0.36 |
| $T_9$ | $L_1O_0I_0$ | 0.30 | 0.29 | 0.36 | 0.34 | 0.29 | 0.38 |
| $T_{10}$ | $L_1O_0I_1$ | 0.35 | 0.39 | 0.37 | 0.35 | 0.39 | 0.38 |
| $T_{11}$ | $L_1O_0I_2$ | 0.40 | 0.41 | 0.37 | 0.36 | 0.41 | 0.38 |
| $T_{12}$ | $L_1O_0I_3$ | 0.40 | 0.41 | 0.39 | 0.37 | 0.41 | 0.40 |
| $T_{13}$ | $L_1O_1I_0$ | 0.31 | 0.32 | 0.32 | 0.35 | 0.32 | 0.32 |
| $T_{14}$ | $L_1O_1I_1$ | 0.33 | 0.34 | 0.38 | 0.38 | 0.34 | 0.34 |
| $T_{15}$ | $L_1O_1I_2$ | 0.39 | 0.38 | 0.42 | 0.41 | 0.48 | 0.48 |
| $T_{16}$ | $L_1O_1I_3$ | 0.39 | 0.38 | 0.44 | 0.44 | 0.38 | 0.38 |
| $T_{17}$ | $L_2O_0I_0$ | 0.36 | 0.37 | 0.39 | 0.38 | 0.37 | 0.37 |
| $T_{18}$ | $L_2O_0I_1$ | 0.37 | 0.38 | 0.41 | 0.40 | 0.38 | 0.38 |
| $T_{19}$ | $L_2O_0I_2$ | 0.36 | 0.37 | 0.42 | 0.42 | 0.37 | 0.37 |
| $T_{20}$ | $L_2O_0I_3$ | 0.39 | 0.40 | 0.44 | 0.41 | 0.40 | 0.42 |
| $T_{21}$ | $L_2O_1I_0$ | 0.39 | 0.38 | 0.41 | 0.39 | 0.38 | 0.39 |
| $T_{22}$ | $L_2O_1I_1$ | 0.43 | 0.42 | 0.43 | 0.42 | 0.42 | 0.39 |
| $T_{23}$ | $L_2O_1I_2$ | 0.44 | 0.43 | 0.44 | 0.43 | 0.43 | 0.42 |
| $T_{24}$ | $L_2O_1I_3$ | 0.45 | 0.44 | 0.46 | 0.45 | 0.44 | 0.42 |

## APPENDIX - III

| Treatment | | K content in seeds (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 1.13 | 1.20 | 1.10 | 1.10 | 1.20 | 1.18 |
| $T_2$ | $L_0O_0I_1$ | 1.23 | 1.25 | 1.20 | 1.20 | 1.25 | 1.28 |
| $T_3$ | $L_0O_0I_2$ | 1.26 | 1.28 | 1.30 | 1.30 | 1.28 | 1.31 |
| $T_4$ | $L_0O_0I_3$ | 1.29 | 1.31 | 1.40 | 1.40 | 1.31 | 1.34 |
| $T_5$ | $L_0O_1I_0$ | 1.24 | 1.32 | 1.30 | 1.30 | 1.32 | 0.32 |
| $T_6$ | $L_0O_1I_1$ | 1.28 | 1.34 | 1.40 | 1.40 | 1.34 | 1.38 |
| $T_7$ | $L_0O_1I_2$ | 1.30 | 1.41 | 1.50 | 1.50 | 1.41 | 1.40 |
| $T_8$ | $L_0O_1I_3$ | 1.58 | 2.03 | 1.60 | 1.60 | 2.53 | 2.11 |
| $T_9$ | $L_1O_0I_0$ | 1.45 | 2.42 | 1.50 | 1.50 | 2.42 | 2.11 |
| $T_{10}$ | $L_1O_0I_1$ | 1.47 | 2.45 | 1.60 | 1.60 | 2.45 | 2.13 |
| $T_{11}$ | $L_1O_0I_2$ | 1.49 | 2.49 | 1.70 | 1.70 | 2.49 | 1.91 |
| $T_{12}$ | $L_1O_0I_3$ | 1.52 | 2.48 | 1.80 | 1.80 | 2.48 | 1.95 |
| $T_{13}$ | $L_1O_1I_0$ | 1.44 | 2.33 | 1.70 | 1.70 | 2.33 | 1.99 |
| $T_{14}$ | $L_1O_1I_1$ | 1.62 | 2.33 | 1.80 | 1.80 | 2.33 | 2.28 |
| $T_{15}$ | $L_1O_1I_2$ | 1.66 | 2.23 | 1.90 | 1.90 | 2.23 | 2.28 |
| $T_{16}$ | $L_1O_1I_3$ | 1.88 | 2.21 | 2.00 | 2.00 | 2.21 | 2.24 |
| $T_{17}$ | $L_2O_0I_0$ | 1.59 | 1.71 | 1.90 | 1.90 | 1.71 | 1.95 |
| $T_{18}$ | $L_2O_0I_1$ | 1.94 | 1.94 | 2.00 | 2.00 | 1.94 | 2.16 |
| $T_{19}$ | $L_2O_0I_2$ | 2.09 | 1.95 | 2.10 | 2.10 | 1.95 | 2.20 |
| $T_{20}$ | $L_2O_0I_3$ | 2.11 | 2.23 | 2.20 | 2.20 | 2.23 | 2.24 |
| $T_{21}$ | $L_2O_1I_0$ | 2.25 | 2.08 | 2.10 | 2.10 | 2.08 | 2.19 |
| $T_{22}$ | $L_2O_1I_1$ | 2.29 | 2.32 | 2.20 | 2.20 | 2.32 | 2.34 |
| $T_{23}$ | $L_2O_1I_2$ | 2.37 | 2.34 | 2.30 | 2.30 | 2.34 | 2.33 |
| $T_{24}$ | $L_2O_1I_3$ | 2.38 | 2.41 | 2.40 | 2.40 | 2.41 | 2.42 |

# APPENDIX - IV

| Treatment | | S content in seeds (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 0.18 | 0.17 | 0.20 | 0.17 | 0.18 | 0.18 |
| $T_2$ | $L_0O_0I_1$ | 0.19 | 0.23 | 0.21 | 0.19 | 0.19 | 0.16 |
| $T_3$ | $L_0O_0I_2$ | 0.21 | 0.19 | 0.20 | 0.20 | 0.21 | 0.19 |
| $T_4$ | $L_0O_0I_3$ | 0.22 | 0.21 | 0.22 | 0.21 | 0.22 | 0.18 |
| $T_5$ | $L_0O_1I_0$ | 0.22 | 0.19 | 0.18 | 0.17 | 0.22 | 0.18 |
| $T_6$ | $L_0O_1I_1$ | 0.23 | 0.22 | 0.19 | 0.21 | 0.23 | 0.16 |
| $T_7$ | $L_0O_1I_2$ | 0.24 | 0.24 | 0.21 | 0.21 | 0.24 | 0.21 |
| $T_8$ | $L_0O_1I_3$ | 0.26 | 0.28 | 0.22 | 0.23 | 0.26 | 0.22 |
| $T_9$ | $L_1O_0I_0$ | 0.24 | 0.24 | 0.19 | 0.19 | 0.24 | 0.21 |
| $T_{10}$ | $L_1O_0I_1$ | 0.27 | 0.22 | 0.21 | 0.21 | 0.27 | 0.24 |
| $T_{11}$ | $L_1O_0I_2$ | 0.29 | 0.28 | 0.21 | 0.25 | 0.29 | 0.26 |
| $T_{12}$ | $L_1O_0I_3$ | 0.31 | 0.28 | 0.24 | 0.23 | 0.31 | 0.25 |
| $T_{13}$ | $L_1O_1I_0$ | 0.26 | 0.27 | 0.19 | 0.21 | 0.26 | 0.23 |
| $T_{14}$ | $L_1O_1I_1$ | 0.24 | 0.26 | 0.21 | 0.24 | 0.24 | 0.21 |
| $T_{15}$ | $L_1O_1I_2$ | 0.31 | 0.25 | 0.22 | 0.26 | 0.31 | 0.25 |
| $T_{16}$ | $L_1O_1I_3$ | 0.33 | 0.24 | 0.25 | 0.26 | 0.33 | 0.26 |
| $T_{17}$ | $L_2O_0I_0$ | 0.28 | 0.24 | 0.23 | 0.24 | 0.28 | 0.24 |
| $T_{18}$ | $L_2O_0I_1$ | 0.27 | 0.29 | 0.24 | 0.26 | 0.27 | 0.24 |
| $T_{19}$ | $L_2O_0I_2$ | 0.28 | 0.34 | 0.23 | 0.28 | 0.28 | 0.26 |
| $T_{20}$ | $L_2O_0I_3$ | 0.30 | 0.30 | 0.24 | 0.33 | 0.30 | 0.24 |
| $T_{21}$ | $L_2O_1I_0$ | 0.31 | 0.30 | 0.29 | 0.26 | 0.31 | 0.30 |
| $T_{22}$ | $L_2O_1I_1$ | 0.29 | 0.32 | 0.31 | 0.27 | 0.30 | 0.29 |
| $T_{23}$ | $L_2O_1I_2$ | 0.34 | 0.30 | 0.35 | 0.28 | 0.34 | 0.29 |
| $T_{24}$ | $L_2O_1I_3$ | 0.31 | 0.33 | 0.35 | 0.30 | 0.31 | 0.30 |

# APPENDIX - V

| Treatment | | N content in stover (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 1.33 | 1.24 | 1.21 | 1.26 | 1.33 | 1.30 |
| $T_2$ | $L_0O_0I_1$ | 1.42 | 1.33 | 1.28 | 1.34 | 1.42 | 1.40 |
| $T_3$ | $L_0O_0I_2$ | 1.63 | 1.37 | 1.33 | 1.38 | 1.63 | 1.41 |
| $T_4$ | $L_0O_0I_3$ | 1.59 | 1.40 | 1.35 | 1.42 | 1.59 | 1.45 |
| $T_5$ | $L_0O_1I_0$ | 1.57 | 0.35 | 1.30 | 1.34 | 1.57 | 1.40 |
| $T_6$ | $L_0O_1I_1$ | 1.61 | 1.37 | 1.38 | 1.39 | 1.61 | 1.45 |
| $T_7$ | $L_0O_1I_2$ | 1.50 | 1.42 | 1.39 | 1.45 | 1.50 | 1.50 |
| $T_8$ | $L_0O_1I_3$ | 1.62 | 1.49 | 1.40 | 1.63 | 1.62 | 1.55 |
| $T_9$ | $L_1O_0I_0$ | 1.45 | 1.42 | 1.35 | 1.48 | 1.45 | 1.50 |
| $T_{10}$ | $L_1O_0I_1$ | 1.62 | 0.51 | 1.48 | 1.53 | 1.62 | 1.55 |
| $T_{11}$ | $L_1O_0I_2$ | 1.64 | 1.58 | 1.52 | 1.58 | 1.64 | 1.58 |
| $T_{12}$ | $L_1O_0I_3$ | 1.66 | 1.63 | 1.52 | 1.58 | 1.66 | 1.59 |
| $T_{13}$ | $L_1O_1I_0$ | 1.62 | 1.63 | 1.55 | 1.59 | 1.62 | 1.55 |
| $T_{14}$ | $L_1O_1I_1$ | 1.67 | 1.66 | 1.55 | 1.61 | 1.67 | 1.59 |
| $T_{15}$ | $L_1O_1I_2$ | 1.65 | 1.64 | 1.60 | 1.62 | 1.65 | 1.61 |
| $T_{16}$ | $L_1O_1I_3$ | 1.67 | 1.68 | 1.67 | 1.61 | 1.67 | 1.62 |
| $T_{17}$ | $L_2O_0I_0$ | 1.66 | 1.59 | 1.62 | 1.61 | 1.66 | 1.59 |
| $T_{18}$ | $L_2O_0I_1$ | 1.68 | 1.59 | 1.61 | 1.58 | 1.68 | 1.62 |
| $T_{19}$ | $L_2O_0I_2$ | 1.70 | 1.63 | 1.53 | 1.57 | 1.70 | 1.65 |
| $T_{20}$ | $L_2O_0I_3$ | 1.72 | 1.65 | 1.65 | 1.62 | 1.72 | 1.69 |
| $T_{21}$ | $L_2O_1I_0$ | 1.65 | 1.61 | 1.62 | 1.68 | 1.65 | 1.65 |
| $T_{22}$ | $L_2O_1I_1$ | 1.69 | 1.72 | 1.63 | 1.71 | 1.69 | 1.69 |
| $T_{23}$ | $L_2O_1I_2$ | 1.71 | 1.75 | 1.72 | 1.69 | 1.71 | 1.75 |
| $T_{24}$ | $L_2O_1I_3$ | 1.72 | 1.78 | 1.78 | 1.79 | 1.72 | 1.78 |

# APPENDIX - VI

| Treatment | | P content in stover (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 0.20 | 0.17 | 0.18 | 0.18 | 0.20 | 0.19 |
| $T_2$ | $L_0O_0I_1$ | 0.22 | 0.19 | 0.17 | 0.19 | 0.22 | 0.20 |
| $T_3$ | $L_0O_0I_2$ | 0.24 | 0.21 | 0.19 | 0.20 | 0.24 | 0.22 |
| $T_4$ | $L_0O_0I_3$ | 0.25 | 0.22 | 0.21 | 0.21 | 0.25 | 0.24 |
| $T_5$ | $L_0O_1I_0$ | 0.26 | 0.22 | 0.20 | 0.20 | 0.26 | 0.24 |
| $T_6$ | $L_0O_1I_1$ | 0.27 | 0.23 | 0.22 | 0.21 | 0.27 | 0.25 |
| $T_7$ | $L_0O_1I_2$ | 0.20 | 0.23 | 0.21 | 0.22 | 0.20 | 0.23 |
| $T_8$ | $L_0O_1I_3$ | 0.21 | 0.24 | 0.24 | 0.23 | 0.21 | 0.23 |
| $T_9$ | $L_1O_0I_0$ | 0.19 | 0.20 | 0.22 | 0.22 | 0.19 | 0.23 |
| $T_{10}$ | $L_1O_0I_1$ | 0.20 | 0.20 | 0.21 | 0.23 | 0.20 | 0.26 |
| $T_{11}$ | $L_1O_0I_2$ | 0.22 | 0.21 | 0.23 | 0.24 | 0.22 | 0.24 |
| $T_{12}$ | $L_1O_0I_3$ | 0.23 | 0.25 | 0.24 | 0.25 | 0.23 | 0.26 |
| $T_{13}$ | $L_1O_1I_0$ | 0.21 | 0.23 | 0.24 | 0.24 | 0.21 | 0.22 |
| $T_{14}$ | $L_1O_1I_1$ | 0.24 | 0.23 | 0.25 | 0.25 | 0.24 | 0.25 |
| $T_{15}$ | $L_1O_1I_2$ | 0.27 | 0.28 | 0.26 | 0.26 | 0.27 | 0.24 |
| $T_{16}$ | $L_1O_1I_3$ | 0.26 | 0.26 | 0.26 | 0.27 | 0.26 | 0.28 |
| $T_{17}$ | $L_2O_0I_0$ | 0.24 | 0.26 | 0.25 | 0.26 | 0.24 | 0.25 |
| $T_{18}$ | $L_2O_0I_1$ | 0.27 | 0.29 | 0.27 | 0.27 | 0.27 | 0.28 |
| $T_{19}$ | $L_2O_0I_2$ | 0.26 | 0.30 | 0.28 | 0.28 | 0.26 | 0.29 |
| $T_{20}$ | $L_2O_0I_3$ | 0.27 | 0.31 | 0.27 | 0.29 | 0.27 | 0.30 |
| $T_{21}$ | $L_2O_1I_0$ | 0.25 | 0.29 | 0.26 | 0.28 | 0.25 | 0.29 |
| $T_{22}$ | $L_2O_1I_1$ | 0.25 | 0.29 | 0.28 | 0.29 | 0.25 | 0.32 |
| $T_{23}$ | $L_2O_1I_2$ | 0.27 | 0.32 | 0.31 | 0.30 | 0.27 | 0.32 |
| $T_{24}$ | $L_2O_1I_3$ | 0.29 | 0.33 | 0.32 | 0.31 | 0.29 | 0.35 |

# APPENDIX - VII

| Treatment | | K content in stover (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 1.75 | 1.91 | 1.76 | 1.79 | 1.91 | 1.86 |
| $T_2$ | $L_0O_0I_1$ | 1.86 | 1.93 | 2.89 | 2.19 | 1.93 | 1.99 |
| $T_3$ | $L_0O_0I_2$ | 1.89 | 2.00 | 2.99 | 2.28 | 2.00 | 2.08 |
| $T_4$ | $L_0O_0I_3$ | 1.99 | 2.12 | 2.18 | 2.33 | 2.12 | 2.05 |
| $T_5$ | $L_0O_1I_0$ | 1.95 | 2.22 | 2.10 | 2.31 | 2.22 | 2.14 |
| $T_6$ | $L_0O_1I_1$ | 2.05 | 2.28 | 2.19 | 2.31 | 2.28 | 2.26 |
| $T_7$ | $L_0O_1I_2$ | 2.15 | 2.32 | 2.28 | 2.39 | 2.32 | 2.34 |
| $T_8$ | $L_0O_1I_3$ | 2.29 | 2.38 | 2.33 | 2.44 | 2.38 | 2.26 |
| $T_9$ | $L_1O_0I_0$ | 2.25 | 2.28 | 2.31 | 2.51 | 2.28 | 2.31 |
| $T_{10}$ | $L_1O_0I_1$ | 2.30 | 2.25 | 2.31 | 2.55 | 2.25 | 2.41 |
| $T_{11}$ | $L_1O_0I_2$ | 2.40 | 2.28 | 2.39 | 2.51 | 2.28 | 2.43 |
| $T_{12}$ | $L_1O_0I_3$ | 2.50 | 2.35 | 2.44 | 2.61 | 2.35 | 2.43 |
| $T_{13}$ | $L_1O_1I_0$ | 2.40 | 2.36 | 2.40 | 2.65 | 2.36 | 2.43 |
| $T_{14}$ | $L_1O_1I_1$ | 2.46 | 2.40 | 2.48 | 2.66 | 2.40 | 2.41 |
| $T_{15}$ | $L_1O_1I_2$ | 2.48 | 2.42 | 2.51 | 2.74 | 2.42 | 2.51 |
| $T_{16}$ | $L_1O_1I_3$ | 2.56 | 2.56 | 2.59 | 2.78 | 2.56 | 2.55 |
| $T_{17}$ | $L_2O_0I_0$ | 2.51 | 2.48 | 2.61 | 2.80 | 2.48 | 2.46 |
| $T_{18}$ | $L_2O_0I_1$ | 2.63 | 2.51 | 2.61 | 2.74 | 2.51 | 2.48 |
| $T_{19}$ | $L_2O_0I_2$ | 2.68 | 2.55 | 2.68 | 2.81 | 2.55 | 2.56 |
| $T_{20}$ | $L_2O_0I_3$ | 2.72 | 2.60 | 2.64 | 2.95 | 2.60 | 2.51 |
| $T_{21}$ | $L_2O_1I_0$ | 2.70 | 2.65 | 2.65 | 2.99 | 2.65 | 2.63 |
| $T_{22}$ | $L_2O_1I_1$ | 2.80 | 2.75 | 2.75 | 3.03 | 2.75 | 2.68 |
| $T_{23}$ | $L_2O_1I_2$ | 2.95 | 2.89 | 2.86 | 3.09 | 2.89 | 2.72 |
| $T_{24}$ | $L_2O_1I_3$ | 3.15 | 2.96 | 3.08 | 3.11 | 2.96 | 3.14 |

# APPENDIX - VIII

| Treatment | | S content in stover (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Year 1 | | | Year 2 | | |
| | | $R_1$ | $R_2$ | $R_3$ | $R_1$ | $R_2$ | $R_3$ |
| $T_1$ | $L_0O_0I_0$ | 0.19 | 0.16 | 0.16 | 0.16 | 0.17 | 0.16 |
| $T_2$ | $L_0O_0I_1$ | 0.17 | 0.18 | 0.17 | 0.19 | 0.17 | 0.16 |
| $T_3$ | $L_0O_0I_2$ | 0.18 | 0.19 | 0.16 | 0.21 | 0.18 | 0.17 |
| $T_4$ | $L_0O_0I_3$ | 0.20 | 0.21 | 0.20 | 0.2 | 0.2 | 0.21 |
| $T_5$ | $L_0O_1I_0$ | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 |
| $T_6$ | $L_0O_1I_1$ | 0.19 | 0.18 | 0.18 | 0.19 | 0.19 | 0.21 |
| $T_7$ | $L_0O_1I_2$ | 0.19 | 0.21 | 0.19 | 0.24 | 0.19 | 0.23 |
| $T_8$ | $L_0O_1I_3$ | 0.20 | 0.22 | 0.21 | 0.23 | 0.2 | 0.21 |
| $T_9$ | $L_1O_0I_0$ | 0.19 | 0.20 | 0.19 | 0.22 | 0.19 | 0.21 |
| $T_{10}$ | $L_1O_0I_1$ | 0.21 | 0.21 | 0.21 | 0.24 | 0.21 | 0.25 |
| $T_{11}$ | $L_1O_0I_2$ | 0.22 | 0.22 | 0.22 | 0.27 | 0.22 | 0.24 |
| $T_{12}$ | $L_1O_0I_3$ | 0.20 | 0.21 | 0.24 | 0.27 | 0.2 | 0.22 |
| $T_{13}$ | $L_1O_1I_0$ | 0.21 | 0.22 | 0.22 | 0.19 | 0.21 | 0.21 |
| $T_{14}$ | $L_1O_1I_1$ | 0.24 | 0.21 | 0.22 | 0.21 | 0.24 | 0.22 |
| $T_{15}$ | $L_1O_1I_2$ | 0.26 | 0.23 | 0.24 | 0.21 | 0.26 | 0.22 |
| $T_{16}$ | $L_1O_1I_3$ | 0.27 | 0.21 | 0.25 | 0.23 | 0.27 | 0.21 |
| $T_{17}$ | $L_2O_0I_0$ | 0.15 | 0.22 | 0.20 | 0.21 | 0.15 | 0.22 |
| $T_{18}$ | $L_2O_0I_1$ | 0.25 | 0.22 | 0.19 | 0.21 | 0.25 | 0.27 |
| $T_{19}$ | $L_2O_0I_2$ | 0.28 | 0.24 | 0.21 | 0.22 | 0.28 | 0.26 |
| $T_{20}$ | $L_2O_0I_3$ | 0.28 | 0.26 | 0.25 | 0.22 | 0.28 | 0.28 |
| $T_{21}$ | $L_2O_1I_0$ | 0.24 | 0.25 | 0.25 | 0.22 | 0.24 | 0.24 |
| $T_{22}$ | $L_2O_1I_1$ | 0.27 | 0.26 | 0.26 | 0.26 | 0.27 | 0.26 |
| $T_{23}$ | $L_2O_1I_2$ | 0.30 | 0.27 | 0.24 | 0.26 | 0.3 | 0.27 |
| $T_{24}$ | $L_2O_1I_3$ | 0.30 | 0.29 | 0.28 | 0.27 | 0.3 | 0.31 |