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Effect of lime, farmyard manure and fertilizers on growth, yield and quality of soybean (*Glycine max* L. Merrill) in acid soils of Nagaland

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Abstract
A field experiment was conducted for two consecutive years to study the effect of lime, farmyard manure and fertilizers application on growth, yield and quality of soybean (*Glycine max* L. Merrill) in an acid soil of Nagaland. The experiment was laid down in split-split plot design with 24 treatment combinations comprising of three levels of lime *i.e.*, L_0: 0 kg ha^{-1}, L_1: 400 kg ha^{-1} and L_2: 10% of LR as main plot, two levels of FYM *i.e.*, O_0: 0 t ha^{-1} and O_1: 5 t ha^{-1} as sub-plot and four levels of fertilizers *i.e.*, I_0: 0% RDF, I_1: 50% RDF, I_2: 75% RDF and I_3: 100% RDF as sub-sub plot which were replicated thrice. 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 leaves, number of nodules and dry weight of nodules. Treatment $L_2O_1I_3$ gave significantly higher stover yield (4549.11 kg ha^{-1}), seed yield (2301.33 kg ha^{-1}) and number of pods plant^{-1} (95.83) than rest of the treatments. Oil content in seed was not significantly affected by the treatments however, oil and protein yield were higher in $L_2O_1I_3$ treatment. Highest available NPKS (400.63 kg ha^{-1}, 24.78 kg ha^{-1}, 109.09 kg ha^{-1} and 0.45 mg kg^{-1} respectively) content at harvest was associated with treatment of $L_2O_1I_3$.

Keywords: lime, fertilizers, farmyard manure, soybean, acid soils

Introduction
Soybean (*Glycine max* L. Merrill) is a leguminous crop which is a rich and cheap source of protein and fat (Protein 40-42%, oil 18-20%). Soybean has a very good adaptability towards a wide range of soils and climate. The North Eastern Region of India, including Nagaland, is an important soybean producing belt. It is grown on slopes, fallow jhum land, terraces and plains. In Nagaland, it is primarily utilized as a fermented product as well as a pulse crop. Despite of its popularity among the people and usage in various food items, there is less priority for cultivation in large scale and less importance has been given for commercial production. Cultivation can be found in all the districts and in almost all the villages but majority of the production is primarily for domestic home consumption only.

The agro-climatic conditions prevailing in Nagaland have been found to be highly favourable for soybean cultivation. Soil contains various nutrients that enables the plants to grow but these sources are exhaustible in the long run without proper nutrient management practices. 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) [3]. The productivity and income from soybean had 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) [25]. Since no single source is enough to meet all the nutrients requirement of the plant, integrated use of all the sources namely organic manures, fertilizers and biofertilizers needs careful attention.

Materials and Methods
The experiment was carried out at the research farm of the Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Nagaland University for two consecutive years *i.e*., 2014 and 2015. The experiment was laid out in Split-Split Plot Design (SSPD) with 24 treatment combinations consisting of three levels of lime *i.e.*, L_0: 0 kg ha^{-1}, L_1: 400 kg ha^{-1} and L_2: 10% of LR as main plot, two levels of FYM *i.e.*, O_0: 0 t ha^{-1} and O_1: 5 t ha^{-1} as sub-plot and four levels of fertilizers *i.e.* I_0: 0% RDF, I_1: 50% RDF, I_2: 75% RDF and I_3: 100% RDF as sub-sub plot which were replicated thrice. The whole experimental field was divided into three equal blocks and each block was again divided into 24 equal sized plots measuring 2.5 m x 2.5 m in order to accommodate the treatments.

The initial soil samples were 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. FYM was applied one month before the sowing to allow proper decomposition of the organic manures. Liming was done one month prior to sowing. Lime requirement was calculated using the Buffer method (Shoemaker *et al.*, 1960) [24]. The lime requirement as $CaCO_3$ was calculated to be 14.58 tonnes ha^{-1} to raise to pH 6 from intitial pH 5.53. Thus, 10% LR is 1458 kg ha^{-1}. Nitrogen content in both seed and stover was estimated by modified kjeldhal method as described by Black (1965) [5]. 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) [12]. Potassium was determined by flame photometry as described by Chapman and Pratt (1961). The plant samples were digested using HNO_3-$HClO_4$ and the sulphur content was determined turbidimetric method as described for soil sulphur (Chesnin and Yien, 1950) [11]. Oil content was estimated using soxhlet extraction unit as per method described by AOAC (1960). Available nitrogen was estimated by alkaline potassium permanganate method as outlined by Subbiah and Asija (1956). Available phosphorus was estimated using 0.03N NH_4F in 0.025N HCl extractant by Bray and Kurtz No. 1 method (Bray and Kurtz, 1945). The available potassium was determined by flame photometer after extracting the soil with neutral normal ammonium acetate (pH 7.0) (Jackson, 1973) [12]. The available sulphur was determined by turbidimetric method using 1:5 soil and extractant of 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) [11].

Results and Discussion

Effect of lime, farmyard manure and fertilizers on plant height

The mean plant height of crop growth was found to be significantly influenced by the application of lime (Table 1). The maximum and minimum plant height was recorded in the treatment L_2 and L_0 with 102.63 and 90.81 cm, respectively. In general, the application of lime was observed to boost the growth of the crop due to increase in the soil pH towards neutrality. It was also found to be significantly affected by the application of farmyard manure (Table 1). The maximum and minimum plant height was recorded in treatment O_1 and O_0 with 98.36 and 94.75 cm at 60, respectively. Application of fertilizers also significantly influenced plant height (Table 1). The maximum and minimum plant height was recorded in treatment I_3 and I_0 with 97.92 and 95.14 cm, respectively. The plant height of crop was significantly affected by the application of lime, farmyard manure and fertilizers (Table 2). Among the treatments, the maximum and minimum plant height was recorded in $L_2O_1I_3$ and $L_0O_0I_0$ with 107.17 cm and 86.67 cm, respectively. The results revealed that $L_2O_1I_3$ enhanced plant growth significantly as compared to the other treatments.

Combined effect of lime @ 10% LR along with FYM @ 5 t ha^{-1} and 100% RDF resulted in maximum plant height 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) [15].

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

The number of leaves of crop growth was found to be significantly influenced by the application of lime (Table 1). The maximum and minimum number of leaves was recorded in the treatment L_2 and L_0 with 23.81 and 21.56, respectively. 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. The application of farmyard manure also significantly affected the number of leaves (Table 1). Among the treatments, the maximum and minimum number of leaves was recorded in O_1 and O_0 with 23.31 and 22.06, respectively. The number of leaves of crop growth was also found to be significantly influenced by the application of fertilizers (Table 1). The maximum and minimum number of leaves was recorded in treatment I_3 and I_0 with 24.33 and 21.33, respectively. The mean number of leaves of crop growth was found to be significantly affected by the application of lime, farmyard manure and fertilizers (Table 2). Among the treatments, the maximum and minimum number of leaves was recorded in $L_2O_1I_3$ and $L_0O_0I_0$ with 26.33 and 18.83, respectively. The results revealed that application of $L_2O_1I_3$ enhanced plant growth significantly as compared to the other treatments.

The combined effect of lime @ 10% LR along with FYM @ 5 t ha^{-1} and 100% RDF resulted in maximum number of leaves with 26.33. 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. Similar results on the number of leaves were observed by Bier and Singh (2021) [7] with combined application of sulphur and boron. 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}.

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

The number of nodules was found to be significantly influenced by the application of lime (Table 1) where the maximum and minimum number of nodules was recorded in L_2 and L_0 with 64.85 and 53.04, respectively. 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. The maximum and minimum number of nodules was recorded in the treatment O_1 and O_0 with 61.61 and 59.06, respectively (Table 1) with application of farmyard manure. The maximum and minimum number of nodules was recorded in treatment I_2 and I_0 with 61.61 and 57.94, respectively (Table 1) with application of fertilizers. The mean number of nodules of crop growth was found to be significantly affected by the application of lime, farmyard manure and fertilizers (Table 2). Among the treatments, the maximum and minimum number of nodules was recorded in $L_1O_1I_2$ with 67.67 and 49.50, respectively. The results revealed that application of $L_2O_1I_3$ enhanced nodulation significantly compared to the other treatments.

Overall, 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 and this could be due to addition of nutrients through FYM and fertilizer sources. Similar results were reported by Najar *et al.* (2011) [16], Bier and Singh (2021) [7] and Longkumer *et al.*, (2017). Increased production of nodules with the increased application of P was also observed by Vyas *et al.* (1987) [28].

Effect of lime, farmyard manure and fertilizers on dry weight of nodules

The mean dry weight of nodules of crop growth was found to be significantly affected by the application of lime (Table

1). The highest dry weight of nodules was recorded in the treatment L_2 and L_0 with 0.462 and 0.380 g, respectively. 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. Application of farmyard manure (Table 1) resulted in maximum dry weight of nodules in treatment O_1 and O_0 with 0.455 and 0.410 g, respectively. The mean dry weight of nodules was also found to be significantly affected by the application of fertilizers (Table 1). The highest dry weight of nodules was recorded in treatment I_3 and I_2 with 0.453 and 0.409 g g in 2014 and 2015, respectively. The mean dry weight of nodules of was found to be significantly influenced by the application of lime, farmyard manure and fertilizers (Table 2). Among the treatments, the maximum and minimum dry weight of nodules was recorded in $L_1O_1I_3$ and $L_0O_0I_2$ with 0.573 and 0.317 g, respectively. The dry weight of nodules per plant corresponds with the number of nodules per plant. Similar dry weight of nodules was also reported by Lakshman *et al.* (2015) [13].

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

The maximum number of pods plant^{-1} was recorded in the treatment L_2 as 81.48, whereas the minimum was recorded in the treatment L_0 as 59.85 with application of lime (Table 3). The number of pods plant^{-1} was found to be significantly influenced by the application of farmyard manure (Table 3) where the maximum number of pods plant^{-1} was recorded in treatment O_1 as 72.65 whereas the minimum was recorded in O_0 as 66.76. Application of fertilizers (Table 3) also significantly affected number of pods plant^{-1} maximum number of pods plant^{-1} was recorded in treatment I_3 as 77.19 and the minimum was recorded in the treatment I_0 as 64.86. The number of pods plant^{-1} was also found to be significantly influenced by the application of lime, farmyard manure and fertilizers (Table 4). Among the treatments, the maximum number of pods plant^{-1} was recorded in $L_2O_1I_3$ and $L_0O_1I_0$ with 95.83 and 52.17. 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. The increased number of pods per plant could be due to the enhanced root development, fruiting and overall improved growth and development of the plant with application of RDF + Zinc (Sentimenla *et al*., 2022) [20]. Similar findings were reported by Mishra *et al.* (1999) [15] using treatment combinations of lime, FYM and fertilizers. Saxena *et al.* (2013) [19] 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}.

Effect of lime, farmyard manure and fertilizers on seed yield

Application of lime significantly affected seed yield (Table 3) and the maximum and minimum seed yield was recorded in L_2 and L_0 with 2065.09 kg ha^{-1} and 1429.81 kg ha^{-1}, respectively. The seed yield was also found to be significantly influenced by the application of farmyard manure (Table 3). Among the treatments, the maximum and minimum seed yield was recorded in O_1 and O_0 with 1897.19 and 1688.08 kg ha^{-1}, respectively. The highest seed yield was recorded in treatment I_3 as 1910.42 kg ha^{-1} whereas the lowest was recorded in treatment I_0 as 1698.15 kg ha^{-1} with application of fertilizers (Table 3). The seed yield was found to be significantly influenced by the application of lime, farmyard manure and fertilizers (Table 4). The maximum and minimum seed yield was recorded in $L_2O_1I_3$ and $L_0O_1I_0$ with 2301.33 and 1176.34 kg ha^{-1}, respectively. 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) [15] reported that the lime, organic and inorganic combination gave significant higher yield in acidic red soils. Sarkar (2012) [18] 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.

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

The protein and oil content were found to be significantly affected by the application of lime (Table 5) where the maximum protein content was recorded in L_2 as 36.78 whereas the minimum was recorded in L_0 as 32.16. In terms of oil content, the maximum and minimum was recorded in L_2 and L_0 with 18.69 % and 17.11 %, respectively. Farmyard manure also had significant effect (Table 5) resulting in maximum protein content in treatment O_1 as 35.06 whereas the minimum was recorded in O_0 as 33.78. In terms of oil content, the maximum was recorded in treatment O_1 as 18.21 % whereas the minimum was recorded in O_0 as 17.58 % during 2014 and 2015, respectively. The protein and oil content were also found to be significantly affected by the application of fertilizers (Table 5). Among the treatments, the maximum protein content was recorded in treatment I_3 as 35.16 whereas the minimum was recorded in I_0 as 33.64. In terms of oil content, the maximum was recorded in treatment I_3 as 18.29 % whereas the minimum was recorded in O_0 as 17.45 %. Application of lime, farmyard manure and fertilizers (Table 6) had significant effect and among the treatments, the maximum and minimum protein content was recorded in $L_2O_1I_2$ and $L_0O_0I_0$ with 38.29% and 31.21%, respectively. In terms of oil content, the maximum and minimum was recorded in $L_2O_1I_1$ and $L_0O_0I_0$ with 19.20 % and 15.97%, respectively. 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. Agarwal *et al.* (2007) [2] also reported that protein content increased through liming when compared to unlimed treatments. Saxena *et al.* (2013) [19] 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) [19]. Singh and Rai (2004) [26] also

reported that application of recommended NPK with FYM resulted in higher oil content in soybean seeds.

Effect of lime, farmyard manure and fertilizers on stover yield

The stover yield of crop growth was found to be significantly affected by the application of lime (Table 3). The highest stover yield was recorded in treatment L_2 as 3968.81 kg ha^{-1} whereas the minimum was in L_0 as 2578.75 kg ha^{-1}. The stover yield of crop growth was found to be significantly influenced by the application of farmyard manure (Table 3). The maximum stover yield was recorded in treatment O_1 as 3474.15 kg ha^{-1} whereas the minimum was associated with O_0 as 3072.97 kg ha^{-1}. Application of fertilizers also significantly affected the stover yield (Table 3) where the highest stover yield was recorded in treatment I_3 as 3644.65 kg ha^{-1} whereas the lowest was recorded in treatment I_0 as 3019 kg ha^{-1}. Stover yield was found to be significantly influenced by the application of lime, farmyard manure and fertilizers (Table 4). Among the treatments, the maximum and minimum stover yield was recorded in $L_2O_1I_3$ and $L_0O_1I_0$ with 4549.11 kg ha^{-1} and 1176.34 kg ha^{-1}, 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) [19]. Palve *et al.* (2011) also observed similar results with application of 100% RDF along with FYM @ 5 t ha^{-1}.

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

The protein and oil yield were significantly affected by the application of lime (Table 5) where the maximum and minimum protein yield was recorded in L_2 and L_0 with 761.00 and 460.79 kg ha^{-1}, respectively. In terms of oil yield, the maximum and minimum was recorded in treatment L_2 and L_0 with 388.17 and 245.91 kg ha^{-1}, respectively. It was also significantly influenced by the application of farmyard manure (Table 5) where the maximum and minimum protein yield was recorded in O_1 and O_0 with 670.51 and 575.49 kg ha^{-1}, respectively and in terms of oil yield, the maximum and minimum was recorded in the treatment O_1 and O_0 with 347.92 and 299.61 kg ha^{-1}, respectively. The protein and oil yield were also found to be significantly affected by the application of fertilizers (Table 5). Among the treatments, the maximum and minimum protein yield was recorded in I_3 and I_0 with 677.38 and 576.44 during 2014 and 2015, respectively. In terms of oil yield, the minimum and minimum oil yield was recorded in I_3 and I_0 with 352.00 kg ha^{-1}and 299.45 kg ha^{-1} during 2014 and 2015, respectively. The protein and oil yield were also found to be significantly influenced by the application of lime, farmyard manure and fertilizers (Table 6). Among the treatments, the maximum and minimum protein and was recorded in $L_2O_1I_3$ with 881.23 and 367.74, respectively. In terms of oil yield, the maximum and minimum was recorded in treatment $L_2O_1I_3$ and $L_0O_0I_0$ with 445.73 kg ha^{-1} 189.44 kg ha^{-1}, respectively. Overall, the highest protein yield of 881.23 kg ha^{-1} was recorded with treatment of 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 has 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. 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) [19]. The increased in protein and oil yield could also attributed to the attributed to the increased seed yield as a result of balanced fertilization (Bier and Singh, 2021) [7].

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

The N, P, K and S uptake had shown significant difference among different treatments. It was apparent from table 7, the maximum N, P, K and S uptake was recorded in L_2 as 188.27, 19.61, 154.01 kg ha^{-1} and 16.03 mg kg^{-1}, respectively. The minimum N, P, K and S uptake was recorded in L_0 as 110.27, 10.61, 75.72 kg ha^{-1} and 7.92 mg kg^{-1}, respectively. The N, P, K and S uptake was observed to follow an increasing trend with the increase in application of lime. With application of farmyard manure, there was significant difference in N, P, K and S uptake. It was apparent from the table 7, the maximum N, P, K and S uptake was recorded in O_1 as 163.24, 16.40, 127.41 kg ha^{-1} and 13.24 mg kg^{-1}, respectively whereas the minimum N, P, K and S uptake by seeds were recorded in O_0 as 139.14, 13.64, 104.00 kg ha^{-1} and 10.76 mg kg^{-1}, respectively. The results revealed that there was a significant difference among the treatments (Table 7) with application of fertilizers and the maximum N, P, K and S uptake was recorded in I_3 as 168.01, 17.40, 133.51 kg ha^{-1} and 14.09 mg kg^{-1}, respectively. The minimum N, P, K and S uptake were recorded in I_0 as 137.43, 12.89, 101.18 kg ha^{-1} and 10.10 mg kg^{-1}, respectively. The data indicated that the N, P, K and S uptake was found to be significantly influenced by the application of lime, farmyard manure and fertilizers (Table 8). Among the treatments, the maximum N, P, K and S uptake was recorded in $L_2O_1I_3$ with 220.99, 24.41, 194.53 kg ha^{-1} and 20.56 mg kg^{-1}, respectively. The minimum N, P, K and S uptake was recorded in $L_0O_1I_0$ with 89.61, 8.17, 57.22 kg ha^{-1} and 6.14 mg kg^{-1} during 2014 and 2015, respectively. Higher nutrient uptake which is directly proportional to more nutrient input was reported by Saxena *et al.* (2013) [19]. Increased N uptake by soybean by applying 100% RDF in combination with FYM has also been reported by Singh and Rai (2004) [26]. Application of lime along with NPK increases the N uptake (Chaterjee *et al.*, 2005). The

increased N uptake could be attributed to the synthesis of protein, fats and carbohydrates due to stimulation on the enzyme proteinase (Sentimenla *et al.*, 2022) [20]. 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) [15] and Singh and Rai (2004) [26] 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) [15, 19]. In acidic soils, NPK + lime resulted in higher K uptake as reported by Singh *et al.* (2009). 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. Sharma *et al.* (2014) [22] 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) [29].

Effect of lime, farmyard manure and fertilizers on available nutrient content in soil after 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 9 and had resulted in significant difference among various treatments. The maximum available N, P, K and S content in soil was recorded in L_2 with 369.02, 23.26, 97.81 kg ha^{-1} and 0.396 mg kg^{-1}, respectively. The minimum available N, P, K and S content in soil was recorded in L_0 with 340.26, 16.17, 83.69 kg ha^{-1} and 0.262 mg kg^{-1}, 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. 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 9, the maximum N, P, K and S content in soil at harvest was recorded in O_1 with 364.68, 20.62, 92.76 kg ha^{-1} and 0.351 mg kg^{-1}, respectively. The minimum available N, P, K and S content in soil at harvest were recorded in O_0 with 341.82, 18.92, 89.34 kg ha^{-1} and 0.326 mg kg^{-1}, respectively. The data presented in table 5 revealed that there was a significant difference among the treatments (Table 9). The maximum available N, P, K and S content in soil at harvest was recorded in I_3 with 372.01, 20.60, 98.68 kg ha^{-1} and 0.376 mg kg^{-1}, respectively. The minimum available N in soil at harvest was observed in I_1 as 343.62 kg ha^{-1} while the minimum available P and K content in soil after harvest was recorded in O_0 with 18.63 and 81.35 kg ha^{-1}, respectively. The minimum available S content in soil at harvest was recorded in I_1 as 0.315 mg kg^{-1}.

The data indicated that available N, P and K in soil at harvest were found to be significantly affected by the application of lime, farmyard manure and fertilizers (Table 10). Among the treatments, the maximum available N, P and K content in soil at harvest was recorded in $L_2O_1I_3$ with 400.63, 24.78 and 109.09 kg ha^{-1}, respectively. The minimum available N content in soil at harvest was recorded in $L_0O_0I_1$ with 303.15 kg ha^{-1} whereas in case of P and K the minimum available content in soil at harvest was recorded in $L_0O_0I_0$ with 14.38 and 70.06 kg ha^{-1}, respectively. The increase in available N is attributed to the higher supply of nutrients through fertilizers and FYM. Chatterjee *et al.* (2005) [10] reported that available N in soil is more when the treatments of NPK are incorporated with various doses of lime. The increase in available P content in soil is due to the increase in pH due to application of lime. Chatterjee *et al.* (2005) [10] 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) [26]. 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) [10]. The maximum available S in soil at harvest was recorded in treatments $L_2O_1I_2$ and $L_2O_1I_3$ with 0.45 mg kg^{-1} whereas the minimum available S was recorded at 0.22 mg kg^{-1} in $L_0O_0I_1$. 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.

Table 1: Effect of lime, farmyard manure and fertilizers on plant height, number of leaves per plant, number of nodules per plant, dry weight of nodule of soybean

Treatments	Plant height (cm)			Number of leaves $plant^{-1}$			Number of nodules $plant^{-1}$			Dry weight of nodule (g)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
L_0	90.50	91.13	90.81	21.46	21.67	21.56	53.04	53.04	53.04	0.380	0.380	0.380
L_1	95.83	96.63	96.23	22.67	22.67	22.67	62.88	63.00	62.94	0.455	0.456	0.455
L_2	102.17	103.08	102.63	23.63	24.00	23.81	64.58	65.13	64.85	0.460	0.464	0.462
SEm±	*3.24*	*3.64*	*2.44*	*0.17*	*0.15*	*0.11*	*1.13*	*1.04*	*0.77*	*0.008*	*0.007*	*0.006*
CD(P=0.05)	*12.71*	*14.31*	*7.95*	*0.65*	*0.57*	*0.36*	*4.43*	*4.10*	*2.51*	*0.032*	*0.029*	*0.018*
O_0	94.36	95.14	94.75	21.92	22.19	22.06	58.94	59.17	59.06	0.409	0.411	0.410
O_1	97.97	98.75	98.36	23.25	23.36	23.31	61.39	61.61	61.50	0.454	0.455	0.455
SEm±	*1.25*	*3.75*	*1.98*	*0.17*	*0.11*	*0.10*	*1.01*	*0.99*	*0.71*	*0.007*	*0.007*	*0.005*
CD(P=0.05)	*NS*	*NS*	*NS*	*0.60*	*0.37*	*0.31*	*NS*	*NS*	*NS*	*0.024*	*0.024*	*0.015*
I_0	94.83	95.44	95.14	21.33	21.33	21.33	57.83	58.06	57.94	0.436	0.437	0.436
I_1	95.72	96.61	96.17	22.06	22.17	22.11	59.94	60.33	60.14	0.429	0.432	0.430
I_2	96.61	97.39	97.00	22.78	23.11	22.94	61.50	61.61	61.56	0.408	0.409	0.409

I_3	97.50	98.33	97.92	24.17	24.50	24.33	61.39	61.56	61.47	0.453	0.454	0.453
SEm±	*2.49*	*5.02*	*2.80*	*0.21*	*0.20*	*0.14*	*1.57*	*1.54*	*1.10*	*0.011*	*0.011*	*0.008*
CD(P=0.05)	*NS*	*NS*	*NS*	*0.60*	*0.56*	*0.40*	*NS*	*NS*	*3.10*	*NS*	*NS*	*NS*

Table 2: Interaction effect of lime, farmyard manure and fertilizers on plant height, number of leaves per plant, number of nodules per plant, dry weight of nodule of soybean

Treatments	Plant height (cm)			Number of leaves plant^{-1}			Number of nodules plant^{-1}			Dry weight of nodule (g)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
$L_0O_0I_0$	86.33	87.00	86.67	19.00	18.67	18.83	49.00	50.00	49.50	0.358	0.365	0.361
$L_0O_0I_1$	87.67	88.33	88.00	20.00	20.33	20.17	51.67	51.33	51.50	0.366	0.363	0.364
$L_0O_0I_2$	89.00	89.67	89.33	21.00	21.67	21.33	52.00	51.33	51.67	0.319	0.315	0.317
$L_0O_0I_3$	90.33	91.00	90.67	23.00	23.67	23.33	54.67	54.67	54.67	0.364	0.364	0.364
$L_0O_1I_0$	91.67	92.00	91.83	20.67	21.00	20.83	51.33	50.33	50.83	0.471	0.461	0.466
$L_0O_1I_1$	92.33	93.00	92.67	21.67	21.33	21.50	55.67	56.33	56.00	0.425	0.430	0.428
$L_0O_1I_2$	93.00	93.67	93.33	22.33	23.00	22.67	56.67	57.33	57.00	0.320	0.324	0.322
$L_0O_1I_3$	93.67	94.33	94.00	24.00	23.67	23.83	53.33	53.00	53.17	0.416	0.413	0.415
$L_1O_0I_0$	94.33	95.00	94.67	21.67	22.00	21.83	60.67	61.33	61.00	0.443	0.448	0.446
$L_1O_0I_1$	94.67	95.33	95.00	21.67	21.67	21.67	58.33	58.67	58.50	0.403	0.405	0.404
$L_1O_0I_2$	95.00	96.00	95.50	23.00	22.67	22.83	62.67	62.33	62.50	0.458	0.456	0.457
$L_1O_0I_3$	95.67	96.33	96.00	24.67	24.33	24.50	63.33	63.67	63.50	0.443	0.445	0.444
$L_1O_1I_0$	96.00	96.67	96.33	21.33	21.33	21.33	60.67	60.00	60.33	0.390	0.385	0.388
$L_1O_1I_1$	96.00	97.33	96.67	22.33	22.33	22.33	65.33	65.67	65.50	0.422	0.424	0.423
$L_1O_1I_2$	97.33	98.00	97.67	22.33	22.33	22.33	67.33	68.00	67.67	0.506	0.511	0.509
$L_1O_1I_3$	97.67	98.33	98.00	24.33	24.67	24.50	64.67	64.33	64.50	0.574	0.571	0.573
$L_2O_0I_0$	98.33	99.00	98.67	21.33	21.00	21.17	61.67	62.33	62.00	0.487	0.493	0.490
$L_2O_0I_1$	99.67	100.33	100.00	22.00	22.33	22.17	63.67	64.33	64.00	0.451	0.456	0.454
$L_2O_0I_2$	100.33	101.33	100.83	23.00	23.67	23.33	64.67	64.33	64.50	0.366	0.364	0.365
$L_2O_0I_3$	101.00	102.33	101.67	22.67	24.33	23.50	65.00	65.67	65.33	0.449	0.453	0.451
$L_2O_1I_0$	102.33	103.00	102.67	24.00	24.00	24.00	63.67	64.33	64.00	0.465	0.470	0.468
$L_2O_1I_1$	104.00	105.33	104.67	24.67	25.00	24.83	65.00	65.67	65.33	0.507	0.512	0.510
$L_2O_1I_2$	105.00	105.67	105.33	25.00	25.33	25.17	65.67	66.33	66.00	0.480	0.485	0.482
$L_2O_1I_3$	106.67	107.67	107.17	26.33	26.33	26.33	67.33	68.00	67.67	0.471	0.476	0.473
SEm±	*6.10*	*12.29*	*6.86*	*0.51*	*0.48*	*0.35*	*3.85*	*3.77*	*2.70*	*0.027*	*0.027*	*0.019*
CD(P=0.05)	*NS*	*NS*	*19.34*	*1.46*	*1.37*	*0.98*	*11.05*	*10.83*	*7.60*	*0.078*	*0.077*	*0.054*

Table 3: Effect of lime, farmyard manure and fertilizers on number of pods per plant, seed yield and stover yield of soybean

Treatments	Number of pods plant^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
L_0	59.58	60.13	59.85	1428.86	1430.76	1429.81	2578.64	2578.87	2578.75
L_1	67.71	67.88	67.79	1883.03	1882.96	1883.00	3272.83	3273.40	3273.11
L_2	81.42	81.54	81.48	2064.74	2065.45	2065.09	3968.42	3969.20	3968.81
SEm±	*0.93*	*1.00*	*0.69*	*48.20*	*39.95*	*31.30*	*53.03*	*85.13*	*50.15*
CD(P=0.05)	*3.66*	*3.94*	*2.24*	*189.27*	*156.86*	*102.08*	*208.23*	*334.25*	*163.54*
O_0	66.61	66.92	66.76	1687.23	1688.93	1688.08	3072.51	3073.42	3072.97
O_1	72.53	72.78	72.65	1897.19	1897.18	1897.19	3474.08	3474.22	3474.15
SEm±	*1.07*	*0.89*	*0.70*	*42.33*	*35.75*	*27.70*	*41.88*	*28.69*	*25.38*
CD(P=0.05)	*3.71*	*3.09*	*2.15*	*146.47*	*123.70*	*85.36*	*144.92*	*99.29*	*78.21*
I_0	64.67	65.06	64.86	1696.72	1699.58	1698.15	3018.67	3019.47	3019.07
I_1	66.50	66.83	66.67	1750.46	1750.07	1750.27	3127.79	3127.28	3127.53
I_2	70.17	70.06	70.11	1810.12	1813.27	1811.70	3302.49	3303.47	3302.98
I_3	76.94	77.44	77.19	1911.53	1909.31	1910.42	3644.23	3645.07	3644.65
SEm±	*2.01*	*1.24*	*1.18*	*46.31*	*47.85*	*33.29*	*72.27*	*56.32*	*45.81*
CD(P=0.05)	*5.76*	*3.54*	*3.32*	*132.82*	*137.24*	*93.86*	*207.30*	*161.53*	*129.16*

Table 4: Interaction effect of lime, farmyard manure and fertilizers on number of pods per plant, seed yield and stover yield of soybean

Treatments	Number of pods plant^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2014	2014	2014	2014	2015	Pooled	2014	2015	Pooled
$L_0O_0I_0$	56.33	56.33	56.33	1173.91	1178.77	1176.34	2383.50	2385.17	2384.33
$L_0O_0I_1$	59.33	59.33	59.33	1210.39	1218.72	1214.56	2262.57	2261.91	2262.24
$L_0O_0I_2$	59.00	59.00	59.00	1277.26	1282.26	1279.76	2346.84	2349.51	2348.17
$L_0O_0I_3$	60.33	60.33	60.33	1450.58	1445.56	1448.07	2411.13	2414.00	2412.57
$L_0O_1I_0$	52.00	52.00	52.00	1547.15	1551.13	1549.14	2437.76	2433.63	2435.69
$L_0O_1I_1$	57.00	57.00	57.00	1543.82	1537.80	1540.81	2688.84	2686.84	2687.84
$L_0O_1I_2$	59.67	59.67	59.67	1557.38	1564.71	1561.04	2607.50	2610.61	2609.05
$L_0O_1I_3$	73.00	73.00	73.00	1670.41	1667.07	1668.74	3490.95	3489.28	3490.12
$L_1O_0I_0$	62.33	62.33	62.33	1677.19	1681.12	1679.15	3235.33	3238.46	3236.90

$L_1O_0I_1$	63.00	63.00	63.00	1767.18	1765.51	1766.35	3114.56	3115.90	3115.23
$L_1O_0I_2$	63.00	63.00	63.00	1820.60	1824.48	1822.54	3199.68	3200.75	3200.22
$L_1O_0I_3$	72.33	72.33	72.33	1980.49	1976.14	1978.32	3358.11	3357.25	3357.68
$L_1O_1I_0$	68.33	68.33	68.33	1837.17	1839.84	1838.51	2954.31	2956.37	2955.34
$L_1O_1I_1$	64.33	64.33	64.33	1947.25	1945.25	1946.25	3022.17	3020.50	3021.34
$L_1O_1I_2$	68.67	68.67	68.67	2070.56	2072.23	2071.40	3574.16	3572.66	3573.41
$L_1O_1I_3$	79.67	79.67	79.67	1963.81	1959.15	1961.48	3724.28	3725.32	3724.80
$L_2O_0I_0$	69.67	69.67	69.67	1914.33	1917.67	1916.00	3068.66	3069.93	3069.29
$L_2O_0I_1$	68.00	68.00	68.00	1903.68	1900.35	1902.01	3424.28	3422.85	3423.57
$L_2O_0I_2$	85.00	85.00	85.00	1967.76	1970.82	1969.29	3732.45	3731.11	3731.78
$L_2O_0I_3$	81.00	81.00	81.00	2103.41	2105.75	2104.58	4333.02	4334.25	4333.63
$L_2O_1I_0$	79.33	79.33	79.33	2030.58	2028.92	2029.75	4032.45	4033.28	4032.86
$L_2O_1I_1$	87.33	87.33	87.33	2130.47	2132.81	2131.64	4254.31	4255.68	4254.99
$L_2O_1I_2$	85.67	85.67	85.67	2167.14	2165.14	2166.14	4354.31	4356.17	4355.24
$L_2O_1I_3$	95.33	95.33	95.33	2300.50	2302.17	2301.33	4547.90	4550.33	4549.11
SEm±	*4.92*	*4.92*	*4.92*	*113.43*	*117.21*	*81.55*	*177.04*	*137.95*	*112.22*
CD(P=0.05)	*14.11*	*14.11*	*14.11*	*325.34*	*336.18*	*229.92*	*507.77*	*395.67*	*316.37*

Table 5: Effect of lime, farmyard manure and fertilizers on protein and oil content and yield

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

Table 6: Effect of lime, farmyard manure and fertilizers on protein and oil content and yield

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

Table 7: Effect of lime, farmyard manure and fertilizers on nutrient uptake by soybean

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})			S (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 8: Effect of lime, farmyard manure and fertilizers on nutrient uptake by soybean

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})			S (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*

Table 9: Effect of lime, farmyard manure and fertilizers on available nutrient content in soil after harvest

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})			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 10: Effect of lime, farmyard manure and fertilizers on available nutrient content in soil after harvest

Treatments	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})			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*

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. 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. Combined treatment of lime, farmyard manure and fertilizers showed the best results across various parameters and helped to improve crop production.

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