Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2016, Volume 29, Issue 2, Page 145-152

Growth and Physiology of Groundnut as Influenced by Micronutrients and Liming in Acid Soil of North East India

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ARTICLE INFO

Article history:
Received 20 February 2016
Revision Received 8 March 2016
Accepted 9 March 2016

Key words:
Micronutrient, liming, acidity, nodule, growth rate, groundnut

ABSTRACT

The field experiment was conducted in ICAR Research complex for NEH Region, Umiam, Meghalaya (980 m above mean sea level) in groundnut with six micronutrient treatments *viz,* control (no micronutrient), Zn @ 5 kg/ha, B @ 1 kg/ha, Mo @ 0.5 kg/ha, Zn + Mo, Zn + B + Mo (all the micronutrients were applied through soil application) and two soil amendment practices *viz*, lime @ 500 kg/ha (furrow application) and no lime. The objectives were to assess the effect of liming and micronutrient application on growth and physiological attributes of groundnut. Application of Mo produced significantly taller groundnut plants, dry matter/plant, nodule counts and weight/plant than control at all growing stages, which was at par with combined application of Zn + Mo and Zn + B + Mo. Liming significantly increased plant height, leaf area index, dry matter production, nodule weight and counts/plant than no liming. Application of micronutrients and liming also improved crop growth rate and relative growth rates of plant than those under control. Mo application alone registered significantly higher kernel yield (1720 kg/ha) than control (1316 kg/ha) and sole application of B (1624 kg/ha) and Zn (1562 kg/ha). The kernel yields obtained with integrated application of Zn + B + Mo and Zn + Mo were statistically similar to Mo alone. Furrow liming also enhanced the kernel yield (1756 kg/ha) significantly than that of no-liming (1511 kg/ha).

1. Introduction

Groundnut is an important edible oilseed crop in India, cultivated in about 8 million ha. It is also known as earthnuts, peanuts, goobers, goober peas, pindas, jack nuts, pinders, manila nuts, g-nuts, and monkey nuts (Annadurai *et al.,* 2009). Groundnut is primarily used for oil extraction and also consumed directly because of its high food value which is due to higher content of protein (22%), carbohydrates (10%), minerals (3%), niacin (17 mg/100g) and vitamin B especially thiamin content of 1 mg /100g (Rajagopal *et al*., 2000). Groundnut is cultivated in 108 countries around the world. The average productivity of groundnut in India is around 1178 kg/ha, which is far less than the world's average 1400 kg/ha (Directorate of Groundnut Research 2008). In India groundnut is grown mostly in five states namely Andhra Pradesh, Gujarat, Tamilnadu, Karnataka, Maharashtra, and together they account for about 90% of the total crop area. Groundnut is a non - traditional crop in north eastern region (NER) of India. However, the production potential of groundnut in this region is very high as indicated by the average production under demonstrators. Groundnut is a highly potential crop under existing upland rice and maize based cropping systems in NER of India. In 2006, it was reported that groundnut in NER was cultivated in an area of about 4,000 ha (Munda *et al.,* 2006). The potential of groundnut production in NER can be substantially increased by amelioration of soil acidity and application of micronutrients such as boron (B), Zinc (Zn), and molybdenum (Mo). Zn plays an important role in biochemical pathways like carbohydrate metabolism,

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photosynthesis, conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, integrity of biological membranes and promote resistance to infection by certain pathogens (Alloway 2008). Application of B have received a great deal of importance in high responsive oil seed crops during the last few years, because of widespread occurrence of deficiency from different parts of India. B is very useful in the production of legume seed and also for proper seed setting, oil content and seed quality and helps in the absorption of nitrogen to a certain extent. Significant response of oil seed crops to the application of boron containing fertilizers have also been reported (Chakraborty and Das 2000; Mandal *et al.,* 2009).

Mo is needed by nodule bacteria in the process of nitrogen fixation from the atmosphere and its deficiency symptoms appear pale green colour in developing leaves which ultimately decrease the growth, yield and quality of crops (Boswell 2000). Mo has a positive effect on yield, quality and nodules forming in legume crops. The functions of Mo in leguminous plants include nitrate reduction, nodulation, nitrogen fixation and general metabolism (Togay *et al.,* 2008).

The acid soils occur primarily in high rainfall, hilly/mountainous. A substantial area with pH value less than 5.5 is more problematic with severe deficiencies of P, Ca, Mg and Mo and toxicities of Al and Fe. The harmful effects of soil acidity can be eliminated by raising pH by adding suitable quantity of lime. Addition of lime neutralizes soil acidity, increases microbial activity and nutrient availability and improves the physical condition of soil. Liming helps to provide available Ca to the soil which improves gynophore development (pegging) in groundnut (Slack 1972).

There is lack of sufficient information on the effect of micronutrients and soil amendments for cultivation of groundnut in acid soil condition. Keeping these points in view, the present study was undertaken to study the effect of micronutrients and liming on growth and physiology of groundnut.

2. Materials and Methods

The field experiment was conducted on the upland Agronomy experimental field, ICAR Research complex for NEH Region, Umiam, Meghalaya during *Kharif* season of 2013. The site was previously under rice + groundnut intercropping system for two consecutive years under uniform package of practices. The experimental site receives an average long term rainfall of 2450 mm annually. During the experimental season, 1062 mm rainfall was received for growing period of groundnut. The relative humidity (RH) ranged from 69.3 to 88.7%. Max temperature ranged from 28.5 to 29^{0}C and minimum temperature ranged from 18.9 to 20.2^{0}C.

The experiment was laid out in a factorial randomized block design (FRBD) with six micronutrients treatment *viz.,* control (no micronutrient), Zn @ 5 kg/ha, B @ 1 kg/ha, Mo @ 0.5 kg/ha, Zn + Mo, Zn + B + Mo and two soil amendment practices viz. lime @ 500 kg/ha (furrow application) and no lime application. All the micronutrients were applied through soil application. The plot size was 12 m^2 with adequate drainage facility. Groundnut was sown at the spacing of 30×10 cm^2. N, P and K (30:60:40 kg/ha) were applied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Lime @ 500 kg/ha was applied in furrows seven days before sowing and properly mixed with the soil.

All recommended agronomic practices were followed for groundnut. The rate of dry matter production per plant per unit land area per unit time *i.e.,* crop growth rate (CGR) was calculated using the formula proposed by Watson (1952) and expressed mg/cm^2/day. The rate of increase in dry weight of plant per unit dry weight *i.e.,* relative growth rate (RGR) was expressed in mg/g/day was calculated by using the formula suggested by Blackman (1919). The chlorophyll index of groundnut was determined with chlorophyll meter SPAD-502 (Konica Minolta Sensing Inc Japan), which gives the chlorophyll index of the leaf samples inserted, along with provision for averaging. Five plants were selected randomly from each plot and recorded chlorophyll index on fully opened leaf from top at 30, 60, 90 days after sowing (DAS) of Groundnut. The leaf area of the destructive plant samples of groundnut was obtained by using the graph paper method. Maximum length and maximum width of the leaf lamina of ten plants per plot was taken. The factor obtained was multiplied to the maximum length and width of each leaf and average was taken for calculating leaf area per plant. The average leaf area per plant was expressed in cm^2 per plant. Finally the leaf area index was estimated by dividing leaf area per plant to the ground area covered by the plants.

Data obtained from the study were statistically analyzed in FRBD using the technique of Analysis of Variance. The difference between the treatments means were tested as to their statistical significance with appropriate critical difference (C.D.) value at 5 per cent level of probability.

3. Results and Discussions

Results obtained from the study indicated that micronutrients and liming significantly increased the plant height at 30, 60 and 90 DAS compared to that under no liming and micronutrient application. Application of Mo produced significantly taller groundnut plant than control at all growing stages, which was at par with combined application of Zn + Mo and Zn + B + Mo (Table 1). Application of Mo increased plant height by 13.4, 13.2 and 12.5% than that of control. Application of lime significantly increased plant height at all the growing stages as compared to no lime application.

Significantly higher number of branches were recorded due to sole application of Mo over control at 30 (22.4%) and 60 DAS (18.8%) and noted at par with combined application of Zn + Mo and Zn + B + Mo (Table 1). Application of lime significantly increased number of branches/plant at 30 (14.5 %) and 60 DAS (7.8%) over no lime application.

Sole application of Mo significantly improved dry matter production at 30 (26.7%), 60 (48.7%), 90 DAS (45.4%) and at harvest (27.3%) and remained at par with other treatments except control. Whereas, liming significantly improved dry matter production at 30 (2.78%), 60 (14.7%), 90 DAS (4%) and at harvest (0.8%) over no lime application (Table 2).

Table 1. Effect of micronutrient and lime on plant height and number of branches of groundnut at different growth stages

Treatments	Plant height (cm)			Number of branches/plant		
	30 DAS*	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Micronutrient						
Control	23.2	50.9	56.6	5.8	6.9	7.1
Zinc (Zn)	25.9	56.1	63.6	6.8	8.1	7.9
Boron (B)	25.1	55.1	63.4	6.5	8.0	7.9
Molybdenum (Mo)	26.3	57.6	63.7	7.1	8.2	8.0
Zn + Mo	26.4	57.4	63.0	6.7	8.3	7.6
Zn + B + Mo	26.2	57.4	63.3	6.9	8.3	7.6
S.Em±	0.21	0.47	0.47	0.11	0.12	0.17
C.D. (*P=0.05*)	0.61	1.37	1.38	0.31	0.35	NS
Soil amendment						
Lime	26.7	58.3	63.9	7.1	8.3	7.8
No Lime	23.9	52.8	60.3	6.2	7.7	7.6
S.Em±	0.07	0.16	0.16	0.04	0.04	0.06
C.D. (*P=0.05*)	0.20	0.46	0.46	0.10	0.12	NS

*DAS- days after sowing

Table 2. Effect of micronutrient and lime on dry matter production, chlorophyll index and LAI of groundnut

Treatments	Dry matter production (g/plant)				Chlorophyll index			LAI
	30 DAS*	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	60 DAS
Micronutrient								
Control	3.0	11.3	15.2	20.5	29.3	51.7	33.4	3.46
Zinc (Zn)	3.7	16.4	22.0	25.6	32.8	55.0	37.1	4.95
Boron (B)	3.7	15.1	21.2	24.5	31.0	53.5	34.5	4.90
Molybdenum (Mo)	3.8	16.8	22.1	26.1	34.8	57.2	38.8	4.97
Zn + Mo	3.8	15.9	21.5	26.4	33.7	55.3	37.7	4.91
Zn + B + Mo	3.9	16.4	20.4	26.6	34.1	56.3	37.5	4.89
S.Em±	0.07	0.36	0.28	0.53	0.2	0.1	0.1	0.06
C.D. (*P=0.05*)	0.21	1.05	0.83	1.56	0.7	0.3	0.4	0.17
Soil amendment								
Lime	3.7	16.4	20.8	25.0	33.5	58.1	40.4	5.26
No Lime	3.6	14.3	20.0	24.8	31.1	51.5	32.6	4.10
S.Em±	0.02	0.12	0.09	0.18	0.1	0.0	0.0	0.02
C.D. (*P=0.05*)	0.07	0.35	0.28	0.54	0.2	0.1	0.1	0.06

*DAS- days after sowing

Maximum chlorophyll index was recorded under sole application of Mo at 30 (18.77%), 60 (10.6%) and 90 DAS (16.16%), whereas, application of lime registered significantly higher chlorophyll index over no lime application at all growth stages. Similarly the highest leaf area index (LAI) was obtained under sole application of Mo at 60 DAS (Table 2), which was 43.6% higher than control and also superior over other treatments.

Sole application of Mo improved nodule weight of groundnut at all growing stages over control and remained at par with combined application of Zn + Mo and Zn + B + Mo. Application of lime significantly enhanced weight of nodules/ plant at 30, 60 and 90 DAS over no lime application (Table 3).

Application of Mo increased number of nodules/plant by 85, 101 and 62% over control at 30, 60 and 90 DAS, respectively, whereas weight of nodules increased by 77.5, 59.1 and 16.5%, respectively, over control at respective growing stages. Application of micronutrients and lime had no significant effect on duration of flowering and maturity of groundnut (Table 4).

Sole application of Mo registered significantly higher crop growth rate (CGR) at 0-30, 30-60 and 60-90 DAS over control and remained at par with remaining treatments (Fig. 1). Similar trends were also observed with respect to relative growth rate (RGR). Whereas, application of lime significantly improved CGR and RGR at all growing stages of groundnut than control (Fig. 2 to 4).

Table 3. Effect of micronutrient and lime on number and weight of nodules at different growth stages of groundnut.

Treatments	**Number of nodules/plant**			**Weight of nodules (mg/plant)**		
	30 DAS*	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
Micronutrient						
Control	21.7	23.6	23.3	52.7	94.3	48.1
Zinc (Zn)	35.5	46.5	36.1	87.3	129.7	53.3
Boron (B)	35.2	46.1	33.6	86.9	115.1	52.6
Molybdenum (Mo)	40.2	47.5	37.9	93.67	150.1	56.1
Zn + Mo	39.8	47.3	36.7	108.0	150.2	54.1
Zn + B + Mo	39.2	47.8	36.7	105.6	151.8	55.9
S.Em±	0.41	0.43	0.60	1.29	2.00	0.60
C.D. (*P=0.05*)	1.22	1.26	1.77	3.80	5.86	1.77
Soil amendment						
Lime	36.5	46.2	35.0	92.6	147.3	74.07
No Lime	34.1	40.1	32.6	85.6	116.5	32.61
S.Em±	0.14	0.14	0.20	0.43	0.67	0.20
C.D. (*P=0.05*)	0.41	0.42	0.59	1.27	1.94	0.59

*DAS-days after sowing

Table 4. Effect of micronutrient and lime on days to flowering and maturity of groundnut

Treatments	**Days to flowering**	**Days to maturity**
Micronutrient		
Control	38.4	116.9
Zinc (Zn)	39.8	116.9
Boron (B)	38.8	120.4
Molybdenum (Mo)	38.7	119.8
Zn + Mo	38.6	118.6
Zn + B + Mo	39.1	119.7
S.Em±	0.6	1.3
C.D. (*P=0.05*)	NS	NS
Soil amendment		
Lime	38.7	119.3
No Lime	39.1	118.1
S.Em±	0.2	0.4
C.D. (*P=0.05*)	NS	NS

Mo is required for nitrate reductase and glutamine synthesis which are involved at initial steps of nitrate assimilation (Hristozkova *et al.,* 2006). Thus, Mo application facilitated better growth and development of the groundnut at all growth stages. Combined application of Zn + Mo and Zn + B + Mo was also found effective for growth and development of groundnut but did not increase growth parameters significantly compared with sole application of Mo. When lime is applied to acid soil, it supplies Ca^{++} which is essential for plant growth (White and Broadley 2003) and also enhances Mo availability in soil that helps in nitrogen fixation and provide better vegetative growth. Similar results were also reported by Mandal and Mandal (1998).

Groundnut kernel yield was significantly influenced by micronutrient and liming (Fig. 5 & 6). Mo application alone registered significantly higher kernel yield than control and sole application of B or Zn. However, integrated application of Zn + B+ Mo recorded the highest kernel yield and remained at par with Zn + Mo and sole application of Mo. The results indicated that integrated application of micronutrients and lime significantly increased growth and physiological parameters of groundnut.

Sole application of Mo or combined application of Mo with other micronutrients such as Zn and B was found more effective for growth and physiological developments of groundnut as compared to soil application of Zn and B. Mo enhances the activity of nitrogenase, thereby increasing the N supply to plants through biological N fixation, resulting in better growth and increased yield (Awomi *et al.,* 2012). Nodule number per plant and weight of nodules were increased due to application of Mo as Mo in leguminous plants is required for nitrate reduction, nodulation, nitrogen fixation and general metabolism (Togay *et al.,* 2008). Ca supplied to plants through lime performs multiple functions in plants such as symbiotic N_2-fixation and nodule formation in legumes, which ultimately helps to retain crop growth and development (Graham 1992; Banath *et al.,* 1996). Application of Zn + B + Mo recorded the highest CGR at 0-30 and 30-60 DAS. Relative growth rate (RGR) was recorded the highest due to application of Zn + B + Mo at 0-30 and 30-60 DAS and at 60-90 DAS, application of Zn + Mo recorded maximum RGR in groundnut. Mo is component of leghaemoglobin found in root nodules and thus, promotes better nodulation of groundnut crop and enhances N-fixation. Use of B help the plants to better utilize the available nutrients with increased leaf area, high photosynthesis and dry matter accumulation which enhances growth rate of groundnut.

Figure 1. Effect of micronutrient on crop growth rate (CGR) of of groundnut

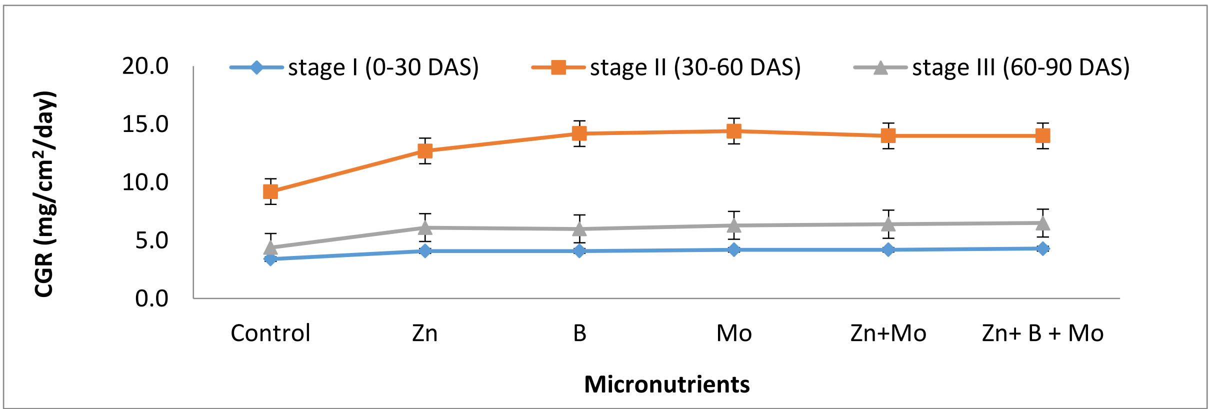
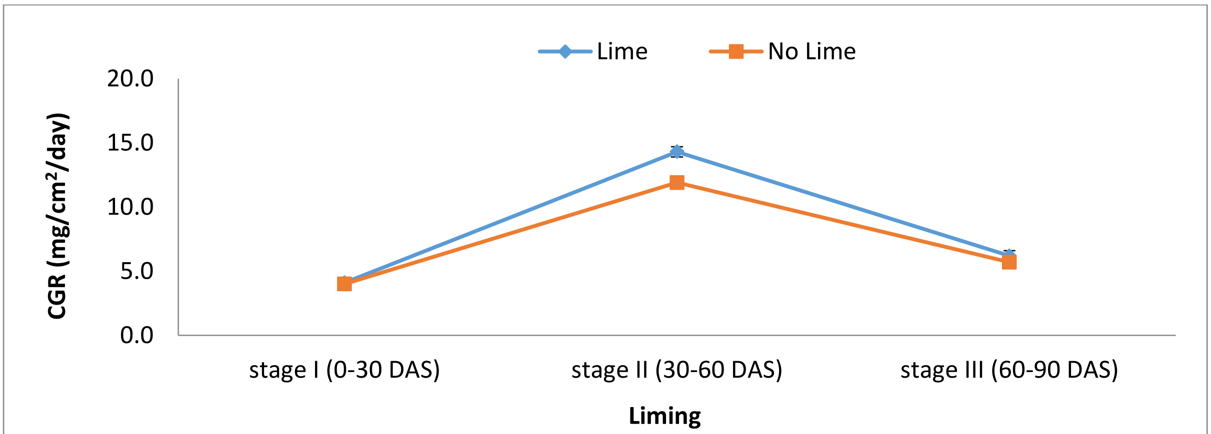


Figure 2. Effect of liming on crop growth rate (CGR) of groundnut



Similar results were indicated by Asad and Rafique (2002). The CGR and RGR were significantly influenced by liming over no liming. This might be due to the reason that liming improves soil health and maintains soil pH which ultimately increases macro and micronutrient availability to the plants.

Due to improvement in growth attributes such as dry matter production, LAI, CGR, RGR, nodule count and weight etc. owing to application of micronutrient and furrow application of lime, there was better translocation of photo-synthates to sink leading to higher kernel yield of groundnut. Thus, the study indicated the need for micronutrient application especially Mo and liming for achieving optimum productivity of groundnut in acid soil condition of NER of India.

Conclusion

Results of this study indicated that sole application of Mo @ 0.5 kg/ha and furrow application of lime @500 kg/ha significantly improved growth and physiological attributes of groundnut crop which leads to the increased production of groundnut in acidic soil condition of Meghalaya.

Acknowledgement

The first author is thankful to College of post Graduate Studies, Central Agricultural University, Umiam and ICAR Research Complex for NEH Region, Umiam, Meghalaya for providing necessary financial, lab and field support to conduct the study.

Figure 3. Effect of micronutrient on relative growth rate (RGR) of groundnut.

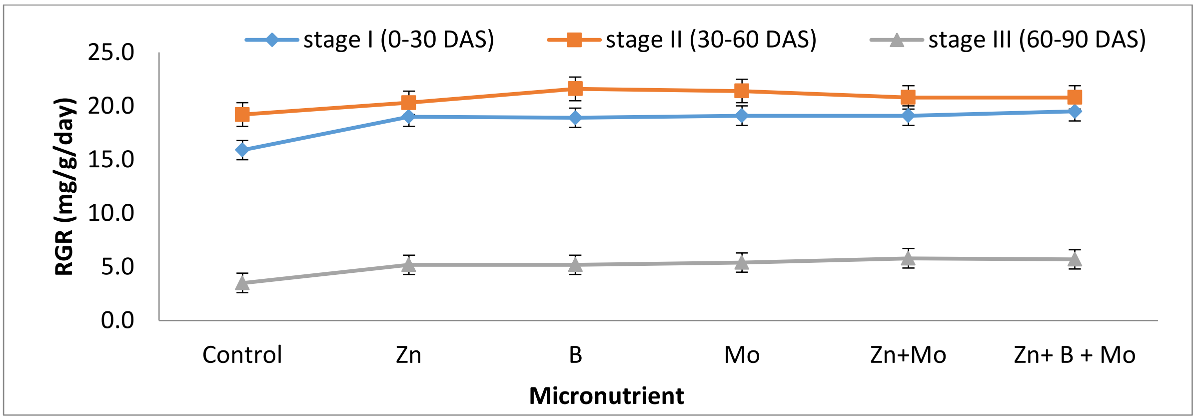


Figure 4. Effect of liming on relative growth rate (RGR) of groundnut.

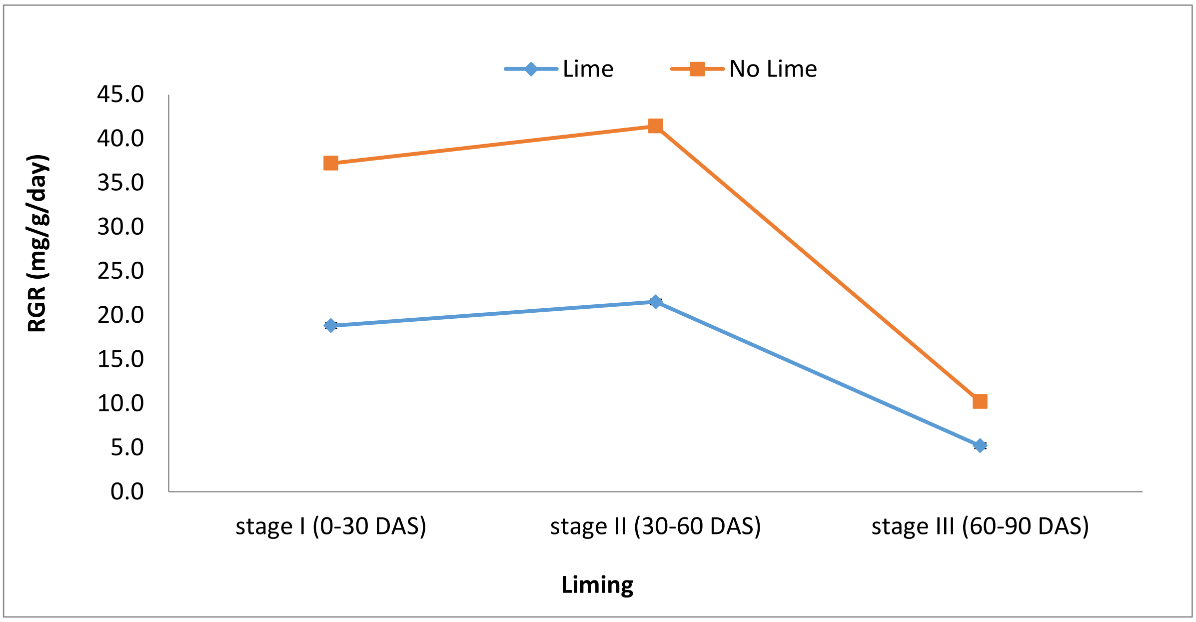


Figure 5. Effect of liming on seed yield of groundnut

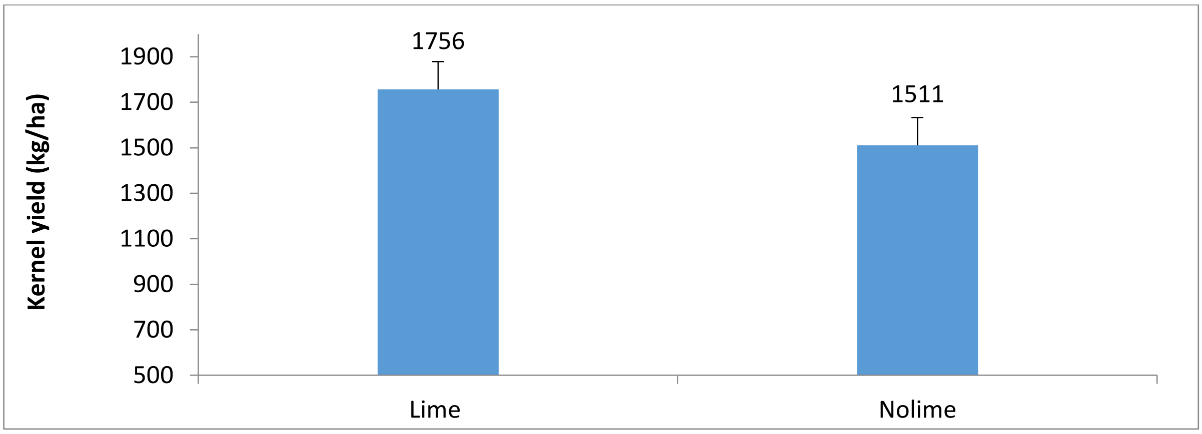
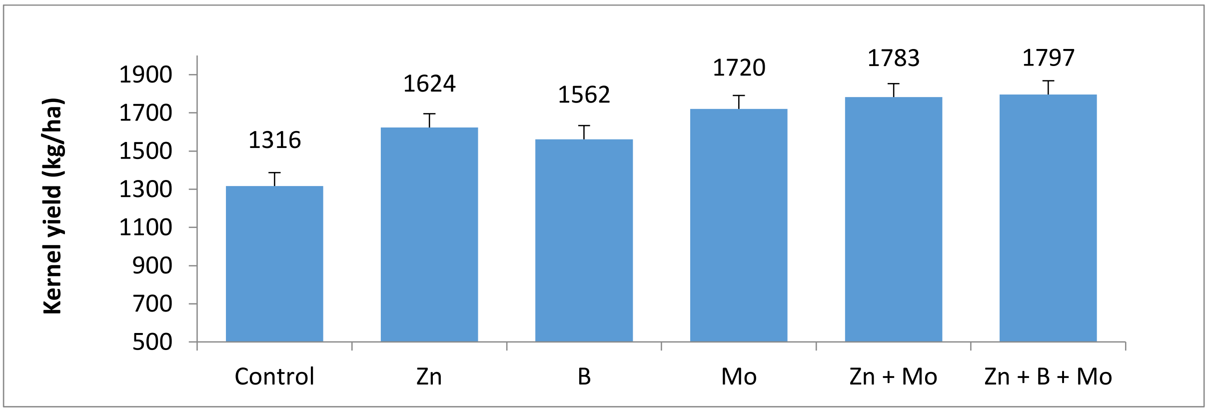


Figure 6. Effect of micronutrints on seed yield of groundnut



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