International Journal of Plant & Soil Science

32(4): 9-17, 2020; Article no.IJPSS.56383
ISSN: 2320-7035

Impact of Application of Fertilizer and Lime on Yield of Banana (Grand Naine) and Soil Parameters in Acidic Soil of Arunachal Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2020/v32i430264
Editor(s):
(1) Dr. L. S. Ayeni, Adeyemi College of Education, Nigeria.
(2) Dr. Yong In Kuk, Sunchon National University, South Korea.
Reviewers:
(1) Enjugu Achukwu Manasseh, Usmanu Danfodiyo University, Nigeria.
(2) Maria Lúcia Pereira da Silva, University of São Paulo, Brazil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56383

Original Research Article

Received 20 February 2020
Accepted 27 April 2020
Published 28 April 2020

ABSTRACT

The present study was aimed at standardizing fertilizer and lime requirement for tissue banana (Grand Naine) cultivation in acidic soil of mid hill of Arunachal Pradesh The experiment was conducted at ICAR RC farm Gori, ICAR RC for NEH Region, AP centre, Basar. The effect of twelve different treatments of combination of fertilizers and Lime was studied on growth parameters of banana plant, post harvest fruit quality parameters and on the soil chemical and physical parameter their availability & uptake of major nutrients were also studied. The results revealed. Plant growth parameters like pseudo stem circumference (36.96 cm) and Plant height (92.85 cm) was highest in the treatment receiving L1F2. Similarly, treatment L2F2 recorded highest number of leaves (5.96), suckers (1.41) and leaf area (3586 cm^2). Treatment L2F1 recorded lowest stem circumference (22.3 cm), number of leaves (3.52) and leaf area (1420 cm^2). Similarly, treatment having L3F1 recorded lowest number of suckers (0.41). The plants treated with (50% lime + 100% RDF) performed best in terms of both yield and quality attributes. The effects of lime application

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significantly improve pH of soil that resulted in the improved the availability of phosphorous. Application of 125% fertilizer was not found to significantly enhance the yield of Banana. The lime application significantly improve the soil nutrient concentration Viz Available N, P K, Ca pH and reduced Al concentration that resulted into enhance banana production compare to the control.

Keywords: Grand Naine; banana; acidic soil; Arunachal Pradesh; lime application.

1. INTRODUCTION

India is the largest producer of banana and an annual production of 29.78 million tonnes from an area of 0.83 million ha and accounts for 19.2 % of the world's production [1]. Banana is the 4th largest food crop in the world and can add to food security system for many of the countries. The productivity of banana in Arunachal Pradesh is very low i.e. 4.0 t per ha compare to our National average of 35.9 t per ha [1]. In Arunachal Pradesh banana can be grown & harvested throughout the year due to the availability of wide range of agro-climatic conditions and high rainfall. In subtropical mid-hills of Arunachal Pradesh, Recognizing that banana is very important for the livelihood, The production is often constrained by several growth limiting factors typical of highly acid soils. The optimum soil pH for banana growth ranges from 5.8 to 6.5 (in water) or 5.0 to 5.8 (in KCl extracts) [2]. Low soil pH (< 5) is often associated with low contents of base cations and nutrients such as Ca^2+ and Mg^2+ or with high contents of aluminum and manganese [3,4]. In addition to low inherent soil pH, improper application of chemical fertilizers and especially the excessive use of fertilizer nitrogen (N) further accelerates soil acidification [5] and leads to low fruit quality [6]. Lime application is a viable strategy to adjust soil pH for optimum plant growth in acid soils. Lime application significantly increases soil pH and base cations (Ca and Mg), and ameliorates the toxic effects of aluminum [7,8]. Lime application increases soil biological activity and alters soil bacterial and fungal community composition [9,10]. Here, we compare the influence of liming and organic fertilizer amendment on banana yield and nutrient accumulation at the vegetative and shooting growth stages within the context of remediating the soil which is having high pH.

2. MATERIALS AND METHODS

The study was conducted in West Siang district of Arunachal Pradesh (Fig. 1) longitude 93.57°E to 95.23°E & Latitude 27.69°N to 29.20°N. At an altitude of approximately 680 m. The mean annual precipitation approximately 2100 mm, with nearly 79% falling between May and September the mean annual temperature is 20.2°C, with a maximum monthly mean value of 26.2°C (August) and a minimum monthly mean value of 11.9°C (January). The whole district covers 7643 km^2 approximately 62% of total geographical area of the district is covered by the forest.

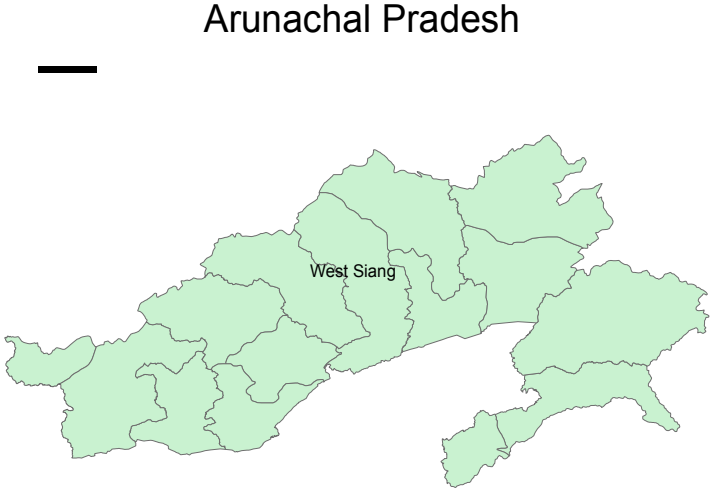

Fig. 1. Study area

Table 1. Characteristics of the 0–15 cm layers of the soil before the trial

Soil parameters	Value	Method	Reference
pH (1:2)	4.8	pH meter	[11]
Organic carbon (%)	1.72	Walkley and Black's rapid titration method	[12]
Available N (kg/ha)	268	Potassium permanganate oxidizable soil N	[13]
Available P (kg/ha)	14.53	Olsen Method	[14]
Ammonium acetate extractable K (kg/ha)	339.3	Ammonium acetate Extractable	[15]
Exchangeable Ca(mg kg−1)	245	Flame photometer	[16]
Exchangeable Al (mg kg−1)	521	Titrimetric method	[17]
Bulk Density (Mg/m^3)	1.04	Pycnometer bottle	[18]
Water holding capacity (%)	24.27	Keen-Rackzowski box	[19]

The vegetation is temperate forest. The Horticultural land use in this study has a cultivation history of over 20 years and was planted with khasi Mandarine, Pine apple Banana etc.

Field experiment was conducted at the Gori Research farm ICAR RC for NEH Region AP centre Basar. During 2013-16.The experiment was conducted in two factorial Randomised Completely Block Design (RCBD) with 3 replications and 12 treatments. Factor 1: (200:50:200 g per plants were provided. N, P and K were applied to the respective plants in form of urea, diammonium phosphate (DAP) and muriate of potash (MOP). At the time of planting 100% phosphorus, 25% nitrogen and 50% potassium was applied at time of planting.) F1: 0% RDF, F2: 75% RDF, F3: 100% RDF & F4: 125% RDF. Factor 2: (lime requirement @ 20 t/ha for three years applied at the time of field preparation) L1: 0% Lime, L2: 50% Lime & L3: 100% Lime. Tissue culture plantlet of variety Grand Naine was planted at a spacing of 1.8 m x 1.8 m. planting was done on the 5th April 2013.

Observation on pseudostem height (cm), pseudostem cicumfrence (cm), no of leaves no of suckers, leaf area of 3rd leaves days taken for shooting, average bunch weight (kg), number of hands per bunch, number of fingers per bunch, weight of finger (g), Total soluble solid (TSS) acidity and Ascorbic acid of fruits were recorded after harvesting of fruit.

Soil samples were collected from the top soil layer of each treatment once in a year, samples were mixed to make composite sample by quartering method for each field replicates. Soil samples were processed and passed through 2mm sieve and analysed for soil parameter (Table 1) following standard techniques.

2.1 Statistical Analysis

Treatments were analyzed by one-way ANOVA and significant differences between means were judged by Duncan's Multiple Range test using SAS 9.3.

3. RESULTS AND DISCUSSION

3.1 Effect of Different Levels of Liming and Fertilizers on Growth Parameters of Banana var. Grand Naine

Plant growth parameters like pseudostem circumference (36.96 cm) and Plant height (92.85 cm) was highest (Table 2) in the treatment receiving L1F2. Similarly, treatment L2F2 recorded highest number of leaves (5.96), suckers (1.41) and leaf area (3586 cm^2). Treatment L2F1 recorded lowest stem circumference (22.3 cm), number of leaves (3.52) and leaf area (1420 cm^2). Similarly, treatment having L3F1 recorded lowest number of suckers (0.41). Study on the effect of different levels of liming and fertilizers on yield and quality attributes of banana var. Grand Naine under mid hill conditions of Arunachal Pradesh showed that the plants treated with (50% lime + 100% RDF) performed best in terms of both yield and quality attributes. The growth in the control was lower than the other treatment was mostly associated with typical chemical constraints reported in acid soils such as low Ca concentration lower pH and high Al concentrations [20]. It was reported that excessive use of lime leads to nutrient imbalance. Lime application rate was 3.75 t ha−1 significantly decreased foliar Mg content [21] in a field experiment. Therefore, the poor growth of banana may be attributable to lime-induced antagonistic effects on plant uptake of Mg2+ and K+ [21] as found elsewhere in acid soils [23,24].

Table 2. Effect of different levels of liming and fertilizers on growth parameters of banana var. Grand Naine

Treatment	Circumference (cm)		No. of leaves		No. of suckers		3rd Leaf area		Plant height (cm)	
	Circum-ference	Rank	Leaves	Rank	Suckers	Rank	Leaf area	Rank	Height	Rank
L1F1	27.93	10	4.22	10	1.07	11	2115.33	10	63.33	10
L1F2	36.96	1	5.59	4	1.33	4	3333.04	3	92.85	1
L1F3	34.30	2	5.93	2	1.26	6	3539.33	2	92.59	2
L1F4	31.89	5	5.56	5	1.15	9	3067.33	6	85.44	4
L2F1	22.26	12	3.52	12	1.30	5	1419.70	12	48.41	12
L2F2	33.93	4	5.96	1	1.41	1	3585.74	1	90.19	3
L2F3	29.67	9	5.00	7	1.33	3	2438.41	9	73.04	8
L2F4	34.07	3	5.22	6	1.19	8	3289.44	4	83.85	5
L3F1	25.56	11	3.96	11	0.41	12	1908.44	11	60.19	11
L3F2	30.15	7	4.78	8	1.26	7	2459.04	8	71.96	9
L3F3	31.70	6	4.70	9	1.41	2	2932.00	7	82.56	6
L3F4	29.85	8	5.63	3	1.07	10	3073.07	5	77.93	7
$LSD_{(0.05)}$	7.5852	.	1.5267	.	NS	.	NS	.	26.23	.

Table 3. Effect of different levels of liming and fertilizers on yield and quality attributes of banana var. Grand Naine (pooled data 2014-15, 2015-16)

Treatments	Bunch wt. (Kg)	No. of hands/bunch	No. of fingers/bunch	Finger wt. (g)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100 g)
L1F1	19.56	10.33	137.89	134.33	11.35	0.32	8.70
L1F2	21.17	12.44	149.11	135.83	14.67	0.31	10.34
L1F3	21.50	12.50	150.57	137.33	15.48	0.30	11.58
L1F4	21.22	12.06	149.89	136.28	16.08	0.28	11.01
L2F1	20.78	10.61	145.83	135.95	13.83	0.32	9.62
L2F2	22.22	12.89	154.89	139.72	17.19	0.27	12.91
L2F3	**24.83**	**14.34**	**161.00**	**143.61**	20.96	**0.21**	**13.47**
L2F4	23.17	13.28	157.72	140.06	**23.07**	0.23	13.12
L3F1	20.44	11.00	140.56	136.72	11.74	0.31	9.90
L3F2	23.50	13.44	159.67	141.50	22.16	0.22	**14.45**
L3F3	23.56	13.67	160.50	141.33	19.65	0.25	11.89
L3F4	21.67	12.56	150.39	137.22	21.39	0.26	12.33
LSD (0.05)	1.16	1.15	4.00	3.03	0.91	0.05	1.25

Table 4. Effect of different levels of liming and fertilizers on Soil parameters

Treatments	SOC (%)	AN (Kg ha-1)	AP (Kg ha-1)	AK (Kg ha-1)	BD (Mg m-3)	WHC (%)	pH	Exchangeable Ca (mg kg−1)	Exchangeable Al (mg kg−1)
L1F1	1.72bc	182.5i	11.85i	269.3d	1.04	24.50	4.82c	141.0d	344a
L1F2	1.65c	220h	10.85i	296.5d	1.04	24.60	4.92c	134.0d	345a
L1F3	1.84a	242g	14.35g	297.5d	1.03	27.50	4.77c	153.5d	337.5a
L1F4	1.73bc	299d	20.15e	427a	1.04	25.40	4.67c	165.5d	355.5a
L2F1	1.8ab	217.5h	16.5g	271.5d	1.02	24.00	5.87b	433.5c	87b
L2F2	1.73bc	381a	18.75e	358.5c	1.02	26.00	5.92b	453.5c	89b
L2F3	1.75bc	315c	35.25a	400.3ab	1.00	26.00	6.5a	491.5c	80.5b
L2F4	1.65cd	318c	28.3c	405a	1.01	25.00	6.07b	441.5c	83b
L3F1	1.585d	282.5e	23.5d	276d	1.09	24.40	6.42a	553.5a	50c
L3F2	1.82ab	328c	26.75c	370c	0.99	23.50	6.52a	544.5a	52.5c
L3F3	1.8ab	347.5b	32.25b	373.6bc	1.00	25.20	6.42a	557.5a	56c
L3F4	1.89a	393a	28.35c	421.2a	0.98	26.50	6.46a	454.56	79b
LSD (0.05)	0.13	15.98	2.78	50.79	NS	NS	0.17	17.31	6.01

3.2 Effect of Different Levels of Liming and Fertilizers on Yield and Quality Attributes of Banana var. Grand Naine

The effect of different levels of liming and fertilizers on yield and quality attributes (Table 3) of banana var. Grand Naine under mid hill conditions of Arunachal Pradesh (pooled data 2014-15, 2015-16) showed that the plants treated with (50% lime + 100% RDF) performed best in terms of both yield and quality attributes. It attained a bunch weight of 24. 83 kg, no. of hands per bunch (14.34), no. of fingers per bunch (161.00), finger weight (143.61 g), least acidity (0.21%). Application of RDF also increased the yield of banana [25]. The present findings are agreements with the findings of [26,27,28]. However, highest ascorbic acid content (14.45 mg/100 g) was recorded from plants treated with (100% lime + 75% RDF) followed by the treatment L2F3 (50% lime + 100% RDF). The total soluble solids and soluble sugar content are often used to assess banana quality [29]. Potassium (K) plays an important role in photosynthesis and transport of metabolites; hence in banana management of K fertilizers are often supplied at sufficient or sometimes excessive rates. In our finding similar result was obtained highest amount of fertilizer application with 125% RDF with 50% lime application showed highest TSS. A studied on the effect of integrated nutrient management on tissue culture banana variety Grand Naine and reported that the yield attributing characters like number of fingers/bunch, finger volume, circumference of finger, weight of finger were significant by application of biofertilizer, organic manures along with inorganic fertilizers where as in excessive fertilizer inhibits some growth parameters by inhibiting biological activities of soil [30]. Hence the L2F3 showed good performance compare to other treatment with even 100% Lime of RDF and 125% RDF this result is with the agreement of over use of fertilizer nitrogen, often leads to soil acidification [31], and this accelerates the runoff of base cations such as Ca^{2+} and Mg^{2+} from the soil profile, leading to poor banana quality as these elements are essential for high fruit quality.

3.3 Influence of Different Levels of Liming on Soil Parameters

Application of lime alone significantly increased the concentrations of Ca, Soil organic carbon (SOC) AN (available nitrogen), AP (available phosphorus) and pH compared to the control. The Al concentrations was decreased (Table 4) this is attributed due to lime application in acid soils results in the precipitation of exchangeable Al as amorphous, positively charged hydroxy-Al polymers [32]. Whereas non significant effect was recorded in the Bulk density (BD and water holding capacity. Influence of lime application was not significant on available potassium, however slightly increase in the concentration of Available Potash (AK) was recorded in 100% recommended dose of lime application (276 kg ha^{-1}) compare to the control (269.3 Kg ha^{-1}). The highest concentration of Ca was recorded in 100% lime application (L3F1) 553 $mgkg^{-1}$ compare to control 141 mg kg^{-1}. This result was in consistent with [7,8] studied lime application significantly increases soil pH and base cations (Ca and Mg), and ameliorates the toxic effects of aluminum. Due to lime application, the pH of L3F1 is increased from 4.82 (control) to 6.42. Al concentration was also decreased from 344 $mgkg^{-1}$ (control) to 50 $mgkg^{-1}$ (L3F1). This result in consistent with [7,8] studied lime application ameliorates the toxic effects of aluminum, Available Phosphorous (AP) was significantly influenced due to lime application this is might be due to increasing the pH the fixed Phosphorous become soluble and come into soil solution. The Physical parameters was showed that there was no significant effect of application of nutrient and lime application, However substantial improvement was recorded in both bulk density and water holding capacity with the application of lime that result in the improvement of water holding capacity. This result was in agreement with Some workers [33,34] have observed that liming decreases surface cracking and increases water holding capacity.

3.4 Influence of Different Levels of Lime Application in Combination with Fertilizer on Soil Parameters

Application of different levels of lime in combination with doses of inorganic fertilizers was found significantly affect the concentration of AN, AP AK, exchangeable Ca was found progressively increases with same rate of lime application and the inorganic fertilizer application increases from 0% to 125% (Table 4). The highest AN (393 Kg ha^{-1}) was recorded in L4F4 that comprising 100% Recommended dose of lime and 125% of fertilizers. And lowest (182.5 $Kgha^{-1}$) was recorded in control. The availability of P was highest recorded in L2F3. It is well

known that calcium (Ca) makes an important contribution to fruit quality by playing a crucial role in cell wall strength, the fruit quality of Ca-deficient banana plants is inferior and the fruit peel splits easily when ripe. Hence lime application plays a critical role to reduce fruit cracking and enhance the quality of fruit. Ca was highest found in L3F3 followed by L3F1. Increased pH was also recorded in L3F2 6.5 compare to 4.8 (Control) these improvement was also reflected in terms of growth parameters of Banana (Tables 2 and 3) The treatment comprising 125% of RDF had slightly lower AP and Ca concentration this is might be acidification due to over chemical fertilization. The Al concentration was also significantly reduced due to application of lime and fertilizers lowest Al concentration was found in L3F4 that lower the acidity of the soil. Our results are consistent with [35,36] was reported beneficial effects of lime and nutrient application on crop production in terms of increased soil fertility by reinforcing soil physical and chemical properties of soil.

4. CONCLUSION

In conclusion, the application of lime and fertilizer are considered to be important tools for the amelioration of acidic soil of mid hill of Arunachal Pradesh. The use of lime in combination with fertilizers is recommended to increase soil fertility and Banana Yield and quality. Our results highlight the importance of lime application on reducing the Al toxicity and enhancing the concentration of Ca that is well known that calcium (Ca) makes an important contribution to fruit quality by playing a crucial role in cell wall strength, The excess application of RDF with particular K was resultant into increase TSS that enhance the fruit Quality. Fertilizer increased soil pH and nutrient availability. Our results indicate that heavy liming alone may not be a viable approach to overcome the growth limiting factors in banana production. 50% of RDF of liming in combination of 100% RDF can be recommended to promote the yields and quality of banana in mid hill of Arunachal Pradesh.

ACKNOWLEDGEMENT

We gratefully acknowledge to the director ICAR RC for NEH Region, Umroi Road, Umiam for approval of the project and providing financial support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/56383