Influence of nitrogen and lime on the morphological and reproductive attributes of okra (A*belmoschus esculentus* (l.) Moench) in Calabar

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Abstract

A field experiment was carried out during the early planting season (March - June) of 2010 at Calabar to evaluate the response of Okra (Abelmoschus esculentus (L.) Moench) variety NHAE 47-4, to four rates of nitrogen (0, 40, 80 and 120kg/ha) and three rates of lime (0, 500 and 1000kg/ha). The treatment combinations were factorized and laid out in a randomized complete block design with three replications. Increasing nitrogen rates significantly increased morphological and reproductive attributes of okra up to the 80kg/ha rate but not beyond. Lime application significantly influenced plant height, number of leaves, number of branches, stem girth and yield attributes. The number of pods/plant, fresh weight of pod (g) and total fresh pod yield (t/ha) at 80kg N/ha rate were 62.84, 124.81 and 288.36%, respectively higher than the control. Total fresh pod yield was highest at 500kg/ha lime rate which was 87.13 and 23.84% higher than the zero and 1000 kg/ha rates, respectively. Significant interactions were recorded between nitrogen and lime for reproductive attributes. Reproductive attributes such as fresh weight of pod and total fresh pod yield, peaked with the combination of nitrogen and lime at 80kg/ha and 500kg/ha while number of pods/plant was maximized with the combination of 80kg N/ha and 1000 kg/ha lime rate. The total fresh pod yield obtained with the combination of 80 kg N/ha and 500kg/ha lime was more than seven times of that obtained at the control.

Keywords: Okra, nitrogen, lime, yield

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is a popular vegetable crop grown for its immature fruits and young leaves in tropical, sub- tropical and warm temperate regions of the world (Siemonsma and Kouamé, 2004).Okra is used as a soup thickener which could be served with rice, stew and the mucilaginous properties of the immature fruits and young leaves aid easy consumption of bulky staple foods like pounded yam, gari and fufu. The fresh fruit is also a good source of vitamins, minerals and protein (Eke *et al*., 2008). Okra is particularly rich in calcium, phosphorus, ascorbic acid and iodine which help control goiter (Som, 2007). The fruits can also be dried or sliced into pieces, dried and ground into powered form and stored for use in soups during the dry season where fresh okra fruits are scarce (Sanni*etal.*,2015). The yield of okra in domestic and commercial farms are observed to be very low as a result of several constraints which includes declining soil fertility as a result of organic matter and nutrient depletions, soil acidity and nutrient imbalance arising from continuous use of inorganic fertilizers. Inadequate knowledge of the soil and crop management systems and the use of unimproved local crop varieties by farmers also contribute to the low yield (Akinrinde and Obigbesan, 2000).

Soils of the forest zone of Nigeria are acidic in nature, classified as *ultisols* and *oxisols* which are inherently low in pH, organic matter, N, K and other nutrients(Brady and Weil,2008).These soils are prevalent in areas experiencing high annual rainfall (above 1500 mm) and usually have problems associated with aluminum toxicity, low nutrients status, nutrients imbalance and multiple nutrient deficiencies (Sanchez *et al*., 1987). These soils therefore require fertilization and liming for good crop growth and yield. Nitrogen is the main limiting nutrient for most crops on these soils because of heavy leaching occasioned by the high rainfall experienced and the sandy nature of the soil (Asiegbu, 1989). Liming is an ancient agricultural practice for rehabilitating acidic soils. The overall effects of lime on soils include among others increased soil pH, Ca, Mg, and P availability, neutralization of toxic concentrations of Al and Mn increase in pH dependent CEC and improved nutrient uptake by plant (Oluwatoyinbo *et al*., 2005 and Onyegbule, 2012).In addition, liming also counteracts the acid forming tendency of nitrogen containing fertilizers, the use of which has increased steadily in several areas of humid tropics. Oluwatoyinbo *et al*. (2005) reported that lime reduced the amount of fertilizer P required for optimum growth and fruit yield of okra with the highest yield obtained at 0.5t/ha lime rate. Eze and Obi (2008) and Effa *et al.* (2011) equally obtained the highest grain yield of popcorn at0.5t/ha lime rate. This however, falls short of the 4 to 6t/ha $CaCO_3$ recommended by Mengel and Kirkby (2001). Ibia *et al.*(1997) recommended the liming of the coastal soils of south eastern Nigeria if improved crop yield was to be achieved, but added that excessive lime application was wasteful, if not detrimental.

Determination of the optimum rates of N and lime at which the best performance can be obtained in okra production therefore deserves some research attention. Thus, this study was conducted to evaluate the significance of liming acidic soils, in combination with efficient use of N fertilizer such that maximum benefits are derived from both crop and fertilizer.

Materials and methods

Field trial was carried out during the early planting season from March to June, 2010 at the Teaching and Research Farm of the Department of Crop Science, University of Calabar. Calabar is located along the humid coastal region of south eastern Nigeria (4°57' N, 8° 19' E; 37m altitude) (Iloeje, 2001). The trial investigated the response of common okra (*Abelmoschusesculentus*(L.) Moench) variety NHAE 47-4 to four levels of nitrogen (0, 40, 80 and 120 KgN/ha), applied as urea (46%N), and three levels of lime (0, 500 and 1000kg/ha) applied as $CaCO_3$. Okra seed was sourced from the National Agricultural Seed Council, Umudike, while the lime material was obtained from Cross River State Water Board, Calabar. Each rate of N was applied in two-split doses. The first dose of N together with all the lime rates, single superphosphate (25kgP/ha) and muriate of potash (50kgK/ha) were broadcast and worked under a day before planting. The second dose of N was placed as side-dressing about 8cm deep and8-10cm away from the plants at 6 weeks after sowing (WAS).

The experiment was a 4 x 3 factorial arrangement fitted into a randomized complete block design with three replications. Each gross plot was 2.4 x 1.8m(4.32m^2) and the net plot was 1.2 x 1.2m(1.44m^2).Soil samples were collected from the site at depths of 0-30cm prior to fertilizer and lime applications using standard procedures as described by 11TA(1982). The site was cleared of vegetation, ploughed to a depth of 20cm and demarcated into three blocks of 12plots each. An alley of 1.5 m was left between blocks and 1m between plots. Sowing was done on flat tilled beds on 20th March, 2010 with three seeds per stand spaced 30 x 40cm. The seedlings were later thinned to one per stand two weeks after sowing to give 36 plants per plot and 83,333 plants per hectare. Manual weeding was done twice at 2 and 6WAS by hand pulling and hoeing.

Harvesting of immature okra pods commenced 56 days after sowing and was carried out every three days from nine randomly tagged plants from the net plot areas in each plot until all the plants withered and died. From the nine tagged plants, the following growth and yield attributes were measured: plant height, number of leaves per plant, number of branches per plant, stem girth/plant, number of days to 50% flowering, number of pods/plant, okra fresh pod weight and total fresh pod yield (t/ha). Data generated were subjected to analysis of variance using GENSTAT Release 7.22 DE Statistical Software (Lawes Agricultural Trust, 2008) and treatment effects were tested for significance at 5% level of probability.

Results and discussion

The soil used was sandy loam, slightly acidic (pH 5.2), low in total N (0.46g/kg), exchangeable K (0.09cmol/kg) and organic matter (18.40 g/kg) but moderately high in available P (11.77mg/kg) and had exchangeable acidity of 2.00 cmol/kg. Generally, the low soil organic matter, N and K contents indicated poor soil fertility.

Effect of nitrogen fertilizer on growth and yield attributes of okra

Plant height, number of leaves, number of branches per plant and stem girth were all significantly influenced by nitrogen fertilizer application at all sampling periods (Tables 1 and 2). In all, the 80kg/ha rate performed significantly ($P<0.05$) better than the other N rates. Each incremental rate of N resulted in significant reduction in the number of days to 50% flowering up to the 80kg N/ha rate. Okra plants on plots amended with 80 and 120kg N/ha, flowered earlier than those at other rates.

The highest number of pods/plant was obtained at 80kg N/ha rate even though this was not significantly different from the number of pods obtained at 40kg N/ha rate (Table 3). Nitrogen at 80kg/ha rate maximized the number of okra pods/plant by as much as 62.84% above those at the control plots. Similarly, fresh pod weight (g/pod) and total fresh pod yield (t/ha), were all significantly influenced by N application (Table 3). Fresh pod weight and total fresh pod yield obtained at the 80kg N/ha rate were both significantly higher than those obtained at other N rates. The result showed that okra fresh pod weight and total fresh pod yield increased relative to the control by 51.55, 124.81 and 18.48% and 95.50, 288.36 and 1.32%, respectively for 40, 80 and 120kg N/ha rates.

Effect of lime on growth and yield attributes of okra

Lime had significant ($P<0.05$) effects on all the vegetative attributes. The 500kg/ha rate produced on the average tallest plants with more number of leaves and branches and the widest stem girth (Tables 1 and 2). The number of days to 50% flowering was shortest at the 1000kg/ha lime rate which however, was statistically similar with the 500kg/ha lime rate (Table 3). The number of pods/plant and fresh pod weight produced at the applied lime rates were statistically similar but higher than the control while the total fresh pod yield peaked at the 500kg/ha lime rate. The 500kg/ha lime rate increased okra fresh pod weight by 18.27 and 7.06% above the zero and 1000kg/ha lime rates, respectively, while total fresh pod yield gave a corresponding yield increases of 87.13 and 21.78% respectively, over the control and 1000kg/ha lime rate.

Interactions effect of nitrogen and lime on growth and yield attributes of okra

The interactions between nitrogen and lime had no significant effects on all the vegetative attributes measured. However, the interactions between N and lime on number of pods/plant and fresh pod weight were significant, while that of total fresh pod yield was highly significant (Table 3). The best performance in terms of number of pods/plant was obtained with the combination of 80kg N/ha and 1000 kg/ha lime rate (Table 4). The combination of 80kg N/ha and 500kg/ha lime rate gave the best results for fresh pod weight and total fresh pod yield. This was followed in both cases by the combination of 80kg N/ha and 1000kg/ha lime rate (Table 4). Number of pods/plant obtained with the combination of 80kg N/ha and 1000kg/ha lime rate was 95.82% higher than that of the control plots while the total fresh pod yield obtained with the combination of 80kg N/ha and 500kg/ha lime rate was more than 7 times that of the control plots.

The superior responses shown by okra plant height, number of leaves and branches/plant and stem girth to N application up to the 80kg N/ha rate, was indicative of the role of N in the vegetative growth of plant. Adequate supply of N must have been responsible for the higher number of leaves produced, leading to enhancement of radiation – use efficiency and higher dry matter accumulation. Leaf expansion is sensitive to N supply (Gimenez *et al*., 1994), and radiation interception is reduced under low N supply (Vos *et al*., 2005). This agrees with the findings of Ahmadu *et al*. (2000) and Uwah *et al*. (2010).

Reduction in number of days to 50% flowering due to increased rates of N and lime application, could be attributed to the ability of lime to provide a more favourably environment for plant growth by reducing toxic concentrations of Al and Mn thereby increasing microbial activity and availability of major plant nutrients in acidic soils (Onyegbule *et al*., 2012). The maximization of pod yield with increasing rates of N was probably as a result of the significant increases in almost all the yield contributing attributes especially numbers of leaves and branches per plant which enhanced greater photosynthetic activities and translocation of assimilates. This is consistent with the reports of Majanbu *et al*. (1986) and Uwah *et al*. (2010). Majanbu *et al*. (1986) recommended 35-70kg N/ha for okra depending on cultivar and soil N status, while Uwah *et al*., (2010) recorded the highest pod yield at 80kg N/ha rate. The inability of N to increase pod yield beyond 80kg N/ha rate in this study, might be due to the application of lime which reduced the amount of fertilizer N required for optimum crop performance. The positive response exhibited by okra vegetative and reproductive characters to lime application is in agreement with the findings of Oluwatoyinbo *et al*. (2005) who observed significant increases in plant height, number of leaves and fruits of okra with the application of all rates of lime up to the 1000kg/ha rate used. This also agrees with the assertion that liming provides a chemical and physical environment that encourages the growth of most plants (Brady and Weil, 2008). In general, all yield – contributing characters were influenced positively by lime application up to 500kg/ha rate. Increasing the lime rate to 1000kg N/ha rate, resulted in significant yield reduction which could be attributed to over liming effect that is wasteful and detrimental to the soil and crop (Ibia *et al*., 1997).

Significant interaction between N and lime was observed in the study. This confirmed the importance of the two treatments in the performance of okra plant. Furthermore, the result is indicative of the ability of lime to enhance the release of nutrients for plant use (Onyegbule*et al*., 2012). A general reduction in yield attributes was observed with the combined use of high rates of both N and lime. This may be an indication of over liming effect which might have caused nutrient imbalance or antagonism in the soil (Ibia *et al*., 1997; Brady and Weil, 2008).

Conclusion

The findings of this study showed that for optimum performance of okra, the application of both N at 80kg/ha and lime at 500kg/ha were beneficial as this optimized both growth and pod yield.

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Table 1. Okra plant height (cm) and number of leaves per plant as affected by nitrogen and lime rates in Calabar

Treatment	**Plant height (cm)**			**Number of leaves/plant**		
	Weeks after sowing			**Weeks after sowing**		
Nitrogen (kg/ha)	**7**	**9**	**11**	**7**	**9**	**11**
0	16.33	23.78	30.67	7.00	10.67	8.22
40	26.89	39.67	45.11	11.67	15.78	14.22
80	31.89	48.89	60.89	16.11	23.33	15.67
120	12.56	20.00	26.22	5.33	11.67	9.78
LSD (0.05)	**1.22**	**1.46**	**4.28**	**1.25**	**2.26**	**1.95**
Lime (kg/ha)						
0	18.50	28.58	32.50	8.42	12.67	7.50
500	25.17	39.17	44.67	11.58	17.92	14.47
1000	22.08	31.50	45.00	10.08	15.50	14.25
LSD (0.05)	**1.05**	**1.26**	**3.70**	**1.08**	**1.95**	**1.69**
Interaction						
N x L	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 2. Number of branches and okra stem girth/plant (cm) as affected by nitrogen and lime rates in Calabar

Treatment	**Number of branches/plant**			**Stem girth(cm)**		
	Weeks after sowing			**Weeks after sowing**		
Nitrogen (kg/ha)	**7**	**9**	**11**	**7**	**9**	**11**
0	2.78	3.56	3.89	4.23	6.28	6.44
40	4.89	4.97	5.08	5.44	7.94	8.22
80	6.33	6.76	6.87	6.78	10.33	10.44
120	2.00	3.22	3.33	3.67	6.00	6.11
LSD (0.05)	**0.56**	**0.62**	**0.60**	**0.74**	**1.23**	**0.65**
Lime (kg/ha)						
0	3.17	3.42	3.92	4.98	7.63	8.33
500	4.83	5.17	5.33	5.08	7.67	8.98
1000	4.00	4.33	4.92	5.03	7.63	8.56
LSD (0.05)	**0.48**	**0.53**	**NS**	**NS**	**NS**	**0.56**
Interaction						
N x L	NS	NS	NS	NS	NS	NS

NS = Not significant

Table 3. Number of days of 50% flowering, number of pods/plant, okra fresh pod weight (g/pod) and total pod yield (t/ha) as affected by nitrogen and lime rates in Calabar

Treatment	Number of days of 50% flowering	Number of pods/plant	Okra fresh pod weight (g/pod)	Total pod yield (t/ha)
Nitrogen (kg/ha)				
0	51.67	5.14	7.74	3.79
40	50.22	7.11	11.73	7.39
80	48.44	8.37	17.40	14.68
120	47.89	4.31	9.17	3.83
LSD (0.05)	**1.33**	**1.27**	**1.69**	**1.39**
Lime (kg/ha)				
0	52.00	5.36	10.51	5.05
500	51.17	6.65	12.43	9.45
1000	50.75	6.69	11.61	7.76
LSD (0.05)	**1.15**	**1.10**	**1.46**	**1.21**
Interaction				
N x L	NS	*	*	**

NS = Not significant
*Significant at p<0.05 , **Significant at p<0.01

Table 4. Interactions between nitrogen and lime for number of pods/plant, fresh weight of pods (g/pod) and total fresh pod yield (t/ha)

	Nitrogen (kg/ha)			
	0	**40**	**80**	**120**
Lime (kg/ha)		**Number of pods/plant**		
0	5.50	6.00	6.17	4.77
500	5.77	8.67	8.17	4.00
1000	5.17	6.67	10.77	4.17
LSD (0.05%)	2.20			
Lime (kg/ha)		**Fresh weight of pods (g/pod)**		
0	6.47	9.80	15.20	10.57
500	8.37	13.63	20.03	7.67
1000	8.40	11.77	19.97	9.30
LSD (0.05%)	2.93			
Lime (kg/ha)		**Total fresh pod yield (t/ha)**		
0	2.50	3.97	9.13	4.60
500	4.57	11.60	18.30	3.33
1000	4.25	6.69	16.73	3.57
LSD (0.05%)	2.41			