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Leaf Characteristics and Mineral Element Concentration of Okra *(Abelmoschus esculentus L. Moench)* as Influenced by Fertilizer Application, Variety and Plant Age in the Nigerian Savanna

Blatteigenschaften und Mineralstoffgehalte von Okrablättern *(Abelmoschus esculentus L. Moench)* in Abhängigkeit von Düngergaben, Sorte und Pflanzenalter in der nigerianischen Savanne

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1 Introduction

Okra *(Abelmoschus esculentus L. Moench)* is one of the popular local vegetables grown in most parts of the tropics and sub-tropics. Unfortunately, this crop, like many other local vegetables, had hitherto not received as much research attention in Nigeria as most arable crops. FATOKUN et al., (1978) described two okra varieties which had then just been released but only limited information is yet available on the mineral nutrition of these varieties. If the genetic potential for fruit and green leaf yields of such varieties is to be fully exploited their nutrient requirements would have to be adequately met. Earlier research work in Nigeria (FATOKUN and CHHEDA, 1981; MAJANBU et al., 1985) and in Nepal (SHRESTHA, 1983) revealed that green pod yield, little or no attention has so far been directed at leaf growth and production; even though its green leaves are also edible and therefore of economic significance.

In a study comparing two okra varieties, ADELANA (1981) observed similar growth patterns for both varieties but they differed in terms of leaf area and dry matter accumulation. Since okra varieties differ in their genetic potential for green pod yield, the ability of a variety to achieve maximum economic yield is therefore likely to depend on the rate

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and quantity of assimilate transport to developing pods and the maintenance of a slow rate of leaf senescence.

The amounts of mineral nutrients in plant tissues generally have some close relationships with growth and productivity levels in crop plants (MUNSON and NELSON, 1973). It has been asserted that young plants are likely to be richer in nutrients than older ones. Plant tissue analysis has long been recognised as a useful tool in the assessment of the nutritional requirement or status of crop plants. Although the concentrations of various nutrients in the plant tissue are often a reflection of the amounts of the various fertilizers applied (AHMAD and TULLOCH-REID, 1968), plant age may also be an important factor. The use of plant tissue analysis as a diagnostic tool in the estimation of the levels of mineral nutrients available in plants and as a useful aid in plant nutrition studies therefore continues to receive increasing attention.

The present investigation was aimed at studying the effect of nitrogen and phosphorus application, variety and plant age on some leaf characteristics and mineral element concentration of okra in the Nigerian savanna.

2 Materials and Methods

Field experiments were conducted at the University and the Horticultural Farms of the Ahmadu Bello University, Samaru (11°11′N, 07°38′E), Nigeria during the 1981 and 1982 wet seasons respectively. The experimental sites had a sandy loam, leached ferruginous tropical soil with top soil (0–20 cm depth) having 0.06 and 0.03% total N, 118 and 122 ppm available P, 104 and 64 exchangeable K, and pH (1:1 soil:water) 4.8 and 4.3 in 1981 and 1982 respectively. Prior to planting the sites received a basal fertilizer dressing of 33 kg K/ha as muriate of potash. Each gross plot was 4.2 m × 6.0 m and net plot was 2.8 m × 6.0 m.

Two okra varieties, namely, "White velvet" and "NHAE 47–4", were planted 42 cm apart in 70 cm rows. Fertilizer treatments were factorial combinations of four nitrogen rates (0, 25, 50, 100 kg N/ha) and three phosphorus rates (0, 13, 26 kg P/ha). The experimental design was a randomised complete block with three replications. Var. "White velvet" has longish pods and it is popular in northern Nigeria; and "NHAE 47–4" is high-yielding, with roundish short pods.

Number of leaves (fully expanded) and leaf dry weight per plant were estimated from four plants selected in each plot at 6, 8 and 10 weeks after planting (WAP). Harvested leaves were oven-dried to constant weight at 70°C and their dry weights recorded. For purposes of tissue analysis okra leaves were sampled from each plot at 6, 8 and 12 WAP in 1981 and at 8, 12 and 15 WAP in 1982. Leaf samples were ground to pass through a 40-mesh screen and then bulked according to treatments, except those harvested at 15 WAP in 1982 which were not bulked. Duplicate sub-samples were analysed for N, P, K, Ca and Mg concentrations on dry weight basis.

Total nitrogen was determined by the semi-micro Kjeldahl method (BREMNER, 1965). P content was determined by the vanado-molybdate yellow colour method (JACKSON, 1958); K by flame photometry; Ca and Mg by atomic absorption spectrophotometry, using lanthanum chloride to suppress interferences.

Data were subjected to one-way analysis of variance and treatment means compared using the test of least significant difference (L.S.D.).

3 Results and Discussion

3.1 Leaf characteristics

In both years, nitrogen application influenced number of leaves per plant significantly while phosphorus application did not (Table 1). N application only up to a mere 25 kg N/ha increased leaf number at 6 and 8 WAP in 1981; however, at 10 WAP leaf number was increased even up to 100 kg N/ha. Response was about 28% increase in number of leaves per plant when the latter N rate was applied. In 1982 response to N application was also only up to 25 kg N/ha at 6 WAP but it was considerably greater at 8 WAP that same year, up to 100 kg N/ha. Apparently, the positive effect of nitrogen application on okra leaf development seemed to have intensified with time after N application. As plants advanced in age, the disparity between the control (no-N) and the highest N rate (100 kg N/ha) in terms of number of leaves per plant became greater. At 8 WAP in 1982 and at 10 WAP in 1981, plants which received 100 kg N/ha had about 5 more leaves per plant than those of control plants, representing some 28–49% more leaves.

Tab. 1: Effect of nitrogen and phosphorus application on number of leaves per plant in okra at 6, 8 and 10 weeks after planting at Samaru, 1981 and 1982.

Treatment	Weeks after planting				
	6	8	10	6	8
	1981			1982	
N rate*					
0	6.70	8.50	16.00	9.90	10.70
25	7.10	9.80	17.90	11.40	13.30
50	7.00	10.00	18.30	12.10	13.30
100	7.00	9.40	20.50	12.40	15.90
S.E. (±)	0.12	0.23	0.64	0.43	0.30
L.S.D. (0.05)	0.34	0.66	1.82	1.22	0.85
P rate*					
0	6.70	9.20	17.40	11.80	13.30
13	7.00	9.80	18.30	11.40	13.30
26	7.20	9.20	18.90	11.10	13.30
S.E. (±)	0.10	0.20	0.55	0.37	0.26
L.S.D. (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.

* (in kg/ha) N.S. = Not significant

As long as soil moisture and other factors were not lilmiting, it seemed that leaf senescence and abscission, two associated physiological processes, that are likely to became more pronounced as plants aged, were delayed by the application of higher N rates. Phosphorus application had no noticeable effect on leaf number in okra in any of the two years. The present result corroborates that of CHAUHAN and GUPTA (1973), who had earlier reported that size and number of okra leaves were not enhanced by phosphorus application in sand culture.

Leaf dry weights were significantly increased by increasing rates of nitrogen application in both years and by increasing phosphorus supply in 1981 only (Table 2). Generally, there was no discernible effect of fertilizer application on leaf dry weight at 6 WAP but as plants grew older, at 8, 10 and 12 WAP, nitrogen supply increased leaf dry weights by 37–163% over the unfertilized control. There was a much greater response to fertilizer application in 1982 than in 1981, probably due to the earlier planting in 1982. At the later growth stages response to N supply was up to 100 kg N/ha. Phosphorus supply influenced leaf dry weight positively up to 13 kg P/ha (Table 2).

Tab. 2: Effect of nitrogen and phosphorus application on leaf dry weight per plant (g) in okra at 6, 8, 10 and 12 weeks after planting at Samaru, 1981 and 1982.

Treatment	Weeks after planting					
	6	10	12	8	10	12
	1981			1982		
N rate*						
0	6.60	18.40	26.60	19.90	27.30	42.30
25	7.50	23.50	35.30	38.90	39.50	41.40
50	7.00	19.40	37.20	45.90	44.70	57.40
100	6.60	25.30	43.80	52.30	58.60	68.80
S.E. (±)	0.61	1.15	3.37	2.21	2.77	1.88
L.S.D. (0.05)	N.S.	4.30	6.74	6.29	7.89	5.88
P rate*						
0	5.70	18.40	32.60	36.90	38.30	53.00
13	7.00	22.60	39.10	43.10	43.50	51.50
26	8.00	23.90	35.60	37.80	45.80	53.00
S.E. (±)	0.53	1.31	2.05	1.91	2.40	1.63
L.S.D. (0.05)	1.50	3.73	N.S.	N.S.	N.S.	N.S.

* (kg/ha), N.S. Not significant

After 10 WAP the relative tendency for N supply to increase leaf dry weight per plant began to decline. Increase in the size of photosynthetic apparatus of the okra plant in response to N supply would seem to explain the observed increase in green pod yield earlier reported by MAJANBU et al. (1985). A larger photosynthetic apparatus thus making available more assimilate, which can then be translocated to developing okra green pods.

Leaf numbers and leaf dry weights of var. "White velvet" and "NHAE 47–4" okra at different growth stages are shown in Table 3. Differences in these two leaf characteristics for the two varieties were found to be extensive. Variety "NHAE 47–4" had considerably more green leaves and larger leaf dry weights than var. "White velvet"; with differences in the order of 31–42% and 40–80% respectively, depending on plant age. Differences between the two varieties became more extensive as plants grew older. With respect to green pod yield, var. "NHAE 47–4" had been observed to be more fertilizer-responsive and having greater yield potential than var. "White velvet" (MAJANBU et al., 1985).

Tab. 3: Leaf number and leaf dry weight of cv. 'White velvet' and 'NHAE 47-4' okra at Samaru, 1981 and 1982.

	Weeks after planting (No. leaves/plant)				
Variety	6	8	10	6	8
		1981			1982
'White velvet'	7.00	9.10	15.70	9.90	11.00
'NHAE 47-4'	7.00	9.70	20.60	13.00	15.60
S.E. (±)	0.08	0.16	0.45	0.31	0.21
L.S.D. (0.05)	N.S.	0.46	1.26	0.88	0.68

	Weeks after planting (Leaf dry weight/plant [g])					
Variety	6	10	12	8	10	12
		1981			1982	
'White velvet'	6.60	18.00	25.50	30.70	34.40	40.60
'NHAE 47-4'	7.20	25.30	46.00	47.80	50.70	64.30
S.E. (±)	0.43	1.07	1.67	1.56	1.96	1.33
L.S.D. (0.05)	N.S.	3.04	4.77	4.44	5.58	3.79

N.S. = Not significant

3.2 Mineral element concentration

Data on the concentrations of N, P and K in okra leaves at 6, 8 and 12 WAP as affected by nitrogen and phosphorus application are shown in Tables 4, 5 and 6 respectively. Application of higher N rates tended to increase the concentration of N in okra leaves. With the exception of 8 WAP in 1981, N concentration was generally enhanced up to 100 kg N/ha rate (Table 4). The supply of N to the plants was associated with the absorption of N. However, the direct effect of N supply on leaf-N concentration began to diminish as N rate was increased above 50 kg N/ha, possibly due to dilution effect of enhanced vegetative growth. N concentration in leaf tissue declined as plants aged, at which stage N is likely to be translocated from the vegetative organs to the reproductive organs of the plant. In 1981, N concentration began to diminish as N rate was increased above 50 kg N/ha, possibly due to dilution effect of enhanced vegetative growth. N concentration in leaf tissue declined as plants aged, at which stage N is likely to be translocated from the vegetative organs to the reproductive organs of the plant. In 1981, N concentration in okra leaves increased as P supply was increased but this was not observed in 1982, when N content tended to decline as P supply was increased. FATOKUN and CHHEDA (1981) had earlier reported a lack of increase in N uptake by okra with P subbly; while CHHONKAR and SINGH (1963) concluded that N concentration in plant tissue and P application were negatively correlated.

Tab. 4: Effect of nitrogen and phosphorus application on the total nitrogen concentration (% in DM) in okra leaves at 6, 8, 12 weeks after planting at Samaru, 1981 and 1982.

Treatment	Weeks after planting				
	6	8	12	8	12
		1981		1982	
N rate*					
0	4.05	3.37	2.70	3.42	2.77
25	4.13	3.45	2.94	3.93	3.05
50	4.08	3.38	3.15	3.95	3.17
100	4.41	3.37	3.63	4.17	3.50
P rate*					
0	3.95	3.25	3.01	4.08	3.17
13	4.12	3.49	3.20	3.72	3.05
26	4.44	3.45	3.11	3.80	3.15
Mean	4.17	3.39	3.11	3.87	3.12

* (kg/ha)

Tab. 5: Effect of nitrogen and phosphorus application on the phosphorus concentration (% in DM) in okra leaves at 6, 8 and 12 weeks after planting at Samaru, 1981 and 1982.

Treatment	Weeks after planting				
	6	8	12	8	12
		1981		1982	
N rate*					
0	0.43	0.37	0.36	0.31	0.25
25	0.39	0.37	0.36	0.30	0.26
50	0.40	0.37	0.35	0.32	0.26
100	0.44	0.40	0.35	0.30	0.26
P rate*					
0	0.42	0.34	0.32	0.34	0.25
13	0.42	0.39	0.38	0.29	0.26
26	0.40	0.40	0.39	0.30	0.24
Mean	0.41	0.38	0.36	0.31	0.26

* (kg/ha)

Application of N had no effect on P concentration in okra leaves (Table 5). However, P supply tended to slightly enhance leaf-P at 8 and 12 WAP in 1981. As plants grew older, the concentration of P in okra leaves decreased marginally. Although the present data do not offer a clear picture, the application of N in increasing rates depressed K concentrations in 1981 but seemed to have increased K concentration in 1982 (Table 6). P application however had no effect on K concentration in leaves. K uptake by plants is more influenced by K availability in the soil solution than that of any other macronutrient, such as phosphorus. It is not clear why increasing P supply failed to result in increased P concentration in plant tissue. Vigorous plant growth resulting from optimum or supra-optimum fertilizer dressing might have caused dilution effects with respect to the concentrations of macronutrients in the plant tissue (SMITH, 1962).

Tab. 6: Effect of nitrogen and phosphorus application on the potassium concentration (% in DM) in okra leaves at 6, 8 and 12 weeks after planting at Samaru, 1981 and 1982.

Treatment	Weeks after planting 6	8	12	8	12
	1981			1982	
N rate*					
0	3.62	3.54	3.05	2.29	1.75
25	3.39	3.47	2.77	2.23	1.66
50	3.49	3.65	3.05	2.44	2.13
100	3.45	3.54	3.41	2.45	1.95
P rate*					
0	3.57	3.51	3.06	2.65	2.09
13	3.39	3.69	3.08	2.13	1.75
26	3.50	3.46	3.06	2.28	1.77
Mean	3.47	3.55	3.07	2.35	1.87

* (kg/ha)

Tab. 7: Concentrations of N, P, K, Ca and Mg in cv 'White velvet'and 'NHAE 47-4'okra leaves at 15 weeks after planting at Samaru, 1982 (in DM).

Variety	% N	% P	% K	% Ca	% Mg
'White velvet'	3.76	0.49	2.05	3.57	0.61
'NHAE 47-4'	3.66	0.42	2.31	3.20	0.54
S.E. (±)	0.07	0.01	0.07	0.06	0.01
L.S.D. (0.05)	N.S.	0.03	0.20	0.17	0.03

N.S. Not significant

Data in the concentrations of N, P, K, Ca and Mg in leaves of var. "White velvet" and "NHAE 47–4" okra at 15 WAP are shown in Table 7. Although the concentrations of N in the leaves of the two varieties were similar, P, Ca and Mg concentrations in var. "White velvet" were significantly higher than those in var. "NHAE 47L4". The concentration of K in var. "NHAE 47–4" was however higher than that in var. "White velvet". The present result is a clear demonstration of varietal influence on the accumulation of mineral elements by okra plants. Since var. "NHAE 47–4" is the more fertilizer-responsive variety, with a more vigorous growth (MAJANBU et al., 1985), dilution effect could explain why its leaves contained lower concentrations of certain macronutrients than did the leaves of var. "White velvet".

Even though as a research tool leaf analysis has become more widely used in recent years than ever before, care should be taken in collecting leaf samples for analysis and, also, varietal differences and plant age should be considered in result interpretation. Periodic effects of leaf age on mineral patterns, the dynamic nature of mineral composition of a tissue and the phenological changes which may radically affect tissue composition, make the use and interpretation of tissue analysis even more difficult.

4 Summary

Two okra varieties ("White velvet" and "NHAE 47–4") were supplied with varying rates of nitrogen (0–100 kg/ha) and phosphorus (0–26 kg P/ha) fertilizer at Samaru, Nigeria. In the two years leaf number and leaf dry weight were increased by N application. Leaf number at 10 weeks was increased 28% by 100 kg N/ha, while leaf dry weight was increased 33, 40 and 60% by 25, 50 and 100 kg N/ha respectively in 1981. P. application did not influence any of these two leaf characteristics. Variety "NHAE 47–4" had more leaves and higher leaf dry weight than var. "White velvet". Increased N supply increased N concentration in okra leaves, had no effects on P concentration, but depressed K concentration. P supply enhance N concentration in 1981 but not in 1982 and did not influence K concentration. The concentrations of P, Ca and Mg in var. "White velvel" were higher than those in var. "NHAE 47–4", which in turn had the higher K concentration.

Zusammenfassung

Zwei Okra Sorten (White velvet und NHAE 47–4), angebaut in Samaru, Nigeria, wurden mit unterschiedlichen Gaben Stickstoff (N), 0–100 kg N/ha und Phosphor (P), 0–26 kg P/ha gedüngt.

In den zwei Versuchsjahren stiegen Blattanzahl und Trockenmasse der Blätter durch N-Gaben. Die Blattanzahl stieg in 10 Wochen um 28% bei 100 kg N/ha, während die Blatttrockenmasse um 33,40 und 60% bei 25, 50 und 100 kg N/ha stieg, alles im Versuchsjahr 1981. Die Phosphorgaben beeinflußten keine der beiden Blatteigenschaften. Die Sorte NHAE 47–4 hatte mehr Blätter und eine höhere Blatttrockenmasse als die Sorte White velvet.

Höhere N-Gaben erbrachten höhere N-Gehalte und hatten keine Auswirkungen auf die P-Gehalte, aber verringerten die K-Gehalte in den Okrablättern. P-Gaben erhöhten die N-Gehalte in 1981 aber nicht in 1982 und hatten keinen Einfluß auf den K-Gehalt. In der Sorte White velvet lagen die Konzentrationen von P, Ca und Mg höher als bei der Sorte NHAE 47–4, die im Gegensatz eine höhere K-Konzentration hatte.

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