Nigerian J. Anim. Sci. 2021, 23 (3): 140-150

Forage elemental concentrations and ratios of two groundnut (*Arachis hypogaea L*) varieties: effect of fertilizer type

***Dele, P. A., Akinyemi, B. T., Okukenu, O. A., Anotaenwere, C. C., Enwete, F. E., Kasim, O. B., Amole, T. A[1]., Sowande, O. S[2]., Olanite, J. A., Arigbede, O. M. and Jolaosho, A. O.**

Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria.
[1] International Livestock Research Institute, Ibadan, Nigeria
[2] Department of Animal Production and Health, Federal University of Agriculture, Abeokuta, Nigeria.

***Corresponding author:** delepeter2003@yahoo.com; delepa@funaab.edu.ng*

***Target Audience:** Pasture Agronomists, Forage Scientists, Ruminant Nutritionists, Ruminant Farmers*

Abstract

Forages are the main source of minerals needed for growth and maintenance of bone, osmotic balance, muscle and nerve function, body enzymes, hormones, body cells and general well being of animals. This study was carried out to evaluate effect of fertilizer type on the elemental concentrations and ratios of two groundnut fodders. The study was a 3 x 2 factorial experiment in a split-plot design with the fertilizer type (poultry droppings, NPK and the control) as the main plot and variety (SAMNUT 22 and Local) as the sub-plot which amounts to six treatments with three replicates. The Ca value has affected by fertilizer type ranged from 12.95 g/kg DM to 16.50 g/kg DM for the organic-fertilized groundnut forage and the inorganic-fertilized, respectively. The two varieties that were inorganically-fertilized had the highest Ca contents. The phosphorus (2.65 g/kg DM) content of SAMNUT 22 variety was higher than that of the Local variety. A higher value of Fe was recorded for the Local variety, whereas the organic-fertilized forage had the highest Fe (229.46 mg/kg DM) content. The Ca:P ratio as influenced by varietal difference was significant with the Local variety having a higher ratio (8.09). The K:(Ca+Mg) ratio was affected by the fertilizer type, with the organic fertilized forage having a higher ratio. It can be concluded that the two varieties are a good source of calcium and could also help to combat grass tetany in cattle.

***Keywords**: Mineral, legumes, ruminant, groundnut, elements, varieties.*

Description of Problem

Groundnut (*Arachis hypogaea*) is a multipurpose species as it could be used for human consumption, its fodder for livestock consumption especially ruminants and could be use for green manuring. Groundnut is a major crop grown in the arid and semi-arid zone of Nigeria and recently, has started gaining attention in the derived savannah of the Southern part of the country (1) as a major source of fodder for ruminant animals as the fodder is rated to have more economical and nutritional value than the cowpea fodder (2) that had been a major source of fodder before now (3). The conscious effort of sowing groundnut for the purpose of fodder cannot be overemphasized. A major limitation to this is the generally low nutrient status of tropical soils, especially nitrogen and phosphorus (4). Groundnut being a member of the legume family could be said not to need fertilizer either in the organic of inorganic form because if its nitrogen fixing ability (5; 6)

but researchers have reported divergent opinions (7; 8) that legumes need starter doses before nitrogen fixing would begin. Forages are an important source of minerals for ruminants and especially legumes (9). Mineral concentrations in forages have been known to vary greatly, and affected different factors such soil mineral level, soil pH, plant species, stage of forage maturity, and application of fertilizers or waste materials (10). The study is focused on evaluating the effect of fertilizer type on the mineral concentrations and ratios of two groundnut varieties as a forage resource in South west, Nigeria.

Materials and Method

Experiment sites

The field study was carried out at the Pasture unit of the Directorate of University farms, Federal University of Agriculture, Abeokuta, (FUNAAB) and the NIRS screening was in the laboratory of the International Livestock Research Institutes, Ibadan, Nigeria. The experimental site lies within the savanna agro-ecological zone of South Western Nigeria (latitude: 7°N, longitude 3.5°E, average annual rainfall: 1037 mm). Abeokuta has a bimodal rainfall pattern that typically peaks in July and September with a break of two to three weeks in August. Temperatures are fairly uniform with daytime values of 28 to 30^{o}C during the rainy season and 30 to 34°C during the dry season with the lowest night temperature of around 24 °C during the harmattan period between December and February. Relative humidity is high during the rainy season with values between 63 and 96 % compared to 55 to 84 % during the dry season. The temperature of the soil ranges from 24.5 to 31.0 °C across the seasons (Source: Agrometeorology department, FUNAAB)

Land preparation

The land earmarked for the field study was cleared, followed by ploughing and harrowing after a period of two weeks of ploughing. The experimental land measuring 1,050 m^2 was mapped out after harrowing. After land preparation and before planting, soil samples were randomly collected from the plots at the depth of 0-15 cm using soil auger to represent the topsoil. The samples were bulked per replicate, mixed thoroughly and subsamples taken for analysis to determine the pre-planting nutrient status of the soil. The soil was analyzed to be made up of sand 75.13 %, silt 16.70 %, clay 5.17 %, pH (in H_2O) 6.9, organic carbon 1.31 %, total nitrogen 0.10 %, available phosphorus (P)43.82 mg/kg, potassium (K) 0.21 cmol/kg, calcium (Ca) 2.56 cmol/kg, magnesium (Mg) 2.55 cmol/kg and sodium (Na) 0.79 cmol/kg.\

Experimental design and plot management

The study was a 3 x 2 factorial experiment in a split-plot design. The main plot dimension was 12 m x 5 m while that of the sub plot was 5 m x 5 m. The fertilizer types were allotted to the main plot and the groundnut varieties to the sub plot. The three fertilizer types (NPK 15:15:15, poultry (layer battery cage) manure with 30:10:10 g/kg of NPK, respectively) and unfertilized (control) and the two varieties of groundnut (SAMNUT 22 and Local) amounted to six (6) treatment combinations with three replicates. The seeds of SAMNUT 22 and local variety were sourced from Institute of Agricultural Research Shika - Zaria, Kaduna State and a local market in Abeokuta, Ogun State, respectively.

The rate of fertilizer application was 60 kg P/ha and quantities of the fertilizer were determined based on the phosphorus content

and the application was done at the 4th week after planting. The seeds were sown at a spacing of 0.5 m x 0.3 m with 2 seeds per hole. The inter-plot and intra-plot spaces were kept weed-free throughout the experimental period by hand weeding. The fodder (leaves and stems) of the groundnut varieties were harvested at 16 weeks after planting and to determine the dry matter yield a 1 m^2 quadrat was used which was thrown three times within a subplot at 5 cm aboveground level. Sub samples were taken, weighed and oven – dried at 65 ^{0}C to constant weight and stored for analysis.

Mineral analysis

The oven-dried samples were milled and allowed to pass through 1mm screen and stored in air tight bag for subsequent analysis at the International Livestock Research Institute, Ibadan. Five grams of each of the samples were scanned with NIRS and mineral contents (Ca, P, K, Mg, N, Fe, Cu, Zn and Mn) of the samples were assessed using equation for the plant sample analysis based on the mixed feed global calibration model using the software package (Win ISI II FOSS, Denmark Model NIRS™ 5000). Spectral information was registered in the wavelength range 1100-2500nm using NIR system mode 5000 scanning monochromatic infrared spectrophotometer. To determine the relationships between the minerals, Ca:P ratio, K:Ca + Mg ratio, N:P ratio, N:K ratio and K:P ratio values were calculated. Milliequivalents per 100 g were used to calculate K:(Ca + Mg) and g/kg values to calculate others.

Statistical analysis

Data collected were subjected to analysis of variance using the Statistical package (11) and significant means were separated using Duncan Multiple Range Test.

Results

Table 1 show the main and interaction effects of variety and fertilizer type on the macro minerals of two groundnut forage. The calcium contents were significantly ($p<0.05$) affected except for the varietal differences. The Ca value has affected by fertilizer type ranged from 12.95 g/kg DM to 16.50 g/kg DM for the organic-fertilized groundnut forage and the inorganic-fertilized, respectively. The two varieties that were inorganically-fertilized had the highest Ca contents. The phosphorus (2.65 g/kg DM) content of SAMNUT 22 variety was higher than that of the Local variety, whereas the organic-fertilized groundnut forage had the highest P content. The interaction effect of variety and fertilizer type had significant ($p<0.05$) effect on the P concentration of the forage with the organic-fertilized SAMNUT 22 having the highest P value.

The potassium and magnesium contents were not influenced ($p>0.05$) by the variety. The K content as influenced by fertilizer type followed similar trend as in P concentration. The K content as affected by the interaction ranged from 13.80 g/kg DM to 26.10 g/kg DM with the organic-fertilized SAMNUT 22 having the highest K content. The Mg content was influenced by fertilizer type with the inorganic-fertilized groundnut forage having the highest value. The organic-fertilized SAMNUT 22 had the highest Mg (4.70 g/kg DM) content.

The varietal influence on the N content was significant ($p<0.05$) with the Local variety having a higher content and the fertilized forages had higher N contents than the unfertilized. The organic-fertilized Local variety had the highest N (34.74 g/kg DM) content while the unfertilized SAMNUT 22 had the least N (29.26 g/kg DM) content.

Table 1: Main and interaction effects of variety and Fertilizer type on the macro-mineral contents (g/kg DM) of groundnut forage

Variety	Fertilizer type	Calcium	Phosphorus	Potassium	Magnesium	Nitrogen
SAMNUT 22		14.30	2.63^{a}	20.33	3.50	31.95^{b}
LOCAL		14.43	2.00^{b}	19.90	3.47	33.47^{a}
SEM		0.11	0.05	0.31	0.07	0.10
	Control	13.65^{b}	1.36^{c}	13.95^{c}	2.10^{c}	30.80^{b}
	Organic	12.95^{c}	3.05^{a}	24.90^{a}	3.80^{b}	33.69^{a}
	Inorganic	16.50^{a}	2.60^{b}	21.50^{b}	4.55^{a}	33.64^{a}
	SEM	0.04	0.03	0.07	0.02	0.09
SAMNUT 22	Control	13.50^{b}	1.53^{e}	13.80^{d}	1.90^{e}	29.26^{e}
	Organic	13.20^{bc}	3.40^{a}	26.10^{a}	3.90^{c}	32.64^{d}
	Inorganic	16.20^{a}	3.10^{b}	21.10^{c}	4.70^{a}	33.94^{b}
LOCAL	Control	13.80^{b}	1.20^{f}	14.10^{d}	2.30^{d}	32.34^{d}
	Organic	12.70^{c}	2.70^{c}	23.70^{b}	3.70^{c}	34.74^{a}
	Inorganic	16.80^{a}	2.10^{d}	21.90^{c}	4.40^{b}	33.33^{c}
SEM		0.30	0.15	0.87	0.19	0.33

$^{a,b,..f}$: Means with different superscripts along same column are significantly ($p<0.05$) different
SEM: standard error of means

The iron content was influenced ($p<0.05$) by the variety, fertilizer type as well as the interaction. A higher value of Fe was recorded for the Local variety, whereas the organic-fertilized forage had the highest Fe (229.46 mg/kg DM) content. The Fe values ranged from 198.85 mg/kg DM (unfertilized Local variety) to 237.36 mg/kg DM (organic-fertilized Local variety).

There was no varietal difference on the Cu and Mn content of the groundnut forage. The unfertilized forage had higher Cu (9.41 mg/kg DM) than that of the fertilized. The unfertilized SAMNUT 22 had the highest ($p<0.05$) Cu content. The Mn content was affected by the fertilizer type with the inorganic-fertilized forage having the highest Mn (97.75 mg/kg DM) value. The SAMNUT 22 to which inorganic fertilizer was applied recorded the highest Mn value whereas same variety, which was not fertilized, recorded the least value of Mn. SAMNUT 22 had higher content of Zn and the inorganic-fertilized forage had the highest concentration (62.21 mg/kg DM) of Zn. The Zn content as influenced by the interaction ranged from 19.34 mg/kg DM to 67.19 mg/kg DM with the inorganic-fertilized SAMNUT 22 recording the highest value for Zn (Table 2).

The Ca:P ratio as influenced by varietal difference was significant with the Local variety having a higher ratio (8.09). The unfertilized groundnut forage had the highest Ca:P ratio value. The Ca:P ratio as influenced by the interaction of variety and fertilizer type ranged from 3.88 (organic fertilized SAMNUT 22) to 11.56 (unfertilized Local variety). The main effect of variety and fertilizer type on the elemental ratio of N:P, N:K and K:P were significantly ($p<0.05$) different (Table 3). The Local variety had higher N:P, N:K and K:P ratio with 18.62, 1.76 and 10.35 values, respectively. The fertilizer type effect on the elemental ratio of N:P, N:K and K:P showed that the unfertilized had higher values than the fertilized. The unfertilized Local variety had the highest value for the elemental ratios for N:P, N:K and K:P while the values for

N:P and N:K were recorded for organic-fertilized SAMNUT 22 and K:P value was least for inorganic-fertilized SAMNUT 22. The K:(Ca+Mg) ratio was not influenced ($p>0.05$) by the variety but was affected by the fertilizer type, with the organic fertilized forage having a higher ratio. The K:(Ca+Mg) ratio as influenced by the interaction varied. The least value was noted with the unfertilized Local variety and the organic-fertilized SAMNUT 22 having the highest value.

Table 2: Main and interaction effects of Fertilizer type and variety on the micro-mineral content (mg/kg DM) of groundnut forage

Variety	Fertilizer type	Iron	Copper	Manganese	Zinc
SAMNUT 22		202.51^{b}	7.44	78.56	50.96^{a}
LOCAL		216.43^{a}	7.70	80.35	42.98^{b}
SEM		1.21	0.09	1.13	1.16
	Control	191.51^{c}	9.41^{a}	57.53^{c}	22.82^{c}
	Organic	229.46^{a}	6.63^{b}	83.08^{b}	55.87^{b}
	Inorganic	207.50^{b}	6.67^{b}	97.75^{a}	62.21^{a}
	SEM	0.96	004	0.36	0.36
SAMNUT 22	Control	184.18^{d}	9.80^{a}	54.00^{f}	26.31^{d}
	Organic	221.56^{b}	6.15^{d}	79.98^{d}	59.38^{b}
	Inorganic	201.79^{c}	6.38^{d}	101.71^{a}	67.19^{a}
LOCAL	Control	198.85^{c}	9.02^{b}	61.07^{e}	19.34^{e}
	Organic	237.36^{a}	7.11^{c}	86.19^{c}	52.37^{c}
	Inorganic	213.13^{bc}	6.97^{c}	93.79^{b}	57.23^{b}
SEM		3.62	0.26	3.19	3.31

$^{a,b,..f}$: Means with different superscripts along same column are significantly ($p<0.05$) different
SEM: standard error of means

Table 3: Main and interaction effects of Fertilizer type and variety on the elemental ratio of groundnut forage

Variety	Fertilizer type	Ca:P	N:P	N:K	K:P	K:(Ca+Mg)
SAMNUT 22		5.98^{b}	13.24^{b}	1.66^{b}	7.85^{b}	0.52
LOCAL		8.09^{a}	18.62^{a}	1.76^{a}	10.35^{a}	0.51
SEM		0.16	0.35	0.02	0.08	0.01
	Control	10.19^{a}	23.12^{a}	2.20^{a}	10.43^{a}	0.42^{c}
	Organic	4.30^{c}	11.25^{c}	1.36^{c}	8.24^{b}	0.66^{a}
	Inorganic	6.62^{b}	13.42^{b}	1.57^{b}	8.62^{b}	0.46^{b}
	SEM	0.09	0.23	0.01	0.12	0.01
SAMNUT 22	Control	8.82^{b}	19.16^{b}	2.12^{b}	9.05^{c}	0.43^{de}
	Organic	3.88^{e}	9.61^{e}	1.25^{e}	7.67^{d}	0.68^{a}
	Inorganic	5.23^{d}	10.95^{e}	1.61^{c}	6.81^{e}	0.45^{cd}
LOCAL	Control	11.56^{a}	27.09^{a}	2.29^{a}	11.81^{a}	0.41^{e}
	Organic	4.71^{d}	12.89^{d}	1.47^{d}	8.81^{c}	0.65^{b}
	Inorganic	8.01^{c}	15.88^{c}	1.52^{d}	10.43^{b}	0.47^{c}
SEM		0.50	1.11	0.07	0.33	0.02

$^{a,b,..e}$: Means with different superscripts along same column are significantly ($p<0.05$) different
SEM: standard error of means

Discussion

Legumes are generally known to produce high quality forage, which are major source of minerals and with their inclusion, mineral supplementation will have to reduce thereby reducing the cost of production. The Ca contents recorded in this study were higher than the range (1.8 – 8.2 g/kg DM) needed to meet the Ca requirement of all classes of ruminant animals (12; 13) and fell within the range (3.10 – 19.80 g/kg DM) reported to be typical of tropical forage legumes (14). The Ca values recorded are below the maximum tolerable level above which intake depression might occur (15).The suppression of calcium concentration with the application of manure is in line with the reports of (16) and (17). This might be as a result of salinity that is associated to the application of manure (18), whereas the increase in the Ca content with the application of inorganic fertilizer is consonance with the report of (19).

The P content of the two varieties in this study as relates to the application of fertilizer fell within the range (1.8-4.8 g/kg DM) reported by (12;13) and the lower value of the unfertilized showed that tropical soils are really deficit in phosphorus (20) and that for tropical forages to meet up with P requirement of ruminant animals that forages will have to be fertilized. The increase in the P. content with the application of fertilizer either in organic or inorganic form is in line with the report of (21) and (19) could be as a result of the compound inorganic fertilizer (NPK) and manure used. The P content in this study are below the maximum tolerable level (6 g/kg DM) as reported by (22) in sheep, which could lead to urinary calculi as a result of its antagonism of calcium.

The K content noted in this study were higher than 8 g/kg DM recommended for grazing animals (23) and 10 g/kg DM for ruminant animals under stress (24). The increase in the K content as influenced by fertilizer type can be associated with the K in the inorganic and organic fertilizers applied (25). The K values recorded were higher than those reported for some forage legumes by (20), (26) and (27) within same agroecological zone. This might be due to species differences and fertilizer applied and also fell within the range (10.9 – 27.3 g/kg DM) reported by (28) for peanut forage.

The Mg values recorded in this study are lower than the maximum tolerable level reported by (15) and above the recommended requirement for ruminants as reported by (29). Therefore, the forages could theoretically meet recommended range (1.2-2.1 g/kg DM) of Mg requirement for beef cattle and lactating cows (30). The values of Mg of the two groundnut varieties are able to meet the ruminants' needs for metabolic activities (31) and preventing hypomagnesemia tetany (32). The values were high enough to mitigate the occurrence of grass tetany in cattle.

The higher N content of the groundnut forage with the application of organic and inorganic fertilizer is in consonance with the reports of (33) and (34) that nitrogen application promotes increase in N accumulation which might be as a result of cell multiplication that N is known to promote.

Iron is naturally well supplied by forages and deficiencies of the element in ruminants is rare but may result from blood loss due to heavy parasitic infestation or some other cause of haemorrhage (35). The iron contents of the forages in this study were lower than the range (250-1200 mg/kg) reported by (36) and (37) for the reduction of Cu status in cattle and sheep, respectively.

The Cu concentrations of the forages in this study are within the range (5 - 15 mg/kg)

recommended for ruminants' diet to ensure normal physiological functions of the animals (35). The reduction in the Cu content might be as a result of the presence of phosphate in the fertilizers applied, which was affirmed by the report of (38). The reduction in the Cu with fertilizer application whereas Fe increased with same fertilizer application, which confirms the antagonistic nature of these two elements as reported by (10). Invariably, the higher content of either will lead to the deficiency of the deficiency of the other in ruminant animals. The Cu contents are far less than 100 mg/kg for which can be toxic to cattle as reported by (22). The Cu content was above 3 mg/kg for which infertility could occur in ruminant animals (39)

Manganese is one of the minerals needed for normal reproduction and its deficiency can be associated with delayed or irregular estrus and as well as low conception rate in ruminants (40). The Mn content recorded for the two varieties in this study was similar to that reported by (41). The Mn content under study are higher than Mn requirements for growth (10 mg/kg) and normal reproduction (20 to 40 mg/kg) (10) and far lesser than the maximum tolerable limit (1000 mg/kg) as reported by (21)

Zinc is important to a variety of biological and metabolic processes in ruminant animals; it is widely distributed throughout the body as a component of metalloenzymes and metalloproteins (42), with its germane roles, it was observed that the range recorded in this study is high enough to meet the nutritional requirements of all classes of ruminants. The higher Cu values noted in this study with fertilizer application is in line with the report of (43). This might be associated to the fact that increased acidity through fertilizer application could account for the improved Zn absorption. The values recorded in this study are below the maximum tolerable value (500 mg/kg) reported by (21) for beef cattle, excess of which could lead to depress food consumption and may induce copper deficiency (44)

The dietary ratios of minerals in animal diets have been reported to play important roles than the individual elements (45). The higher Ca:P in this study as affected by fertilizer type indicated that the unfertilized forages have lower P content, thereby making the Ca:P ratio for the unfertilized forage higher than the range of 1-7:1 recommended (32) as the optimal Ca:P ratio for maintaining optimal ruminant performance. The higher Ca:P ratio above the recommendation in this study has been reported to be common to legumes (45), metabolic disorders is the symptom of such ratio but can be corrected by the introduction of dietary P supplementation (46) to cattle.

The N:P ratio is a nutrient indicator with N:P ratio less than 14, indicating that nitrogen is the limiting factor, 14 – 16, indicate that either N or P can be limiting and N:P ratio greater than 16, clearly indicates P as limiting (47; 48). The SAMNUT 22 is limiting in Nitrogen and the unfertilized forages are limiting in P content. The higher N:P ratio for the unfertilized has recorded in this study is in line with the report of (49).

The K:(Ca + Mg) values in this study are lower than 2.2 (32), which is the maximum tolerable ratio. When the ratio K:(Ca + Mg) exceeds 2.2 grass tetany symptoms can be seen. Grass tetany is also seen when Mg is less than 2g/kg, and when Ca is less than 4 g/kg (50; 51). The lower K:(Ca + Mg) ratio in this study confirms the report of (52) that legumes as dicotyledonous have the ability to accumulate high concentrations of Ca and Mg

Conclusion and Applications

1. The results showed that the two varieties of groundnut are good sources of macro minerals for ruminant animals and that P content especially for the unfertilized forages when fed to ruminants will need P supplementation to balance the Ca:P ratio.
2. The feeding or grazing of the varieties used in the study might be an antidote for grass tetany.

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