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# Leaf N, P, Mg and K Concentrations of Groundnut (*Arachis Hypogaea* L.) Varieties as Influenced by Plant Population and Basin Sizes Under Irrigated Conditions

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**Abstract:** Plant analysis has been used as a method for determining the relative quantities of mineral elements in plants. In order to measure the leaf N, P, K and Mg of groundnuts (*Arachis hypogaea* L.) grown under irrigation, an experiment was conducted during 2006 dry season at the Irrigation substation of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria. The results showed that there was no significant influence of the plant populations used on the leaf N, P, K and Mg concentration although Leaf N concentration was slightly higher at 100,000 plants $ha^{-1}$ than at other populations. The leaf P, Mg and K concentrations were slightly but not significantly higher at 50,000-plant $ha^{-1}$. Basin size did not have significant effect on leaf concentrations of N, P, K and Mg. It was observed that leaf N concentration was high in the 3m x 3m basin while leaf P Mg and K concentrations were higher in the 3m x 5m basin than others. However, among the varieties used, Samnut 21 and 11 had significantly higher leaf Mg concentration than Samnut 23

**Keywords:** Basin size, leaf concentration, irrigation, plant population, variety.

## INTRODUCTION

Groundnut is a very important crop in the tropics and subtropics. It has a high content of edible oil, which ranges from 50 to 65% Taira [1]; Boye-Goni *et al.,* [2] and protein content ranging from 25 to 35% De Waele and Swanevelder [3]; Anonymous [20], making it a very popular human food and source of cheap protein.

Plant analysis is used to diagnose nutrient related problems with crop growth, either a deficiency or toxicity within plant tissue. This information may be obtained at different growth or sampling stages, when mature or when harvested. Lundergardh [4] who is regarded by many as the father of leaf analysis established some fundamental concepts regarding the techniques of plant analysis in his extensive researches on oats. Similarly, the important work of Thomas [5] attracted attention to foliar diagnosis. Hellriegel [6] further stressed that "Crop analysis will provide a satisfactory basis for the determination of both the relative and absolute proportions of plant nutrients present and available in the soil and can suitably give the supplementary information needed to evaluate the results of soil analysis".

Proper plant nutrition is also a good strategy to enhance water use efficiency and productivity in crop plants. This is because a limited water supply inhibits the photosynthesis of plants, causes changes of chlorophyll contents and components and damage to photosynthetic apparatus. It also inhibits photochemical activities and decreases the activities of enzymes in plants. Several workers Smith [7]; Balasubramaniah [8] and Yayock [9]; Tanimu [10]; Chang, [11]; Ramamantha Rao [12]; Bell, *et al.,* [13] have identified moisture stress and temperature as major environmental factors affecting growth and development of groundnut. In their work on groundnut nutrient removal, *Cox et al*, [14] found that N and P concentrations decreased steadily from plant age 2 to 21 weeks; K increased nearly a full percent from week 2 to week 6 before decreasing slightly with further age; Mg tended to increase slowly to weeks 10-12 and then decrease slightly.

Experiments on groundnut have shown marked responses to plant population in terms of dry matter accumulation, economic yield and yield components (Tarimo, [15]. Studies with groundnut under irrigation observed that water quality appeared to reduce the concentration of Mg and increase the concentration of K in plant tissue.

Nutrient status is an unseen factor in plant growth except when imbalances become so severe that visual symptoms appear on the plant. Several factors including crop variety selection, available moisture, soil fertility, adaptation to the area, plant densities, weed densities, presence of disease, pests and weeds could have profound effect on the nutrient element composition of the plant. Similarly in cases where the soil tests are adequate but there are deficiencies showing up in the plant tissue, it may indicate some problem reducing the ability of the plant to access the nutrients in the soil, such as diseases, insects or soil compaction impeding root

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**Table 1. Physico-Chemical Characteristics of Soil Taken from the Experimental Site**

| Soil Properties | 2006 |
|---|---|
| Physical properties | |
| % sand | 61 |
| % silt | 30 |
| % clay | 9 |
| Textural | Sandy loam |
| Chemical properties | |
| pH in $H_20$ | 5.8 |
| pH in 0.1m $calc_2$ | 4.8 |
| % organic carbon | 0.43 |
| Available P (c mo1kg$^{-1}$) | 9.44 |
| % Total nitrogen | 0.088 |
| Exchangeable cations (c mol kg$^{-1}$) | |
| K | 0.18 |
| Mg | 0.33 |
| Ca | 1.0 |
| Na | 1.18 |
| CEC | 1.80 |
| Exchangeable acidity $H^+$ and Al | 0.80 |

function. The use of low plant population density per unit area is also responsible for low yields of groundnut. It is possible to get higher yields of groundnut by planting at higher densities instead of the lower densities traditionally employed and practiced by farmers. There is a dearth of information regarding groundnut production with irrigation much less the type of method used, however basin irrigation is the most popular method of irrigation in developing countries generally and particularly in the area where this study was undertaken. In experiments with other crops, Falaki [16] recommended that depending on the degree of land leveling, basin size ranging from 2m x 2m to 5m x 5m should be used for optimum growth and yield of wheat while Abubakar [17] working on tomato obtained the highest fruit yield in the 2m x 2m basin. This study was therefore conducted to investigate the influence of plant populations and different basin sizes on leaf nitrogen, phosphorus, potassium and magnesium concentration of groundnut varieties under irrigation

## MATERIALS AND METHODS

### Experimental Site

The experiment was conducted at the Irrigation Research Substation of the Institute for Agricultural Research, Ahmadu Bello University Kadawa (11° 39'N, 08" 27'E; 500m above sea level) during the 2006 dry season.

### Treatments and Experimental Design

The treatments consisted of three basin sizes (3m x 3m, 3m x 4m and 3m x 5m), three plant population densities (50,000, 100,000 and 200,000 plants ha-1) and three varieties of groundnut Samnut 23, Samnut 21 and Samnut 11. The treatments were laid out in a split - plot design with a factorial combination of the three plant populations and three varieties occupying the main plot while the three basin sizes were allocated to the subplots. The net plot size per basin was 1.5 x 3, 1.5 x 4 and 1.5 x 5 for the gross plots of 3m x 3m, 3m x 4m and 3m x 5m basin respectively.

### Cultural Practices

After harrowing and ridging at 0.75m width, the field was marked out into plots and thereafter leveled. Sowing was done on at a fixed inter-row spacing of 50cm. The intra-row spacing was however varied at 40, 20 and 10cm in order to give the predetermined plant density of 50,000, 100,000 and 200,000 plants ha-1 respectively. In this process 2 seeds per hole were sown at a depth of 3cm by hand. The first irrigation was applied immediately after seeding. The crop was fertilized with 20kg N, 23.6kg P and 24.9 K/ha-1 as basal dose using urea, single super phosphate (SSP) and muriate of potash (MOP) Weed control was done by pre-emergence application of Metolachlor + Terbutryne (Igram Combi(R) 500EC) at the rate of 4 liters ha-1. Hoe weeding at four (4) and eight (8) weeks after sowing was done in order to remove the weeds that emerged later.

### Leaf Tissue Analysis

At 12WAS samples of two plants plot$^{-1}$ were taken from the border rows. From these the leaves were removed before drying in an oven at $70^0$C for 48 hrs. The dried samples were then ground with a Willey mill and subjected to chemical analysis to determine the concentrations of N, P K and Mg on a dry weight basis. Total nitrogen was determined by the micro-Kjeldahl method Black, [18] after digestion with concentrated sulphuric acid. P concentration was determined by the vanado-molybdate yellow method Olsen and Sommers [19] after digesting with 2, 4 N perchloric acid while K was determined using flame photometer. After extracting with mixture of 25% hydrochloric acid and 55% nitric acid, Mg concentration in plant tissue was determined by atomic absorption spectro-photometry Johnson and Ulrich [20].

### Data Collection and Statistical Analysis

Data collected were subjected to statistical analysis using SAS (SAS Institute Inc.) statistical software. When the *F*-test indicated statistical significance at the $P = 0.05$ level, Duncan's multiple-range test (DMRT) was used to separate the means Duncan [21].

## RESULT

Results of soil analysis taken from the experimental site are presented in Table **1**. The soil of the experimental site was of the sandy loam textural classification; of moderate acidity and having low organic carbon (0.43%). Available P was 9.44 c mol while N was 0.088 percent. Of the exchangeable cations, K had higher values than Na Ca and Mg in that order.

Results of leaf tissue analysis for N, P, K and Mg elements showed that plant populations did not significantly influence their concentrations. Leaf N concentration was slightly higher at 100,000 plants ha-1 than at other populations but the differences were not significant. The leaf

**Table 2. Effect of Plant Population and Basin Size on the leaf N, P, Mg and K Concentrations of Three Varieties of Groundnut in 2006 Dry Season at Kadawa, Sudan Savanna**

| Treatments/Years | | | | |
|---|---|---|---|---|
| | N | P | Mg | K |
| **Plant Population ('000plants ha$^{-1}$)** | | | | |
| 50 | 0.24 | 3.07 | 3.29 | 0.073 |
| 100 | 0.25 | 2.93 | 3.42 | 0.074 |
| 200 | 0.23 | 2.61 | 3.16 | 0.072 |
| SE ± | 0.038 | 0.164 | 0.096 | 0.0012 |
| **Variety** | | | | |
| Samnut 23 | 0.24 | 2.49 | 3.11b | 0.073 |
| Samnut 21 | 0.25 | 3.03 | 3.36a | 0.074 |
| Samnut 11 | 0.26 | 3.09 | 3.40a | 0.071 |
| SE ± | 0.038 | 0.164 | 0.096 | 0.0012 |
| **Basin Size** | | | | |
| 3m x 3m | 0.25 | 2.85 | 3.29 | 0.071 |
| 3m x 4m | 0.24 | 2.86 | 3.26 | 0.073 |
| 3m x 5m | 0.24 | 2.90 | 3.32 | 0.075 |
| SE ± | 0.445 | 0.228 | 0.086 | 0.0018 |
| **Interaction** | | | | |
| P x V | NS | NS | NS | NS |
| P x B | NS | NS | NS | NS |
| V x B | NS | NS | NS | NS |
| P x V x B | NS | NS | NS | NS |

NS- Not significant. Means followed by the same letter within the same treatment group and year are statistically the same.

P, Mg and K concentrations were slightly and insignificantly higher at 50,000-plant ha-1 (Table **2**).

The varieties were not significantly different in their leaf concentrations of N, P and K. However they were significantly different in their Mg contents. Samnut 21 and 11 had significantly higher leaf Mg concentration than Samnut 23.

Basin size did not have significant effect on leaf concentrations of N, P, K and Mg. It was observed that leaf N concentration was slightly higher in the 3m x 3m basin while leaf P Mg and K concentrations were slightly higher in the 3m x 5m basin than others. There were no significant interactions between treatments for leaf N, P, K and Mg concentrations.

## DISCUSSION

The most common use for plant analysis is to diagnose nutrient related problems with crop growth, either a deficiency or toxicity. In cases where the soil tests are adequate but there are deficiencies showing up in the plant tissue, it may indicate some problem reducing the ability of the plant to access the nutrients in the soil, such as diseases, insects or soil compaction impeding root function. While Ulrich and Hills [22] established relationships between maximum yield and concentrations of essential nutrients, Campbell and Plank [23] established interpretation ranges, notably the sufficiency range. They reported sufficiency range for groundnut as follows: N 3.5-4.5; P 0.2 -0.5; K 1.7-3.0 and Mg 0.3 – 0.8. In this study the values obtained for N and K were well below the sufficiency range for leaf tissue concentration of the crop pointing to a low N and K status of the soil of the experimental area. This is not surprising as soils of the savanna are inherently low in N. This low inherent N status had not been corrected by application of sufficient N fertilizer as only a starter dose of 20 kg N/ha was applied. However for P and Mg the reverse was the case, where higher values of the sufficiency ranges were observed for these two elements, indicating luxury consumption of these nutrient elements by the crop

Proper plant nutrition is a good strategy to enhance water use efficiency and productivity in crop plants. In our study, no significant differences were observed in the leaf concentrations of N, P, Mg and K due to plant population and basin size. With respect to this study the assumption that competition for moisture due to higher plant population densities than are normally used, will have negative effect on tissue concentrations of these elements, did not hold true. This is attributed to sufficient amounts of the nutrients especially P in the applied fertilizers. Plant tissue analysis is primarily used to assess the N, P, K and Mg and other micronutrient elements in plants. The micronutrient content of these nutrients in plants may be affected by environmental and genetic factors. Researchers like Pandey and Sinha [24] have reported that analysis of a plant reveals the presence of a large number of mineral elements of which the amount and number of elements present in the plant may differ from plant to plant, place to place and medium to medium in which the plants grow. However, among the varieties, Samnut 21 and Samnut 11 had significantly higher leaf Mg concentration than Samnut 23. This indicates that leaves of the latter varieties were better accumulators of Mg than Samnut 23. This trait is attributed to differences in the genetic composition of Samnut 21 and Samnut 21 compared to Samnut 23. This corroborates the findings of Russell [25] who observed that the concentrations of cations in most plant tissues such as actively functioning leaves are also characteristics of the crop. In experiments with Bambara groundnut, Ramolemana [26] observed that increasing the P rate from 0 to 280mg P $pot^{-1}$ had no significant effect on shoot P content of Bambara groundnut. Plant analysis is most useful if combined with visual inspection of the crop and soil conditions, knowledge of past management in the field, and a current soil test to provide information about soil nutrient levels and soil pH.

## CONCLUSION

In our study, plant populations and basin sizes used did not have any significant effect on the leaf concentrations of N, P, Mg and K. However Samnut 21 and Samnut 11 had significantly higher leaf Mg concentration than Samnut 23.

## CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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