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***Original Research Article***

# Foliar Concentrations of Some Crops Grown in Kano, Nigeria

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**ABSTRACT**
This research paper looked into the foliar concentrations of different crops at the developmental stages of the crops growth. This work was aimed to determine and compare plant foliar nutrients (nitrogen, phosphorus and potassium) concentrations. Total foliar nitrogen (N) was determined by Micro-Kjeldal digestion method, total foliar phosphorus (P) was determined colorimetrically by Vanado-Molybdate method and total foliar potassium (K) was determined by Flame Photometery. Interaction between sites and foliar nutrients for Groundnut ($F_{2, 0.05}$; $P$ = 0.000, $F_{4, 0.05}$; $P$ = 0.010) were significant, Cowpea significant between sites and foliar nutrients ($F_{4, 0.05}$; $P$ = 0.000), and significant ($F_{4, 0.05}$; $P$ = 0.015) for Sorghum as well, millet was insignificant between sites and foliar nutrients ($F_{2, 0.05}$; $P$ = 0.251, $F_{4, 0.05}$; $P$ = 0.193), . There were abundance of foliar nutrients across the sites and high correlation between foliar nutrients, growth phases and some soil properties.

**Keywords: Leaves, Nitrogen, Phosphorus, Potassium, Development stages.**

## INTRODUCTION

The mycorrhizal symbiosis is of key interest to biologists and ecologists because mycorrhizal fungi influence plant productivity and plant diversity, and mycorrhizal fungi connect plants below ground via a hyphal network allowing the movement of resources among coexisting plants. Additionally, the symbiosis plays a key role in the cycling of carbon (C), nitrogen (N), and phosphorus (P) in ecosystems. Given that the vast majority of the Earth's plant species form at least one of the four mycorrhizal associations and given the amount of resources that can move above or below ground because of the mycorrhizal symbiosis, it is likely that the role of the symbiosis in global nutrient cycling is significant (Marcel *et al*., 2015).

There is increasing evidence that mycorrhizal fungi play a key role in the biogeochemical cycles in terrestrial ecosystems. Glasshouse experiments and field studies suggest that plants allocate between 10 and 20 % of their photosynthates to arbuscular mycorrhizal (AM) fungi (Jakobsen and Rosendahl, 1990; Johnson *et al*., 2002; Nottingham *et al*., 2010). Approximately 20 %, and sometimes up to 50 %, of assimilates can be allocated to ectotrophic mycorrhiza (EM) fungi and ericoid mycorrhizal fungi (Hobbie and Hobbie, 2008). Mycorrhizal fungi provide significant amounts of nitrogen (N) and phosphorus (P) to their host plants in natural ecosystems, especially those with reduced soil nutrient availability (Bala and Safianu, 2020). Experiments with single plants and plant communities have shown that AM fungi contribute up to 90 % of plant P (Jakobsen *et al*., 1992; Leake*et al*., 2004; Smith and Smith, 2011). This work however, was aimed at analyzing foliar nutrients (nitrogen, phosphorus and potassium) concentrations of the crops at the different growth stages (pre-flowering, flowering and ripening) and between Bayero University Old Campus and Centre for Dryland Agriculture (CDA) farm.

## MATERIALS AND METHODS

### Collection and processing of Leaves

This work was carried out at Centre for Dryland Agriculture (CDA), and the Old Campus of Bayero University Kano, Nigeria. The coordinates for the sites are 11°58'58"N 8°24'53"E and 11°58'42"N 8°28'40"E, respectively. Plants leaves were collected from Bayero University Old Campus and Centre for Dryland Agriculture (CDA) farm, Bayero University, Kano. Leaves were labeled and transported to soil laboratory of the CDA in envelops. Leaves from the crops sampled were oven dried, ground into powder and analyzed for total foliar nitrogen, phosphorus and potassium concentrations. Total foliar nitrogen (N) was determined by Micro-Kjeldahl digestion method, total

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foliar phosphorus (P) was determined colorimetrically by the Vanado-Molybdate method and total foliar potassium (K) was determined by Flame Photometery, all as described by (Okon and Solomon, 2014).

## RESULTS

Table 1 shows the foliar concentration for Groundnut crop, the Foliar nitrogen for pre-flowering stage tends to go from high to low across Bayero University Old Campus and CDA farm. Bayero University Old campus recorded higher value (1.60 %) than CDA farm (1.28 %). Phosphorus had a higher amount in Bayero University Old campus (2095.17 $mgkg^{-1}$) compared to CDA farm (1170.59 $mgkg^{-1}$). The same goes to potassium with 130.73 $cmolkg^{-1}$ and 101.28 $cmolkg^{-1}$ for Bayero University Old Campus and CDA farm, respectively. At the Flowering Stage, nitrogen, phosphorus and potassium had the same trend of being higher at Bayero University Old campus compared to CDA farm. At the Ripening Stage, the reverse was the case as CDA farm recorded higher amounts of nitrogen, phosphorus and potassium against Bayero University Old campus. From Analyses of Variance (ANOVA), the sites differ significantly ($F_{2, 0.05}$; $P = 0.028$), foliar nutrients also vary significantly as the interaction between sites and foliar nutrients ($F_{2, 0.05}$; $P = 0.000$, $F_{4, 0.05}$; $P = 0.010$), respectively.

**Table 1.** Foliar Nutrient Concentrations of Groundnut at Developmental Stages.

| Stage | Site | Nitrogen (%) | Phosphorus (mg/kg) | Potassium (cmol/kg) |
|---|---|---|---|---|
| **Pre-flowering** | A | $1.60{\pm}0.02^{b}$ | $1073.46{\pm}1.24^{b}$ | $115.91{\pm}1.26^{b}$ |
| | B | $1.28{\pm}0.03^{ab}$ | $821.86{\pm}1.02^{c}$ | $98.78{\pm}0.85^{bc}$ |
| **Flowering** | A | $2.00{\pm}0.15^{a}$ | $1321.64{\pm}1.33^{b}$ | $130.73{\pm}0.59^{b}$ |
| | B | $2.03{\pm}0.10^{b}$ | $772.91{\pm}1.81^{bc}$ | $100.11{\pm}0.42^{c}$ |
| **Ripening** | A | $2.04{\pm}0.08^{b}$ | $2095.17{\pm}2.27^{a}$ | $141.70{\pm}1.88^{a}$ |
| | B | $3.82{\pm}0.15^{a}$ | $1170.59{\pm}1.74^{b}$ | $101.28{\pm}1.66^{c}$ |

**Key:** A= Bayero University Old campus, B= CDA farm. Values are Mean±SD. Means followed by different superscript letters are significantly different at $p < 0.05$ level of probability.

For the Cowpea crop (Table 2), Bayero University Old campus recorded higher values of foliar Nitrogen compared to CDA farm. The same goes to phosphorus and potassium at this stage. At the Flowering Stage, CDA farm recorded higher amount of Nitrogen (1.66 %) compared to Bayero University Old campus (1.49 %). As for phosphorus and potassium, Bayero University Old campus has the upper level then CDA farm. At the ripening stage, Bayero University Old campus had low amount of nitrogen (0.99 %) whilst CDA farm had a higher amount (2.03 %). Phosphorus and potassium also followed the trend of Bayero University Old campus having higher amount than CDA farm. ANOVA similarly detect statistical significance between sites at $F_{2, 0.05}$; $P = 0.000$, also significant between the foliar nutrients for this crop ($F_{2, 0.05}$; $P = 0.000$) and similarly significant between sites and foliar nutrients ($F_{4, 0.05}$; $P = 0.000$).

**Table 2.** Foliar Nutrients Concentrations of Cowpea at Developmental Stages.

| Stage | Site | Nitrogen (%) | Phosphorus (mg/kg) | Potassium (cmol/kg) |
|---|---|---|---|---|
| **Pre-flowering** | A | $1.89{\pm}0.05^{b}$ | $782.52{\pm}0.99^{b}$ | $139.52{\pm}0.83^{b}$ |
| | B | $1.83{\pm}0.11^{b}$ | $584.53{\pm}0.54^{b}$ | $74.33{\pm}0.96^{ab}$ |
| **Flowering** | A | $1.49{\pm}0.02^{c}$ | $985.04{\pm}1.30^{a}$ | $151.36{\pm}1.62^{a}$ |
| | B | $1.66{\pm}0.07^{b}$ | $791.11{\pm}1.12^{a}$ | $81.08{\pm}1.26^{b}$ |
| **Ripening** | A | $0.99{\pm}0.01^{c}$ | $1169.81{\pm}0.65^{a}$ | $127.52{\pm}0.67^{b}$ |
| | B | $2.03{\pm}0.10^{a}$ | $960.25{\pm}0.81^{b}$ | $80.28{\pm}0.52^{b}$ |

**Keys**: A= Bayero University Old campus, B= CDA farm. Values are Mean±SD. Means followed by different superscript letters are significantly different at $p < 0.05$ level of probability.

Table 3 showed the foliar concentration of the Millet crop. For the pre-flowering stage, all parameters had higher concentration in Bayero University Old campus compared to CDA farm. As for the Flowering Stage, CDA farm recorded higher amount of nitrogen (1.66 %) than Bayero University Old campus (1.49 %). Phosphorus and potassium both recorded higher concentrations at this stage. For the Ripening Stage, all parameters were highly concentrated at Bayero University Old campus except of nitrogen which was higher in CDA farm. Foliar nutrients were significant for this crop ($F_{2, 0.05}$; $P = 0.000$), but no significant difference between sites and between sites and foliar nutrients ($F_{2, 0.05}$; $P = 0.251$, $F_{4, 0.05}$; $P = 0.193$).

**Table 3.** Foliar Nutrients Concentrations of Millet at Developmental Stages.

| Stage | Site | Nitrogen (%) | Phosphorus (mg/kg) | Potassium (cmol/kg) |
|---|---|---|---|---|
| Pre-flowering | A | 1.32±0.11$^{b}$ | 1026.19±1.34$^{b}$ | 119.06±1.36$^{b}$ |
| | B | 0.67±0.07$^{bc}$ | 909.70±1.01$^{c}$ | 81.31±0.62$^{bc}$ |
| Flowering | A | 1.59±0.08$^{b}$ | 1645.05±0.16$^{b}$ | 127.52±0.67$^{a}$ |
| | B | 0.87±0.10$^{bc}$ | 1000.61±0.86$^{b}$ | 97.89±0.79$^{c}$ |
| Ripening | A | 1.79±0.05$^{a}$ | 959.90±0.31$^{c}$ | 9.01±0.13$^{d}$ |
| | B | 1.02±0.16$^{c}$ | 1743.59±2.34$^{a}$ | 118.15±0.45$^{b}$ |

**Keys**: A= Bayero University Old campus, B= CDA farm. Values are Mean±SD. Means followed by different superscript letters are significantly different at $p < 0.05$ level of probability.

Table 4 shows the foliar concentration of the Sorghum crop. The pre-flowering stage recorded high concentration of nitrogen and phosphorus at Bayero University Old campus compared to CDA farm, but potassium was recorded in higher amount in CDA farm than Bayero University Old campus. At the Flowering Stage, all factors were observed to be higher in concentration at Bayero University Old campus against CDA farm except with potassium which was higher in CDA farm. At the Ripening Stage, only phosphorus was much in Bayero University Old campus than CDA farm, nitrogen and potassium were both recorded in higher amounts in CDA farm than Bayero University Old campus. For this crop, all parameters (sites, foliar nutrients and between sites and foliar nutrients) were all significant at ($F_{2, 0.05}$; $P = 0.013$, $F_{2, 0.05}$; $P = 0.000$, and $F_{4, 0.05}$; $P = 0.015$).

**Table 4.** Foliar Nutrients Concentrations of Sorghum at Developmental Stages.

| Stage | Site | Nitrogen(%) | Phosphorus(mg/kg) | Potassium(cmol/kg) |
|---|---|---|---|---|
| Pre-flowering | A | 1.69±0.05$^{a}$ | 1685.14±1.32$^{b}$ | 124.08±1.46$^{b}$ |
| | B | 1.10±0.16$^{a}$ | 1748.47±3.72$^{a}$ | 219.01±0.78$^{a}$ |
| Flowering | A | 2.01±0.12$^{b}$ | 1613.95±1.48$^{bc}$ | 116.90±0.13$^{a}$ |
| | B | 1.80±0.08$^{b}$ | 983.18±2.43$^{c}$ | 150.15±0.67$^{b}$ |
| Ripening | A | 1.49±0.07$^{b}$ | 1452.76±1.62$^{b}$ | 104.08±0.85$^{ab}$ |
| | B | 2.31±0.09$^{a}$ | 1195.19±2.33$^{c}$ | 134.11±1.29$^{b}$ |

**Key**: A= Bayero University Old campus, B= CDA farm. Values are Mean±SD. Means followed by different superscript letters are significantly different at $p < 0.05$ level of probability.

Table 5 showed the correlation between foliar phosphorus and growth stages, foliar nitrogen and foliar potassium of the selected plants. This was performed using Spearman's rank correlation coefficient ($r$). This result revealed there was significant difference between foliar phosphorus and growth stages, and also between foliar phosphorus and foliar nitrogen and potassium ($p< 0.05$). The highest correlation was seen between foliar potassium and foliar phosphorus ($r = 0.516$), low correlation ($r = 0.298$) was observed at flowering stage and foliar phosphorus. This is followed by preflowering stage and soil phosphorus ($r = 0.021$) and finally $r = 0.022$ at flowering stage and soil phosphorus.

**Table 5.** Bivariate Correlation between Foliar Phosphorus and growth stages, Folia Nitrogen and Foliar Potassium of the selected plants.

| Variables | Foliar Phosphorus (mg/kg) | Soil Phosphorus (mg/kg) | Soil Potassium (cmol/kg) | Soil Nitrogen (%) |
|---|---|---|---|---|
| Pre-Flowering | -0.107 | 0.021 | 0.256 | -0.088 |
| Flowering | -0.292 | -0.022 | 0.145 | -0.110 |
| Ripening | 0.145 | -0.131 | 0.073 | -0.119 |
| Foliar Nitrogen (%) | -0.282 | -0.262 | 0.308** | 0.045 |
| Foliar Potassium (mg/kg) | 0.516*** | 0.220 | 0.194 | 0.208 |

Spearman's rank correlation coefficient (*r*) is significant at $P < 0.05$ level (2-tailed); RLC = root length colonization. *** Values showing high correlation. ** Values showing medium correlation.

## DISCUSSION

The result of foliar analyses of groundnut plants showed that the foliar nitrogen (2.04 %), phosphorus (2095.17 $mgkg^{-1}$) and potassium (141.70 $cmolkg^{-1}$) in Bayero University Old Campus and foliar nitrogen (3.82 %), phosphorus (1170.59 mg/kg) and potassium (101.28 cmol/kg) in CDA farm were highest during the ripening growth phase of the plant. The result indicated that foliar nutrients play significant role in the ripening growth phase of the plant than in the pre-flowering and flowering growth phase. In agreement to this result, Jagadeesh *et al.* (2006) observed in their findings that concentration of foliar nutrients change in both plant anatomical fractions, as well as in whole plant with plant maturation. In direct contrast, the result of the foliar analyses of cowpea, millet and sorghum plants showed that foliar Nitrogen, the considerable decline in the foliar nutrient concentration with increasing crop maturity and the consistently high Nitrogen, Phosphorus and Potassium concentrations of the plants were in agreement with earlier experiments (Kidambi, 1990). The result of the present study is also in close conformity with the observations recorded by Yildirim *et al.*, (2007), Shelake *et al.*, (2011) and Aslihan *et al.*, (2011) who also reported response of plants to different foliar nutrients.. The greater mobilization of phosphorus in the presence of nitrogen may also be a reason for higher uptake of P as reported by Hocking and Pinkerton (1993) and Manasa (2013). In addition, it has been suggested that phytohormones, such as indole acetic acid (IAA) and cytokinins, released by mycorrhizal fungi may also contribute to the enhancement of plant growth (Frankenberger and Arshad, 1995).

## CONCLUSIONS

The study concludes that plant foliar nutrients were in abundance in both sites. In addition, the study indicated that there was very high correlation between foliar phosphorus and growth stages, and also between foliar nitrogen and soil potassium of the selected plans, indicating that foliar phosphorus is essential for plant growth and also for the assimilation of nitrogen and potassium in the soil by the plant.

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