Influence of Microdose of Mineral Fertilizer and Organic Manure on the Production of Groundnuts in Southern Benin

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors KS, ELS and NFA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors PGT, TOYC, FGHK, JFDS and CEA managed the analyses of the study. Author ELS managed also the literature searches. Authors BAS and CEA supervised all of this study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2020/v32i130232

Received 01 December 2019
Accepted 06 February 2020
Published 14 February 2020

Original Research Article

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### ABSTRACT

The use of mineral fertilizers improves crop production and soil productivity. However, its access remains limited to smallholder farmers. This study aims to assess the influence of microdose of mineral fertilizer and organic manure on the production of groundnuts. Field experience was carried out using Fischer design with five treatments and five replications: T control (Without organic matter and fertilizer); T0 recommended dose of mineral fertilizer (103.77 kg/ha or 0.93 g/poquet 15 days after sowing); T1 recommended dose of mineral fertilizer and organic matter (0.5 kg/m²); T2 microdose of mineral fertilizer (0.57 g NPKSB [14-23-14-5-1] 15 days after sowing); T3 microdose of mineral fertilizer and organic matter (0.5 kg/m²). Linear mixed-effect models were used to analyze the data. The results showed that the microdose of mineral fertilizer and / or organic manure had a significant effect on yield parameters such as aboveground biomass (fresh or dry), the number of nodules and the weight of the groundnuts pods (Prob < 0.05). The treatment T2 (microdose of mineral fertilizer) increased grain yields (8.1±1.5 g/plant) compared to other treatments. Thus, the microdose of mineral fertilizer is economically more profitable than the recommended dose.

**Keywords:** Microdose; mineral fertilizer; organic manure; groundnut.

### 1. INTRODUCTION

Benin is a developing country where agriculture is the basis of the economy which represents 32.7% of the Gross Domestic Product (GDP) and provides around 70% of jobs. Like other countries in the world, it faces the challenges of increasing food production to meet the needs of an increasingly growing population. Seventy-two percent (72%) of farmers are smallholder producers with low financial capacity to cope with adverse effects of climate change [1,2]. This induces increasingly fragile and precarious production conditions and the consequences of which are, among other things, the low income of populations. Recent studies show that low soil fertility keeps people in chronic poverty [3,4]. Faced with this major constraint limiting agricultural productivity, it is necessary to work on the development of agricultural practices that sustainably increase food production and farmers' incomes while protecting and restoring the environment. To this end, a number of technological packages have been developed. Unfortunately socio-economic difficulties linked to access to mineral fertilizers, sufficient quantities of manure, compost and labor considerably limit the effective implementation of these technological packages developed by various research institutions and development projects.

To cope with these difficulties, the technique of microdose of mineral fertilizers which consists to supply small amount of mineral fertilizers in the seed hole has been developed by the institutions of Research in particular the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in partnership with the national research institutes [5,6]. It is cited as one of the methods with the potential to increase crop yields in order to optimize the efficient use of fertilizers and to increase substantial crop yields and therefore farmer income [7,8]. However, groundnuts identified as one of the main legumes cultivated in Benin, record low yields. In terms of consumption, the 4% of the value of household spending on plant and animal products is spent on buying groundnuts or their by-products. Beninese takes from groundnut 5; 8.9 and 20.5% of their calorie, protein and fat needs respectively. It is used in food, animal feed and in industry. The main objective of this study is to assess the influence of microdose of mineral fertilizer and organic manure on the production of groundnuts.

### 2. MATERIALS AND METHODS

#### 2.1 Study Site

This study was carried out in the municipality of Za-Kpota limited in the North-West by the municipality of Djidja, in the North-east by the municipality of Zagnanando, in the South-west by the municipality of Bohicon, in the East by the municipality of Cové and to the South-East by the municipality of Zogbodomey (Fig. 1). The town is located between 7°12' and 7°32' north and 2°15' and 2°30' East. It covers an area of approximately 600 km² on which 87,076 people live (RGPH3, 2002). Located in the center of the Zou department, the town is influenced and dominated by sub-equatorial climate determined...
Fig. 1. Geographical location of the municipality of Za-Kpota
(www.Googlemap.com)
two dry seasons and two rainy seasons. Three types of soil are encountered in the municipality of Za-Kpota. These are: ferrallitic soils commonly called “terres de barre”, poor in organic matter and minerals because of their long use, tropical ferruginous soils, but less poor, very shallow due to concrete outcrops and hydromorphic soils still rich and suitable for agricultural production which are encountered in depressions and shallows.

2.2 Experiment Design and Data Collection

The field experiment was installed in 2019 during the rainy season with local variety of groundnuts (Arachis hypogaea) of spanish group. The experimental was carried out in Fischer design with five treatments and five replications. The elementary plots had a dimension of 3 m x 3 m (9 m²). The treatments were T control (without organic matter, without mineral fertilizer), T0 recommended dose of mineral fertilizer (103.77 kg / ha or 0.93 g / poquet 15 days after sowing); T1: recommended dose of mineral fertilizer and organic matter (0.5 kg / m²); T2: microdose of mineral fertilizer (0.57 g of NPKSB (14-23-14-5-1) / poquet 15 days after sowing); T3: microdose of mineral fertilizer and organic matter (0.5 kg / m²). The organic manure was brought during plowing to an amount of 4.5 kg per experimental unit; the recommended dose was brought per poquet at a quantity of 93.4 g per experimental unit. The microdose consisted in bringing a small quantity (0.57 g) of mineral fertilizer 15 days after sowing in a bucket made at most 10 cm from the groundnut plant while taking care not to injure the roots. The rates of mineral fertilizer applied are summarized in Table 1. The soil texture of the site was sandy loam. The organic carbon and total nitrogen contents were 0.39 and 0.032% respectively. Soil pH was 5.99. The contents of exchangeable potassium and assimilable phosphorus were 0.13 Cmol/kg and 4 mg/kg respectively.

Burial of organic matter (rabbit droppings) was done during ploughing for experimental units requiring organic matter. Sowing was carried out in poquets with a spacing of 15 cm between poquets and 60 cm between rows, i.e. a density of 101,000 plants per hectare. Growth data (height and number of leaves) were collected on 10 groundnut plants selected at random by the diagonal method. Yield data was collected at plant maturity. Biomass, kernel and shell yields were estimated after drying under study until constant weights were obtained.

2.3 Data Analysis

The General Linear Mixed Effects Model (lme function from the nlme library) was used to analyze continuous variables such as plant height and yield parameters. The mixed-effect generalized linear model (glmer function from the lmertest library) with the Poisson family was used to analyze count data (leaf count and nodule count). In the different analyses, microdoses of fertilizer and organic matter were considered as fixed factors and producers as random factor. All statistical analysis were carried out in R Software (version 3.5.3). Graphs were made using the ggplot2 package in R.

3. RESULTS

3.1 Effect of Microdose Mineral Fertilizer and/or Organic Manure on Groundnut Growth Parameters

The analysis of the influence of microdose mineral fertilizer and/or organic manure on groundnut growth parameters (Table 2) showed that the treatments had a significant effect on both parameters (leaf height and number of leaves).
The evolution of growth parameters as a function of time (Fig. 2) showed that the leaf count initially increased and peaked at 60 days and then decreased. The trends were the same regardless of the treatment, but the simultaneous application of the recommended dose and organic matter proved to be more effective, followed by T3, T2 and T0 treatment in last position. The influence of treatment on height was similar to that noted for leaf count with the only difference being that the height did not decrease during the 75 days of collection.

Table 2. Results of the analysis of the influence of treatment on growth parameters

| Factors          | Height | Number of sheets |
|------------------|--------|------------------|
|                  | DF     | chisq            | prob   | chisq            | prob   |
| Time             | 4      | 888.54           | $< 10^{-3}$ | 4733.988           | $< 10^{-3}$ |
| Treatment        | 3      | 131.55           | $< 10^{-3}$ | 301.492           | $< 10^{-3}$ |
| Time Treatment   | 12     | 35.8             | 3.5 $< 10^{-4}$ | 41.153           | $< 10^{-3}$ |
| ICC production (%) | -      | 43.63           | -       | 8.69             | -       |

ICCs: Interclass coefficients

3.2 Effect of Microdose of Mineral Fertilizer and/or Organic Manure on Groundnut Yield Parameters

The results of the model estimation (Table 3) indicated that the application of microdose mineral fertilizer and/or organic manure had a significant effect on yield parameters such as aerial biomass (fresh or dry), nodule number and groundnut pod weight (Prob <0.05). The random effect of growers was not negligible as the Interclass Coefficients (ICCs) were all greater than 17%.

The combination of microdose and organic matter (T3) resulted in higher yields of fresh aerial biomass (46.6 ± 5.5 g/plant; Fig. 3). On the other hand, application of the recommended
dose (T0) was more effective followed by T2 for dry biomass yield (2.3 ± 0.9 and 2.2 ± 0.7 g/plant, respectively). For nodule count, pod weight and grain weight, microdose application (T2) was more effective followed by the recommended dose plus organic matter (T1).

4. DISCUSSION

It appears from our work that the treatments carried out had a significant effect on the number of leaves and height. The T1 and T3 treatments had a positive impact on the above-ground biomass; this could be explained by the contribution of organic manure. The significant yield increases observed with the application of the microdose fertilizer technique show that they induce a positive effect on the production of the groundnut crop. Grain yields were high using this technique compared to the T control and the recommended T0 rate. Similar results were obtained by Aune et al. [9], Sogodogo et al. [7]

Fig. 3. Effect of microdose of mineral fertilizer and/or organic manure on groundnut yield parameters

T = control (without organic matter, without mineral fertilizer); T0 = recommended dose of mineral fertilizer (103.77 kg/ha or 0.93 g/poquet 15 days after sowing); T1 = recommended dose of mineral fertilizer plus organic matter; T2 = microdose of mineral fertilizer (0.57 g of NPKSB (14-23-14-5-1) 15 days after sowing); T3 = microdose of mineral fertilizer plus organic matter
5. CONCLUSION

This study showed that microdose technique of mineral fertilizer and organic manure compared to the producers practice on groundnut (Arachis hypogaea L.) cultivation significantly increases yields. The highest seed yields were obtained with mineral fertilizer applied in microdose compared to yields from the recommended dose. In view of the high yields obtained by the use of the microdose fertilizer technique in groundnut production, it appears that the cultivation system based on this technique contributes to the improvement of food security and income of producers in our regions. However, constraints on access to mineral fertilizer limit the large-scale adoption of the technique by producers. Efforts must be made to reduce the cost of mineral manure so that producers can afford it.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tabo R, Batiano A, Diallo MK, Hassane O, and Koala S. Fertilizer microdosing for the prosperity of small scale farmers in the Sahel. Final Report 2001-2004, ICRISAT, Niamey. 2005;28.
2. Vall E, Koutou M, Blanchard M, Coulibaly K, Diallo AM, Andrieu N. Intégration agriculture-élevage et intensification écologique dans les systèmes agrosylvopastoraux de l’Ouest du Burkina Faso (Prov. Tuy); 2011.
3. Barrett CB, Bervis LEM. The selfreinforcing feedback between low soil fertility and chronic poverty. Nature Geoscience. 2015;8:907-912.
DOI: 10.1038 / ngeo 2591
4. Vanlauwe B, Six J, Sanginga N, Adesina AA. Soil fertility decline at the base of rural poverty in sub-Saharan Africa. Nature Plants. 2015;1:15101.
DOI: 10.1038 / nplants.2015.101
5. Palé S, Mason SC, Taonda SJB. Water and fertilizer influence on yield of grain sorghum varieties produced in Burkina Faso. S.Afr. J. Plant Soil. 2009;26(2): 91-97.
DOI:http://dx.doi.org/10.1080/02571862.2009.10639939
6. FAO (Food and Agriculture Organization of the United Nations), TERRAFRICA. Part 2: good practices for sustainable land management adapted to sub-Saharan Africa. Technology groups and case studies. Integrated soil fertility management. In: The practice of sustainable land management. Guidelines and good practices for sub-Saharan Africa. FAO, Rome. 2011;64-93. Available:www.fao.org/docrep/014/i1861f/i1861f04.pdf (Accessed 10/7/2017)
7. Sogodogo D., Coulibaly B., Coulibaly BY, Sacko K. Impact of mineral fertilizer microdosing on the yield of sorghum in adoption fields of women trained in farmers’ field School of Niako in South Sudan Area of Mali. International Journal of Current Microbiology and Applied Sciences. 2016;5(4):698-704.

8. Tovihoudji PG, Akponikpé, PI, Agbossou EK, Bertin P, Bielders CL. Fertilizer microdosing enhances maize yields but may exacerbate nutrient mining in maize cropping systems in northern Benin. Field Crops Research. 2017;213:130-142.

9. Aune JB, Traoré CO, Mamadou S., Lowcost technologies for improved productivity of dryland farming in Mali. Outlook Agr. 2012;41(2):103-108.

10. Ouattara K. Improved soil and water conservatory managements for cottonmaize rotation system in the western cotton area of Burkina Faso. Doctoral thesis. Swedish University of Agricultural Sciences (SLU), SE90183, Umea, Sweden. 2007;50.

11. Muehlig-Versen B, Buerkert A, Batino A, Roemheld V. Phosphorus placement on acid arenosols of the West African Sahel. Exp. Agric. 2003;39:307-325.

12. Agbé CO. Efficacité et efficience de la fertilisation du sol par micro dose de l'engrais NPK selon le type de sol dans le terroir de Nagréongo. Rapport de stage CAP/Matourkou. 2007;46.

13. Taonda SJB, Yagho E, Soubeiga J, Kabré A. Projet : Transfert de la technologie de fertilisation microdose et des variétés tolérantes à la sécheresse pour la prospérité des petits producteurs agricoles du Sahel. Burkina Faso. 2008;66.

14. Saba F. Performances de la fertilisation par microdose au poquet suivant les niveaux de toposéquence dans le terroir de Nagréongo (Plateau Central). Mémoire ingénieur Institut du Développement Rural/Université Polytechnique de Bobo. 2011;76.

15. Tovihoudji, PG, Akponikpé, PI, Agbossou, EK, Bielders CL. Variability in maize yield and profitability following hill-placement of reduced mineral fertilizer and manure rates under smallholder farm conditions in northern Benin. Field Crops Research. 2019;230:139-150.

16. Aune BJ, Batino A. Agricultural intensification in the sahel. The ladder approach. Agricultural Systems. 2008;98:119-125.

17. Bielders CL, Gérard B. Millet response to microdose fertilization in south – western Niger: Effect of antecedent fertility management and environmental factors. Field Crops Research. 2015;171:165-175.