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EVALUATION OF THE PRODUCTIVITY OF ONION (*ALLIUM CEPA* L) PRODUCTION FACTORS OF SMALLHOLDERS IN THE FAR NORTH CAMEROON ZONE

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ABSTRACT

In the Sudano-Sahelian zone of Cameroon, one of the significant challenges is the low yield observed with onion varieties. An assessment of the productivity of the factors of production would enable the determination of the efficiency or inefficiency of utilizing these production inputs. A stratified random sampling method conducted in 112 representative villages enabled the survey of a sample of 1,561 farmers in the Far North area. The non-parametric approach (Linear Programming) based on the Data Envelopment Analysis (DEA) method focused on production inputs was used to determine technical efficiency and/or inefficiency. The results revealed that mapping the fertilizer variety and formulations showed that the traditional Goudami variety and formulations (NPK 20-10-10 or 22-15-10-5S-1B) are more popular with small and medium-sized producers. While great onion producers' use more imported seeds (Violet de Galmi) with the 20-10-10-6S03 formulation. A technical efficacy/ineffectiveness evaluation showed that except for the Chagari variety (12.20% vs. 11.38%), all other onion varieties (Goudami, Sokoto and Violet de Galmi) used had higher values of inefficiencies (43.09% vs. 11.79%; 3.25% vs. 1.22% and 14.23% vs. 2.44% respectively). In addition, a proportion of 82.87% of use of two formulations (NPK 20-10-10-2.5CaO and NPK 22-15-10-5S-1B) of fertilizers was recorded, but its instructions for use are still ineffective (41.06% compared to 23.17% respectively). The mapping of fertilizer formulations and seeds used presented the same trends in distribution around 02 axes of standardization. The application of a few production inputs by onion producers is inefficient. However, the productivity of nutrients and onion varieties appears interesting when selecting the best nutrients, which would constitute one of the significant steps in improving onion bulb yield.

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INTRODUCTION

The onion (*Allium cepa* L.) is a globally renowned vegetable with enormous economic potential and diverse uses in the food industry (Baco et al., 2005). Its global production exceeds 4365.95 million tonnes (FAO, 2024). This volume of production contributes

economically to the GDP of some onion-producing countries. In West Africa, onion cultivation contributes between 19 and 47 billion of the Community of Africa's Francs (CFA francs) to Niger's GDP (Boukary et al., 2012). In Senegal and Burkina Faso, the added value is around 35 billion CFA francs (CGERV, 2017) and 24.87

billion CFA francs (Yili, 2013) respectively. In addition, particularly in the Far North of Cameroon, where 74.65% (338,634.66 t/year) of national production comes, this annual production contributes more than 19 billion CFA francs/year to Cameroon's GDP (Agristat, 2022). This economic value allows onion producers to improve their incomes, which plays a crucial role in poverty reduction by developing the onion value chain (Abebe et al., 2018). Thus, substantial remuneration allows small-scale rural producers in the Far North to meet their basic needs (nutrition, clothing, health care costs, and school fees) within agricultural households (Kamga et al., 2016). Despite the multiple importance of this cash crop, its production is highly fluctuating and less efficient due to specific production constraints (Cathala et al., 2003). The lack of information on the nature and quantity of amendments especially on the types of mineral fertilization is an obstacle to the improvement of low yields of onion bulbs, which vary between 7.9 t/ha and 11 t/ha (Kamga et al., 2016). In addition, the lack of control of the technical itinerary and the inefficiency of the management of production factors are also the causes of low onion yields in the Far North (M'Biandoun and Essang, 2008; Mamadou, 2012; Kamga et al., 2016, Sakatai et al., 2019). On the other hand, some West African countries have high yields (22 t/ha to 35.6 t/ha in Niger (SOFRECO, 2022); 21.2 t/ha in Mali and 20 t/ha in Burkina Faso (CSA, 2011). However, Niger has edapho-climatic conditions and main varieties almost similar to those of the Far North region of Cameroon (Boukary et al. (2012); Kamga et al. (2016); Bassole et al., 2017); Abdou et al., 2015). Despite these almost similar pedoclimatic and varietal characteristics, low yields are recorded in the Far North compared to those of Niger, Mali and Burkina Faso. Fleissner et al. (2015) and PADFA (2017) found that onion bulb yields of up to 27 to 38 t/ha in the Sudano-Sahelian zone of Cameroon with the local Goudami "Landraces" in a farmer environment.

Recent characterization studies on 05 onion varieties conducted by Sakatai et al. (2019) in the locality of Gazawa in the dry season also revealed high yields (50.48 t/ha and 49.24 t/ha) with these local varieties (Chagari and Goudami respectively). These studies carried out focused on improving yield, but now it is more relevant to explore the efficiency of the use of production inputs. Thus, it would be convenient to explore how they manage factors of production by

assessing factor efficiencies to determine the key factors that need to be addressed to induce increased yields.

MATERIALS AND METHODS

Study area

Description of study

The climate of the Far North region is Sudano-Sahelian (dry tropical type), characterized by a dry season of 7 to 8 months (November to April) compared to 3 to 4 months (July-August-September to October) of rainfall with an annual rainfall of 810 mm in Maroua, for 1 month less humid in September-October during this period (ONACC, 2018; Onana, 2020). According to Djocgoue (2012), the hydrographic network of the Far North region is composed of two basins (Chadian and Nigerian). The Mandara Mountains (1,442 m), a very contiguous area that is also mainly made up of uncultivated land (boulders, pebbles, etc.), are marked by a poverty of vegetation cover due to the intensification of agriculture and pastoral activities (Djocgoue, 2012; Onana, 2020). This Sahelo-Saharan sector has a pedological diversity with its contrasts which are linked to rainfall and relief. The soils of the Far North have specific soil formations and are adapted to different crops. These include sandy soils in plains favourable to sorghum and groundnuts; alluvium-rich loamy soils along watercourses favourable to cotton, sorghum, cassava and sweet potato; vertisols or clay soils favourable to the cultivation of moussouri and sterile or Hardé soils which are sodic (Djocgoue, 2012). The mountainous parts are characterized by domestic trees such as *Acacia albida*, *Celtis integrifolia*, *Ficus* spp., *Khaya senegalensis*, *Parkia biglobosa*, etc. The Far North Region is characterized by great ethnic and religious variability (Muslims, Christians and animists). This region is characterized by a low availability of arable land, insufficient socio-economic infrastructure and a high population density (77 inhabitants/km²) (ONACC, 2018).

Sampling of the survey

The survey was based on the stratified random sampling technique (Gumuchian and Marois, 2000). The first stratum consists of the onion production basins' levels (small, medium and large). The second stratum was made considering the degree of accessibility (Baïz, 2020). Some areas (Kolfata, Moskota and, Guetchewé, Zelevet) that are most difficult to access (insecurity)

were not surveyed. A representative sample in 112 villages was chosen according to the geographical diversity of the physical and human conditions of the exploitation of the environment (topography, soil structure and texture, cultivation practices, etc.) (Demont and Jouve, 2000). We have accepted a percentage of 20% of households as the proportion of onion producers in the total population of the Far North region. Thus, in this hypothesis, the theoretical minimum number of households, which was representative of the entire area, was determined using the following formula reported by Durand (2002).

$$n = \frac{z \times P (1-p)}{\varepsilon^2}$$

n = minimum sample size

Z = standardized value corresponding to the confidence level at = 1.963 i.e approximately 2

p = proportion of households = 0.5

$1 - p = 1 - 0.5 = 0.5$

α = Error = 0.05

On this basis, the theoretical minimum required is calculated to be 399.6 roughly per 400 households. However, we worked on 1561 onion producers in five departments. Then, for each of these villages, a representative subsample of onion producers was surveyed based on secondary criteria such as gender, age, religion, ethnicity, occupation and size of the area allocated to onion cultivation. An exhaustive list has been drawn up within the subgroup of the onion producer population, the sub-samples have been distributed according to the number of people surveyed within this groups, and thus all individuals have an equal chance of being selected as for the simple random sample. Individuals were randomly selected based on secondary criteria of interest from heterogeneous subgroups. The sample size distribution is shown in Table 1.

Table 1. Sampling of onion producers surveyed from the study population in 2021 in Far North Cameroon.

Departments	Populations (2020)	Number villages	Number onion producers (2020)	Sample
Diamaré	966 396	21	6728	300
Logone-et-Chari	707 387	18	6152	274
Mayo-Danay	827 200	19	139	/
Mayo-Kani	624 551	17	8056	206
Mayo-Sava	534 561	15	44566	387
Mayo-Tsanaga	1 075 765	22	49486	394
Totaux	4 735 860	112	115 127	1 561

Sources : Atanga et al. (2020) and DRADER-EN (2021).

Data processing and analysis

Data collection

The question was developed by structuring the questionnaire on the basis of the themes that were discussed with their sub-sections. This consisted of a process that started from general questions to the most specific ones. We started with the simple introductory preamble. And then we addressed factual and circumstantial questions relating to the habits and behaviours of individuals. And finally, we also addressed questions of opinion which deal with preference and above all to characterize the respondents (age, employment, sex) and to understand their answers as well as their behaviour with regard to the use of certain factors of production. Once this step was completed, we moved on to the writing by focusing on the specific objectives that were quite clear,

understandable and concise. To further refine the questions developed, the most relevant questions were selected such as the way in which fertilizers are used, the source of onion seed, the type of soil most used in onion production, etc. These choices are based on questions that are easy to deal with statistically because all individuals answer with the same terms. Before the administration of the questionnaires at the sample level, a pre-test was carried out in the locality of Kongola-Djoulgof in order to validate the questionnaire to check its quality, length, clarity, relevance of the questions, ease of taking notes, etc. The survey was carried out using a questionnaire intended for onion growers in the study area at harvest time (April-May). The questionnaire was administered to each producer in isolation in order to avoid follow-the-following and conformism with regard to the respondent. Given the

fact that farmers do not have an accounting document, as is the case for most farms of other crops in the different production basins in Africa. The information collected is based on their memory recall (Cochet et al., 2002). Observations were also made in the field and at the bulb storage stores for each collection site.

Variable definitions

The data used consist of all the inputs and outputs of onion bulb production. The variables taken into account are defined by the production (output) of the onion bulbs and the different production inputs. They are:

- Production: it is measured by production and expressed in the number of 100 kg bags
- Labor: the labor used for all cultivation operations. This input is expressed in man/day
- Capital: they constitute the money allocated for fuel, pesticides, transport, etc. it is expressed in CFA francs.
- The capital for the purchase of onion seed varieties
- The capital for the purchase of the type of fertilizer for fertilization
- Cultivated areas by type of soil: The cultivated areas are expressed in hectares

Empirical model

The nonparametric approach, which utilizes linear programming techniques to measure technical efficiency and/or inefficiency, has been employed. The technical efficiency of onion bulb producers has been evaluated using the model developed by Charnes et al. (1978), which is a data envelopment analysis (DEA) analysis method known as the CCR Model (Farrell, 1957). This DEA model is oriented towards the production inputs of onion bulbs. The DEA model calculates the technical efficiency scores of different farms based on an efficiency frontier. Farms located on the border are considered technically efficient, with a score of 1 (100%), and those located below the border are inefficient, with a score of less than 1 (Coelli et al., 2002; Heidari et al., 2011). The econometric model used is presented in the form of:

$$\phi = \frac{\sum_{n=1}^N \mu_n \gamma_{n,j}}{\sum_{p=1}^P \theta_p x_{p,j}} \dots\dots\dots (1)$$

$$TE(x_i, y_i) = \min \phi(\phi_j, x_i, y_i) \dots\dots\dots (2)$$

$$\sum_{j=1}^J \beta_j \gamma_{n,j} \geq \gamma_{n,0} \dots\dots\dots (3)$$

Pour

$$\sum_{j=1}^J \beta_j x_{p,j} \geq \phi \cdot x_{p,0} \dots\dots\dots (4)$$

$$\sum_{j=1}^J \beta_j = 1 \dots\dots\dots (5)$$

- ϕ = being the estimate of technical efficiency to be calculated for each family farm;
- y = inputs (used) and μ = la quantity of inputs;
- x = outputs obtained and v = quantity of outputs;
- β = intensity vector determining the technical efficiency for each operation;
- n = is the number of outputs ($n = 1, 2, \dots, N$);
- p = is the number of inputs ($p = 1, 2, \dots, P$);
- j = represent the j^{eme} DMU (decision making unit).

The underlying assumptions of this model are that the family farm j (1, 2, ..., j) produces the y_n output using a combination of XP inputs (labor, land, fertilizer); and a production frontier focused on variable returns to scale (VRS) inputs. The objective function ϕ_j is a scalar representing the minimum level at which input usage can be reduced without altering the output level. Step 2 uses the Tobit model to identify factors associated with efficiency. The Tobit model is commonly used in regression to estimate technical efficiency values about the factors that may influence it. Efficiency is described by the following equation 8.

$$TE = \beta_0 + \beta_1 \sum_{i=1}^n X_i \dots\dots\dots (6)$$

With TE the efficiency scores obtained by the AED. Therefore, each DMU has a positive efficiency factor, limited to the range 0 to 1. x_i represents the levels of variables that can influence technical efficiency.

RESULTS AND DISCUSSION

Peasant practices of onion producers in the Far North

Types of seeds used in onion production

Table 1 shows that onion producers in the Far North use 92.50% of traditional seeds, i.e. a proportion of 59.39% in favor of the Goudami variety. This low percentage of imported seed use is sometimes justified by the non-availability of imported seeds, especially in July and August when seeds must be sourced. In addition, the Goudami variety is preferred by producers because of its availability (growing history) and especially its seasonality. In addition, in Niger, the main varieties most used are Galmi Violet, Soumarana Blanc and Galmi Blanc, varieties listed in the national catalogue of species and varieties (PRODEX, 2012). Daouda et al. (2013) noted that in the Tarka Valley, it is more the "violet of Galmi" that constitutes a veritable onion mine for more than 75% of the bulbs grown in Niger. The local Goudami and

the Galmi violet are the most widely cultivated varieties in neighbouring Benin (Gotoéchan and Savi, 2001).

Table 1. Type of seeds and varieties used in the production of onion bulbs

Seed type	Frequencies	Percentages (%)	Different varieties used	Frequencies	Percentages (%)
Traditionally	1444	92,50	<i>Goudami</i>	927	59,39
Imported	80	5,13	<i>Chagari</i>	367	23,51
All comers seed	37	2,37	<i>Sokoto</i>	29	1,86
Total	1561	100	<i>Violet de Galmi</i>	238	15,25
			Total	1561	100

On the other hand, in Senegal, several varieties (Violet de Galmi, Mercedes, Gaia and Red-Créole (short-day varieties); Orient, Yellow of Spain, Red of Amposta, Red of Valencia (intermediate varieties) and Red of Amposta, Yellow of Spain (long-day varieties)) are used by growers (CGERV, 2014). In Reunion Island and Mauritius, the veronica and "Kaskavel" varieties are the most used by producers (Gourc et al., (2007). This diversity in the nomenclature of onion varieties can be explained on the one hand by the ethnobotanical name linked to the different languages spoken in each locality. On the other hand, seasonality traits (Sakatai et al., 2019); the botanical aspects and agro-climatic conditions (Deu et al., 2008) are at the origin of the diversity of these onion varieties. It is in this perspective, the results were also obtained by Abdou et al. (2014) showed the existence of diversity between onion ecotypes according to localities of study in Niger. A nuance that exists between onion varieties also makes it possible to differentiate them based on certain stages of the technical itinerary. Under the conditions of the Far North of Cameroon, the appropriate times for farmers to establish onion nurseries are shown in Figure 1. It follows from Figure 1 that the producers of Mayo-Tsanaga, Mayo-sava and Diamaré set up their nurseries in October and November. Meanwhile, Onion producers in Logone et Chari and Mayo-kani prefer to set up their nurseries in September as soon as the rain starts. In the same vein as the establishment of the onion nursery, the favorable periods in Benin and Niger are similar to those in Cameroon. In the Dosso region of Niger, the Dosso CRA (2018) mentioned that the beginning of October is a perfect month for the establishment of the onion nursery.

On the other hand, in Reunion Island (French department of the Indian Ocean) and Mauritius, the right time to sow onions is located from 15 June to 15 July (Gourc et al., (2007). This difference in the establishment

of the nursery is due to the climatic conditions of the production areas. In addition, according to producers in the Sudano-Sahelian zone of Cameroon, a duration of 45 to 55 days for the plants at the germinator level directly leads to transplanting the plants. At the same time, one less duration (2 to 3 weeks) was recorded in Benin (Baco et al., 2005). In addition, the difference in the establishment of the nursery between sub-Saharan countries is explained by the fact that each producer has their own production objectives. In the conditions of the Far North Cameroon zone, the early installation (September) of the nursery constitutes on the one hand the degree of mastery of the technical itinerary of the production of the seedlings and on the other hand, the goal of the producers is the direct sale after harvest of the bulbs because the products are cheap. In addition, water scarcity at onion bulb production sites leads to the early production of transplanted onion plants. In addition, producers who set up their nurseries late (end of October and November) have little control over output. Their objectives for producing onion bulbs are intended for post-harvest storage. Once the plants have been established, the choice of fertilizing elements remains an essential step in the onion bulb production process.

Choice of mineral fertilizers by onion producers in the Far North

Table 3 shows the manufacturing firms and types of mineral fertilizers used in producing onion bulbs. Table 3 shows that producers use all kinds of fertilizers found on the markets. In general, producers use SOLEVO's fertilisers most (82.89%). While in Côte d'Ivoire, the Hydroriz fertilizer developed by YARA West Africa is preferred by producers because it meets the needs of certain crops grown, such as rice in lowland and plateau ecosystems (Gala et al., 2007). More specifically, compared to this fertilizer manufacturing firm, a

distribution of 51.18% against 31.71% was recorded for the NPK 20-10-10-2.5CaO and NPK 22-15-10-5S-1B formulations, respectively. Meanwhile, the fertilizers of the companies YARA and SAMSAM are used little (4.61% and 9.35% respectively) by producers in the Far North.

The small values of these companies are justified by the fact that these formulations are less known to producers. In addition, in Niger, fertilizer of the NPK formulation 15.15.15 is the most widespread in onion production basins (PRODEX, (2012); CRA Dosso (2018).

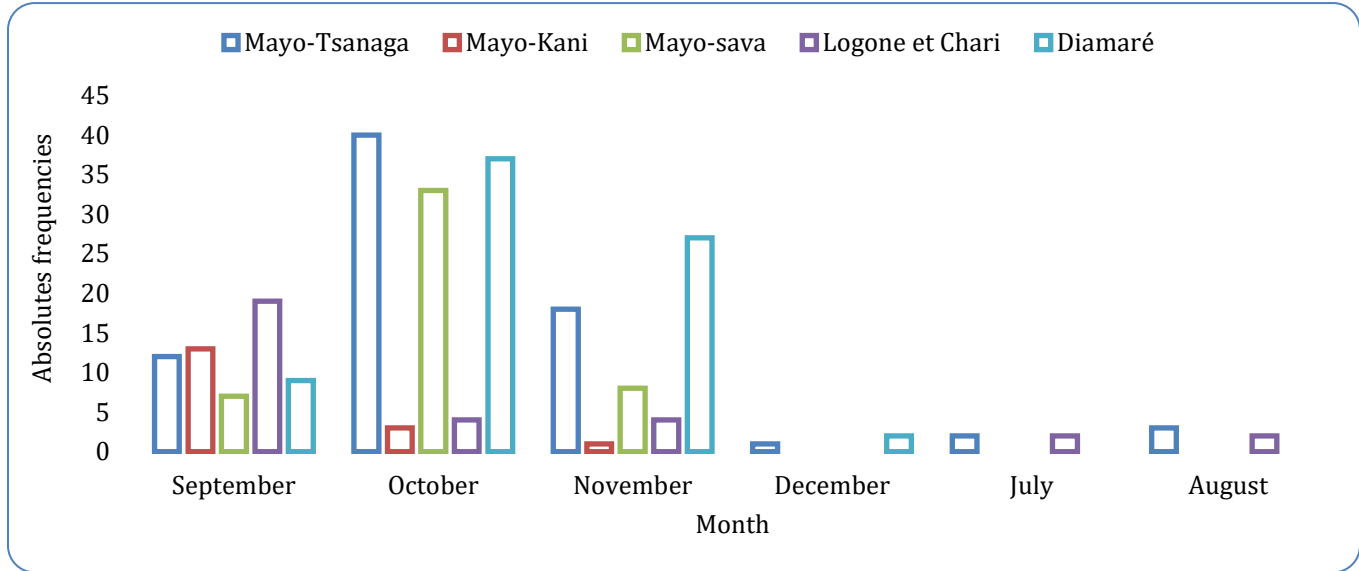


Figure 1. Timing of onion nursery establishment.

However, this formulation is less well-known and underutilized by farmers due to the preference for urea, which provides more nitrogen. This nitrogen is a determinant of yield seems to be the concern of almost all farmers interviewed in the Tarka Valley in Niger (Daouda et al., 2013). On the other hand, in Cameroon, according to the technical sheet developed by Minader (2020), NPK 22-15-10-5S-1B and 14-23-14-5S-1B are recommended for onion cultivation in the Far North. Additionally, in the southern part of Cameroon, complex fertilizers with NPK formulations of 20-10-10 and 12-14-19 are applied to vegetable crops (SehNgoun, 2009). Formulations (9-23-25-1S-1K, 20-20-20, and 18-6-26) with a high proportion of phosphorus and potassium elements were applied to Reunion Island (Gourc et al., (2007).

In Benin, the usual fertilizer applied is cotton fertilizer (NPKSB (14-23-14-5-1)) mixed with urea (Baco et al., (2005); Dugué, 2010)). Overall, there are nuances in the use of mineral fertilizers; this difference lies in the availability of these fertilizers, especially in the soil nature of the soils enhanced by onion cultivation. These onion producers have different characteristics concerning the factors of production.

Typology of onion farmers in the Far North

Figure 2 shows the distribution of variables around two axes of normalization. The analysis in Figure 2 enables the structuring of the diversities of the variables along the two dimensions of the multiple correspondence analysis. This structuring has made it possible to group its variables into 04 classes that vary from one variable to another. From the point of view of the onion production area, their distribution around two axes is composed of four classes, of which the Mayo-Tsanaga constitutes Class 1. Class 2 is represented by Mayo-Sava and Diamaré, class 3 is essentially made up of Mayo-Sava. Moreover, finally, class 4 corresponds to Logone and Chari. The similarity of the same characteristics between the Diamaré and Mayo-Kani production areas is undoubtedly justified by the extension of the plain with similar pedo-climatic characteristics.

Similar studies such as Baco et al. (2005) in Benin showed that based on the areas allocated to onion cultivation, a typology of farms was constituted with 3 groups (ranging from small producers to large producers and medium producers). Additionally, the mapping of fertilizer formulations and seeds used by producers in the Far North revealed similar trends in

distribution along the axes of standardization. Additionally, the traditional Goudami variety used is widespread throughout all production areas of the Far North. This variety of Goudami, along with the NPK formulations 20-10-10-2.5CaO or 22-15-10-5S-1B, is more popular among small and medium-sized

producers. Meanwhile, the wealthiest producers use more imported seeds (such as 'violet de Galmi') with YARA fertilizers to produce onion bulbs in the Far North. The minimal use of imported seed by small and medium-sized producers is justified by the fact that they lack the means, such as large producers, to obtain it.

Table 3. Mineral fertilizer formulations are used in onion production.

Mineral fertilizer manufacturing companies	Fertilizers formulations	Frequencies	Percentages
YARA	NPK 13-13-21-3S-0,01Zn-0,01B	12	0,77
	NPK 20-10-10-6SO ₃	60	3,84
Total	/	72	4,61
SOLEVO (SODECOTON)	NPK 22-15-10-5S-1B	495	31,71
SOLEVO (Bulk)	NPK 20-10-10-2,5CaO	799	51,18
Total	/	1294	82,89
SAMSAM	NPK 21-9-11-5S+1,5MgO+0,15B ₂ O ₃	96	6,15
	NPK 12-14-19-3,5MgO-0,15B	50	2,18
Total	/	146	9,35
OCP	NPK 14-23-14-6S-1B ₂ O ₂	49	3,14
Total	/	49	3,14
UREE	NPK 46-00-00	130	8,33
Grand Total	/	130	8,33
		1561	100

In contrast, in Colombia, small producers, despite a much less intensive system, achieve a profitability similar to that of large producers. However, a breakdown of profitability has shown that among the three groups of producers, their proportions are 73%, 72%, and 67% for small, medium, and large onion producers (Álvarez, 2009). Studies by Sossou et al. (2013) also showed that farmers in Benin are categorized into four groups: the poorest and most vulnerable, the poor, the rich, and the richest, with the latter being the most privileged. In terms of the type of farm operator, the management or use of factors of production varies according to their typology. These authors have shown that labor needs vary according to the type of farm. Additionally, access to agricultural equipment and inputs remains limited and varies depending on the type of farm. Similarly, agricultural inputs remain poorly adopted by farms. Studies by Guéye et al. (2008) on the characterization of resources for onion production in Senegal showed that the mode of land acquisition is highly variable, with the prevalence of axe rights, especially in Vélingara and Kédougou. Its use is varied in agricultural equipment but is more oriented towards animal traction. It was noted that agro-pastoral farms featured a diversity of crops characterized by high

labor intensity due to the limited use of mechanized equipment. The studies on typological characterization carried out by Ndiaye (2018) in the Kaolack region of Senegal have shown considerable variation within three distinct classes, categorized by small, medium, and large producers (farmers). The author demonstrates that the first class is under-equipped and generates the lowest incomes yet yields better results. The second class has average incomes, while the third class is better equipped with labor and agricultural equipment, allowing them to sow a large area (up to 53 ha). As a result, substantial revenues are generated for water. In addition, in Niger, Soukaradji et al. (2017) categorized farmers into 4 groups in which medium-sized large livestock farmers have sufficient production and agricultural income (food self-sufficiency). While large breeders and small farmers hold the largest herds, they face strong pastoral pressure. To do this, Soukaradji et al. (2017) have shown in the same way in which the farmers who have means with good purchasing power manage land allows them to acquire this land, but for its development, they are obliged to have recourse to external labor. Because those who own small areas tend to cultivate them in a short, time and work off their farm to earn a little money through agricultural wages.

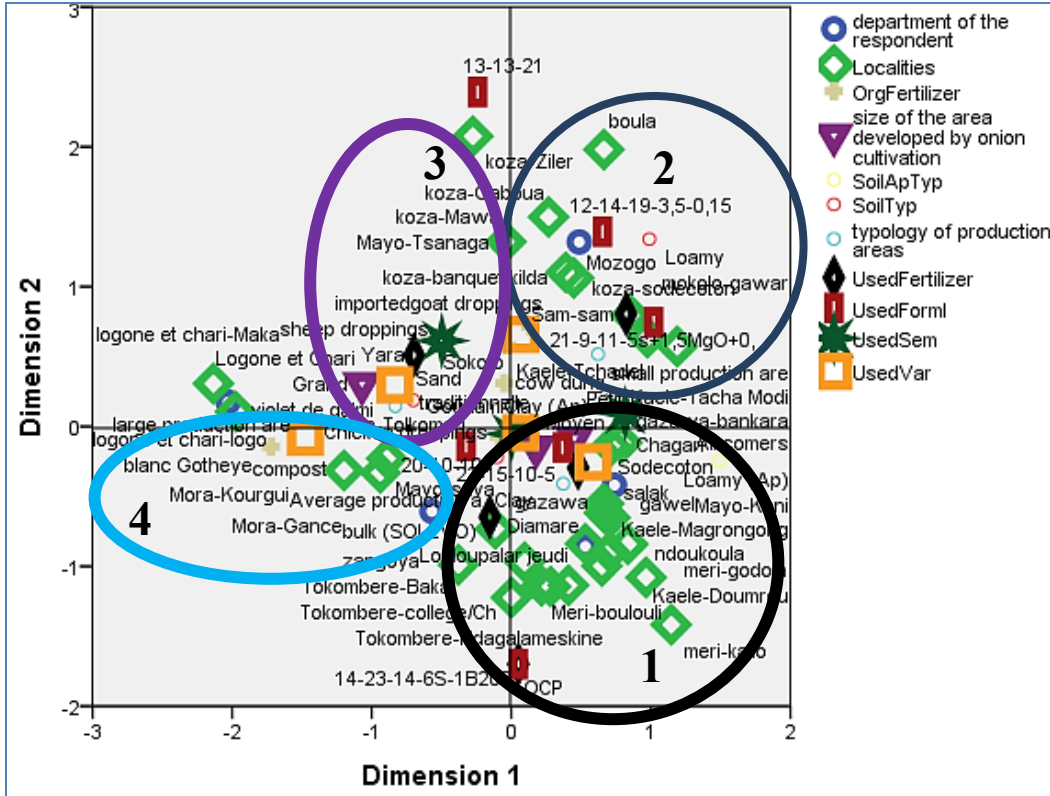


Figure 2: Mapping of the different production areas investigated according to the variables considered. This variation in the typology of producers generally depends on the study's objectives. The assessment of the mode of management of production inputs by different categories of producers involves evaluating performance indicators of production factor productivity to measure the degrees of technical efficiency among onion producers in the Far North.

Technical efficiency of the factors of production of onion bulbs

Table 4 presents the frequency distribution of the technical efficiency of the factors of production used by onion producers in the Far North of Cameroon. Table 4 shows that high proportions (28.05%, 26.83%, and 17.89%, respectively, for small, medium, and large producers) of onion producers make inefficient use of production factors. Specifically, a high percentage (67.89%) of technical inefficiency in the use of conventional seed was recorded compared to other types of seeds, including imported and commodity seeds. Regarding the different varieties used by onion producers, except for the Chagari variety, which recorded a higher percentage (12.20%) of technical efficiency compared to technical inefficiency (11.38%). All other onion varieties (Goudami, Sokoto and Violet de Galmi) recorded higher values of technical inefficiency

(43.09% vs. 11.79%; 3.25% vs. 1.22% and 14.23% vs. 2.44%, respectively) of use. Out of 1,561 onion growers surveyed, 10.12% of the growers effectively use this NPK 20-10-10-2, 5CaO. Additionally, a high percentage (23.17%) of inefficiency was also recorded when applying NPK fertilizer with the formulation 22-15-10-5S-1B. The high values of technical inefficiency recorded by onion producers in the Far North are justified by several factors related to the application of the technical production itinerary. From this perspective, Ouellette and Vierstraete (2004) have demonstrated that failing to integrate agricultural inputs into the production process leads to a decrease in estimated inefficiency. However, if there were a decrease, this type of input would be considered very relevant. In short, the use of a few production inputs by onion producers is inefficient. According to Cooper (2006), these inefficient agricultural producers, therefore, have room for

improvement in their technical production performance. They can refer farmers who are technically efficient to apply their best practices. Some qualitative parameters of the respondents could explain this degree of inefficiency in using these production inputs. Studies by Derera et al. (2022) indicate that the technical efficiency of most wheat producers in Ethiopia exceeded the average value (0.5) of producer efficiency. For these authors, this inefficiency is significantly influenced by the level of formal education. As a result, some authors have demonstrated that literate farmers are technically less inefficient than uneducated farmers (Derera et al., 2022; Mburu et al., 2014; Ateka et al., 2018). For example, promoting education would be wise to reduce the technical inefficiency of production. In Palestine and Zambia, the contradictory results were obtained by Dhehibi et al. (2014) and Chigoma (2015), respectively. Additionally, it has been demonstrated that agricultural experience has a positive and significant impact on the efficiency of wheat farmers in Ethiopia. This means that more experienced farmers are more technically effective than less experienced ones because they may be better equipped to assess the complexity of the right farm decision. In sum, agricultural producers are more technically efficient in allocating factors of production (Derera et al., 2022; Rukwe and Zubairu, 2019); Otitoju et al., 2018; Wake et al., 2019); Fatima, 2016). In particular, soil fertility has been a significant contributor to the technical efficiency of wheat producers in Ethiopia. This means that farmers who have maintained their soil fertility are more efficient than those who have maintained less (Derera et al., 2022; Tenaye, 2016)). While the divergent results were also obtained in Ethiopia by Mamo et al. (2018). This variability in technical efficiency/inefficiency is likely due to several intra- and inter-agricultural aspects of onion production in the far north.

Estimation of coefficients of the explanatory variables of technical efficiency of onion production factors

Table 5 shows the determinants of the technical efficiency of onion bulb production in far-north Cameroon. Table 5 shows that, depending on the typology of farmers, certain socio-demographic parameters (marital status, year of experience of the producer, ethnicity and age group of the respondent) of medium and large onion producers are significant with

the dependent variable (technical efficiency). This substantial difference in coefficient between large and medium producers explains the group categorization of onion producers based on their socio-demographic profiles. Studies by Ouedraogo and Ouedraogo (2008) on production using the stochastic onion cost frontier function highlight the importance of labor variables, "mechanization," "seed," and "irrigation" as the most influential variables in the cost function.

In addition, studies by Abraham et al. (2021) have shown that the quantity produced, off-farm income, land rental, and market prices are considered independent variables that significantly influence the number of bulbs sold on the market in Ethiopia.

In contrast, in Ghana, gender, education, year of production experience, off-farm income, household size, and extension greatly influenced the preference for voandzou agronomic attributes (Agyeman et al., 2020). In Benin, research has demonstrated that the degree of adoption of new rice varieties is influenced by several variables, including the level of formal education, land size, land ownership, and the use of nutrient elements (Loko et al., 2021). This nuance in the explanatory variable would be due to the nature of the study in question. The spatial and geographical distribution, including the gene pools, of the study population is also a primary factor in this variability in variables, independent of the efficiency of production input use. In addition, the duration and distribution of rainfall due to climate variability and change are the uncontrollable factors influencing the production system (Yabi and Afouda, 2012).

These results indicate that for onion producers, an increase in the prices of production factors, such as mechanization, seed, and irrigation, leads to higher production costs. This change in technology and the instability of production input prices may affect all the production systems undertaken by farmers. A specific assessment of each factor's share would be necessary to determine the contribution of each factor of production to bulb production, taking into account the variables considered. The NPK fertilizer formulation of 13-13-21 recorded the highest contribution (14,084.917 CFA francs), while the smallest contribution was 1.011 CFA francs, relating to the variety of Goudami used by onion producers. The results of Abraham et al. (2021) showed that land is one of Ethiopia's most important factors in onion production.

Table 4. Proportion of technical efficiency scores of onion producers according to certain variables.

Sources of variation		Scores of technical efficiency with by the inputs oriented (BCC, 1984)					Percentages of producers		
Modalities of variables	Scores	0,00-0,25	0,26-0,50	0,51-0,75	0,76-0,99	1	% inefficiencies	% efficiencies	total
Small producers	Efficiency /inefficiency	0,247	0,398	0,631	0,862	1	28,05	11,79	39,84
	Frequencies	13	114	178	133	184	438	184	622
Middle Producers	Efficiency /inefficiency	0,199	0,385	0,587	0,863	1	26,84	9,73	36,57
	Frequencies	70	89	133	127	152	419	152	571
Big producers	Efficiency /inefficiency	0,195	0,353	0,568	0,855	1	17,87	5,7	23,57
	Frequencies	38	95	70	76	89	279	89	368
<i>Goudami</i> Variety	Efficiency /inefficiency	0,199	0,383	0,606	0,867	1	47,60	11,79	59,39
	Frequencies	102	179	265	197	184	743	184	927
<i>Chagari</i> Variety	Efficiency /inefficiency	0,235	0,37	0,617	0,878	1	11,33	12,17	23,5
	Frequencies	6	44	57	70	190	177	190	367
<i>Sokoto</i> Variety	Efficiency /inefficiency	0,627	0,846	/	/	1	1,28	0,57	1,85
	Frequencies	8	12	0	0	9	20	9	29
Violet de <i>galmi</i> Variety	Efficiency /inefficiency	0,193	0,387	0,579	0,814	1	12,81	2,43	15,24
	Frequencies	25	72	71	32	38	200	38	238
NPK 20-10-10-2,5CaO	Efficiency /inefficiency	0,199	0,369	0,602	0,869	1	41,06	10,12	51,18
	Frequencies	63	197	191	190	158	641	158	799
NPK 22-15-10-5S-1B	Efficiency /inefficiency	0,226	0,382	0,608	0,864	1	24,40	7,30	31,36
	Frequencies	32	112	129	108	114	381	114	495
NPK 21-9-11-5S+1,5MgO+0,15B2O3	Efficiency /inefficiency	/	0,491	0,602	0,81	1	3,26	2,88	6,14
	Frequencies	0	6	32	13	45	51	45	96
NPK 12-14-19-3,5MgO-0,15B	Efficiency /inefficiency	/	0,463	0,586	0,758	1	2,24	0,96	3,20
	Frequencies	0	12	10	13	15	35	15	50
NPK 14-23-14-6S-1B2O2	Efficiency /inefficiency	0,057	0,486	/	0,95	/	3,14	0,00	3,14
	Frequencies	6	26	0	17	0	49	0	49
20-10-10+6SO3	Efficiency /inefficiency	0,17	0,39	0,52	0,89	1	2,88	0,96	3,84
	Frequencies	6	7	22	10	15	45	15	60
NPK 13-13-21-3S-0,01Zn-0,01B	Efficiency /inefficiency	/	0,37	0,604	0,86	1	0,51	0,25	0,76
	Frequencies	0	1	4	3	4	8	4	12

In addition, access to institutional services (closest distance to market, proximity to extension services, access to information and irrigation) are the most important determinants that drive onion production and supply

in the market (Abraham et al., 2021). The availability and cost of these production inputs would certainly influence the difference in factor contribution to the production of onion bulbs.

Table 5. Estimation of the coefficients the determinants of technical efficiency onion producers.

Sources of variation	Big producers			Average Producers			Small producers		
	Coef	t-test	Sig (p)	Coef	t-test	Sig (p)	Coef	t-test	Sig (p)
Linear regression model (Tobit) (Constant)	0,131	0,335	0,738	-0,164	0,142	0,888	0,711	1,058	0,296
Sex of respondent	-0,120	0,845	0,401	0,082	0,146	0,884	0,076	0,172	0,864
Ethnicity of the respondent	0,060	3,658	0,000****	0,112	2,827	0,006***	0,009	0,335	0,740
Religion of the respondent	0,073	0,723	0,471	0,090	0,405	0,687	-0,275	1,618	0,113
Age group of the respondent	0,134	2,119	0,037**	0,045	0,359	0,720	0,054	0,624	0,536
Profession of the respondent	0,010	0,315	0,753	0,010	0,145	0,885	-0,022	0,589	0,559
Marital status	-0,074	0,802	0,425	-0,136	0,331	0,741	-0,047	0,214	0,832
Size of the producer's household	-0,008	0,692	0,491	0,057	2,494	0,015**	0,002	0,186	0,853
Level of education	0,009	0,257	0,798	-0,008	0,087	0,931	0,086	1,598	0,117
Year of experience of the producer	-0,003	0,432	0,667	-0,023	1,486	0,141*	-0,003	0,370	0,713
Membership of the group	-0,126	1,174	0,244	-0,518	1,930	0,057*	0,076	0,445	0,659

Note: Significance levels: * = 10% ** = 5% *** = 1% **** = 0.1%; Coef: coefficient, t-test = student's test and Sig (p) = probability.

Table 6. Average values of partial factor productivity by variables studied.

Sources of variation		Factors of production			
Variables	Modalities	Area (cfa F/ha)	CI (cfa F/cfa F)	MO (cfa F/Manday)	Amort (cfa F/cfa F)
Type of producers	Small	1,464	1,044	1,534	1,508
	Average	1,891	1,437	1,932	1,889
	Big	2,120	1,856	2,152	2,102
Fertilizers formulations	20-10-10-2,5CaO	50,590	5,413	3314,353	57,845
	22-15-10-5	72,815	6,846	5778,412	61,877
	21-9-11- 5S+1,5MgO+0,15B ₂ O ₃	1,784	1,068	104,357	2,309
	12-14-19-3,5-0,15	19,876	5,124	1130,305	39,278
	14-23-14-6S-1B ₂ O ₃	13,797	1,677	417,204	76,567
	13-13-21	311,963	6,875	14084,917	78,529
Seed type	Traditional	56,694	5,624	4336,015	59,336
	Imported	28,999	4,754	1443,724	17,779
	All comers seed	14,769	2,812	1493,692	25,543
Varieties used	<i>Chagari</i>	13,692	2,149	931,141	12,352
	<i>Goudami</i>	1,236	1,011	3,607	1,156
	<i>Sokoto</i>	22,743	3,313	1606,801	11,325
	<i>Violet de Galmi</i>	16,018	9,343	336,163	20,975

Note: CI: intermediate consumption (inputs); MO: workforce; Amort: Depreciation of materials and equipment.

CONCLUSION

At the end of this analysis, few onion producers in the Far North seem to respect certain significant stages of the technical production itinerary but have diversified behaviours related to the management of production factors. Evaluations of a few inputs used in producing onion bulbs with a majority of them seem ineffective.

This ineffectiveness is not explained by specific socio-demographic data (marital status, the producer's year of experience, the ethnicity and age group of the respondent) of the producers. Despite the technical inefficiency of production inputs, the partial productivity of nutrient elements, such as seeds and varieties, seems interesting in production. Given their essential

contributions to production, the choice of nutrient elements with the best varieties would be one of the major steps in improving the yield of onion bulbs in the Sudano-Sahelian zone of Cameroon.

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