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# Assessment of the agronomic performances of ten improved varieties of bean (Phaseolus vulgaris L.) introduced at Loudima, Republic of Congo.

Auguste Emmanuel ISSALI[1,2], Aidhna Hemerson MOUELET KITSOUKOU[1], Estherline Roguela KONGO KIKABOU[1], Fridolin MOUTSOUKA[2], NZOBADILA Kindiela Budet Winckler[2]

[1]*Laboratory of Plant Production and Biotechnology, Marien N'GOUABI University, Brazzaville, Republic of Congo*

[2]*National Agronomic Research Institute, Ministry of Higher Education, Scientific Research and Technological Innovation, Brazzaville, Republic of Congo*

***ABSTRACT***

*The aim of this study was to evaluate the behavior of ten bean varieties introduced at the Maléla station in Loudima. The experimental set-up was a single-factor design, represented by the "Variety" with ten variants, inserted in a randomized complete block Design with three replications. The thirty plots were uniformly fertilized with triple superphosphate at a rate of 6g per seed hole. Non-parametric methods were used, notably the Kruskal-Wallis Anova equivalent and the independent samples median comparison test. Results showed that block and variety did not influence germination percentage or disease incidence. For the variables discriminated by the blocks, the idea of dividing the experimental site into blocks was justified. The variety TY 3396-12 recorded the highest percentage of germinated seeds, at 81.67%. The highest plant height was recorded by varieties NUV-109-3 and MEX-142. The earliest flowering and ripening times were recorded by Blanc local, while the latest were those of NUV-109-2, MAC-55, P.N.N. and MEX-142. In terms of production, TY 3396-12 had the highest number of seeds produced per pod 5, while Local Yellow, GLP-190-S, Local White and TY 3396-12 had the highest median number of pods produced per plant. GLP-190-S and Local Yellow had the highest medians for pod weight, seed weight and number of attacked pods. Varieties NUV-109-2 and MEX-142, which showed the above-mentioned growth performances, could be recommended to agropastoralists. The varieties Local Yellow, GLP-190-S, Local White and TY 3396-12 would benefit from being offered to farmers and seed producers for their production.*

***Keywords:*** *germination, growth, pests, production*

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## I. Introduction

Common bean (*Phaseolus vulgaris* L.) is an annual herbaceous plant of Fabaceae family. Its worldwide production was estimated at 20.4 million tons in 2008, for a cultivated area of 26.47 million hectares in temperate and tropical regions of America, Africa and Asia ( (Djeugap et al., 2014). In Africa, smallholder farmers grow more than four million hectares of beans each year, feeding more than 100 million Africans. East Africa holds the world record for per capita bean consumption, at around 50-60 kg per year. Beans are an important and growing source of income for rural households, with annual sales in Africa exceeding $580 million in 2005. Their legume quality makes them a fertilizer as well as a source of food and income for households (Web1, 2024). The Republic of Congo boasts considerable agricultural potential, with 10 million hectares of arable land. The agricultural sector employs approximately 40% of the working population but contributes only 5% of gross domestic product (GDP). Since the dissolution of state farms in 1986, the agricultural sector, which currently relies on family farms for 80% of the land under cultivation, has witnessed a significant decline in production. Agricultural exports, which represented around 30 percent of the country's exports until the early 1970s, have become virtually non-existent (Web2, 2024). In the Republic of Congo, the promotion of varietal agro-biodiversity remains a nascent endeavor. Conversely, the yields of beans are markedly deficient, averaging between 600 and 700 kilograms per hectare, a figure that falls considerably short of the potential yield of 2 tons per hectare. The estimated national need is in excess of 5,000 tons per annum, whereas production was approximately 4,100 tons in 2007 (Web2, 2024). It is therefore necessary to introduce new, improved varieties, created and selected by PABRA/CIAT and IRAD, and to assess their performance in terms of adaptability to the Republic of Congo, particularly in the agronomic research zone of the National Agronomic Research Institute (IRA) located in Loudima. The present study was

designed to assess the behavior of the ten bean varieties introduced at the Maléla station. This background information is provided to contextualize the study.

## II. Materials and Methods

### 2.1 Experimental Site and Plant Material

The field experiment was carried out dry-season at Loudima Agronomic Research Zone study site is the Zone de Recherche Agronomique de Loudima on station of Malela. Malela station is located in south of republic of Congo, on Bouenza region at about 12 km from the railway station, on the national road n°1 and situated at 013°04'047" N and 04°09'527" E, overlooking a plateau 154 m high. The area is known for its dominant tropical climate, with an average annual temperature of 25.3°C. Average annual rainfall is 1281mm. Highly desaturated ferralitic soils, characterized by complete alteration of primary minerals, great profile thickness, abundance of iron oxides and hydroxides, elimination of bases along the profile and accumulation of manganese in the form of fine concretions (Nzila, 1992).

The plant material consisted of seeds od eight improved varieties introduced by International Institute for Tropical Agriculture (IITA) of Cameroon and seeds of two local varieties commonly used in the Loudima area. Seeds were sorted and treated with MOMTAZ 45 WS insecticide-fungicide at a rate of 100 g of product per 10 kg of seed.

### 2.2 Experimental Design and Crop Management

The experimental set-up is a single-factor one, represented by the "Variety" with ten variants in a complete randomized block. A single repetition of an elementary plot per block, each containing ten varieties, was planned. The trial area was 402.5 m², with thirty elementary plots of dimensions 1.5 m×5 m. The spacing between blocks and between plots was 1 m. The sowing distances were 50 x 50 cm, between blocks on the row and between rows. This corresponds to a density of 54,444 plants per hectare.

Three hundred and sixty seeds per variety were sown at a rate of three seeds per poquet, one of which was removed. Maintenance involved bottom dressing with triple super phosphate (TSP) in a localized dose of 6 g per packet, i.e. a dose of 78 kg per hectare; watering depended on the dryness of the soil; sarclo-binage consisted in manually pulling up weeds and then turning over the soil with a hoe. Sheep droppings macerated in water for 2 days were applied to the inter-rows at a rate of 32 liters for the total surface area. It was applied twice a week for 4 weeks, twenty days after sowing.

### 2.3 Data Collection

Germination tests were carried out on the ten varieties in the laboratory. The germination percentage of each variety was recorded from a batch of 100 seeds divided into four culture boxes of the ten varieties. After 120 hours of observation, the germination percentage was calculated using the following formula:

$$P = \frac{Number\ of\ germinated\ seeds}{Total\ of\ seeds} \times 100$$

During the vegetative growth period and production, the plant height at maturity was taken using a metal tape measure from the collar to the tip of the terminal leaflet for ten plants in the two central lines. the duration of flowering and maturity of varieties are noted when 50 percent of the plants in a plot have respectively reached 50 percent of open flower buds and 95 percent of dry pods (taste maturity). The number of pods produced per plant and the number of seeds per pod for each variety, observed on 10 plants in the middle rows. Pod weight and seed weight were determined for the entire harvest. These variables are determined at harvest. Phytosanitary observations were conducted, and the number of affected pods was documented. Data on disease incidence and severity were collected at flowering from ten plants from the two central lines of each plot. The following formula was employed to determine the incidence of disease:

$$I = \frac{Number\ of\ plants\ showing\ disease\ symptoms}{Number\ of\ plants\ sampled}$$

Disease severity was assessed on the basis of the 1-9 severity scale established by Mbeugang et al., 2017.

### 2.4 Analysis of Data Collected

The collected data was subjected to non-parametric methods, in particular the H equivalent ANOVA of Kruskal-Wallis using SPSS 26.0 software. Medians were separated using the eponymous test at the 5 % level of probability.

## III.Results

### 3.1 Laboratory germination of seeds of the ten varieties tested

Figure 1 shows the variation in seed germination percentage for the ten bean varieties studied in the laboratory. The general shape of the curves is sigmoidal, with three phases observed for certain varieties: an increasing phase

characterizing seed imbibition, a progressive phase and a plateau marking stability or a halt in the progression of the number of germinated seeds. In contrast, other varieties demonstrate no lag phase in response to rapid imbibition. Figure 1 also demonstrates that the varieties in question achieve germination percentages in excess of 80% 120 hours after germination. The lowest germination percentages were observed in the varieties GLP-190-S, PNN, MAC-55, and Blanc local, with values of 92%, 96%, 98%, and 98%, respectively. The highest germination percentages were recorded by the varieties ECAPAN 021, NUV-109-2, G-16157, Jaune local, MEX-142, and TY 3396-12, with each variety reaching 100%.

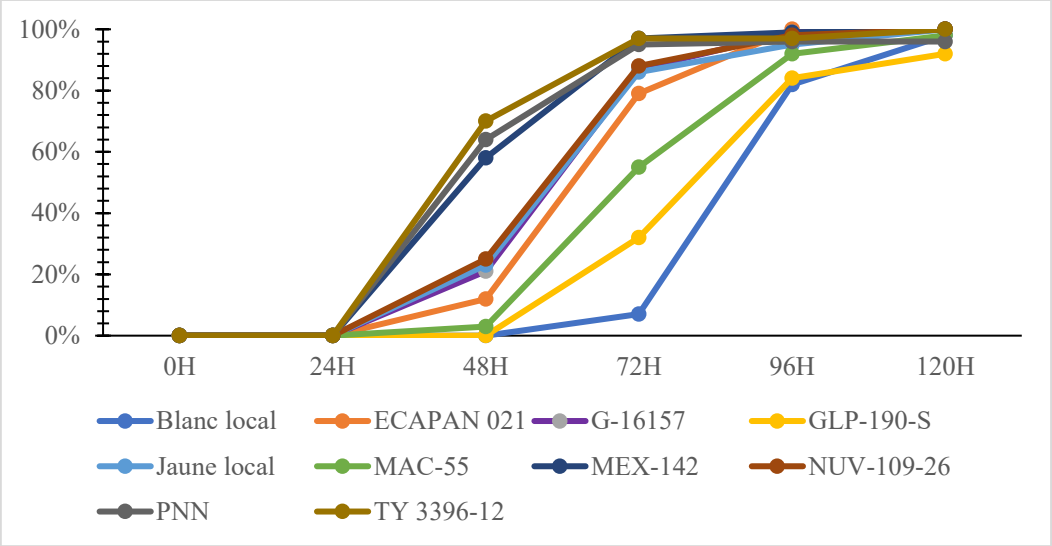


**Figure 1:** Germination percentage of ten varieties tested

Statistical results showed no significant differences between the medians of germination percentage according to factors block and varieties (p-value>0.050, Table 1a et b).

Table 1. Influence of block and varieties of germination percentage for the ten varieties tested

| (a) | Dependent variable* | Source | Calculated value | (b) Dependent variable* | Source | Calculated value |
|---|---|---|---|---|---|---|
| | Pouger | Statistics of test | 3,402 | Pouger | Statistics of test | 12,484 |
| | | Df* | 3 | | Df* | 9 |
| | | p-value | 0,334 | | p-value | 0,187 |
| | | Total | 40 | | Total | 40 |

### 3.2 Agronomic performance of the ten introduced bean varieties and related “Block” and “Variety” effects

The agronomic performance of the ten bean varieties was assessed in the study. The main effects of "Block" and "Variety" were analyzed in relation to plant height at maturity (HautPl), flowering time (DurFlo), plant maturation time (DurMat), number of seeds produced per pod (NbGrG), and number of pods produced per plant (NbGoPl). The analysis revealed that six out of seven variables were not discriminated by the "Block" effect (p-value > 0.05). These variables included pod weight (PoGous) and seed weight (PoGrai), as well as the number of seeds produced per pod (NbGrG) and the number of pods produced per plant (NbGoPl). However, the number of pods produced per plant is influenced by the "Block" effect (p-value NbGoPl= 0.021<0.050). This influence enables the identification of two statistical groups, with the group comprising blocks 2 and 3 exhibiting elevated median values for the number of pods produced per plant (see Table 2). With regard to the "Variety" main effect, significant variations were detected among varieties for the seven variables at the 5% probability threshold (p-value < 0.05; table 3).

Table 2: Classification of median number of pods per plant by block

| (a) | Dependent variable* | Block | Median |
|---|---|---|---|
| NbGoPl | | 3 | 2,00a |
| | | 2 | 3,00b |
| | | 1 | 4,00b |

Values followed by the same letter indicate that they belong to the same statistical class.

Table 3 : Classification of medians for plant height (HautPl), flowering time (DurFlo), ripening time (DurMat), number of seeds per pod (NbGraiG), number of pods per plant (NbGoPl), pod weight (PoGou), seed weight (PoGrai) as a function of the "Variety" effect.

| Dependent variable (a) | Variety | Median (cm) | Dependent variable (b) | Variety | Median (JAS) |
|---|---|---|---|---|---|
| HautPl | G-16157 | 19,15a | DurFlo | Blanc local | 28,00a |
| | ECAPAN 021 | 20,95a | | G-16157 | 28,00ab |
| | Jaune local | 28,2ab | | GLP-190-S | 28,00ab |
| | Blanc local | 30,55b | | Jaune local | 28,00ab |
| | GLP-190-S | 32,7b | | ECAPAN 021 | 30,00ab |
| | P.N.N. | 52,6c | | MEX-142 | 30,00ab |
| | TY 3396-12 | 98,6cd | | NUV-109-2 | 30,00ab |
| | MAC-55 | 99,25cd | | P.N.N. | 30,00ab |
| | NUV-109-2 | 115,7d | | TY 3396-12 | 30,00ab |
| | MEX-142 | 125,1d | | MAC-55 | 50,00b |
| **Dependent variable (c)** | **Variety** | **Medians (JAS)** | **Dependent variable (d)** | **Variety** | **Median** |
| DurMat | Blanc local | 53,00a | NbGrGo | ECAPAN 021 | 1,00a |
| | G-16157 | 53,00ab | | MAC-55 | 2,50a |
| | GLP-190-S | 53,00ab | | MEX-142 | 2,50a |
| | Jaune local | 53,00ab | | G-16157 | 3,00a |
| | TY 3396-12 | 60,00ab | | NUV-109-2 | 3,00ab |
| | ECAPAN 021 | 66,00ab | | Jaune local | 4,00abc |
| | NUV-109-2 | 75,00b | | Blanc local | 4,00abc |
| | MAC-55 | 75,00b | | GLP-190-S | 4,00abc |
| | P.N.N. | 76,00b | | P.N.N. | 4,00bc |
| | MEX-142 | 77,00b | | TY 3396-12 | 5,00c |
| **Dependent variable (e)** | **Variety** | **Median** | **Dependent variable (f)** | **Variety** | **Median (g)** |
| NbGoPl | ECAPAN 021 | 1,00a | PoGous | ECAPAN 021 | 1,800a |
| | MEX-142 | 1,00a | | NUV-109-2 | 8,00a |
| | NUV-109-2 | 1,00a | | MEX-142 | 10,00a |
| | MAC-55 | 1,50a | | MAC-55 | 17,00a |
| | G-16157 | 3,00a | | P.N.N. | 23,00ab |
| | P.N.N. | 3,00a | | G-16157 | 40,00ab |
| | Jaune local | 6,00b | | Blanc local | 93,00ab |
| | GLP-190-S | 6,00b | | TY 3396-12 | 174,00ab |
| | Blanc local | 6,50b | | GLP-190-S | 202,00b |
| | TY 3396-12 | 7,00b | | Jaune local | 311,00b |
| **Dependent variable (g)** | **Variety** | **Median (g)** | | | |
| PoGrai | ECAPAN 021 | 1,8a | | | |
| | NUV-109-2 | 5a | | | |
| | MEX-142 | 8a | | | |

| | |
|---|---|
| MAC-55 | 8a |
| P.N.N. | 9ab |
| G-16157 | 20ab |
| Blanc local | 67ab |
| TY 3396-12 | 116ab |
| GLP-190-S | 140b |
| Jaune local | 234b |

### 3.3 Diseases severity and impact on production of the ten introduced varieties.

Statistical analysis of the number of pods attacked revealed that there were no significant differences according to the Block factor (p-value=0.642>0.050), whereas there were clear statistical differences according to the Variety factor (p-value=0.010<0.050), making classification possible (Table 4). With regard to the incidence of the two main diseases observed (angular leaf spot disease and halo blight) on the experimental site, statistical analysis revealed no differences for any of the ten varieties studied (p-value MTA=p-value Halo blight=0.251>0.050; figure 2).

Table 4: Classification of median number of pods attacked by variety

| Dependent Variable | Variety | Median |
|---|---|---|
| NbGoAt | ECAPAN 021 | 6,00a |
| | NUV-109-2 | 9,00a |
| | MEX-142 | 12,00a |
| | MAC-55 | 13,00ab |
| | P.N.N. | 13,00ab |
| | G-16157 | 17,00abc |
| | Blanc local | 67,00bc |
| | TY 3396-12 | 69,00bc |
| | Jaune local | 145,00bc |
| | GLP-190-S | 152,00c |

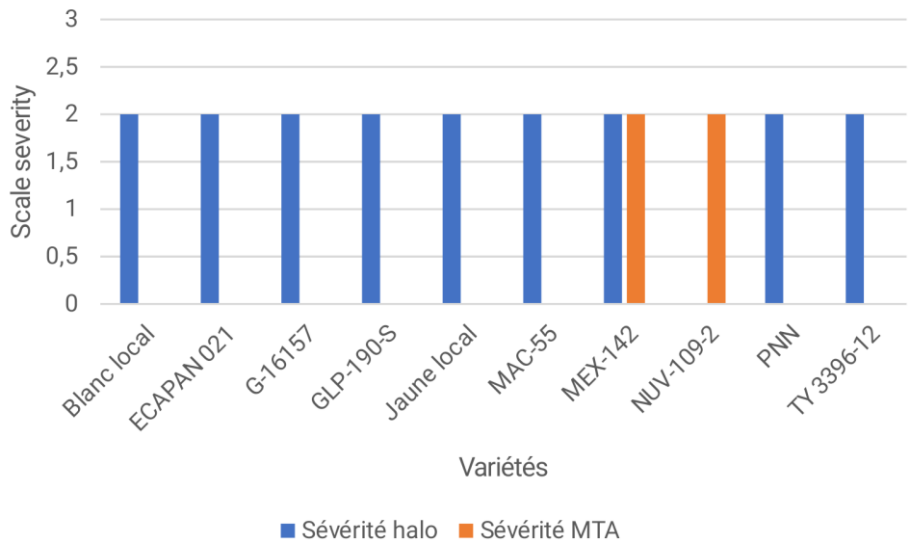


**Figure 2:** Severity of diseases

## IV.Discussion

The germinative capacity and agronomic performance of the ten introduced bean varieties were analyzed, as was the severity of diseases and their impact on production. Varied responses were noted. Our work showed that seed germination percentages for the ten bean varieties tested ranged from 92% to 100%. The varieties ECAPAN 021, NUV-109-2, G-16157, Jaune local, MEX-142 and TY 3396-12 each achieved 100% germination.

The evolution of germination percentages of the ten varieties compared over time shows a sigmoidal pattern. This phenomenon aligns with the conventional paradigm of germination curves, which are typified by

three distinct phases. The latent phase is characterised by the initial absorption of water by the seeds. The subsequent exponential phase is distinguished by a marked acceleration in the rate of germination, concomitant with the mobilisation of metabolites that serve to stimulate the elongation of the radicle, ultimately resulting in the rupture of the seed coats. The third phase is characterised by a plateau, indicating a halt in germination, where all mobilised metabolites stimulate growth. However, with regard to the results obtained, it appears that the differences between the curves may be attributable to an artefact. Indeed, the germinative capacity of these ten varieties is comparable. It can be hypothesised that the metabolic processes responsible for germination in these species may be analogous, with particular emphasis on the processes of imbibition and metabolite mobilisation, which result in radicle elongation. The results obtained in this study have surpassed the 85% standard that was previously defined by Salcedo (2008) within the context of the common bean regeneration guidelines. The varieties NUV-109-2 and MEX-142 demonstrated the highest median heights. This phenomenon can be attributed to the fact that the NUV-109-2 and MEX-142 varieties are voluble and therefore exhibit indeterminate growth, whereas the so-called dwarf varieties demonstrate determinate growth. It is evident that an increase in plant height is associated with an increase in the number of leaves and flowers produced, and consequently, an increase in yield. As demonstrated in the research conducted by Likiti et al. (2021) and Alca et al. (2021), it has been established that different varieties of beans exhibit divergent growth patterns. These findings suggest a correlation between these variations in growth and the genetic potential inherent in the plants. The findings of this study are analogous to those reported by Alca et al. (2021), yet they surpass the outcomes documented by Likiti et al. (2021), who conducted their research on disparate bean varieties. The sowing-flowering cycle exhibited fluctuations ranging from 28 to 50 days post-sowing. The maturation period exhibited a range from 53 to 77 days following the process of sowing. The Blanc local variety exhibited the shortest flowering and ripening times, with these occurring at 28 and 53 days after sowing respectively. The onset of flowering was premature. The variation in flowering time can be attributed not only to differences in variety, i.e. genetic factors, but also to environmental influences, particularly the photoperiod. The research conducted by Shadrach et al. (2008) examined the capacity of four distinct cowpea cultivars for fresh seed production. The study revealed that the green cowpea varieties Coronet, Quick Pick, Early Scarlet and Excel Select, which were cultivated in the United States, reached flowering stage within 39 to 43 days post-sowing. In this respect, the work of Alca et al (2021) demonstrated that the sowing-flowering cycle where 50% flowering occurred was between 30 and 37 days, with an average of 35 days for all the varieties tested. It is evident that the present study bears a strong resemblance to the work of Shadrach et al. (2008). The ripening times of the ten introduced bean varieties were recorded, with NUV-109-2, MAC-55, P.N.N. and MEX-142 exhibiting the longest ripening times, which are incompatible with pre-selection. The present findings are analogous to those of Amongi et al. (2021), yet divergent from those of Binagwa et al. (2018). The latter had obtained ripening times between 67 and 90 JAS for bush bean varieties released in Tanzania. As demonstrated in the research conducted by Amongi et al. (2021), the range of ripening times for commercial dwarf bean varieties was found to be between 53 and 75.67 JAS. The Blanc local variety would benefit from involvement in breeding programmes as a progenitor. The variety designated as TY 3396-12 exhibited the highest median value of five seeds produced per pod. This characteristic is of significant importance, as it constitutes a component of the yield. While this is an inherent characteristic of the variety, the quantity of seeds produced per pod is susceptible to environmental influences, particularly during the phase of pod filling. As posited by Tsibingu et al. (2017), the observed variations among varieties are attributable to genetic factors. The findings of this study demonstrate that the numerical outcomes obtained are higher than those reported by Mufind et al. (2017), who achieved an average of 4.35 seeds per pod, and those of Alca et al. (2021), who obtained an average of 4.5 seeds per pod. Consequently, TY 3396-12 is a variety that could be pre-selected. Local Yellow, GLP-190-S, Local White and TY 3396-12 showed the highest number of pods per plant at harvest. The differences observed in the number of pods produced between blocks are due not only to the heterogeneity of the environment, but also to the fact that block 3 suffered several antelope attacks. The number of pods per plant is one of the components of seed yield. Although genotype-dependent, it can be affected by environmental factors (Walangululu et al., 2019). Our results go beyond those obtained by Likiti et al., (2021). The varieties GLP-190-S and Jaune local, revealed the highest pod weight. This variable could be correlated with the weight of seeds counted at the end of the crop. Our results fall short of those obtained by Likiti et al, (2021). The climatic adaptation factor could also be responsible for the higher seed weight for which the varieties GLP-190-S and Jaune local recorded potential yields of 186.67 kg.ha-1 and 312kg.ha-1. Nevertheless, with regard to susceptibility to attack. Zaghouane (1997), claims that local varieties are not very productive, sensitive to biotic and abiotic stresses. The GLP-190-S variety exhibited tolerance to pest attacks present on the experimental site. Dwarf varieties exhibited a higher incidence and severity of disease in comparison to climbing varieties. As posited by Buruchara et al. (2010), a significant proportion of the causal agents of fungal diseases, including MTA (angular leaf spot disease or ALS), are known to be preserved in soil and plant debris. Consequently, soil could be the primary source of inoculum for MTA and Halo blight. Consequently, dwarf varieties would be more susceptible to the pathogens responsible for MTA (Phaeoisariopsis griseola) and halo blight (Pseudomonas savastanoi pv. Phaseolicola), which are present in the soil. Given that all these varieties are found under the same climatic and edaphic conditions, it can be hypothesised that the results

could be justified by the genetic heritage of each variety. Consequently, varieties demonstrating resistance to the aforementioned diseases may possess genes in their genotypes that confer resistance to these diseases. In accordance with the modified severity scale established by Mbeugang et al. (2017), all varieties are resistant. Our results are comparable to those of Djeugap et al (2014) who, having worked in the locality of Foumbot in Cameroon, showed that the severity of TAM is higher in dwarf varieties than in climbing varieties, whether in untreated or fungicide-treated plots. The incidence and severity of halo blight and MTA could also be due to the fact that the Loudima agronomic research station is located at an altitude of 154 m, since according to Ddamulira et al. (2014), low altitudes favor the rapid development of MTA.

## V.CONCLUSION

Following the conclusion of the experimental work, the germination data, agronomic performance and disease incidence and severity were analysed. The results of the study indicate that: The capacity of the ten varieties to germinate was found to be high overall. It is recommended that agropastoralists and farmers consider the agronomic performance of the varieties NUV-109-2, MEX-142, Local Yellow, GLP-190-S, Local White and TY 3396-12, which have demonstrated optimal aptitudes. It was demonstrated that ECAPAN 021, NUV-109-2 and MEX-142 exhibited resistance, while GLP-190-S demonstrated tolerance. The present study demonstrated that dwarf varieties exhibited a higher incidence and severity of disease in comparison to climbing varieties.

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**AUTHOR CONTRIBUTIONS**
Auguste Emmanuel ISSALI: Conceptualization, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing
Aidhna Hemerson MOUELET KITSOUKOU: Conceptualization, Investigation, Methodology, Formal Analysis, Supervision, Writing - original draft, Writing - review & editing

Estherline Roguela KONGO KIKABOU: Data curation, Writing – original draft, Writing - review & editing
Fridolin MOUTSOUKA, supervision
Budet Winckler NZOBADILA KINDIELA

**CONFLICTS OF INTEREST**
There is no conflicts of interest regarding this article project.

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