

Morphological Evaluation of the Production Parameters of Cowpea Varieties (*Vigna unguiculata*) Grown in Maniema (D.R. Congo)

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ABSTRACT

Cowpea (*Vigna unguiculata* [L.] Walp.) is a major dietary legume contributing to food security in Africa. In Maniema, Democratic Republic of Congo, data on the productive diversity of local cowpea accessions remain limited. This study aimed to evaluate this diversity of cowpea cultivated in this Province on the basis of a few production parameters. An experimental test was conducted according to an appropriate set-up and accessions were evaluated according to a number of production parameters. The data were subjected to an analysis of variance (ANOVA), supplemented by the calculation of coefficients of variation and the analysis of correlations between traits. The results revealed significant differences ($p < 0.05$) between accessions for the majority of the parameters studied, reflecting an exploitable productive variability. Significant positive correlations were observed between the number of pods per plant, the number of seeds per pod, and seed yield. Some accessions have been distinguished by superior performance, indicating interesting agronomic potential and good adaptation to local agro-ecological conditions. This diversity is a strategic resource for varietal selection and the sustainable improvement of cowpea production in Maniema.

Keywords: accession, collection, yield, characterization, cowpeas

INTRODUCTION

Cowpeas, *Vigna unguiculata* (L.) Walp. is a diploid species ($2n = 2x = 22$) of the family Fabaceae (Coulibaly et al., 2002; Kuruma et al., 2008); a seed legume native to Africa (Padulosi and Ng, 1997; Kuruma et al., op.cit.), now cultivated in almost all tropical and subtropical regions. However, East and Central Africa contains the greatest diversity of cultivated cowpea forms (Ng and Padulosi, 1991).

In the D.R. Congo, cowpea cultivation is mainly practiced in the provinces of Kinshasa, Bandundu, Bas-Congo and two Kasai; and in Maniema, it is cultivated in all territories but much more pronounced in the territories of Kasongo, Pangi, Kailo and Kibombo (IPA, 2017).

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In Africa, as in DR Congo, yields rarely exceed 400 to 500 kg of seeds per hectare in traditional cultivation (Baoua et al., 2012). However, cowpea varieties are grown in various parts of the province in pure cultivation or in association with other crops; mainly with maize or cassava during the short rainy season from mid-February to mid-May (IPA, 2017).

Despite its wide adaptation and importance, cowpea productivity is generally very low due to many biotic and abiotic constraints, including seed attacks by insects in the field and during storage (DSDIA, 2003; Dugé et al., 2009).

The in situ conservation of cowpea varieties by farmers and their management has generated a significant agromorphological diversity of these cultivated varieties of this crop. For breeding and varietal improvement programmes, knowledge of the diversity of cowpea varieties and their evaluation are necessary (Adigoun, 2002; Doumbia et al., 2013). In this article, we present the results of a study based on morphological evaluation on some production parameters of cowpea varieties grown in the Province of Maniema in D.R. Congo.

As a result, an adequate evaluation of different cowpea accessions from different environments in the Maniema Province was established.

MATERIAL AND METHODS

Midfield

The experimental site was installed less than 50 m from the Congo River at the extreme left of the mouth of the Losomba River (Malonga block) during the 2 growing seasons of 2024 (in season A or S1 and in season B or S2).

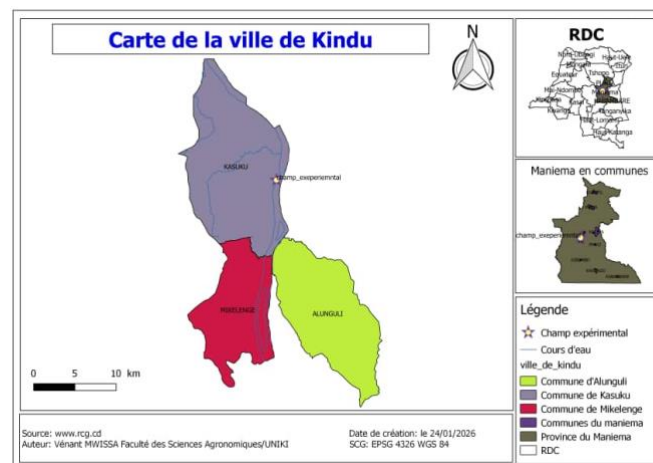


Figure 1. Location map of the experimental field

The Province of Maniema enjoys a hot and humid climate of the Aw4 type of the Köppen classification (Makondambuta, 1997). However, the experimental site (collection) was installed in the part with sandy-clay soils. Two major plant formations cover Maniema: the dense humid forest and the savannah. However, the vegetation of the experimental site is characterized by fallow; the plant species encountered in this area before the establishment of the culture were: *Pueraria javanica*, *Eupatorium odoratum*, *Elaeis guineensis*.

Material

As biological material, four (4) varieties were collected from the different territories and collected in the experimental field in Kindu. Table 1 presents the list of cowpea varieties collected from farmers' fields in the study area. Hence; V1 = Variety VITA7, V2 = Variety MUYAYA, V3 = LOCAL Variety and V4 = Variety H4.

Methods

Experimental design

This study was based on the accelerated participatory research method (MARP) which consists of documentation, investigation and field observation from a device made up of elongated plots spread over a block and which was also repeated once in which each plot represented a variety of the environment. The plot dimensions were 8 m in all directions, separated from each other by 2 m. The experimental field had an area of 684 m² ; i.e. 38 m long and 18 m wide, including 512 m² of space covered by varieties. For these varieties, the spacing adopted was 80 x 50 cm; from which each varietal plot consisted of 160 vines.

Conduct of the test

These are mainly the preparation of the land (choice, preparation and delimitation of the land, land clearing, stump removal and cleaning); ploughing; the delimitation of plots and the staking of sowing lines; labelling and signage; sowing (3 seeds per pocket); maintenance (restocking of voids and manual weeding at 15 days after sowing at two-week intervals from each other) as well as picking the pods by hand uprooting.

Observed parameters

These are: the mean number of pods/plant (NMGoP), the mean number of empty pods/plant (NMGoVP) and the average number of pods infested by *Maruca vitrata* (NMGoIP) by the count of pods for each case; the incidence of *Maruca vitrata* (InMa) by determining the proportion of plants attacked in the two seasons and an average was made to present only one incidence value; the average pod length/plant (LMGoP) using a graduated lath; the average number of seeds per pod (NMGrGo) after manually counting seeds; the weight of 100 seeds (P100) using a precision scale; pod yield (RdtGo) and seed yield (RdtGr) by extrapolation.

Data were taken according to the recommendations in the cowpea descriptors (IBPGR, 1983) and Cobbinah et al. (2011).

Statistical analyses

The quantitative data recorded were first subjected to a descriptive analysis. Means, minima, maxima, standard deviations and coefficients of variation were calculated for all quantitative traits based on the mean values of the traits observed on each accession. An analysis of variance (ANOVA) was performed between the different accessions for quantitative variables to assess the level of variability of the plant material. Finally, the mean values of the quantitative variables were used as input data for an analysis of correlations between variables. The software used is that of R 4.3.2 on its RStudio interference.

PRESENTATION OF RESULTS AND DISCUSSION

Results

Average number of pods harvested

Figure 2 shows, after counting, the average number of pods harvested from individuals of each variety.

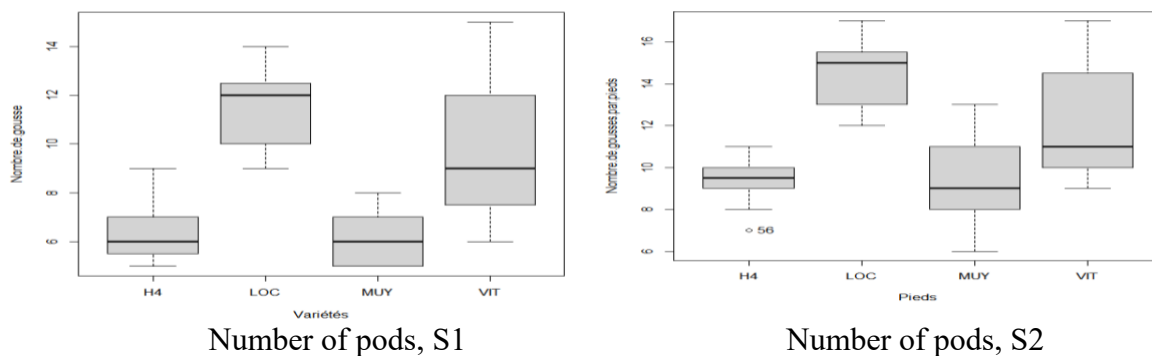


Figure 2. Average number of pods per plant of the varieties experimented

Figure 2 shows that the local variety yielded a significantly higher pod count (12 to 15) compared to the H4 and Muyaya varieties which yielded statically similar and lower numbers (6 to 9). The intermediate number was obtained in the Vita7 variety during season 1 and season 2, i.e. 10 and 12 pods. ANOVA reported a very highly significant difference between varieties in S1 ($p\text{-value}=30.23492e-12$ ***).

Average pod length (cm)

Figure 3 shows the characteristic mean pod length of the varieties under observation.

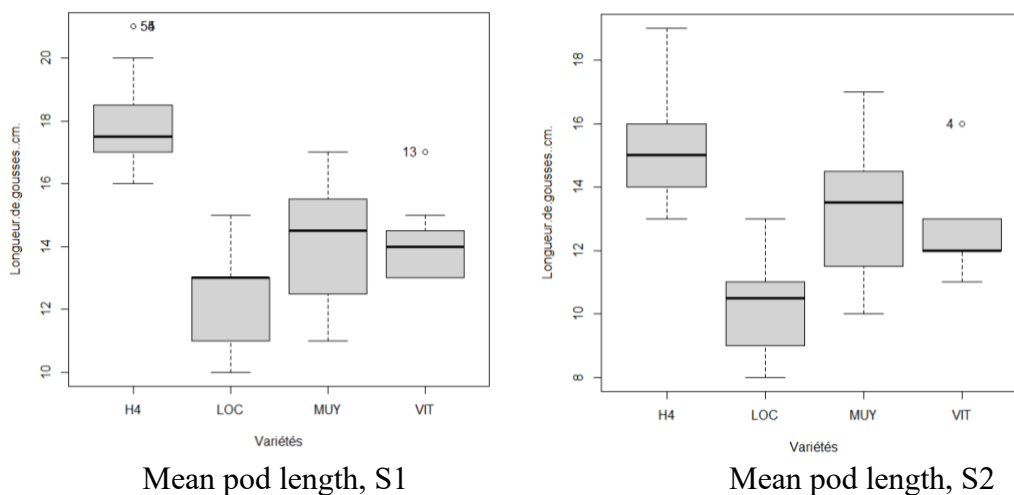


Figure 3. Average pod lengths of the two seasons

Overall, the values are higher in S1. The differences observed between varieties remained stable between the two seasons, suggesting a marked genetic effect. In the first season, the analysis of variance (ANOVA) applied to the values relating to the parameters and the 0.05% threshold, showed a very highly significant difference ($p\text{-value}=40.77171e-14$ ***). The same was true for the second season of this trial.

Average number of seeds per pod

The contents of the pods (seeds) are given in Figure 4 for each variety monitored in two growing seasons.

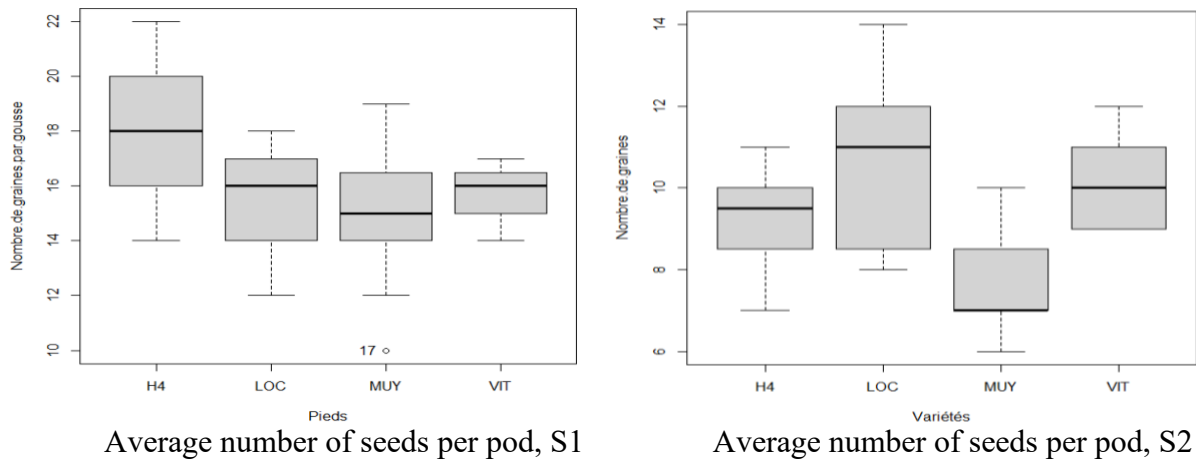


Figure 4. Average number of seeds per pod for both seasons

The observations in this figure show that the varieties showed a difference according to the number of seeds produced where the local variety stood out with the highest values in S2 against the Muyaya variety with lower values for these two seasons S1 and S2. The differences of the varieties with respect to this parameter were confirmed by ANOVA, which indicated that the number of seeds per pod of four varieties varied significantly according to these varieties in the first (p-value = 0.000007368 ***) and in the second season (p-value = 0.00974 ***). However, the comparison of means between the two seasons did not report any significant difference (t-student, p-value = 0.0625).

Average Number of Empty Pods Per Plant

The number of empty pods obtained after counting four varieties used on each plant is shown in Figure 5.

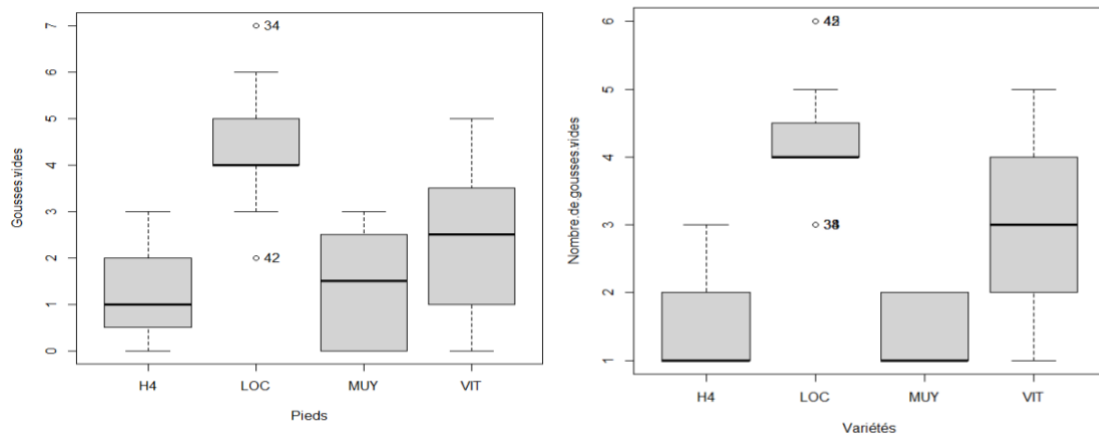
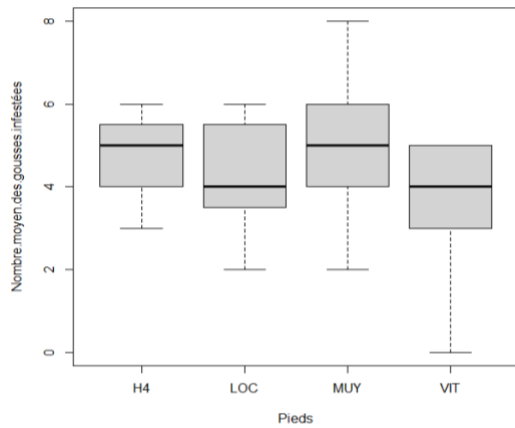


Figure 5. Average number of empty pods in both seasons

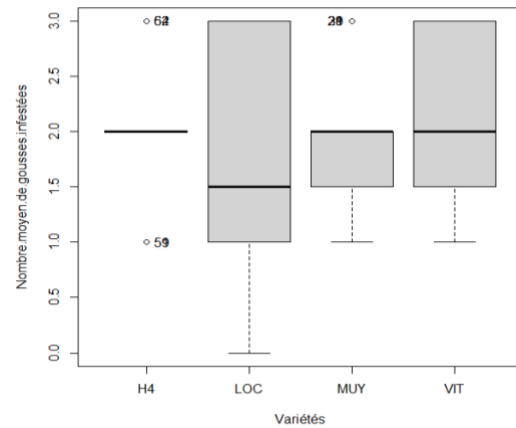
Figure 5 shows that variety types influenced the production of empty pods. This is why the local variety first gave the highest number of empty pods, an average of 4 per plant, while the Muyaya and H4 varieties showed the lowest, an average of 1 empty pod during S1. The same general trend is observed in S2 with the local variety and the Muyaya and H4 varieties with averages of 1 and 2; giving the idea of a better reproductive efficiency of the latter. The amplitude of the values is slightly higher in S1 than in S2. As for the other parameters, the differences in the means of varieties in S1 and S2 remained very significant.

Average Number of Infested Pods per Plant

Averages of infested pods on the vine were also recorded and represented in Figure 6.



Average number of infested pods, S1



Average number of infested pods, S2

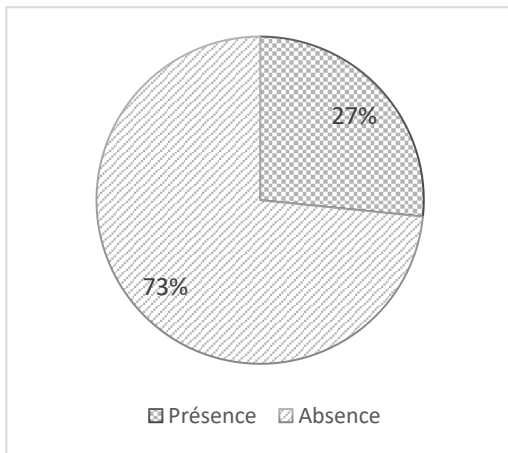
Figure 6. Average number of infested pods per plant of 4 varieties

Figure 6 indicates that there has been dispersal of many of the infested pods of the collected varieties whose sampled plants of varieties H4 and MUYAYA have a high number of infested pods compared to the Locale and VITA7 varieties for both seasons S1 and S2. However, this shows that the average number of infested pods varies slightly between varieties.

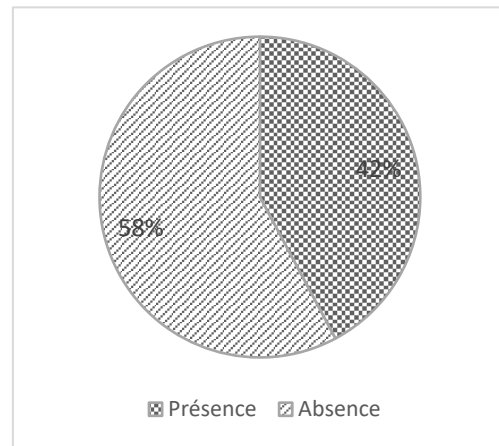
A significant difference was indicated by ANOVA (p-value = 0.272900518) in the first season between the different values.

Impact of *Maruca vitrata* on pods

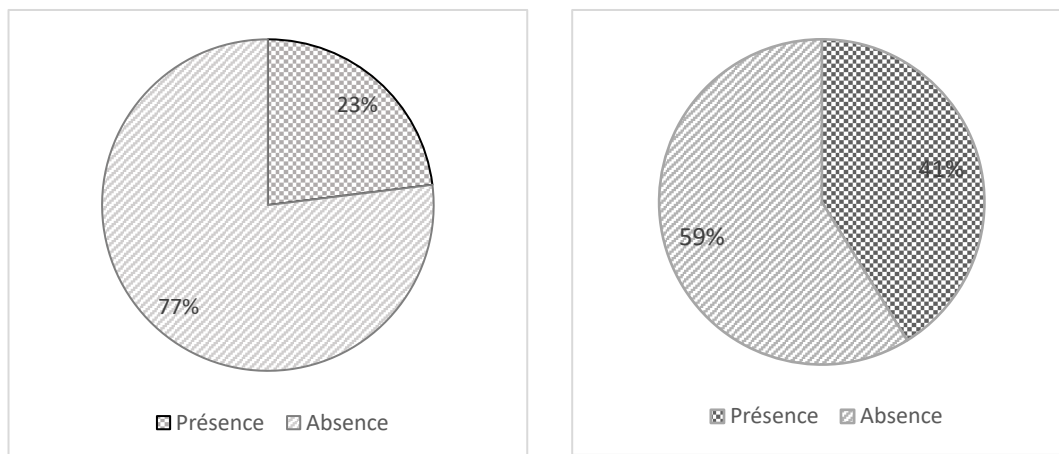
Figure 7 shows the impact of *Maruca vitrata* on pods of each variety and in two different seasons.



Presence and absence of *Maruca vitrata* in 2 seasons (VIT7)



Presence and absence of *Maruca vitrata* in 2 seasons (Muy)



Presence and absence of Maruca vitrata in 2 seasons (Loc) Presence and absence of Maruca vitrata in 2 seasons (H4)

Figure 7. Average incidence rate of Maruca vitrata in two seasons

Figure 7, which reveals the infestation rate of 4 varieties under the conditions of the trial, shows that the proportions varied greatly between the varieties, from 23% to 42% for the presence of Maruca vitrata, which reveals a major influence on these varieties in cultivation during S1 and S2. On the other hand, the varieties local and Vita7 showed a low incidence with successively 23% and 27%. However, the presence of signs of foot attack of the Muyaya variety was significant, i.e. 42% compared to 23% incidence recorded on the plants of the local variety, a highest incidence of the trial.

Average weight of 100 seeds

Figure 8 shows the average weight (in grams) of 100 seeds extracted from the pods of test varieties.

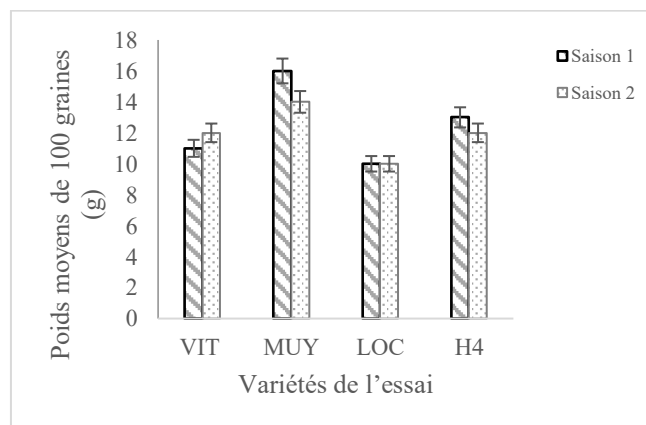


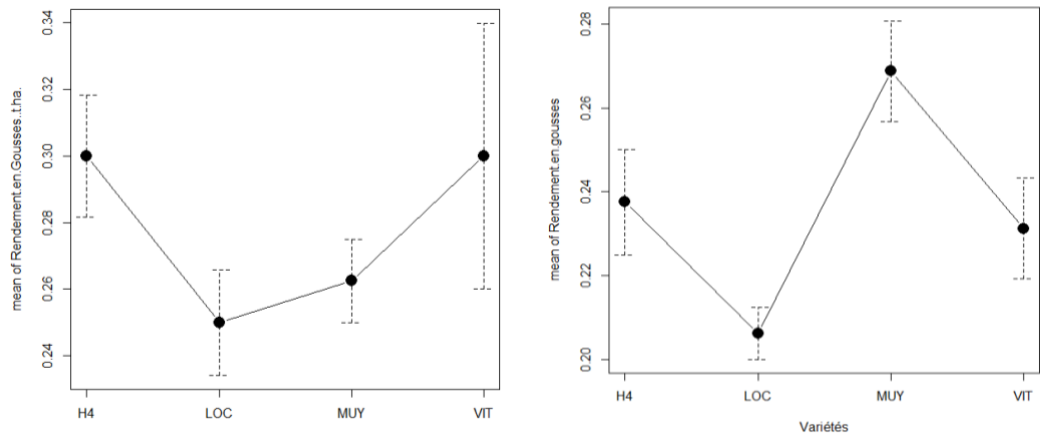
Figure 8. Average weight (g) of 100 seeds of the varieties

The 4 varieties presented the weights of 100 seeds which varied according to the size of the seeds. Hence, the Muyaya variety was distinguished by its higher weight than the other varieties placed in the same conditions of the trial during the two seasons. As with the other parameters analysed, the local variety remained last in terms of average seed weight. However, this last variety has shown a lot of stability for this parameter which has not changed according to the seasons. In the first and second seasons, the weight was 10g per 100 seeds.

The analysis of variance (ANOVA) applied to the values for this factor alone indicated a very highly significant difference ($p = 7.88e-11^{***}$) between the varieties. However, Tukey's post-hoc revealed that this difference is mainly induced by the local variety for each time it is confronted by another variety in the trial. The same case of significant difference was also found between the varieties Muyaya and VIT7 (p -value = 0.000216).

Average pod yield

Figure 9 gives the average pod yield of 4 cowpea varieties under experiment.

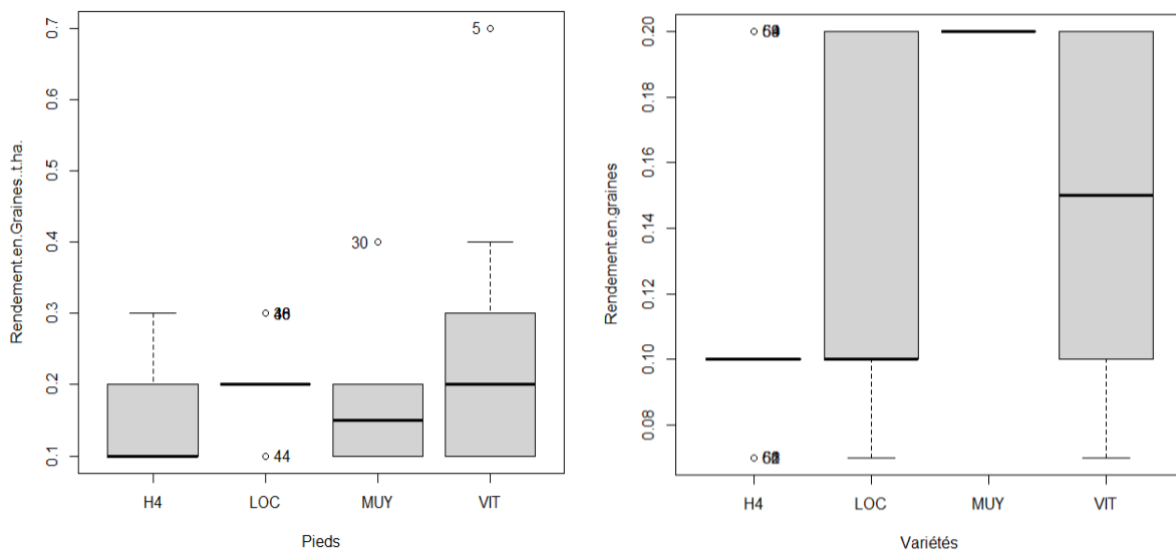


Average yield (t/ha) in S1 pods Average yield (t/ha) in S2 pods
Figure 9. Average pod yield of 4 varieties

The different pod yields shown in Figure 9 indicate that average yields ranged from approximately 0.25 to 0.30 t/ha. These results show that pod yield has direct links to the variety rather than to the environment represented in this trial by both seasons. A high level of stability of this characteristic within varieties. However, some correlation was found between this parameter (pod yield) and plant height ($r=0.605$). It was observed that stem elongation directly influenced the number of pods and consequently the yield of the pods.

Average seed yield

The average seed yields of the test varieties are recorded in the dispersal box shown in Figure 10.



Average yield (t/ha) of S1 seeds Average yield (t/ha) of S2 seeds
Figure 10. Average seed yield (t/ha) of the 4 varieties

Regarding the average seed yield of 4 cowpea varieties, it was found that the Muyaya variety stands out as the most efficient and stable while the H4 and local varieties have lower yields in the first and second seasons. The Vita7 variety shows an intermediate yield but with high variability. A significant difference was indicated by ANOVA (p-value = 0.03194*) in the first season and (p-value = 0.0060057) in the second.

Discussion

The objective of the present study was to morphologically evaluate the cowpea varieties in the Maniema collection on the basis of production parameters. The results obtained reveal a significant morphological variability in the various parameters studied (number of pods, number of seeds, length of pods, etc.).

Hence, in terms of the number of pods per plant, this result corroborates with that of François et al. (2013) who obtained 13 pods in Côte d'Ivoire. However, the result of Kindu is higher than that obtained by Joseph et al. (2014) with 8 pods in the Republic of Congo. It should also be noted that all these results are much lower than those obtained in Benin and Chad by Gbaguidi et al. (2015) and Djirabaye et al. (2015) with 25 pods and 43 pods respectively.

In Benin as in Chad, these same authors cited above each obtained a pod length of 16 cm; a result that corroborates with the one obtained in Kindu. Regarding the number of seeds, the result of this research is similar to the results of François et al. (2013) and Djirabaye et al. (2015) with 14 seeds and 13 seeds respectively in Côte d'Ivoire and Chad.

Regarding the incidence of *Maruca vitrata*, the results really proved the presence of the pod sucker *Maruca vitrata* with proportions varying greatly between varieties, i.e. from 24 % to 71 % per plant for all varieties collected in Maniema; a similar result obtained by Idrissou et al. (2023) in South Benin, where 50 % of perforated pods were due to infestations of this pod sucker. On the other hand, this result was 25 % in Niger by Fatokun et al. (2018). In the same vein, this result explains the number of infested pods per plant, which was 1 to 6 pods for all the varieties tested.

This difference in weight of 100 seeds observed in Maniema cowpea varieties has already been mentioned in a similar study by Doumbia et al. (2013) in Ghana, who estimate that the accumulation of reserves in seeds depends on the type of genotype (Khan et al., 2010). Nevertheless, the results of this research corroborate with those of Côte d'Ivoire for François et al. (2013) with 15 g; Republic of Congo for Joseph et al. (2014) with 16 g ; Algeria for Ben (2017) with 13 g and Burkina Faso for Wendbenedo et al. (2017) with 17 g. Regarding cowpea seed yield, the results of this research were similar to those obtained by François et al. (2013) and Joseph et al. (2014) in Côte d'Ivoire and Algeria with 2.1 t/ha and 1.7 t/ha. Moreover, these results were higher than those of Gbaguidi et al. (2015) with 0.9 t/ha in Benin; Ben (2017) in Algeria and Wendbenedo et al. (2017) in Burkina Faso, which each obtained 2.1 t/ha.

Thus, the FAO (2019) recommends the characterization and conservation of local varieties as an essential strategy to strengthen food security and preserve agricultural biodiversity. However, a molecular characterization of the varieties collected at Maniema is necessary and will allow for more precision.

CONCLUSION

The present study on the characterization of some production parameters of cowpea accessions (*Vigna unguiculata* [L.] Walp.) collected in the Maniema Province, Democratic Republic of Congo, revealed a significant variability in the yield components between the genotypes evaluated. Differences observed in the number of pods per plant, the number of

seeds per pod, the weight of 100 seeds, the seed yield,... confirm the existence of exploitable productive diversity.

Statistical analysis (ANOVA and correlations) showed that some yield components strongly contribute to overall performance, including the number of pods per plant and the number of seeds per pod. Accessions with higher values for these traits appear to be the most promising for breeding and varietal improvement programmes.

These results underline the importance of valuing local plant genetic resources with a view to sustainably intensifying cowpea production in Maniema. However, multi-local assays and complementary molecular analyses are needed to assess performance stability and to better understand the genetic structuring of accessions.

Ultimately, this study provides a solid scientific basis for the selection of high-performance genotypes and contributes to strengthening regional food security.

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