

(RESEARCH ARTICLE)



EVALUATION OF THE GROWTH AND DEVELOPMENT OF SIX (06) ONION VARIETIES GARLIC ONION IN THE AGRO-PEDOCLIMATIC CONDITIONS OF BAMBEY.

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ABSTRACT

Onion production has experienced remarkable growth in various sub-Saharan African countries over the past two decades. In Senegal, this sector plays a significant role in horticultural production, which is primarily concentrated in the Niayes region and the Senegal River Valley. The Violet de Galmi and Red Bombay varieties exhibit the highest average survival rates, at 97.99% and 97.31% respectively; conversely, the Gandiol+ variety has the lowest rate, with an average of 89.99%. The HSD (Heads-Steering Difference) mean comparison test identified three (3) groups of varieties and one intermediate group. The Red Bombay, Violet de Galmi, and Safari varieties are the most vigorous, with averages of 0.59, 0.55, and 0.54 respectively. At the 4th Over the course of two weeks, the Red Bombay, Violet de Galmi, and Safari varieties were more vigorous, with averages of 0.59, 0.55, and 0.54, respectively. The study results showed that the plant survival rate was higher for the Violet de Galmi and Red Bombay varieties. Gross yields were generally high, ranging from 90.19 t/ha (Texas Early Grano) to 44.92 t/ha (VDG American). The Texas Early Grano variety appeared to be the highest performing in terms of field productivity.

Keywords: Growth, Development, Agronomic Performance, Varieties, Onion

1 INTRODUCTION

In Africa, agriculture remains the most important economic sector. It contributes at least 40% of exports, 30% of GDP, 30% of foreign exchange earnings, and 70 to 80% of jobs (Ouedraogo, 2019). In Senegal, agriculture employs nearly 60% of the active population and contributed 16.1% to GDP in 2017 (ANSD, 2019). It is considered one of the most promising sectors due to the wide range of products it brings to market and the level of income it generates for farmers, particularly in urban and peri-urban areas (Gueye, 2014). Horticultural production has seen remarkable growth over the past five years, increasing from 1,144,940 tonnes during the 2015-2016 season to 1,624,456 tonnes in 2019-2020 (Savana, 2021). According to the Directorate of Horticulture, 60% of the harvest comes primarily from the coastal strip of the Niayes region (Dakar to Saint-Louis), thanks to favorable agro-climatic conditions (Seck, 2018). However, the intense market gardening activity in the area has led to: degradation of water resources; and soil degradation due to

overexploitation of fields and the disappearance of fallow practices (Zucchini, 2015). The use of high doses of chemical inputs appears to be an inevitable option (Ndiaye, 2019). However, the risks of environmental degradation, land encroachment, and poor-quality harvested products necessitate the exploration of alternative solutions. One such solution is the revitalization of the country's traditional market gardening basins. These basins, concentrated in the heart of the peanut-growing region, face significant challenges, and mastering plant material management can lead to increased production.

Among horticultural crops, the cultivation of onions (Garlic onion L.) play a significant role in Senegalese agriculture. The onion sector has been notable for its growing momentum over the past twenty years, with production exceeding 430.000 tons in 2021 (FAOSTAT, 2021). This figure makes Senegal the third-largest onion producer in West Africa, after Nigeria and Niger. Despite this steady increase in production and government efforts (Seck, 2018), local onions do not meet the entire demand. Senegal therefore imports more than 50% of its domestic needs each year (Ndiaye, 2019). This shortage is due to the poor quality of these onions, which, according to the FAO, results in significant losses and makes storage virtually impossible.

Faced with this situation, it is therefore necessary to provide producers with high-performing plant material well-adapted to the biotic and abiotic conditions of the peanut basin in order to boost production in this area. It is with this in mind that ISRA, through the PAPSEN PAIS project (Technical Assistance, Research and Development - PP-AT&RD), is conducting studies on the adaptability of horticultural varieties to the environmental and socio-economic context in the project's intervention areas, particularly the Thies, Diourbel, and Fatick (TDF) regions.

The overall objective of this study is to contribute to improving onion crop productivity through the diversification of production areas. Specifically, it aims to:

- Evaluate the growth of 06 varieties of onion in full season cultivation, under the agro-pedo-climatic conditions of Bambey;
- Identify the most suitable varieties in order to promote them in the central area of the peanut basin;

2 MATERIALS AND METHODS

2.1 Presentation of the study area

The trials were conducted during the off-season (2021/2022 growing season) within the research areas of the Support Program for the National Agricultural Investment Program in Senegal (PAPSEN) at the National Center for Agronomic Research (CNRA) in Bambey. The CNRA is located at latitudes 14°42'N and 16°28'W (CNRA, 2020) at an altitude of 20 meters above sea level (Siene, Muller and Ake, 2010; Lô, 2018). The tropical climate is characterized by a long dry season (cool dry season and hot dry season) from November to May and a rainy season from June to October. Temperatures vary from 12.4°C to 44.6°C throughout the year, according to data obtained from the CNRA weather station. The minimum relative humidity is 16% and the maximum is 100% (Ndoeye, 2022). The soil is of the Dior type (slightly leached tropical ferruginous), dark brown in color, with a predominantly sandy texture (S) in the surface horizons and sandy-loam (SL) to silty-sandy (LS) at depth (CNRA, 2020). The soil pH varies from 5.5 to 7.0 with a nitrogen (N) content < 0.1% and an organic matter (OM) content < 1%.

2.2 Material

2.2.1 Plant material

Table 1: Characteristics and code of the studied varieties

Varieties	Variety code	Bulb color
Violet de Galmi	V1	Violet
Gandiol+	V2	Violet
Safari	V3	Violet
Texas Early Grano	V4	YELLOW
Red Bombay	V5	Rouge
VDG American	V6	Violet

The plant material consists of six purebred onion varieties from the PAPSEN project collection. The VIOLET DE GALMI variety is used as a control. The characteristics of these ecotypes are summarized in Table 1.

2.3 Methods

2.3.1 Experimental setup

The experimental design used was a three-replicates Fisher block design with six treatments corresponding to the different varieties tested (from Violet de Galmi to VDG Amican). The plot units were 6 m x 2 m, or 12 m². They were separated by 1 m wide paths, and the blocks by 2 m wide paths. The area of a block was 66 m², and that of the entire trial was 242 m². Randomization consisted of assigning the varieties to the plots according to a random distribution block by block. The design was laid out lengthwise along the drip irrigation lines (Figure 4). The experiment was conducted during the off-season (November 2021–May 2022).

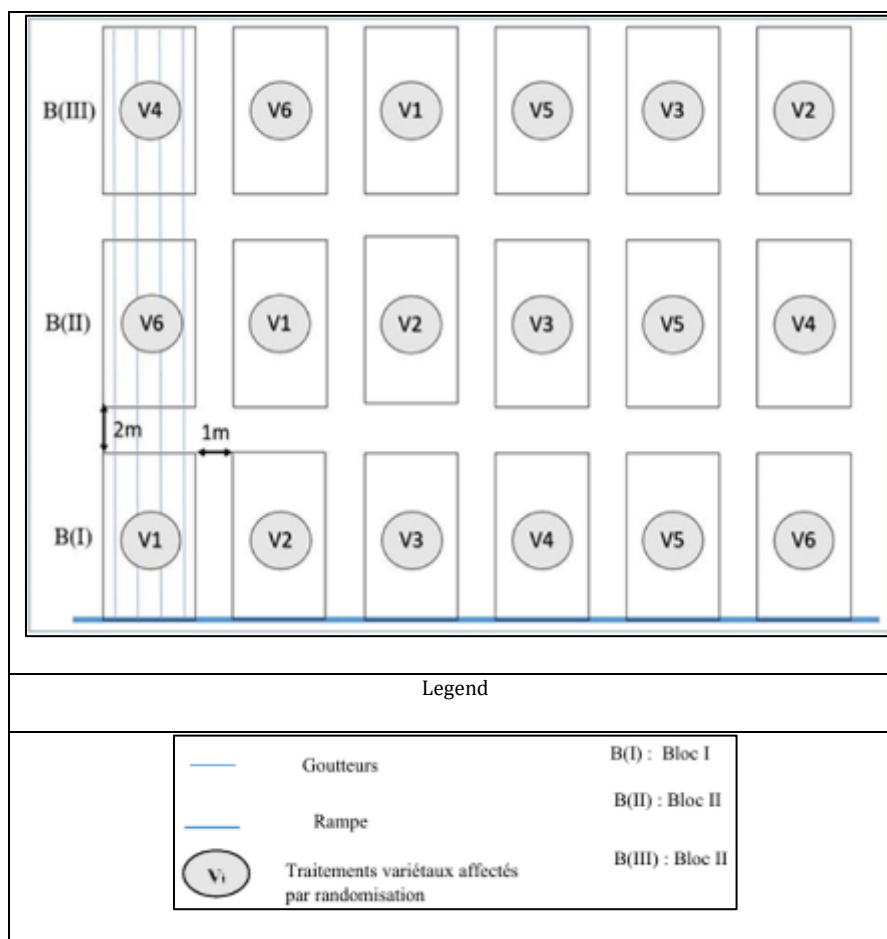


Figure 1: Site plan of the experimental setup

2.3.2 Conducting the test

The plots were prepared by incorporating sheep manure at a rate of 5 kg per m², followed by the application of the insecticide "Savanem". A layer of topsoil was then placed on the plots as a seedbed. Parallel lines approximately 10 cm apart were marked for seed distribution. The onion seeds were sown in nurseries in six (6) plots, each 3 m long and 1 m wide. Each variety occupied one plot. Watering was carried out in the morning and evening. Before transplanting, the land was cleared, moistened, plowed, and leveled, then subdivided into 3 blocks of 6 plots, each with an area of 6 m². The drip irrigation lines were laid, and a base dressing of sheep manure was applied at a rate of 2 kg/m² and a soil insecticide (Ethoprophos) at a rate of 5g/m² were incorporated into the soil. After sixty-five (65) days, transplanting was carried out at a spacing of 10 cm x 10 cm. Two consecutive blocks were separated by a 2 m walkway, while two consecutive plots were separated by 1 m. The frequency and quantity of irrigation water depended on the phenological stage of the seedlings. Two types of fertilizer, 10-10-20 and 46-0-0, were applied at rates of 100 kg/ha and 50 kg/ha, respectively, on the 20th, 40th, and 60th days after transplanting (DAR). Hoeing was carried out after each fertilizer application. A preventative treatment plan was followed, alternating between two insecticides and fungicides to prevent infestations.

Table 2: Schedule of phytosanitary treatments for experimental plots

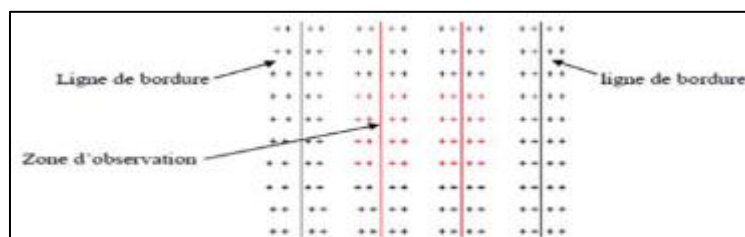
Target diseases and pests	Active ingredient	Application period
Trips	Deltaméthrine	15 JAR; 30 JAR and 45 JAR
Alternately	Mancozebe	20 JAR
Termites	Chlorpyrifos 10% granules	90 JAR

The bulbs are harvested manually after all the leaves have completely dried. They were placed under shade immediately after harvesting before being transported to the CDH plant genetics laboratory.

**Figure 2: Harvesting and processing of onion varieties**

2.3.3 Agronomic observations and measurements

The evaluation was carried out on a sample of 15 randomly selected plants located in the two central rows of each plot. The agronomic parameters evaluated included:

**Figure 3: Data collection device**

2.3.3.1 Recovery Rate (RR%)

This involves counting the number of surviving plants for each elementary plot after one week of transplanting and relating it to the number of plants transplanted.

$$\text{Recovery rate} = \frac{\text{Number of living plants}}{\text{Total number of transplanted plants}} \times 100$$

2.3.3.2 Vigor (Vg)

It was determined by a device called Greenseeker at 15th, 30th, 45th JAR.

2.3.3.3 Leaf length (Lf)

It was made using a ruler graduated in centimeters (cm) and was done from the base to the top of the sheet, taking the longest measurement. 15th, 30th, 45th JAR.

2.3.3.4 Footprint (Enc)

It was obtained by measuring the distance in centimeters between the two most extreme leaves on either side of the plant using a graduated tape measure during the first three fortnights.



Figure 4: Measurement of variables in the field

2.3.3.5 Number of leaves (Nf)

This involves counting the number of leaves on the fifteen (15) plants randomly selected from the two central rows at 90th.

2.3.3.6 Flowering rate (Tf%)

This involves counting the plants that have produced a flower stalk for each individual plot. Then, the number of plants that have produced a flower stalk is divided by the total number of plants in that plot, by multiplying the ratio by one hundred.

$$\text{Flowering rate} = \frac{\text{Number of plants that flowered}}{\text{Total number of feet}} \times 100$$

2.3.3.7 Cycle length (80% C)

This involves noting the dates when 80% of the plants had their leaves drooping. The cycle length (80% C) is calculated as the number of days elapsed between the 80% C date and the date of the first transplanting.

2.3.3.8 Data analysis methods

An analysis of variance (ANOVA) was performed using XLStat software version 2022 4.1.1630. When a significant difference was observed, the ANOVA was followed by Tukey's HSD test. The quantitative variable data were then subjected to principal component analysis (PCA) and hierarchical ascending classification (HAC) using XLStat software.

3 RESULTS

3.1 Effect of ecotype on growth and development parameters

3.1.1 Recovery Rate (RR%)

Analysis of variance showed a highly significant effect ($P=0.007$) for the recovery rate variable. Figure 4 shows that the Violet de Galmi and Red Bombay varieties have the highest average recovery rates, at 97.99% and 97.31% respectively; conversely, the Gandiol+ variety has the lowest rate, with an average of 89.99%. The HSD mean comparison test allowed for the identification of three (3) groups of varieties and one intermediate group.

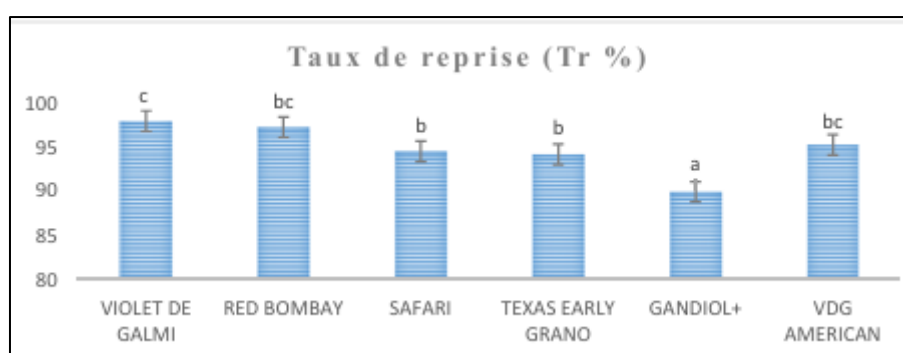


Figure 5: Variety survival rates

3.1.2 Plant vigor (Vg)

Analysis of variance (ANOVA) did not show a significant difference between varieties at day 15 ($P = 0.15$) and day 30 ($P = 0.053$) for plant vigor. However, at the fourth half of the month (day 45), ANOVA revealed a highly significant effect ($P = 0.000$) between varieties. Figure 5 shows that at this date, the varieties Red Bombay, Violet de Galmi, and Safari were more vigorous, with mean values of 0.59, 0.55, and 0.54, respectively. Conversely, the varieties Texas Early Grano, Gandiol+, and VDG American were less vigorous, with mean values of 0.47, 0.47, and 0.44, respectively. Furthermore, the HSD test identified two groups with no intermediate group at day 45 (Figure 5).

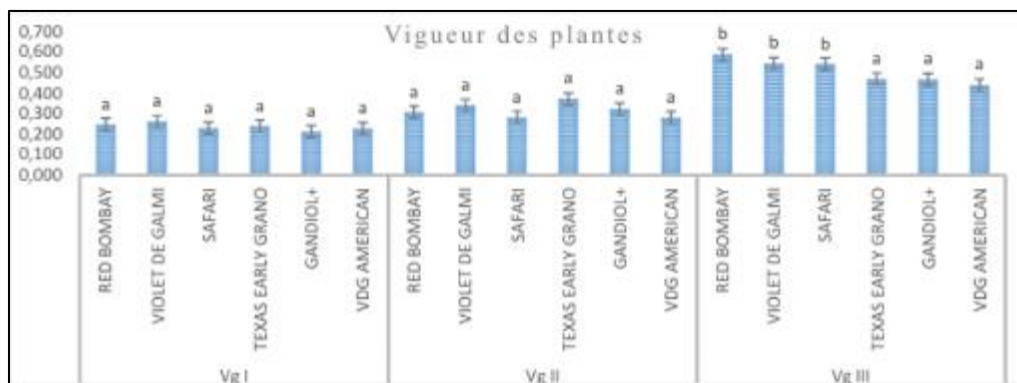


Figure 6: Variation in plant vigor according to variety for the first three fortnights

3.1.3 Leaf length (Lf)

The ANOVA of leaf length (Lf) revealed a highly significant difference ($p = 0.001$) between the varieties at the end of the first two weeks (D15 AR) following transplanting, and a significant difference at the end of the second two weeks (D30 AR) and the third two weeks after transplanting (D45 AR), with significance levels of ($P = 0.0014$) and ($P = 0.040$), respectively. At D15 AR, the longest leaves (LfI) were observed on Red Bombay (28.11 cm), and the shortest on Gandiol+ and VDG American, with values of 19.51 cm and 19.89 cm, respectively. Thirty days after transplanting (D30 AR), Red Bombay produced the longest leaves (LfII) (37.63 cm), and Texas Early Grano (26.48 cm) and VDG American (27.79 cm) the shortest. On day 45 after transplanting (D45 AR), the SAFARI variety, with 60.26 cm, recorded the longest leaves (LfIII), while VDG American had the shortest at 49.61 cm. The HSD test ranking is shown in Figure 6.

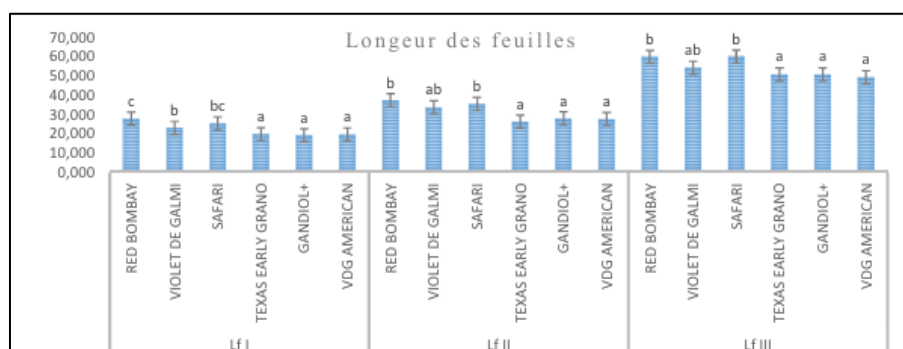


Figure 7: Leaf lengths for the first three fortnights

3.1.4 The bulk (Enc)

Regarding plant height (Enc), significant effects of the varieties were observed at day 15 AR ($P=0.001$) and day 45 AR ($P=0.045$). However, the varieties were not significantly affected ($P=0.351$) by height at day 30 AR. According to Figure 7, regardless of the measurement time, the minimum height values were recorded for the VDG AMERICAN variety (4.18 cm, 11.66 cm, and 16.73 cm at days 15 AR, 30 AR, and 45 AR, respectively). While the maximum height was recorded for the RED BOMBAY variety at day 15 AR (6.98 cm), the maximum heights were recorded for VIOLET DE GALMI (19.18 cm) and SAFARI (27.31 cm) at days 30 AR and 45 AR.

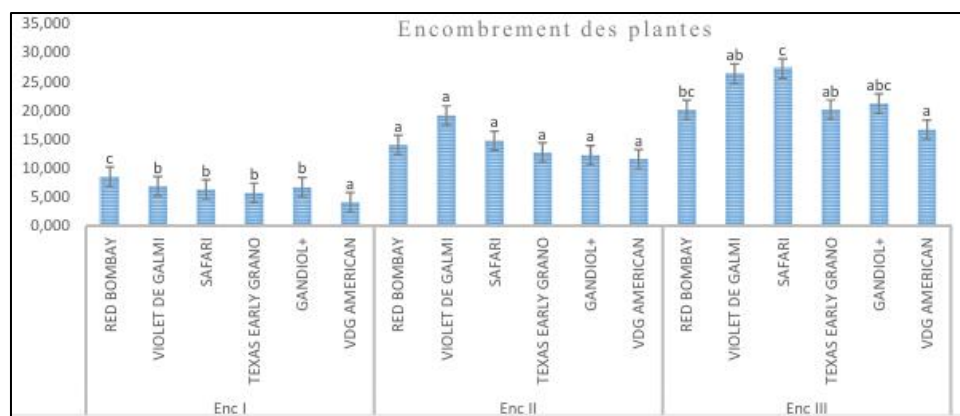


Figure 8: Plant space constraints for the first three fortnights

3.1.5 Number of leaves (Nf)

Analysis of variance revealed a significant effect at day 60 AR ($P=0.037$) between the studied varieties for the variable number of leaves. This effect was more pronounced for the Violet de Galmi and Red Bombay varieties, with respective mean values of 12.38 and 12, in contrast to Texas Early Grano, which produced few leaves (9.49). The mean comparison test in Figure 8 showed three groups and two intermediate groups.

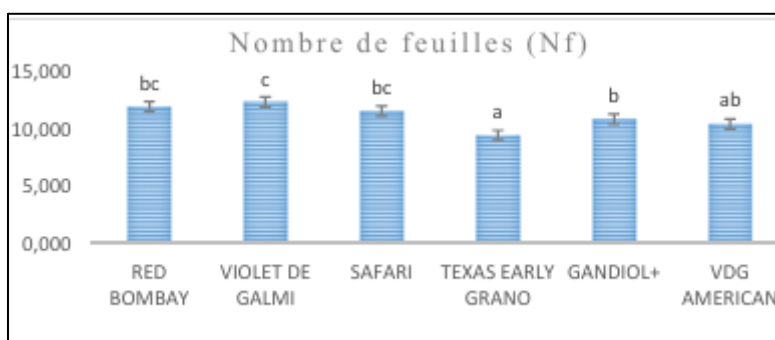


Figure 9: Number of leaves on plants according to variety

3.2 Physiological parameters

Table 3: Results of the analysis of variance of the physiological variables of the varieties

Varieties	Tf %	80%C
Violet de Galmi	12,07 b	91.00 a
Red Bombay	34,21 c	98.00 b
Safari	0,88 a	96.00 ab
Texas Early Grano	0,00 a	91.00 a
Gandiol+	0,37 a	91.00 a
VDG American	0,00 a	91.00 a
Averages	7,92	92,94
Standard deviation	14,15	3,226
Pr	0,001**	0,4760 ns
%Cv	178,66	3,47

*** : probability < 0.001; ** : probability < 0.01; * : probability < 0.05; ns: not significant Legend: Tf%: flowering rate; 80%C: 80% of plants lying down.

ANOVA shows that the flowering rate (Tf%) is significantly affected ($P=0.001$) by the varieties. The Red Bombay variety exhibits a maximum flowering rate of 34.21%, while varieties such as Texas Early Grano and VDG American did not

flower. However, a low flowering rate is noted for varieties like Gandiol+ and Safari, with respective averages of 0.4% and 0.4%. For the vegetative cycle, characterized by a leaf drop rate of 80% (80% C), ANOVA reveals a highly significant effect ($P=0.00001$). The HSD test allows us to classify the ecotypes into three classes. The first group consists of "early" varieties with an average cycle of 91 JAR. These include the Violet de Galmi, Gandiol+, Texas Early Grano, and VDG American ecotypes. The second group consists of a single accession, namely Safari, with a 96 JAR cycle, and finally, the Red Bombay ecotype forms the third group, characterized by a 98 JAR cycle. However, it should be noted that all varieties exhibit shorter vegetative cycles than those usually observed (Table 3).

4 DISCUSSION

The results of the quantitative analyses identified a significant agromorphological variable among the studied varieties. The high plant mortality observed after transplanting in some varieties could be explained by their sensitivity to the study environment. For example, the local varieties Violet de Galmi and Red Bombay had very high survival rates of 97.99% and 97.31%, respectively. These results corroborate those of Fondon et al. (2001), who, in a similar study, revealed that the first week after transplanting is a critical phase for seedling survival; only resistant ecotypes are minimally affected by environmental factors. Similarly, Garane et al. (2018) attribute these results to the adaptability of the varieties depending on the study period. The high values of the quantitative traits of the aboveground parts and plant vigor of the Violet de Galmi, Red Bombay, and Safari varieties, as well as their positive correlations, could be explained by efficient utilization of nutrients available in the soil or applied during cultivation. These results are consistent with those of Gateri (2019), Limeneh et al. (2019), and Tilahun et al. (2021), who found that nitrogen fertilizer application significantly improves plant growth. In contrast, the Texas Early Grano and Gandiol+ varieties have lower leaf lengths, plant size, and vigor. These results contradict those of Thioye (2021). This difference may be explained by the immaturity of the nursery stock for these two varieties at the time of transplanting, which is consistent with the work of Ba et al. (2001) which show that nursery age plays an important role in the vegetative development of onions. The first-year flowering rate of the local varieties Red Bombay and Violet De Galmi in this study is close to that obtained by Assoumane et al., (1994) on onion improvement in Niger. This rate could confirm the genetic basis of first-year flowering in West African onion varieties. According to Nana (2016), the rate of early bolting depends on ecotypes. However, these results contradict those of Sanon et al., (2001) who showed that a temperature between 20 and 31°C decreases the flowering rate, as our study was conducted in Bambe with temperatures ranging from 26.67° to 29.30°C. Therefore, this high flowering rate in the first year could be associated with the method of seed production, confirming the work of Tarpaga et al., (2013). According to them, plants produced from annual seeds exhibit a high susceptibility to bolting.

5 CONCLUSION

The study showed that the Violet de Galmi, Red Bombay, and Safari varieties were the best adapted to the study area in terms of growth and development. Regarding flowering, the local varieties (Violet de Galmi and Red Bombay) retained their stem elongation characteristics in their first year, while none of the introduced varieties flowered. Ultimately, the performance evaluation identified the three best varieties across all the variables studied: Violet de Galmi, Gandiol+, and Safari. Indeed, the control variety Violet de Galmi, created from local ecotypes in the Maggia and Tarka valleys of Niger in 1970 (ONEP, 2021), demonstrated superior performance compared to all other tested varieties. This study not only provides a collection of varieties adapted to the agro-pedoclimatic conditions at the Bambe station but also a diversity of varieties that will contribute to improved yields in smallholder farming environments.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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