INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
25–263/2025/34:340408
http://www.fspublishers.org

Full Length Article

Agromorphological Evaluation of Eight Onion Varieties (*Allium cepa*) in Northern Côte d'Ivoire

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Received 18 March 2025; Accepted 31 May 2025; Published online 29 June 2025

Editor: Mubshar Hussain

Abstract

Onion production in Côte d'Ivoire remains insufficient to meet the growing domestic demand. This study aimed to identify high-performing onion varieties based on agromorphological traits, with the goal of enhancing local production. Eight onion varieties were evaluated using a randomized complete block design with three replications. Data on agronomic and yield-related traits were collected following standardized protocols. One-way analysis of variance (ANOVA) was used to assess statistical significance, and a Hierarchical Ascendant Classification (HAC) was performed to group the varieties based on their morphological characteristics. The analysis revealed three distinct agromorphological groups. Group II, comprising Super Violet, H1, and Ares, exhibited superior performance, characterized by tall plants (50.16–52.73 cm), long and broad leaves (up to 48.16 cm in length and 1.34 cm in diameter), heavy bulbs (66.60 g) and the highest yield (79.3 t/ha). Group III, represented solely by the Safari variety, had the lowest performance, with a yield of 19.6 t/ha, though it showed early maturity. Group I, including Karibou, Natangue, Bati and Violet De Galmi, displayed intermediate traits. Based on these findings, varieties in Group II are recommended to improve onion yield in northern Côte d'Ivoire.

Keywords: Onion breeding; Bulb yield; Vegetative descriptor; Côte d'Ivoire

Introduction

Onion (*Allium cepa* L.) is an herbaceous monocotyledonous plant belonging to the Liliaceae family (Fritsch and Friesen 2002). It is widely cultivated as a vegetable for its bulbs and leaves, valued for both nutritional and medicinal properties (Konan *et al*. 2021; Soro *et al*. 2025). Globally, onion is cultivated predominantly in warm climates, with an annual production exceeding 100 million tons (Acar and Gül 2022). India and China lead global production, contributing approximately 26.7 and 23.6 million tons per year, respectively. In Africa, Egypt, Algeria, and Morocco are the top producers, with annual outputs of 3.2, 1.6 and 0.8 million tons of fresh bulbs, respectively (MADR 2021; Acar and Gul 2022; Hamidi and Bourkhiss 2023). Several West African countries, including Nigeria, Niger, Senegal, and Burkina Faso, also contribute significantly to regional production (Cortese *et al*. 2021; Kaka *et al*. 2021). However, only Niger and Burkina Faso meet both domestic demand and export requirements (Hema *et al*. 2019; Cortese *et al*. 2021).

Despite its considerable agricultural potential, Côte d'Ivoire's onion production remains low, with annual output estimated at 8,227 tons (Dagnogo *et al.* 2018; FIRCA 2023). Consequently, the country depends heavily on imports, which account for about 90% of local consumption, mainly sourced from Burkina Faso and Niger (Diemkoudre *et al*. 2023; Konan and Kouamé 2023). This imbalance highlights a significant opportunity to revitalize the onion sector, which could play a pivotal role in economic development. Local onion production offers multiple benefits, including improved farmer income, reduced consumer price volatility, and enhanced trade balance. In 2023, Côte d'Ivoire exported onions valued at $735,000, primarily to Mali, Ghana, and Liberia, while imports totaled $94.7 million, sourced mainly from the Netherlands, Niger and China (OEC 2025).

In order to reduce this dependency and boost local production, it is essential to identify onion varieties that are well-adapted to local growing conditions. This study aimed to contribute to the development of the onion sector by evaluating and selecting high-yielding varieties suitable for cultivation in the Korhogo region of northern Côte d'Ivoire.

To cite this paper: Koffi EBZ, MPWA Daramcoum, NY Konan, I Kouyaté, SDM Yao, RS Sié, N Diarrassouba (2025). Agromorphological evaluation of eight onion varieties (*Allium cepa* L.) in Northern Côte d'Ivoire. *Intl J Agric Biol* 34:340408. https://doi.org/10.17957/IJAB/15.2380

Materials and Methods

Study site

The experiment was conducted in the botanical garden of the University Peleforo Gon Coulibaly, located in Korhogo, northern Côte d'Ivoire (latitude 9° 27′ 28″ N, longitude 5 ° 37′ 46″ W, altitude 360 m). The region experiences a Sudano-Guinean tropical climate with annual rainfall between 1,100 and 1,600 mm and two distinct seasons: a rainy season (May to October) and a dry season (November to April) (Boko-Koiadia *et al*. 2016). The soil is acidic (pH 5.0 to 6.5), with nitrogen content ranging from 0.06 to 0.16 g/kg and phosphorus levels from 21.0 to 47.33 mg/kg, classified as moderately fertile (Diomandé *et al*. 2021). Cation exchange capacity ranged from medium (5.12–6.68 cmol/kg) to high (15.1–18.2 cmol/kg). During the study, temperatures ranged from 37°C to 39°C, relative humidity varied from 21% to 73%, and total rainfall was 4 mm.

Plant material

Eight onion varieties were used: Karibou, Bati, Safari, Natangue, Super Violet, Violet De Galmi, Ares, and H1. These were acquired through the KAFACI (Korea-Africa Food and Agriculture Cooperation Initiative) project (ID: KAH20200103), which supports onion production in Côte d'Ivoire. All varieties are commonly cultivated within the country, except H1, which was introduced from South Korea. Violet De Galmi, originally from Niger, is the most widely used variety. Some characteristics of these varieties are shown in Table 1.

Nursery establishment and management

Nursery beds (2 m² each) were prepared following Koffi *et al.* (2021), using a seeding rate of 4 g/m². On November 25, 2021, 8 g of seeds per variety were sown per bed. Watering was done twice daily using a sprayer. After 40 days, seedlings were transplanted into field beds on January 5, 2022.

Experimental design and crop management

The trial followed a randomized complete block design with three replications. Each plot measured 300 cm × 100 cm × 15 cm (3 m²). On transplanting day, plots were watered to ease planting. Each plot contained 119 transplants arranged in 7 rows, with 17 plants per row, spaced 15 cm apart.

Fertilization and maintenance

The NPK 15-15-15 fertilizer was applied at 90 g per bed (150 kg/ha), totaling 2.16 kg for 24 beds, three days prior to transplanting. Weeding was done regularly, and each bed received 15 liters of water daily until bulb formation.

Sampling

Ten plants were randomly selected per bed, totaling 30 plants per variety and 240 plants overall for the eight varieties.

Data collection method

Nine agromorphological descriptors were measured, based on IPGRI (2001) standards. Sixty days after transplanting, vegetative traits were assessed: plant height (measured from collar to tip of the longest leaf), number of leaves (including terminal buds), maximum leaf length and diameter. Maturity rate at three months was calculated as the percentage of mature bulbs. Post-harvest, bulb length (pole to pole), diameter (midsection), and weight (precision scale, 0.01 g) were measured. Bulb yield was estimated from the mean bulb weight per 3 m² bed and extrapolated per ha using the formula: Bulb yield × 10,000/3.

Data analysis

Descriptive statistics and one-way ANOVA were conducted at a 95% confidence level. The Student-Newman-Keuls test (5% significance) was applied to compare means. To classify the varieties, Hierarchical Ascendant Classification (HAC) was performed using standardized data and Euclidean distance with the WARD linkage method. ANOVA was also used to identify descriptors that discriminated between groups. Analyses were performed using SPSS version 22.0.

Results

Agromorphological characteristics of onion varieties

All evaluated parameters significantly distinguished the eight (08) onion varieties (Table 1). Plant heights ranged from 33.63 cm to 52.73 cm, with the varieties Super Violet, Ares, and H1 exhibiting the tallest plants, measuring between 50.16 cm and 52.73 cm. In contrast, the Safari variety showed the shortest stature at 33.63 cm. Intermediate plant heights were observed in the Karibou, Violet De Galmi and Natangue varieties, ranging from 43.23 cm to 44.86 cm.

Regarding leaf production, the varieties Natangue, H1, and Ares developed the highest average number of leaves per plant, with 8.36, 8.76 and 9.63 leaves respectively. The Safari variety produced the fewest leaves, averaging 5.40 per plant. Maximum leaf lengths were greatest in the Super Violet, Ares, and H1 varieties, ranging from 46.43 cm to 48.16 cm. Conversely, Bati and Safari produced shorter leaves, with mean lengths of 34.83 cm and 30.00 cm, respectively. Maximum leaf diameters for Bati, Karibou, Violet De Galmi, Natangue, Ares, H1 and Super Violet ranged between 1.27 cm and 1.43 cm, significantly larger than Safari's leaf diameter of 0.96 cm.

Table 1: Some qualitative characteristics of onion varieties

Varieties	Bulb Shape	Bulb color	Taste	Storage life
Karibou	Semi-flattened	Dark purple	Pungent	Short
Bati	Flattened	Yellowish	Moderate	Medium
Safari	Semi-flattened	Purple	Pungent	Very good
Natangué	Semi-flattened	Dark red	Pungent	Good
Super Violet	Flattened round	Light purple	Pungent	Good
Violet de Galmi	Flattened thick	Light purple	Pungent	Good
Ares	Semi-flattened	Dark purple	Pungent	Medium
H1	Round	Red	Moderate	Medium

Table 2: Morphological and yield characteristics of onion varieties

Varieties	Plant height (cm)	Number of leaves per plant	Maximum leaf length (cm)	Maximum leaf diameter (cm)	Bulb weight (g)	Bulb length (cm)	Bulb diameter (cm)	Three-month maturity rate (%)	Bulb Yield (t/ha)
Ares	51.23 a	9.63 a	47.93 a	1.31 a	66.6 a	5.57 a	5.04 a	12.5 c	79.3 a
Bati	38.03 c	6.7 c	34.83 c	1.23 a	39.25 d	3.92 e	4.26 b	52.5 b	46.7 d
Karibou	43.23 b	7.56 c	40.70 b	1.27 a	50.95 bc	4.18 de	4.75 a	47.5 b	60.6 c
Natangue	44.86 b	8.36 ab	41.83 b	1.3 a	55.33 b	4.56 c	4.74 a	55.0 b	65.7 b
Safari	33.63 d	5.4 d	30d	0.96 b	16.30 f	3;64 f	2.96 d	77.5 a	19.6 e
Super Violet	50.16 a	7.76 bc	46.43 a	1.43 a	42.16 cd	4;52 c	4.35 b	17.5 c	50.2 d
Violet De Galmi	44. b	7.40 bc	41.43 b	1.29 a	30;79 e	4.25 cd	3.66 c	47.5 b	42.3 d
H1	52.73 a	8.76 ab	48.16 a	1.34 a	44.95 cd	5.05 b	4.29 b	50 b	53.5 d
F	38.86	11.16	38.53	7.61	29.871	40.906	32.136	43.325	26.441
P value	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Means indexed in the same column by the same letter are not significantly different at the 5% threshold (Newman Keuls test). F: ANOVA test File statistic; *P* value: probability value associated with the ANOVA test

Bulb weight analysis revealed that Ares, Natangue and Karibou varieties produced the heaviest bulbs ($P < 0.001$), with mean weights of 66.6 g, 55.33 g and 50.95 g, respectively (Table 2). The Safari variety recorded the lightest bulbs, averaging 16.30 g. For bulb length (LB), Ares and H1 exhibited the greatest values, measuring 5.57 cm and 5.05 cm, respectively, whereas Safari produced the shortest bulbs at 3.64 cm. Bulb diameter was largest in Natangue, Karibou, and Ares, ranging from 4.74 cm to 5.04 cm; Safari had the smallest diameter at 2.96 cm. The varieties Bati, H1, Super Violet and Violet De Galmi showed intermediate bulb diameters between 3.66 cm and 4.25 cm.

Maturity rates at three months varied significantly, with Safari reaching the highest bulb maturity rate of 77.5%, while Ares exhibited the lowest at 12.5%. Yield measurements demonstrated that Ares achieved the highest production, with an estimated yield of 79.3 t/ha, whereas Safari recorded the lowest yield at under 19.6 t/ha.

Structure of the agromorphological diversity of onion varieties

The Hierarchical Ascending Classification (HAC) of the eight onion varieties, conducted using the nine variables identified through Principal Component Analysis (PCA), delineated three distinct clusters (Fig. 1). The first cluster comprises four varieties: Karibou, Natangue, Bati and Violet De Galmi. The second cluster groups the Super Violet, H1 and Ares varieties. The third cluster is exclusively represented by the Safari variety. The test statistic (F = 217.298) indicates a highly significant difference among the three agromorphological groups identified by the HAC ($P < 0.001$).

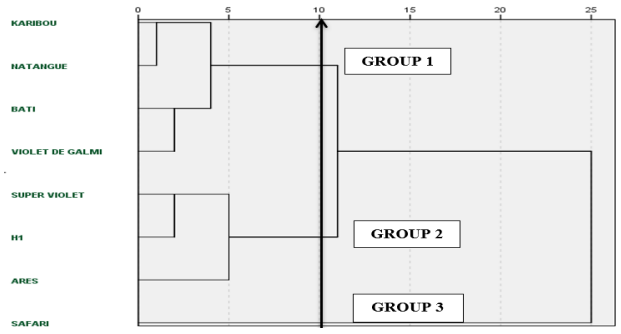

Fig. 1: Dendrogram of studied onion varieties

Agromorphological characteristics of the three classes of onion varieties

The varieties in Group II (Super Violet, H1, and Ares) demonstrated superior agronomic performance. These varieties are characterized by relatively tall plants (average height of 51.23 cm), large leaves (mean length of 47.93 cm and diameter of 1.2 cm), and the production of large bulbs (average diameter of 5.5 cm, length of 5.57 cm, and weight of 66.60 g), which collectively contribute to a high yield of 79.3 t/ha. In contrast, Group III (Safari) exhibited the lowest agronomic values, characterized by shorter plants (33.63 cm), smaller leaves (length 30 cm and diameter 0.96 cm), and small bulbs (diameter 2.96 cm, length 3.64 cm and weight 16.30 g). This group also showed a lower yield (19.6 t/ha) and a shorter production cycle with a high maturity rate of 77.5%. The varieties in Group I (Karibou, Natangue, Bati, and Violet De Galmi) displayed intermediate agronomic traits relative to Groups II and III (Table 3).

Table 3: Agro-morphological characteristics (Mean ± standard deviation) of the three onion classes

Traits	Group I	Group II	Group III	*F*	*P value*
Plant height (cm)	45.51 ± 7.49 b	51.23 ± 6.32 c	33.63 ± 5.18 a	50.181	*< 0.001*
Maximum leaf length (cm)	42.23 ± 6.8 b	47.93 ± 5.92 c	30 ± 8 a	58.503	*< 0.001*
Maximum leaf diameter (cm)	1.31 ± 0.27 b	1.32 ± 0.32 b	0.96 ± 0.28 a	21.827	*< 0.001*
Bulb weight (g)	43.91 ± 17.8 b	66.60 ± 17.59 c	16.30 ± 4.77 a	68.281	*< 0.001*
Bulb length (cm)	4.42 ± 0.69 b	5.57 ± 0.48 c	3.64 ± 0.35 a	77.349	*< 0.001*
Bulb diameter (cm)	4.35 ± 0.78 b	5.50 ± 0.66 c	2.96 ± 0.35 a	68.754	*< 0.001*
Three-month maturity rate (%)	50.125 ± 4.786 b	20 ± 1.68 a	77.5 ± 2.739 c	49.269	*< 0.001*
Bulb Yield (t/ha)	53.2 ± 6.33 b	79.3 ± 6.27 c	19.6 ± 1.74 a	68.347	*< 0.001*

Means indexed in the same column by the same letter are not significantly different at the 5% threshold (Newman Keuls test). F: ANOVA test File statistic; *P* value: probability value associated with the ANOVA test

Discussion

The results of the basic statistical analysis of agromorphological descriptors revealed significant differences among the onion varieties for most traits. Given that all varieties were evaluated under uniform conditions these differences can be primarily attributed to genetic variation. However, previous studies have shown that factors such as sowing dates and planting densities can also influence the agromorphological characteristics of onion varieties, either positively or negatively (Walle *et al*. 2018; Addai and Kugbe 2019; Konan *et al*. 2020a). In this trial, the environmental conditions appeared more favorable for the varieties Ares, Natangue, and Karibou, which exhibited superior performance, whereas the Safari variety seemed less well adapted.

In this study, the Ares variety outperformed Violet De Galmi, which contrasts with the findings of Konan *et al*. (2024), who reported that Violet De Galmi performed better than Ares during the dry season. It is important to highlight that their evaluations were conducted in central Côte d'Ivoire, whereas the current experiment took place in the northern region. These two areas are agroecologically distinct, likely explaining the relatively lower performance of Violet De Galmi in this trial. This suggests that Ares is better adapted to the northern growing conditions.

The observed genetic diversity among the onion varieties, as revealed by HAC, provides a valuable tool for quantifying the relative contribution of different traits to overall diversity and assessing the degree of similarity or divergence among genotypes (Tiendrebeogo *et al*. 2016). Based on nine quantitative variables, HAC grouped the eight onion varieties into three morphologically distinct clusters. These morphogroups, which display contrasting characteristics, can serve as a foundation for targeted varietal development. In this study, the highest-performing group included the varieties Ares, H1, and Super Violet, while the lowest-performing group consisted solely of the Safari variety. Similar clustering patterns were reported by Konan *et al*. (2020b). Notably, the Safari variety has the advantage of earlier maturity. Therefore, hybridization between these morphogroups could potentially produce progenies that combine early maturity with high bulb yield.

Several studies have consistently highlighted the strong performance of the Ares variety during the rainy season (Konan *et al*. 2020b), making it a promising candidate for use as a parent in breeding programs. Furthermore, other varieties within the same morphogroup as Ares should also be evaluated under rainy season conditions to determine their adaptability and performance.

Conclusions

The agromorphological evaluation of the eight onion varieties revealed significant inter-varietal variability, resulting in their classification into three distinct clusters. The cluster comprising Ares, H1 and Super Violet demonstrated superior agronomic traits and is therefore recommended for initiatives aimed at improving onion bulb yields in northern Côte d'Ivoire.

Acknowledgements

The authors gratefully acknowledge the Korea Africa Food and Agriculture Cooperation Initiative (KAFACI) for funding this study (Project number KAH20200103).

Author Contribution

EBZK drafted the manuscript. MPWAD and NYK collected the data. EBZK and IK analyzed the data and prepared the illustrations. SDMY and RSS reviewed and revised the manuscript. ND supervised the entire study.

Conflict of Interest

All authors declare no conflict of interest.

Data Availability

All data during this study is present in its full form in this manuscript.

Ethics Approval

Not applicable to this paper.

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