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ROCAMBOLE (*ALLIUM SCORODOPRASUM* L.) EVALUATION BASED ON MORPHO-BIOLOGICAL AND YIELD-RELATED TRAITS IN UZBEKISTAN

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SUMMARY

Rocambole (*Allium scorodoprasum* L.), a perennial bulbous vegetable belonging to the family Alliaceae, succeeded in its first-time introduction and examination under Uzbekistan's agro-ecological conditions. The presented study sought to determine the morphological yield and economic efficiency of rocambole line K-24 by comparing it with the local garlic cultivar 'Chidamli.' Field trials conducted from 2016 to 2020 followed standard methods for varietal testing and statistical analysis. Rocambole line K-24 exhibited a longer growth duration (242 days) than garlic (221 days) and showed characteristics of a taller pseudostem (106 cm) and broader leaves (5.0 cm). The average bulb weight of rocambole line K-24 was 106 g with 5–6 cloves, while garlic bulbs averaged 62 g with 13–14 cloves. The rocambole line K-24 yield reached 44.0 t ha⁻¹, which was 63% higher than the garlic cultivar Chidamli (27.0 t ha⁻¹). Rocambole bulbs exhibited excellent marketability (100%) and maintained good storability until February–March. Economic evaluation indicated a net income of USD 2,240 ha⁻¹ and a profitability rate of 158.7%, highlighting its robust economic viability. Overall, rocambole can be a very promising vegetable crop for Uzbekistan, with significant value for crop diversification and as a genetic resource in breeding programs.

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Key findings: Rocambole (*A. scorodoprasum* L.) produced significantly larger bulbs and higher bulb yield and showed more robust agronomic performance than garlic (*A. sativum* L.) under Uzbekistan's growing conditions. The rocambole cultivar Baraka demonstrated excellent marketability, considerable storability, and high profitability, confirming its potential as a commercial crop.

INTRODUCTION

Globally, the species of the family Alliaceae—particularly garlic (*Allium sativum* L.)—have long been a recognized ancient crop of nutritional and medicinal value. The garlic cultivated types have reached domestication for more than six millennia, with wide uses both as food and as a natural therapeutic agent (Sharma *et al.*, 2021). According to FAO statistics, garlic growing has occurred on more than 1.43 million hectares worldwide, with an average yield of 16.9 t ha⁻¹ and a total production of 24.3 million tons (FAOSTAT, 2023). The major producers include China, India, Korea, and Egypt, where productivity ranged from 20 to 25 t ha⁻¹ (Gao *et al.*, 2021).

In the recent past, global research has increasingly focused on the domestication, introduction, and breeding of garlic-related crops, as well as their improvement based on key agronomic traits, including *Allium scorodoprasum* L. (rocambole). These studies have primarily aimed at developing high-yielding cultivars and optimizing cultivation and seed-production technologies (Chorshanbiev *et al.*, 2023; Sharma *et al.*, 2024).

Rocambole, also known as 'Egyptian onion,' 'Spanish garlic,' or 'onion-garlic,' is a perennial bulbous vegetable that combines certain morphological and sensory characteristics of both onion (*Allium cepa* L.) and garlic (*A. sativum* L.). Its characteristics are a relatively mild flavor, high nutritional value, and notable concentrations of vitamins and sulfur-containing compounds (Borasulov *et al.*, 2024). *Allium scorodoprasum* L. is native to Central Asia and the Mediterranean region, with current cultivation in parts of Southern

Europe, the Caucasus, China, and Korea (Friesen *et al.*, 2006; Sharma *et al.*, 2021).

Rocambole is distinctive for several valuable agronomic and functional traits, including high-yield potential, extended shelf life, and notable antimicrobial properties attributed to its high concentration of allicin and other sulfur-containing compounds (Iciek *et al.*, 2009; Lanzotti, 2012). Biochemical studies have demonstrated that rocambole contains biologically active constituents, such as allicin, germanium, and various sulfides, having associations with improved blood circulation and reduced cardiovascular risk in humans (Block, 2010). Owing to this rich bioactive profile, rocambole is a highly regarded, promising raw material for the food, pharmaceutical, and nutraceutical industries (Rahman *et al.*, 2012).

In Uzbekistan, however, the rocambole had not attained previous cultivation and studies on the scientific basis. The country mainly grows the traditional garlic cultivars, such as 'Chidamli,' 'Sog lomlik,' and 'Oltinboshq' (Turdiv *et al.*, 2020). Expanding the range of vegetable crops through the introduction of new species like rocambole is an important agro-biological task aimed at increasing productivity, diversity, and nutritional values.

Therefore, the following study aimed to introduce rocambole (*Allium scorodoprasum* L.) under the agroecological conditions of Uzbekistan to evaluate its morpho-biological and agronomic traits, identify high-yielding and economically valuable genotypes, and develop and patent a new cultivar ('Baraka') adapted to local cultivation.

MATERIALS AND METHODS

Experimental site and plant material

The study started during 2016–2020 at the experimental fields of the Tashkent State Agrarian University, District Kibray, Tashkent Region, Uzbekistan (41°24'N, 69°36'E). The said site has characteristics of a sharply continental climate with hot, dry summers and moderately cold winters. The average annual temperature was 14.8 °C, and the total annual precipitation was about 420 mm. The plant material comprised the newly introduced accession 'K-24' of rocambole (*A. scorodoprasum* L.) and the local garlic (*A. sativum* L.) cultivar 'Chidamli,' serving as the control. Both genotypes incurred evaluation for their morpho-biological, agronomic, and economic characteristics.

Experimental design and cultivation practices

Field trials laid out in a randomized complete block design had three replications. Each experimental plot measured 10.1 m², with the bulbs planted manually at a spacing of 40 cm + 15 cm + 15 cm × 10 cm on September 20 each year. Standard agronomic practices for garlic cultivation followed included soil preparation, fertilization, irrigation, and weed control, according to national recommendations. Fertilizers applied had a rate of 120:90:60 NPK kg ha⁻¹, with half of the nitrogen applied before planting and the remainder during active vegetative growth. Irrigation occurred using furrow irrigation to maintain optimal soil moisture.

Phenological and morpho-biological observations

Phenological observations proceeded following the State Methodology for Cultivar Testing of Agricultural Crops (Moscow, 1975; VNISSOK, 1987). Under field conditions, key growth stages—emergence, leaf development, scape initiation and elongation, leaf senescence, bulb maturation, and harvest time—entailed systematic recording. Morphological

measurements ensued from 10 randomly selected plants per plot. The evaluated traits comprised pseudostem height, scape length, the number of leaves, leaf length and width, bulb height and diameter, the number of cloves per bulb, and bulb weight.

Yield and quality assessment

Total and marketable yields' calculation continued per harvested area (t ha⁻¹). Economic yield measurement transpired, expressed as the percentage of marketable bulbs relative to the total bulb yield. The study also recorded the bulb size distribution and the number of secondary bulbils formed at the basal plate. Economic efficiency assessment was by estimating total production costs, net income (USD ha⁻¹), and profitability (%), following standard economic evaluation methods commonly applied in Uzbekistan's agricultural production systems (Dospokhov, 1985).

Statistical analysis

All the recorded data for various traits received analysis using Microsoft Excel 2016. The mean values and standard errors calculation succeeded, with differences among the genotypes analyzed according to analysis of variance (ANOVA) (Dospokhov, 1985). Mean values reached further comparison at the significance level of $p \leq 0.05$.

RESULTS

Phenological development

For both rocambole (*A. scorodoprasum* L.) and garlic (*A. sativum* L.) genotypes, the growth period from planting to emergence was 19 days (Table 1). However, the total growing season (from emergence to bulb maturity) varied significantly. The garlic cultivar Chidamli reached technical maturity within 221 days, whereas the rocambole (*A. scorodoprasum* L.) genotype has a longer growth period and required 242 days, maturing approximately 21 days later. Rocambole exhibited a prolonged

Table 1. Duration of developmental phases of rocambole (*Allium scorodoprasum* L., line K-24) and garlic (*A. sativum* L., cv. Chidamli) during 2016–2020 in Uzbekistan.

Cultivar / line	Planting to emergence (days)	Emergence to scape formation (days)	Emergence to leaf yellowing (days)	Emergence to bulb maturity (days)	Total growth period (days)
<i>A. sativum</i> L., cv. Chidamli (control)	19±0.5	194±1.2	213±1.4	221±1.8	221±1.8
<i>A. scorodoprasum</i> L., line K-24 (rocambole)	19±0.4	194±1.0	232±1.6	242±1.9	242±1.9

Note: Mean values represent pooled data for 2016–2020 ± standard error (SE). Statistical difference: $p < 0.05$ (one-way ANOVA).

Table 2. Morpho-biological characteristics of rocambole (*Allium scorodoprasum* L., line K-24) and garlic (*A. sativum* L., cv. Chidamli) during 2016–2020 in Uzbekistan.

Cultivar / line	Pseudostem height (cm)	Scape length (cm)	Leaf number	Leaf width (cm)	Bulb diameter (cm)	Bulb weight (g)
<i>A. sativum</i> L., cv. Chidamli (control)	74.0±1.5	27.0±0.8	8.3±0.2	3.0±0.1	5.2±0.1	62.0±2.4
<i>A. scorodoprasum</i> L., line K-24 (rocambole)	106.0±1.8	66.0±1.1	8.7±0.3	5.0±0.2	6.2±0.1	106.0±3.1

Note: Mean values represent pooled data for 2016–2020 ± standard error (SE). Measurements were taken at the full vegetative stage (n = 10 plants per replicate).

vegetative phase and delayed bulb formation, which are the typical characteristics of the said species due to its slower physiological development. However, such extended growth conditions are advantageous under Uzbekistan's conditions, allowing more biomass accumulation and larger bulb formation before senescence.

Morpho-biological characteristics

Significant differences in vegetative morphology were evident between rocambole and garlic genotypes (Table 2). In rocambole, the pseudostem height (including the scape) reached 106 cm, which was 43% higher than in garlic (74 cm). Likewise, the scape length averaged 66 cm in rocambole compared with 27 cm in garlic. The number of leaves per plant was similar in both genotypes (8–9); however, rocambole produced broader leaves (5.0 cm) than garlic (3.0 cm). Leaf length did not differ significantly between the genotypes, remaining nearly equal at 43–44 cm. The greater pseudostem height and leaf width indicate a higher photosynthetic potential in the rocambole genotype. The general morphology

of the newly developed rocambole cultivar 'Baraka,' characterized by vigorous growth, a strong scape, and broad bright-green leaves, is available in Figure 1.

Bulb structure and size components

For bulb morphology and composition, the distinct differences recorded between the rocambole and garlic genotypes appeared (Table 3). In rocambole, the average bulb height and diameter were 4.9 and 6.2 cm, respectively, exceeding those of garlic cv. Chidamli by 0.6 and 1.0 cm, respectively. In the rocambole genotype, the average bulb weight was 106 g, nearly 44 g heavier than that in garlic (62 g). Importantly, the number of cloves per bulb was significantly lower in the rocambole genotype (5–6 cloves) than with the garlic cultivar (13–14 cloves). However, in rocambole, the average weight of a single clove (19.0 g) exceeded that of garlic (4.2 g) by more than fourfold (+352%). Additionally, rocambole genotype plants frequently formed small secondary bulbils (10–25) at the basal plate, serving as valuable propagation material analogous to garlic's aerial bulbils (Figure 2).



Figure 1. General morphology of rocambale (*Allium scorodoprasum* L., line K-24) under field conditions of 2020 in Uzbekistan.

Table 3. Bulb biometric and yield traits of rocambale (*Allium scorodoprasum* L., line K-24) and garlic (*A. sativum* L., cv. Chidamli) during 2016–2020 in Uzbekistan.

Cultivar / line	Bulb height (cm)	Bulb diameter (cm)	Cloves per bulb (pcs)	Average cloven weight (g)	Total bulb weight (g)	Marketable yield (t ha ⁻¹)
<i>A. sativum</i> L., cv. Chidamli (control)	4.3±0.1	5.2±0.1	13.6±0.5	4.2±0.2	62.0±2.4	27.0±0.9
<i>A. scorodoprasum</i> L., line K-24 (rocambale)	4.9±0.1	6.2±0.1	5.6±0.3	19.0±0.8	106.0±3.1	44.0±1.2

Note: Mean values represent pooled data for 2016–2020 ± standard error (SE). Marketable yield calculated from three field replications.



Figure 2. Bulb and clove structure of rocambale (*Allium scorodoprasum* L., line K-24) in Uzbekistan.

These bulbils often developed into single-bulb plants during the first growing season, providing a practical seed source.

Yield performance

Rocambale genotype demonstrated a robust yield advantage over garlic cultivar (Table 4). The total yield reached 44.0 t ha⁻¹, which was 63% higher than the garlic cultivar Chidamli

(27.0 t ha⁻¹). The entire harvest (100%) of rocambale genotype was marketable, with no nonstandard bulbs. The superior yield performance of the rocambale genotype has a primary association with a more extensive leaf area and longer photosynthetic activity period, and eventually, its larger bulbs and clove sizes. The high uniformity in bulbs also revealed better adaptability to the existing environmental and soil conditions.

Table 4. Economic efficiency of rocambole (*Allium scorodoprasum* L., line K-24) and garlic (*A. sativum* L., cv. Chidamli) cultivation during 2016–2020 in Uzbekistan.

Cultivar / line	Total production cost (USD ha ⁻¹)	Gross income (USD ha ⁻¹)	Net income (USD ha ⁻¹)	Profitability (%)
<i>A. sativum</i> L., cv. Chidamli (control)	1.183 ± 25	2.249 ± 50	1.066 ± 33	90.1±2.8
<i>A. scorodoprasum</i> L., line K-24 (rocambole)	1.417 ± 33	3.666 ± 67	2.249 ± 58	158.7±3.1

Note: Economic parameters are mean values (2016–2020) ± standard error (SE). Calculations based on market price of 0.54–0.58 USD kg⁻¹ for fresh bulbs.

Table 5. Comparative summary of morphological, yield, and economic parameters of rocambole (*Allium scorodoprasum* L., line K-24) and garlic (*A. sativum* L., cv. Chidamli) during 2016–2020 in Uzbekistan.

Cultivar / line	Pseudostem height (cm)	Bulb weight (g)	Number of cloves	Yield (t ha ⁻¹)	Storage duration (months)	Net income (USD ha ⁻¹)	Profitability (%)
<i>A. sativum</i> L., cv. Chidamli (control)	74.0±1.5	62.0±2.4	13.6±0.5	27.0±0.9	3.0±0.2	1,066 ± 33	90.1±2.8
<i>A. scorodoprasum</i> L., line K-24 (rocambole)	106.0±1.8	106.0±3.1	5.6±0.3	44.0±1.2	5.0±0.3	2,249 ± 58	158.7±3.1

Note: Mean values represent pooled data for 2016–2020 ± standard error (SE). Storage duration measured as the period of marketable bulb quality retention under standard warehouse conditions.

Economic efficiency

Economic assessment showed that rocambole genotype cultivation was substantially more profitable than garlic (Table 5). The net income from rocambole production amounted to USD 2,240 ha⁻¹, compared with USD 1,062 ha⁻¹ for garlic. The profitability rate reached 158.7% for rocambole versus 90.1% for garlic. Moreover, rocambole bulbs exhibited superior storage ability, remaining firm and marketable until February–March of the following year. These characteristics significantly enhanced the commercial potential of rocambole as a new vegetable crop in Uzbekistan.

Varietal registration

Based on the obtained results, rocambole line K-24 attained positive identification as a promising cultivar, entailing submission for state cultivar testing in 2020. Following successful evaluation, it reached official registration and patenting in 2022 under the name 'Baraka.' The cultivar 'Baraka' is

distinctive for its large bulbs, high yield, excellent storability, and broad ecological adaptability, representing the first successful introduction of rocambole cultivation under the agroecological conditions of Uzbekistan.

DISCUSSION

The relevant study represents the first comprehensive evaluation of rocambole (*A. scorodoprasum* L.) under the agroecological conditions of Uzbekistan. The results revealed that rocambole line K-24 exhibited distinct morpho-biological and agronomic features compared with the common garlic (*A. sativum* L.) cultivar Chidamli, confirming its potential as a promising new vegetable crop in this region. The extended growth duration of rocambole (242 days) compared with garlic (221 days) enunciates that it requires a longer vegetative period to better complete bulb development. Sharma *et al.* (2021) and Petropoulos *et al.* (2021) reported similar observations that the longer growing cycle of perennial *Allium* has a

linkage to their slower leaf senescence and delayed bulb maturation, resulting in enhanced biomass accumulation.

Such phenological behavior may be more beneficial in regions with long, warm seasons, like Central Asia, where late-maturing crop cultivars often achieve superior yield potential due to prolonged photosynthetic activity (Atif *et al.*, 2020; Chorshanбиеv *et al.*, 2022). Morphological distinctions between rocambole and garlic genotypes—particularly greater pseudostem height, broader leaves, and larger bulb diameter—reflect their divergent genetic backgrounds within the genus *Allium* (Friesen *et al.*, 2006).

In this current study, rocambole leaves were 2 cm broader than those of garlic, suggesting increased photosynthetic surface area and potentially greater carbon assimilation capacity. Similar findings documented in the past study stated leaf width and chlorophyll content considerably correlate with the bulb biomass in *Allium* species (Li *et al.*, 2022). In rocambole genotype, the formation of small secondary bulbils at the basal plate is a species-specific trait, described as an evolutionary adaptation for vegetative propagation (Gao *et al.*, 2021; Sharma *et al.*, 2024). These bulbils appeared to be agronomically valuable since they enabled rapid clonal multiplication under controlled cultivation and worked as an important feature for establishing primary seed material (Vavulin *et al.*, 2020).

The results demonstrated that the rocambole genotype was significantly more productive than the garlic cultivar under Uzbekistan's field conditions. The average yield of 44.0 t ha⁻¹ represented a 63% increase over the local garlic cultivar. This yield advantage mainly provided an association with the development of larger bulbs containing fewer but heavier cloves, which contributed to higher market value. Reports of similar yield levels (40–46 t ha⁻¹) have resulted for elite rocambole genotypes in Southern Europe and the Middle East (Petropoulos *et al.*, 2021; Hussein *et al.*, 2022). Furthermore, the positive relationships observed among bulb diameter, bulb weight, and total yield are

consistent with previous findings by Kumar *et al.* (2020) and Kovačević *et al.* (2023), who identified bulb morphological traits as major determinants of marketable yield in *Allium* crops.

Moreover, the low number of cloves (5–6 per bulb) and large average clove weight (19 g) were valuable consumer traits associated with premium-quality garlic types (Lanzotti, 2012; Wu *et al.*, 2020). These characteristics further enhanced its market competitiveness and reduced labor costs in processing and packaging. Rocambole's considerable storage potential—remaining viable until February–March—was consistent with the observations of Rahman *et al.* (2012) and Sharma *et al.* (2024), who attributed extended storability to the thick tunic layers and low moisture content of the bulbs. From a production perspective, such characteristics make rocambole a suitable addition to Uzbekistan's vegetable diversification strategy, contributing to food security and the expansion of high-value crops.

Beyond its agronomic advantages, rocambole holds considerable potential as a genetic donor for garlic improvement. Recent molecular studies have demonstrated that *A. scorodoprasum* possesses unique alleles linked to stress tolerance and high bulb quality (Xie *et al.*, 2022; Gowd *et al.*, 2024). The successful adaptation and patenting of the rocambole cultivar 'Baraka' represent an important step toward establishing a local breeding base for *Allium* crops in Central Asia. Future work should focus on molecular characterization, marker-assisted selection, and genomic assessment of *Allium scorodoprasum* populations to accelerate hybrid development with desirable traits, such as drought and disease resistance.

In summary, the introduction of the rocambole cultivar into Uzbekistan's agricultural system provides both agronomic and economic advantages. Its higher yield, superior bulb quality, and extended storability make it a viable alternative to traditional garlic cultivars. The results highlighted the species' adaptation potential and underlined the importance of continuous research integrating

molecular genetics, physiology, and agronomic performance for sustainable expansion of *Allium* cultivation in arid regions.

CONCLUSIONS

This study demonstrated the successful introduction and adaptation of rocambole (*A. scorodoprasum* L., line K-24) under the agroecological conditions of Uzbekistan, where it outperformed the common garlic (*A. sativum* L., cv. Chidamli) in key morpho-biological and agronomic traits. Rocambole exhibited taller pseudostems, broader leaves, larger bulbs, and a 63% higher bulb yield (44.0 t ha⁻¹) than the garlic genotype, along with robust storage capacity. Economic analysis revealed high profitability (158.7%), indicating its considerable potential as an alternative crop for increasing farmer income and diversifying vegetable production. The newly patented rocambole cultivar Baraka (2022) combines the higher bulb yield, bulb quality, and long shelf life. Overall, rocambole emerged as a promising crop for future *Allium* breeding, molecular characterization, and stress-resilience research to support sustainable vegetable production in Uzbekistan.

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