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Research Article

# Performance Evaluation of BINArashun-1 and Selected Garlic Cultivars Under the Agro-climatic Conditions of Mymensingh, Bangladesh

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## Abstract

Garlic (*Allium sativum* L.) is an important global bulb crop valued for its nutritional, medicinal, and economic benefits. However, its yield in Bangladesh remains below potential. This study evaluated the performance of BINArashun-1, a newly released high-yielding variety, alongside four commonly grown cultivars (Local, Italy, China, and Patnai) under the agro-climatic conditions of Mymensingh during the Rabi season of 2023-24. A randomized complete block design with three replications was employed at BINA's Horticulture Research Farm, Mymensingh. Key traits including plant height, number of leaves, neck and bulb diameter, number of cloves per bulb, bulb weight, cured bulb weight, weight loss, and final yield were recorded and analyzed using ANOVA. Significant differences were observed for most traits. Although plant height was statistically similar across cultivars, BINArashun-1 had the highest number of leaves. China exhibited the widest neck diameter (0.90cm) but the smallest bulb diameter, while Local and Italy showed larger bulbs. Patnai and Local had the highest number of cloves per bulb, and China the fewest. Bulb and cured bulb weights were statistically similar, though Italy showed the highest weight loss during curing. In terms of yield, China produced the highest (11.62 t/ha), followed closely by BINArashun-1 (10.60 t/ha). Despite slight yield gaps from reported potential, BINArashun-1 demonstrated strong adaptability and productivity under local conditions. Its adoption could enhance domestic garlic production and reduce dependence on costly imported seed bulbs.

## Keywords

BINArashun-1, Garlic Cultivars, Bulb Yield, Mymensingh

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# 1. Introduction

Garlic (*Allium sativum* L.), a crucial bulb crop belonging to the family Alliaceae, holds significant global importance [1]. It originated from the northwestern Tien Shan mountains and gradually spread to regions including Central Asia, Africa, Europe, and the America around 10,000 years ago [2, 3]. Globally, garlic ranks as the second most cultivated Allium crop after onion, a position it also holds in Bangladesh [4]. Its prominence is attributed to its nutritional value, being rich in antioxidants, minerals, and vitamins. Studies suggest garlic's cardiovascular benefits, including reducing cholesterol and load pressure levels [5-7]. Garlic's antioxidant properties contribute to numerous health benefits, such as anti-aging, cancer prevention, cardiovascular protection, and antithrombotic effects [8]. Research has shown a strong link between its antioxidant activity and phenolic compounds [9] as well as flavonoid content [10]. Despite its potential, garlic yields in Bangladesh are comparatively low, averaging 3,099.16 kg/acre with a total production of 549,000 metric tons over 177,000 acres in 2022-23 [11]. In recent years, Bangladesh has made progress in garlic production. In 2021-22, the country produced 526,819 metric tons across 178,435.56 acres, yielding an average of 2,952.43 kg/acre. The preceding year, 2020-21, produced of 501,611.52 metric tons from 180,034.75 acres [11]. However, in 2023, green garlic were produced in 71,706 ha of land with an average yield of 7.67 t/ha. Notably, Bangladesh ranked third globally in green garlic production in 2023 after India producing 548,907 tons [12]. The price of garlic also reflects its market dynamics. In 2022, the wholesale price of local garlic averaged 5,270 Taka per quintal, whereas imported garlic was priced higher, at an average of 10,997 Taka per quintal [11]. Exports have also shown growth, with volumes increasing from 97,406,831 kg in 2020-21 to 117,547,248 kg in 2022-23 [11]. Overall Bangladesh has made significant improvement in yield and production of spices with the adoption of modern agricultural technologies [13, 14].

Garlic shows significant genetic and morphological diversity in traits such as bulb weight, bulbing ratio, total soluble solids (TSS), and storability [15, 16]. Its varieties are categorized into two types: soft neck (*Allium sativum* sub var. sativum) and hard neck (*Allium sativum* sub var. ophioscorodon). Soft neck garlic, which has smaller cloves, a longer shelf life, and greater economic importance, contrasts with hard neck garlic, favored for its larger, brighter bulbs and ease of peeling [17]. Factors such as soil nutrients [18], cultivation methods [19], and storage conditions significantly impact garlic's quality and consumer appeal [17, 20]. Moreover, farmers now demand climate smart crop varieties which can tolerate and sustain a wide range of environmental conditions [21-23].

National agricultural research institutes like BARI have developed four high yielding varieties of garlic, which are- BARI Roshun-1, BARI Roshun-2, BARI Roshun-3, BARI Roshun-4 and BINA has recently developed one variety named BINArashun-1. The mean bulb yield of the BARI varieties are between 7-11 t/ha [24], but potential yield of newly released BINArashun-1 is not less than 13 t/ha [25]. Contrary there are some local and imported cultivars (seed/bulb) of garlic which are also in cultivation. If the farmers use the research institutes garlic varieties a good sum of money can be saved as imported seed bulbs are expensive. Considering this situation, the present study was undertaken to evaluate the yield and related attributes of BINArashun-1 with some other popular garlic cultivars in the agroclimatic conditions of Mymensingh district.

# 2. Materials and Methods

## 2.1. Location and Growing Season

The experiment was conducted at the Horticulture research farm of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh which was under the agro ecological zone (AEZ)-9 known as old Brahmaputra floodplain. It is located in central to north-central Bangladesh, features level to gently undulating land with old ridges and basins. Soils are mostly silt loam to silty clay loam, moderately to highly fertile, and slightly acidic to neutral (pH 5.5–7.0). Ridges are well-drained, while basins are poorly drained. The area receives 2000–2500 mm of rainfall annually, mainly during the monsoon. Seasonal flooding occurs but is less intense than in active floodplains. AEZ-9 is well-suited for rice, jute, wheat, mustard, vegetables, and pulses. Latitude and longitude of the location was 24.724750 ° and 90.430123 ° respectively. The experiment was conducted during the Rabi (winter) season (from November 2023 to March 2024) of 2023.

## 2.2. Design and Plant Materials

A randomized complete block design (RCBD) with three replicated was followed for the experimentation. Five garlic cultivars such as BINArashun-1, local, Italy, China, and Patnai was used as planting materials. Bulbs of BINArashun-1 were collected from horticulture division of BINA and the remaining cultivars were collected from local markets. Individual plot size was 2m × 2m, with a spacing of 15cm × 10cm (line to line × plant to plant).

*Table 1. Major characteristics of the garlic cultivars used for experimentation.*

| Variety/Cultivar | Characteristics | Mean yield (t/ha) |
|---|---|---|
| BINArashun-1 | HYV, developed by BINA | 13-15 |
| Local | Deshi *rashun* or local garlic, is a variety popular in Bangladesh. More number of cloves, smaller bulbs and intense, pungent flavor | 5.5-6.5 |
| Italy | Exotic cultivar, moderate number of cloves, bulb size and weight medium. Pungency is lower than Local or Patnai cultivar. | 9.5-11 |
| China | Exotic cultivar. Less number of cloves, higher bulb size and weight. Pungency is lower than Local or Patnai cultivar. | 12-13 |
| Patnai | Similar to Local cultivar | 6-7 |

### 2.3. Land Preparation, Fertilizer Application, and Other Managements

Experimental land preparation was done as per the procedures described by Chowhan and Islam [26] and fertilizer application was done as per the guidelines of fertilizer recommendation guide 2024 [27].

### 2.4. Data Collection and Analysis

When all the garlic plants reached to maturity, all plots were harvested and bulbs were cured for 30 days at room temperature and data on growth and yield attributing characters like plant height (cm), number of cloves/plant, neck diameter (cm), bulb diameter (cm), number of cloves/bulb, bulb weight (g), cured bulb weight (g), weight loss (%), total bulb yield (t/ha) were collected after final harvest of each plots. Data of three plants from each plot were collected randomly. All collected data were later analyzed separately using the ANOVA (Analysis of Variance) technique in Statistix 10 software. The significance of mean differences was determined using the LSD (Least Significant Difference) test at the 5% probability level [28].

## 3. Results and Discussion

### 3.1. Growth Traits

Among the cultivars, no significant differences were observed in the case of plant height (Figure 1). However, mean number of leaves per plant were most in BINArashun-1 (5.40) and the least was observed in China cultivar (4.13). Rest of the three cultivars viz. local, Italy and Patnai were statistically identical and beard almost same number of leaves per plant (Figure 2).

Though plant height and leaf number are genetically determined trait. In our study we harvested all the garlic cultivars after final maturity at once. Thus, it is possible that, we did not observe any significant changes in plant height. We did not find big difference in case of number of leaves per plant among cultivars but BINArashun-1 had highest leaves. Similar results were previously reported by Kumar and Prasad [29]. Little variation in leaf number among the cultivars indicate that the cultivars were of mostly similar type. Contrary uniform soil nutrition, fertility and management might be also responsible [30].

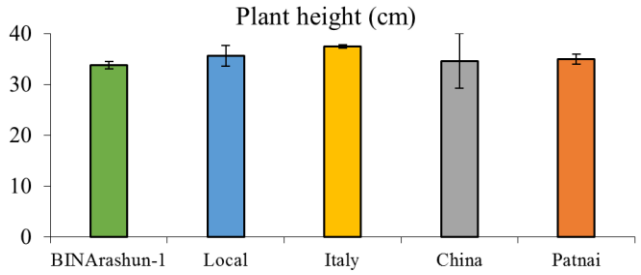


*Figure 1. Plant height of five garlic cultivars. Error bars indicate ±SE (n=3). Significant differences calculated using LSD test. $LSD_{0.05}$ = 9.50; here changes are NS (Non-significant).*

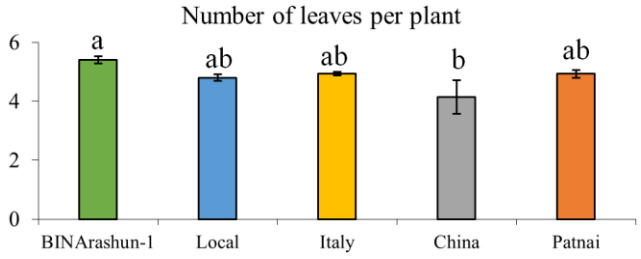


*Figure 2. Mean number of leaves in the studied garlic cultivars. Error bars indicate ±SE (n=3). Significant differences calculated using LSD are indicated by different letter(s). $LSD_{0.05}$ = 0.95.*

### 3.2. Yield Attributes

We found maximum neck diameter in the cultivar China

(0.90cm). Which was significantly greater than those of other four cultivars (Figure 3). Interestingly, China showed tiniest bulb diameter (2.27cm) whereas Italy and the local cultivar exhibited statistically larger bulb diameter (3.38cm and 3.45cm respectively) (Figure 4). We noticed that Patnai and local garlic cultivar produced significantly utmost number of cloves per bulb (18.53 and 15.93). While statistically least number of cloves were attained in the China cultivar (8.33) (Figure 5). Remarkably, we did not see any significant statistical differences in bulb weight and cured bulb weight among the five cultivars (Figure 6). Although, weight loss was significantly most (25%) in Italy and least in the local cultivar (17.20%). Other cultivars demonstrated similar weight loss (%) (Figure 6).

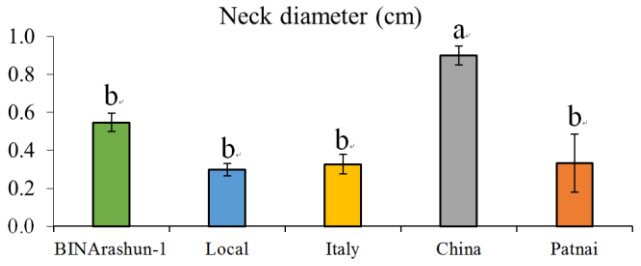


***Figure 3.*** *Average neck diameter of five garlic cultivars. Error bars indicate ±SE (n=3). Significant differences calculated using LSD are indicated by different letter(s). $LSD_{0.05}$ = 0.27.*

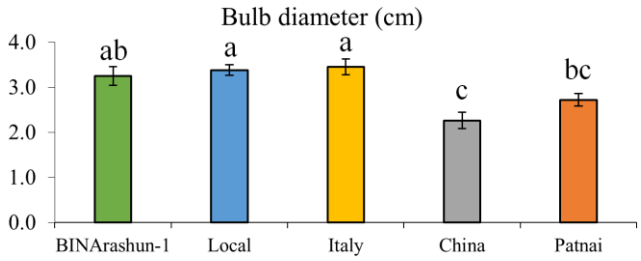


***Figure 4.*** *Bulb diameter (mean) of the tested garlic cultivars. Error bars indicate ±SE (n=3). Significant differences calculated using LSD are indicated by different letter(s). $LSD_{0.05}$ = 0.53.*

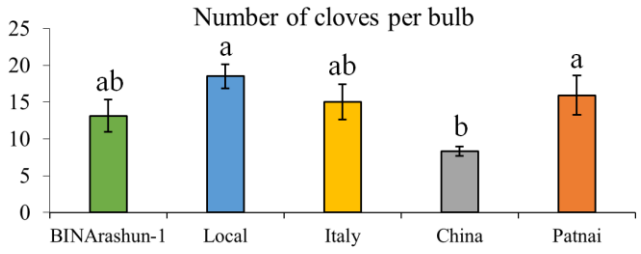


***Figure 5.*** *Mean clove number per bulb for the examined garlic cultivars. Error bars indicate ±SE (n=3). Significant differences calculated using LSD test are indicated by different letter(s).; $LSD_{0.05}$ = 6.82.*

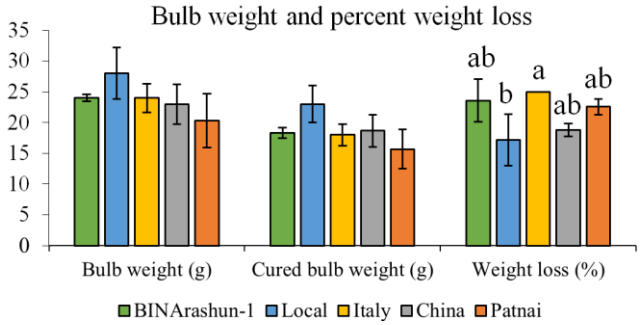


***Figure 6.*** *Weight characteristics and loss dynamics of five garlic cultivars during curing. Error bars indicate ±SE (n=3). Significant differences calculated using LSD test are indicated by different letter(s). $LSD_{0.05}$ = 11.58, 8.54, 7.47 for Bulb weight, cured bulb weight and weight loss respectively. NS difference among cultivars in case of bulb and cured bulb weight.*

The highest neck diameter in China cultivar might be due to its genetic characteristics as other cultivars attained statistical identical diameters. Bulb diameter is also a genetic trait but it can also be influenced by soil, temperature and other environmental factors responsible during the cultivation. These findings were in line with the findings of Karthikeyan *et al.* [31] and Khadi *et al.* [32].

Generally, local and Patnai garlic cultivars bear smaller and more number of cloves compared to the high yielding and exotic garlic cultivars. Thus, this outcome was consistent with the variety/cultivar characteristics in Table 1. Unexpectedly, we observed no significant variation in bulb weight and cured bulb weight among the cultivars. Though previously genotypic variation in bulb and cured bulb weight was reported by Sultana *et. al.* [33]. But we did not spot any variation(s) presumably due to synchronized harvesting and curing time. Yet changes in weight loss was clear as during curing water is lost from raw garlic. Cultivars which accumulate less dry matter might release more water, so Italy had highest weight loss. These outcomes were in agreement with the findings of Talukder *et al.* [34].

## 3.3. Bulb Yield

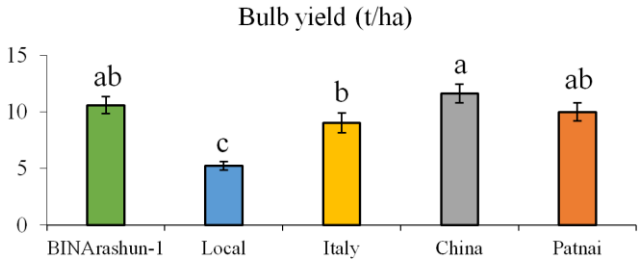


***Figure 7.*** *Yield performance of five garlic cultivars. Error bars indicate ±SE (n=3). Significant differences calculated using LSD test are indicated by different letter(s) n=3; $LSD_{0.05}$ = 2.20.*

Bulb yield of the studied garlic cultivars differed significantly. The China cultivar gave the maximum bulb yield (11.62 t/ha) followed by BINArashun-1 (10.60 t/ha) and Patnai (9.98 t/ha). The lowest yield (5.23 t/ha) was obtained from the local cultivar which was also statistically distinct from the other four cultivars (Figure 7). All improved cultivars showed a significant yield advantage over the Local cultivar, with China showing the highest increase (122.2%), followed by BINArashun-1 (102.7%), Patnai (90.6%), and Italy (72.7%).

We observed some yield gap (compared to Table 1) in the studied cultivars. Satisfactory bulb yield of garlic is dependent on many factors specially soil nutrition and fertilization. In our experiment plot we did not check the soil nutrient status prior to experiment setup, rather we applied recommended dose of fertilizer as per fertilizer recommendation guide 2024 [27]. Previously many researchers reported that bulb yield of garlic might be influenced by sowing time, cultivar/genotypes and fertilizer management [33, 35-37].

## 4. Conclusion

The study revealed significant variation in yield and related traits among five garlic cultivars grown under Mymensingh's agroclimatic conditions. BINArashun-1, developed by BINA, showed strong performance with the second-highest bulb yield after the China cultivar. While other cultivars excelled in specific traits like bulb diameter or clove count, BINArashun-1 offered a balanced combination of desirable agronomic characteristics. Its adaptability and consistent yield highlight its potential to boost garlic production in Bangladesh. Wider adoption of such improved varieties could reduce dependence on imported seed bulbs and enhance national self-sufficiency. Further multi-location trials and soil analyses are recommended to optimize productivity across diverse regions.

## Abbreviations

| | |
|---|---|
| ANOVA | Analysis of Variance |
| BARI | Bangladesh Agricultural Research Institute |
| BINA | Bangladesh Institute of Nuclear Agriculture |
| HYV | High Yielding Variety |
| LSD | Least Significant Difference |

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## Author Contributions

**Shampa Rani Ghosh:** Conceptualization, Investigation, Data collection and Supervision.

**Md. Rafiqul Islam:** Conceptualization, Investigation, Data collection and Supervision.

**Sushan Chowhan:** Data analysis, Interpretation and Writing final version of the manuscript.

**Md. Tanjilur Rahman Mondal:** Writing review, and Editing.

**Sultana Razia:** Writing review, and Editing.

**Nasim Mohammad Nayan:** Writing review, and Editing. All authors read, reviewed and approved the final version of the manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest.

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