Morphological characterization of flowering in local shallot (*Allium cepa* L.) varieties in the lowlands region of Jember

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Abstract. Shallots are an important commodity in Indonesia. Production declined from 2021 to 2023 due to limited land availability and high production costs. Flowering is a crucial stage in plant reproduction that affects yield, yet it often occurs unevenly and is highly influenced by environmental and genetic factors. Morphological characterization of shallot flowering is necessary to understand the genetic basis of flowering in local varieties, in order to support the breeding of superior cultivars with stable flowering and resistance to environmental stress. The study was conducted in Jember Regency starting in July 2025. The research used a non-factorial randomized block design, using local shallot varieties as treatments, namely Bima, Sumenep, Eban, Biru Lancor, Batu Ijo and Tajuk. The experiment was repeated four times. This study used a morphological characterization approach to flowering through direct observation. The observed parameters included: time of umbel emergence,the age at umbel cracking number of umbels per plant, number of flowers per umbel, time of flower blooming. Data were statistically analyzed using Analysis of Variance (ANOVA) and Honestly Significant Difference (HSD) test. Studies show that all varieties except the Sumenep variety were able to flower. Among the flowering varieties observed, Tajuk was the slowest to initiate flowering. The Bima variety produced the greatest number of flower umbels and the highest percentage of flowering plants, as well as the most flowers per umbel.

1 Introduction

Shallots (*Allium cepa* L.) are one of Indonesia's most important horticultural commodities, especially in East Java. Indonesia's shallot production has been declining from 2021 to 2023. National shallot production reached 2,004,590 tons in 2021, then dropped to 1,982,360 tons in 2022, with no significant improvement in 2023, where it only reached 1,985,233 tons [1]. Low production is caused by the influence of land area and production costs [2]. To boost

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shallot production, it is crucial to understand the genetic factors that affect flowering, as flowering is a key stage in plant reproduction that influences both yield and seed quality.

Flowering in shallots is often unsynchronized and highly influenced by environmental factors such as temperature, humidity, and photoperiod (duration of light) [3-4],. Asynchronous flowering can lead to uneven harvests and difficulties in cultivation management, making studies on the genetics of flowering in local shallots highly important. The flowering process in shallots is also influenced by genetic factors. However, the specific genes that regulate flowering in local Indonesian shallots have not yet been fully identified. An understanding of the genetic factors affecting flowering is crucial for increasing shallot production, as flowering is a key stage in plant reproduction that influences both yield and seed quality. Morphological and molecular characters can be used to identify genetic diversity in shallots, there has been no specific focus on flowering genes [5] .

Morphological characterization is an approach used to study the physical traits of a plant, including the shape and size of its leaves, stems, flowers, and bulbs. In shallots, the morphological characteristics of flowering can include the timing of blooming, the number and shape of the flowers, and the plant's resilience to environmental stress. Understanding these morphological traits is crucial for differentiating various shallot varieties and identifying the features that support desired flowering. Morphological and molecular characteristics can be used to identify genetic diversity in shallots [6]. Therefore, it is essential to understand the genetic factors that influence flowering in order to develop superior and more stable shallot varieties in terms of blooming. Genetic mapping is a crucial step in developing superior varieties. Understanding gene-environment interactions is important for developing superior varieties with stable flowering and resilience to environmental stress [7]. Genetic diversity is essential in plant breeding to improve yield and disease resistance [8].

2 Materials and Methods

The research activities were conducted from July to November 2025. The study takes place at the research field in Kalisat District, Jember Regency, located at an altitude of 200 meters above sea level. The research site consisted of former paddy fields previously used for rice cultivation, with soil texture predominantly ranging from sandy loam to loam. Additionally, the research will also be carried out at the Bioscience Laboratory and the Seed Technology Laboratory of Jember State Polytechnic.

2.1 Procedure

The experiment was conducted using a non-factorial randomized block design with four replications. Materials used in this research were local shallot varieties, namely Bima, Sumenep, Eban, Biru Lancor, Batu Ijo and Tajuk.The shallot bulbs used as planting material in this research were healthy, disease-free bulbs, harvested approximately 1-1.5 months prior to use, and having a weight of 5-10 grams per bulb. Shallot bulbs were vernalized at a temperature of 5-10°C for four weeks in the Seed Technology Laboratory. The bulbs were then planted in a research plot where the land and growing media had been prepared. The growing media consisted of topsoil, manure, and rice husk charcoal in a 1:1:1 ratio. During the preparation of the growing media, SP36 fertilizer was also applied at a dose of 200 kg/ha. Subsequent fertilization was carried out at 10 days after planting (DAP) using NPK (15:15:15) at a dose of 600 kg/ha. Observations were conducted from the emergence of the flower umbel until harvest.

2.2 Observation Variables

For the shallot morphological characterization experiment, the parameters observed included time of flower emergence, the age at umbel cracking, number of flower stalks (umbels), number of flowers, percentages of flowering plants, and the number of flower per stalks (umbel). The data for the flowering ability parameters were analyzed using ANOVA at a 5% significance level and further tested with the Honestly Significant Difference (HSD) Tukey Test at a 5% significance level.

3 Results and Discussion

The research findings show that each plant variety has different flowering characteristics. Almost all local varieties tested were able to flower, with the exception of the Sumenep variety. The Biru Lancor variety produced its first umbel the quickest, at 23 days after planting (DAP), but this was not significantly different from the Batu Ijo, Bima, Eban, and Tajuk varieties. The Sumenep shallot variety is genetically unable to flower. Sumenep variety did not flower even when given different photoperiod treatments [9]. Meanwhile, Biru Lancor and Batu Ijo are referred to as superior local varieties which may have a different tendency to flower or different adaptations[10]. The minimal flowering response of the Sumenep shallot variety is suspected to be due to its higher content of metabolites that can prevent flowering, such as organosulfur compounds (thiophene and trisulfide) and proline [11].

These findings are also consistent with research reported that Sumenep variety is difficult to induce to flower, even after being treated with vernalization and plant growth regulators[10]. Shallot flowering is strongly influenced by the genetics of the variety and environmental factors. Different varieties show differing sensitivity to these factors; some varieties exhibit low inherent flowering ability and remain difficult to induce to flower without specific treatments [12]. Several varieties require long-day conditions to trigger flowering, whereas in tropical lowland environments, variation in day length may alter the plant's flowering response [13]. Additionally, persistently warm temperatures in tropical lowlands often suppress the flowering rate even when vernalisasi or plant growth regulators have been applied [14].

Table 1. Time of Flower Emergence, age at umbel cracking and time of flower blooming in Local Shallot Varieties

Treatments	Time of Flower Emergence (DAP)	Age at umbel cracking (DAP)	Time of flower blooming (DAP)
Sumenep	0 ± 0 a	0 ±0 a	0±0 a
Biru loncor	23.09 ± 0.55 b	37.10 ±0.77 b	40.56±1.16 b
Batu Ijo	23.40 ± 1.04 b	37.76 ±1.05 b	41.7±1.29 b
Bima	24.33 ± 1.66 b	37.21 ±0.27 b	41.14±1.07 b
Eban	24.58 ± 3.05 b	38.35 ±1.46 b	42.43±0.85 b
Tajuk	25.81 ± 0.99 b	38.18 ±0.64 b	41.45±0.72 c

Note : Numbers followed by the same letter within the same column are not significantly different using the HSD test at $\alpha = 0.05$.

All local varieties that flowered, except for Sumenep, showed no significant difference in the parameter of flowering umbel bursting time (**Table 1**). The bursting of the umbel (or the opening of the spathe/umbellate inflorescence) is a visible morphological sign that the plant has transitioned from the vegetative phase to the generative/flowering phase. As an indicator, this is useful because it signifies that the floral meristem is already actively forming the umbel and the open umbel allows the florets to form flowers, and subsequently seeds (or bulbils) if the variety/seed agent permits[10].

In this study, the Tajuk variety exhibited the slowest flowering and the most delayed flower opening compared to the other tested varieties. This is presumably because the Tajuk variety requires greater vernalization exposure and a longer photoperiod stimulus than the others, and it may also be associated with an extended juvenile phase. Moreover, the speed of floral initiation, indicated by bolting, is largely determined by the genotype. Certain varieties possess a longer juvenil phase or allelic variants that render them less responsive to flowering triggers, resulting in naturally slower flower emergence than in other varieties. The timing of floral initiation (bolting) is regulated by different genes and alleles across varieties; some display delayed flowering due to prolonged juvenile development or postponed expression of flowering-related genes [15].

Table 2. Number of Umbels, Percentage of Flowering Plants and The Number of Flowers per Umbel in 6 Local Shallot Varieties

Treatments	Number of Umbels	Percentage of Flowering Plants (%)	The number of flowers per umbel
Sumenep	0±0.00a	0 ± a	0 ±0.00 a
Eban	1.325±0.39 ab	28.75±2.5 a	73.25±30.60 b
Biru loncor	1.537±0.20 ab	63.75±1.26 a	51.88±18.43 b
Tajuk	1.562±0.97 ab	51.25± 4.35a	77.02±7.84 b
Batu Ijo	1.691±0.22 ab	62.50±3.32 a	61.71±6.39 b
Bima	2.02±0.30 b	66.25±2.22 a	85.32±2.78 b

Note: Numbers followed by the same letter within the same column are not significantly different using the HSD test at $\alpha = 0.05$.

The results of this study show that the number of umbels per plant among the six shallot varieties was significantly different (**Table 2**). Except for the Sumenep variety, the other five varieties produced a varied number of flower umbels. The Bima variety produced the most flower umbels, with an average of 2 per plant, but this was not significantly different from the Eban, Biru Lancor, and Tajuk varieties. This study also found that the percentage of flowering plants varied among the varieties. The percentages for Eban, Biru Lancor, Tajuk, Batu Ijo, and Bima were 28.75%, 63.75%, 51.25%, 62.5%, and 66.75%, respectively. The flowering percentage is an important morphological trait in the production of true shallot seed (TSS) in onion grown in lowland areas. The high flowering percentage of onion in lowlands is influenced by various factors, including vernalization [16] and plant growth regulators [17,18,19] , the cultivars used [20], bulb size as planting material [21] and photoperiod [22][23]. Bima Brebes variety belongs to the "sensitive flowering" group according to [14]. Also Bima Brebes is the variety with the highest flowering ability among the tested varieties (around 91.66%) and has the highest shLFY gene expression [15]. The same result also reported that Bima Brebes showed a significant flowering percentage after vernalization treatment and had the highest pollen viability following the treatment vernalization and PGR [16].

The results for the Tajuk variety in this study were considerably lower than those reported by [24] who found that the Tajuk variety had a flowering plant percentage per plot of 26.3-78.7%. The results of the study also showed that the Bima variety had the highest number of flowers per umbel, followed by the Tajuk, Eban, Batu Ijo, and Biru Lancor varieties. Studies by [14,17,18] studies show that Bima responds to vernalization treatment (cold exposure) and hormone application (BAP) with an increase in percentage of flowering and number of umbels; this confirms that Bima has the genetic capacity for flowering and can be optimized agronomicall. Number of flowers per umbel in shallot varieties grown in lowland areas can be maximized through the application of vernalization and plant growth regulators[18].

A study conducted by [15] reported that genes such as LEAFY (LFY) trigger meristem differentiation towards floral organs. This study found a higher expression of shLFY in Bima Brebes, which was associated with a greater percentage of flowering and a larger number of florets per umbel. The number of umbels and florets per umbel isn't solely genetic; agro-ecological conditions (altitude, temperature, climate, pollinators) also determine the outcome. Bima exhibits superior performance in several locations/trials—indicating a favorable G×E (Genotype Environment) interaction for this variety [19-20].

4 Conclusion

All varieties except the Sumenep variety were able to flower. Among the flowering varieties observed, Tajuk was the slowest to initiate flowering. The Bima variety produced the greatest number of flower umbels and the highest percentage of flowering plants, as well as the most flowers per umbel.

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