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Research Article

Bulb selection of shallot local varieties from true shallot seeds (TSS) for bulb split components

Linda Nursalma [1], Awang Maharijaya [2,3]*, and Sobir [2,3]

[1] Plant Breeding and Biotechnology Study Program, Graduate School of IPB University (Bogor Agriculture University), Jl. Meranti, Kampus IPB Dramaga, Bogor 16680, INDONESIA
[2] Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University (Bogor Agriculture University), Jl. Meranti, Kampus IPB Dramaga, Bogor 16680, INDONESIA
[3] Center for Tropical Horticulture Studies, IPB University (Bogor Agriculture University), Jl. Raya Padjajaran, Kampus IPB Baranangsiang, Bogor 16144, INDONESIA
* Corresponding author (✉ awangmaharijaya@apps.ipb.ac.id)

ABSTRACT

The development of quality shallot seeds from new superior varieties needs to be done because only about 10% of the shallot seed needs are currently covered. However, true shallot seeds (TSS) production from the local varieties, such as the Bima Brebes variety, is still rarely developed and has not been able to produce many split bulbs from TSS. The existence of split bulbs in one plant is preferred by consumers and is beneficial for shallot seedlings. This is related to the number of seeds farmers can use per kilogram of seed obtained. Therefore, this study aimed to select shallots that produce split bulbs from seeds produced from TSS. This research was conducted at Tajur Experimental Farm, Center for Tropical Horticulture Studies IPB University, Bogor. Seedlings were done in beds shaded with transparent plastic that can be opened and closed. The split bulbs produced by the Bima Brebes variety derived from TSS seed sources were still relatively low at 39.69% and significantly different from the comparison varieties at more than 60%. Sanren variety produced split bulbs from TSS seed sources as high as 64.13% and the Maserati variety about 61.25%.

Keywords: spit bulb; dry weight; fresh weight; true shallot seed

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INTRODUCTION

Shallot (*Allium cepa* var *aggregatum*.) is one of the staple foods in Indonesia and one of the crucial food components. It is categorized as the major condiment in Indonesia with high economic value that cannot be substituted (Adiyoga et al., 2020; Satar & Buraerah, 2020). National consumption of shallots continues to increase as the population grows in Indonesia. Data from the 2021 Economic Survey (Susenas) shows that Indonesian consumption is 2.49 kg per capita per month (BPS, 2022a). However, the increase in shallot production is limited due to the availability of quality seeds of superior varieties and the dependence on long-standing varieties being too high. Developing quality seeds from new superior varieties needs to be conducted because only about 10% of the shallot seed needs are currently covered. The need for shallot seeds in 2022 is 184,386 tons, calculated from the total harvest area of 184,386 ha with a seed requirement of 1 tons ha^{-1} (BPS, 2022b). So far, shallot varieties in production centers are limited to the Bima Brebes because farmers and consumers favor them. However, a true shallot seed (TSS) production from the Bima Brebes variety is rarely developed. In addition, the Bima Brebes variety has not been able to produce many split bulbs from TSS. Thus, it is necessary to select Bima Brebes varieties from TSS that produce split bulbs that are healthy and free of bulb-borne pathogens.

Shallot cultivation is a significant source of income for millions of farmers, especially in developing countries, including Indonesia. It provides a reliable livelihood and contributes to food security in many regions, including Indonesia. However, traditional propagation methods, such as dividing bulbs and using bulbs from previous harvests, have several disadvantages. These methods can lead to the spread of soil-borne diseases from one generation to the next, limiting the genetic diversity of shallot plants and ultimately resulting in decreased yields over time. This may pose challenges for farmers in maintaining crop health and productivity. The use of TSS has many advantages, especially in terms of yield increase, but this can only be achieved if the TSS used are homozygous or inbred lines.

The yield of shallots grown from TSS is influenced by a complex interplay of agroecosystem, socioeconomic, and cultural factors specific to local farming communities. These factors include climate, soil conditions, irrigation practices, farmer knowledge and experience, resource access, and cultural preferences. Integrating these factors is critical to optimizing shallot production using TSS in various farming environments. (Sumarno et al., 2021). Technological innovations using TSS that combine the principles of new superior variety selection, high-density planting, and precision nutrient and pest management to maximize shallot yield can double shallot production and improve the farmer's income compared to usual methods used by the local farmer. The technology is called Proliga (Sudaryono & Prihardini, 2020). Rahayu et al. (2019) reported that socioeconomic factors, infrastructure facilities, and farmer group existence groups supported the development of TSS, while farmer knowledge of TSS application needs to be improved.

Bulbs produced from TSS can produce more than one bulb per plant clump and are called split bulbs. The existence of split bulbs in one shallot planting is very beneficial for shallot seeding and domestic consumers. This is related to the number of seeds that farmers can use per kilogram of seeds obtained either purchased or produced by themselves. Thus, seeds play an important role in the magnitude of production and productivity. Ulfa et al. (2023) stated that supplying shallot seeds through TSS easily, abundantly, and sustainably can overcome the problem of seed scarcity after the off-season. The TSS is one of the technological breakthroughs with great development potential. According to Manwan et al. (2020), improvement of the shallot production system generatively has been launched by the government by using seed sources from TSS in three ways, namely the formation of mini bulbs, direct planting of TSS, and planting TSS through seedbeds and transplanting. Therefore, this study aimed to select shallots that produce split bulbs from seeds produced from TSS.

MATERIALS AND METHODS

The planting materials used in this research were three varieties consisting of one test variety and two comparison varieties. The test variety was a local variety commonly used and bred by shallot farmers in Indonesia, namely Bima Brebes. The TSS of Bima Brebes was obtained from previous research TSS production. The comparison varieties used were commercially purchased Sanren and Maserati. The TSS from the two comparison varieties is very easy to obtain because many seed producers produce it, while TSS from Bima Brebes is still quite difficult to obtain from shallot seed producers.

This research was conducted at Tajur Experimental Farm, Center for Tropical Horticulture Studies IPB University, Bogor, using a one-factor completely randomized complete group design, which consisted of three varieties with four replications. Seeding was performed in beds shaded with transparent plastic that can be opened and closed. TSS seeds were spread equally on the seedling bed at 10 g TSS m^{-2} and then covered with fine soil and banana leaves. According to (Sumarni et al., 2012; Sopha, 2020), elevating shallot plant density derived from TSS can augment the number of bulbs produced per plot and affect the number of plants harvested.

In this study, shade was used to protect the TSS seeds from intense sunlight and heavy rainfall of more than 10 mm per day (Figure 2). After 40 days of seeding, shallot seeds with mini bulbs were planted into beds in the prepared field with transparent plastic shade with a spacing of 10 cm x 10 cm. Cultivation was optimized using standard cultivation techniques according to the standard operating procedure (SOP) of shallot planting, except for the use of transparent plastic shade. Subsequently, the plants that produced split bulbs in each experimental plot were selected. The selected bulbs were combined and dried as genetic material to produce the next generation of TSS.

The data analyzed contained all plants in the population as samples in each experimental unit. F-test was used to analyze the variance of each data at the 5% level. Data showing a significant effect on the F test were analyzed using the Tukey's honestly significant difference (HSD) test to compare the mean values of each treatment at the 5% level. Data were analyzed using Microsoft Excel 2013 and SAS® OnDemand for Academics.

RESULTS AND DISCUSSION

The germination rate of shallot

The germination rate of shallot showed that Bima Brebes TSS had a high value and was significantly different from Maserati but not significantly different from Sanren at about 80.06% (Figure 1). These results indicated that the germination rate of Bima Brebes TSS as a local shallot variety can compete with comparison as commercial varieties. The germination rate was relatively high even though the TSS of Bima Brebes was obtained from its production. This indicates that the methods used in flower production to obtain shallot seeds have been well conducted. Agung and Diara (2019) and Pangestuti et al. (2021) observed that biostimulants and seed priming using a mixture of GA3 and NAA can increase the germination percentage of TSS. In this study, the germination rate of Maserati, as a comparison, showed the lowest germination rate at <80%. According to (Sopiana et al., 2023), the combination of rice husk and cocopeat as the media planting exhibited a higher germination rate.

TSS from commercial varieties tend to be better than TSS newly developed from bulbs in several ways, like genetic stability, germination rate, and seed availability. The results of a pilot project in collaboration between the Indonesian government and a research institution in the Netherlands through Wageningen University conducted by Basuki and Brick (2010) showed that farmers in the test areas (Yogyakarta, Nganjuk, and Brebes) tended to favor TSS of the Sanren variety because they valued the characteristics of Sanren TSS in terms of crops growth, resistance to pest and diseases, tuber size, tuber color and market acceptance were better.

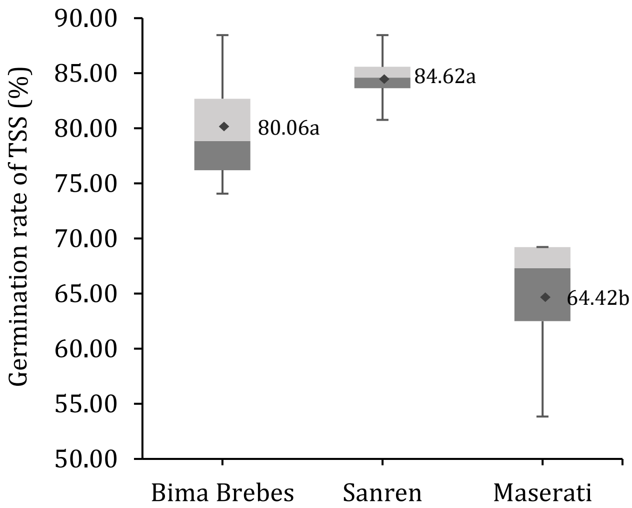

Figure 1. The germination rate of shallot from TSS. Value followed by the same letter was not significantly different based on the HSD test at α = 5%.

TSS production in Indonesia is still relatively limited. Most of the locally produced TSS aims to supply the demand for research and pilot projects. TSS of commercial varieties currently available in the market came from imported seeds. TSS seed producers only import seeds and distribute them to local markets in Indonesia (Sayaka et al., 2020). Indonesia has several local varieties that are suitable for TSS propagation. Four local shallot varieties have the potential for TSS production, namely Bima Brebes, Maja Cipanas, Pancasona, and Trisula (Waluyo & Sinaga, 2015).

Growth of shallots from TSS

The growth of shallot plants can be seen from several characteristics throughout the vegetative stage. Plant growth is an important process in the life cycle of a plant that is influenced by a complex interplay of factors, including water availability, nutrient uptake, the presence of growth regulators, and the environmental conditions surrounding the plant. Shallot varieties significantly affected plant height, number of tillers, number of leaves per tiller, and number of leaves per clump of shallots observed (Table 1).

Table 1. ANOVA summary of shallot growth from TSS of different shallot varieties.

Variable	Variety	CV (%)
Plant height	*	5.13
Number of tillers	*	12.72
Number of leaves per tiller	*	8.33
Number of leaves per clump	*	8.10

Note: * = Significant at 5% level

Bima Brebes had the highest plant height at 56.59 cm (Table 2). Gunaeni et al. (2020) and Purwito et al. (2022) reported that shallot growth from seeds was affected by transparent plastic shade and planting density because it can reduce disease attacks. In this study, the transparent plastic shade was employed to shield shallot from excessive perspiration (>10 mm per day) (Figure 2). The optimal water requirement for shallot cultivation, as determined by Hariyanti et al. (2020), is approximately 1.6-2.3 mm per day. According to Prahardini et al. (2021), the amount of rainfall significantly affects the growth of shallot during the vegetative and flowering stages. Marseva et al. (2022) claimed that rainfall variability can increase the prevalence of plant pathogens, thereby compromising shallot growth and potentially resulting in substantial yield losses.

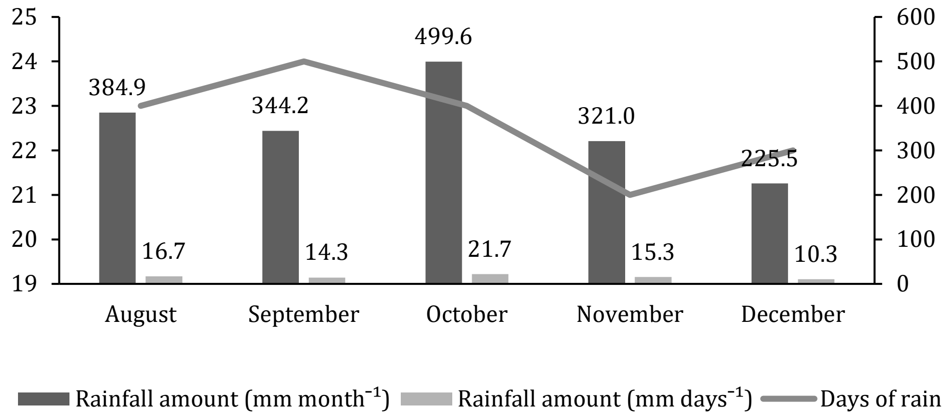

Figure 2. Rainfall amount and days of rain per month in 2022 (BPS, 2024).

The Bima Brebes variety was not significantly different from the Sanren variety in terms of the character of the number of leaves per tiller, which was about 8 strands of leaves (Tabel 2). The highest number of leaves per tiller and the number of leaves per clump were shown by the Sanren variety. Devy et al. (2021) revealed that plants showed an increased number of leaves and tiller in less dense populations, likely attributed to the lack of competition between plants for the main factors supporting growth. Atman et al. (2021) also reported that in shallot from TSS with a high plant density, there is a lack of light, resulting in fewer leaves because photosynthesis is reduced. Moreover, Irawan et al. (2018) mentioned that the positive effect of population on vegetative growth is related to the capability of the plant to adapt with all growth factors to reach maximal growth. Shimeles (2014) said that shallots are a typical plant that adapts well to hot and cold climatic conditions in the lowlands and highlands. Some shallot lines show specific adaptability to favorable and unfavorable environments.

Table 2. Plant height, number of tiller, number of leaves per tiller, and number of leaves per clump from different shallot varieties.

Variable	Average			F-value
	Bima Brebes	Sanren	Maserati	
Plant height (cm)	56.59a	49.98b	51.70ab	6.40*
Number of tillers	1.10b	1.29ab	1.52a	6.31*
Number of leaves per tiller	7.77ab	8.58a	6.76b	7.02*
Number of leaves per clump	8.46b	10.77a	10.13ab	9.07*

Note: * = significant effect at the level α = 5%. The numbers followed by the same letter in the same row are not significantly different based on the HSD test at α = 5%

Weight bulb characterization of shallot

The percentage of weight loss of shallot plants was significantly different. The Bima Brebes variety had the lowest weight loss compared to the two varieties at about 7.85%. In general, Maserati had the highest weight loss at 22.39%, but statistically, it was not significantly different from Sanren variety weight loss at 17.73% (Figure 3).

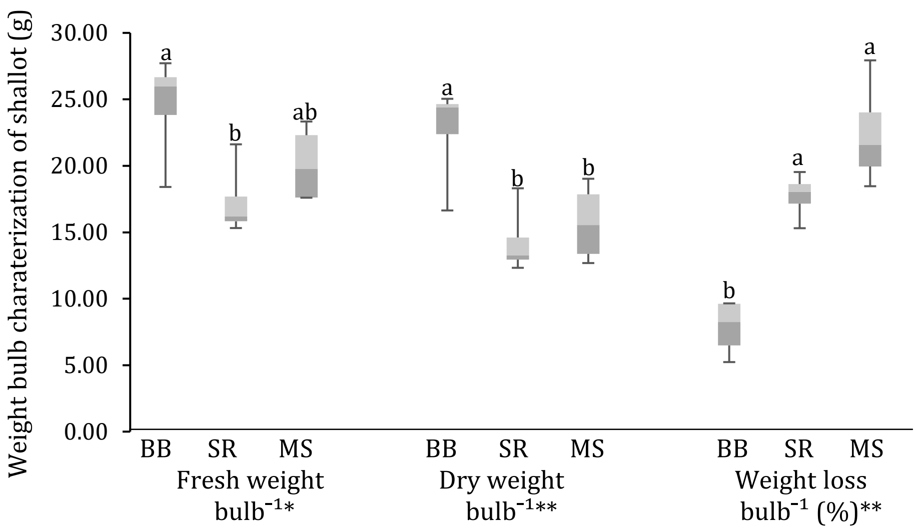

Figure 3. Weight bulb characteristics are from different varieties of shallot. BB = Bima Brebes, SR = Sanren, MS = Maserati. The same letter above the bar in the same variable indicates non-significant difference based on the HSD test at α = 5%. *=significant at 5% level, ** = significant at 1% level.

The results showed that the values between varieties were significantly different for the characters of fresh weight per bulb and very significantly different for the characters of dry weight per bulb and weight loss per bulb. Bima Brebes had the highest values for the character of fresh weight per bulb (24.52 g) and dry weight per bulb (22.62 g). The Sanren variety showed the smallest value compared to the other two varieties in fresh weight per bulb (17.32 g) and dry weight per bulb (14.21 g) and had a higher percentage of weight loss per bulb compared to Bima Brebes. This was allegedly due to damage to the bulbs. Mutia (2019) claimed that the damage during storage is caused by high water content in shallot bulbs. This affects the high weight loss and can cause a decrease in the quality of the bulbs. Wibisono and Bintoto (2021) reported that storage temperature greatly affects the O_2 and CO_2 changes between the product and the surrounding environment. Lower temperatures are known to inhibit the metabolism of shallots and would influence the decrease of O_2 and CO_2 as a result.

Nitrogen is a major limiting factor in shallot production and using nitrogen fertilizer results in higher biomass yields. Dry bulb weight increased due to higher nitrogen application (Shimelis et al., 2020). Excess nitrogen leads to excessive vegetative growth, reduced dry matter content, and storability (Tesfa et al., 2015), as well as reduced yield and quality of marketable bulbs. Meriati (2019) mentioned that cow manure can increase the weight of shallot bulbs. Although there was no direct correlation between wet and dry weights, this study demonstrated that favorable growth conditions can produce better quality bulbs, including higher dry matter content. High fresh weight values can affect the bulbs' shelf life and weight loss during storage. A great disparity causes a higher weight loss of shallot bulbs.

Split bulb component

Yield characters observed included the percentage of plants producing split bulbs. Bima Brebes variety showed the lowest value compared to comparison varieties. Bima Brebes tend to produce one bulb per clump of plants. Bulb of *Allium cepa* L. has a very large genome composed of a high proportion of repetitive DNA (Masuzaki et al., 2006). Split bulbs can be helpful for farmers who want to grow shallots from seed or who want to develop new shallot varieties. Some farmers may prefer to produce shallot plants with single bulbs (Figure 4), as they can be more aesthetically pleasing and may be preferred by consumers in some markets. However, for commercial shallot production, a split bulb is generally the preferred propagation method.

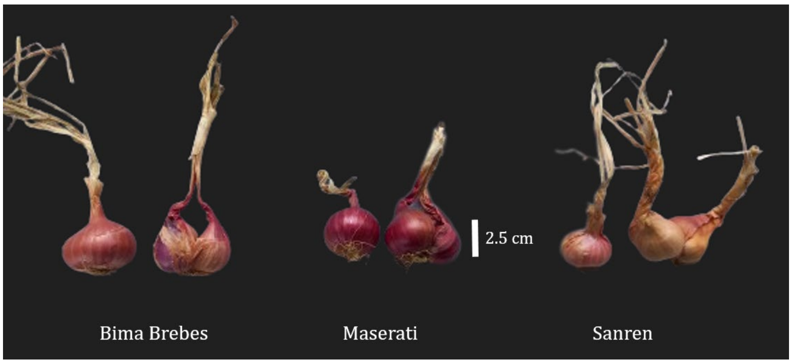

Figure 4. The difference between single bulbs and split bulbs in shallots.

Sanren and Maserati varieties, already commercial varieties for TSS, have been proven to form more than split bulbs per plant. In this study, variety significantly affected the percentage of split bulb yield per clump. Maserati dan Sanren varieties showed the highest values, about 61.25%-64.13%, while the Bima Brebes variety was significantly lower than the two commercial varieties tested, about 39.69% (Figure 5). According to Gubb and MacTavish (2002), some of the key factors affecting shallot quality are the choice of appropriate long-storing varieties for the production area, careful timing of sowing and transplanting to avoid environmental conditions, which may lead to splitting and doubling of the bulbs, careful use of fertilizers such that nitrogen is not scarce in the early growth stages. However, it is mostly used up by the plant by the time of harvest, irrigation management to encourage the bulb to dry down fully by the time of harvest, and the use of a sprouting inhibitor during the last stages of leaf die-down but while the foliage is still green. Devy et al. (2021) stated that reducing the population would trigger the formation of multiple bulbs in response to the environment. (Sulistyaningsih et al., 2020) observed that shallots with split bulbs had a higher number of leaves than the plants with single bulbs, which had about 10-15 leaves per clump. In this study, Sanren and Maserati, as a comparison, had 10 leaves, while Bima Brebes had less than 10 leaves per clump (Table 2).

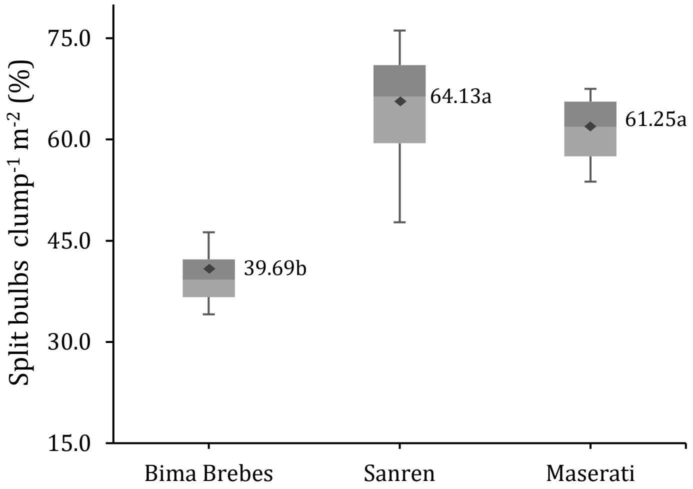

Figure 5. Percentage of split bulbs from different shallot varieties. Values followed by the same letter are not significantly different based on the HSD test at α = 5%.

Generally, shallot bulbs derived from TSS produce a single bulb of large size. However, in some shallot species described as being able to flower and produce TSS, when the TSS is planted, it produces more than one bulb per clump of plants. Shallot plants that produce split bulbs can be helpful for farmers who want to grow shallots from seed or to develop new shallot varieties. This research showed that the split bulbs produced by the Bima Brebes variety tended to be significantly lower than the two commercial varieties, Sanren and Maserati. There was a significant percentage difference in the number of bulbs that produce split bulbs. Sanren and Maserati's shallots produced more than 60% of the population, producing split bulbs, while Bima Brebes was still below 40%. This may be due to genetic differences or environmental influences such as soil type and planting distance. According to Currah et al. (2012), splitting and doubling in shallot bulbs is indicated by several factors, including the type of variety suitable for the production area, planting time, and transplanting. This condition causes farmers and even shallot seed breeders to be uninterested in producing the TSS of the Bima Brebes variety. On the other hand, the prospect of local shallots of Bima Brebes is favored and has become a national consumption shallot preference favored by consumers in Indonesia.

The aggregation of shallot bulbs can be seen in the split bulbs due to the first or second stage of aggregation, which forms more than one bulb and even splits up to four bulbs. The number of tillers may be related to the development of bulb aggregation, which will contribute to increased bulb yield (Sulistyaningsih et al., 2020; Pangestuti et al., 2023). Preliminary selection results of split bulbs produced from the Bima Brebes variety grown from TSS seed genetic sources have shown the results of split bulbs. Although the results were relatively low, there was still an opportunity to obtain split bulbs from local varieties that were difficult to obtain. Further breeding development can be done by conducting gene identification or by crossing. Before crossing, some shallot varieties have difficulty flowering. Selection of the right varieties with good flowering properties can help increase the chances of successful flowering. Crossbreeding between local genotypes, including Bima Brebes, resulted in a lower capsule yield, lower TSS weight per plant, and lower germination rate (Maulidha et al., 2024).

CONCLUSIONS

The split bulbs produced from TSS of the Bima Brebes variety were still relatively low, below 40%, when compared to the Sanren and Maserati varieties, which have been able to produce split bulbs from TSS of more than 60%. The existence of split bulbs in one plant is preferred by consumers and profitable for farmers and seed producers. This is related to the number of seeds that farmers can use per kilogram of seed obtained. A further selection of Bima Brebes varieties that can form split bulbs needs to be done to support the stages of gene identification or modification of planting distance and seed treatment.

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