

Research Article

Evaluating the Onfarm Performance of True Seed Shallot Varieties in Northwest Ethiopia

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Abstract

Shallot (*Allium cepa* L. var. *aggregatum*) is an important vegetable crop in Ethiopia, but its production has declined in recent years due to a lack of true seed-propagated varieties. This study aimed to demonstrate and evaluate the performance of true seed shallot varieties in three districts of the Amhara region: Fogera, Libokemkem, and Dera. The study involved the participation of host farmers in variety demonstrations and the evaluation of the demonstrated varieties by experienced farmers. Two true seed shallot varieties, DZsht-157-1B and DZsht-91-2B, were compared to the local Bombay red variety. Bulb yield data was collected from one-meter square quadrants, and farmers' preferences were assessed using a direct matrix ranking approach. The results showed that the true seed shallot varieties outperformed the local Bombay red variety in terms of bulb yield. In the Fogera district, DZsht-157-1B and DZsht-91-2B had 40.1% and 0.3% higher bulb yields, respectively, compared to Bombay red. In the Libokemkem district, DZsht-91-2B had a 4.2% yield advantage over the local variety. The farmer evaluation results revealed that the true seed shallot varieties were preferred over the local Bombay red variety in various aspects, such as higher bulb yield, redness, and prolonged food span. The findings of this study suggest that the true seed shallot varieties have the potential to improve shallot production in the study areas and potentially in other parts of Ethiopia. To promote the adoption of these varieties, it is crucial to ensure the availability and accessibility of high-quality seeds to farmers, as well as to educate them on the importance of maintaining the true seed to bulb and bulb to true seed cycle. This will enable the continuous propagation of the true seed shallot varieties and ensure a sustainable supply of high-quality planting material, contributing to the revitalization of shallot production in Ethiopia and enhancing the livelihoods of smallholder farmers.

Keywords

Farmers Preference, Fogera, Host Farmers, Shallot, True Seed

1. Introduction

Ethiopian agriculture has played a significant role in GDP growth, with crop production contributing 72.7%. The service and industry sectors have also made notable contributions of 40.8% and 37.9%, respectively [1]. Vegetables, root crops, and fruit production are the basic components of horticulture

development. Root crops share 70.7% of horticultural crop production [2].

Horticulture development in Ethiopia focuses on vegetables, root crops, and fruit production. Root crops account for 70.7% of horticultural crop production [2]. The major root

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crops cultivated in the country include Goderie, potatoes, sweet potatoes, and onions/shallots, with production volumes of 1,426,924, 1,309,566, 913,785, and 207,662 metric tons, respectively. Goderie and potatoes are primarily cultivated in the South Nations Nationalities and Peoples Region, while sweet potatoes and onions/shallots have higher production in the Oromia region [3].

In the Amhara region of Ethiopia, onion and shallot production contributes to 49.9% of the national production [2]. In terms of root crop production, onions and shallots account for 14.7% in the Amhara region and 5% in Ethiopia overall. It's productivity is estimated to be around 8.2 tons per hectare [3]. It is worth noting that onion production in potential areas of the Amhara region has traditionally relied on true seed propagation, while shallot varieties have been propagated through bulbs. This historical practice suggests that the volume of onion production is expected to be significantly higher than that of shallot production in the country.

Shallot (*Allium cepa* L. var. *aggregatum*) is closely related to onion (*Allium cepa* L. var. *cepa*) [4]. Smallholder farmers in Ethiopia cultivate shallot for both income generation and consumption purposes [5]. The crop exhibits a wide range of adaptability to different climatic and soil conditions, making it suitable for cultivation under both rain-fed and irrigated systems [6]. It is preferred over onion for its high pungency and unique flavor [7]. For example, it is important to flavor local dishes such as 'Wot'¹, which can be kept overnight or more without spoilage [8]. It is dominantly produced and adapted in areas where the climate is rainy and the growing season is short to tolerate purple blotch disease. It is more tolerant to downy mildew disease than onion [6]. The research report by [9] on evaluation of true seed shallot varieties for yield and yield Components showed that shallot is preferred for its shorter growth cycle, better tolerance to disease and drought stresses, and longer storage life than onion.

The propagation of shallot has traditionally relied on vegetative means, specifically through the use of bulbs. However, this method presents several challenges. One of the main issues is the requirement for a large quantity of bulbs as planting material, with an estimated amount of 1.2 tons per hectare [10]. Dealing with such a bulky and perishable planting material becomes problematic, as it necessitates long-term storage and often results in significant postharvest losses. As a result, smallholder farmers often face difficulties in accessing planting materials during peak planting times. They are compelled to sell their entire produce immediately after harvest to meet immediate cash needs and overcome storage problems. Consequently, farmers are forced to purchase planting materials of any kind available in the market, often at high prices and from distant locations. Moreover, a study by [5] identified the need to use 1.5 to 2 tons per hectare of bulbs as planting material, accounting for approximately

40% of the total production cost. This further highlights the financial burden associated with the traditional propagation method. In contrast, using botanical or true seed as a planting material requires only 4 to 5 kg per hectare, significantly reducing the quantity needed. Another concern with bulb propagation is the potential transmission of diseases. Bulbs can carry various pathogens such as viruses, fungi, bacteria, and nematodes from one generation to the next [11, 12]. This can lead to the perpetuation and spread of fungal diseases, further impacting shallot production.

To address the decline in shallot production and the shift towards onion cultivation, research centers in Ethiopia have undertaken efforts to test and promote true seed shallot varieties as an alternative. The Melkasa Agricultural Research Center (MARC) conducted trials in 2005 to evaluate the performance of various shallot lines across different agro-ecological zones. Similarly, the Debre Zeit Agricultural Research Centre selected and released three promising true seed shallot varieties (DZsht-91-2B, DZsht-193-1A, and DZsht-157-1B) from local collections (MoA, 2016).

Building on the results from Debre Zeit and Melkasa research centers, the horticulture research team of the Fogera National Rice Research and Training Centre (FNRRTC) conducted adaptation trials of true seed shallot varieties (including DZsht-91-2B and DZsht-157-1B) in Fogera, Libokemkem, and Dera districts during the dry seasons of 2018 and 2019. These trials aimed to assess the performance of the varieties in these specific regions. The recommended varieties, DZsht-91-2B and DZsht-157-1B, exhibited average productivities of 23.7 and 28.8 tons per hectare, respectively. Consequently, to gather feedback and assess the acceptance of these true seed shallot varieties from smallholder farmers, pre-extension demonstrations and evaluations were conducted in Fogera, Libokemkem, and Dera districts in 2021 and 2022.

2. Methodology

2.1. Study Area Description

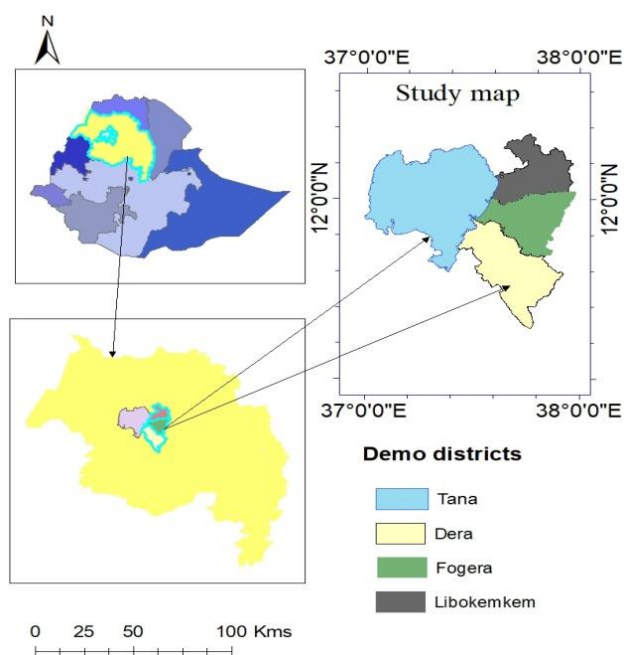
Fogera: Fogera district is demarcated by the Farta, Dera, Lake Tana, and Libokemkem regions to the east, south, west, and north, respectively. The district spans an altitude range of 1774 to 2410 meters above sea level, with an average annual rainfall of 1216 mm and a mean annual temperature of 19 °C. The primary agricultural crops cultivated in this area include rice, maize, and finger millet. However, shallot production in Fogera is relatively scarce. Of the total cultivated land, which amounts to 57,535 hectares, onion cultivation accounts for just 4%.

Libokemkem: Fogera district is bordered to the south by Fogera, to the north by Gonder Zuria, to the west by Lake Tana, and to the east by Ebinat. The altitude in the area varies from 1800 to 2850 meters above sea level, and the annual rainfall ranges from 900 mm to 1200 mm. The average annual

¹ is equivalent to stew, which is a delicious and satisfying dish that brings together ingredients in a flavorful and nourishing way, making it a popular choice in many culinary traditions.

temperature in the district falls between 12 °C and 26 °C. The major crops cultivated in this district include maize, rice, and tef. While there is some limited production of bulb-propagated shallots in the area, it is not extensive. The total cultivated land covers an area of 39,509 hectares, with onion cultivation accounting for 4% and shallot cultivation comprising 0.4% of the total land area.

Dera: Dera district is surrounded by the Abay River to the south, Lake Tana to the west, Fogera to the north, and Este to the east. The altitude in the area varies from 1500 to 2600 meters above sea level, while the mean annual rainfall ranges from 1000 mm to 1500 mm. The average annual temperature in the district ranges from 15 °C to 32 °C. The major crops cultivated in this area include maize, tef, and finger millet. However, shallot production in the area is almost non-existent. The total cultivated land covers an area of 56,882 hectares, with onion cultivation accounting for just 2% of the total land area.



Source: Ethiopian Geospatial data

Figure 1. Location map of shallot demonstration districts.

2.2. Farmers' Selection and Demonstration Field Establishment

During the demonstration process, the first crucial step is to obtain the required inputs, which include the technological options to be demonstrated and the budget for training. In this particular case, the selected true seed shallot varieties for demonstration were DZsht 91_2B and DZsht 157-1B. As a point of comparison, the dominant onion variety commonly cultivated in Fogera, Libokemkem, and Dera districts, namely Bombay red, was included as a check variety.

Once the necessary inputs were obtained, specific kebeles known for onion production and having access to water were carefully selected for the participatory demonstration activity. The chosen kebeles were Kokit and Quar Mikael in Fogera district, Ginaza and Angot in Libokemkem district, and Wagra and Jigna in Dera district. In the subsequent step, host farmers were identified based on their willingness to actively participate in the demonstration. A total of 24 farmers who expressed their eagerness to engage in the activity were carefully selected for the 2021 and 2022 dry seasons. The participatory demonstration adhered to the "farmer first" approach, which places emphasis on involving farmers in decision-making processes and prioritizing their needs and perspectives. This approach seeks to bring about organizational and policy changes in agricultural research and development, aligning them with the aspirations and requirements of farmers [13]. To foster a sense of ownership, the host smallholder farmers contributed by sharing farmland, labor, chemicals, and fertilizer. Prior to establishing the demonstration fields, comprehensive training sessions were conducted for the host farmers and agricultural experts at the district and kebele levels. These training sessions equipped the participants with the necessary knowledge and skills to effectively implement the demonstration and monitor its progress. After the training session, roles among relevant stakeholders (Fogera National Rice Research and Training Center, Agricultural Office at district and kebele level, and host farmers) were shared. Accordingly, Fogera National Rice Research and Training Center was responsible for seed acquisition, training provision, and organizing district level field days. The district and kebele level agricultural offices were responsible for host farmers and site selection, orienting the whole family of host farmers regarding the objective of the demonstration, and organizing kebele level field days. Host farmers were responsible for the management of the whole demonstration field. The common roles for the three stakeholders were preparing a cropping calendar and action plan, practical establishment of the demonstration field, and explaining true seed shallot varieties to neighbors.

During the land preparation and transplanting stages of the participatory demonstration, ridges were formed along the sides for the purpose of transplanting. For the true seed shallot varieties, the spacing between furrows, rows, and plants was set at 40cm, 20cm, and 10cm, respectively. However, for the control variety (Bombay red), the spacing between plants was reduced to 5cm. In terms of fertilizer application for commercial purposes, 100 kg/ha of urea and 242 kg/ha of NPS (nitrogen, phosphorus, and sulfur) were applied. The urea was administered in two splits, with the first half at the establishment of seedlings (around 1-2 weeks after transplanting), and the second half one and a half months after transplanting. All the recommended quantities of NPS were applied during the transplanting process. One common disease observed in the established demonstration field was Downey mildew (*Pronospora destructor*), which was managed through the

application of Ridomil MZ at a rate of 3 kg/ha on a weekly basis. Additionally, the insecticide Ajanta was used at a rate of 0.5 liters/ha to control thrips (*Thrips tobaci*). Weeding was carried out as required to maintain the field's cleanliness. Furrow irrigation was employed once a week until two weeks prior to harvesting.

2.3. Data Collection and Analysis

Bulb yield was measured from all demonstration plots us-

$$CYA = \frac{\text{Yield of true seed shallot varieties in ton/ha} - \text{Yield of Bombay red in ton/ha}}{\text{Yield of Bombay red in ton/ha}} \times 100$$

Beyond bulb yield, onion-producing farmers are interested in quality parameters (pungency, color, prolonged food span, maturity level, etc.) to select the varieties. Accordingly, farmer feedback, opinions, and perceptions were collected by selecting one well performed demonstration field by the researchers and agricultural experts from each district. Although gender is not well addressed in research and development [14], it has been considered and has participated in this variety selection process. Ten farmers, which have been selected by kebele level agricultural experts, form a group in each district (five males and five females) were selected by development agents. Farmers' selection for variety evaluation was based on their experience with onion cultivation and their willingness to participate in evaluating demonstrated true seed shallot varieties.

To collect farmers' feedback, focus group discussions (FGDs) were conducted. FGDs involve bringing together a group of individuals, typically ranging from 8 to 12, who share similar backgrounds or experiences to discuss a specific topic of interest [15]. The aim of gathering farmers' feedback is rooted in the belief that their opinions and perceptions reflect the realities of their intricate farming systems. The procedures for conducting the focus group discussions were as follows: Firstly, farmers and development agents were provided with an orientation on the purpose of evaluating different varieties. In using focus group discussion, the initial step in conducting FGDs is to clearly define the purpose or objective of the gathering. Secondly, to facilitate the selection of criteria, farmers and development agents conducted a practical visit to the demonstration plots. This allowed them to make informed comparisons among the demonstrated varieties. Thirdly, a group of smallholder farmers collaborated to compile a list of criteria to be used in evaluating the varieties. They also assigned relative weights to each criterion. Throughout the process, researchers acted as facilitators in the group discussions, while development agents contributed by providing essential information before and during the discussions. During the facilitation process, particular emphasis was placed on encouraging the active participation of female farmers in the variety selection process. Any differences of opinion between male and female farmers were addressed

ing a one-meter square quadrant. From each plot, three samples were taken at three points to make the sample representative (at two opposite corners and in the middle of each plot along the corners). So, the average bulb yield of varieties per location in two years was considered to understand the production performance of true seed shallot varieties. Comparative yield advantage (CYA) was used to compare the bulb yield performance among true seed shallot and onion varieties. It can be computed using the following simple formula:

through further discussions to reconcile their perspectives.

Farmers' opinions and perceptions regarding the demonstrated varieties were analyzed using a direct matrix ranking method. This approach aimed to assess the varieties based on the identified criteria. To rank the varieties and weigh the criteria, a Likert scale was employed as a measurement tool. The Likert scale, to measure attitudes, was utilized in this study. For evaluating the varieties against each criterion, a five-point Likert scale was used, where a score of 5 indicated excellent performance, 4 represented very good, 3 denoted good, 2 indicated poor, and 1 represented very poor performance. Additionally, a three-point Likert scale was used to determine the relative importance of the variety selection criteria, with a score of 3 indicating very important, 2 indicating important, and 1 reflecting less important. A similar approach utilizing five and three-point Likert scales was employed in a study by [16] on farmers' selection of food barley genotypes in the Gozamin District of Northwestern Ethiopia. The Likert scales were used to measure the relative weight of variety selection criteria and the variety scores, respectively. Consequently, the total score for each variety was computed by multiplying the performance rating value of each variety score by the weight assigned to each criterion. The varieties were then ranked based on their total scores, with higher scores indicating a higher ranking [17].

3. Results and Discussion

3.1. Yield Performance of Shallot Varieties Across Districts

In Fogera district, DZsht-157-1B and DZsht-91-2B exhibit yield advantages over Bombay Red of 40.1% and 0.3%, respectively, as shown in Table 1. Similarly, in the Libokemkem district, DZsht-91-2B demonstrates a yield advantage of 4.2% over Bombay Red. This indicates that DZsht-157-1B and DZsht-91-2B have a greater comparative yield advantage over Bombay Red in Fogera and Libokemkem districts, respectively. Furthermore, the adaptation trial result of [8] indicates that the average yield of DZsht-157-1B, DZsht-91-2B, and

Nasik red is 28.8, 23.7, and 26.4 tons/hectare, respectively. It implies that these shallot varieties have a competitive yield advantage when compared to improved onion varieties.

According to [5], the 'Huruta' variety (DZsht-91) exhibited a significant average true seed yield advantage of approximately 321% over the onion varieties used as a check. Additionally, in a study by [4] focusing on the development of seed-propagated shallot varieties in Ethiopia, it was found that DZsht-91-2B had a 7.2% yield advantage over Bombay red. This indicates that DZsht-91-2B performs better in terms of bulb yield when compared to Bombay red. In the Dera district, despite Bombay red showing a higher yield performance compared to DZsht-91-2B and DZsht-157-1B, farmers still preferred the two shallot varieties over Bombay red. This preference can be attributed to several factors, including the red color of the shallot varieties, higher pungency, disease tolerance, and a better market price. These additional qualities and market preferences outweighed the slightly lower yield performance of the shallot varieties compared to Bombay red, as shown in Table 4.

Table 1. Bulb yield performance of shallot varieties.

Districts	Varieties	Marketable yield (ton/ha)		
		2021	2022	Average
Fogera	DZsht-91-2B	32.4	28.1	30.25
	DZsht-157-1B	43.8	40.7	42.25
	Bombay red	35.3	25.0	30.15
Libokmkem	DZsht-91-2B	28.7	41.4	35.05
	DZsht-157-1B	21.4	45.8	33.60
	Bombay red	32.3	35.0	33.65
Dera	DZsht-91-2B	9.0	24.8	16.9
	DZsht-157-1B	12.5	21.0	16.8
	Bombay red	15.0	25.6	20.3

Source: Author's computation

3.2. Farmers' Preference

The provided information highlights the importance of specific criteria and preferences of farmers in the Fogera district when selecting shallot varieties. Farmers in this district prioritize high bulb yield, bulb redness, followed by prolonged food span, and disease resistance (see Table 2). Bulb yield is a significant criterion for both breeders and smallholder farmers, as shallots are a cash crop. Farmers in the Fogera district seek shallot varieties that offer comparable or higher bulb yields than existing onion varieties, such as Bombay red. Smallholder farmers in Fogera district related

bulb redness to the high quality of bulbs for local "*dikus chew*"² making and high pungency. Shallot bulbs with a red color are used to prepare long-lasting dishes and spiced stew, and their bulbs can be stored for up to nine months. Shallot bulbs are usually smaller and more highly flavored than those of the onion bulb [18]. Farmers during the focus group discussion explained that the high flavor and pungency of shallot are due to the red color of its skin. Shallot bulbs with red skin color have better storage life [19]. Shallots are closely associated with traditional French recipes, such as Beef Bourguignon, which are truly international vegetables. Shallots are an authentic ingredient in many Asian cuisines, from Thai soups and red and green curries to Indonesian and fried rice dishes such as Nasi goreng [20]. According to a study conducted by [21] in the nearby Khao Luang Mountain Hill Region, Southern Thailand, the shallot is used as a traditional remedy for lipoma. Prolonged food span is valued for making quality "*wot*" or spiced stew, as shallot-based dishes can be kept overnight or more without spoilage. Shallot varieties are reported to be evergreen and disease-free in farmers' fields, indicating their tolerance to the hot and humid tropical climate and better resistance to pests and diseases compared to onions [18].

In the Libokemkem district, farmers prioritize specific criteria when selecting shallot varieties. These criteria include high bulb yield, prolonged food span, and high pungency (see Table 3). High bulb yield is considered crucial for income generation, as both onion and shallot production are sold at farmgate prices. Smallholder farmers value varieties that offer high bulb yields to maximize their earnings. Prolonged food span is an important criterion related to food preservation. Farmers in the district aim to keep foods with desired features or qualities for as long as possible after preparation. Locally produced "*dikus chew*" using shallot as an input is reported to have a relatively long shelf life without spoilage. Based on the study by [21] on food preservation, proper preservation is important to store foodstuffs for a longer period without spoilage. Moreover, it is one of the important vegetables used for seasoning local dishes in Ethiopia [4]. Farmers explained that locally produced "*dikes chew*" using shallot can last for a relatively long time without spoilage. Pungency is the technical term used by scientists to refer to the characteristic of food commonly referred to as spiciness or hotness, which is found in foods such as chilli peppers. It is associated with the sense of taste, which has traditionally been considered a basic taste in various Asian countries and Ethiopia. The basic drawback of onion (Bombay red) is that it is unable to conserve '*wot*' for a relatively long time. These two shallot varieties are preferred by farmers for their quality of '*wot*' making, which can exist for a long time without spoilage. Shallot varieties with high pungency are preferable for their quality of '*dikus chew*'-making.

² is a traditional dish that is prepared by combining a variety of ingredients such as pepper, salt, garlic, and more. It is specifically used in the preparation of Ethiopian "*wot*," which is a flavorful and spicy stew enjoyed in Ethiopian cuisine.

In the Dera district, farmers prioritize certain criteria when selecting shallot varieties. These criteria include high bulb yield, bulb redness, high pungency, and disease tolerance (see Table 4). Similar to the cases in Fogera and Libokemkem, high bulb yield is valued for better income generation to meet daily expenditures. Although Bombay red has a higher bulb yield compared to the two shallot varieties, farmers in the Dera district explained that the shallot varieties have a better price advantage in the market. This suggests that smallholder farmers can benefit more from cultivating shallot varieties

over Bombay red. Bulb redness is associated with the quality of making "*dikus chew*" and producing a quality spiced stew. Shallot varieties with a higher level of pungency are preferred, as they add spiciness and flavor to the dishes. Moreover, shallot varieties in farmers' fields demonstrate relatively higher disease tolerance compared to Bombay red. Some plots with shallot varieties were even disease-free, indicating their potential for better disease management and reduced crop losses. Overall, farmers preferred DZ-91-2B and DZ-157-1B over Bombay red in Fogera, Libokemkem, and Dera districts.

Table 2. Summary of farmers preference in Fogera district, Kokit kebele.

Criteria	High bulb yield	High pungency	Early maturity	Disease resistance	Prolonged food span	Bulb redness	Total score	Rank
Weight	3	1	1	2	2	3	-	-
DZ-91-2B	5	5	4	5	5	5	59	1 st
DZ-157-1B	5	5	3	4	5	4	53	2 nd
Bombay red	3	3	5	3	3	3	38	3 rd

Source: Authors computation

Table 3. Summary of farmers' preference in Libokemkem district, Ginaza kebele³.

Criteria	High bulb yield	Early maturity	Disease resistance	Prolonged food span	High pungency	Bulb redness	Total score	Rank
Weight	3	1	1	3	3	2	-	-
DZ-91-2B	3	3	5	4	5	5	63	2 nd
DZ-157-1B	5	4	5	5	5	5	64	1 st
Bombay red	3	5	2	2	2	2	32	3 rd

Source: Authors computation

Table 4. Summary of farmers preference in Dera district, Jigna kebele.

Criteria	High bulb yield	Large bulb size	Early maturity	Disease resistance	High pungency	Bulb redness	Total score	Rank
Weight	3	1	1	2	2	3	-	-
DZ-91-2B	4	5	3	5	4	5	53	1 st
DZ-157-1B	3	4	4	4	5	4	47	2 nd
Bombay red	5	3	5	3	2	2	39	3 rd

Source: Authors computation

³ It is the smallest administrative division in Ethiopia, equivalent to a neighborhood or village.

4. Conclusion and Recommendations

True seed shallot varieties DZsht-157-1B and DZsht-91-2B were successfully demonstrated and evaluated in Fogera, Dera, and Libokemkem districts. In Fogera district, these varieties yielded 42.25 tons/ha and 30.25 tons/ha, respectively, surpassing the local check (Bombay red). Farmers across the districts preferred the improved varieties due to their desirable qualities such as high pungency, prolonged food span, and attractive bulb redness. To promote their adoption, it is recommended that the district agriculture office and research center must conduct large-scale demonstrations of DZsht-91-2B and DZsht-157-1B, while emphasizing the importance of maintaining the true seed to bulb and bulb to true seed cycle in shallot production.

Abbreviations

CSA Central Statistical Agency

Author Contributions

Ayele Tesfahun Gashu: Conceptualization, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing

Adane Melak Beyene: Formal Analysis, Methodology

Conflicts of Interest

The authors declare no conflicts of interest.

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