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Germination Behavior of Deteriorated Shallot Seeds Applied with Zinc as Priming Agent

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ABSTRACT

This study aims to see the effect of applying the seed priming method with the provision of micronutrient zinc (Zn) on the germination performance of two types of shallot varieties from deteriorated botanical seeds. The study was arranged on a completely randomized design with two factors. The first factor was the type of variety consisting of two combinations: Lokananta and Maserati. The second factor is priming, composed of unprimed, hydropriming indole 3 acetic acid (IAA), zinc oxide (ZnO), zinc sulfate heptahydrate ($ZnSO_4.7H_2O$), zinc ethylenediaminetetraacetic acid (Zn-EDTA). The combination of the Maserati variety and Zn-EDTA priming recorded the fastest mean germination time (2.82 days), the highest germination rate index (16.15%/day), and the coefficient velocity of germination (35.51) compared to other treatment combinations. The combination of the Maserati variety and $ZnSO_4.7H_2O$ priming recorded the highest germination percentage (86%) compared to different treatment combinations. Then, the combination of Lokananta and ZnO priming recorded the most increased vigor index (453.20), produced the most extended plumule length (55.30 mm), longest radicle length (11.00 mm), fresh weight (19.00 mg), and dry weight (2.34 mg) compared to other treatment combinations. Combining two varieties with seed priming with Zn improves deteriorated shallot seed germination potential.

Keywords: Path analysis, principal component analysis, seed priming, shallots, variety

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INTRODUCTION

Shallots are one of the primary commodities in Southeast Asia, including Indonesia. Shallots have a high economic value and play a role in shaping the country's inflation. Shallots are rich in polyphenols, organic

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sulfur compounds, and vitamins. These bioactive compounds have antioxidant properties that can reduce the occurrence of various diseases, such as ischemic heart disease, several types of cancer, and atherosclerosis (Salata et al., 2022) so that shallot consumption continues to increase along with the increasing population and the diversity of culinary preparations. The average shallot consumption of the Indonesian population reaches 3.01 kg/capita/year. However, until now, productivity has still been far below the potential yield of shallots. In 2022, the national shallot production reached 1.98 million t/ha, which decreased by 22.23 thousand tons from the previous year. Until now, national shallot productivity has reached 10.71 t/ha, still far from the potential yield of shallots (Central Bureau Statistics of Indonesia, 2023). Therefore, there is a need for intensification efforts in shallot cultivation.

Shallots are generally cultivated using bulbs as planting material. Seeds from bulbs have a short shelf life and limited availability. Currently, the available quality seeds are only 20% of the needs, so the consumption of bulbs and imports fulfills the need for bulb seeds. One of the efforts that can be made to increase shallot productivity is by using true shallot seed (TSS), which has high potential as an alternative to bulb seeds. The advantages of using TSS include: (1) the average seed requirement is 5 kg/ha, (2) relatively low cost, (3) easy transportation, (4) 1–2 years of shelf life, (5) produce healthy bulbs, avoid pathogens, (6) high productivity (Adin et al., 2023).

The problem is more than seed availability. The use of planting material from seeds also faces various obstacles in terms of the growth of seeds and the low quality of seedlings produced in the seeding process. Seeding is a crucial stage because maximum yield production is reflected in the quality of the seedlings. Botanical shallot seeds are very susceptible to quality decline if stored long. Seed germination is a parameter that shows that TSS has decreased; if seed viability is low, seed vigor is also low. Indications of quality decline can be seen from seed growth's low viability and speed (Tanjung et al., 2022). The use of planting materials from seeds needs intensive control to affect the potential quality of seed germination. Seed germination is an essential stage because maximum yield production is reflected in the quality of the seeds. Deteriorating seeds can be improved by applying invigoration technology. Invigoration is a physical, physiological and biochemical treatment that increases seed viability so that it can grow faster and synchronously in diverse environments (Triyadi et al., 2023). The seed invigoration technique that can be used is the seed priming method, a hydration technique that controls water absorption to stimulate seed germination. In the priming process, the physiological conditions of the seeds are controlled, resulting in increased and improved metabolic processes before germination. This method has various benefits, including reducing fertilizer use, increasing production by improving the quality of seed germination, inducing plant resistance, and being cheap and environmentally friendly (Tanjung et al., 2022).

Zinc (Zn), an essential micro-nutrient for shallots, is one of the seed priming agents that can be used. Zn acts as a catalyst and structural constituent in proteins and can affect some biochemical pathways and cell functions such as enzyme activity, deoxyribonucleic acid (DNA) biosynthesis, gene expression, cell division, and defense against oxidative cell damage conditions (Cakmak et al., 2023). It is an essential micronutrient for humans, animals, and plants and a component of enzymes that catalyze plant metabolic reactions. Zn increases plant resistance to disease, plays a role in photosynthesis, maintains cell membrane integrity, is needed in protein synthesis and pollen formation, and increases antioxidant enzymes and chlorophyll levels in plant tissues. Zn deficiency negatively affects plant growth, causing plants to be stunted, have short internodes, small leaves, chlorosis, and delayed maturity. Thus, Zn sufficiency is critical for crop yield and quality (Hacisalihoglu, 2020; Vadlamudi et al., 2020). Saranya et al. (2017) concluded that seeds given Zn are well used to refresh shallot seedlings and get quality seedlings. Priming induces germination metabolic activity and produces glucose, which is used in protein synthesis during germination to increase germination rate and plant growth uniformity. This study aims to see the effect of applying the seed priming method with the provision of micronutrient Zn on the germination performance of two types of shallot varieties from deteriorated botanical seeds.

MATERIALS AND METHODS

Experiment Location

The research was conducted from June to July 2023 at the Laboratory of Mushroom and Biofertilizers, Department of Agronomy, Agriculture Faculty, Hasanuddin University, Makassar, Indonesia. The average laboratory temperature was 26.1°C.

Experimental Design

The research was arranged on a completely randomized design with two factors. The first factor is the type of variety (v) consisting of two varieties: (1) Lokananta (v_0) and (2) Maserati (v_1). The second factor is the type of Zn priming agent (z) consisting of (1) unprimed (z_0), (2) hydropriming (z_1), (3) IAA (z_2), (4) ZnO (z_3), (5) $ZnSO_4.7H_2O$ (z_4), and (6) Zn-EDTA (z_5). Twelve treatment combinations were repeated three times, resulting in 36 observation units.

Preparation for Priming Agents

This study used Zn and IAA priming agents with a solution concentration of 100 ppm. The solution was obtained by dissolving 125.72 mg/L ZnO, 444.04 mg/L $ZnSO_4.7H_2O$, 700.77 mg/L zinc EDTA and 100 mg/L IAA in distilled water solution.

Seed Priming Implementation

The shallot seeds used are Lokananta and Maserati varieties with an expiration date of 15 months. The shallot seeds were then primed according to the treatment. A 4.5 g of seeds were added to each treatment solution in a 1:20 (W/V) ratio in a glass jar connected to an aerator. Then, the seeds were soaked for 20 h. Afterward, the seeds were removed and dried until they reached their initial moisture content—the character of the seed priming solution in Table 1.

Table 1
Character of seed priming solution

Treatments	Electrolyte Conductivity (µS cm^{-1})		pH		Temperature (°C)		Solute (ppm)	
	X	Y	X	Y	X	Y	X	Y
Unprimed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydropriming	0.00	316.00	7.08	7.12	30.00	28.80	0.00	158.00
Priming IAA	123.00	418.00	6.75	7.24	29.80	28.70	61.00	209.00
Priming ZnO	87.00	536.00	6.93	7.07	29.60	29.70	43.00	268.00
Priming $ZnSO.7H_2O$	521.00	854.00	5.41	6.92	29.70	29.10	260.00	427.00
Priming Zn-EDTA	366.00	719.00	5.74	7.03	29.70	29.00	181.00	359.00

Note. Description: X (before priming), Y (after priming)

Germination Assay

The germination assay was done using a paper method test. Seeds primed are sterilized using 70% alcohol and washed with distilled water. Then, 50 seeds are placed in a petri dish for each treatment. The seeds are then placed in a plant growth chamber (©Labtech made in Indonesia) in the laboratory.

Parameters and Data Analysis

The parameters observed included mean germination time (days), germination percentage (%), coefficient velocity of germination, germination rate index (%/day), vigor index, radicle length (mm), plumule length (mm), fresh weight (mg), and dry weight (mg). These parameters were calculated using the Weerasekara et al. (2021) formula (Table 2). The data collected were then analyzed for correlation, principal component analysis (PCA), path analysis, and analysis of variance. If the data were significant, further tests with Duncan's new multiple range test (DMRT) at a significant level of 5% would be needed to detect the differences among treatments.

Table 2
The observation parameter formula mean germination time, germination percentage, coefficient velocity of germination, germination rate index, and vigor index

Parameters	Formula
Mean Germination Time (days)	$MGT = \frac{\Sigma fx}{\Sigma f}$ Remarks: F = number of seeds germination on day x
Germination Percentage (%)	$GP = \frac{A}{B} \times 100$ Remarks: A = number of seeds germination B = total test seeds
Coefficient Velocity of Germination	$CVG = \left(\frac{G1+G2+G3+\ldots+Gn}{G1T1+G2T2+G3T3+\ldots+GnTn}\right) \times 100$ Remarks: G1/2/3/n= number of seeds germination on day 1/2/3/n T1/2/3/n= observation day
Germination Rate Index (%/day)	$GRI = \frac{G1}{1} + \frac{G2}{2} + \frac{G3}{3} + \ldots + \frac{Gn}{n}$ Remarks: G1/2/3/n= number of seeds germination on day 1/2/3/n
Vigor Index	VI = GP × PL Remarks: GP = germination percentage PL = plumule length

RESULTS

Germination Parameter

Analysis of variance showed an interaction between the use of shallot seed varieties and seed priming agents that significantly affected the mean germination time, germination rate index, and coefficient velocity of shallot seeds (Table 3). The combination of the Maserati variety and Zn-EDTA priming recorded the fastest mean germination time (2.82 days), which was not significantly different from the combination of the Lokananta variety and IAA priming, the highest germination rate index (16.15%/day), and the coefficient velocity of germination (35.51) compared to other treatment combinations.

Analysis of variance showed an interaction between the use of shallot seed varieties and seed priming types that significantly affected the germination percentage, vigor index, and plumule length of shallot seeds (Table 4). The combination of Maserati varieties and $ZnSO_4.7H_2O$ priming recorded the highest germination percentage (86%), which was not significantly different from the combination of Maserati varieties and ZnO priming, Maserati and Zn-EDTA priming, Lokananta and Zn-EDTA priming, Lokananta and ZnO, Lokananta and hydropriming, but significantly different compared to other treatment combinations. Then, the combination of Lokananta variety and ZnO priming recorded the highest vigor index (453.20) and produced the most extended plumule length (55.30 mm), which was not significantly different from the combination of Lokananta and IAA priming, Lokananta and $ZnSO_4.7H_2O$ priming, Lokananta and Zn-EDTA priming, Maserati and IAA priming, Maserati and ZnO priming, Maserati and $ZnSO_4.7H_2O$ priming, Maserati and Zn-EDTA priming, but significantly different compared to other treatment combinations.

Analysis of variance showed an interaction between the use of shallot seed varieties and seed priming types that significantly affected radicle length, fresh weight, and dry weight of shallot seedlings (Table 5). The combination of Lokananta variety and ZnO priming recorded the most extended radicle length (11.00 mm), which was not significantly different from the combination of Lokananta and IAA priming, Lokananta and $ZnSO_4.7H_2O$ priming, Lokananta and Zn-EDTA priming, Maserati and IAA priming, Maserati and ZnO priming, Maserati and $ZnSO_4.7H_2O$ priming, Maserati and Zn-EDTA priming, but significantly different compared to other treatment combinations, the heaviest fresh weight (19.00 mg), which was not significantly different from the combination of Lokananta and Zn-EDTA priming, Maserati and IAA priming, Maserati and $ZnSO_4.7H_2O$ priming, Maserati and Zn-EDTA priming, but significantly different compared to other treatment combinations, and the heaviest dry weight (2.34 mg) compared to other treatment combinations.

Table 3
The effect of combining two varieties with priming agents on the mean germination time, germination rate index, and coefficient velocity of germination

Combination Treatment		**Mean Germination Time (days)**	**Germination Rate Index (%/day)**	**Coefficient Velocity of Germination**
Lokananta	Unprimed	4.14 ± 0.46^{b}	7.95 ± 0.50^{cd}	24.42 ± 2.68^{bc}
	Hydropriming	5.29 ± 0.32^{b}	8.36 ± 0.89^{bcd}	18.96 ± 1.14^{cd}
	IAA	3.98 ± 0.40^{ab}	10.00 ± 1.40^{bcd}	25.40 ± 2.54^{b}
	ZnO	4.45 ± 0.48^{b}	10.57 ± 0.51^{bc}	22.72 ± 2.43^{bcd}
	$ZnSO_4.7H_2O$	4.90 ± 0.04^{b}	8.61 ± 0.19^{bcd}	20.40 ± 0.18^{bcd}
	Zn-EDTA	5.04 ± 0.43^{b}	9.42 ± 0.68^{bcd}	19.98 ± 1.71^{bcd}
Maserati	Unprimed	7.49 ± 0.94^{c}	1.42 ± 0.53^{e}	13.57 ± 1.71^{e}
	Hydropriming	5.33 ± 0.06^{b}	7.50 ± 0.22^{d}	18.75 ± 0.20^{d}
	IAA	4.93 ± 0.30^{b}	8.09 ± 0.54^{bcd}	20.35 ± 1.25^{bcd}
	ZnO	5.01 ± 0.11^{b}	9.32 ± 0.52^{bcd}	19.95 ± 0.43^{bcd}
	$ZnSO_4.7H_2O$	4.39 ± 0.07^{b}	10.79 ± 0.37^{b}	22.81 ± 0.35^{bcd}
	Zn-EDTA	2.82 ± 0.15^{a}	16.15 ± 1.71^{a}	35.51 ± 1.88^{a}

Note. Mean ± SE values with different letters in the column indicate significant ($p < 0.05$) differences by Duncan's new multiple-range test

Table 4
Effect of combination of two varieties with priming agents on germination percentage, vigor index, and plumule length

Combination Treatment		Germination Percentage (%)	Vigor Index	Plumule Length (mm)
Lokananta	Unprimed	59.00 ± 1.00^{d}	166.30 ± 1.90^{c}	28.20 ± 0.80^{b}
	Hydropriming	76.00 ± 4.00^{abc}	248.32 ± 38.08^{c}	32.50 ± 3.30^{b}
	IAA	70.00 ± 6.00^{c}	359.00 ± 86.36^{ab}	50.60 ± 8.00^{a}
	ZnO	82.00 ± 2.00^{ab}	453.20 ± 0.40^{a}	55.30 ± 1.30^{a}
	$ZnSO_4.7H_2O$	72.00 ± 2.00^{bc}	354.32 ± 12.72^{b}	49.20 ± 0.40^{a}
	Zn-EDTA	81.00 ± 1.00^{ab}	413.84 ± 0.56^{ab}	51.10 ± 0.70^{a}
Maserati	Unprimed	18.00 ± 4.00^{e}	31.62 ± 19.86^{d}	15.90 ± 7.50^{c}
	Hydropriming	72.00 ± 0.00^{bc}	232.56 ± 5.04^{c}	32.30 ± 0.70^{b}
	IAA	69.00 ± 1.00^{c}	356.50 ± 10.70^{ab}	51.70 ± 2.30^{a}
	ZnO	84.00 ± 2.00^{a}	427.80 ± 15.00^{ab}	51.00 ± 3.00^{a}
	$ZnSO_4.7H_2O$	86.00 ±2.00^{a}	448.08 ± 48.24^{ab}	52.00 ± 4.40^{a}
	Zn-EDTA	81.00 ± 5.00^{ab}	414.90 ± 10.70^{ab}	51.50 ± 4.50^{a}

Note. Mean ± SE values with different letters in the column indicate significant ($p < 0.05$) differences by Duncan's new multiple-range test

Table 5
Effect of combination of two varieties with priming type on radicle length, fresh weight, and dry weight

Combination treatment		Radicle length (mm)	Fresh weight (mg)	Dry weight (mg)
Lokananta	Unprimed	3.70 ± 1.90^{cd}	7.50 ± 0.50^{d}	1.53 ± 0.005^{g}
	Hydropriming	3.90 ± 1.50^{bcd}	8.50 ± 2.50^{d}	1.66 ± 0.010^{fg}
	IAA	7.40 ± 4.60^{abcd}	12.50 ± 1.50^{bcd}	1.82 ± 0.000^{de}
	ZnO	11.00 ± 0.20^{a}	19.00 ± 0.00^{a}	2.34 ± 0.075^{a}
	$ZnSO_4.7H_2O$	10.20 ± 1.00^{ab}	10.50 ± 3.50^{cd}	1.84 ± 0.095^{de}
	Zn-EDTA	9.30 ± 2.30^{abc}	15.50 ± 2.50^{abc}	2.06 ± 0.015^{bc}
Maserati	Unprimed	1.60 ± 0.60^{d}	0.00 ± 0.00^{e}	0.00 ± 0.000^{h}
	Hydropriming	3.30 ± 1.10^{cd}	10.50 ± 2.50^{cd}	1.78 ± 0.060^{ef}
	IAA	6.60 ± 1.00^{abcd}	15.00 ± 0.00^{abc}	1.93 ± 0.000^{cde}
	ZnO	8.60 ± 0.40^{abcd}	12.00 ± 1.00^{bcd}	1.88 ± 0.070^{de}
	$ZnSO_4.7H_2O$	6.60 ± 1.20^{abcd}	17.00 ± 1.00^{ab}	2.12 ± 0.050^{b}
	Zn-EDTA	7.60 ± 1.60^{abcd}	15.50 ± 0.50^{abc}	1.99 ± 0.055^{bcd}

Note. Mean ± SE values with different letters in the column indicate significant ($p < 0.05$) differences by Duncan's new multiple-range test

Correlation Analysis

A correlation map based on color between observation parameters is shown in Figure 1. Correlation value is a parameter used to evaluate the relationship between characters. The correlation value is between -1 and 1, where if it is positive, then if the value of a character increases, it will increase the value of other characters. If it is negative, then an increase in the value of a character will reduce the value of other characters. The correlation coefficient value is in the range of weak (<0.40), moderate (>0.4), and strong (>0.70) (Schober et al., 2018).

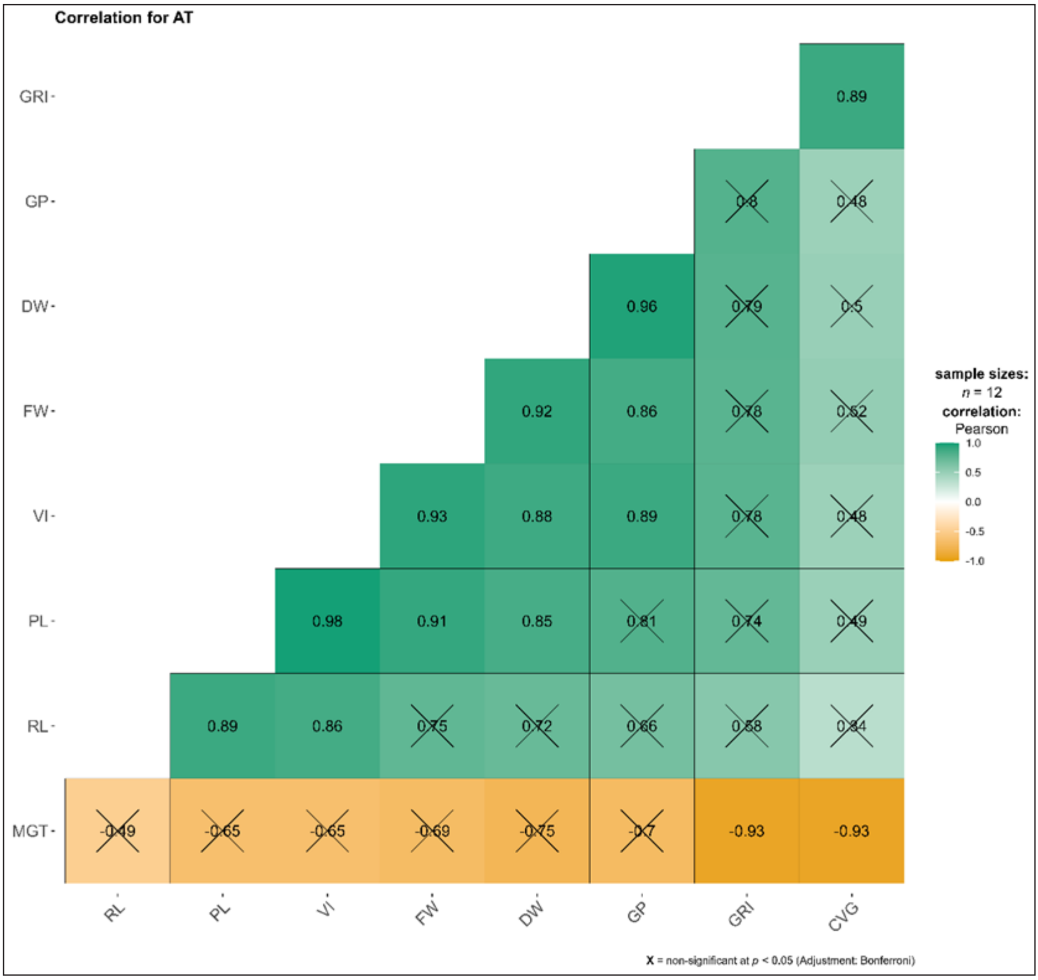

Figure 1. Correlation maps among parameters. (MGT) mean germination time; (RL) radicle length; (PL) plumule length; (VI) vigor index; (FW) fresh weight; (DW) dry weight; (GP) germination percentage; (GRI) germination rate index; (CVG) coefficient velocity of germination
Note. The x symbol indicates a non-significant relationship between parameters according to the Bonferroni test, as stated in the figure caption

A strong correlation was shown in the relationship parameters between vigor index with plumule length (0.97), fresh weight with dry weight (0.92), radicle length with fresh weight (0.75), radicle length with dry weight (0.71), plumule length with radicle length (0.89), radicle length with fresh weight (0.91), radicle length with dry weight (0. 85), vigor index with radicle length (0.86), vigor index with fresh weight (0.93), vigor index with dry weight (0.88), germination percentage with vigor index (0.88), germination percentage with plumule length (0.80), germination percentage with fresh weight (0.85), germination percentage with dry weight (0.95), germination rate index with coefficient velocity of germination (0.89), germination rate index with germination percentage (0.80), germination rate index with vigor index (0.78), germination rate index with plumule length (0.74), germination rate index with fresh weight (0.77), and germination rate index with dry weight (0.78).

A moderate correlation was shown in the relationship parameters between germination percentage with radicle length (0.66), the coefficient velocity of germination with germination percentage (0.47), the coefficient velocity of germination with vigor index (0.48), the coefficient velocity of germination with radicle length (0.48), the coefficient velocity of germination with fresh weight (0.51), and the coefficient velocity of germination with dry weight (0.50). A weak correlation is shown in the relationship parameter between the coefficient velocity of germination with radicle length (0.33). The relationship between the mean germination time and all parameters showed a negative correlation.

Principal Component Analysis

Based on the principal component analysis in Figure 2, the first principal component (PC1) significantly positively affected germination percentage, dry weight, fresh weight, vigor index, plumule length, and radicle length. PC1 also has a significant negative impact on mean germination time. The second principal component (PC2) significantly positively affects the germination rate index and coefficient velocity of germination. PC2 also has a significant negative impact on the mean germination time. Based on the principal component analysis in Figure 2, the biplot results show that combining two varieties of treatment with seed priming can increase the value of the first principal component. Therefore, seed priming treatment with IAA, ZnO, $ZnSO_4.7H_2O$, and Zn-EDTA on Lokananta and Maserati varieties increases the value of germination percentage, dry weight, fresh weight, vigor index, plumule length, and radicle length compared to water priming and no priming treatments. Biplot results also show that combining two varieties of treatment with seed priming can increase the value of the second principal component. Therefore, seed priming treatment with IAA and Zn-EDTA on Lokananta and Maserati varieties increased the germination rate index and coefficient velocity of germination.

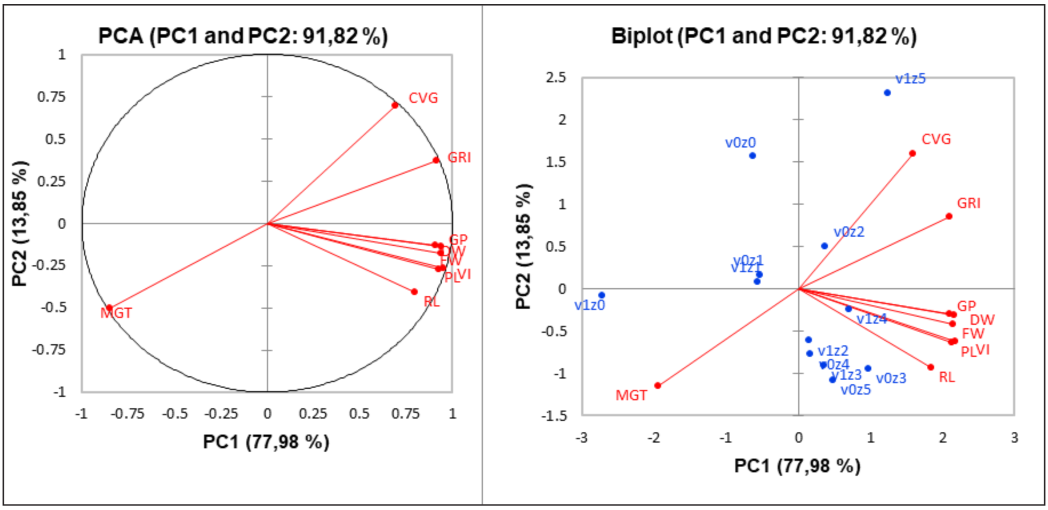

Figure 2. Biplot of shallot seed germination based on PC1 and PC2. MGT=mean germination time; RL=radicle length; PL=plumule length; VI=vigor index; FW=fresh weight; DW=dry weight; GP=germination percentage; GRI=germination rate index; CVG=coefficient velocity of germination. Lokananta + unprimed (v_0z_0), Lokananta + Hydropriming (v_0z_1), Lokananta + IAA priming (v_0z_2), Lokananta + ZnO priming (v_0z_3), Lokananta + $ZnSO_4.7H_2O$ priming (v_0z_4), Lokananta + Zn-EDTA priming (v_0z_5), Maserati + unprimed (v_1z_0), Maserati + Hydropriming (v_1z_1), Maserati + IAA priming (v_1z_2), Maserati + ZnO priming (v_1z_3), Maserati + $ZnSO_4.7H_2O$ priming (v_1z_4), and Maserati + Zn-EDTA priming (v_1z_5)

Path Analysis

Correlation analysis can identify the relationship between two characters but does not explain the relationship. Thus, insignificant correlation coefficient values cannot be taken to show a functional relationship between each variable. Path coefficient analysis explains it by dividing the total correlation coefficient into components that have direct and indirect effects (Waluyo et al., 2022). The path coefficient value, according to Solanki et al. (2015), is divided into very high (>1), high (0.30–0.99), medium (0.2–0.29) and low (0.1–0.19).

The results of path analysis between observation parameters are shown in Figure 3. The value of the observation parameter that has a very high direct effect on the dry weight of seedlings is the germination percentage (1.01). The value of the observation parameter that has a high direct effect on the dry weight of the seedlings is plumule length (0.43) and fresh weight of the seedlings (0.54). Observation parameter values that have a low direct effect on the dry weight of seedlings are the coefficient velocity of germination (0.13) and radicle length (0.19). Parameters of germination percentage, plumule length, and fresh weight of seedlings have a very high direct effect and have a positive value: germination percentage (1.01), plumule length (0.43), and fresh weight of seedlings (0.54). It is in line with the results of the correlation between the dry weight of seedlings and the germination percentage (0.95), plumule length (0.85), and fresh weight of seedlings (0.92). If the correlation between parameters is almost the same as the direct effect, the correlation can explain the actual relationship and direct selection through these variables will be effective (Waluyo et al., 2022). So, the dry weight of seedlings can be determined by direct selection on germination percentage, plumule length, and fresh weight. In contrast, the dry weight of shallot seedlings can be increased by increasing these growth parameters.

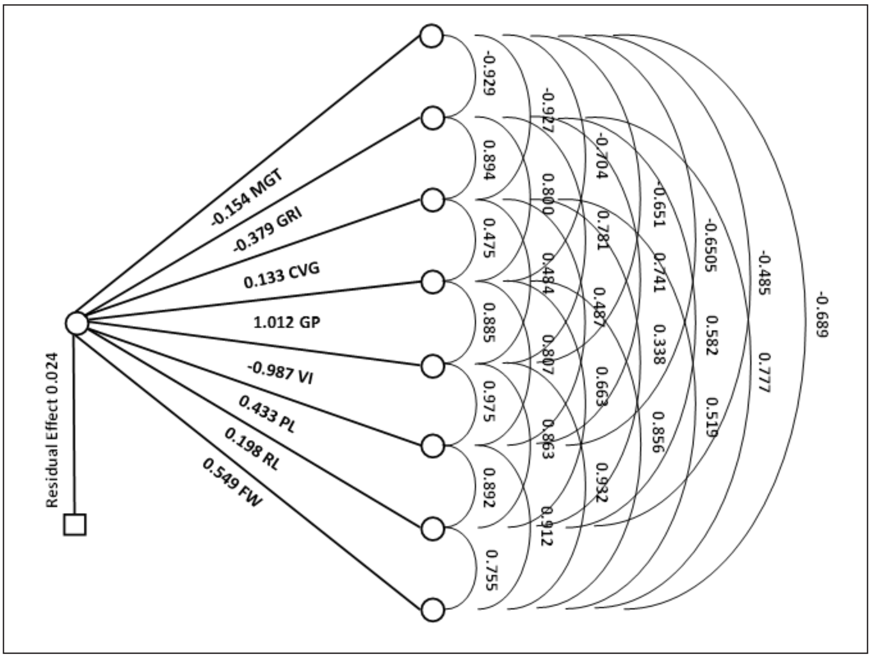

Figure 3. Path coefficient analysis diagram for dry weight of shallot seedlings. MGT=mean germination time; RL=radicle length; PL=plumule length; VI= vigor index; FW=fresh weight; DW=dry weight; GP=germination percentage; GRI=germination rate index; CVG=coefficient velocity of germination

DISCUSSION

The priming method affects the physiological process of seeds, which refers to the amount of metabolic activity in the early stages of seed germination that can be seen from the germination parameters (Choukri et al., 2022). In this case, the germination test showed that combining the Maserati variety treatment and Zn-EDTA priming increased the mean germination time, germination rate index, and coefficient velocity of germination. The differences that occur are due to genetic factors from two different varieties. Yeshiwas et al. (2022) explained that the differences between each variety for plant height and leaf length of shallots are due to differences in genotypes and responses to different environmental conditions. On the other hand, priming with Zn-EDTA is more efficient than other types of priming. Zn-EDTA compounds are more difficult to mobile than ZnO and $ZnSO_4.7H_2O$ due to the high stability constant of the Zn complex (Doolette et al., 2018). The chelated form of Zn-EDTA has the effect of reducing the mobility of Zn transport in plant tissues and limiting Zn translocation, so it is more beneficial because it can avoid the effect of toxicity on plant tissues, which can further reduce the decrease in Zn availability in plants.

True shallot seeds are highly susceptible to deterioration due to prolonged storage. The decline in seed quality can be seen from the seeds' low germination and growth strength. The germination test showed that the treatment combination of the Maserati variety and Zn-EDTA priming increased the germination percentage, and the combination of the Lokananta variety and ZnO priming increased the vigor index and plumule length of the seedlings. Differences can be seen in unprimed seeds. Two seed varieties have deteriorated due to long seed storage. Then, Hiremat et al. (2018) reported that onion seeds progressively lost their vigor and germination as they age. Germination percentages decreased to 69% and 55%, and the percentage of seedlings emerging in the field to 66% during the storage period of nine months. The results showed that free radicals in aged seeds can cause membrane damage when mitochondrial respiration is activated. Increased reactive oxygen species result from less efficiency in mitochondrial activity. DNA, RNA, proteins, and lipids are essential molecules that can undergo oxidation due to increased reactive oxygen species. Furthermore, the mitochondrial membrane oxidizes, reducing aerobic respiration potential (Ranganathan & Groot, 2023). Priming Zn can increase the germination percentage where Zn has structural and catalytic functions in several proteins and affects several biochemical pathways and cell functions such as enzyme activity, DNA, and protein biosynthesis and maintains defense against oxidative cell damage (Cakmak et al., 2023).

The germination test showed that the treatment combination of Lokananta variety and ZnO priming increased radicle length, fresh weight, and dry weight of seedlings. Zn has a vital role in protein synthesis, where Zn deficiency reduces the rate of protein synthesis and protein concentration in plant tissues. Zn is a structural component in ribosomes. In the absence of Zn, ribosomes will be destroyed but can be reversed when given a supply of Zn. The results showed that the need for Zn in the apical part of the growing plant is about 150 µg compared to the need for the basal part of only about 50 µg (Ender et al., 1983). At the root tip of newly grown plants, there is 220 µg of Zn concentration (Ozturk et al., 2006). Zn concentration is at least 100 µg in shoot meristem tissue, and other meristems are required in the process of protein synthesis, which is translocated by the roots to the shoot meristem through the xylem-phloem network (Cakmak et al., 2023). Protein concentration is reduced in plants caused by Zn deficiency, where there is a decrease caused by the higher rate of RNA degradation due to increased RNAse activity (Sharma et al., 1982). To support the process of DNA translation and transcription, adding an addition is necessary to increase RNA activity significantly.

CONCLUSION

Based on the research that has been done, micronutrient zinc seed priming treatment affects the germination of shallot seeds. Both varieties have different responses to seed priming treatment. The combination of Maserati varieties and Zn-EDTA priming recorded the fastest mean germination time, the highest germination rate index, and the coefficient velocity of germination. The combination of the Maserati variety and $ZnSO_4.7H_2O$ priming recorded the highest germination percentage. Combining the Lokananta variety and ZnO priming recorded the highest vigor index and produced the most extended plumule length. Then, the combination of Lokananta and ZnO priming recorded the most extended radicle length, heaviest fresh weight, and heaviest dry weight.

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