

Effect of Natural Growth Regulators from Banana Corm Filtrate and Mung Bean Sprouts on The Viability and Vigor of Tomato Seeds (*Solanum Lycopersicum* L.)

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Abstract

Tomato seeds (*Solanum lycopersicum* L.) that have passed their expiration date generally exhibit reduced viability and quality. Seed quality can be improved through invigoration using natural plant growth regulators (PGRs) derived from banana corms and mung bean sprouts, which contain hormones such as auxins, gibberellins, and cytokinins that stimulate the germination of expired seeds. This study aimed to determine the effect of concentration and type of filtrate (banana corm and mung bean sprout) as natural PGRs, as well as their interaction, on the viability and vigor of expired tomato seeds. The study employed a Randomized Complete Block Design (RCBD) with two factors: filtrate concentration (0%, 20%, 40%, 60%, and 80%) and filtrate type (banana corm and mung bean sprout), with three replications. The observed parameters included seed viability (germination percentage) and vigor (vigor index, germination speed, and uniformity of growth). The results showed that both concentration and type of filtrate had a significant effect on all observed parameters. The best treatment was obtained from the combination of banana corm and mung bean sprout filtrates at a concentration of 60% and combination of banana corm and mung bean sprout filtrates at a concentration of 80%, which significantly enhanced the viability and vigor of the seeds compared to other treatments. Furthermore, the interaction between filtrate concentration and type had a significant effect on all parameters, including germination percentage.

Keywords: Tomato seeds, viability, vigor, growth regulators.

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INTRODUCTION

Tomato is one of the horticultural commodities categorized as a seasonal plant from the Solanaceae family. In Indonesia, tomato is considered one of most important agricultural commodities and widely cultivated by farmers due to its promising market prospects. According to the Central Bureau of Statistics, tomato production in Indonesia decreased in 2023 to 1.143 million tons, from 1.168 million tons in 2022. The decline in tomato production accrued alongside increased public demand and rising domestic and international market needs, prompting more producers to engage in tomato cultivation and market sales. In addition, a major recurring issue is related to seed storage that exceeds the seed's shelf life (expiration) (Ernawati *et al.*, 2017). Tomato seeds are among the seeds that are not resistant to prolonged storage. Due to their small size, the food reserves contained within them are limited. A reduction in

food reserves such as carbohydrates, proteins, fats, and minerals causes the seeds to struggle with germination (Darmawan *et al.*, 2014).

Seed quality is determined by its viability and vigor. Viability refers to the seed's ability to germinate, indicated by signs of metabolic activity or growth. Meanwhile, vigor refers to the seed's ability to germinate under suboptimal environmental conditions. A seed is considered to have high vigor if it can grow and develop well even in less favorable environments for the species' growth. In addition, other factors that influence seed vigor include the speed and uniformity of germination, environmental conditions that are not conducive to growth, and the seed's performance after storage (ISTA, 2021).

Plant Growth Regulators (PGRs), or ZPT in Indonesian, are chemical compounds found in plants that play a role in regulating various growth and developmental processes. Several PGRs that influence plant growth include auxins, cytokinins, gibberellins, abscisic acid, and ethylene (Lorenza, 2023). PGRs function by interacting with specific receptors in the cells and triggering various biochemical and physiological responses in plants (Asra *et al.*, 2020). Materials with potential as natural PGRs include banana corms and mung bean sprouts.

Mung bean sprouts are the result of the germination process of legume seeds such as mung beans. These sprouts contain plant growth regulators such as antioxidants like phytosterols, vitamin E (α -tocopherol), phenols, and various minerals (including selenium, manganese, copper, zinc, and iron), as well as hormone levels of auxin at 227.37 ppm, gibberellin at 371.56 ppm, and cytokinin at 220.45 ppm (Tini *et al.*, 2022). Research on the use of mung bean sprout filtrate was conducted by Kurniawan *et al.* (2023), showing that mung bean sprout extract can increase the vigor and viability of expired tomato seeds by up to 90% for the SL 4517 variety after 14 months of storage.

Banana corms, on the other hand, are part of the banana plant's bulbous structure that is beneficial to plants due to its cytokinin and gibberellin content (Hariyani *et al.*, 2018). According to Tini *et al.* (2018), the hormone content in banana corm includes auxin at 94.20 ppm, gibberellin at 104.12 ppm, and cytokinin at 317.35 ppm. The application of banana corm extract has also shown a significant effect on 2-year expired red chili seeds, as indicated by a maximum growth potential of 85%, germination rate of 85%, and a vigor index of 80% (Liana *et al.*, 2022). Research on the effect of combinations in increasing germination has been studied by Nugroho *et al.* (2022), a combination of coconut water and mung bean sprouts increased germination by 87% in coffee seeds. In addition, in Rachmat *et al.* (2022), giving a combination of banana and shallot extracts has an effect on the growth of tomato seeds. Despite these findings, there is limited information regarding the optimal concentration and combination of banana corm and mung bean sprout filtrates specifically for improving the viability and vigor of 12-month expired tomato seeds. Therefore, this study aimed to determine the effect of concentration and type of filtrate, as well as their interaction, on the viability and vigor of such seeds.

METHODS

This study was an experimental study conducted in January 2025 in Randuagung Village, Kebomas District, Gresik Regency, Indonesia. The research material consisted of expired tomato (*Solanum lycopersicum* L.) seeds treated with

natural plant growth regulators in the form of banana corm filtrate and mung bean sprout filtrate.

Research Materials

The plant material used in this study consisted of 12-month expired tomato (*Solanum lycopersicum* L.) seeds. The seeds were soaked in banana corm filtrate, mung bean sprout filtrate, and a combination of both at concentrations of 0% (control), 20%, 40%, 60%, and 80%. The experiment was arranged in a two-factor factorial Randomized Block Design (RBD) consisting of 15 treatment combinations with three replications, resulting in a total of 45 experimental units, each comprising 100 seeds.

Materials and Equipment

The equipment used in this study included a digital balance, measuring cylinder, blender, sieve, plastic cups, plastic trays, CD paper, thin-wall plastic containers, seedling trays, forceps, hand trowel, hand sprayer, labels, and stationery. The materials consisted of 12-month expired tomato (*Solanum lycopersicum* L.) seeds, banana corms, mung bean sprouts, distilled water, and a planting medium composed of soil, sand, and compost mixed at a ratio of 1:1:1.

Procedur

The research procedure consisted of making banana stump filtrate and mung bean sprouts as much as 1 kg washed thoroughly, then cut into various small parts, mashed using a blender, and filtered twice. The filtering results were then diluted using distilled water with each concentration of 80%, 60%, 40%, and 20%. Then the tomato seeds with banana pith filtrate and mung bean sprouts were soaked for 6 hours with each filtrate concentration of 0%, 20%, 40%, 60%, 80%. The treatment was repeated three times. The preparation of planting media was done after filtrate soaking. Seeds were planted as many as 100 seeds per replication based on ISTA rules. The initial planting media was made by using three layer paper, moisturizing with water and inserting into a plastic thinwall, the seeds were sown as many as 100 grains in each experimental replicate. After that, the thinwall was closed to prevent contamination. The seeding process was carried out after three days, the sprouts that had shown initial growth were then transplanted to the planting media, namely a mixture of soil, compost and sand in a ratio of 1:1:1 which was placed on a seedling tray with a hole size of 2.5 × 2.5 cm. Maintenance activities were carried out for 14 days. Maintenance of paper media was by keeping the media moist and not allowed to dry, if the media looks dry, you can spray it with water. As for the mixed media of soil, sand, compost. Maintenance is carried out by watering twice a day, namely morning and evening. In addition, periodic checking of weeds that grow in the seedling tray. Observations were made for 14 days to calculate viability and vigor values. Viability observations in the form of germination capacity, and vigor testing in the form of vigor index, growth speed and growth uniformity.

Observation Parameters

Seed viability and vigor were evaluated based on four parameters: germination percentage, vigor index, germination rate, and germination uniformity. Germination percentage was assessed on day 14, vigor index on day 5, germination uniformity on day 9, whereas germination rate was recorded daily for 14 days. The calculation of each parameter was as followed by:

1. Germination Capacity (%)

Observations of germination were made by counting the number of normal sprouts for 14 HST, after which the value was expressed in percent with the following formula (ISTA, 2021):

$$GC (\%) = \frac{\text{Number of normal sprouts}}{\text{Number of seeds planted}} \times 100\%$$

2. Vigor Index (%)

Observations of the vigor index were calculated based on the percentage of normal sprouts on the first count on the 5th day after planting, then the following formula was calculated (Kurnianingrum, 2024):

$$VI (\%) = \frac{\text{First count sprouts}}{\text{Number of seeds planted}} \times 100\%$$

3. Growth Uniformity (%)

Observations of uniformity of growth were carried out on day 10 by counting between normal sprouts at first count (5 HST) and final count (14 HST), then calculated using the following formula (Shakina *et al.*, 2024):

$$GU (\%) = \frac{\text{Number sprouts day to..}}{\text{Number of seeds planted}} \times 100\%$$

4. Growth Rate (etmal/%)

Observations of growth speed were carried out on days 1 to 14 by calculating the number of normal sprouts divided by the period (days/hour), the can be calculated using the following formula (Tefa, 2017):

$$GR (\text{etmal}/\%) = \% \frac{NS}{\text{etmal}}$$

NS = Normal Sprouts

Etmal = 1 days

Data Analysis

Data were first subjected to a homogeneity test to ensure that all samples were homogeneous prior to treatment. Subsequently, a normality test was performed to determine the distribution of the data. Data that met the assumptions of normality and homogeneity were analyzed using a two-way analysis of variance (ANOVA) to evaluate the effects of filtrate concentration and type (banana corm filtrate and mung bean sprout filtrate) on the viability and vigor of tomato (*Solanum lycopersicum* L.) seeds. When significant differences were detected, Duncan's Multiple Range Test (DMRT) at the 5% significance level ($\alpha = 0.05$) was conducted to compare the effects of the different concentrations and filtrate types.

RESULTS AND DISCUSSION

This study was conducted to determine the effect of filtrate type, concentration, interaction of natural growth regulators from banana pith filtrate and mung bean sprouts on the viability and vigor of tomato seeds (*Solanum lycopersicum* L.). Expired for 12 months. The filtrate concentrations used were 0%, 20%, 40%, 60%, 80%. The types of filtrates used were banana stump and mung bean sprouts and a combination of both filtrates. The observation time for this study was 14 days with several parameters used such as germination, vigor index, growth speed, and growth uniformity.

Table 1. The Effect of Banana Corm and Mung Bean Sprout Filtrate Concentrations on the Germination Capacity of Tomato Seeds (*Solanum lycopersicum* L.)

Filtate type	Filtrate Concentration (%)										Average (%)
	0%		20%		40%		60%		80%		
Banana corm	52,67	±	67,00	±	72,00	±	76,00	±	80,00	±	69.33 ^a
	1.52 ^b		1.00 ^c		1.00 ^{def}		1.00 ^g		1.00 ^{hi}		
Mung bean sprout	47.33	±	70.67	±	72.67	±	80,33	±	79,33 ± 1.52 ^h		70.07 ^a
	0.57 ^a		1.15 ^d		0.57 ^{ef}		0.57 ^{hij}				
Combination	51,33	±	71,33	±	73,67	±	82,00 ± 1.00 ⁱ		81,33 ± 0.57 ^{ij}		71.93 ^b
	0.57 ^b		1.52 ^{de}		0.57 ^f						
Average (%)	50.44 ^a		69.67 ^b		72.78 ^c		79.44 ^d		80.22 ^d		70.51

Note: Numbers followed by different letters in the same column indicate a significant difference based on Duncan's Multiple Range Test (DMRT) at a 5% significance level ($\alpha = 0.05$).

Based on **Table 1**, above, it shows that there is an effect between the type of filtrate and concentration on the germination parameter. The treatment of combination of banana stump filtrate and mung bean sprouts + 60% concentration gave a result of 82.00%, but not significantly different with combination of filtrate + 80% concentration of 81.33% and mung bean sprout filtrate + 60% concentration of 80.33%. In parameter germination power, the highest value is in the treatment of combination of banana stump filtrate and mung bean sprouts + 60%.

Table 2. The Effect of Banana Corm and Mung Bean Sprout Filtrate Concentrations on the Vigor Index of Tomato Seeds (*Solanum lycopersicum* L.)

Filtrate type	Filtrate Concentration (%)					Average (%)
	0%	20%	40%	60%	80%	
Banana corm	28.33 ± 1.52 ^b	40.67 ± 1.52 ^c	44.33 ± 0.57 ^d	48.67 ± 0.57 ^e	53.67 ± 0.57 ^f	43.13 ^a
Mung Bean sprouts	21.33 ± 1.15 ^a	45.33 ± 1.52 ^d	48.00 ± 1.00 ^e	54.33 ± 1.52 ^f	52.67 ± 0.57 ^f	44.33 ^b
Combination	20.00 ± 1.00 ^a	45.67 ± 1.15 ^d	48.33 ± 1.15 ^e	59.00 ± 1.00 ^g	57.67 ± 1.52 ^g	46.13 ^c
Average (%)	23.22 ^a	43.89 ^b	46.89 ^c	54.00 ^d	54.67 ^d	44.53

Note: Numbers followed by different letters in the same column indicate a significant difference based on Duncan's Multiple Range Test (DMRT) at a 5% significance level ($\alpha = 0.05$).

Based on **Table 2**, shows that there is an effect of filtrate type and concentration on vigor index parameters. The treatment of a combination of banana stump filtrate and mung bean sprouts + 60% concentration gave a result of 59.00%, but not significantly different from filtrate combination + 80% concentration of 57.67%. The lowest value in control treatment (0%) is 20%. In the vigor index parameter, the highest value was in of combination of banana stump filtrate and mung bean sprouts + 60% treatment which shows the ability of seeds to germinate quickly and uniformly.

Table 3. The Effect of Banana Corm and Mung Bean Sprout Filtrate Concentrations on the Uniformity of Tomato Seed Germination (*Solanum lycopersicum* L.)

Filtrate type	Filtrate Concentration (%)					Average (%)
	0%	20%	40%	60%	80%	
Banana corm	2.33 ± 1.52 ^{ab}	3.33 ± 0.57 ^{bc}	4.67 ± 1.15 ^{cde}	6.33 ± 0.57 ^{ef}	7.33 ± 0.57 ^{fg}	4.80 ^a

Mung bean sprouts	1.33 ± 0.57 ^a	4.00 ± 1.00 ^{bcd}	4.33 ± 0.57 ^{bcd}	8.67 ± 1.52 ^g	6.00 ± 1.00 ^{def}	4.87 ^a
Combination	2.67 ± 1.52 ^{abc}	4.00 ± 1.00 ^{bcd}	5.67 ± 1.15 ^{def}	10.67 ± 1.52 ^h	9.00 ± 1.00 ^{gh}	6.40 ^b
Average (%)	2.11 ^a	3.78 ^b	4.89 ^c	7.44 ^d	8.56 ^e	5.36

Note: Numbers followed by different letters in the same column indicate a significant difference based on Duncan's Multiple Range Test (DMRT) at a 5% significance level ($\alpha = 0.05$).

In the results of **Table 3**, it is known that the type of filtrate and concentration have an effect on the parameters of growth uniformity. In the interaction treatment, the value of combination of filtrate + 60% concentration gave the highest value of 10.67% not significantly different from the combination of combination of filtrate + 80% concentration of 9.00%. Treatment control (0%) gave the lowest value of 1.33%. The highest value of seedling growth is in the of combination of banana stump filtrate and mung bean sprouts + 60% treatment which shows the simultaneous and stable growth of seeds at one time.

Table 4. The Effect of Banana Corm and Mung Bean Sprout Filtrate Concentrations on the Growth Rate of Tomato Seeds (*Solanum lycopersicum* L.)

Filtrate type	Filtrate Concentration (%)					Average (%/etmal)
	0%	20%	40%	60%	80%	
Banana corm	9.16 ± 0.47 ^b	14.17 ± 0.28 ^c	15.24 ± 0.35 ^d	19.35 ± 0.53 ^h	21.15 ± 0.44 ⁱ	15.81 ^a
Mung bean sprouts	7.71 ± 0.46 ^a	16.26 ± 0.55 ^e	18.44 ± 0.44 ^g	20.94 ± 0.44 ⁱ	21.27 ± 0.31 ⁱ	16.92 ^b
Combination	7.67 ± 0.43 ^a	17.35 ± 0.35 ^f	18.82 ± 0.37 ^{gh}	22.92 ± 0.56 ^k	22.18 ± 0.27 ^j	17.79 ^c
Average (%/etmal)	8.18 ^a	15.92 ^b	17.50 ^c	21.07 ^d	21.53 ^e	16.84

Note: Numbers followed by different letters in the same column indicate a significant difference based on Duncan's Multiple Range Test (DMRT) at a 5% significance level ($\alpha = 0.05$).

The results of **Table 4**, show that the provision of filtrate type and concentration has an effect on the seed growth speed parameter. All types filtrate and filtrate concentrations provide significant differences between treatments one to another. In the treatment combination of filtrate + 60% concentration gave the highest value of 22.92%/etmal. While the lowest value was control treatment which was 7.67%/etmal. The growth speed value obtained from the BC.K3 treatment showed that the seeds were able to grow faster than other treatments.

Based on the observation of the four parameters which include germination, vigor index, uniformity of growth, growth speed, it shows that the treatment combination of banana pith filtrate and mung bean sprouts with a concentration of 60% is not significantly different from the treatment combination of banana pith filtrate and mung bean sprouts with a concentration of 80%. This indicates that the use of filtrate of banana pith and mung bean with a concentration of 60% is sufficient in increasing the viability and vigor of tomato seeds. Because at a concentration of 60%, active substances in the filtrate have reached the ideal level, so that the seeds are able to absorb and respond to growth optimally. Conversely, at 80% concentration, it may have exceeded the ideal limit of seeds, because too many active substances are received by seeds so that they can inhibit the process of absorption of water and nutrients. Therefore, the highest value is in the treatment combination of banana stump filtrate and mung bean sprouts + concentration 60%.

Seeds are a crucial part of a plant, containing the embryo and food reserves necessary for the germination and growth. Maintaining seed quality is a primary factor in determining the successful growth of a plant. Seed deterioration is a common issue, especially in older seeds or those past their viability period. This aligns with the statement by Wahidah *et al.* (2017), who reported that seeds beyond their expiration experience a decline in their germination capacity. In this study, the filtrates used were banana corm and mung bean sprout filtrates. Both filtrates contain growth hormones that can aid germination, particularly in expired seeds. The banana corm, which is the growth point for new shoots, contains nutrients such as iron, potassium, vitamin B6, fiber, and carbohydrates (Ardiansyah, 2010). According to Tini *et al.* (2022), banana corm contains auxin at 94.20 ppm, gibberellin at 104.12 ppm, and cytokinin at 317.35 ppm, which are believed to promote stem elongation, leaf formation, and shoot development. Meanwhile, mung bean sprouts contain nutrients like vitamin B1, minerals, and hormones, including auxin at 227.37 ppm, gibberellin at 371.56 ppm, and cytokinin at 220.45 ppm (Tini *et al.*, 2022). Based on the results from the four tables, the BC treatment (combination of banana corm and mung bean sprout filtrates) influenced all tested parameters. This effect is likely due to a synergistic interaction between the natural plant growth regulators (PGRs) contained in both filtrates. The seeds receive complementary hormonal signals, enhancing the overall germination process. Moreover, the combination of filtrates creates a more favorable environment for reactivating seed metabolism, repairing cellular damage, and improving the seed's ability to germinate and grow uniformly (Kurniawan *et al.*, 2021). Similar research by Azmi and Handriatni (2018) showed that the combination of mung bean sprout filtrate and coconut water had a significantly greater effect on germination and growth parameters compared to single filtrate treatments.

The tomato seeds used in this study were seeds that had expired for 12 months. Under these conditions, the seed's physiological parts experience membrane damage due to decreased enzyme activity and the depletion of energy reserves during the germination process. Therefore, the seeds require assistance from plant growth regulators (PGRs) at adequate concentrations to replace or strengthen the weakened hormonal functions within the seeds. Based on the research results, treatments with 60% concentration and 80% concentration of banana corm and mung bean sprout filtrates showed a significant effect compared to treatments with 20% concentration and 40% concentration, especially on the parameters of maximum germination potential, germination rate, vigor index, uniformity of growth, and growth rate. This is because, at concentration 20% and treatments, the hormone content in the filtrates was insufficient to stimulate proper cell division and the complete breakdown of reserves, causing delayed and uneven germination. This finding aligns with the study by Prabawa *et al.* (2020), which found that low concentrations of plant growth regulators are less effective in improving seed viability. The higher the hormone concentration in the filtrate, the greater the support for better germination, particularly for seeds that have long expired (Wahid and Wangiyana, 2021). According to Kurnianingrum (2024), applying 60% and 80% concentrations significantly affects the viability and vigor of tomato seeds. The increased hormone

levels in high-concentration filtrates help accelerate the recovery of damaged seed cell structures and improve membrane permeability, making water absorption and solute transport more efficient. This is because higher concentrations contain greater amounts of nutrients such as amino acids, sugars, and vitamins. The 60% concentration is the optimal dose to increase seed viability and vigor without causing side effects. At a concentration of 80%, the active compounds of the filtrate cause the osmotic pressure formed to be very large, thus inhibiting the process of water absorption. The high concentration of a solution will result in a decrease in water in seed imbibition, which results in a reduction in the amount of water so that the rate of seed germination will be increasingly inhibited due to changes in metabolic processes, disorganization of cell membranes, and decreased cell division (Fatikhasari *et al.*, 2022). Conversely, at a concentration of 60%, osmotic pressure is within the physiological tolerance limits of seeds, and the active substance content is still available in sufficient quantities to stimulate metabolic activity effectively (Rusdiana *et al.*, 2023). This is in line with the research of Nawariah *et al.* (2022) which states that the use of natural growth regulators at high concentrations can inhibit seed growth because it stimulates physiological stress reactions. According to Zainudin and Andini (2019), 60% concentration gives superiority over 80% concentration on germination parameters for soaking papaya seeds using coconut water. Application of plant growth regulators up to a certain concentration threshold aids in cell division, elongation, and enlargement essential for plant growth (Ramadhanti *et al.*, 2023).

The treatment combination of banana corm filtrate and mung bean sprout filtrate at 60% concentration produced the best results across all parameters. Furthermore, among the single filtrate treatments, mung bean sprout filtrate at 60% concentration gave better results compared to banana corm filtrate at 80% concentration. The positive effect of mung bean sprout filtrate at 60% concentration aligns with the findings of Nopiyanto (2020), who reported that mung bean sprout extract significantly influences growth at concentrations of 40-60%. Additionally, the use of banana corm filtrate was studied by Liana *et al.* (2022), who found that concentrations between 75-80% showed significant effects on chili seeds that had expired for 2 years. The hormones contained in both filtrates include cytokinin, auxin, and gibberellin (Kurnianingrum *et al.*, 2024). In the combined filtrate, the hormone contents complement each other. Banana corm contains auxin and gibberellin, which play roles in accelerating cell elongation and division, while mung bean sprouts contain gibberellin and cytokinin, which function to speed up cell division and repair damaged seed tissues. This filtrate combination also improves the permeability of the seed cell membranes, optimizing water and nutrient absorption. This is especially important for seeds that have been stored for a long time and have experienced cell structure damage and a decline in internal enzyme activity. According to research by Rachmat *et al.* (2022), the application of a combination of banana corm extract and red onion extract significantly influences tomato seed growth.

The improvement in viability and vigor of expired seeds through the application of these filtrates can be attributed to several physiological mechanisms. Firstly, the exogenous hormones, particularly gibberellins and cytokinins, reactivate

dormant metabolic pathways by stimulating the de novo synthesis of hydrolytic enzymes such as α -amylase. This enzyme is crucial for breaking down stored starch into simple sugars, providing the necessary energy for embryo growth. Secondly, auxins and cytokinins promote cell division and elongation in the embryo axis, facilitating radicle protrusion. Thirdly, the combination of hormones works synergistically to repair cellular membranes damaged during storage, as indicated by reduced electrolyte leakage, thereby improving the seed's ability to imbibe water and resume metabolic activities. This comprehensive hormonal action effectively reverses some of the physiological deterioration associated with seed aging, leading to improved germination parameters.

In the germination parameter shown in **Table 1**, the provision of banana pith filtrate, mung bean sprouts, and the combination of both gave a significant effect on increasing germination. The highest germination value was obtained in the treatment combination of filtrate + 60% concentration, which amounted to 82.00%. While the lowest value was obtained in the control treatment, which amounted to 47.33%. According to Mewangi *et al.*, (2019), the low germination value may be due to seed dormancy and decreased germination ability due to physiological degradation and enzymatic damage, so the use of zpt is needed for the seeds to grow optimally. Seeds that produce normal sprouts around 80-85% are said to have good vigor (Marom *et al.*, 2017).

The high value of germination at a concentration of 60% is due to the hormones auxin, gibberellin and cytokinin contained in the filtrate of mung bean sprouts and banana stump at the most appropriate concentration. The presence of each hormone element in both types of filtrate will help in accelerating the germination process. The increase in germination is closely related to the content of growth hormones such as auxins, gibberellins, and cytokinins contained in the filtrate (Paksi *et al.*, 2023). This is in line with the research of Kurniawan *et al.* (2023), mung bean sprout extract can increase germination by 90% of expired tomato seeds for 14 days. Research on the effect of combinations in increasing germination has been studied by Nugroho *et al.* (2022), a combination of coconut water and mung bean sprouts increased germination by 87% in coffee seeds. In addition, in Rachmat *et al.* (2022), giving a combination of banana and shallot extracts has an effect on the growth of tomato seeds.

Factors affecting seed germination are influenced by the quality of seeds before the storage period, seed moisture content, humidity and room temperature, as well as the presence of disturbances from pests and diseases. The length of storage is also an important factor, because the longer the seeds are stored, the greater the risk of damage to cell structures and enzymes, which leads to a decrease in the ability of seeds to germinate (Perdana *et al.*, 2023).

In the vigor index parameter shown in **Table 2**, filtrate type and concentration affect the vigor index. Treatment filtrate + 60% concentration combination gave the highest value of 59.00%, significantly different from all treatments, but not significantly different from filtrate + 80% concentration combination. The results showed that the combination treatment gave the best results compared to the single filtrate treatment. This is in accordance with the research of Liana *et al.*, 2022 which

states that giving a combination of banana powder and shallots gives the best results in the vigor index parameter of 84% against expired chili seeds. The increase in vigor index is due to the content of growth hormones such as gibberellins, auxins, and cytokinins which are more diverse and balanced in the filtrate combination.

Seeds with high vigor have the ability to maintain good growth despite being stored in sub optimal conditions including environmental stress and quality decline during storage (Perdana *et al*, 2023). The length of time the seeds are stored is also a factor in determining whether the seeds have strong vigor or not. This is because over time, physiological and biochemical degradation occurs in the internal structure of seeds, such as cell membrane damage, decreased enzyme activity, and fat oxidation which can damage seed food reserves (ISTA, 2021). The cause of low vigor index results is due to the use of seeds that have entered the expiration period so that growth also slows down (Faisal *et al.*, 2022). Seeds stored with a shelf life of more than six months will be able to reduce the quality of seeds

and are included in the expiration period, where the physiological quality, especially vigor and viability of seeds, decreases. According to Tefa (2017), physiological changes caused by internal factors such as expiration are irreversible. Over time, expired seeds that are germinated will be able to decrease vigor and viability characterized by a decrease in germination power, the number of abnormal sprouts.

On the parameter of growth uniformity **Table 3**. Shows the highest value in combination of filtrate + 60% concentration of 10.67% is significantly different from other treatments but not significantly different from combination of filtrate + 80% concentration of 9.00%. This is in accordance with the research of Liana *et al.*, 2022, the combination of banana stump and shallots gave the best results on the simultaneous growth of 8, 54% in 14-year-old expired red chili seeds.

An optimal imbibition rate will fulfill the need for water, so that metabolic processes can run smoothly and produce good germination. In addition, the hormones gibberellin, auxin, and cytokinin in the filtrate play a role in stimulating the metabolic activity of seeds, which triggers the formation of enzymes and helps accelerate the recovery of damaged tissues (Miftakhurrohmat & Jannah, 2021). This high bioactive compound also facilitates the imbibition process by increasing the capillarity of the cell membrane, so that water more easily enters the seed cells. Optimal water absorption will make the amylase enzyme more active in converting food reserves into simple sugars needed for embryo growth (Asra, 2014). The value of vigor is said to be good if the range of values for vigor to grow is between 40-70% if the value of vigor to grow below 40% indicates low vigor in the seed group. Conversely, a value of more than 70% indicates very high vigor (Sulandjari & Azizah, 2021). Low uniformity is due to a decrease in seed.

On the parameter of growth speed **Table 4**. Shows that the treatment of combination of filtrate + 60% concentration has a significant effect on all treatments at 22.92%/ thermal while the lowest value in control treatment at 7.71%/thermal. The high value in the combination of filtrates is due to the presence of auxin, gibberellin, and cytokinin hormones contained in banana stem filtrate and mung bean sprouts which are more complex than the single filtrate treatment. Mung bean sprouts contain

the hormones auxin 227.37 ppm, gibberellin 371.56 ppm, and cytokinin 220.45 ppm, while banana stem contains auxin 94.20 ppm, gibberellin 104.12 ppm, cytokinin 317.35 ppm (Fadhillah *et al.*, 2025).

Seed storage is one of the factors that affect growth speed. At the beginning of the storage period, seed growth speed tends to increase, but towards the end of the storage period there is a decrease. This indicates that the seeds most likely have not reached the physiological maturity level when harvested and stored. Physiologically immature seeds usually have lower storability and growing ability. Seeds harvested when they reach physiological maturity have a higher growth speed compared to seeds harvested too early or too late (Kolo and Tefa, 2016). Other factors that affect the speed of seed growth are food reserves, seed condition, availability of optimal environmental conditions (Fazal *et al.*, 2016).

In the research results, the control treatment gave the lowest values compared to the filtrate treatments. This is because water is a solution that does not contain hormones, so the response of tomato seeds was not evident, whereas an optimal concentration facilitates the imbibition process (Kurnianingrum, 2024). Suboptimal imbibition causes slowed metabolism and damaged seed structures that cannot be repaired, resulting in decreased germination ability. Seeds that have passed their storage period or expired generally experience a decline in quality, known as deterioration. This deterioration is characterized by reduced seed quality, viability, and vigor, leading to slower plant growth and decreased yield. Seeds affected by deterioration typically germinate unevenly, develop into abnormal seedlings, or may fail to germinate altogether (Faisal *et al.*, 2022). This decline occurs due to an overall reduction in the physiological and biochemical quality of seeds. Iriana *et al.*, (2020) stated that signs of physiological and biochemical deterioration in seeds can be observed through decreased enzyme activity, reduced food reserves in seeds, and increased conductivity values as an indication of cell membrane damage.

CONCLUSION

Based on research on the effect of natural growth regulators from banana corm and mung bean sprouts on the viability and vigor of 12-month-expired tomato seeds, it is known that the type of filtrate has a significant effect on germination, vigor index, growth uniformity, and growth speed, with the combination of banana corm filtrate and mung bean sprouts giving the best results. Concentrations of 80% and 60% proved to be the most optimal in increasing seed viability and vigor, while the best interaction occurred in the combination of banana corm and mung bean sprout filtrates at a concentration of 60% and in the combination of banana corm and mung bean sprout filtrates at a concentration of 80% as the most effective treatment to improve the quality of expired tomato seeds. Practically, these findings suggest that farmers can utilize a 60% concentration of combined banana corm and mung bean sprout filtrates as a cost-effective and accessible method to invigorate aged tomato seeds, potentially improving germination and crop establishment.

RECOMMENDATION

Based on the results of this study, the combined treatment of banana corm filtrate and mung bean sprout filtrate at a concentration of 60% is recommended for improving the viability and vigor of tomato (*Solanum lycopersicum* L.) seeds, as its performance was not significantly different from the highest concentration (80%) across the observed parameters, including germination percentage, vigor index, germination rate, and germination uniformity. Furthermore, the seedlings evaluated for viability and vigor parameters consisted only of normal seedlings. Therefore, to ensure data consistency and validity, future studies are recommended to use a uniform number of seeds for all observed parameters, with observations based exclusively on normal seedlings that meet the criteria established by the *International Seed Testing Association* (ISTA).

REFERENCES

- Ardiansyah, R. (2010). *Budidaya Pisang*. JPBOOKS.
- Asra, R., Samarlina, R. A., & Silalahi, M. (2020). *Hormon tumbuhan*. Jakarta. UKI Press.
- Azmi, R., & Handriatni, A. (2018). Pengaruh macam zat pengatur tumbuh alami terhadap pertumbuhan setek beberapa klon kopi robusta (*Coffea canephora*). *Ilmu Pertanian*, 14(2), 71-81.
- Badan Pusat Statistika. (2023). *Statistik Hortikultura 2023*. Jakarta. Badan Pusat Statistik.
- Darmawan, A. C., Respatijarti, R., & Soetopo, L. (2014). Pengaruh tingkat kemasakan benih terhadap pertumbuhan dan produksi cabai rawit (*Capsicum frutescent* L.) varietas comexio. *Jurnal Produksi Tanaman*. 2(4), 339-346. <https://doi.org/10.21176/protan.v2i4.115>
- Ernawati, E., Rahardjo, P., & Suroso, B. (2017). Respon benih cabai merah (*Capsicum annum* L.) kadaluarsa pada lama perendaman air kelapa muda terhadap viabilitas, vigor dan pertumbuhan bibit. *Agritrop*, 15(1), 273744. <https://doi.org/10.32528/agr.v15i1.794>
- Fadhillah, A. N., Septirosya, T., & Taslapratama, I. (2025, January). INVIGORASI BENIH PADI (*Oryza sativa* L.) KADALUARSAS MENGGUNAKAN ZAT PENGATUR TUMBUH ALAMI PADA LAMA PERENDAMAN BERBEDA: Invigoration of Expired Rice (*Oryza sativa* L.) Seeds Using Natural Plant Growth Regulators at Different Soaking Times Different Soaking Duration. In *Prosiding Seminar Nasional Integrasi Pertanian dan Peternakan* (Vol. 3, No. 1, pp. 253-267).
- Faisal, F., Ismadi, I., & Rafli, M. (2022). Upaya peningkatan performa perkecambahan benih dalam pengujian di laboratorium melalui perancangan alat pengecambah benih yang ideal. *Jurnal Agrium*, 19(1), 9-17. <https://doi.org/10.29103/agrium.v19i1.6762>
- Fatikhasari, Z., Lailaty, I. Q., Sartika, D., & Ubaidi, M. A. (2022). Viabilitas dan vigor benih kacang tanah (*Arachis hypogaea* L.), kacang hijau (*Vigna radiata* (L.) R. Wilczek), dan jagung (*Zea mays* L.) pada temperatur dan tekanan osmotik

- berbeda. *Jurnal Ilmu Pertanian Indonesia*, 27(1), 7-17. <https://doi.org/10.18343/jipi.27.1.7>
- Fazal, H., Shinwari, Z. K., Ahmad, N., & Abbasi, B. H. (2016). Factors influencing in vitro seed germination, morphogenetic potential and correlation of secondary metabolism with tissue development in *Prunella vulgaris* L. *Pakistan Journal of Botany*, 48(1), 193-200.
- Hariani, F., Suryawaty, S., & Arnansi, M. L. (2018). Pengaruh beberapa zat pengatur tumbuh alami dengan lama perendaman terhadap pertumbuhan stek jeruk nipis (*Citrus aurantifolia* Swingle). *AGRIUM: Jurnal Ilmu Pertanian*, 21(2), 119-126. <https://doi.org/10.30596/agrium.v21i2.1871>
- Sulandjari, K., & Azizah, E. (2021). Pengaruh perendaman bahan organik air kelapa dan air cucian beras terhadap viabilitas dan vigor benih timun apel (*Cucumis* sp.) dalam periode simpan yang berbeda. *Jurnal Agrotek Indonesia*, 6(1), 65-72.
- [ISTA] International Rules For Seed Testing. (2021). *Pengujian Mutu Benih Tanaman Pangan Dan Hortikultura Berdasarkan Ista Rules*. Depok. Balai Besar Pengembangan Pengujian Mutu Benih Tanaman Pangan Dan Hortikultura.
- Miftakhurrohmat, A., & Jannah, F. Y. N. (2021). The Effects of PGR Soaking Treatment and Cow Manure Fertilizer Dosage On Corn (*Zea mays* L.) Variety Arjuna Growth and Yield: Pengaruh Perendaman ZPT dan Dosis Pupuk Kandang Sapi Terhadap Pertumbuhan dan Produksi Tanaman Jagung (*Zea mays* L.). *Nabatia*, 9(2), 29-37. <https://doi.org/10.21070/nabatia.v9i2.1599>
- Kurnianingrum, I., & Rosya, A. (2024). Optimalisasi pemberian zat pengatur tumbuh alami untuk perlakuan benih tomat (*Solanum esculentum*) dengan variasi konsentrasi guna peningkatan viabilitas benih. *Jurnal Ilmiah Hijau Cendekia*, 9(1), 65-72. <https://doi.org/10.32503/hijau.v9i1.4912>
- Kurniawan, M., Utami, E. P., & Rachmawati, Y. S. (2023, December). Efektivitas Ekstrak Tauge dengan Periode Perendaman Terhadap Invigorasi Benih Tomat (*Solanum lycopersicum*) yang Telah Mengalami Kemunduran. In *Gunung Djati Conference Series* (Vol. 33, pp. 288-301). <https://doi.org/10.15575/gdcs.v33i.1973>
- Kolo, E., & Tefa, A. (2016). Pengaruh kondisi simpan terhadap viabilitas dan vigor benih tomat (*Lycopersicum esculentum* Mill). *Savana Cendana*, 1(03), 112-115.
- Liana, N. F. M., Anwar, S., & Kusmiyati, F. (2022). Pengaruh hormon alami dan lama perendaman benih cabai merah (*Capsicum annum* L.) kedaluwarsa terhadap perkecambahan, pertumbuhan, dan produksinya. *Jurnal Ilmiah Pertanian*, 19(3), 155-164. <https://doi.org/10.31849/jip.v19i3.10569>
- Lorenza, R. (2023). Penerapan model predator-prey pada proses perkecambahan biji kacang hijau. *Indonesian Journal of Applied Mathematics*, 2(2), 44-50. <https://doi.org/10.35472/indojam.v2i2.1027>
- Nawariah, S., Fajri, S. R., & Royani, I. (2022). Efektivitas Pemanfaatan Kulit Bawang Merah dan Air Cucian Beras sebagai Zat Pengatur Tumbuh bagi Tanaman Tomat (*Solanum lycopersicum* Mill.) dalam Upaya Penyusunan Buku Petunjuk Praktikum Fisiologi Tumbuhan. *Educatoria: Jurnal Ilmiah Ilmu Pendidikan*, 2(3), 156-167. <https://doi.org/10.36312/ejiip.v2i3.100>
- Nugroho, S. A., Bagiatus, S., Setyoko, U., Fatimah, T., Novenda, I. L., & Pujiastuti, P. (2022). Pengaruh Zpt Nabati Dan Media Tumbuh Terhadap Perkembangan

- Kopi Robusta. *Jurnal Biosense*, 5(2), 62-76.
<https://doi.org/10.36526/biosense.v5i2.2279>
- Paksi, S. N., Setyawati, E. R., & Andayani, N. (2023). PENGARUH BERBAGAI JENIS DAN LAMA PERENDAMAN ZAT PENGATUR TUMBUH ALAMI TERHADAP PERTUMBUHAN STEK *Mucuna bracteata*. *Jurnal Pertanian Agros*, 25(1), 376-384. <http://dx.doi.org/10.37159/jpa.v25i1.2410>
- Perdana, M. A., Moeljani, I. R., & Soedjarwo, D. P. (2023). Pengaruh masa simpan dan suhu simpan terhadap viabilitas dan vigor benih coating kedelai. *Jurnal Agrium*, 20(1), 1-7. <https://doi.org/10.29103/agrium.v20i1.10620>
- Rachmat, R., Syaifuddin, S., Hamzah, P., & Kanan, N. (2022). Efektivitas Zat Pengatur Tumbuh Alami dari Ekstrak Bonggol Pisang dan Bawang Merah terhadap Pertumbuhan Tanaman Tomat (*Solanum lycopersicum* L.): The Effectiveness of Natural Growth Regulatory Substances from Banana and Onion Webs Extract on Tomato Plants Growth (*Solanum lycopersicum* L.). *Jurnal Agrisistem*, 18(2), 46-51. <https://doi.org/10.52625/j-agr.v18i2.233>
- Ramadhanti, R., Marlia, A., & Hayati, R. (2023). Respon Konsentrasi Giberelin dan Dosis Biochar terhadap Pertumbuhan dan Hasil Tanaman Bawang Merah (*Allium ascalonicum* L.). *Jurnal Ilmiah Mahasiswa Pertanian*, 8(4), 54-62.
- Rusdiana, R. Y., Sa'diyah, H., & Fariroh, I. (2023). TOLERANSI TEKANAN OSMOTIK PADA PERKECAMBAHAN PADI VARIETAS INPARI MENGGUNAKAN MANNITOL. *Jurnal Agrotek Tropika*, 11(4), 555-561.
<https://doi.org/10.23960/jat.v11i4.6683>
- Shakina, V. D., Nuraini, A., & Nurbaiti, A. (2024). Response of tomato seed germination to several extraction techniques and magnetic field exposure treatments. *Jurnal Kultivasi*, 23(1), 2.
<http://dx.doi.org/10.24198/kultivasi.v23i1.44455>
- Tini, E. W., Sakhidin, S., Saporso, S., & Haryanto, T. A. D. (2022). Perbandingan Kandungan Hormon Endogenous pada Beberapa Tanaman. *Jurnal Galung Tropika*, 11(2), 132-142.
- Wahid, S., & Wangiyana, I. G. A. S. (2021). PENGARUH APLIKASI FITOHORMON TERHADAP PERKECAMBAHAN BENIH GAHARU (*Gyrinops versteegii*) PASCA PROSES PENYIMPANAN. *Jurnal AGROTEK Vol*, 8(1).
- Wahidah, B. F., & Hasrul, H. (2017). Pengaruh pemberian zat pengatur tumbuh indole acetic acid (IAA) terhadap pertumbuhan tanaman pisang sayang (*Musa paradisiaca* L. var. sayang) secara in vitro. *Teknosains: Media Informasi Sains dan Teknologi*, 11(1). <https://doi.org/10.24252/teknosains.v11i1.7408>
- Zainudin, A., & Adini, A. A. (2019). The response of seed germination and seedling growth of papaya (*Carica papaya* L.) CV Calina to the concentration treatments and the duration of seed soaked in coconut water. *Journal of Tropical Crop Science and Technology*, 1(1), 1-7. <https://doi.org/10.22219/jtcst.v1i1.7871>