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The Effect of Moringa Leaf and Water Hyacinth Root Filtrate on Seed Germination and Growth of Expired Red Chili (*Capsicum annuum* L.) Plants

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Abstract
This study aims to describe the effects of filtrate types and seed expiration periods on the germination and growth of expired red chili pepper (*Capsicum annuum* L.). The research used a Completely Randomized Design (CRD) for germination and a Randomized Block Design (RBD) for growth, with two treatment factors: filtrate types (6 types) and seed expiration periods (1, 2, and 3 months). Each germination treatment used 200 seeds in 2 replicates, totaling 36 experimental units. For growth, each treatment had 5 replicates with one plant per replicate, totaling 90 experimental units. The observed parameters included germination parameters (seed growth rate, vigor index, germination uniformity, and germination rate) and growth parameters (plant height, number of leaves, root length, and fresh weight). Data were analyzed using two-way ANOVA followed by Duncan's test. Treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) showed the most optimal results for germination, while treatments B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and C (75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate) showed the most optimal results for growth. Seeds with a 1-month expiration period showed the highest results for all parameters.

Keywords: Expired seed, phytohormones, viability.
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INTRODUCTION

Chili (*Capsicum* sp.) is an important horticultural commodity related to eggplant plants and is classified as an annual crop with a short shelf life (Edowai *et al*., 2016). This plant can grow well in highland and lowland areas and is widely consumed in Indonesia due to its spiciness. Besides being used as a spice and raw material for the food industry, chili is also utilized in the pharmaceutical industry for producing essential oils and cold remedies (AgroMedia, 2008). Red chili (*Capsicum annuum* L.) has high economic value and export potential, although its productivity in Indonesia is still suboptimal (Setiawan *et al*., 2019). According to the Central Bureau of Statistics (2023), chili productivity in East Java fluctuated, increasing from 578,883 tons/ha in 2021 to 646,740 tons/ha in 2022 but declining to 562,816 tons/ha in 2023. With growing demand, per capita consumption of red chili in 2023 rose by 4.3% to 2.42 kg/year, while bird's eye chili consumption increased by 5.8% to 2.19 kg/year. The total national demand for red chili reached 675 thousand tons/year (up 5.7%), while the demand for bird's eye chili reached 610.8 thousand tons/year (up 6.9%). Given this condition, chili has become one of Indonesia's leading commodities alongside shallots.

Chili productivity heavily depends on the use of high-quality superior seeds. However, seed quality can be affected by improper storage or expiration. The utilization of expired seeds can be an alternative for maintaining plant availability and production stability (Saleh and Rosni, 2022). Therefore, proper seed storage is crucial for maintaining its quality until planting. In Indonesia, the decline in seed viability is a major issue in the agricultural sector due to inadequate storage, improper handling, and unfavorable environmental conditions (Avivi, 2021). This results in low crop productivity, as low-quality seeds produce weak and unproductive plants (Wardani *et al*., 2023). Improper storage can lead to deterioration, which is a decline in seed vigor and viability due to genetic and environmental factors during storage (Triani, 2021). The tropical conditions in Indonesia, with high temperatures and humidity, can accelerate seed deterioration. Consequently, seeds become susceptible to diseases and fungi, ultimately inhibiting germination. Several key factors influencing seed viability

during storage include genetic traits, seed coat condition, initial moisture content, packaging type, gas composition, and storage temperature and humidity (Justice and Bass, 1994).

Based on the study by Septirosya *et al*., (2024), expired red chili seeds stored for 12 months and soaked in 60% young coconut water exhibited a germination rate of 1.86%, whereas the control group showed only 0.43%. Similarly, Prabawa *et al*., (2020) found that invigorating 6-month-old expired pagoda mustard seeds with 50% shallot extract resulted in a vigor index of 65.33%, compared to 53.33% in the control. Additionally, research by Sagita and Rahayu (2022) demonstrated that invigorating expired spinach seeds with water hyacinth root extract at 100 g/L yielded a vigor index of 70% for 6-month expired seeds, 73% for 3-month expired seeds, and 83% for 1-month expired seeds. These findings indicate that seeds older than three months generally experience quality decline, which hinders germination. Therefore, to enhance seed quality, invigorating treatments such as soaking and the application of plant growth regulators (PGRs) are essential. Various plant hormones, including auxins, cytokinins, and gibberellins, play crucial roles in regulating plant growth by accelerating germination, promoting enzyme production, and supporting organogenesis (Asra *et al*., 2020). Moringa leaves and water hyacinth roots are known to contain plant hormones that can serve as effective PGRs to support plant growth. Moringa (*Moringa oleifera* L.) is a tropical plant that thrives in Indonesia (Maryani and Suryadarma, 2019). Moringa leaves contain endogenous hormones such as auxin (662.17 ppm), kinetin (161.37 ppm), zeatin (55.5 ppm), and GA3 (417.88 ppm), with auxin and gibberellin being the most abundant (Tini *et al*., 2022). These hormones stimulate growth, development, seed germination, and strengthen root and stem systems (Rehman *et al*., 2017). In addition to hormones, moringa leaf extract also contains proteins, minerals, vitamins, essential amino acids, glucosinolates, isothiocyanates, and phenolics, which enhance plant growth and can be used as organic fertilizers (Culver *et al*., 2012). However, studies have shown varying effects of moringa leaf extract on plant growth.

Based on these studies, it can be stated that moringa leaf extract has not yet shown optimal results. Therefore, additional gibberellin from water hyacinth root extract can be used to enhance seed viability. Water hyacinth roots contain gibberellin hormones at a concentration of 2,995.50 ppm (Ummah and Rahayu, 2019). The gibberellin in water hyacinth roots can substitute for the endogenous gibberellin typically produced by seeds with good viability. Thus, the hormones from water hyacinth roots can meet the hormonal requirements necessary to accelerate germination. Additionally, water hyacinth roots contain high protein levels (approximately 12–18%) and a complete set of amino acids, which can serve as an organic nitrogen source (Benson, 2000). Water hyacinth root extract has been proven to improve seed viability and vigor during germination (Wahdah *et al*., 2021). Research by Sagita and Rahayu (2022) showed that a water hyacinth root extract concentration of 100 g/L produced the best results for one-month-expired seed germination, with an average plant height of 6.02 cm and an average fresh weight of 5.89 grams for spinach plants. Ummah and Rahayu (2019) reported that treating seeds with 500 ppm water hyacinth root extract had the highest effect on germination percentage, averaging 80.55% across three types of hard seeds. Furthermore Wahdah *et al*. (2020) found that priming with 22.5% water hyacinth root extract was the most effective treatment for increasing germination percentage on the fifth day, seed growth rate, plumule length, and dry weight of normal seedlings.

This study aims to investigate the effects of different types of filtrates (moringa leaf filtrate and water hyacinth root filtrate), the duration of seed expiration, and their combination on the germination and growth of expired red chili (*Capsicum annuum* L.) seeds. It also seeks to identify which filtrate and seed age produce the best results for the germination and growth of expired red chili seeds.

MATERIALS AND METHODS

This study is an experimental research conducted in the Greenhouse, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, from October to December 2024. The study employed a Completely Randomized Design (CRD) for germination due to the homogeneous environmental conditions and a Randomized Block Design (RBD) for plant growth due to the heterogeneous environment, with two treatment factors. The first factor was the type of filtrate, consisting of six treatments: A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate The second factor was the seed expiration period, which consisted of three levels: 1 month, 2 months, and 3 months.

The research procedure consisted of two main stages: filtrate preparation and treatment application. The preparation of moringa leaf filtrate followed the method described by Wahyuni *et al*.,

(2019), while the preparation of water hyacinth root filtrate was based on the method of Sagita and Rahayu (2022). The moringa leaves were separated from the stems, and the water hyacinth roots were detached from the stems and leaves. Both plant materials were washed thoroughly with running water and air-dried for seven days. Once dried, they were ground using a blender to obtain plant powder (simplisia). In preparing the filtrate, 286.7 grams of moringa leaf powder were dissolved in 1000 ml of distilled water, resulting in a filtrate concentration of 300 g/L. Meanwhile, 200 grams of water hyacinth root powder were dissolved in 2000 ml of distilled water to obtain a filtrate concentration of 100 g/L. The filtrates were left to stand for 24 hours and then filtered using a cloth strainer to obtain stock solutions of moringa leaf filtrate and water hyacinth root filtrate (Kamila *et al.*, 2022).

The second stage involved soaking expired chili seeds in the prepared filtrates for 6 hours. Expired seeds were obtained from Netafarm Store and were considered expired as they had exceeded the storage period indicated on the packaging. After soaking, the seeds were drained and dried on clean tissue paper. For germination, polyethylene (PE) plastic sheets were lined with two sheets of moistened brown paper (20 × 30 cm). Each treatment used 200 seeds, divided into two replications of 100 seeds each. The seeds were arranged horizontally in 10 rows, with each row containing 10 seeds. The seeds were then covered with two additional layers of moistened brown paper. The rolled-up substrate was labeled according to the treatment and placed vertically in a shaded area. In maintaining moisture, the medium was sprayed with water once a day using a hand sprayer. Germination was observed for 7 days. Seedlings that met the selection criteria (having a pair of leaves, approximately 5 cm in height, with green stems and leaves) were transferred to polybags filled with a planting medium consisting of soil, manure, and rice husk charcoal in a 2:1:1 ratio. Plant maintenance included watering every morning and evening until 45 Days After Transplanting (DAT), filtrate application every 15 days until 45 DAT with a dosage of 50 ml per polybag, fertilization using Mutiara fertilizer (16:16:16) at 2, 4, and 6 Weeks After Transplanting (WAT) with 2 grams per liter of water (50 ml per plant), and manual weeding once a week.

Germination parameters were calculated based on established formulas, including germination speed, vigor index, germination uniformity, and germination capacity. Germination speed was determined based on the number of normal seedlings emerging each day over 7 days after sowing (DAS). The vigor index was measured based on the number of normal seedlings on the 5th DAS. Germination uniformity was determined from the percentage of normal seedlings on the 6th DAS. Germination capacity was calculated based on the number of normal seedlings on the 5th and 7th DAS. These calculations followed the formulas by ISTA (2010) and Sadjad (1993), as presented below:

1. Germination Speed (%/day)
   $GS\ (\%/Etmal) = \frac{n1}{D1} + \frac{n2}{D2} + \ldots\ldots + \frac{n7}{D7}$
   Description:
   n: Number of normal seedlings that emerged on days 1, 2, 3, ... n after sowing.
   D: Observation day.
2. Vigor Index (%)
   $VI\ (\%) = \frac{\sum \text{Total KN I}}{\text{Total seed}} \times 100\%$
   Description:
   KN: Number of normal seedlings
3. Germination Uniformity (%)
   $GU\ (\%) = \frac{\text{Total KN}}{\text{Total seed}} \times 100\%$
   Description:
   KN: Number of normal seedlings
4. Germination Capacity (%)
   $GC\ (\%) = \frac{\sum \text{Total KN I} + \text{Total KN II}}{\sum \text{Total seed}} \times 100\%$
   Description:
   KN: Number of normal seedlings.

Observations on plant growth included plant height, leaf count, root length, and fresh weight. Plant height was measured at 15, 30, and 45 DAS from the stem base to the highest leaf tip using a ruler in centimeters. The number of leaves was counted at 15, 30, and 45 DAS. Root length was measured at 45 DAS using a ruler. Fresh weight was recorded at the end of the observation period (45 DAS) using a digital balance after washing and drying all plant parts.

Data analysis was carried out in several steps, beginning with normality and homogeneity tests. Two-way ANOVA (Analysis of Variance) was used to determine the effects of filtrate type, seed expiration period, and their interactions on the germination and growth of expired red chili seeds. Duncan's Multiple Range Test (DMRT) at a 5% significance level was performed to determine significant differences between treatments. The data analysis was concluded with a descriptive analysis.

RESULTS

This study examined the effects of different filtrate types, seed expiration periods, and their interactions on the germination and growth of expired red chili seeds. Germination parameters observed included germination speed, vigor index, germination uniformity, and germination capacity. Meanwhile, plant growth parameters included plant height, number of leaves, root length, and fresh weight. The two-way ANOVA results (Tables 1, 2, 3, 4, 5, 6, 7, and 8) showed that filtrate application significantly influenced all germination parameters (germination speed, vigor index, germination uniformity, and germination capacity) and plant growth parameters (plant height, number of leaves, root length, and fresh weight). The seed expiration period also significantly affected all germination and growth parameters. Additionally, the interaction between filtrate type and seed expiration period had a significant impact on all parameters.

Table 1. Effects of filtrate type and seed expiration period on germination speed.

Type of Filtrate	Seed Expiration Period			Average (%/Etmal)
	1 month	2 month	3 month	
A	11.07 ± 1.00^{b}	6.27 ± 1.42^{a}	4.14 ± 1.79^{a}	7.16^{a}
B	27.45 ± 1.37^{fg}	22.40 ± 2.16^{de}	17.84 ± 1.24^{c}	22.57^{b}
C	29.65 ± 2.10^{gh}	24.61 ± 2.43^{ef}	19.48 ± 2.16^{cd}	24.58^{c}
D	31.98 ± 1.03^{hi}	26.96 ± 1.69^{fg}	21.68 ± 2.09^{de}	26.88^{d}
E	33.47 ± 1.35^{ij}	29.03 ± 1.04^{gh}	24.69 ± 1.53^{ef}	29.06^{e}
F	35.12 ± 2.18^{j}	31.22 ± 1.34^{hi}	26.73 ± 1.55^{fg}	31.02^{f}
Average (%/Etmal)	28.12^{c}	23.41^{b}	19.09^{a}	23.54

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Based on Duncan's test, filtrate type and seed expiration period significantly affected germination speed. Treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) resulted in the highest germination speed of 31.02%/etmal, while treatment A (distilled water) produced the lowest at 7.16%/etmal. Furthermore, seeds with a 1-month expiration period exhibited the highest germination speed at 28.12%/etmal. The interaction between treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) and the 1-month expired seeds produced the highest germination speed of 35.12%/etmal, whereas the interaction between treatment A (distilled water) and the 3-month expired seeds resulted in the lowest germination speed of 4.14%/etmal.

Besides growth rate, seed vigor index is also influenced by the type of filtrate and seed expiration period. Treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) resulted in the highest vigor index of 36%, while treatment A (distilled water) had the lowest at 9.17%. Additionally, seeds with a 1-month expiration period exhibited the highest vigor index at 35.08%. The interaction between treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) and 1-month expired seeds produced the highest vigor index of 43%, whereas the interaction between treatment A (distilled water) and 3-month expired seeds resulted in the lowest vigor index of 6%.

In addition, the type of filtrate and seed expiration period significantly affect the seed germination uniformity. Treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) resulted in the highest germination uniformity of 63.50%, while treatment A (distilled water) had the lowest at 15.50%. Additionally, seeds with a 1-month expiration period exhibited the highest germination uniformity at 58.67%. The interaction between treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) and 1-month expired seeds produced the highest germination uniformity of 72.5%, whereas the interaction between treatment A (distilled water) and 3-month expired seeds resulted in the lowest germination uniformity of 9.5%.

Table 2. Effects of filtrate type and seed expiration period on vigor index.

Type of Filtrate	Seed Expiration Period			Average (%)
	1 month	2 month	3 month	
A	12.5 ± 1.80^{b}	9 ± 1.00^{ab}	6 ± 2.00^{a}	9.17^{a}
B	36 ± 1.00^{g}	25 ± 2.00^{de}	19 ± 1.00^{c}	26.67^{b}
C	38 ± 2.00^{gh}	27 ± 3.00^{e}	20 ± 4.00^{c}	28.33^{bc}
D	40 ± 3.00^{ghi}	29 ± 3.00^{ef}	22 ± 2.00^{cd}	30.33^{c}
E	41 ± 3.00^{hi}	31.5 ± 2.29^{f}	26 ± 2.00^{de}	32.83^{d}
F	43 ± 1.80^{i}	36.5 ± 4.09^{g}	28.5 ± 1.80^{ef}	36^{e}
Average (%)	35.08^{c}	26.33^{b}	20.25^{a}	27.22

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Table 3. Effects of filtrate type and seed expiration period on seed germination uniformity.

Type of Filtrate	Seed Expiration Period			Average (%)
	1 month	2 month	3 month	
A	23 ± 1.00^{c}	14 ± 1.00^{b}	9.5 ± 0.86^{a}	15.50^{a}
B	58 ± 1.00^{i}	45.5 ± 1.80^{f}	36 ± 1.00^{d}	46.50^{b}
C	62.5 ± 1.80^{j}	50 ± 1.00^{g}	39 ± 1.00^{e}	50.50^{c}
D	66.5 ± 1.80^{k}	54.5 ± 1.80^{h}	43.5 ± 1.80^{f}	54.83^{d}
E	69.5 ± 1.80^{l}	58.5 ± 1.80^{i}	50 ± 1.00^{g}	59.33^{e}
F	72.5 ± 1.80^{m}	64.5 ± 1.80^{jk}	53.5 ± 1.80^{h}	63.50^{f}
Average (%)	58.67^{c}	47.83^{b}	38.58^{a}	48.36

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Table 4. Effects of filtrate type and seed expiration period on seed germination capacity.

Type of Filtrate	Seed Expiration Period			Average (%)
	1 month	2 month	3 month	
A	21.5 ± 1.50^{c}	12.5 ± 1.80^{b}	8 ± 1.00^{a}	14.00^{a}
B	56 ± 2.00^{hi}	44.5 ± 1.32^{f}	35 ± 2.00^{d}	45.17^{b}
C	60 ± 2.00^{jk}	48.5 ± 1.80^{g}	38 ± 1.73^{e}	48.83^{c}
D	65 ± 2.00^{l}	53 ± 2.00^{h}	42 ± 1.00^{f}	53.33^{d}
E	67.5 ± 1.50^{lm}	57.5 ± 2.50^{ij}	48 ± 1.00^{g}	57.67^{e}
F	70.5 ± 2.00^{m}	62 ± 1.00^{k}	53 ± 2.00^{h}	61.67^{f}
Average (%)	56.67^{c}	46.33^{b}	37.33^{a}	46.78

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Table 5. Effects of filtrate type and seed expiration period on plant height.

Type of Filtrate	Seed Expiration Period			Average (cm)
	1 month	2 month	3 month	
A	8.27 ± 0.63^{bc}	6.82 ± 1.27^{ab}	4.79 ± 0.35^{a}	6.63^{a}
B	19.01 ± 1.00^{j}	17.55± 1.50^{ij}	15.91 ± 1.13^{ghi}	17.49^{e}
C	17.46 ± 0.50^{ij}	14.96 ± 2.62^{fgh}	13.07 ± 2.00^{defg}	15.16^{d}
D	16.45 ± 0.50^{hij}	13.76 ± 1.65^{efgh}	11.88 ± 2.01^{de}	14.03^{cd}
E	15.41 ± 1.43^{ghi}	12.89 ± 2.00^{defg}	11.15 ± 1.23^{cde}	13.15^{bc}
F	14.14 ± 1.02^{efgh}	11.62 ± 1.19^{de}	10.03 ± 0.95^{cd}	11.93^{b}
Average (cm)	15.12^{c}	12.93^{b}	11.14^{a}	13.07

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Table 6. Effect of filtrate type and seed expiration period on the number of leaves.

Type of Filtrate	Seed Expiration Period			Average (leaves)
	1 month	2 month	3 month	
A	3.50 ± 0.50^{ab}	3.27 ± 0.46^{ab}	3.00 ± 0.00^{a}	3.26^{a}
B	8.50 ± 0.50^{f}	7.30 ± 1.47^{ef}	6.63 ± 2.02^{def}	7.48^{e}
C	7.30 ± 1.12^{ef}	6.10 ± 2.8^{cdef}	5.50 ± 1.80^{bcde}	6.30^{d}
D	6.50 ± 1.32^{cdef}	5.50 ± 0.51^{bcde}	4.77 ± 0.68 ^{bcde}	5.52^{cd}
E	5.80 ± 0.72^{bcde}	4.80 ± 0.34^{bcde}	4.13 ± 0.80^{bcd}	4.91^{bc}
F	5.13 ± 1.20^{bcde}	4.10 ± 0.17^{bcd}	3.73 ± 0.64^{bcd}	4.32^{ab}
Average (leaves)	6.12^{b}	5.14^{a}	4.62^{a}	5.30

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Table 7. Effect of filtrate type and seed expiration period on root length.

Type of Filtrate	Seed Expiration Period			Average (cm)
	1 month	2 month	3 month	
A	11.05 ± 0.54^{c}	7.86 ± 0.54^{b}	5.38 ± 0.71^{a}	8.10^{a}
B	29.04 ± 2.10^{j}	25.03 ± 1.54^{i}	21.82 ± 1.43^{gh}	25.30^{e}
C	26.19 ± 1.61^{i}	22.91 ± 0.55^{h}	19.68 ± 1.39^{f}	22.93^{de}
D	23.18 ± 1.43^{h}	20.59 ± 1.21^{fg}	17.84 ± 1.68^{e}	20.54^{cd}
E	20.94 ± 1.71^{fg}	17.83 ± 1.08^{e}	14.13 ± 0.50^{d}	17.63^{bc}
F	17.96 ± 1.72^{e}	13.82 ± 1.21^{d}	11.14 ± 0.49^{c}	14.31^{b}
Average (cm)	21.39^{c}	18.01^{b}	15.00^{a}	18.13

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Table 8. Effect of filtrate type and seed expiration period on plant fresh weight.

Type of Filtrate	Seed Expiration Period			Average (gram)
	1 month	2 month	3 month	
A	0.7 ± 0.10^{ab}	0.4 ± 0.00^{a}	0.3 ± 0.10^{a}	0.46^{a}
B	3.38 ± 1.60^{d}	2.88 ± 1.81^{cd}	2.28 ± 1.43^{abcd}	2.85^{d}
C	2.82 ± 2.34^{bcd}	2.26 ± 1.41^{abcd}	1.73 ± 0.64^{abcd}	2.27^{cd}
D	2.25 ± 1.39^{abcd}	1.81 ± 0.73^{abcd}	1.23 ± 0.40^{abc}	1.76^{bcd}
E	1.86 ± 0.75^{abcd}	1.53 ± 0.92^{abcd}	0.92 ± 0.11^{abc}	1.44^{abc}
F	1.38 ± 0.65^{abcd}	1.04 ± 0.77^{abc}	0.65 ± 0.00^{a}	1.02^{ab}
Average (gram)	2.07^{b}	1.65^{ab}	1.19^{a}	1.63

Notes: Different notations indicate significant differences based on Duncan's test (5%). A = Distilled water (control) B = 100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate C = 75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate D = 50 ml moringa leaf filtrate + 50 ml water hyacinth root filtrate E = 25 ml moringa leaf filtrate + 75 ml water hyacinth root filtrate F = 100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate.

Seed germination capacity is also influenced by the type of filtrate and expiration period. Treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) resulted in the highest germination capacity of 61.67%, while treatment A had the lowest at 14.00%. Additionally, seeds with a 1-month expiration period exhibited the highest germination capacity at 56.67%. The interaction between treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) and 1-month expired seeds produced the highest germination capacity of 70.5%, whereas treatment A (distilled water) and 3-month expired seeds resulted in the lowest germination capacity (8%).

Overall, treatment F (100 ml water hyacinth root filtrate + 0 ml Moringa leaf filtrate) the most optimal results on all four germination parameters: seed growth rate, vigor index, germination uniformity, and germination capacity. A seed shelf life of 1 month also showed significant results, with clear differences between treatments for all four germination parameters. The interaction between treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) and a seed shelf life of 1 month had the most optimal results on the germination parameters of red chili seeds.

In addition to germination parameters, plant growth parameters are also influenced by the type of treatment and seed expiration period. Treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth

root filtrate) resulted in the highest average plant height of 17.49 cm, while treatment A (distilled water) produced the lowest average of 6.63 cm. Furthermore, seeds with a 1-month expiration period showed the highest average plant height of 15.12 cm. The interaction between treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and a 1-month expiration period resulted in the highest average plant height of 19.01 cm, whereas the interaction between treatment A (distilled water) and a 3-month expiration period produced the lowest average of 4.79 cm.

Based on Duncan's test, treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) resulted in the highest average number of leaves at 7.48, while treatment A (distilled water) produced the lowest average of 3.26 leaves. Additionally, seeds with a 1-month expiration period showed the highest average number of leaves at 6.12. The interaction between treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and a 1-month expiration period resulted in the highest average number of leaves at 8.50, whereas the interaction between treatment A (distilled water) and a 3-month expiration period produced the lowest average of 3.00 leaves.

For root length, treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) resulted in the highest average root length of 25.30 cm, while treatment A (distilled water) produced the lowest average of 8.10 cm. Additionally, seeds with a 1-month expiration period showed the highest average root length of 21.39 cm. The interaction between treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and a 1-month expiration period resulted in the highest average root length of 29.04 cm, whereas the interaction between treatment A (distilled water) and a 3-month expiration period produced the lowest average of 5.38 cm.

Finally, the plant fresh weight parameter also showed a significant influence from the type of filtrate and seed expiration period. Treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) resulted in the highest average fresh weight of 2.85 grams, while treatment A (distilled water) produced the lowest average of 0.46 grams. Additionally, seeds with a 1-month expiration period showed the highest average fresh weight of 2.07 grams. The interaction between treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and a 1-month expiration period resulted in the highest average fresh weight of 3.38 grams, whereas the interaction between treatment A (distilled water) and a 3-month expiration period produced the lowest average of 0.3 grams.

Overall, the filtrate type treatment, particularly treatment B (100 ml Moringa leaf filtrate + 0 ml water hyacinth root filtrate) and treatment C (75 ml Moringa leaf filtrate + 25 ml water hyacinth root filtrate), a seed shelf life of 1 month, and the interaction between treatment B (100 ml Moringa leaf filtrate + 0 ml water hyacinth root filtrate) and a seed shelf life of 1 month showed an optimal results on all growth parameters (plant height, number of leaves, root length, and fresh weight).

DISCUSSION

Based on the conducted research, the application of different filtrate types influenced the germination and growth of expired red chili seeds, as observed in all germination and growth parameters. Treatment F (100 ml of water hyacinth root filtrate + 0 ml of moringa leaf filtrate) showed optimal results for all germination parameters, including seed germination rate, vigor index, germination uniformity, and germination capacity (Tables 1, 2, 3, and 4). Meanwhile, Treatment B (100 ml of moringa leaf filtrate + 0 ml of water hyacinth root filtrate) and Treatment C (75 ml of moringa leaf filtrate + 25 ml of water hyacinth root filtrate) yielded optimal results for all growth parameters, namely plant height, number of leaves, root length, and fresh weight (Tables 5, 6, 7, and 8). The seed expiration period (1 month, 2 months, and 3 months) also significantly affected all germination and growth parameters. The interaction between Treatment F (100 ml of water hyacinth root filtrate + 0 ml of moringa leaf filtrate) and a 1-month expiration period resulted in optimal outcomes for all germination parameters. Meanwhile, the interaction between Treatment B (100 ml of moringa leaf filtrate + 0 ml of water hyacinth root filtrate) and a 1-month expiration period yielded optimal results for all growth parameters, including plant height, number of leaves, root length, and fresh weight. Seeds with a 1-month expiration period exhibited the best performance across all observed germination and growth parameters, indicating that seeds with a 1-month expiration period had better viability and vigor compared to those with a 2-month or 3-month expiration period.

The research results indicate that seed germination quality improves when the storage period after expiration is shorter. Conversely, prolonged storage tends to reduce germination capacity and seed quality. This decline occurs due to several factors affecting seed viability and vigor during storage. The first factor is seed aging, a natural process that leads to a gradual decrease in quality over time (Pamungkas *et al*., 2009). The second factor is internal damage, where long-term storage can harm DNA,

proteins, and cell membranes, thereby reducing seed viability (Rajjou *et al*., 2012). The third factor is increased respiration, which leads to the breakdown of food reserves, the production of free fatty acids, and a decline in seed vigor. This condition causes deterioration, marked by a reduction in the energy required for germination (Perdana *et al*., 2023; Kolo and Tefa, 2016). The fourth factor is decreased enzyme activity, where improper storage can inhibit enzymes such as amylase and protease, which are essential for breaking down food reserves. As a result, key seed components, such as proteins and carbohydrates, are damaged, leading to a decline in seed quality (Copeland and McDonald, 2005). Additionally, seed quality deterioration is also indicated by morphological changes, such as seed coat (testa) darkening due to oxidation, which serves as an indicator of seed deterioration (Marliah et al., 2010). Seeds with a 1-month expiration period have better viability and vigor than those stored for longer periods, leading to more optimal germination (Juanda and Mulyani, 2017). Short-term storage helps maintain seed physiological integrity by minimizing metabolism, preserving nutrients, and sustaining growth hormones such as gibberellins and auxins (Tikafebrianti *et al*., 2019; Bewley *et al*., 2013). The primary factors contributing to the decline in viability and vigor in longer-stored seeds include reduced moisture content, oxidative damage, and the degradation of enzymes, proteins, and hormones. Additionally, storage temperature and humidity play crucial roles in maintaining seed viability (Copeland and McDonald, 2001). The integrity of cell membranes in freshly stored seeds also supports water absorption and enzyme activation during germination, resulting in stronger and more uniform seedlings (Marcos-Filho, 2015).

Based on the observations, treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) showed optimal results across all germination parameters, including seed growth rate, vigor index, germination uniformity, and germination capacity (Tables 1, 2, 3, and 4). These parameters are crucial for assessing seed quality and predicting the success of plant cultivation. According to Sadjad (1993), the ideal seed growth rate is >30% per day, while the ideal germination uniformity ranges between 40% and 70%. Seed growth rate, vigor index, germination uniformity, and germination capacity are key parameters of seed vigor. These four parameters are interrelated, as high-quality seeds generally exhibit high values in each category. This indicates that the seeds have the potential to grow quickly and uniformly, increasing the chances of successful germination under suboptimal conditions. Low values in these four parameters indicate a decline in seed quality due to reduced food reserves, internal structural damage, and decreased levels of growth hormones (Tatipata *et al*., 2004). This occurs due to limited energy in the endosperm and the inability of endogenous hormones to activate metabolism. Consequently, seeds have a reduced ability to initiate germination and grow optimally (Sadjad, 1999). Additionally, prolonged storage can also lower hormone levels, thereby inhibiting germination and seed growth (Asra *et al*., 2020). Seeds with low germination capacity tend to take longer to initiate imbibition due to poor seed quality, which hampers early metabolic activity. These limitations include suboptimal water absorption, delayed enzyme activation, and disrupted gibberellin (GA) synthesis, which plays a role in breaking down food reserves within the seed (Numba *et al*., 2024).

The invigoration treatment of expired chili seeds through soaking with moringa leaf filtrate and water hyacinth root filtrate can restore the physiological condition of the seeds to near their original state. These filtrates function to balance water potential during imbibition, allowing seeds to absorb water more efficiently and optimize their internal metabolism. Additionally, damage to the seed cell walls due to aging can be repaired, preventing cell leakage or nutrient loss during imbibition. The improvement in membrane integrity resulting from this process prepares the seeds for better germination (Afdharani *et al*., 2019). Research by Putri *et al*., (2022) states that soaking seeds in a gibberellin hormone solution can increase seed growth rate, as the hormone softens the seed coat, facilitating water and oxygen absorption. The treatment also enhances water uptake, while osmotic pressure differences within the seed stimulate growth. Kuswanto (2018) adds that pre-sowing treatment with specific substances, such as gibberellin, can stimulate germination by increasing imbibition rate, respiration, metabolism, and seed moisture content, thereby promoting germination. This aligns with Lakitan (1996), who states that imbibition is a crucial process for initiating seed germination. Once the seed absorbs sufficient water and metabolic processes are activated by hormones, germination begins, and the seed produces its first root and shoot. The initial stage of germination is influenced by the availability of respiratory substrates in the embryo and the activity of enzymes within the seed during imbibition (Sadjad, 1993). Heydecker (1973) explains that soaking seeds in hormones for a specific duration can enhance water imbibition into the seed coat, ultimately improving germination capacity. Good seed vigor, marked by the emergence of the radicle, affects the uniformity of hypocotyl length, which reflects the seed's ability to lift the cotyledons evenly.

In treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate), the seeds not only fulfill their water requirements during imbibition but also receive additional nutrients in the form of organic compounds from the filtrate, which can enhance seed germination quality and support early plant growth (Wahdah *et al*., 2021). One of the organic compounds that can improve seed viability and vigor is gibberellin, which is present in water hyacinth root filtrate. According to Musbakri (1999), water hyacinth roots contain gibberellin hormones that can replace endogenous gibberellin, which is typically produced by seeds with good viability, thereby ensuring sufficient hormone availability. This condition enables seeds to germinate more quickly compared to those that do not receive moringa leaf filtrate and water hyacinth root filtrate treatments. Therefore, expired chili seeds can still grow well under suboptimal environmental conditions after being soaked in moringa leaf filtrate and water hyacinth root filtrate, compared to untreated seeds. Research by Wahdah *et al*., (2021) demonstrated that priming treatment with 7.5% water hyacinth root extract significantly increased seed growth rate and seedling uniformity in Cowpea (*Vigna unguiculata*) by 21.94% and 40.00%, respectively. This finding confirms that water hyacinth root extract can restore seed vigor that has deteriorated, thereby enhancing seed growth rate and uniformity.

According to Supardy *et al*. (2016), gibberellin has two main functions in the germination process; mobilizing food reserves through the activation of hydrolytic enzymes and supporting embryo growth, thereby enhancing the seed's ability to germinate. Meanwhile, auxin plays a crucial role in stimulating seed germination. According to Copeland and McDonald (2001), growth hormones such as gibberellin and auxin act as stimulants in the germination process by enhancing the seed's ability to absorb water, thus accelerating imbibition and improving germination success when applied in the appropriate dosage. Research by Rashid *et al*. (2014) demonstrated that the application of gibberellin and auxin can accelerate and enhance germination success. These two hormones contribute to softening the seed coat and creating osmotic pressure differences that stimulate the release of gibberellin from the embryo.

According to Asra *et al*., (2020), the application of external gibberellin can increase the internal gibberellin levels in seeds, thereby triggering the germination process. Additionally, gibberellin promotes the formation of cell wall-softening enzymes and enhances auxin levels by releasing precursors such as the amino acid tryptophan, which is essential for auxin biosynthesis. Auxin stimulates shoot formation, cell division, elongation, and enlargement in roots and shoots during germination. According to Hendaryono and Wijayani (2014), auxin also supports metabolism and enhances imbibition. Furthermore, auxin promotes the synthesis of hydrolytic enzymes, such as protease, which breaks down food reserves to provide energy for the embryo. The increased imbibition induced by auxin also contributes to a higher seed vigor index, leading to a faster germination process. The combination of gibberellin and auxin can enhance seed vigor, as indicated by an increase in germination speed and improved resilience to suboptimal environmental conditions. The application of these plant growth regulators (PGRs) also helps seeds overcome physiological dormancy, allowing them to initiate germination more quickly. Overall, the administration of gibberellin and auxin provides significant benefits by accelerating germination and improving early plant growth quality. Additionally, the concentration of these substances plays a crucial role in the germination process. Based on research by Silmy *et al*. (2024), treating expired corn seeds with a 300 ppm gibberellin solution increased the vigor index by 94.67% and accelerated imbibition, positively impacting germination quality. In contrast, at a concentration of 150 ppm, the vigor increase was only 72.00%, indicating that lower concentrations were insufficient to activate the essential enzymes required for germination. As a result, the gibberellin solution was unable to fully optimize internal factors.

Based on the observations, treatments B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and C (75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate) showed optimal results across all growth parameters, including plant height, number of leaves, root length, and fresh weight (Tables 5, 6, 7, and 8). The application of moringa leaf filtrate on red chili plants proved effective in enhancing plant height, increasing the number of leaves, stimulating root growth, and promoting fresh weight gain through mechanisms involving hormones and bioactive compounds that support hormonal activity and balance. Moringa leaf filtrate contains various bioactive compounds, including growth hormones such as auxin, cytokinin, and gibberellin, with auxin being the dominant component (Tini *et al*., 2022). Auxin plays a crucial role in plant growth by influencing cell elongation, division, and differentiation. This hormone contributes to plant height growth through a polar transport mechanism that concentrates auxin in the apical shoot, thereby stimulating cell elongation. Additionally, auxin

interacts with other hormones, such as gibberellin, to optimize growth in the meristematic regions (Asra *et al*., 2020).

According to Taiz and Zeiger (2002), auxin influences cell elongation, division, and differentiation by activating proton pumps (H±ATPase), which lower the cell wall pH to approximately 4.5. This pH reduction weakens the hydrogen bonds between cellulose fibers, making the cell wall more flexible and allowing cells to stretch and elongate. This condition facilitates water uptake into the stem and stimulates gene activity by enhancing DNA transcription into mRNA. The resulting mRNA is then translated into enzymes with high catalytic activity, even at low concentrations. These enzymes break down proteins or polysaccharides in the epidermal cell wall, generating the energy required to support cell formation and elongation, thereby promoting cell division and root growth (Salisbury and Ross, 1995). According to Budiman (2000), auxin not only accelerates root growth but also increases root number and uniformity. Cleland (1995) explained that auxin stimulates root growth by increasing cell osmotic pressure, improving cell permeability to water, and reducing wall pressure. Yama & Kartiko (2019) stated that higher plant metabolic activity leads to increased photosynthesis, which in turn enhances plant growth. Aditania *et al.*, (2023) reported that the application of auxin at a concentration of 200 ppm significantly increased the root length of vanilla plants. This treatment resulted in an average root length of 57.65 cm, compared to the control treatment, which only reached an average of 45.47 cm. Additionally, research by Pamungkas and Puspitasari (2019) showed that using red onion extract positively affected the plant height and root length of sugarcane. The highest recorded plant height was 78.75 cm, with a root length of 39.4 cm, whereas the control treatment resulted in the lowest plant height of 56.62 cm and a root length of 28.44 cm.

Additionally, according to Gardner *et al*., (1991), the faster cell elongation occurs, the greater the number of leaves formed in plants. This supports the development of leaf organs essential for photosynthesis, particularly in higher plants. Once leaves are formed, auxin accelerates growth through cell elongation and division, contributing to an increased number of leaves. Auxin also plays a role in leaf initiation by promoting the proliferation of meristematic cells in the shoot apical meristem (SAM), forming lateral leaf primordia, and regulating leaf arrangement and morphology. This process requires localized auxin transport and accumulation. During development, cells enlarge and divide along the proximodistal, centrolateral, and adaxial-abaxial axes, accompanied by programmed cell differentiation from the embryonic stage to form leaf tissues. An optimal auxin concentration is required to trigger new leaf organ formation, while excessively low or high concentrations can inhibit this process (Meriem, 2019). Besides auxin, the cytokinin content in moringa leaves, which includes 161.37 ppm of kinetin and 55.5 ppm of zeatin, also plays a crucial role in influencing leaf growth in plants (Tini *et al*., 2022). Cytokinins contribute to cell expansion, ultimately increasing metabolite production and accelerating the translocation of nutrients to developing young shoots (Rady and Mohamed, 2015). Additionally, moringa leaf filtrate helps delay plant aging. According to Davies (2004), auxin can enhance shoot meristem activity, directly affecting the number of leaves produced by a plant. Research by Marfirani *et al*., (2014) demonstrated that 100% red onion filtrate significantly stimulated the growth of jasmine stem cuttings at 60 days after planting (DAP), with the highest average leaf count reaching 1.085 leaves, compared to the control treatment, which produced an average of only 0.471 leaves. Furthermore, a study by Syamsiah and Marlina (2024) found that applying 150 g/L red onion extract and 150 g/L mung bean sprout extract resulted in the highest number of mulberry leaves at week 8, with an average of 6.00 leaves, surpassing the control treatment, which only achieved an average of 4.83 leaves.

Fresh weight is an indicator of overall plant growth and development. Factors such as plant height, leaf number and area, root length, water content, and nutrient composition significantly influence fresh weight. The taller a plant and the greater its leaf count, the higher its fresh weight tends to be (Saufani and Wawan, 2017). A study by Jonet *et al*., (2024) also states that fresh weight includes all plant parts, and as the number of leaves increases, fresh weight also rises. Additionally, plant height contributes significantly to fresh weight. In plants like mustard greens, an increase in height and leaf number is directly proportional to an increase in fresh weight. Total fresh weight reflects the plant's accumulated growth, meaning that the more optimal the plant's growth, the higher its final fresh weight. This is because the treatment provides sufficient nutrients for the plant to grow and develop properly, as evidenced by its growth patterns. This aligns with the findings of Syahputra *et al*., (2014), who state that an increase in plant height and leaf number is directly proportional to fresh weight. This occurs because most leaf organs contain water, so as leaf number increases, the plant's water content also rises, ultimately increasing fresh weight. According to Mutryarny *et al*., (2020), the application of various types of natural plant growth regulators (PGRs) significantly increased plant height, leaf

number, and fresh weight in scallion plants. Among the treatments tested, red onion extract produced the best results, with an average plant height of 23.58 cm and an average of 11.25 leaves, resulting in a fresh weight of 33.38 grams. These results were significantly higher than the control treatment, which produced an average plant height of 21.96 cm, an average of 6.87 leaves, and a fresh weight of 16.93 grams. Similarly, research by Hanum *et al*., (2020) found that applying 100% red onion filtrate to sunflower plants significantly increased plant height and flower number, which correlated with an increase in fresh weight. The treatment with 100% red onion filtrate and the addition of 3 mL of Atonik resulted in the highest plant height of 25.67 cm, with an average of 13.40 flowers, yielding a fresh weight of 48.42 grams. In contrast, the untreated control (0% filtrate) produced the lowest plant height of 12.25 cm, with an average of 2.00 flowers, yielding a fresh weight of 8.92 grams.

Additionally, treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) resulted in an average plant height of 11.93 cm, which was lower compared to treatments B, C, D, and E. Meanwhile, the interaction between treatment F and various seed expiration periods did not show a significant effect, likely due to the hormone concentration in the treatment. This aligns with the findings of Wudianto (1991) and Kusumo (1990), who stated that the effectiveness of hormones is highly dependent on the concentration applied. Optimal hormone concentrations can promote plant growth and development, accelerating these processes effectively within a relatively short period. Conversely, using concentrations that are too high or too low can inhibit plant growth and development. Excessively high concentrations may interfere with these processes due to competition among hormone molecules for receptor binding sites in plant cells. Additionally, plant responses to hormones vary significantly depending on the sensitivity of specific organs (Gardner *et al*., 1991). According to research by Sagita and Rahayu (2018), the use of water hyacinth root extract at various concentrations did not show a significant effect on the height of expired spinach plants. Furthermore, the study also indicated that different seed expiration periods (1 month, 3 months, and 6 months) did not result in significant differences in spinach growth when treated with water hyacinth root extract at concentrations of 75 g/L and 100 g/L. Similarly, research by Kamila *et al*., (2022) found that applying water hyacinth root extract at a concentration of 6000 ml/L had no significant effect on the growth of water spinach. Plants in this treatment only grew to 3.08 cm, which was significantly lower than the control group treated with AB Mix, which reached a growth of 8.24 cm. Additionally, a study by Ngadiani *et al*., (2021) showed that varying concentrations of water hyacinth root extract (10%, 15%, and 20%) did not result in significant differences in the growth of Phalaenopsis orchids during the first subculture stage.

CONCLUSION

The application of different filtrate types influenced all germination parameters and the growth of expired red chili (*Capsicum annuum* L.) seeds. Treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) showed the most optimal results on all germination parameters, including germination speed, vigor index, germination uniformity, and germination capacity. Treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and Treatment C (75 ml moringa leaf filtrate + 25 ml water hyacinth root filtrate) showed the most optimal results on all plant growth parameters, including plant height, number of leaves, root length, and fresh weight. Seeds with an expiration period of 1 month showed the most optimal results and performed better than seeds that had been expired for 2 and 3 months across all germination and growth parameters. The interaction between Treatment F (100 ml water hyacinth root filtrate + 0 ml moringa leaf filtrate) and a seed expiration period of 1 month showed the most optimal results on all germination parameters. Meanwhile, the interaction between Treatment B (100 ml moringa leaf filtrate + 0 ml water hyacinth root filtrate) and a seed expiration period of 1 month showed the most optimal results on all plant growth parameters.

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CONFLICT OF INTEREST

There is no conflict of interest.

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