Effect of Priming Duration with Some Plant Extracts on the Viability of Safflower Seeds.

Basim Mohanad Lateef [1*], Salam Ali Khuit [3*], Jawad Kadhim Ali[3*],

[1]Department of Field Crop, College of Agriculture, Al-Qasim Green University, Babylon, Iraq.
[2]Department of Field Crop, College of Agriculture, Al-Qasim Green University, Babylon, Iraq
[3]Department of Field Crop, College of Agriculture, Al-Qasim Green University, Babylon, Iraq

*Corresponding author's email: basim.mohand@agre.uoqasim.edu.iq

Abstract

A laboratory experiment was conducted in the Seed Technology Laboratories at Al-Qasim Green University, College of Agriculture, Department of Field Crops, in 2025, to study the effect of soaking in three plant extracts (Eucalyptus, Licorice, and Conocarpus) in addition to a control treatment (distilled water only) and five soaking durations (6, 10, 14, 18, and 24 hours) on the seed viability traits of spineless Safflower seeds .The results showed that Licorice extract significantly outperformed the other treatments by achieving the highest mean values for germination percentage (91.16%), radicle length (8.64 cm), plumule length (5.947 cm), seedling dry weight (14.800 mg), and seedling vigor index (1342), while recording the lowest mean germination time (4.316 days). In contrast, Conocarpus extract recorded the lowest means for germination percentage (72.04%) and seedling vigor index (645), in addition to the longest germination period (5.703 days).Regarding soaking duration, the 10-hour soaking period produced the highest averages (germination 91.76%, radicle length 7.56 cm, seedling vigor index 1243), whereas the 24-hour soaking duration resulted in the lowest values for all studied traits and did not differ significantly from the 18-hour duration. It recorded the lowest germination percentage (71.14%), the longest mean germination time (6.180 days), the shortest radicle length (4.91 cm), the shortest plumule length (4.542 cm), the lowest seedling dry weight (10.688 mg), and the lowest seedling vigor index (617).For the interaction effect, the combination (Licorice extract × 10 hours) recorded the highest values for germination percentage (99.00%) and seedling vigor index (1655), as well as the shortest germination time (3.535 days). Conversely, the interaction (Conocarpus extract × 24 hours) produced the lowest values for germination percentage (61.97%) and seedling vigor index (418).Overall, the results indicate that seed priming with plant extracts for appropriate soaking durations enhances germination uniformity and reduces the time required for the formation of normal seedlings per unit area.

Keywords: Licorice extract, plant extracts, soaking, seed viability.

1: Introduction

Safflower (*Carthamus tinctorius L.*) belongs to the family Asteraceae. It is a multipurpose crop whose oil is considered high quality due to its richness in polyunsaturated fatty acids, particularly linoleic acid, which constitutes approximately 78% of the oil composition. Despite the considerable potential of this crop for cultivation under diverse environmental conditions and its utilization for various purposes, the global cultivated area of Safflower remains relatively limited. This limitation is largely attributed to the lack of sufficient information regarding its crop management practices and product development [1].

Aqueous plant extracts are considered safe biological alternatives that contribute to improving germination and enhancing seed viability, owing to their content of

ISSN 2072-3857

bioactive compounds such as phenolics, flavonoids, alkaloids, and volatile oils. The technique of seed soaking in botanical extracts is used as a pre-sowing treatment, as it promotes the activity of enzymes responsible for the hydrolysis of stored nutrients within the seeds and regulates the oxidative balance through natural antioxidants. In addition, it contributes to reducing the microbial load on the seed surface, which ultimately leads to increased germination percentage and accelerated germination [3].Plant extracts are among the most promising biostimulants in sustainable agriculture, due to their richness in effective secondary metabolites such as phenolic compounds and flavonoids, which play a key role in stimulating germination and enhancing seedling growth. Previous studies have demonstrated that soaking seeds in different plant extracts improves germination rates and seedling development. In particular, extracts of Licorice roots (*Glycyrrhiza glabra L*.) have been reported to enhance plant growth and crop productivity [4].The effectiveness of these extracts varies depending on the concentration used and the application method, and therefore seed priming with plant extracts is regarded as one of the promising sustainable approaches for improving seed quality and germination efficiency [5].

2: Material and Methods

2-1: Laboratory Experiment

This study was conducted in the Seed Technology Laboratories at Al-Qasim Green University, College of Agriculture, Department of Field Crops, in 2025, to investigate the effect of seed treatment with certain plant extracts on the viability of Safflower seeds. Three plant extracts were used: Eucalyptus, Licorice, and Conocarpus, in addition to a control treatment (distilled water only). Seeds were subjected to five soaking durations (6, 10, 14, 18, and 24 hours).

The experiment was conducted using a Completely Randomized Design (CRD) within a factorial arrangement, with the aim of determining the most effective extract and soaking duration that would produce the best results for the studied seed traits prior to sowing.

2-2. Materials Used

2-2-1. Plant Variety

Spineless Safflower seeds of the proposed cultivar "Al-Warkaa" were used. The seeds were supplied by the Abu Ghraib Agricultural Research Directorate, affiliated with the Ministry of Agriculture, Iraq.

2-2-2. Plant Extracts

The following plant extracts were used and prepared according to the hot water extraction method [10]:

- Leaves of Eucalyptus
- Leaves of Conocarpus
- Roots of Licorice

2-3. Collection, Cleaning, and Drying of Plant Samples

Plant samples of Eucalyptus and Conocarpus were collected manually from the gardens of the College of Agriculture, Al-Qasim Green University, while Licorice roots were obtained from orchards in Babylon Province. The samples were washed first with tap water and then with distilled water to remove dust and impurities.

After washing, the samples were air-dried for 3–5 days at room temperature (25–28 °C) away from direct sunlight in order to preserve their bioactive compounds.

2-4. Preparation of Plant Extracts

The aqueous extracts of Eucalyptus leaves, Licorice roots, and Conocarpus leaves were prepared separately according to the method described by [6]. The plant materials were ground using an electric grinder, after which 50 g of plant powder from each species was placed in a 1000 ml

ISSN 2072-3857

glass flask containing 500 ml of boiling distilled water.

The mixture was stirred using a magnetic stirrer for 15 minutes, then left for 24 hours to ensure better extraction while being tightly covered to prevent contamination. The solution was filtered several times using medical gauze cloth, and the filtrate was collected.

Subsequently, impurities were precipitated using a centrifuge at 3000 rpm for 10 minutes. The filtrate was then concentrated using a Rotary Evaporator at 40–45 °C to obtain the dry extract, which was stored in small airtight glass bottles after recording their empty weight. The samples were preserved in a refrigerator until use.

The required concentration of the extract was prepared according to the method described by [7] by dissolving 6 g of the dry extract and completing the volume to 100 ml with distilled water, resulting in a 60% stock solution (60 mg ml^{-1}), from which a 1% working concentration was prepared.

2-5. Experimental Design and Studied Factors

Two factors were examined in this study:

First factor (A): Plant extracts

- Eucalyptus extract (1%)
- Licorice extract (1%)
- Conocarpus extract (1%)
- Control treatment (distilled water)

Second factor (B): Soaking duration

- 6 hours
- 10 hours
- 14 hours
- 18 hours
- 24 hours

The experiment consisted of:
4 soaking treatments × 5 soaking durations × 4 replicates = 80 experimental units

The plant extracts and distilled water were placed in sterilized containers, and seeds were soaked in the three plant extracts and distilled water while ensuring complete immersion of the seeds. The soaking process covered the five specified durations to evaluate the effect of soaking length on subsequent germination traits.

Soaking was conducted at laboratory temperature (25 ± 2 °C) while the containers were covered to minimize evaporation and prevent contamination. After completing the specified soaking duration, seeds were removed and rinsed with distilled water to eliminate residual extracts.

The seeds were then surface-dried using filter paper before sowing. After drying, 50 seeds were placed on moistened filter paper in each sterilized plastic Petri dish, and the moisture level was maintained by adding 5–7 ml of distilled water. Moisture was checked daily and water was added when necessary to prevent drying.

Studied Traits

2-5-1. Germination Percentage

Fifty seeds were placed on moistened filter paper in Petri dishes with four replicates and incubated at 25 ± 2 °C while maintaining adequate moisture. Germinated seeds were counted daily for 10 days, and germination percentage was calculated using the following equation:

Germination Percentage (G%)= (Number of germinated seeds / Total number of seeds) × 100 [8]

2-5-2. Mean Germination Time (MGT)

The average number of days required for seed germination was calculated using the following formula: [8]

2-5-3. Seedling Vigor Index (SVI)

After completion of germination, the radicle and plumule lengths were measured (cm), and the vigor index was calculated using:

ISSN 2072-3857

SVI = Germination Percentage (%) × Mean Seedling Length (cm) [9]

2-5-4. Shoot Length

The shoot (plumule) length of each seedling was measured using a ruler after the completion of standard germination [9].

2-5-5. Root Length

The radicle length of each seedling was measured using a precision ruler 7–10 days after germination [9].

2-5-6. Seedling Dry Weight

Seedlings were collected After completing the standard germination test10-14 days after germination and dried in an oven at 70 °C for 48 hours. The dry weight was measured for 10 seedlings, and the average was calculated for each Petri dish based on four replicates [9].

2-6. Statistical Analysis

The data were statistically analyzed using the GenStat software according to a Completely Randomized Design (CRD) with a factorial experiment arrangement. The first factor (A) represented the plant extracts (Eucalyptus, Licorice, Conocarpus, and distilled water as the control), whereas the second factor (B) represented the five soaking durations (6, 10, 14, 18, and 24 hours), with four replicates per treatment.

Treatment means were compared using the Least Significant Difference (LSD) test at a 5% probability level. Germination percentage data were subjected to angular transformation (arcsin √P) prior to analysis of variance to satisfy the assumption of normal data distribution, while the means were presented in the tables using their original values.

3: Results and Discussion

3-1. Effect of Plant Extracts and Soaking Duration on Germination Percentage (%) of Safflower Seeds

The statistical analysis presented in Table 1 showed significant differences among the plant extracts, soaking durations, and their interaction on the germination percentage of Safflower seeds. Licorice extract recorded the highest mean germination percentage (91.16%), surpassing all other treatments, followed by Eucalyptus extract (85.92%). In contrast, Conocarpus extract exhibited the lowest mean germination (72.04%), which was even lower than the control treatment (distilled water, 78.14%).Regarding soaking duration, seeds soaked for 10 hours achieved the highest germination percentage (91.76%). A significant and gradual decline in germination was observed with increasing soaking durations, reaching the lowest value (71.14%) at 24 hours of soaking.For the interaction effect, the combination (Licorice extract × 10-hour soaking) recorded the highest germination percentage (99.00%), Moreover, a soaking duration of 6 hours achieved a significant superiority, while it did not differ significantly from a soaking duration of 10 hours.

whereas the combination (Conocarpus extract × 24-hour soaking) produced the lowest value (61.97%). This superior performance of Licorice extract is attributed to its richness in triterpenoid saponins and flavonoids, which are the main bioactive compounds [10]. These compounds are classified as natural plant biostimulants, which have been proven effective in enhancing seed germination and seedling growth [11].These results are consistent with the findings of [12], who reported that extracts rich in phenolic compounds and flavonoids improved germination percentage, seedling biomass, and seedling length when evaluating 25 herbal extracts as growth stimulants on wheat.Regarding the effect of soaking durations, the results align with the triphasic water uptake principle, which emphasizes that both water and oxygen are essential for metabolic activity in the seed, and prolonged soaking can inhibit germination [13]. Moreover, That precise soaking duration has a critical effect on seedling vigor and germination rate, noting

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that extended soaking leads to a marked decline in germination percentage [14] highlighted that precise soaking duration has a critical effect on seedling vigor and germination rate, noting that extended soaking leads to a marked decline in germination percentage.

Table 1. Effect of Plant Extracts and Soaking Duration on Germination Percentage (%) of Safflower Seeds

Extracts (A) / Soaking Time (B)	Eucalyptus	Licorice	Conocarpus	Control treatment (distilled water)	Mean
6	94.88	99.00	79.85	85.60	89.83
10	95.73	99.00	82.55	89.78	91.76
14	89.22	95.52	73.02	79.87	84.41
18	75.28	81.50	62.80	68.12	71.93
24	74.50	80.75	61.97	67.35	71.14
Mean	85.92	91.16	72.04	78.14	
L.S.D	A= 1.159	B= 1.296	AB= 2.592		

3-2: Effect of Plant Extracts and Soaking Duration on Mean Germination Time (Days) of Safflower Seeds

The statistical analysis presented in Table 2 indicated highly significant effects of plant extracts, soaking duration, and their interaction on the mean germination time (MGT) of Safflower seeds. Licorice extract produced the best results, achieving the shortest germination time (4.316 days), which was significantly superior to all other treatments, followed by Eucalyptus extract with an average of 4.779 days. In contrast, Conocarpus extract resulted in the longest germination period (5.703 days), which was higher than the control treatment (distilled water, 5.213 days).

Regarding soaking durations, seeds soaked for 10 hours exhibited the shortest mean germination time (4.124 days), while a significant and gradual increase in germination time was observed with longer soaking durations, reaching the maximum of 6.180 days at 24 hours.

For the interaction effect, the combination (Licorice extract × 10-hour soaking) recorded the shortest germination time (3.535 days), whereas the combination (Conocarpus extract × 24-hour soaking) resulted in the longest germination period (6.978 days).

The superior performance of Licorice extract is attributed to its bioactive compounds, which stimulate α-amylase activity, promoting the conversion of

ISSN 2072-3857

complex carbohydrates into simple sugars that are readily available for embryo nutrition [15]. This accelerates cell division in the apical meristems, thereby shortening the germination period.

Furthermore, [16] reported that seed priming with biostimulants improves mean germination time under both normal and stress conditions. The longer germination observed with Conocarpus extract, exceeding the control treatment, aligns with previous findings [17] showing that high concentrations of Conocarpus significantly reduce germination rate, with the effect increasing at higher concentrations.

Regarding soaking duration, the 10-hour period produced the shortest MGT (4.124 days), which gradually increased to its maximum at 24 hours (6.180 days). This is explained by imbibitional stress due to oxygen deficiency, as prolonged immersion shifts seed metabolism toward anaerobic respiration, leading to the accumulation of fermentation by-products such as ethanol and acetaldehyde, which inhibit embryo activity [18]. This is accompanied by a disruption in reactive oxygen species (ROS) dynamics, where excessive ROS accumulation causes oxidation of seed proteins and deterioration of seed viability [19].

Table 2. Effect of Plant Extracts and Soaking Duration on Mean Germination Time (Days) of Safflower Seeds

Extracts **(A)** / Soaking Time **(B)**	Eucalyptus	Licorice	Conocarpus	Control treatment (distilled water)	Mean
6	3.992	3.632	4.903	4.405	4.233
10	3.908	3.535	4.685	4.370	4.124
14	4.168	3.655	5.160	4.715	4.424
18	6.020	5.272	6.788	6.120	6.050
24	5.805	5.485	6.978	6.453	6.180
Mean	**4.779**	**4.316**	**5.703**	**5.213**	
L.S.D	**A= 0.1189**	**B= 0.1329**	**AB= 0.2659**		

3-3. Effect of Plant Extracts and Soaking Duration on Radicle Length (cm) of Safflower Seeds

The statistical analysis presented in Table 3 revealed highly significant effects of plant extracts, soaking duration, and their interaction on radicle length (cm) of Safflower seeds. Licorice extract produced the highest mean radicle length (8.64 cm), significantly surpassing all other treatments, followed by Eucalyptus extract (6.64 cm). In contrast, Conocarpus extract recorded the lowest mean radicle length (4.24 cm), which was even lower than the control treatment (distilled water, 4.90 cm).Regarding soaking duration, seeds soaked for 10 hours exhibited the highest mean radicle length (7.56 cm). A significant and gradual decrease in radicle length was observed with increasing soaking durations, reaching the minimum (4.91 cm) at 24 hours.For the interaction effect, the combination (Licorice extract ×

ISSN 2072-3857

10-hour soaking) recorded the highest mean radicle length (10.05 cm), whereas (Conocarpus extract × 24-hour soaking) resulted in the lowest mean value (3.05 cm).The superior effect of Licorice extract is attributed to its bioactive compounds, which stimulate cell division in the root apical meristem. According to [16], seed hydropriming enhances radicle elongation by activating amylase and protease enzymes, providing the energy required for early cell division. Moreover, [10] reported that natural biostimulants rich in bioactive compounds promote radicle and plumule growth by enhancing endogenous hormones such as auxins and gibberellins, which stimulate cell elongation in the apical meristems.Conversely, the low radicle length observed with Conocarpus extract reflects the inhibitory effects of phenolic compounds, which impede radicle elongation and suppress the activity of growth enzymes [20].Regarding soaking duration, the 10-hour period that produced the highest radicle length aligns with findings by [14], who indicated that optimal soaking allows sufficient water uptake to activate metabolic enzymes without exposing the seed to oxygen-deficiency stress, which can reduce radicle elongation. Oxygen deficiency inhibits cell elongation in the root apex, resulting in significantly shorter radicle length, as demonstrated by [18].The highest radicle length observed in (Licorice × 10-hour soaking) and the lowest in (Conocarpus × 24-hour soaking) reflect the combined negative effects of allelopathic inhibition and oxygen-deficiency stress [20, 18].

Table 3. Effect of Plant Extracts and Soaking Duration on Radicle Length (cm) of Safflower Seeds

Extracts **(A)** / Soaking Time **(B)**	Eucalyptus	Licorice	Conocarpus	Control treatment (distilled water)	Mean
6	7.30	9.30	4.90	5.50	6.75
10	8.05	10.05	5.64	6.50	7.56
14	6.45	8.45	4.05	4.65	5.90
18	5.95	7.95	3.55	4.15	5.40
24	5.45	7.45	3.05	3.68	4.91
Mean	**6.64**	**8.64**	**4.24**	**4.90**	
L.S.D	**A= 0.743**	**B= 0.831**	**AB= 1.662**		

3-4. Effect of Plant Extracts and Soaking Duration on Shoot Length (cm per seed) of Safflower Seeds

The statistical analysis presented in Table 4 revealed highly significant effects of plant extracts, soaking duration, and their interaction on shoot length (cm) of Safflower seeds. Licorice extract produced the highest mean shoot length (5.947 cm per seed), significantly exceeding all other treatments, followed by Eucalyptus extract

ISSN 2072-3857

(5.484 cm per seed). In contrast, Conocarpus extract recorded the lowest mean shoot length (4.398 cm per seed), which was lower than the control treatment (distilled water, 5.068 cm per seed).Regarding soaking duration, seeds soaked for 10 hours exhibited the highest mean shoot length (5.923 cm per seed). A significant and gradual decline in shoot length was observed with increasing soaking durations, reaching the lowest value (4.542 cm per seed) at 24 hours.For the interaction effect, the combination (Licorice extract × 10-hour soaking) recorded the highest mean shoot length (6.668 cm per seed), whereas (Conocarpus extract × 24-hour soaking) resulted in the lowest mean value (3.697 cm per seed).The superior performance of Licorice extract is attributed to its role as a biostimulant, activating endogenous growth hormones, particularly gibberellins, which promote cell elongation in shoot tissues. According to [10], soaking seeds in natural biostimulants improves the levels of auxins, gibberellins, and cytokinins, accelerating cell division and elongation in the embryonic axis. These results are consistent with [16], who reported that priming with biostimulants significantly enhances shoot length in Sweet pepper.Conversely, the low shoot length observed with Conocarpus extract reflects the allelopathic effects of Phenolic compounds and tannins, which inhibit elongation of the embryonic axis [20, 17].The gradual decline in shoot length with longer soaking durations aligns with [15], who noted that excessive seed imbibition inhibits cellular elongation in the shoot due to the accumulation of anaerobic respiration by-products, which impede the activity of cell wall–building enzymes. Furthermore, [16] indicated that short-to-medium priming durations produce better shoot elongation compared to prolonged priming.The highest shoot length recorded in (Licorice × 10-hour soaking) and the lowest in (Conocarpus × 24-hour soaking) illustrates the positive synergistic effect of optimal biostimulants with ideal soaking durations on shoot elongation, and the negative synergy between the least effective extracts and the most damaging extended soaking periods [18, 20].

Table 4. Effect of Plant Extracts and Soaking Duration on Shoot Length (cm per seed) of Safflower Seeds.

Extracts **(A)** / Soaking Time **(B)**	Eucalyptus	Licorice	Conocarpus	Control treatment (distilled water)	Mean
6	6.100	6.425	5.067	5.558	5.788
10	6.332	6.668	5.123	5.568	5.923
14	5.627	6.350	4.692	5.260	5.483
18	4.907	5.393	4.115	4.418	4.708
24	4.500	4.900	3.697	3.973	4.268
Mean	**5.494**	**5.947**	**4.539**	**4.955**	
L.S.D	**A= 0.1448**	**B= 0.1619**	**AB= 0.3237**		

ISSN 2072-3857

3-5. Effect of Plant Extracts and Soaking Duration on Seedling Dry Weight (mg per seedling) of Safflower Seeds

The statistical analysis presented in Table 5 revealed highly significant effects of plant extracts, soaking duration, and their interaction on the seedling dry weight (mg) of Safflower seeds. Licorice extract produced the highest mean dry weight (14.800 mg), significantly surpassing all other treatments, followed by Eucalyptus extract (13.525 mg). In contrast, Conocarpus extract recorded the lowest mean dry weight (11.231 mg), which was even lower than the control treatment (distilled water, 12.688 mg).Regarding soaking duration, seeds soaked for 10 hours exhibited the highest mean dry weight (14.875 mg). A significant and gradual decline in seedling dry weight was observed with increasing soaking durations, reaching the minimum (10.688 mg) at 24 hours.For the interaction effect, the combination (Licorice extract × 10-hour soaking) recorded the highest mean dry weight (18.000 mg), whereas (Conocarpus extract × 24-hour soaking) resulted in the lowest mean value (8.750 mg).The superior effect of Licorice extract is attributed to its bioactive compounds, which enhance the mobilization of food reserves (starch and proteins) in the endosperm, converting them into readily available materials for seedling tissue formation. As reported by [15], activation of α-amylase during germination accelerates starch hydrolysis into simple sugars, which are used for biomass accumulation. Moreover, [16] confirmed that all priming treatments with biostimulants significantly increased total seedling biomass compared to the control.Conversely, the low dry weight observed with Conocarpus extract reflects the negative allelopathic effect, which not only inhibits germination but also disrupts biomass accumulation in seedlings [20].Regarding soaking duration [14] noted that optimal hydropriming durations achieve the highest seedling biomass, whereas prolonged priming depletes seed food reserves without efficiently converting them into seedling tissue. This aligns with [19], who reported that excessive oxidative stress due to oxygen deficiency impedes dry matter accumulation in seedlings.

Table 5. Effect of Plant Extracts and Soaking Duration on Seedling Dry Weight (mg per seedling) of Safflower Seeds.

Extracts **(A)** / Soaking Time **(B)**	Eucalyptus	Licorice	Conocarpus	Control treatment (distilled water)	Mean
6	13.250	17.250	11.500	13.250	13.812
10	16.000	18.000	12.500	13.000	14.875
14	13.250	14.500	10.500	11.750	12.500
18	12.500	12.250	10.250	10.000	11.250
24	10.750	12.000	10.000	10.000	10.688
Mean	**13.150**	**14.800**	**10.950**	**11.600**	
L.S.D	**A= 0.5355**	**B= 0.5987**	**AB= 1.1974**		

ISSN 2072-3857

3-6. Effect of Plant Extracts and Soaking Duration on Seedling Vigor Index of Safflower Seeds

The statistical analysis presented in Table 6 indicated highly significant effects of plant extracts, soaking duration, and their interaction on the seedling vigor index (SVI) of Safflower seeds. Licorice extract recorded the highest mean SVI (1342), significantly surpassing all other treatments, followed by Eucalyptus extract (1045). In contrast, Conocarpus extract showed the lowest mean SVI (645), which was lower than the control treatment (distilled water, 788).Regarding soaking duration, seeds soaked for 10 hours exhibited the highest mean SVI (1243). A significant and gradual decline in SVI was observed with increasing soaking durations, reaching the minimum (617) at 24 hours.For the interaction effect, the combination (Licorice extract × 10-hour soaking) recorded the highest SVI (1655), whereas (Conocarpus extract × 24-hour soaking) resulted in the lowest SVI (418).The superior performance of Licorice extract over Eucalyptus and Conocarpus indicates that SVI serves as an integrative indicator, reflecting both germination quality and seedling strength. SVI is calculated according to the equation [21], which relates germination percentage to seedling length or dry weight. Consequently, the superior performance of Licorice across all measured components—germination percentage, radicle length, shoot length, and dry weight—is reflected in its enhanced SVI [12] reported that plant biostimulants rich in phenolic compounds and flavonoids significantly enhance SVI comprehensively. The lowest SVI observed with Conocarpus extract reflects the cumulative effect of allelopathic inhibition across all seedling vigor components [17, 20].The gradual decline in SVI with increasing soaking duration up to 24 hours aligns with [14], who indicated that prolonged soaking disrupts metabolic balance, negatively affecting all SVI components. [16] confirmed that short-to-medium priming durations yield optimal SVI values by maintaining metabolic enzyme activity and preventing depletion of seed reserves.The lowest SVI in the combination (Conocarpus × 24-hour soaking) illustrates the negative synergy between allelopathic inhibition and oxygen-deficiency stress, resulting in the lowest values across all six measured seedling traits simultaneously [17, 18, 20].

Table 6. Effect of Plant Extracts and Soaking Duration on Seedling Vigor Index of Safflower Seeds.

Extracts **(A)** / Soaking Time **(B)**	Eucalyptus	Licorice	Conocarpus	Control treatment (distilled water)	Mean
6	1272	1557	797	946	1143
10	1379	1655	889	1083	1251
14	1078	1414	638	790	980
18	819	1086	481	584	743
24	742	997	418	515	668
Mean	**1058**	**1342**	**645**	**784**	

ISSN 2072-3857

L.S.D	A= 67.7	B= 75.7	AB= 151.4

4:Conclusion

1. Soaking seeds in plant extracts improved the traits and vigor of Safflower seeds, which was clearly evident in this study.
2. Soaking duration is a critical factor that directly influences seed quality and the formation of uniform seedlings.
5. should be avoided.

5: Recommendations

1. Adopt Licorice root extract for bio-priming of Safflower seeds at an effective concentration to enhance seed vigor prior to sowing.
2. Limit soaking duration to 10 hours to ensure the highest germination percentage and uniform seedling emergence in the field.
3. Avoid using Conocarpus extract for seed soaking treatments due to its clear negative
5. environments.
3. Licorice root extract was identified as the most effective extract for enhancing the quality and vigor of Safflower seeds.
4. Some extracts, such as Conocarpus, exhibited inhibitory effects on germination quality and

effects on seedling growth and development.

4. Conduct future studies to evaluate different concentrations of Licorice root extract under salinity or drought stress conditions to assess its potential for improving seed performance under adverse

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