ALLELOPATHIC POTENTIAL AND CHEMICAL CHARACTERIZATION OF TAIF'S ROSE (*ROSA DAMASCENA* MILL. VAR. *TRIGENTIPETALA*) PLANTS GROWN ON TAIF HIGHLANDS

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Abstract. The goal of the current study was to determine whether Taif's rose trimmed leaves would have an allelopathic effect on the ability of some crop plants to germinate and flourish. Plant samples were collected from a rose farm in Taif city, air dried, and the chemical constituents were analyzed. Egyptian clover seeds, as well as wheat and maize grains were selected for any potential allelopathic effects on germination and seedling growth. Taif's rose leaves contained significant amounts of sugars (0.66 mg g^{-1}), cardiac glycosides (7.66 mg g^{-1}), flavonoids (10.9 mg g^{-1}), and alkaloids (16.33 mg g^{-1}). The germination percentage (GP) of clover seeds increased gradually from 96.0% at the control (0% leaf extract) to its maximum value (100.0%) at 1.0% extract, and then decreased to reach 48.0% at 3.5%. Besides, the maximum GP of wheat and maize (92.0 and 93.2%) was recorded at the control, while the minimum (50.7 and 5.3%) at 3.5% extract concentration. The highest root and shoot length of clover (2.7 and 5.0 cm), wheat (10.8 and 15.3 cm) and maize (8.3 and 5.2 cm) seedlings were recorded at the control treatment, and these values decreased with increasing extract concentration. The mean germination time of clover seeds and wheat grains was the highest (54.0 and 49 days) at the control, while that of maize was 40.3 days at 2.0% extract concentrations. Taif's rose leaves can be used at lower concentrations as soil amendment to stimulate the growth of clover but cannot be used for the other tested crops.
Keywords: *pruned wastes, allelochemicals, rose shrubs, Taif highland, secondary metabolites*

Introduction

Rosa damascene Mill. var. *trigentipetala* is a key agricultural plant that produces essential oils and is planted in many countries, including Saudi Arabia (Galal et al., 2022a). It only blooms once a year in May or June and can reach a height of 2.5 meters. When fully grown, it can produce around 600 flowers (Nunes and Miguel, 2017). At heights between 300 and 2500 m, Taif's rose can flourish in temperate and subtropical climes (to Najem et al., 2011). Additionally, it is a highly aromatic plant used in the food, fragrance, and pharmaceutical industries (Al-Yasi et al., 2020). In addition, it includes a variety of phytochemical components, including phenolic acids, flavonoids, alkaloids, which have several health benefits, including antidiabetic, antioxidant, and antibacterial effect (Pal et al., 2014; Labban and Thallaj, 2020; Ghavam et al., 2021; Galal et al., 2022b; Hamza et al., 2022). Approximately, 860 Taif's rose farms are cultivated in Taif governorate, which produce huge quantities of pruning wastes (Galal et al., 2022b). A tiny portion of these wastes is used for propagation, while the majority is dried and burned posing environmental pollution, and consequently health hazards to the surrounding residents (Galal et al., 2022c). These agricultural wastes can be recycled in different forms; the gasification of crops, using the crop stalks as feed, medicinal purposes, weed control and fertilizers (Yaqoob et al., 2021; Koul et al., 2022).

Allelopathy is the process that includes any direct or indirect effects of the release of allelochemicals into the environment on the growth of one species on that of another (Rice, 1984; Dandelot et al., 2008; Abdel-Farid et al., 2013; Vasishth et al., 2020). Due

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to its potential, allelopathy has drawn attention from all over the world in the last 20 years, and several areas of crop allelopathy have been identified (Asaduzzaman et al., 2010). Numerous reports have demonstrated that allelopathic crops hinder the emergence, growth, and production of other crops planted in the same fields at the same time or later (El-Darier et al., 2014, 2018; El-Kenany et al., 2017), with the latter two constitute the primary sources (Qiming et al., 2006; Hagan et al., 2013). Four biological processes; volatilization, leaching, leaf breakdown, and root exudation, often result in the release of allelochemicals into the soil, with the last two of these serving as the primary sources (Qiming et al., 2006; Hagan et al., 2013). These chemicals are produced as secondary metabolite compounds during various plant metabolisms (Farooq et al., 2011; Bhadoria, 2011). They can prevent root elongation and/or seed germination (Del Fabbro et al., 2014; Farahat et al., 2019), which can occasionally result in the partial or whole loss of sensitive plant root systems (Rudrappa et al., 2007). Secondary metabolites identified as allelochemical compounds include alkaloids, phenols, momilactone, terpenoids, flavonoids, brassinosteroids, salicylates, glucosinolates, hydroxy acids, jasmonates, carbohydrates, and amino acids (Jabran and Farooq, 2012). The effect of these compounds depends on their concentration because in high concentrations they inhibit plant growth and promote that in low concentrations (Cheema et al., 2012).

Perennial species, like Taif's rose shrubs, remain a part of the agroecosystem for a long period (Kumari et al., 2016) which produce large amount of pruning wastes (Galal et al., 2022b). Suppressing or stimulating the impacts of shrubby plants on annual crops because of allelopathic interaction is one of the main factors for selecting or rotating crop groups (Kumari et al., 2016). Our main question is whether the unsafe disposal of Taif's rose pruning wastes impacts the growth of other economic crops? According to Siddiqui et al. (2009), plant leaves are the most potent source of allelochemicals; and thus, the current study was conducted to investigate the possible allelopathic interference of Taif's rose pruned leaves on the germination and growth of some economic crop plants and the chemical constituent, which may be responsible for this effect. Accordingly, one may suggest which of these crops is sensitive or tolerant to allelochemicals produced by Taif's rose pruned leaves for their possible and safe utilization.

Materials and methods

Plant sampling and analysis

The leaves of Taif's rose were obtained from Al-Shafa farms, Taif, Saudi Arabia. Leaves were air-dried at room temperature and then homogenized. A 250 g sample of plant powder was mixed with 1 liter absolute ethanol for 24 hr at room temperature. Then, Whatman No. 1 filter paper was used to filter the extract. Using an evaporator, the filtrate was compressed to dry at 40 °C below low pressure. For the aim of examining the phenolic acids, alkaloids, flavonoids, and cardiac glycosides, the extract was kept between 2 and 8 °C. The cardiac glycosides were measured using the methods described previously (Solich et al., 1992; Tofighi et al., 2016), and the total soluble carbohydrates were calculated using the anthrone method (Sadasivam and Manickam, 2008). The total flavonoids were calculated using by Tofighi et al. (2016), while the phenolics in the plant's ethanol extract was assessed based on Tofighi et al. (2016) and Singleton et al. (1999) methods. The alkaloid content was also calculated using the Adegoke et al. (2010) method. Using HPLC-MS techniques, the various flavonoid, phenolic, and alkaloid

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chemicals in the Taif's rose leaf samples were separated, identified, and quantified (Schütz et al., 2005).

Allelopathy experiment

Allelopathic effect of Taif's rose leaves on the germination and seedling growth on the seed of *Trifolium alexandrinum* L. and the grains of *Triticum aestivum* L. and *Zea mays* L. was assessed using the method that developed by Salhi et al. (2012). Several fresh leaf samples were taken while the plant was being pruned. Samples were then kept at ambient temperature to dry by air. When ready for use, samples are then ground to a fine, homogeneous texture and kept in tubes at a low temperature. By soaking 50 g of air-dried in 500 mL of distilled water at room temperature for 24 h with intermittent shaking, the aqueous extract of the stock was produced. Finally, the mixture was filtrated and then centrifuged at 10,000 rpm/20 min. The stock solution and the control group (distilled water) were used to prepare various concentrations (0.5–5.00%). 2% sodium hypochlorite was applied to seeds and grains for 2 minutes, followed by a washing in distilled water, before they were ready for sowing. 100 seeds or grains (25 seeds/grain x 4 Petri dishes) of each plant crop were put in 9 cm diameter Petri dishes lined with two Whatman No. 1 filter paper discs under conventional laboratory illumination conditions. Between 19 and 22 °C were the permitted daytime temperatures, while 12 to 14 °C were the permitted nightly temperatures. Each concentration was repeated four times.

After 10 days, measurements of the germination percentage (GP), shoot height, and root length were taken. Mean germination time (MGT) was determined as: $\mathrm{MGT} = \sum(\mathrm{ni} \times \mathrm{di}) / \mathrm{N}$, where n is the number of seeds that have germinated as of day i, d is the number of days the seeds have been incubating, and N is the total number of seeds that have germinated in the treatment (Redondo-Gómez et al., 2007).

Statistical analysis

To evaluate the variation in the GP, shoot height, and root length of the tested crops among the various concentrations of Taif's rose water extracts, one-way analysis of variance (ANOVA 1) was employed using SPSS software (SPSS 2012). A post-hoc test was applied according to (Duncan's test) when differences are significant.

Results and discussion

Chemical properties

Because energy for tree regrowth is drawn from the stocks of these carbohydrates in the trimmed plant, trimming plant shoots affects both photosynthesis and non-structural carbohydrate synthesis (Chesney and Vasquez, 2007; Pal et al., 2014). Chemical analysis of the cut Taif's rose leaves revealed the presence of carbohydrates (*Table 1*). Similar results were discovered in the petals of the same species (Fathima and Murthy, 2019), as well as in the pruning wastes (Galal et al., 2022b; Hamza et al., 2022). Since carbohydrates are bio-informative molecules, determining their presence in plants is essential for quality control analyses (Campa et al., 2006).

The leaves contained 0.66 mg mg^{-1} of carbohydrates (*Table 1*), which was lower than that reported by Galal et al. (2022b) for Taif's rose leaves (3.05 mg mg^{-1}) and by El-Bakry et al. (2014) for *Calotropis procera* leaves (9.0-16.3 mg mg^{-1}), but within the range of 0.25-4.05 mg mg^{-1} for medicinal aloe plant leaves (Aseeri et al., 2020). Carbohydrates in

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trimmed leaves could be a reaction to rose plant dehydration after and before pruning (Al-Yasi et al., 2020).

***Table 1.** Phytochemical constituents (mean±SD) of the leaves of Taif's rose collected from Al-Shafa highlands. RT: retention time*

Chemical constituent	Carbohydrates mg mg^{-1}	Cardiac glycosides mg securiaside g^{-1}	Phenolics mg GAE g^{-1}	Flavonoids mg RUE g^{-1}	Alkaloids mg AE g^{-1}
Concentration	0.66±0.08	7.66±0.20	16.33±0.10	10.9±0.2	3.44±0.14

Other phytochemical analysis of the leaves was also determined, and data are shown in *Table 1*. The leaves had higher levels of phenolic compounds, cardiac glycosides, and flavonoids, but lower alkaloid content (*Table 1*). Galal et al. (2022b) reported similar results in another study on the same species. In the past, individuals with congestive heart failure or cardiac arrhythmias have been treated with a class of secondary chemicals known as cardiac glycosides to improve their heart's contractile force (Abarquez, 2001). Additionally, the phenolics were less than the 386.4 mg g^{-1} reported in the flower residue of the Taif's rose (Liu et al., 2020), indicating that the pharmacological effects (antioxidant, whitening, anti-ageing, and anticancer) of the leaves were less than those of the flowers (Galal et al., 2022b). According to published report, Taif's rose has antibacterial and disinfecting properties (Nayebi et al., 2017).

The HPLC analysis of the phytochemicals of leaves indicated that jatrorrhizine, berbamine, isocorydine, reticuline, and boldine were the important alkaloid compounds, while apigenin, quercetin, luteolin, kaempferol, rutin, and chrysoeriol were Flavonoids, and catechol, Ellagic acid, gallic acid, and phloroglucinol were the main phenolics (*Table 2, Fig. 1*). Galal et al. (2022b) mentioned the same compounds beside to chrysoeriol (flavonoid), palmatine (alkaloid), and resorcinol (phenolic) in the leaves and stems of the same plant. According to Baydar and Baydar (2013), When compared to the others, the rose-leaf extract from Taif was highly concentrated in phenolic acids like gallic, ferulic, and flavonoids like catechin. Biologically active, alkaloid chemicals are produced as secondary components in a variety of medicinal plants and are employed as medications; however, many of them are extremely toxic (Algradi et al., 2021; Malhotra et al., 2021). They are frequently found in Chinese medicinal herbs and have been shown to have qualities that reduce inflammation, fight cancer, fight bacteria, promote leukocytosis, and more (Petruczynik, 2012).

According to Dahat et al. (2021), the flavonoids may have anti-inflammatory, antioxidant, and anti-microbial effects. They also reported that quercetin and its glycoside rutin have been found in extracts with nephroprotective properties. Additionally, quercetin reduces the formation of mouth sores, aids in the induction of minor symptomatic relief, and helps to guard against specific cancer types, particularly colon cancer (Sharma and Gupta, 2010). Apigenin and luteolin have been demonstrated to reduce the occurrence of mouth sores and provide minor symptomatic relief while also being able to limit the viability of ovarian carcinoma, colon, leukemia, and mostly human breast cancer cells (Adom et al., 2017). Additionally, the amount of gallic acid detected in Taif's rose leaves was 5.41 mg g^{-1}, which was lower than the amounts of 5.6 mg g^{-1} found in the plant's wastes (Galal et al., 2022b) and 50.3 mg g^{-1} discovered in its flower residue (Liu et al., 2020). Gallic acid has a wide range of pharmacological effects, including anti-inflammatory, antiviral, antibacterial, antimutagenic, and anticancer

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characteristics (Yanni et al., 2017). In addition, ellagic acid is a significant chemical employed in the treatment of chronic ulcerative colitis as an anti-inflammatory, multifunctional antioxidant, and anticarcinogenic agent (Mirsane and Mirsane, 2017).

Table 2. *HPLC analysis of the alkaloids (a), flavonoids (b), and phenolic compounds (c) of the leaves of Taif's rose collected from Al-Shafa highlands*

a)

Factor	**Alkaloids concentration (mg g^{-1})**				
	Berbamine	**Jatrorrhizine**	**Reticuline**	**Isocorydine**	**Boldine**
Leaves	4.79	5.6	5.3	9.1	4.79
RT (min.)	18	20	32	40	51

b)

Factor	**Flavonoids concentration (mg g^{-1})**					
	Quercetin	**Avecularine**	**Apigenin**	**Luteolin**	**Rutin**	**Kaempferol**
Leaves	20.1	2.5	47.02	13.6	25.36	19.1
RT (min.)	40	62	18	26	43	51

c)

Factor	**Phenolics concentration (mg g^{-1})**			
	Gallic acid	**Ellagic acid**	**Catechol**	**Phloroglucinol**
Leaves	5.41	11.69	8.6	1.69
RT (min.)	59	20	36	64

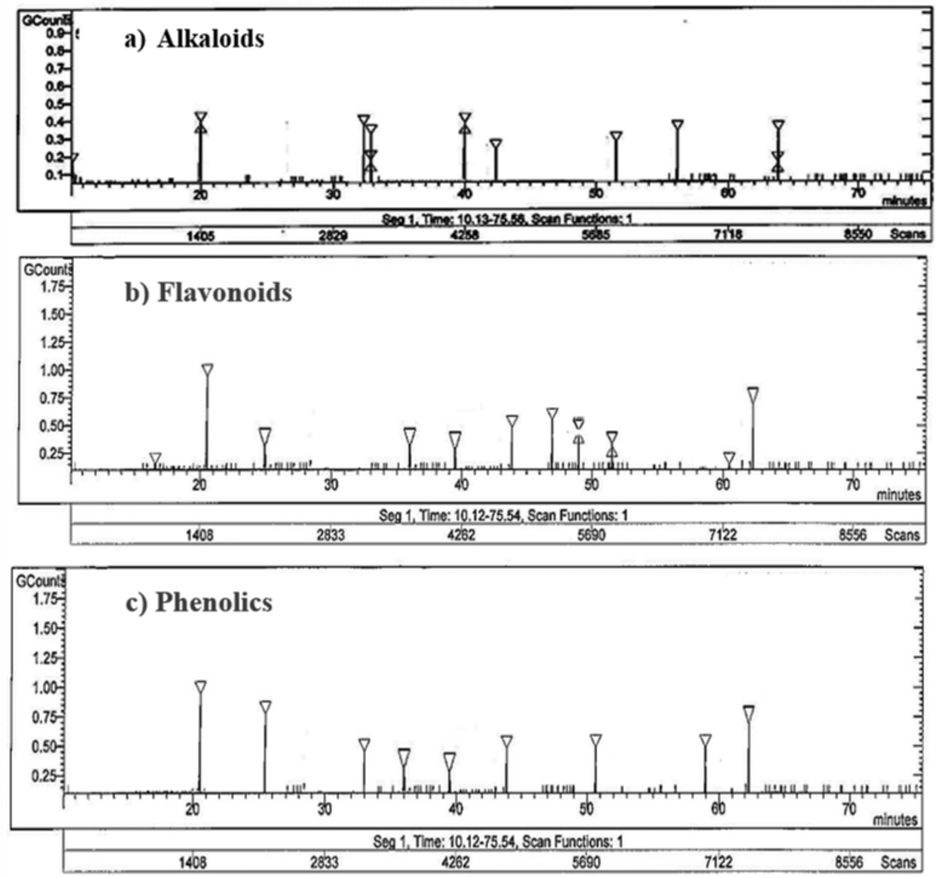

Figure 1. *HPLC analysis of the alkaloids (a), flavonoids (b), and phenolic compounds (c) in the leaves of Taif's rose collected from Al-Shafa highlands. Triangles represent the recorded compounds peaks*

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Allelopathic potential of Tif's rose leaves

Germination percentage (GP)

Allelopathic inhibition is a very complex process. Different chemical types, including flavonoids, phenolic compounds, alkaloids, carbohydrates, steroids, and amino acids, can interact with mixtures of other chemicals, sometimes having a higher allelopathic effect than the components alone (Ferguson et al., 2013).

The statistical analysis assessing the effect of different concentration of Taif's rose leaves water extract on the GP of *Trifolium alexandrinum* (clover), *Triticum aestivum* (wheat), and *Zea mays* (maize) after 10 days from sowing under in-vitro conditions was shown in *Table 3*. Although wheat, maize and Egyptian clover has allelopathic potentiality against some weeds and crops, it appears that it is not protected in contradiction of the allelopathic impacts of other plants (Albuquerque et al., 2011). The present findings indicated the great effect of allelopathic potential of Taif's rose leaf extract on the GP of the tested species. Farooq et al. (2013) attributed the toxicity of plants to the toxic allelochemicals such as alkaloids, cardiac glycosides, and phenolic compounds. Our results also found that Taif's rose leaves included high contents of cardiac glycosides, flavonoids, and phenolic compounds but low alkaloid content. It is generally documented that phenolics are the primary responsible for growth inhibition of competing plants (Nour et al., 2012). In addition, several flavonoids such as isoquercitrin, quercetin, quercetrin, and rutin among numerous others have shown effects on plant growth (Iqbal et al., 2005). Moreover, alkaloids can work by producing the production of ROS at the root meristem, which initiate a series of biochemical and genetic modifications (Hagan et al., 2013).

Table 3. *Germination percentage (mean±SD) of three economic crop seeds treated with different concentrations of Taif's rose leaf extract*

Extract concentration (%)	**Egyptian clover**		**Wheat**		**Maize**	
	Germination%	Reduction %	Germination%	Reduction %	Germination%	Reduction %
Control	96.0±4.0ab		92.0±5.2a		93.3±2.3a	
0.5	97.3±2.3a	-1.4	88.0±6.9a	4.3	73.3±3.4b	21.4
1.0	100.0±0.0a	-4.1	89.3±6.1a	2.9	76.0±3.9b	18.5
1.5	90.7±2.3b	5.5	82.7±8.2a	10.1	72.0±5.8b	22.8
2.0	86.7±2.3b	9.7	81.3±6.1a	11.6	46.7±6.1c	49.9
2.5	66.2±3.1bc	31.0	52.0±0.0b	43.5	16.0±4.0d	82.9
3.5	48.0±7.8c	50.0	50.7±6.1b	44.9	5.3±2.2de	94.3
5.0	0.0d	100.0	0.0c	100.0	0.0e	100.0
F-value	126.9***		50.8***		55.8***	

***: P < 0.001

The GP of the tested species varied significantly ($P < 0.001$) with varying concentrations of the Taif's rose leaf extract. The results indicated that the germination of clover seeds was stimulated at low concentrations of Taif's rose extract, where it was increased gradually from 96.0% at the control (0% leaf extract) to its maximum value (100.0%) at 1.0% extract, and then decrease to reach 48.0% at 3.5% extract concentration with a reduction of 50.0%. Secondary metabolites can promote germination by breaking

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seed dormancy, promoting root growth by increasing moisture availability and by regulating temperature, promoting mineralization, and enhancing nutrient uptake (Harms and Oplinger, 1993; Farooq et al., 2013). Chen (1999) also noted that several allelochemicals could aid in the growth of plants. Al-Zahrani and Al-Robai (2007) provided further evidence that the association is growth promoting at low levels and growth inhibiting at high ones. When the level of an allelochemical exceeded a threshold, organisms could still use them at low levels but became poisoned (Qiming et al., 2006).

The finding of present investigation has clearly revealed that GP of maize grains was significantly higher ($P < 0.001$) in control as compared to the different concentrations of Taif's rose leaf water extract. However, the GP of wheat has similar trend until 2.0% concentration, and then significantly reduced. The maximum GP of wheat (92.0%) was registered at the control, and then it was gradually decreased by increasing the concentration of the extract until it reached 50.7% with reduction percentage 44.9% at 3.5% extract concentration. Similarly, the GP of maize grains reduced from 93.2% at the control to 5.3% at extract concentration of 3.5% with a reduction percentage of 94.3%. The germination of these seeds was found to be sensitive to the high concentrations of Taif's rose leaf extracts. According to Vasishth et al. (2020), the germination inhibition was improved with increasing the concentrations of extract. According to Rice (1984), it was caused by several factors, such as a decline in the activity of the mitotic process in plants, a slower rate of ion uptake, a reduction in photosynthetic respiration, and enzyme activity. Alam and Islam (2002) recognized the inhibition of seed germination of several crop plants to the disruption of the several enzymes activities including peroxidase, alpha-amylase, and acid phosphates. Additionally, *Sida alba* leaves release allelopathic compounds that accumulate to bioactive levels and negatively impact some wheat cultivars' seed germination and growth, according to Abdel-Latif et al. (2015).

It should be noted that there was no germination for the three tested species at 5.0% concentration of leaf water extract. This may be due to the inhibitory effect of allelopathic substances present in the extract (Farooq et al., 2013). The findings appeared to support the claim made by Nasrine et al. (2014) that phenolic acids are possible chemicals that can have an inhibitory effect on germination. Additionally, the accumulation of phenolics in the soil may prevent the related species germination and growth (Soliman, 2022). El-Kenany and El-Darier (2013) additionally stated that the fruits, roots, and leaves of *Lantana camara* contain allelochemicals, primarily aromatic alkaloids and phenolics, which hinder the germination and growth of other species.

Allelochemicals, which include phenolic acids, terpenoids, alkaloids, flavoniods, coumarins, and glycosides, are secondary plant compounds that are mostly derived from medicinal plants (Nasrine et al., 2014). Inhibition of seed germination and seedling growth is widely demonstrated to result from the allelopathic actions of these chemicals early in the life cycle. It is well known that plants emit these compounds to prevent the appearance or growth of competing plants. The behavior of the clover seeds' germination showed that at lower Taif's rose extract concentration the germination started after two days from sowing with the maximum GP at the 3rd day, while at high extract concentrations, the germination started at the 3rd day with the highest GP at the 5th day (*Fig. 2a*). The germination of wheat grains appeared to be sigmoid with gradual increase after the 2nd day with the maximum GP during the 7th day at higher extract concentrations and 6th day at lower concentration treatments (*Fig. 2b*). Likewise, at leaf extract levels from 0.0 – 2.0 %, the clover seeds started to germinate at the 4th day and gradually improved until it reached the highest at the 10th day (*Fig. 2c*). Nevertheless, at higher rates

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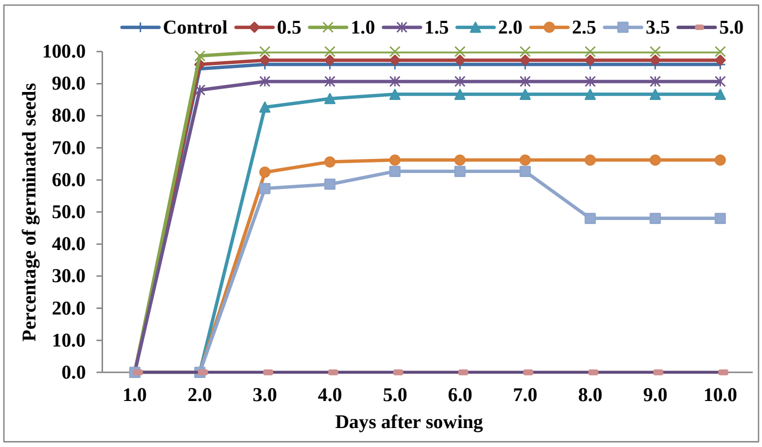
the seeds germinated after 6th day with lower GP. It seemed that the clover seeds were more resistant to the extract than wheat and maize. Similar results were recorded by Alzletni et al. (2020) on the allelopathic influence of common mallow on the germination behaviour of clover and wheat. Earlier investigate examining extracts from glycosides-producing plants have revealed inhibition of other species through decreased germination, and reduced seedling appearance, as well as delayed seed germination (Norsworthy et al., 2007; Malik et al., 2008).



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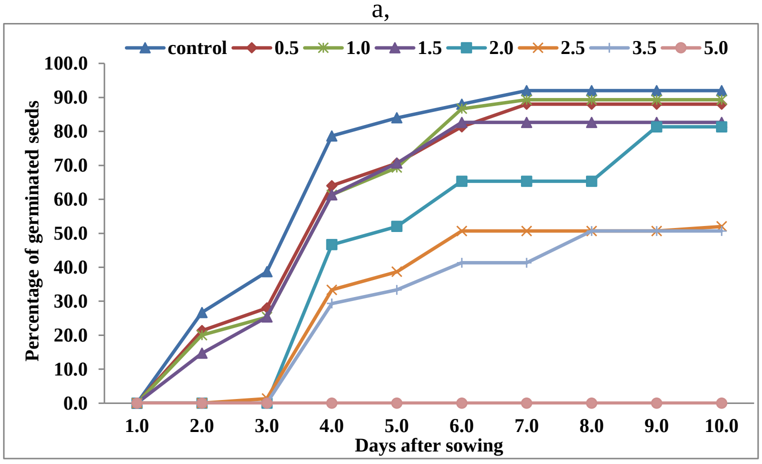

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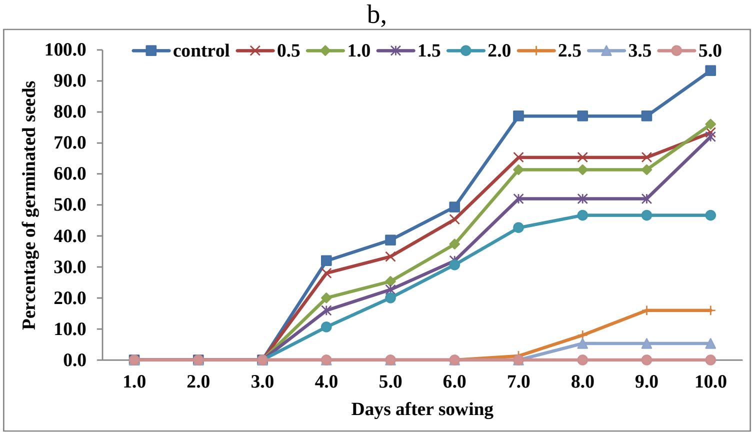

c,

Figure 2. *Germination percentage of clover seeds (a), wheat (b) and maize (c) grains grown under the effect of different concentrations (%) of Taif's rose water extract*

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Root length and shoot height

Allelopathic interactions in tree-crop associations greatly influence the crop production, as well as root and shoot development (Vasishth et al., 2020). The results of allelopathy showed great variation (P < 0.001) in the root and shoot height of the test plants' seedlings with the different concentrations of Taif's rose water extract (*Table 4*). From the present results, it was observed that the roots of the tested plants were more affected than the shoots. This finding is consistent with other research that found water extracts of allelopathic plants had more impacts on root development than shoot growth (Al-Zahrani and Al-Robai, 2007). This is probably because the roots are the first parts of a plant to absorb allelochemicals from the environment (Turk and Tawaha, 2002). The highest root and shoot length of clover seedlings (2.7 and 5.0 cm, respectively) was recorded at the control treatment. Besides, increasing the leaf extract concentration decreased the length of root and shoot until reached the minimum (0.2 and 0.5 cm) at 3.5% extract concentration, and after that the germination stopped. The root and shoot length of wheat seedlings had its maximum values (10.8 and 15.3 cm, respectively) at 0.5% rose extract concentration and then gradually decreased to reach its lowest values (0.5 and 3.0 cm) at 3.5% extract concentration. Besides, the root length of maize seedlings had it maximum (8.3 cm) at the control, while its minimum (0.2 cm) at 3.5% extract concentration. However, the shoot length decreased gradually from 5.2 cm at the control treatment until reach its minimum value (1.6 cm) at 2.0% extract concentration and then no germination occurred. Similar results were reported by Soliman (2022) who found that the longest wheat and clover roots were recorded at the control (0.00% plant extract), while the highest wheat and clover shoot were at 1.50% and 0.50% of Plantago major shoot extract, respectively. The total phenolic content of Sorghum bicolor plant parts was favorably correlated with the inhibition of wheat radicle formation (Ben-Hammouda et al., 2001). Plants like maize were strongly affected by these allelochemicals (El-Darier et al., 2018).

Table 4. *The mean root and shoot length (cm) of the three test plants' seedlings grown under the effect of different concentrations of Taif's rose leaf extract*

Extract concentration (%)	**Egyptian clover**		**Wheat**		**Maize**	
	Root length (Cm)	**Shoot length (Cm)**	**Root length (Cm)**	**Shoot length (Cm)**	**Root length (Cm)**	**Shoot length (Cm)**
Control	2.7±0.5a	5.0±0.9a	8.4±1.7b	14.3±1.3ab	8.3±1.2a	5.2±1.6a
0.5	1.4±0.4b	4.6±0.7ab	10.8±1.4a	15.3±0.9a	6.3±1.3b	2.8±0.6b
1.0	1.1±0.3b	3.8±0.9b	6.9±1.3c	14.8±1.5a	4.3±1.1c	2.9±0.7b
1.5	0.6±0.2c	4.6±0.7ab	5.8±1.2c	13.2±1.7b	2.5±0.6d	1.9±0.4bc
2.0	0.3±0.1cd	1.4±0.3cd	1.5±0.4d	5.9±1.2c	1.5±0.3de	1.6±0.4bc
2.5	0.4±0.1cd	2.2±0.6c	0.6±0.2de	2.8±0.5d	0.4±0.1e	0.0c
3.5	0.2±0.0cd	0.5±0.1de	0.5±0.1de	3.0±0.7d	0.2±0.0e	0.0c
5.0	0.0d	0.0e	0.0e	0.0e	0.0e	0.0c
F-value	**26.9*** **	**30.6*** **	**83.6*** **	**145.4*** **	**26.4*** **	**9.2*** **

***: P < 0.001

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Germination speed

The mean germination time (MGT) is defined as a measure of the speed and time-spread of germination (Bewley et al., 2013). It is the reciprocal of the rate of germination that has been shown to be highly indicative of emergence performance of seeds (Soltani et al., 2015). The germination speed of clover seeds was highest (MGT = 54.0 days) at Taif's rose extract concentrations from 0.0 – 1.0% and then gradually decreased to reach its minimum 51.1 days at 3.5% concentration (*Fig. 3*). In addition, the germination speed of wheat and maize grains had fluctuated pattern with the highest 49 and 40.3 days at control treatment and 2.0 % extract concentrations, respectively. Soliman (2022) reported similar results on the MGT of clover and wheat (44.0 and 38.4 days, respectively) under the allelopathic effect of *P. major*. However, the lowest germination speed (41.4 and 23.6 days) was recorded at 2.0 and 2.5 extract concentration. The decline in the germination rate of the tested species may be attributed to the allelochemicals exuded from Taif's rose leaves. Chu et al. (2014) found that allelochemical concentrations were lower in the plants under natural conditions compared to those created in lab trials, and as a result, more research on the allelopathic potential of Taif's rose is highly advised.

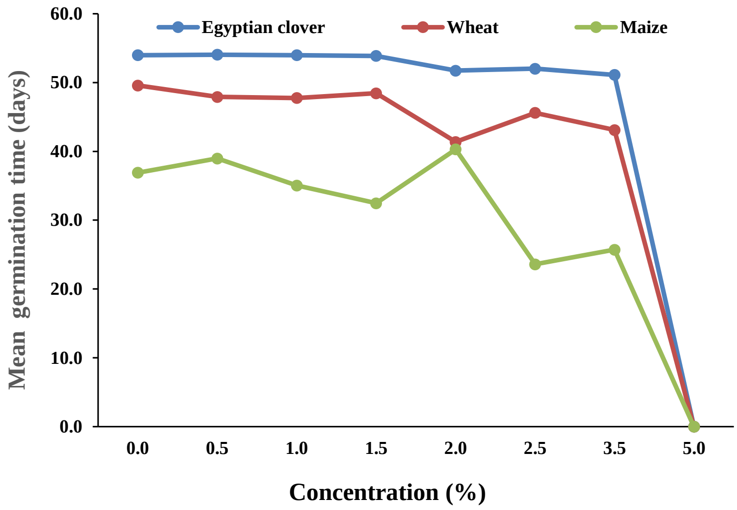

Figure 3. *Mean germination time (MGT) of Egyptian clover seeds, wheat and maize grains grown under the effect of different concentrations of Taif's rose leaf extract*

Conclusion

An extensive amount of cardiac glycosides, flavonoids, carbohydrates, alkaloids, and phenolics were found in Taif's rose leaves. These compounds may be allelopathic to several commercial crop plants. Clover seeds, wheat grains, and maize seeds were all inhibited by the aqueous extract of Taif's rose leaves, and the suppressive effect grew stronger as the extract concentration increased. Clover seed germination and growth were promoted by Taif's rose extract at lower concentrations (0.0–1.0%), whereas adverse effects on wheat and maize grains were observed at higher extract concentrations. As a result, Taif's rose leaves can be utilized as a soil amendment at lower quantities to promote the growth of clover but not for the other examined crops. The current laboratory bioassay has verified the presence of various water-soluble allelochemicals, such as glycosides and phenolic compounds, which have a negative impact on the studied plants' seed

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germination and seedling growth. To evaluate the allelopathic effects of Taif's rose plants in the field and to investigate additional chemical substances accountable for this impact, more research is needed.

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