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Effect of Potassium Fertilization and Chamomile Extract Foliar Spray on Growth and Active Compounds of *Portulaca Oleracea* L. Grown in Gypsiferous Soil

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ABSTRACT

The present study was conducted to investigate the effect of potassium fertilization and foliar application of chamomile extract on the growth and active compounds of *Portulaca oleracea* L. The experiment was carried out at the College of Medicinal and Industrial Plants / University of Kirkuk in the Ronaki area in Kirkuk Governorate using anvils. Four levels of potassium fertilizer (0, 20, 40, 80) kg K ha⁻¹ and three concentrations of chamomile extract (0, 3, 6 g L⁻¹ of water) were used on the growth of the portulaca plant L. oleracea. The variety used in this study is the local variety. The study was carried out with a factorial experiment and a randomized complete block design (R.C.B.D) with three replicates. The results showed that the fertilizer level of 40 kg K ha⁻¹ was significantly superior to the rest of the levels in giving the highest plant height, number of leaves, leaf area, and other studied traits. The results also showed that the concentration (6 g L⁻¹) of chamomile led to a significant increase in all growth characteristics of the barberry plant, while the interaction between potassium fertilization and spraying with chamomile extract had a significant effect at the combination (40 kg K ha⁻¹ + 6 g chamomile L⁻¹ of water) on all the studied traits.

INTRODUCTION

Soils in arid and semi-arid regions are generally poor in their content of nutrients available for plant growth due to their high pH values and elevated calcium carbonate content, as well as the presence of calcium sulfate. Therefore, potassium in such soils is of low availability because it is subjected to fixation processes, particularly due to the dominance of palygorskite and kaolinite minerals in the horizons of these soils [1]. Medicinal plants hold a prominent position in various fields, including therapeutic, complementary, preventive, and nutritional medicine, weight-loss programs, the pharmaceutical and food industries, and biological control. They are the main source of herbal medicines because they contain numerous active constituents involved in drug preparation, which are produced in plants through secondary metabolism. These compounds are characterized by their high efficacy in treating or preventing human and animal diseases, in addition to their minimal side effects compared with chemically manufactured drugs that have severe long-term side effects [2].

Purslane (*Portulaca oleracea* L.), belonging to the family Portulacaceae, is an annual succulent herb with reddish stems and alternate leaves. It is widely distributed throughout many parts of the world, particularly in tropical and subtropical regions [3]. Purslane has been traditionally used as a medicinal

herb to relieve a wide range of ailments, including gastrointestinal disorders, respiratory problems, hepatitis, kidney and bladder ulcers, fever, insomnia, severe inflammations, headaches, and others [4].

Potassium is one of the essential elements that significantly influence the growth and productivity of purslane through its involvement in numerous physiological processes within the plant, which are directly reflected in enhanced plant growth. Therefore, potassium fertilization plays an important role in improving plant growth [5]. Foliar fertilization is used as a means of supplying plants with quantities of macro- and micronutrients, plant hormones, stimulants, and other beneficial substances. The observed effects of foliar fertilization include increased yield, improved resistance to diseases and insect pests, enhanced drought tolerance, and better crop quality. Plant response depends on the type and form of the fertilizer, its concentration, application frequency, and the growth stage at which it is applied. Foliar feeding can be applied to help plants restore their vitality and is recommended in integrated crop production systems because it is more environmentally friendly and may increase crop yield and quality [6]. One of the most important forms of foliar feeding is spraying with plant extracts, which has recently gained global attention as an eco-friendly fertilizer because these extracts decompose rapidly in the environment and are non-toxic. Among these, chamomile extract is notable for containing numerous growth regulators and stimulants that enhance vegetative and floral growth in plants.

Given the medicinal importance of the active compounds in purslane, there has been growing interest in increasing their production. Hence, it has become necessary to study the factors affecting the quantity of active substances in medicinal plants. Due to the scarcity of previous studies on this topic in our country, and considering the medicinal, nutritional, and economic significance of purslane, this study was conducted to investigate the effect of potassium fertilization and chamomile extract on the growth and active compounds of *Portulaca oleracea* L.

MATERIALS AND METHODS

The experiment was conducted at the College of Medical and Industrial Plants, University of Kirkuk, Kirkuk Governorate, during the 2024–2025 growing season. Seeds of the local cultivar of *Portulaca oleracea* L. were sown in pots filled with soil, with three pots per experimental unit. Soil properties were analyzed at the laboratories of the College of Medical and Industrial Plants, and some physical and chemical characteristics of the soil used in the experiment are presented in Table 1.

Table 1. Some physical and chemical properties of the soil used in the experiment

Property	Value	Unit	Property	Value	Unit
Sand	459		Dissolved Ions (Green)	---	—
Silt	203	g kg ⁻¹	Calcium (Ca ²⁺)	12.84	mmol L ⁻¹
Clay	233		Magnesium (Mg ²⁺)	4.70	mmol L ⁻¹
Soil Texture	Loamy	—	Potassium (K ⁺)	0.41	mmol L ⁻¹
Electrical Conductivity (EC)	2.33	dS m ⁻¹	Sodium (Na ⁺)	1.33	mmol L ⁻¹
Cation Exchange Capacity (CEC)	12.21	cmol kg ⁻¹	Chloride (Cl ⁻)	2.77	mmol L ⁻¹
Organic Matter	7.01	g kg ⁻¹ soil	Sulfate (SO ₄ ²⁻)	11.09	mmol L ⁻¹
Carbonate Minerals	209	mg kg ⁻¹	Carbonates	Nil	—
Gypsum	38.28	g kg ⁻¹	Bicarbonate (HCO ₃ ⁻)	2.09	mmol L ⁻¹
Available Potassium	95.88	mg kg ⁻¹	pH	7.61	—
Available Nitrogen	13.14	mg kg ⁻¹	Available Phosphorus	4.89	mg kg ⁻¹

The experiment included two main factors: soil potassium fertilization at four levels (0, 20, 40, and 80 kg K ha⁻¹) applied as potassium sulfate, and foliar application of chamomile extract at three concentrations (0, 3, and 6 g L⁻¹). Potassium fertilizer was applied by mixing with the soil at planting, which was conducted on March 1, 2025. The experiment was laid out as a factorial experiment in a

randomized complete block design (RCBD) with three replications.

The studied traits were measured on plants sampled from the center of each experimental unit before flowering and before the appearance of floral buds [7].

Studied Traits:

- Plant Height (cm): Measured from the soil surface to the tallest shoot using a measuring tape, and the mean height per plant was calculated.
- Number of Leaves (leaves per plant¹): Counted from the bottom to the top of each plant in the experimental unit, and the average per plant was determined.
- Leaf Area (cm² plant⁻¹): Measured according to Zainel [8] using a computer program. Leaves were scanned using a flatbed scanner with a ruler for calibration, and leaf area was calculated.
- Fresh Weight of Vegetative Biomass (g plant⁻¹): Plants were cut near the soil surface, and fresh weight was determined using a sensitive balance. The average per plant was calculated.
- Dry Weight of Vegetative Biomass (g plant⁻¹): Plants were cleaned of soil, dried in an electric oven at 65–70 °C until constant weight, and weighed using a sensitive balance. The mean per plant was recorded Al-Sahaf [9].
- Potassium Concentration: Determined in plant extracts using a flame photometer according to Page et al [10].
- Fatty Acid Concentration: α -Linolenic acid in purslane extracts was analyzed using a gas chromatograph (GC-2010, Shimadzu, Japan) equipped with a flame ionization detector (FID) and a capillary column (SE-30, 30 m $\times$ 0.25 mm) [11].

Collected data were entered into a computer using Microsoft Excel and statistically analyzed using SAS software, according to the RCBD experimental design. Means were compared using the Least Significant Difference (LSD) test at $p \leq 0.05$ [12].

RESULTS AND DISCUSSION

1- Effect of Potassium Fertilization and Chamomile Extract Foliar Application on Plant Height (cm) of *Portulaca oleracea*

The results presented in Table 2 indicate that plant height was significantly influenced by both potassium fertilization levels and chamomile extract concentrations. Application of potassium fertilizer increased plant height significantly compared to the control, with percentage increases of 24.32%, 43.94%, and 7.10% at levels A2, A3, and A4, respectively. This pronounced response is attributed to the low available potassium in the soil (95.88 mg K kg⁻¹; Table 1). Among the tested levels, A3 (40 kg K ha⁻¹) produced the tallest plants, reaching 39.11 cm, while the highest level (A4, 80 kg K ha⁻¹) reduced plant height, likely due to antagonistic effects on the uptake of other nutrients, particularly magnesium, which negatively affected growth [13], [14].

Foliar application of chamomile extract also significantly increased plant height. The highest concentration (6 g L⁻¹) resulted in the tallest plants (38.48 cm) compared to the untreated control (24.87 cm). This effect is attributed to growth regulators and stimulants present in chamomile, which enhance metabolic activities, thereby improving photosynthesis and promoting plant height.

The interaction between potassium fertilization and chamomile extract was also significant. The combination of 40 kg K ha⁻¹ + 6 g L⁻¹ chamomile extract (A3B3) produced the tallest plants (45.32 cm), indicating a strong positive synergistic effect between the two treatments (Table 2).

Table 2. Effect of potassium fertilization and chamomile extract foliar application on plant height (cm) of *Portulaca oleracea*

Potassium Fertilizer (A)	Chamomile Extract (B)			Mean
	0 g L ⁻¹	3 g L ⁻¹	6 g L ⁻¹	
0	18.00	28.08	35.45	27.17
20	24.33	35.89	41.12	33.78
40	31.03	41.00	45.32	39.11
80	26.12	29.13	32.06	29.10
Mean	24.87	33.52	38.48	—
L.S.D (A) 1.02	L.S.D (B) 1.02		L.S.D (A*B) 2.09	

2- Effect of Potassium Fertilization and Chamomile Extract Foliar Application on the Number of Leaves of *Portulaca oleracea*

Results in Table 3 show that the number of leaves was significantly affected by potassium fertilization and chamomile extract foliar application. Potassium fertilization increased leaf number significantly, with increases of 20.09%, 34.52%, and 3.53% at levels A2, A3, and A4, respectively, compared to the control. This response is linked to the initially low soil potassium level (Table 1) and its role in regulating vital physiological processes, including cell division, nutrient uptake, and auxin-mediated leaf expansion [15]. Among the potassium levels, A3 (40 kg K ha⁻¹) produced the highest leaf number (53.22 leaves plant⁻¹), whereas A4 (80 kg K ha⁻¹) reduced leaf number (40.96 leaves plant⁻¹), likely due to nutrient antagonism, particularly with magnesium, negatively affecting leaf development [13].

Foliar application of chamomile extracts also significantly enhanced leaf number. The highest concentration (6 g L⁻¹) produced 50.17 leaves plant⁻¹, compared to 40.17 leaves plant⁻¹ in the control. This effect is attributed to chamomile's role in promoting biosynthesis of natural hormones, enhancing tissue growth and development [16].

Table 3. Effect of potassium fertilization and chamomile extract foliar application on the number of leaves of *Portulaca oleracea*

Potassium Fertilizer (A)	Chamomile Extract (B)			Mean
	0 g L ⁻¹	3 g L ⁻¹	6 g L ⁻¹	
0	35.13	39.45	44.10	39.56
20	41.08	48.26	53.16	47.51
40	47.13	53.23	59.30	53.22
80	37.34	41.43	44.13	40.96
Mean	40.17	45.59	50.17	—
L.S.D (A) 1.16	L.S.D (B)	1.16	L.S.D (A*B)	2.23

3- Effect of Potassium Fertilization and Chamomile Extract Foliar Application on Leaf Area (cm²) of *Portulaca oleracea*

The results presented in Table 5 show that leaf area was significantly influenced by both potassium fertilization levels and chamomile extract concentrations. Potassium application led to clear significant differences, with the highest mean leaf area (5.70 cm²) recorded at the A3 level (40 kg K ha⁻¹), representing a 73.25% increase compared to the control. This positive response can be attributed to potassium's critical role in regulating vital physiological processes, particularly photosynthesis, as well as its indirect role in enhancing nutrient uptake, notably nitrogen, which is the key element responsible for vegetative growth density and consequently leaf area expansion [15], [17].

Although all potassium levels significantly increased leaf area compared to the control, the highest level (A4, 80 kg K ha⁻¹) resulted in a decline, suggesting that excessive potassium disrupts nutrient balance in the soil solution and reduces nutrient availability, thereby limiting optimal growth. Similarly,

foliar application of chamomile extracts significantly increased leaf area. The highest concentration (6 g L^{-1}) produced the largest leaf area (5.48 cm^2), compared to the control (3.94 cm^2). This effect is attributed to chamomile's ability to regulate physiological processes, improve photosynthetic efficiency, and thereby stimulate vegetative growth, particularly leaf expansion [18].

Regarding the interaction, the combination of A3B3 ($40 \text{ kg K ha}^{-1} + 6 \text{ g L}^{-1}$ chamomile extract) gave the highest leaf area (6.44 cm^2), whereas the lowest value (2.17 cm^2) was recorded in the untreated control. This highlights the synergistic effect of integrating potassium fertilization with chamomile foliar application for optimal vegetative growth of *P. oleracea*.

Table 4. Effect of potassium fertilization and chamomile extract foliar application on leaf area (cm^2) of *Portulaca oleracea*

Potassium Fertilizer (A)	Chamomile Extract (B)			Mean
	0 g L^{-1}	3 g L^{-1}	6 g L^{-1}	
0	2.17	3.22	4.50	3.29
20	4.45	4.98	5.67	5.03
40	5.01	5.66	6.44	5.70
80	4.13	4.76	5.32	4.73
Mean	3.94	4.65	5.48	—
L.S.D (A) 0.05	L.S.D (B) 0.03		L.S.D (A $\times$ B) 0.04	

4- Effect of Potassium Fertilization and Chamomile Extract Foliar Application on Fresh Weight (g plant^{-1}) of *Portulaca oleracea*

Table 6 shows the effect of potassium fertilization and spraying with chamomile on the fresh weight of the hyacinth plant. The addition of potassium led to an increase in the fresh weight of the hyacinth plant with the increase in the addition levels. Level A3 gave the highest fresh weight of 153.47 g , with an increase rate of 18.29% compared to the treatment of not adding A1, which gave a fresh weight of 129.74 g , while the results indicated a decrease in the fresh weight. The increase in the fresh weight of the plant may be attributed to the role of ascorbic acid, which contains phenols. Salicylic acid is one of the phenol compounds, and thus it has an important role in regulating the absorption of ions, hormonal balance, and the opening and closing of stomata [19]. It is also attributed to the provision of nutrients (micro and macro) to the plant, their absorption, and the increase of their content in the vegetative system, which in turn increased the activity of vital processes and regulated the level of plant hormones that control the division and growth of meristematic cells and increased the surface area of the leaves (Table 4) and the construction of a root system characterized by high efficiency in absorbing the nutrients manufactured in the leaves, represented by carbohydrates and proteins, and transporting them to the places where they are needed and necessary for building plant tissues, which in turn leads to an increase in the fresh weight of the plant [20].

Table 5. Effect of potassium fertilization and chamomile extract foliar application on fresh weight (g plant^{-1}) of *Portulaca oleracea*

Potassium Fertilizer (A)	Chamomile Extract (B)			Mean
	0 g L^{-1}	3 g L^{-1}	6 g L^{-1}	
0	94.00	116.34	178.89	129.74
20	122.70	130.18	143.34	132.07
40	143.09	156.33	161.00	153.47
80	133.12	147.03	150.78	143.64
Mean	123.22	137.47	158.50	—
L.S.D (A) 2.46	L.S.D (B) 2.46		L.S.D (A $\times$ B) 5.23	

5- Effect of Potassium Fertilization and Foliar Application of Chamomile Extract on the Dry Weight of *Portulaca oleracea* L. (g plant⁻¹):

Table 6 shows the effect of potassium fertilization and foliar spraying with chamomile extract on the dry weight of purslane plants. The application of potassium led to an increase in dry weight with the rise in application levels, where level A3 recorded the highest dry weight of 40.85 g, representing a 74.27% increase compared to the control treatment (A1), which gave 23.44 g. However, results indicated a reduction in dry weight at higher potassium levels, where a decline of 12.68% was observed compared to A3. This indicates that level A3 was the optimal rate for achieving vigorous vegetative growth, which is reflected in both yield and active compounds of purslane plants.

With respect to foliar application of chamomile extract, the results revealed significant and pronounced effects on the dry weight of purslane plants, where level B3 recorded the highest dry weight of 42.67 g, representing a 68.92% increase over the control. The increase in dry weight may be attributed to the role of chamomile extract in stimulating vegetative growth, since it is classified among plant growth-promoting regulators, and also in reducing the adverse impact of abiotic stresses that limit plant growth [21].

Table 6. Effect of potassium fertilization and foliar application of chamomile extract on the dry weight of *Portulaca oleracea* L. (g plant⁻¹)

Potassium Fertilizer (A)	Chamomile Extract (B)			Mean
	0 g L ⁻¹	3 g L ⁻¹	6 g L ⁻¹	
0	14.22	20.02	36.10	23.44
20	23.43	27.98	42.34	31.25
40	33.65	39.78	49.13	40.85
80	29.76	34.14	43.12	35.67
Mean	25.26	30.47	42.67	-
L.S.D (A) 1.46	L.S.D (B) 1.46		L.S.D (A × B) 3.15	

6- Effect of Potassium Fertilization and Foliar Application of Chamomile Extract on Potassium Concentration in *Portulaca oleracea* L(%):

As presented in Table 8, potassium concentration in purslane plants was significantly influenced by both potassium fertilization levels and chamomile extract concentrations. The application of potassium led to a significant increase in potassium concentration, with level A3 recording the highest value of 1.59%, representing a 27.2% increase compared to the control (A1), which recorded the lowest value of 1.25%. This result could be attributed to the role of potassium in promoting root development, thereby enhancing the plant's ability to absorb nutrients and water, which was reflected in the increase in potassium concentration [22].

On the other hand, the highest level of potassium application (A4) reduced potassium concentration, indicating a negative effect of excessive potassium on the availability of other essential nutrients, particularly magnesium, which in turn affected plant growth, dry weight, and potassium concentration in purslane [13]. Regarding foliar application of chamomile extract, results showed significant effects on potassium concentration, where level B3 gave the highest concentration (1.57%), representing a 30.83% increase compared to the control. The increase in potassium concentration may be attributed to the role of chamomile extract in stimulating both vegetative and root growth, as it acts as a growth-promoting regulator, which strengthens the root system and enhances nutrient uptake, including potassium.

The interaction effect indicated that the treatment combination (A3B3) produced the highest potassium concentration (1.72%), representing a 66.99% increase compared to the lowest value (1.03%) obtained from the control treatment (A1B1).

Table 7. Effect of potassium fertilization and foliar application of chamomile extract on potassium concentration in *Portulaca oleracea* L. (%)

Potassium Fertilizer (A)	Chamomile Extract (B)			Mean
	0 g L ⁻¹	3 g L ⁻¹	6 g L ⁻¹	
0	1.03	1.20	1.54	1.25
20	1.23	1.34	1.67	1.41
40	1.43	1.63	1.72	1.59
80	1.13	1.22	1.36	1.23
Mean	1.20	1.34	1.57	
L.S.D (A) 1.64	L.S.D (B) 1.46	L.S.D (A × B) 3.15		

7- Effect of Potassium Fertilization and Foliar Feeding with Chamomile Extract on the Concentration of α -Linolenic Acid in Purslane Plants (%)

The results presented in Table 8 indicate that potassium fertilization and foliar feeding with chamomile extract had a significant effect on the concentration of α -linolenic acid in purslane plants. The application of different potassium levels led to significant variations in fatty acid concentration, with the highest value (11.28%) recorded at treatment level A₃, representing an increase of 13.25% compared to the control treatment. The effect of potassium on increasing concentration can be attributed to its role in enhancing root growth, thus increasing water and nutrient uptake, and increasing physiological activities, including photosynthesis, which in turn affects the concentration of fatty acids in the plant [23]. The results also indicate that despite the significant effect of all potassium levels added to the soil, the concentration of fatty acids began to decline at level A₄, which is not suitable for suitable growth of hyacinth plants. This level affects the balance of nutrients due to the mechanism of competition and antagonism between elements in the soil solution, reducing their availability to the plant, thus affecting plant growth. Spraying with chamomile extract significantly increased the concentration of fatty acids, with concentration A₃ exceeding the highest concentration by 11.00% compared to the treatment without addition, which produced the lowest concentration by 9.68%. This is due to its effect on regulating plant physiological processes and improving the efficiency of photosynthesis, which positively impacts the plant's vegetative growth rate, particularly leaf area and number of leaves [18], which in turn affects the concentration of fatty acids. Regarding the interaction between potassium fertilization and foliar feeding of chamomile, the results indicated that treatment A₃B₃ yielded the highest concentration, 12.14%, compared to the treatment without added fertilizer, which yielded the lowest concentration, 9.23%. This, in turn, highlights the utmost importance of combining potassium fertilizer with chamomile extract spray to achieve the optimal concentration of active ingredients in hyssop, including alpha-linolenic acid.

Table 8. Effect of potassium fertilization and foliar feeding with chamomile extract on the concentration of α -linolenic acid in purslane plants (g plant⁻¹)

Potassium Fertilizer (A)	Chamomile Extract (B)			Mean
	0 g L ⁻¹	3 g L ⁻¹	6 g L ⁻¹	
0	9.23	10.12	10.53	9.96
20	10.13	11.06	11.23	10.80
40	10.23	11.35	12.14	11.28
80	9.01	9.82	10.11	9.64
Mean	9.68	10.58	11.00	
L.S.D (A) 0.10	L.S.D (B) 0.10	L.S.D (A × B) 0.12		

CONCLUSIONS

Potassium fertilization significantly enhanced vegetative growth traits of *Portulaca oleracea* L., with the optimum response recorded at 40 kg K ha⁻¹.

- Excess potassium at 80 kg K ha⁻¹ negatively affected vegetative growth, potassium concentration, and fatty acid accumulation in the plant.
- Foliar application of chamomile extract exerted a significant positive effect on vegetative growth traits at all tested concentrations.
- The combined treatment of 40 kg K ha⁻¹ with foliar application of 6 g L⁻¹ chamomile extract provided the best results in improving vegetative growth parameters of *Portulaca oleracea* L.

Recommendations

- Apply potassium fertilizer at moderate levels in purslane cultivation to enhance vegetative growth while minimizing environmental pollution from excessive chemical fertilizer use.
- Foliar application of chamomile extract is recommended as an eco-friendly and effective plant growth regulator for improving growth traits in *Portulaca oleracea* L.

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