Effects of Crude Ground *Biarum bovei* Powder on the Morphophysiological Characteristics of Two *Lupinus albus* L. Varieties

Efectos del polvo crudo de *Biarum bovei* sobre las características morfofisiológicas de dos variedades de *Lupinus albus* L.

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Highlights

- *Biarum bovei* crude powder, particularly from tubers, significantly inhibited most morphological and biochemical parameters of *Lupinus albus* L., including chlorophyll content, mineral uptake (P, Fe, Na), and seedling development.
- Despite the overall inhibition, treated plants showed increased levels of potassium (K), copper (Cu), total nitrogen, crude protein, and proline—suggesting an induced physiological stress response.
- The sweet variety was more sensitive to allelopathic stress, while the bitter variety exhibited higher levels of phenols and alkaloids, possibly indicating greater resistance mechanisms.

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Biarum bovei Blume, alelopatía, polvo crudo, *Lupinus albus* L., variedades dulce y amarga.

ABSTRACT

Introduction. *Biarum bovei* Blume is a medicinal plant native to eastern Libya. Although its phytochemical profile has been partially documented, its allelopathic behavior toward cultivated species remains unexplored. **Objectives.** This study aimed to evaluate the allelopathic effects of incorporating crude leaf and tuber powder of *B. bovei* into soil on the growth and yield of two *Lupinus albus* L. varieties (sweet and bitter). **Materials and Methods.** The pot experiments were conducted during the 2023 growing season at Omar Al-Mukhtar University. Crude powder of *B. bovei* leaves and tubers was incorporated into pots at 0, 5, and 10 g/kg soil. Ten seeds of each lupine variety were sown per pot in a completely randomized design with three replicates. Morphological and biochemical parameters were measured after four months. **Results.** The crude powder significantly inhibited several morphological and biochemical traits ($P < 0.05$), including seedling emergence rate (from 100% to 25%), shoot length, root length, fresh weight per plant (from 6.4 g to 1.8 g), and photosynthetic pigments, notably chlorophyll a (from 1.66 to 0.48 mg/g). Phosphorus, iron, sodium, phenols, and alkaloids also decreased. In contrast, potassium, copper, total nitrogen, crude protein, and proline increased under treatment. The strongest inhibition was recorded with tuber powder at 10 g/kg, and the sweet variety was more sensitive. **Conclusions.** These findings suggest that *B. bovei* residues can negatively impact *L. albus* growth and productivity, particularly when derived from tubers. Further field studies are needed to assess potential implications for crop management.

RESUMEN

Introducción. *Biarum bovei* Blume es una planta medicinal nativa del este de Libia. Aunque su composición fitoquímica ha sido parcialmente estudiada, sus posibles interacciones alelopáticas con especies cultivadas no han sido exploradas. **Objetivos.** Evaluar los efectos alelopáticos de la incorporación de polvo crudo de hojas y tubérculos de *B. bovei* al suelo sobre el crecimiento y el rendimiento de dos variedades de *Lupinus albus* L. (dulce y amarga). **Materiales y métodos.** Los experimentos en maceta se llevaron a cabo durante la temporada de cultivo de 2023 en la Universidad Omar Al-Mukhtar. Se incorporó polvo crudo de hojas y tubérculos de *B. bovei* al suelo en concentraciones de 0, 5 y 10 g/kg. Se sembraron diez semillas de cada variedad de altramuz por maceta, bajo un diseño completamente aleatorizado con tres repeticiones. Después de cuatro meses, se evaluaron parámetros morfológicos y bioquímicos. **Resultados.** El polvo crudo inhibió significativamente diversos parámetros morfológicos y bioquímicos ($P < 0.05$), como la tasa de emergencia (de 100% a 25%), la longitud de raíces y brotes, el peso fresco por planta (de 6.4 g a 1.8 g) y los pigmentos fotosintéticos, especialmente la clorofila a (de 1.66 a 0.48 mg/g). También se redujeron el fósforo, hierro, sodio, fenoles y alcaloides. En cambio, el potasio, cobre, nitrógeno total, proteína cruda y prolina aumentaron con el tratamiento. La inhibición más fuerte se observó con polvo de tubérculo a 10 g/kg, siendo la variedad dulce la más sensible. **Conclusiones.** Los residuos de *B. bovei*, especialmente de tubérculos, podrían afectar negativamente el crecimiento y la productividad de *L. albus*, lo que sugiere la necesidad de estudios adicionales en campo.

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INTRODUCTION

White lupine (*Lupinus albus* L.) is among the *Lupinus* species suitable for human consumption and is widely cultivated [1-2]. It has diverse agricultural and pharmaceutical applications—as a botanical pesticide, for nitrogen fixation, as green manure, livestock feed, and in treatments for hypertension, inflammation, helminthic infections, and as a diuretic [3-4]. Its seeds are rich in carbohydrates, proteins, dietary fiber, oils, and B-group vitamins such as thiamin and riboflavin [5-6].

However, its nitrogen-fixing capacity can inadvertently promote weed growth, which negatively impacts crop productivity and results in yield losses [7]. Weeds interfere with crop development either directly—by competing for light, water, and nutrients—or indirectly, through allelopathy, by releasing bioactive compounds known as allelochemicals [8-9]. These substances affect plant physiology via multiple mechanisms, including the inhibition of enzyme activity and metabolic processes, respiration, mineral uptake, protein and nucleic acid synthesis, and by altering oxidative and antioxidant systems [10].

Biarum bovei Blume, an endemic species native to the Al-Jabal Al-Akhdar region, belongs to the Araceae family, which comprises perennial, tuberous herbaceous plants [11]. Previous studies have documented allelopathic interactions between members of the Araceae family and *Lupinus albus*. For example, research conducted in Libya found that *Arum cyreniacum* extracts significantly reduced germination percentage and radicle and plumule lengths in *Lupinus albus* L. compared to other legume species [12]. Similarly, a study in Bulgaria reported that aqueous extracts of *Sorghum halepense* inhibited germination and early root and shoot development in *Lupinus luteus* [13].

This study aims to evaluate the allelopathic effects of incorporating crude leaf and tuber powder of *Biarum bovei* Blume into potting soil at concentrations of 0, 5, and 10 g/kg, on the growth and yield of two *Lupinus albus* L. varieties (sweet and bitter) under the environmental conditions of the Al-Jabal Al-Akhdar region.

MATERIALS AND METHODS

Experimental Setup

The pot experiments were conducted during the 2023 growing season under greenhouse conditions (24 ± 2 °C, 14 h photoperiod, and 60 ± 10% relative humidity) at Omar Al-Mukhtar University, Libya. Seeds of *Lupinus albus* L. (sweet and bitter varieties) were obtained from local agricultural markets, and their identities were confirmed at the Department of Crops, Omar Al-Mukhtar University. Samples of *Biarum bovei* leaves and tubers were collected from the city of Aslanta and taxonomically classified according to Salih and Abdulrraziq [11]. After cleaning and drying, the plant materials were ground into a fine powder and incorporated into the potting soil immediately before sowing.

Experimental Design

Ten seeds of each *L. albus* L. variety were sown in plastic pots (19 cm height × 19.5 cm diameter) filled with approximately 6 kg of well-mixed sandy loam soil (w/w). A total of 30 pots were arranged in a completely randomized design: 5 treatments × 2 varieties × 3 replicates. Two weeks after sowing, seedlings were thinned to five plants per pot, which were maintained until the fruiting stage (approximately four months).

Morphological Parameters

The seedling emergence rate (%) was calculated using the formula: (number of emerged seedlings / total number of seeds) × 100**.** After gently washing the roots, samples from each treatment and variety were collected to assess seedling length (cm), root and shoot length (cm), and seedling fresh weight per plant, following the method described by El-Kenany et al. [14]. Additionally, the number of leaves per plant, number of branches per plant, number of pods per plant, pod length (cm), and number of seeds per pod were recorded.

Biochemical Parameters

Photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids) in fresh lupine leaves were quantified spectrophotometrically, following the method described by Metzner et al. [15]. Mineral contents—including phosphorus (P), iron (Fe), sodium (Na), potassium (K), and copper (Cu)—were determined via wet digestion, followed by atomic absorption spectrophotometry and flame photometry. All values were expressed on a dry weight basis [16]. Total nitrogen content (%) in powdered lupine seeds was estimated via digestion with concentrated sulfuric acid, and absorbance was measured at 420 nm using a spectrophotometer according to Nessler's method [17]. Crude protein content (%) was calculated by multiplying total nitrogen (N %) by the conventional factor of 6.25 [18]. Proline was extracted from seeds using acid ninhydrin and quantified according to Bates et al. [19]. Total phenol content (%) was determined from seed extracts using the Folin–Ciocalteu method, with absorbance measured at 765 nm[20]. Total alkaloid content (%) was determined using the alkaline precipitation gravimetric method described by Harborne [21], and calculated based on sample weight, with absorbance measured at 565 nm.

Statistical Analysis

Data were analyzed using two-way analysis of variance (ANOVA) in IBM SPSS Statistics v24. Tukey's HSD test was applied at a significance level of $P < 0.05$. Values presented in tables are expressed as mean ± standard error.

RESULTS

Vegetative Growth Parameters

The application of *Biarum bovei* crude powder (from leaves and tubers) at concentrations of 5 and 10 g/kg of soil significantly reduced several vegetative parameters in both *Lupinus albus* L. varieties (sweet and bitter), when compared to the untreated control **(Tables 1 and 2)**. These parameters included seedling emergence rate, seedling length, root and shoot length, seedling fresh weight, number of leaves and branches per plant, number of pods per plant, pod length, and number of seeds per pod.

Table 1. Effect of crude powder of *Biarum bovei* on vegetative growth of two *Lupinus albus* L. varieties after 4 months of cultivation

Conc. (g/kg)	Variety	Crude Powder	Seedling Fresh Weight (g)	Seedling Length (cm)	Root Length (cm)	Shoot Length (cm)	Seedling Emergence Rate (%)
0	Sweet	Control	6.4 ± 0.4^{a}	67.7 ± 0.7^{a}	29.6 ± 0.6^{a}	38.04 ± 0.4^{a}	100.0 ± 0.0^{a}
5	Sweet	Tubers	4.7 ± 0.4^{b}	47.7 ± 0.7^{e}	20.2 ± 0.2^{d}	27.5 ± 0.5^{d}	63.0 ± 3.0^{d}
5	Sweet	Leaves	4.6 ± 0.6^{b}	51.6 ± 0.2^{d}	21.6 ± 0.6^{c}	30.0 ± 0.7^{c}	76.0 ± 1.0^{c}
10	Sweet	Tubers	1.8 ± 0.3^{d}	29.3 ± 0.3^{i}	13.0 ± 0.5^{f}	16.3 ± 0.3^{g}	25.0 ± 0.5^{h}
10	Sweet	Leaves	3.1 ± 0.1^{c}	38.5 ± 0.5^{g}	18.1 ± 0.1^{e}	20.3 ± 0.3^{f}	40.0 ± 0.5^{f}
0	Bitter	Control	7.2 ± 0.5^{a}	68.2 ± 0.2^{a}	29.5 ± 0.5^{a}	38.6 ± 0.6^{a}	100.0 ± 0.0^{a}
5	Bitter	Tubers	4.8 ± 0.5^{b}	53.7 ± 0.3^{c}	22.6 ± 0.6^{c}	31.0 ± 1.0^{c}	78.0 ± 1.5^{c}
5	Bitter	Leaves	5.2 ± 0.2^{b}	59.6 ± 0.3^{b}	25.4 ± 0.4^{b}	34.2 ± 0.8^{b}	90.0 ± 2.0^{b}
10	Bitter	Tubers	2.4 ± 0.2^{cd}	33.8 ± 0.8^{h}	14.2 ± 0.2^{f}	19.6 ± 0.6^{f}	30.0 ± 2.0^{g}
10	Bitter	Leaves	3.3 ± 0.3^{c}	45.2 ± 0.2^{f}	20.1 ± 0.4^{d}	25.0 ± 1.0^{e}	56.0 ± 1.0^{e}
P-values			0.338	0.018	0.203	0.401	0.000

Values followed by different letters are significantly different at P ≤ 0.05 according to Tukey's HSD test. Comparisons were made for each trait according to concentration, plant part, and variety.

Seedling Emergence Rate

The incorporation of *B. bovei* leaf and tuber powder into the soil markedly reduced the seedling emergence rate in both varieties. In the sweet variety, leaf powder decreased emergence from 100% (control) to 76.0% and 40.0% at 5 and 10 g/kg soil, respectively. Tuber powder resulted in even lower values: 63.0% and 25.0% for the same concentrations. Similarly, in the bitter variety, emergence rates declined from 100% to 90.0% and 56.0% for leaves, and to 78.0% and 30.0% for tubers, respectively.

Effects on Seedling Growth

Crude powder of *B. bovei* significantly inhibited shoot and root development. In both varieties, shoot length decreased from 38.04 cm and 38.6 cm (control) to values between 16.3 cm and 34.2 cm. Root length declined from 29.6 cm and 29.5 cm (control) to a range of 13.0 cm to 25.4 cm in treated plants. Similarly, seedling length was reduced from 67.7 cm and 68.2 cm (control) to 29.3–59.6 cm across treatments. Seedling fresh weight decreased from 6.4 g and 7.2 g (control) to values between 1.8 g and 5.2 g. The most substantial inhibition in seedling growth was recorded at 10 g/kg of tuber powder.

Yield-Related Traits

Application of *B. bovei* powder also negatively affected yield-related traits in both lupine varieties **(Table 2).** Decreases were observed in the number of leaves, number of branches, pods per plant, pod length, and seeds per pod. These reductions were more pronounced at the 10 g/kg concentration, particularly with tuber powder. For example, in the sweet variety, the number of leaves per plant dropped to 9.0, branches to 2.0, pod number to 1.0, pod length to 1.3 cm, and seeds per pod to 2.0. In the bitter variety, corresponding values were 11.0 leaves, 3.3 branches, 1.0 pod, 3.0 cm pod length, and 2.0 seeds per pod.

Table 2. Effect of crude powder of *Biarum bovei* on yield-related traits of two *Lupinus albus* L. varieties after 4 months of cultivation

Conc. (g/kg)	Variety	Crude Powder	Seeds/Pod	Pod Length (cm)	Pods/Plant	Branches/Plant	Leaves/Plant
0	Sweet	Control	4.0 ± 0.0^{a}	5.0 ± 1.0^{a}	4.0 ± 0.0^{a}	6.0 ± 1.0^{a}	18.0 ± 1.0^{a}
5	Sweet	Tubers	3.3 ± 0.3^{b}	4.0 ± 0.0^{a}	3.0 ± 0.0^{bc}	4.0 ± 0.0^{ab}	13.0 ± 1.0^{c}
5	Sweet	Leaves	4.0 ± 0.0^{a}	4.0 ± 0.0^{a}	3.0 ± 0.0^{bc}	4.0 ± 1.0^{abc}	16.0 ± 1.0^{ab}
10	Sweet	Tubers	2.0 ± 0.0^{d}	2.0 ± 0.0^{d}	1.0 ± 0.0^{c}	2.0 ± 0.0^{c}	9.0 ± 0.0^{d}
10	Sweet	Leaves	2.0 ± 0.0^{d}	3.0 ± 1.0^{bc}	1.0 ± 0.0^{c}	2.0 ± 0.0^{bc}	12.6 ± 0.2^{c}
0	Bitter	Control	4.0 ± 0.0^{a}	5.0 ± 0.0^{a}	4.0 ± 0.0^{a}	6.0 ± 0.0^{a}	18.0 ± 1.0^{a}
5	Bitter	Tubers	4.0 ± 0.0^{a}	4.0 ± 0.0^{a}	4.0 ± 1.0^{ab}	4.0 ± 1.0^{ab}	15.6 ± 0.1^{b}
5	Bitter	Leaves	4.0 ± 1.0^{a}	4.6 ± 0.5^{ab}	3.0 ± 1.0^{ab}	5.0 ± 1.0^{ab}	16.3 ± 0.3^{ab}
10	Bitter	Tubers	2.0 ± 0.0^{d}	3.0 ± 0.0^{c}	1.0 ± 0.0^{c}	3.3 ± 0.5^{ab}	11.0 ± 1.0^{cd}
10	Bitter	Leaves	3.0 ± 0.0^{c}	3.3 ± 0.5^{ab}	2.0 ± 0.0^{c}	4.0 ± 0.0^{abc}	13.0 ± 0.1^{c}
	P-values		0.000	0.362	0.250	0.162	0.195

Values followed by different letters are significantly different at $P \leq 0.05$ according to Tukey's HSD test. Comparisons were made for each trait according to concentration, plant part, and variety.

Photosynthetic Pigments

The effects of *Biarum bovei* crude powder (leaves and tubers), applied to the soil at concentrations of 0, 5, and 10 g/kg, on the content of photosynthetic pigments (chlorophyll a, chlorophyll b, carotenoids, and total pigments) in leaves of sweet and bitter *Lupinus albus* L. varieties are presented in **Table 3**. A significant reduction in pigment content was observed in both varieties compared to the control.

The most pronounced decreases were recorded with tuber powder at 10 g/kg. In the sweet variety, chlorophyll a decreased to 0.48 mg/g, chlorophyll b to 0.17 mg/g, carotenoids to 0.10 mg/g, and total pigments to 0.75 mg/g. In the bitter variety, corresponding values were 0.77 mg/g, 0.19 mg/g, 0.13 mg/g, and 1.09 mg/g, respectively. These findings support a dose-dependent inhibitory effect of *B. bovei* on the photosynthetic apparatus of lupine plants.

Mineral Content

Table 4 summarizes the effects of *B. bovei* crude powder (tubers and leaves), applied at 0, 5, and 10 g/kg soil, on the mineral composition of sweet and bitter *Lupinus albus* L. seedlings. The measured minerals included phosphorus (P), iron (Fe), sodium (Na), potassium (K), and copper (Cu).

Table 3. Effect of crude powder of *Biarum bovei* on photosynthetic pigment content (mg/g fresh leaves) in two *Lupinus albus* L. varieties after 4 months of cultivation.

Conc. (g/kg)	Variety	Crude Powder	Chlorophyll a	Chlorophyll b	Carotenoids	Total Photosynthetic Pigments
0	Sweet	Control	1.66 ± 0.03^{a}	0.38 ± 0.01^{a}	0.30 ± 0.01^{b}	2.34 ± 0.01^{a}
5	Sweet	Tubers	1.14 ± 0.01^{d}	0.23 ± 0.02^{cd}	0.16 ± 0.01^{e}	1.52 ± 0.03^{e}
5	Sweet	Leaves	1.29 ± 0.01^{c}	0.31 ± 0.01^{b}	0.23 ± 0.05^{cd}	1.83 ± 0.01^{c}
10	Sweet	Tubers	0.48 ± 0.02^{g}	0.17 ± 0.02^{f}	0.10 ± 0.01^{f}	0.75 ± 0.01^{h}
10	Sweet	Leaves	0.91 ± 0.01^{e}	0.21 ± 0.01^{def}	0.15 ± 0.05^{e}	1.27 ± 0.02^{f}
0	Bitter	Control	1.66 ± 0.03^{a}	0.38 ± 0.0^{a}	0.34 ± 0.0^{a}	2.38 ± 0.03^{a}
5	Bitter	Tubers	1.25 ± 0.04^{c}	0.28 ± 0.02^{bc}	0.22 ± 0.02^{cd}	1.75 ± 0.02^{d}
5	Bitter	Leaves	1.41 ± 0.01^{b}	0.26 ± 0.03^{bcd}	0.25 ± 0.03^{c}	1.92 ± 0.03^{b}
10	Bitter	Tubers	0.77 ± 0.07^{f}	0.19 ± 0.01^{ef}	0.13 ± 0.01^{ef}	1.09 ± 0.05^{g}
10	Bitter	Leaves	1.13 ± 0.02^{d}	0.22 ± 0.03^{def}	0.21 ± 0.01^{d}	1.56 ± 0.02^{e}
	P-values		0.240	0.003	0.013	0.008

Values followed by different letters are significantly different at P ≤ 0.05 according to Tukey's HSD test. Comparisons were made for each trait according to concentration, plant part, and variety.

The results indicated that phosphorus, iron, and sodium levels progressively decreased with increasing powder concentrations, particularly at 10 g/kg. In contrast, potassium and copper levels significantly increased in treated plants compared to the control. These results suggest that *B. bovei* may interfere selectively with mineral uptake mechanisms, possibly as a response to allelopathic stress.

Biochemical Constituents

Table 5 presents the effects of *Biarum bovei* crude powder (tubers and leaves), applied at 0, 5, and 10 g/kg, on biochemical traits in the seeds of sweet and bitter *Lupinus albus* L. varieties. The parameters evaluated included total nitrogen (%), crude protein (%), proline content (mg/100 g), total phenols (%), and total alkaloids (%).

Table 4. Effect of crude powder of *Biarum bovei* on mineral content (mg/g) in seedlings of two *Lupinus albus* L. varieties after 4 months of cultivation

Conc. (g/kg)	Variety	Crude Powder	Phosphorus (P)	Iron (Fe)	Sodium (Na)	Potassium (K)	Copper (Cu)
0	Sweet	Control	2.82 ± 0.02^{a}	1.74 ± 0.03^{a}	0.32 ± 0.02^{ab}	168 ± 2.0^{ef}	3.4 ± 0.5^{a}
5	Sweet	Tubers	1.48 ± 0.01^{e}	1.50 ± 0.05^{b}	0.25 ± 0.02^{bcde}	172 ± 2.6^{cde}	3.5 ± 0.1^{a}
5	Sweet	Leaves	2.64 ± 0.03^{b}	1.58 ± 0.03^{b}	0.28 ± 0.01^{abc}	161 ± 1.7^{f}	3.2 ± 0.2^{a}
10	Sweet	Tubers	0.71 ± 0.02^{g}	0.94 ± 0.01^{d}	0.18 ± 0.01^{e}	210 ± 0.5^{a}	3.8 ± 0.3^{a}
10	Sweet	Leaves	2.02 ± 0.01^{d}	1.23 ± 0.02^{c}	0.20 ± 0.01^{de}	177 ± 2.0^{cd}	3.8 ± 0.1^{a}
0	Bitter	Control	2.79 ± 0.05^{a}	1.29 ± 0.05^{c}	0.35 ± 0.04^{a}	170 ± 4.5^{de}	3.0 ± 0.1^{a}
5	Bitter	Tubers	1.40 ± 0.04^{e}	0.80 ± 0.03^{e}	0.29 ± 0.02^{ab}	193 ± 1.7^{b}	3.5 ± 0.3^{a}
5	Bitter	Leaves	2.61 ± 0.01^{b}	0.82 ± 0.02^{e}	0.30 ± 0.05^{ab}	175 ± 2.8^{cde}	3.3 ± 0.2^{a}
10	Bitter	Tubers	0.83 ± 0.03^{f}	0.31 ± 0.01^{g}	0.21 ± 0.01^{cde}	216 ± 5.7^{a}	3.8 ± 0.3^{a}
10	Bitter	Leaves	2.12 ± 0.02^{c}	0.67 ± 0.01^{f}	0.26 ± 0.01^{bcd}	179 ± 1.0^{c}	3.6 ± 0.1^{a}
	P-values		0.338	0.062	0.492	0.368	0.794

Values followed by different letters are significantly different at P ≤ 0.05 according to Tukey's HSD test. Comparisons were made for each trait according to concentration, plant part, and variety.

A clear pattern emerged: increasing concentrations of *B. bovei* powder led to a significant rise in total nitrogen, crude protein, and proline contents in both varieties. Conversely, total phenols and alkaloids decreased proportionally with increasing concentration of the powder. Despite the reduction, bitter lupine consistently exhibited higher phenol and alkaloid contents than sweet lupine across all treatments.

These findings suggest a dual allelopathic mechanism: stimulation of nitrogenous primary metabolism, and suppression of phenolic and alkaloid secondary metabolites, particularly evident with 10 g/kg of tuber powder.

Table 5. Effect of crude powder of *Biarum bovei* on biochemical constituents in seeds of two *Lupinus albus* L. varieties after 4 months of cultivation

Conc. (g/kg)	Variety	Crude Powder	Total Nitrogen (%)	Total Protein (%)	Proline (mg/100 g)	Total Phenols (%)	Total Alkaloids (%)
0	Sweet	Control	4.66 ± 0.01^{g}	28.50 ± 0.1^{e}	0.86 ± 0.02^{fg}	21.00 ± 1.0^{e}	0.29 ± 0.01^{e}
5	Sweet	Tubers	5.20 ± 0.2^{e}	31.33 ± 1.7^{cd}	1.23 ± 0.01^{e}	19.11 ± 0.0^{f}	0.27 ± 0.02^{e}
5	Sweet	Leaves	4.65 ± 0.01^{g}	28.07 ± 1.0^{e}	0.92 ± 0.03^{f}	20.95 ± 0.02^{e}	0.29 ± 0.0^{e}
10	Sweet	Tubers	6.50 ± 0.0^{a}	35.81 ± 1.0^{b}	1.81 ± 0.01^{a}	13.76 ± 0.01^{h}	0.14 ± 0.04^{f}
10	Sweet	Leaves	5.71 ± 0.01^{c}	32.68 ± 0.01^{c}	1.56 ± 0.01^{b}	15.13 ± 0.02^{g}	0.18 ± 0.01^{f}
0	Bitter	Control	4.24 ± 0.02^{i}	27.50 ± 1.0^{e}	0.83 ± 0.05^{g}	33.15 ± 0.9^{a}	1.37 ± 0.03^{a}
5	Bitter	Tubers	5.10 ± 0.0^{f}	30.87 ± 0.02^{d}	1.30 ± 0.0^{d}	28.23 ± 0.03^{c}	1.31 ± 0.02^{bc}
5	Bitter	Leaves	4.52 ± 0.0^{h}	28.25 ± 0.2^{e}	0.87 ± 0.01^{fg}	30.56 ± 0.02^{b}	1.34 ± 0.01^{ab}
10	Bitter	Tubers	5.78 ± 0.0^{b}	38.12 ± 0.0^{a}	1.87 ± 0.0^{a}	19.45 ± 0.05^{f}	1.21 ± 0.0^{d}
10	Bitter	Leaves	5.26 ± 0.02^{d}	34.78 ± 0.01^{b}	1.49 ± 0.0^{c}	24.62 ± 0.0^{d}	1.28 ± 0.0^{c}
	P values		0.000	0.642	0.096	0.000	0.656

Values followed by different letters are significantly different at P ≤ 0.05 according to Tukey's HSD test. Comparisons were made for each trait according to concentration, plant part, and variety.

DISCUSSION

Weeds pose a major threat to agricultural productivity by inhibiting or slowing crop development, leading to yield reduction through the allelopathic secretion of chemical compounds from donor weeds to receptor crops [22]. To the best of our knowledge, no previous studies have specifically examined the allelopathic potential of *Biarum bovei*. Therefore, the present study was designed to evaluate the allelopathic effects of incorporating crude powder from *B. bovei* leaves and tubers into the soil at concentrations of 0, 5, and 10 g/kg on the growth and yield of two *Lupinus albus* L. varieties.

Our results showed that the crude powder negatively affected most morphological and biochemical parameters of *Lupinus albus* L., although levels of certain minerals such as potassium (K) and copper (Cu) increased. These findings align with those of El-Kenany et al. [14], who reported similar inhibitory effects on *Lupinus* growth when *Nigella sativa* L. seed powder was added to the soil. Likewise, the results are consistent with the findings of Georgieva [23] and Salih et al. [12], who observed allelopathic effects of *Sorghum halepense* and *Arum cyreniacum* extracts on *Lupinus albus* L., respectively.

The observed inhibition may be linked to oxidative stress induced by allelochemicals, as previously reported in studies involving reactive oxygen species (ROS) and the activation of antioxidant defense systems, which can disrupt plant metabolism [12,24]. In the present study, allelochemicals from *B. bovei* powder reduced the contents of chlorophyll (a, b), carotenoids, total pigments, minerals (P, Fe, Na), total phenols, and alkaloids in lupine. Similar reductions have been reported in allelopathic studies on various plant species [26-28].

Allelopathic activity is known to interfere with the absorption and transport of essential mineral nutrients, disrupt chloroplast membrane function, and inhibit chlorophyll synthase activity by increasing the activity of chlorophyll-degrading enzymes, ultimately leading to chlorophyll degradation [26]. Interestingly, an increase in K and Cu content was also observed in lupine seedlings, consistent with the findings of Salih et al. [29], who reported higher K and Cu accumulation in *Vicia faba* treated with increasing concentrations of *Arum cyreniacum* crude powder.

Additionally, the results showed a significant increase in total nitrogen, total protein, and proline levels in lupine seeds exposed to *B. bovei* powder. These outcomes are supported by several studies that link protein accumulation to ROS overproduction, which induces oxidative damage to proteins, DNA, and RNA [30-31]. The elevated proline content observed in lupine seeds agrees with findings in lettuce and wheat treated with allelopathic extracts [32-33]. Proline is widely recognized as a marker of plant tolerance under allelopathic stress[34]. It contributes to ionic homeostasis, membrane stabilization, and maintenance of antioxidant enzyme activity by scavenging or suppressing ROS [35].

Furthermore, the allelopathic effects were clearly dose-dependent and more pronounced with the application of tuber powder compared to leaf powder, particularly at the highest concentration (10 g/kg), indicating a stronger phytotoxicity associated with underground plant parts.

Overall, the results indicated that the sweet variety of *L. albus* was more sensitive to the applied crude powder, while the most pronounced inhibitory effects were observed with tuber powder. This may be attributed to higher concentrations of anthocyanins, glycosides, flavonoids, alkaloids, saponins, tannins, triterpenes, linoleic acid, elaidic acid, palmitic acid, and cinnamic acids, commonly found in *Biarum* species from the Araceae family [36-38]. Under the tested conditions, the bitter variety showed higher levels of phenols and alkaloids than the sweet variety. This observation is consistent with the results of Messiha et al. [39], who reported similar compound profiles in lupine seeds.

CONCLUSIONS

Based on the results obtained in this study, it can be concluded that the application of *Biarum bovei* crude powder exerts significant allelopathic effects on the majority of the morphological and biochemical traits of *Lupinus albus* L. Among the treatments tested, tuber-derived powder demonstrated the most pronounced inhibitory activity, particularly at higher concentrations. Additionally, the sweet variety exhibited greater sensitivity to allelopathic stress than the bitter variety.

These findings suggest that the presence of *B. bovei* residues in agricultural soils may negatively influence the growth and productivity of *Lupinus albus* L., especially under field conditions where residue accumulation is likely. Therefore, further field-based studies are warranted to confirm these effects under natural growing environments and to better understand the allelochemical mechanisms involved.

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ETICHAL CONSIDERATIONS

This study was conducted in accordance with Libyan environmental protection regulations. *Lupinus albus* L. seeds were purchased from local agricultural markets, and *Biarum bovei* plant material was collected responsibly from non-protected areas in Aslanta, without harming endangered species.

DECLARATION OF COMPETING INTEREST

The authors confirm that there are no competing interests to disclose.

REFERENCES

1. Wolko B, **Clements JC**, **Naganowska B**, **Nelson MN**, **Yang HA**. Lupinus. In: Wild Crop Relatives: Genomic and Breeding Resources: Legume Crops and Forages. Berlin, Heidelberg: Springer; 2010. p. 153–206. https://doi.org/10.1007/978-3-642-14387-8_9

2. Prusinski J. White lupin (*Lupinus albus* L.) — Nutritional and health values in human nutrition: a review. Czech J Food Sci. 2017;35(2):95–105. https://doi.org/10.17221/114/2016-CJFS

3. Nigussie Z. Contribution of white lupin (*Lupinus albus* L.) for food security in north-western Ethiopia: a review. Asian J Plant Sci. 2012;11(5):200–205. https://doi.org/10.3923/ajps.2012.200.205

4. Akbar S. *Lupinus albus* L. (Fabaceae/Leguminosae). In: Handbook of 200 Medicinal Plants. Cham: Springer; 2020. p. 1123–1128. https://doi.org/10.1007/978-3-030-16807-0_120

5. Bates LS, **Waldan RP**, **Teare LD**. Rapid determination of free proline under water stress studies. Plant Soil. 1973;39:205–207. https://doi.org/10.1007/BF00018060

6. Martínez-Villaluenga C, **Frías J**, **Vidal-Valverde C**. Functional lupin seeds (*Lupinus albus* L. and *Lupinus luteus* L.) after extraction of α-galactosides. Food Chem. 2006;98(2):291–299. https://doi.org/10.1016/j.foodchem.2005.05.074

7. Juhász C, **Mendler-Drienyovszki N**, **Magyar-Tábori K**, **Radócz L**, **Zsombik L**. Effect of different herbicides on development and productivity of sweet white lupine (*Lupinus albus* L.). Agronomy. 2024;14(3):488. https://doi.org/10.3390/agronomy14030488

8. Sahoo U, **Malik GC**, **Banerjee M**, **Maitra S**, **Sairam M**. Effect of ready mix application of herbicide on weed dynamics and productivity of maize in lateritic belt of West Bengal. Agric Sci Dig. 2024;44(3):505–511. https://doi.org/10.18805/ag.D-5885

9. Kumar N, **Singh H**, **Giri K**, **Kumar A**, **Joshi A**, **Yadav S**, **et al.** Physiological and molecular insights into the allelopathic effects on agroecosystems under changing environmental conditions. Physiol Mol Biol Plants. 2024;30(3):417–433. https://doi.org/10.1007/s12298-024-01440-x

10. Aziz MM, **Ahmad A**, **Ullah E**, **Kamal A**, **Nawaz MY**, **Ali HH**. Plant allelopathy in agriculture and its environmental and functional mechanisms: A review. Int J Food Sci Agric. 2021;5(4):623–626. http://www.hillpublisher.com/journals/jsfa/

11. Salih SM, **Abdulrraziq AA**. Morphological characteristics of endemic species of Araceae to Al-Jabal Al-Akhdar, Libya (Field Simulation). Int J Sci Res Biol Sci. 2024;11(1).

12. Salih SM, Ahmed AA, Alaila AK. Allelopathy effect of aqueous extracts of *Arum cyreniacum* on germination of seeds of some leguminous crops. Bayan. 2022;(11):183–188. https://journal.su.edu.ly/index.php/bayan/article/view/2242

13. Georgieva N, **Nikolova I**, **Marinov-Serafimov P**. Comparative characteristics of *Lupinus albus* L. and *Lupinus luteus* L. under allelopathic effect of *Sorghum halepense* L. (Pers.). Pestic Phytomed (Belgrade). 2015;30(1):41–50. https://doi.org/10.2298/PIF1501041G

14. El-Kenany E, **El-Darier SM**, **Kamal S**, **Belgassem N**. The probable allelopathic interference of *Nigella sativa* L. seed extracts with *Lupinus termis* L. Catrina. Int J Environ Sci. 2014;10(1):9–18. https://doi.org/10.12816/0010691

15. Metzner H, **Rau H**, **Senger H**. Untersuchungen zur Synchronisierbarkeit einzelner Pigmentmangel-Mutanten von *Chlorella*. Planta. 1965:186–194. https://www.jstor.org/stable/23365689

16. Humphries E. Mineral components and ash analysis. In: Modern Methods of Plant Analysis. Springer; 1956. p. 468–502. https://doi.org/10.1007/978-3-662-25300-7_17

17. Hesse R. Textbook of soil chemical analysis. Delhi, India: CBS Publishers; 1971. https://doi.org/10.1017/S0014479700005202

18. Association of Official Analytical Chemists (AOAC). Official Methods of Analysis. 12th ed. Worwitz W, editor. Washington, D.C.: AOAC; 1975.

19. Bates LS, **Waldan RP**, **Teare LD**. Rapid determination of free proline under water stress studies. Plant Soil. 1973;39:205–207. https://doi.org/10.1007/BF00018060

20. Iqbal S, **Bhanger MI**, **Anwar F**. Antioxidant properties and components of some commercially available varieties of rice bran in Pakistan. Food Chem. 2005;93(2):265–272. https://doi.org/10.1016/j.foodchem.2004.09.024

21. Harborne JB. Phenolic compounds. In: Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman & Hall; 1973. p. 33–88. https://doi.org/10.1007/978-94-009-5921-7_2

22. Samal IP, **Jena S**, **Acharya S**, **Babu R**, **Mahalik G**. Study of medicinal and allelopathic effect of different weeds of Odisha, India. Plant Sci Today. 2024;11(2). https://doi.org/10.14719/pst.2877

23. Georgieva N. Allelopathic tolerance in white lupine (*Lupinus albus* L.) accessions to *Sorghum halepense* extracts. J BioSci Biotechnol. 2019;8(1):51–58.

24. Talukder MR, **Asaduzzaman M**, **Ueno M**, **Tanaka H**, **Asao T**. Alleviation of allelochemical stress-induced growth inhibition and oxidative damage in lettuce under closed hydroponics through electro-degradation. Hortic Sci (Prague). 2020;47:53–68. https://doi.org/10.17221/32/2019-HORTSCI

25. Staszek P, **Krasuska U**, **Ciacka K**, **Gniazdowska A**. ROS metabolism perturbation as an element of mode of action of allelochemicals. Antioxidants. 2021;10(11):1648. https://doi.org/10.3390/antiox10111648

26. Li J, **Zhao T**, **Chen L**, **Chen H**, **Luo D**, **Chen C**, et al. *Artemisia argyi* allelopathy: A generalist compromises hormone balance, element absorption, and photosynthesis of receptor plants. BMC Plant Biol. 2022;22(1):368. https://doi.org/10.1186/s12870-022-03757-9

27. Jasim RJ, **Ibrahim RA**, **Yaqub HM**. Physiological responses of *Helianthus annuus* L. plants under allelopathic effect of *Cucurbita moschata*. Revis Bionatura. 2023;8(3):108. http://dx.doi.org/10.21931/RB/2023.08.03.108

28. Uyun Q, **Respatie DW**, **Indradewa D**. Unveiling the allelopathic potential of *Wedelia* leaf extract as a bioherbicide against purple nutsedge: a promising strategy for sustainable weed management. Sustainability. 2024;16(2):479. https://doi.org/10.3390/su16020479

29. Salih SM, **Alaila AK**, **Abdulrraziq AA**, **Asbeeh JA**. Allelopathic effects of *Arum cyreniacum* on germination and growth of two varieties of *Vicia faba*. Sci Al-Mukhtar J Sci. 2022;37(1):57–67. https://doi.org/10.54172/mjsc.v37i1.522

30. Hasanuzzaman M, **Bhuyan MB**, **Parvin K**, **Bhuiyan TF**, **Anee TI**, **Nahar K**, **et al.** Regulation of ROS metabolism in plants under environmental stress: A review of recent experimental evidence. Int J Mol Sci. 2020;21(22):8695. https://doi.org/10.3390/ijms21228695

31. Yan Z, **Li P**, **Xiao Y**, **Cao L**, **Yao L**. Phytotoxic effects of allelochemical acacetin on seed germination and seedling growth of selected vegetables and its potential physiological mechanism. Agronomy. 2022;12(5):1038. https://doi.org/10.3390/agronomy12051038

32. M'barek K, **Zribi I**, **Ullah MJ**, **Haouala R**. The mode of action of allelochemicals aqueous leaf extracts of some Cupressaceae species on lettuce. Sci Hortic. 2019;252:29–37. https://doi.org/10.1016/j.scienta.2019.03.009

33. Abdel-Farid IB, **Massoud MS**, **Al-Enazy Y**, **Abdel Latef AAH**, **Jahangir M**, **Gomaa NH**. Allelopathic potential of *Haloxylon persicum* against wheat and black mustard with special reference to its phytochemical composition and antioxidant activity. Agronomy. 2021;11(2):244. https://doi.org/10.3390/agronomy11020244

34. Omezzine F, **Ladhari A**, **Haouala R**. Physiological and biochemical mechanisms of allelochemicals in aqueous extracts of diploid and mixoploid *Trigonella foenum-graecum* L. S Afr J Bot. 2014;93:167–178. https://doi.org/10.1016/j.sajb.2014.04.009

35. Alagoz SM, **Lajayer BA**, **Ghorbanpour M**. Proline and soluble carbohydrates biosynthesis and their roles in plants under abiotic stresses. In: Plant Stress Mitigators. Academic Press; 2023. p. 169–185. https://doi.org/10.1016/B978-0-323-89871-3.00027-6

36. Williams CA, **Harborne JB**, **Mayo SJ**. Anthocyanin pigments and leaf flavonoids in the family Araceae. Phytochemistry. 1981;20(2):217–234. https://doi.org/10.1016/0031-9422(81)85096-0

37. Iwashina T. Flavonoids in the species of the family Araceae: a review. Buletin Kebun Raya. 2020;23(1):1–24. https://doi.org/10.14203/bkr.v23i1.1

38. Wahab BAA, **Alamri ZZ**, **Jabbar AA**, **Ibrahim IAA**, **Almaimani RA**, **Almasmoum HA**, **et al.** Phytochemistry, antioxidant, anticancer, and acute toxicity of traditional medicinal food *Biarum bovei* (Kardeh). BMC Complement Med Ther. 2023;23(1):283. https://doi.org/10.1186/s12906-023-04080-y

39. Messiha NK, **Ahmed SAA**, **Mohamed SA**, **EMR RR**, **El-Rokiek KG**. The allelopathic activity of the seed powder of two *Lupinus albus* species on growth and yield of *Vicia faba* plant and its associated *Malva parviflora* weed. Middle East J Appl Sci. 2021;11(4):823–831.