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Akdeniz İklimi Koşullarında Yapraktan Çinko Uygulamasının Bezelyede (*Pisum sativum* L.) Verim ve Kalite Özelliklerine Etkileri

Feride ÖNCAN SÜMER[1*], Nermin YARAŞIR[2]

ÖZET: Bezelye Türkiye'de özellikle ılıman iklime sahip batı bölgesinde yaygın olarak yetiştirilmektedir. Akdeniz ikliminin hakim olduğu bu bölgede bezelye ekim alanlarının azaldığı gözlenmektedir. Çinko eksikliği bezelye çeşitlerinde tane verim kayıplarına neden olmaktadır. Bu çalışmada yaygın olarak ekilen bezelye çeşitlerinde (Karina ve Utrillo) tane verimini artırmak icin gerekli optimum çinko dozunun belirlenmesi hedeflenmiştir. Bu sebeple, çiçeklenme başlangıcında yapraktan farklı dozlarda (0-30-60 kg ha-1) çinko uygulanmıştır. Çalışma, Aydın Adnan Menderes Üniversitesinde 2 üretim sezonu (2019 ve 2020) boyunca yürütülmüştür. Çalışmada, bitki boyu, bitki sap kalınlığı, baklada tane sayısı, bakla uzunluğu, 100-Tane ağırlığı, tane verimi, tane protein oranı, protein verimi, tane kül oranı, tane lif içeriği, tane yağ içeriği ve tane çinko içeriği incelenmiştir. Elde edilen sonuçlara göre her iki yılda bitkide bakla sayısı, 100-tane ağırlığı, tane verimi, tane protein oranı ve protein verimi, tane çinko iceriğinde 60 kg ha-1 çinko dozundan en yüksek değerler elde edilmiştir. Çeşitler arasında incelenen özellikler bakımından benzer değerler elde edilmesine karşın tane verimi ve protein oranı bakımından Karina öne çıkmış, tane çinko iceriğinde Utrillo daha iyi performans sergilemiştir. Sonuç olarak elde ettiğimiz değerlere göre yapraktan 60 kg zinc ha-1 dozunun uygulanması tavsiye edilebilir.

Anahtar Kelimeler: Bezelye, yapraktan çinko uygulaması, tane verimi, tane çinko içeriği

The Effects of Foliar Zinc Application on Yield and Quality Components of Pea (*Pisum sativum* L.) in Mediterranean Climate Conditions

ABSTRACT: Peas are widely grown, especially in the western region of Turkey with a temperate climate. Pea cultivation areas are decreasing in this region, where the Mediterranean climate is dominant. Zinc deficiency causes seed yield losses in pea cultivation. This study aimed to determine the optimum foliar zinc application to improve the seed yield of the widely planted pea varieties (Karina and Utrillo). For this reason, foliar application of zinc (0-30-60 kg ha-1) was carried out at the beginning of the flowering period. The study was conducted in two growing seasons (2019 and 2020) at Aydin Adnan Menderes University. In this study, plant height, plant stem diameter, the number of seeds per pod, pod length, 100-seed weight, seed yield, seed protein content, protein yield, seed ash content, seed fibre content, seed oil content, and seed zinc content were determined. According to the results obtained, the highest values for pods per plant, 100-grain weight, seed yield, protein ratio, protein yield, and seed zinc content were obtained from 60 kg of zinc ha-1 in both years. However, zinc foliar application did not affect the plant height or plant stem diameter in either year. Although similar values were obtained regarding the characters examined among the cultivars, Karina stood out in seed yield and protein ratio, and Utrillo performed better in seed zinc content. Based on the values we got, we can recommend applying a dose of 60 kg of zinc per hectare per year from the leaf.

Keywords: Pea, foliar zinc application, seed yield, seed zinc content

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INTRODUCTION

Leguminosae is the third largest family of flowering plants, consisting of over 20.000 species (Doyle and Luckow, 2003). Legumes are a nutritious fibre in diets around the world. They are an inexpensive source of protein, vitamins, mineral substances, complex carbohydrates, and dietary fibre (Grusak, 2002; Erbersdobler et al., 2017; Parca et al., 2018). Thus, it is consumed as a complementary food to low-protein and high-energy foods in developing countries (Ton et al., 2014). Legumes also help to prevent many health problems, such as reduced risks of developing heart disease, type 2 diabetes, hypertension, cancer, Alzheimer's disease, and Parkinson's disease (Willett et al., 1995; Fung et al., 2009; Scarmeas et al., 2009; Esposito et al., 2010; Alcalay et al., 2012).

Peas are the third most-produced legume in the world after beans and chickpeas (FAO, 2020). However, it comes after other legumes, with 1.5 tons of production in Turkey (TUIK, 2020). Due to the favorable climatic conditions and large agricultural area in Turkey, the production of peas can be increased. However, in recent years, pea cultivation areas have been decreasing due to the preference of producers for high-yielding crops such as corn or cotton, increased labor costs, and the lack of an effective and continuous market.

Fertilizing is one essential practice to improve plant production. Foliar mineral fertilizer can increase the seed yield by being a practical application and acting faster. Zinc is an essential element required in the biosynthesis of plant hormones and is a component of some enzymes such as Indole acetic acid (IAA). Zinc plays an essential role in synthesizing nucleic acid and protein (Kitagishi et al., 1987; Cakmak, 2000). Besides, it plays an essential role in synthesizing RNA nucleic acids, which contribute to the production of proteins responsible for the formation of enzymes and plant hormones (Price et al., 1972; Togay et al., 2004). The zinc element contributes to building and forming chlorophyll molecules, has an important role in building and forming proteins, and activates many enzymes, including starch production (Mohamed, 1977).

Foliar and soil application of zinc can be made. The pH of the soil is a determining factor in the way zinc is applied. In alkaline soils with high pH, zinc uptake by the roots is limited and the usefulness of the zinc taken up may be low. Therefore, foliar application is more appropriate in soils with high pH (Slaton et al., 2005; Hafeez et al., 2013). Foliar zinc fertilization is necessary to obtain vegetative tissue with a sufficient zinc content (Cakmak, 2008). It also helps in utilizing phosphorus, nitrogen, chlorophyll, and protein synthesis (Rohith et al., 2020). Zinc application may have stimulated vegetative growth by increasing photosynthesis products in the plant. Vegetative growth results in increased products of photosynthesis, such as carbohydrates and protein (El-Tohamy and El-Greadly, 2007; Garg et al., 2008). Moreover, carbohydrate metabolism and activation of many enzymes are synthesized by zinc application (Rohith et al., 2020). It enhanced the absorption of zinc, nitrogen, and potassium (Ashoka et al., 2008). Zinc is a vital microelement essential for human health (Fereník and Ebringer, 2003). Zinc deficiency is a problem that affects approximately one-third of the world's population, especially children and pregnant women (Ahmed et al., 2012). Due to zinc deficiency, the immune system deteriorates, and physical growth retardation is observed (Hotz and Brown, 2004; Bouis and Saltzman, 2016). The zinc content of products taken from soils deficit zinc content is low; as a result, zinc deficiency occurs in people consuming these products (Sillanpä and Vlek, 1985; Cakmak et el., 2017). It is a common problem in earthlands (Cakmak, 1999). Therefore, agricultural activities are essential to solve the problem. Better crop production leads to better nutritional health (Cakmak and Hoffland, 2012).

Foliar application is a shorter-term approach that allows for more efficient use of nutrients. It will be effective in a shorter time frame than the deficiencies with soil application (Fageria et al., 2009). It is a more practical method for maximum uptake of applied zinc (Cakmak 2008).

Studies on peas are limited in this region, which has a Mediterranean climate and soils with a high pH. The plant can not take zinc through its roots in such alkaline soils. In the present study, foliar treatments were more effective than soil treatments. Therefore, foliar zinc application was made in this study. This study aimed to increase the grain yield and yield components of peas by foliar application of zinc to increase grain yield in alkaline soils.

MATERIALS AND METHODS

Features of Trial Area

The study was conducted in the experimental area (27° 51'E, 37° 51'N, altitude 50 m) of the Department of Field Crops, Faculty of Agriculture, Aydin Adnan Menderes University, in the 2019-2020 growing season.

Some physical and chemical properties of the soils of the trial area are given in Table 1.

Table 1. Soil properties of the trial area

Soil Texture			pH	Organic Matter (%)	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Sodium (ppm)
sand (%)	silt (%)	clay (%)						
72	16.7	11.3	8.4	1.2	21	176	2978	101
Sandy loam			High	Low	High	Low	High	Low

According to the soil analysis results (Table 1), the experimental area has a sandy loam texture, low organic matter, and alkaline character. It has been determined that the amount of potassium is low, the amount of phosphorus and calcium is high, and the amount of sodium is moderate.

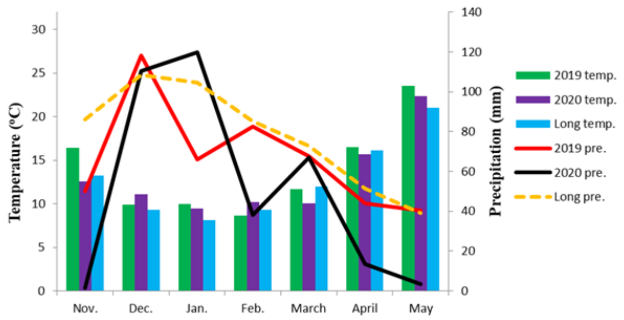

Figure 1. Meteorological data of the trial years (Aydin Meteorology Station, 2021)

According to the meteorological data (Figure 1), the average temperature was low in November and February (2020). It was observed that the total precipitation was irregularly distributed between the months in both years and that excessive precipitation occurred in January of the second year. Also, in May of the second year, the total amount of rain that fell was the least.

Materials

The experiment was conducted in a split plots trial design in randomized blocks with three replications. Karina and Utrillo, pea two genotypes, were used as plant material in the experiment. The seeds were sown with a six-row planting machine with a row spacing of 20 cm. Each plot size was 7.2 m^2. Sowing density was calculated as 70-90 plants per square meter. Sowing was done on November 4, 2019 in the first year and November 14, 2020 in the second year.

During both years, zinc was applied as zinc sulfate (% $ZnSO_4 \cdot 7H2O$) fertilizer in three doses (0-30-60 kg ha^{-1}). The amounts of pure zinc were 0, 11.0 and 22.0 kg Zn ha^{-1} in the experiment.

Methods

Before sowing, 40 kg ha^{-1} of nitrogen, phosphorus, and potassium were applied as 15-15-15 fertilizer. The weeds were controlled twice at the stages of the beginning and post-flowering period by hand. Nitrogen fertilization (20 kg N ha^{-1}) after sowing was applied at a 10-15 cm plant height.

Foliar zinc applications were applied at the beginning of the flowering period. Foliar treatments were applied with a portable hand-held field plot sprayer at 250 kPa pressure using a water carrier volume of 400 L ha^{-1}.

The crop was harvested on May 15 in the first year and May 20 in the second year.

In this study, plant height (cm), plant stem diameter (mm), the number of pods per plant, and pod length (cm) were investigated on ten randomly selected plants when the plants were matured.
Plant stem diameter was measured using a caliper between the second and third node on the main stem. The number of seeds per pod was determined by counting the seeds in the ten pods per plant. Approximately 500 g samples were dried at 70°C for 48 h. 100-seed weight (g) was determined by counting from dry seeds and weighing four replicates of 100 seeds.
Harvesting was done in an 4 m^2 in each plot for the seed yield (t ha^{-1}).
Protein yield was calculated with the formula:
Protein yield (t ha^{-1})= seed protein content (%)*seed yield (t ha^{-1})

Seed protein content (%), seed ash content (%), seed fiber content (%), and seed oil content (%) were measured by NIRS-FT (Bruker MPA) at Adnan Menderes University Agricultural Biotechnology and Food Safety Application and Research Center (ADÜ-TARBİYOMER) (Gislum et al., 2004).
The seed grain's content (mg kg-1) was determined by atomic absorption spectrometry after ashing samples at 550°C and dissolving ash in 3.3% HC1 (Cakmak et al., 1996).

Statistical Analysis

Statistical analyses were conducted using JMP Software (version Pro 13) in the split-plot design. The experimental data about each parameter of the study were subjected to statistical analysis using the analysis technique of variance, and their significance was tested by the "F" test (Gomez and Gomez 1984). When differences were found in ANOVA, means were compared using Fisher's protected least significant difference (LSD) test at $P \leq 0.05$.

RESULTS AND DISCUSSION

The differences between the two years were significant for all observed characteristics (untabulated data). Therefore, data for years were evaluated separately.

Table 2. Analysis of variance (mean squares) for analyzed characters

Source	**Plant Height (cm)**		**Plant Stem Diameter (mm)**		**Number of Seeds Per Pod**		**Pod Length (cm)**		**100-Seed Weight (SW) (g)**		**Seed Yield (t ha^{-1})**	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Cultivars	4.1	118.1*	2.275*	0.02	0.32	2.65	0.347	1.71	39.3	1.59	0.034	0.09*
Doses	151.9	30.2	0.552	0.12	8.12*	6.85*	6.66*	10.4*	40.22*	44.1*	0.204*	0.22*
C*D	69.3	17.2	0.28	0.11	1.68*	5.26	0.648	0.42	8.68	4.17	0.046*	0.002
Source	**Seed Protein Content (%)**		**Protein Yield (t ha^{-1})**		**Seed Fibre Content (%)**		**Seed Ash Content (%)**		**Seed Oil Content (%)**		**Seed Zinc Content (mg kg^{-1})**	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Cultivars	0.38	1.14	4.307	27.5	3.27	0.52	3.29	1.59*	0.03	0.06	14.60*	19.4*
Doses	20.4*	21.5*	585.4*	643.5*	0.72	0.78	1.34	0.57	0.34	0.08	7.94*	12.3*
C*D	2.04	1.31	0.713	8.9	0.13	1.03	0.04	0.37	0.06	0.44	3.9	0.105

**: Significant at $P < 0.01$; *: Significant at $P < 0.05$; ns: Non-significant (C*D:Cultivars*Doses)

According to table 2, the mean of squares of the first year, zinc doses were statistically significant in the number of seeds per pod, 100 seed weight, seed yield, protein ratio, and protein yield. It was determined that the cultivar was insignificant in the characters measured, but the cultivar*dose interaction was significant in protein ratio and grain yield.

According to table 2, the mean of squares of the first year, zinc doses were statistically significant in many characteristics such as the number of grains per pod, pod length, 100 seed weight, seed yield, protein ratio, protein yield and seed zinc content.

The effects of zinc doses or cultivars on plant height were not significant in the first growing season, while the differences between cultivars were significant ($p \leq 0.05$) in plant height in the second growing season. The highest plant height (42.32 cm) was obtained from the Karina, 60 kg Zn ha^{-1} in 2020 (Table 3). The increase in plant height might be due to the contribution of zinc to different physiological events such as IAA synthesis and chlorophyll formation in the plant (Habib, 2009; Yassen et al., 2010).

There is a relationship between stem thickness and strength in peas (Skubisz et al., 2007). Cultivars with strong stems are less likely to lodging. Seed shedding and yield loss increase with lodging. Plant growth and development are limited.

Therefore, carbohydrate assimilation affects the flowering of the plant and its photosynthetic ability (Akgün and Topal, 2006). Although the cultivars were close, utrillo (4.54 mm) stem diameter was measured higher in 2019.

Seeds per pod are a vital yield component and were significantly improved by zinc foliar doses in both years. Zinc, which plays an essential role in the biological process in the plant, has a positive effect on the yield components (Gobarah et al., 2006). The highest values (9.45 and 9.30) were obtained from the 60 kg zinc ha^{-1} in two years.

Pod length was not significantly affected by zinc foliar application and cultivars. Pod length was 9.88 cm and 7.96 cm in 2019 and 2020. Similar results were reported by Pathak et al., 2012. Some researchers have determined a positive and significant relationship between pod length and yield (Lakic et al., 2017). Long pod length is one of the main contributors to seed yield (Uguru 1996).

100-Seed weight is an important seed yield contributing parameter. It was increased significantly ($p \leq 0.05$) with zinc foliar application in both years. 100-seed weight mean values were found as 34.10 g (2019) and 33.73 g (2020), and the highest data was obtained from 36.45 g by Karina with 60 kg zinc ha^{-1}.

Seed yield was significantly ($p \leq 0.05$) affected by zinc levels in both years. Maximum seed yield (3.02 t ha^{-1} and 2.87 t ha^{-1}) was observed with Karina (60 kg zinc ha^{-1}). Zinc is an essential micronutrient for plant growth and development. Zinc application affects pollen production and grain yield (Pathak et al., 2012). Zinc deficiency is reduced at the beginning of flowering with foliar application of zinc. In previous studies, similar to this study, grain yield increased with increasing zinc application (Sujatha, 2001; Choudhary, 2006; Jeyakumar et al., 2008; Pandey et al., 2013; Alag, 2015; Rafique et al., 2015; Koca 2016; Alhasany 2019; Suliman and Alhubaiti, 2020).

As shown in Table 4, while zinc foliar application significantly ($P \leq 0.05$) improved plant seed protein content, protein yield, and seed zinc content were found to be significant, but seed fibre content, seed ash content, and seed oil content were not found to be significant with zinc foliar application in both production seasons. Seed protein content was increased with zinc foliar doses.

Table 3. Mean±standard deviation of seed yield and yield components

	2019			2020		
Plant Height (cm)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	59.27±3.72	53.70±3.63	56.48	36.30±0.94	38.07±0.08	37.18
30	61.00±1.71	69.00±4.69	65.00	38.30±2.45	43.37±2.53	40.83
60	65.17±0.45	65.60±3.59	65.38	37.00±0.37	45.53±1.27	41.27
Mean	61.81	62.77	62.29	37.20 b	42.32 a	39.76
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	12.9			7.41		
Plant Stem Diameter (mm)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	4.93±0.16	3.75±0.20	4.34	4.03±0.08	3.92±0.02	3.98
30	4.00±0.45	3.67±0.20	3.83	3.93±0.20	4.32±0.16	4.13
60	4.68±0.41	4.07±0.16	4.38	4.28±0.27	4.23±0.16	4.26
Mean	4.54 A	3.83 B	4.18	4.08	4.16	4.12
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	7.89			8.02		
Number of Seed Per Pod						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	6.56±1.39 e	7.73±0.53 d	7.14 B	6.20±0.82	6.67±0.24	6.44 B
30	8.33±0.33 c	8.87±0.58 bc	8.60 A	7.90±0.90	8.50±0.41	8.20 A
60	9.90±0.20 a	9.00±0.08 b	9.45 A	9.30±0.82	9.13±0.86	9.22 A
Mean	8.26	8.53	8.61	7.80	8.10	7.96
LSD (Zinc*Cultivar)	0.536			ns		
CV (%)	3.21			12.5		
Pod Length (cm)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	8.30±0.20	8.13±0.24	8.22 B	6.88±0.27	6.87±0.41	6.88 C
30	9.43±0.16	9.40±0.41	9.42 A	8.83±0.57	8.00±0.33	8.42 B
60	9.80±0.16	10.83±0.04	10.32 A	10.00±0.20	9.00±0.12	9.50 A
Mean	9.18	9.46	9.32	8.57	7.96	7.96
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	5.04			8.23		
100-Seed Weight (SW) (g)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	29.5±0.41	28.0±0.82	28.8 B	30.6±0.82	30.5±0.92	30.5 C
30	32.3±0.82	26.6±2.94	29.5 B	32.1±0.41	31.1±0.08	31.6 B
60	34.4±0.20	32.7±0.29	33.6 A	36.5±0.61	34.4±1.22	33.7 A
Mean	32.1	29.1	30.6	33.0	32.0	31.9
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	9.31			7.50		
Seed Yield (t ha^{-1})						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	2.72±0.07 d	2.90±0.04 cd	2.81 B	2.55±0.08	2.65±0.02	2.60 C
30	2.93±0.12 bc	3.13±0.07 a	3.03 A	2.74±0.3	2.90±0.04	2.82 B
60	3.24±0.02 a	3.12±0.02 ab	3.18 A	2.96±0.04	3.07±0.03	3.02 A
Mean	2.96	3.05	3.01	2.75 b	2.87	2.81
LSD (Zinc*Cultivar)	0.17			ns		
CV (%)	2.99			2.45		

LSD: Least Significant Differences

In two years by 60 kg zinc ha-1, the mean seed protein content was% 26.34 and% 28.20. This result was similar to the previous study (Borah et al., 2021). The first-year interaction (zinc*cultivar) of seed protein content was found to be significant, and the highest value (27.21%) was obtained from Karina (60 kg ha^{-1}). While the variety was found to be nonsignificant in both years, Hassan (2002) determined that various effects were significant on the seed protein content. In addition, the foliar application of zinc protects the enzyme activity and ensures the formation of disulphide, which causes an increase in protein synthesis (Cakmak et al., 1989). Seed quality improves with an increase in protein content. Protein yield consists of both grain protein content and seed yield. The zinc application effect on protein yield was found to be significant in both years. In two years, the highest protein yield (8.36 and 8.45) was obtained from 60 kg zinc ha^{-1} zinc.

The effect of the interaction (zinc*cultivar) on seed ash content was significant (P≤0.05) in the second production season. The highest ash value (% 9.86) was obtained from the Utrillo with 30 kg zinc ha^{-1}. Ash content of about % 9 is in two cultivars.

The effects of zinc foliar application and cultivars on seed oil content were insignificant; however, the average seed oil content values increased with zinc application. The seed oil content of around % 0.8 is within the expected range (Onwuliri and Obu, 2002 (1.0–1.2%); Boye et al., 2010 (0.83%)). The highest seed oil contents (% 0.88 and % 0.83) were obtained from 60 kg zinc ha^{-1} in both years. Even though zinc didn't have much of an effect, as in previous studies (Riley et al., 2000; Pable and Patil, 2011; Choudhary et al., 2014; Ashkiani et al., 2020), the amount of oil in the seeds went up as more zinc was added.

The foliar application of zinc significantly increases the zinc content in seed. The increase in zinc in the seed is desirable for most soils, especially zinc-deficient soils. Recently, half of the world's population has been affected by zinc-deficieny (Cakmak 2008; Cakmak 2008; Takka et al., 1989). The majority of the population in India is struggling with diseases caused by zinc deficiency. Crops grown in zinc-deficient soils have low zinc content because of the low uptake. Utrillo responded better to zinc foliar application, and higher seed zinc content (31.37 (2019)–31.52 (2020) mg kg^{-1}) was obtained compared to Karina.

Table 4. Mean±standard deviation of quality characteristics

	2019			2020		
Seed Protein Content (%)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	22.79±0.76	21.97±0.64	22.38 C	24.41±0.07	24.63±0.37	24.63 C
30	24.09±0.39	22.99±0.82	23.54 B	26.96±0.09	25.40±0.25	25.40 B
60	25.47±1.06	26.42±0.48	25.94 A	28.38±0.51	28.20±0.33	28.20 A
Mean	24.11	23.79	23.95	26.58	26.08	26.33
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	2.59			2.35		
Protein Yield (t ha^{-1})						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	62.12±3.66	63.62±1.05	62.87 C	62.25±0.08	65.35±0.02	62.25 C
30	70.59±1.75	71.84±0.93	71.21 B	73.95±0.03	73.73±0.04	73.95 B
60	82.45±3.90	82.35±0.94	82.40 A	82.24±0.04	86.77±0.03	82.24 A
Mean	71.72	72.60	72.16	62.25	65.35	62.25
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	5.46			3.37		
Seed Fibre Content (%)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	19.00±0.07	17.82±1.83	18.41	15.88±1.90	16.07±0.55	15.98
30	19.14±0.05	18.50±0.43	18.82	14.72±0.24	15.96±0.45	15.34
60	19.47±2.44	18.74±1.47	19.11	16.15±1.60	15.76±0.54	15.95
Mean	19.20	18.35	18.78	15.58	15.93	15.76
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	11.8			8.76		
Seed Ash Content (%)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	6.53±0.74	7.21±1.27	6.87	8.75±0.84	8.17±0.16	8.46
30	6.37±0.09	7.26±0.60	6.81	9.46±0.08	8.36±0.03	8.91
60	5.52±0.31	6.51±1.26	6.02	8.38±0.06	8.27±0.05	8.32
Mean	6.14	6.99	6.57	8.86 A	8.27 B	8.56
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	15.5			5.02		

Table 4. continuation

Seed Oil Content (%)						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	0.41±0.22	0.50±0.25	0.46	0.64±0.09	0.55±0.04	0.59
30	0.87±0.26	0.84±0.38	0.86	0.82±0.10	0.52±0.39	0.67
60	1.02±0.35	0.73±0.38	0.88	0.47±0.15	1.19±0.22	0.83
Mean	0.77	0.69	0.73	0.64	0.75	0.70
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	58.3			55.1		
Seed Zinc Content (mg kg^{-1})						
Zinc Foliar Application Levels (kg ha^{-1})	**Utrillo**	**Karina**	Mean	**Utrillo**	**Karina**	Mean
0	30.26±0.09	28.47±0.31	29.37 C	29.94±0.28	28.07±0.37	29.01 C
30	31.28±0.29	29.48±0.38	30.38 B	31.55±0.37	29.57±0.27	30.56 B
60	32.56±0.16	30.76±0.36	31.66 A	33.06±0.33	30.68±0.03	31.87 A
Mean	31.37 a	29.57 b	30.47	31.52 a	29.44 b	30.48
LSD (Zinc*Cultivar)	ns			ns		
CV (%)	0.95			1.34		

LSD: Least Significant Differences

CONCLUSION

Researchers have looked at the effects of foliar zinc on peas before, but this is the first study done in our area, which has a Mediterranean climate.

It was observed that Karina grew faster and competed better with weeds. Utrillo showed slower growth in the early development stages, but the difference was closed during the flowering period.

In the study, protein content, protein yield, seed zinc content, and some yield components such as some seeds per pod, 100-grain weight increased from 0 to 60 kg ha-1 zinc application dose. Therefore, a linear relationship exists between zinc application doses and the characteristics studied. So, it is suggested to keep doing studies based on foliar zinc doses of 60 kg ha-1 to find the highest dose at which the linear relationship stops

Conflict of Interest

The article authors declare that there is no conflict of interest between them.

Author's Contributions

The authors declare that they have contributed equally to the article.

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