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Impact of Foliar Application of Zinc and Yeast Extract on Yield Performance and Seed Quality of Lupin *(Lupinus termis* L.)

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ABSTRACT

This study investigated the effect of foliar application of zinc (0, 75, and 150 ppm/L) and yeast extract (0, 25, and 50 ml/L) on the yield, yield components and seed quality of lupin. Two experiments were conducted at the Agricultural Experimental Farm of Al- Azhar University, Assiut Governorate, during the 2022/2023 and 2023/2024 growing seasons. A randomized complete block design (RCBD) with split-plot arrangement and three replicates was used, with zinc levels assigned to the main plots and yeast extract levels to the sub-plots. Results demonstrated that increasing zinc concentration up to 150 ppm significantly improved all measured traits in both seasons. Similarly, increasing yeast extract concentration to 50 ml/L consistently enhanced yield, yield attributes, and seed protein content. It was concluded that foliar spraying with 150 ppm zinc and combined with 50 ml/L yeast extract provided the best results in terms of productivity and seed quality under the given experimental coditions.

Keywords: Lupin (*Lupnus termis* L.), zinc, yeast extract.

INTRODUCTION

Lupin (*Lupinus termis* L.) is widely cultivated across various regions of Egypt due to its nutritional value and agronomic importance. Its seeds are rich in proteins and oils, offering a nutritional profile comparable to that of soybean and surpassing many other legumes in several aspects (Raza and Jrnsgard, 2005). Historically, lupin has been used as both a staple food and medicinal plant, with its use in human diets dating back thousands of years in Egypt and other civilizations (Kattab, 1986; ARC, 1994). From an agronomic persective, lupin contributes significantly to sustainable farming systems by enhancing soil fertility through biological nitrogen fixation and improving soil structure. It is also a valuable protein source for both animal feed and human consumption, making it a multifaceted crop (Maknickiene, 2001). Moreover, lupin seeds contain low levels of antinutritional factors such as lectins and protease inhibitors, which enhances their digestibility and nutritional efficiency (Australia New Zealand Food Authority, 2001). Zinc is an essential micronutrient that plays a critical role in numerous plant growth and development, including dehydrogenases and peptidases. Zinc also influences the production of auxins-plant hormones that regulate cell elongation, shoot and root development, and fruit setting (Mansour, 2014). Previous studies have shown that foliar application of zinc significantly increases the number of pods per plant, 100-seed weight, and seed protein content (Abd El-Monem *et al.,* 2009). Zahran and Osman (2009) (2009) found that spraying zinc at concentrations of 1.0 and 2.0 g/L significantly enhanced most yield traits and components. Meanwhile, spraying zinc at concentrations of 3.0 g/L resulted in a significant decrease in most of these traits. Saad (2015) indicated that zinc foliar application significantly increased yield and its components protein %. Yeast extract, derived from *Saccharomyces cerevisiae*, is rich in naturally growth regulators such as cytokinins and auxins. These bioactive compounds promote vegetative and reproductive growth, stimulate photosynthesis, improve nutrient translocation, and increase carbohydrate accumulation in plant tissues (Barnett et al., 1990; Amer, 2004). Al-Tawaha (2011) showed that the use of yeast extract gave a significant increase in productivity in soybean plants. Abdo,Fatma *et al.* (2012) reported that foliar spraying with active yeast significantly decreased the number of branches per plant and yield components of soybean cultivar Giza-35. Mohamed *et al.* (2014) pointed that the spraying of yeast increased faba bean yield and pods number / plant, pods weight / plant (g), seeds weight / plant (g) and 100- seed weight (g) on faba bean. Abo-El-Hamd *et al.* (2015) indicated that the addition of yeast extract had a significant effect and increased the number of branches and pods/plant, seed yield/plant, 100-seed weight, and seed yield/acre. This addition also increased the protein content in bean seeds. Khater *et al.* (2023) indicated that the addition of yeast extract resulted in a significant increase in most of the seed yield, its components, and some quality traits in the resulting lupin seeds. Thereby, the present study aims to study the effect of foliar spraying with zinc and yeast extract on the yield, some of its components and quality of lupin crop under the conditions of this study.

MATERIALS AND METHODS

This research was carried out at the Agricultural Experimental Farm of Al-Azhar University in Assiut Governorate, during the 2022/2023 and 2023/2024 growing seasons. The objective was to investigate the effects of foliar applications of zinc and yeast extract on the yield and seed quality of lupin (cv. Giza-2). A split-plot trail in randomized complete block design (RCBD) with three replicates was used. Zinc treatments were assigned to the main plots, while, yeast extract concentrations were randomly assigned to the

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sub-plots. Each experimental plot measured 10.5 m², comprising five ridges (3.5 m long and 0.60 m wide). Lupin seeds were sown at a density of 140,000 plants per faddan, placed in 20 cm spaced hills along both sides of each ridge, and later thinned to two plants per hill. Seeds of lupin sowing occurred on November 19th in both seasons, following inoculation with *Rhizobium leguminosarum*. By combinations of three rates of zinc and yeast extract, there will be 9 treatments Included in each experiment.

A- Zinc concentrations: 0 (control), 75 ppm and 150 ppm.

B - Yeast extract concentrations: 0 (control), 25 ml/L and 50 ml/L.

Zinc was applied as a foliar treatments at three times throughout the growth cycle-at 35, 50, and 65 days after sowing. The active dry yeast (*Saccharomyces cerevisiae*) was dissolved in slight sugar solution and grown for 12 h, then diluted in sterile distilled with the rates 25 and 50 g/l. before foliar spraying. Foliar applications of yeast extract were also conducted three times-on days 25, 40, and 55 after sowing. According to Mahmoued (2001), this is the chemical analysis of yeast extract which presented in Table (1).

The zinc and yeast extract treatments were applied three times as foliar spray using a hand-held compressed air sprayer at a rate of 5 liters per experimental unit. Applications were conducted early in the morning. Normal agricultural practices were followed for growing lupin crops until harvest according to the recommendations of the study area. Some physical chemical and chemical analyses of the experimental site are shown in Table (2).

Table 1. Some chemical analysis of yeast extract (*Saccharomyces cerevisiae*).

Amino acids mg/100g dry weight		Vitam. and carbohydrates mg/100g dry weight	
Aspartic acid	1.33	Vit.B1	2.23
Histidine	2.63	Vit.B6	1.25
Isoleucine	2.31	Vit.B2	1.33
leucine	3.09	Vit B12	0.15
Lysine	2.95	Thimain	2.71
Tyrosine	1.49	Insitol	0.26
Cystine	0.23	Riboflavin	4.96
Threonine	2.09	Biotin	0.09
Tryptophan	0.45	Nicotinic acid	39.88
Valine	2.19	Pyridoxine	2.90
Glutamic acid	2.00	P amino benzoic acid	9.23
Serine	1.56	Folic acid	4.36
Arginine	1.99	Panthothenic acid	19.56
Phenyl alanine	2.01	Glucose	13.32
Proline	1.53		
Methionine	0.72	Total carbohydrates	23.20

Table 2. Some Physical and chemical analyses of the experimental site.

Physical analysis	2022/2023	2023/2024	Chemical analysis	2022/2023	2023/2024
Sand (%)	24.80	25.50	Organic matter (%)	0.98	1.01
Silt (%)	38.90	39.50	Available N (ppm)	74.40	76.50
Clay (%)	36.30	35.00	Available P(ppm)	9.60	10.56
Soil texture	Clay loam		Available K (ppm)	355.15	363.25
			pH (s.p. 65)	7.73	7.99
			E.C. (ds. m^{-1})	1.16	1.17
			Total $CaCo_3$ (%)	2.86	2.61

Recorded data:-

A- Yield and yield attributes:

During harvest, ten plants were selected randomly from the inner rows to evaluate the following traits: plant height (cm), branches and pods number /plant, seeds number /pod, weight of 100 seeds (g), seed yield /plant (g), and seed yield per faddan (kg). The seed yield in kilograms was calculated from the total area of each plot and subsequently converted to yield /faddan.

B- Chemical analysis of seeds:

At the time of harvesting, lupin seed samples were ground and kept for chemical analysis. Protein content (%) was determined by estimating the total nitrogen using the micro-Kjeldahl method as described by A.O.A.C. (1980), then multiplying the nitrogen % by 6.25.

The experimental data were statistically analyzed using analysis of variance according to the procedures established by Gomez and Gomez (1984). Treatment means were compared using the least significant difference (LSD) test at the 5% level. All analyses were performed using the MSTAT-C statistical program developed by Freed *et al.* (1989).

RESULTS AND DISCUSSION

A- Yield and its components:

1 –Effect of foliar application of zinc:

The data presented in Tables 3, 4 and 5, indicate that increasing the concentration of foliar applied zinc from 0 to150 ppm resulted in significant enhancements yield and its components across both studied seasons. The highest values for plant height, branch number /plant, pod number, seed number, 100-seed weight, and overall yield were observed at 150 ppm zinc application during the 2022/2023 and2023/2024 seasons. This enhancement may be attributed to zinc's vital role in synthesizing auxins-plant hormones produced at shoot tips-which regulate cell division, leaf and shoot elongation. These findings are consistent with those of Abd El- Monem *et al.* (2009), Zahran and Osman (2009) and Saad (2015).

Table 3. Plant height (cm) and branches number/plant as affected by zinc and yeast extract (YE) of lupin during 2022/2023 and 2023/2024 seasons.

Zinc	Yeast extract	Plant height (cm) 2022/2023	Plant height (cm) 2023/2024	Branches number/plant 2022/2023	Branches number/plant 2023/2024
Control	0	99.31	102.71	2.90	3.55
	25 m/L	104.64	107.01	3.80	4.75
	50 m/L	107.00	110.95	4.16	4.98
Mean		103.65	106.89	3.62	4.42
75 ppm	0	105.58	111.09	4.00	4.31
	25 m/L	109.87	114.83	4.98	4.99
	50 m/L	113.05	116.35	5.26	5.73
Mean		109.50	114.09	4.74	5.01
150 ppm	0	111.95	116.35	5.19	5.15
	25 m/L	113.61	118.10	5.29	5.77
	50 m/L	116.35	119.89	5.58	5.98
Mean		113.97	118.11	5.35	5.63
All means of yeast extract	0	105.61	110.05	4.03	4.33
	25 m/L	109.37	113.31	4.69	5.17
	50 m/L	112.13	115.73	5.00	5.56
LSD at 5%					
Zinc (Zn)		0.52	1.00	0.11	0.09
Yeast extract(YE)		0.64	0.76	0.17	0.17
Zn X YE		1.12	1.32	0.29	0.30

Table 4. Pods number/plant and seeds number/pod as affected by zinc and yeast extract (YE) of lupin during 2022/2023 and 2023/2024 seasons.

Zinc	Yeast extract	Pods number/plant		Seeds number/pod	
		Seasons			
		2022/2023	2023/2024	2022/2023	2023/2024
Control	0	15.25	16.96	3.45	3.98
	25 m/L	16.50	17.87	3.70	4.21
	50 m/L	16.95	18.31	4.13	4.50
Mean		16.23	17.71	3.76	4.23
75 ppm	0	17.43	17.92	3.50	4.23
	25 m/L	18.64	18.60	3.94	4.65
	50 m/L	19.07	19.10	4.35	4.81
Mean		18.38	18.54	3.93	4.56
150 ppm	0	19.98	20.71	3.71	4.41
	25 m/L	20.81	20.93	4.03	4.60
	50 m/L	21.13	21.75	4.46	4.70
Mean		20.64	21.13	4.06	4.57
All means of yeast extract	0	17.55	18.53	3.55	4.20
	25 m/L	18.65	19.13	3.89	4.48
	50 m/L	19.05	19.72	4.31	4.67
LSD at 5%					
(Zn)		0.51	0.13	0.05	0.05
(YE)		0.25	0.12	0.18	0.14
Zn X YE		NS	0.20	NS	NS

Table 5. 100-seed weight (g), Seed yield (g)/plant and Seed yield (kg)/fad.) as affected by zinc and yeast extract (YE) of lupin during 2022/2023 and 2023/2024 seasons.

Zinc	Yeast extract	100-seed weight (g)		Seed yield (g)/plant		Seed yield (kg)/fad.)	
		Seasons					
		2022/2023	2023/2024	2022/2023	2023/2024	2022/2023	2023/2024
Control	0	34.76	34.90	14.39	15.41	795.1	813.9
	25 m/L	37.05	37.51	16.51	17.60	830.3	851.6
	50 m/L	38.63	38.93	17.90	18.32	871.5	883.0
Mean		36.81	37.11	16.26	17.11	832.3	849.5
75 ppm	0	35.75	36.50	15.93	16.50	835.0	848.1
	25 m/L	38.24	38.33	17.34	17.94	879.5	873.5
	50 m/L	39.34	39.22	17.98	18.77	908.6	911.0
Mean		37.77	38.01	17.08	17.73	874.3	877.5
150 ppm	0	36.40	38.15	17.37	18.01	891.3	898.9
	25 m/L	38.33	38.87	17.86	18.54	924.5	929.8
	50 m/L	39.75	39.61	18.94	18.95	971.9	981.9
Mean		38.16	38.87	18.05	18.50	929.2	936.8
All means of yeast extract	0	35.63	36.51	15.89	16.64	840.4	853.6
	25 m/L	37.87	38.23	17.23	18.02	878.1	884.9
	50 m/L	39.24	39.25	18.27	18.68	917.3	925.3
LSD at 5%							
(Zn)		0.29	0.14	0.36	0.41	0.97	0.67
(YE)		0.13	0.13	0.14	0.08	0.64	0.76
Zn X YE		0.23	0.23	0.24	0.14	1.10	1.30

2 – Effect of yeast extract:

The obtained results in Tables 3, 4, and 5 demonstrate that foliar spraying of yeast extract on lupin significantly improved plant height, number of branches and pods, and seeds per plant, 100- seed weight, and seed yield per plant and per faddan in both growing seasons (2022/2023 and2023/2024). The highest performance was observed in plants applied 50 mL/L of YE. These effects are likely due to the presence of cytokinins (CKs) in the yeast extract, which are known to enhance photosynthesis and promote the accumulation and distribution of dry matter throughout plant tissues. This observation is supported by previous studies, including those by Abdo, Fatma *et al.* (2012), Abo-El-Hamd *et al.* (2015) and Khater *et al.* (2023).

3 – Interaction effects:

The interaction between (Zn x YE) significantly influenced all measured characters in two growing seasons, except for pods number per plant, which showed significance only in the second season, and seed number per pod, which was significant in both seasons. According to Tables 3, 4, and 5, the highest values for these traits were obtained when foliar spraying with 150 ppm zinc and 50 mL/L yeast extract was applied in both growing seasons.

B- Chemical analysis of seeds:-

Protein content (%) of seeds:-

1 –Effect of foliar with zinc:

Results Presented in Table 6, show that foliar application of zinc at various different rates caused a significant increase in seed protein content during 2022/2023 and 2023/2024 seasons. The highest protein percentage was observed with the application of 150 ppm zinc. This increase may be attributed to enhanced photosynthetic activity, which improves protein synthesis. These findings align with those reported by Saad (2015).

2 – Effect of Yeast Extract:

As shown in Table 6, foliar application of yeast extract significantly improved the protein content of lupin seeds in both seasons. The maximum protein percentage was obtained with the application of 50 mL/L yeast extract. This enhancement could be attributed to the growth-promoting hormones present in yeast, which stimulate protein synthesis. These results are consistent with those reported by Abo-El-Hamd *et al.* (2015).

3 – Interaction effects:

The data in Table 6 indicates that interaction between (Zn X YE) did not significantly influence protein percentage in either of the two growing seasons.

Table 6. Protein content (%) as affected by the interaction between zinc and yeast extract (YE) of lupin during 2022/2023 and 2023/2024 seasons.

Seasons	2022/2023				2023/2024			
Zinc	Yeast extract			Mean	Yeast extract			Mean
	0	25 m/L	50 m/L		0	25 m/L	50 m/L	
0	30.9	31.6	31.9	31.4	31.2	31.6	32.2	31.6
75 ppm	31.8	32.0	32.5	32.1	32.0	32.4	32.7	32.3
150 ppm	32.5	32.8	32.9	32.7	32.5	32.6	32.8	32.6
Mean	31.7	32.1	32.4		31.9	32.2	32.5	
	F test		LSD at 5%		F test		LSD at 5%	
(Zn)	*		0.35		*		0.45	
(YE)	*		0.25		*		0.61	
Zn X YE	NS				NS			

CONCLUSION

Based on the experimental conditions, the most favorable seed yield and quality in lupin were achieved with foliar application of 150 ppm zinc combined with 50 mL/L yeast extract.

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تأثير الرش الورقي بمستخلص الخميرة والزنك على إنتاجية وجودة بذور الترمس

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الملخص

أجريت تجربتان حقليتان بمزرعة كلية الزراعة - جامعة الأزهر بأسيوط خلال موسمي ٢٠٢٢/٢٠٢٣ و ٢٠٢٣/٢٠٢٤ م لدراسة استجابة صنف الترمس جيزة-٢ للرش بالزنك (صفر، ٢ - ٤ مل /لتر) وثلاثة تركيزات من مستخلص الخميرة (صفر، ٢٥ و٥٠ مل /لتر) وتاثير ذلك على انتاجية المحصول وجودته وقد أستخدم تصميم القطاعات المنشقة مرة واحدة في ثلاث مكررات حيث وزعت معدلات الزنك في القطع الرئيسية بينما تركيزات مستخلص الخميرة وزعت على القطع المنشقة. وقد أظهرت النتائج المتحصل عليها أن زيادة معدلات الرش بالزنك من صفر، ٢ إلى ٤ مل /لترأدت إلي زيادة معنوية في كل الصفات تحت الدراسة في كلا الموسمين. أدي الرش بمستخلص الخميرة بأعلي تركيز (٥٠ مل/لتر) إلي زيادة معنوية في طول النبات، عدد الأفرع وعدد القرون ومحصول البذور للنبات وعدد البذور للقرن ووزن ال ١٠٠ بذرة ومحصول البذور للفدان والنسبة المئوية للبروتين في البذور في موسمي الزراعة. وبصفة عامة توصى الدراسة بالرش بالزنك بمعدل ٤ مل/لتر مع الرش بمستخلص الخميرة بتركيز ٥٠ مل/ لتر وذلك لتحقيق أعلى محصول وجودة من صنف الترمس جيزة-٢ تحت ظروف إجراء هذه الدراسة .