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The Effect of Irrigation Intervals and Spraying with Nano-Silicon Concentrations on Some quality Characteristics of Three Soybean Cultivars .

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Abstract. *A field experiment was conducted on three soybeans cultivars (Shaimaa, Warka and Rami) during the 2024-2025 growing seasons in one of the farmers' fields located in northern Babylon, 50 km south of Baghdad, to study the effect of irrigation intervals, cultivars, and silicon concentrations on some quality traits. The results showed that the cultivar Shaimaa, with a silicon concentration of 4 ml L^{-1} and an irrigation interval of 6 days, was superior to the other treatments in leaf nitrogen concentration, recording the highest mean values of 3.97 and 4.22 mg kg^{-1} for the two seasons, respectively. In contrast, the cultivar Rami, under the control treatment with a 10 day irrigation interval, gave the lowest mean values of leaf nitrogen concentration, 2.46 and 2.45 mg kg^{-1} for the two seasons, respectively. The triple interaction among cultivars, silicon concentrations, and irrigation intervals had a significant effect on leaf protein percentage. The cultivar Shaimaa with a 6day irrigation interval and 4 ml L^{-1} silicon concentration showed the highest mean values of 24.81% and 26.38% for the two seasons,compared to the control treatment of cultivar Rami with a 10 day irrigation interval, which recorded the lowest mean value of 15.31% for both seasons. The results also indicated that Shaimaa, under a 6day irrigation interval and 4 ml L^{-1} silicon concentration, significantly outperformed the other treatments in seed nitrogen concentration, giving the highest mean values of 6.01 and 6.17 mg kg^{-1} for the two seasons, respectively, compared to Rami under the control treatment with a 10 day irrigation interval, which showed the lowest mean values of 4.20 and 4.21 mg kg^{-1} for the two seasons, respectively. the data were statistically analyzed using the analysis of variance (ANOVA) method based on a split-panel design applied using a randomized complete block design with Genstat software. statistical differences between the arithmetic means were tested using the least significant difference (LSD) value at a probability level of 0.05 for each source of variance .The study recommends adopting nano-silicone spraying with appropriate irrigation intervals, as it plays an effective role in improving the growth of soybean plants and increasing seed yield, taking into account the different responses of the studied varieties.*

Keywords: *soybeans , Glycine max , Nano-Silicon ,irrigation intervelas*

1. INTRODUCTION

Soybean (*Glycine max* L.) is a summer crop whose cultivation is accompanied by many problems that limit its productivity. These problems include those related to the nature of the crop's growth, and the extent to which crop growth is affected by environmental conditions, especially the drought that the region has suffered due to the retreat of the Tigris and Euphrates rivers. The spacing in irrigation intervals led to the deterioration of the plant's condition and a decrease in physiological and biological processes, which negatively affected crop productivity. Drought stress also affects the decrease in metabolic activity and the crop's growth rate, leading to a decrease in soybean productivity [14]. Therefore, it is necessary to find solutions that increase the resistance of plants to various stresses such as drought, heat, and salinity [3]. The use of Nano-silicon is to provide the plant's needs for silicon, as this element is beneficial to the plant since it contributes to strengthening cell walls and thus mechanically supports the aerial parts of the plant, where it stimulates the plant to develop mechanisms through which it can resist or tolerate various stress conditions, whether biotic or abiotic. Silicon also enhances the effectiveness of the antioxidant enzyme system in plants [2].The study aimed to use certain concentrations of nano-silicon 0,2,4 ml L^{-1} , three irrigation intervals 6,8,10 day and three soybean cultivars to develop research on soybean plants, considering them an economic crop, and to find ways to increase their production in Babylon Governorate, as well as to identify the optimal concentration of Nano-silicon to achieve the highest yield and best characteristics, the best irrigation interval, the crop's tolerance to spaced irrigation intervals, and also to select the best interaction between cultivars, silicon concentrations, and irrigation intervals that achieve the best results.

2. MATERIALS AND METHODS

Nitrogen concentration in leaves: This was done using Kjeldal's apparatus through the following process:

Digestion : The leaf sample was dried and ground into a fine, homogeneous powder. The sample was heated with concentrated sulfuric acid and catalysts such as copper sulfate in a digestion flask to oxidize the organic matter and convert the nitrogen present, excluding nitrates and nitrites, to ammonium sulfate.

Distillation: Strong alkali sodium hydroxide (NaOH) was added to the digestion solution to make it alkaline. This resulted in the conversion of the ammonium ion (NH_4^+) to ammonia gas (NH_3). The ammonia gas was evaporated and collected in boric acid solution (H_3BO_3) for collection and fixation.

Titration: The boric acid solution that adsorbed ammonia was titrated with a standard strong acid (e.g., hydrochloric acid HCl of a known concentration, using a suitable indicator). The volume of strong acid consumed was used to calculate the amount of ammonia collected, and thus the total nitrogen in the original sample **[8] [9].**

Protein percentage in leaves (%) : Calculated by multiplying the nitrogen concentration values in the leaves by 6.25.

Nitrogen concentration in seeds: Kjeldahl's apparatus was used for digestion:

Digestion: The leaf sample was dried and ground to a fine, homogeneous powder. The sample was heated with concentrated sulfuric acid and catalysts such as copper sulfate in a digestion flask to oxidize the organic matter and convert the nitrogen present, excluding nitrates and nitrites, to ammonium sulfate.

Distillation: Strong alkali sodium hydroxide (NaOH) was added to the digestion solution to make it alkaline. This resulted in the conversion of the ammonium ion. (NH_4^+) to ammonia gas (NH_3). The ammonia gas was evaporated and collected in boric acid solution (H_3BO_3) for absorption and fixation.

Titration: The boric acid solution that adsorbed the ammonia was titrated with a standard strong acid (e.g., hydrochloric acid HCl of a known concentration) using a suitable indicator. The volume of strong acid consumed was used to calculate the amount of ammonia collected, and therefore the total amount of nitrogen in the original sample **[8] [9].**

Protein percentage in seeds (%) : This was calculated by multiplying the nitrogen concentration values in the seeds by 6.25

Statical Analysis

the data were statistically analyzed using the analysis of variance (ANOVA) method based on a split-panel design applied using a randomized complete block design with Genstat software. statistical differences between the arithmetic means were tested using the least significant difference (LSD) value at a probability level of 0.05 for each source of variance [16].

3. RESULTS AND DISCUSSION

3.1. RESULTS

Table 1. Effect of Nano-silicon Spray, Irrigation Intervals, and their Interactions on the Average Nitrogen Concentration of Soybean Leaf for the 2024 and 2025 Growing Seasons

2024						2025			
Nano-Silicon ml L^{-1}	Cultivars	Irrigations / day			Silicon X Cultivars	Irrigations / day			Silicon X Cultivars
		6	8	10		6	8	10	
0	shaimaa	2.59	2.51	2.51	2.54	2.66	2.51	2.50	2.56
	warka	2.52	2.46	2.45	2.47	3.53	2.48	2.47	2.48
	Rami	2.48	2.48	2.46	2.11	2.48	2.46	2.45	2.48
2	shaimaa	3.81	3.69	3.68	3.73	3.85	3.69	3.67	3.74
	warka	3.17	3.15	3.13	3.15	3.28	3.17	3.15	3.18

	Rami	2.86	2.71	2.69	2.55	2.86	2.71	2.70	2.75
4	shaimaa	3.97	3.81	3.80	3.86	4.22	3.88	3.86	3.98
	warka	3.30	3.22	3.20	3.75	3.38	3.28	3.22	3.29
	Rami	3.04	2.77	2.73	2.75	3.15	2.80	2.77	2.90
L.S.D 5%		0.03			0.02	0.05			0.03
					Cultivars means				Cultivars means
Irrigations X Cultivars	shaimaa	3.46	3.34	3.33	3.37	3.57	3.35	3.35	3.43
	warka	3.00	2.94	2.92	2.95	3.05	2.96	2.94	2.98
	Rami	2.79	2.65	2.63	2.69	2.83	2.65	2.65	2.71
L.S.D 5 %					0.01	0.02			0.01
0.01					Silicon means				Silicon means
Silicon X Irrigations	0	2.53	2.48	2.47	2.49	2.56	2.48	2.47	2.50
	2	3.28	3.18	3.17	3.21	3.31	3.18	3.18	3.23
	4	3.43	3.27	3.24	3.31	3.58	3.31	3.28	3.39
L.S.D 5%		0.02			0.01	0.03			0.02
Irrigations means		3.08	2.98	2.69		3.15	2.98	2.99	
L.S.D 5%		0.01				n.s			

Table 2. Effect of Nano-silicon foliar spray and irrigation intervals on soybean varieties and their interactions on the average percentage of protein in the leaves (%) for the two growing seasons 2024-2025

2024						2025			
Nano-Silicon ml L^{-1}	**Cultivars**	**Irrigations / day**			**Silicon X Cultivars**	**Irrigations / day**			**Silicon X Cultivars**
		6	8	10		6	8	10	
0	shaimaa	16.19	15.69	15.63	15.88	16.63	15.69	15.63	16.00
	warka	15.75	15.50	15.38	15.44	22.06	15.50	15.44	15.50
	Rami	15.50	15.38	15.31	13.19	15.50	15.38	15.31	15.50
2	shaimaa	23.81	23.06	23.06	22.81	24.06	23.06	22.94	23.38
	warka	19.81	19.69	19.56	19.69	20.50	19.81	19.69	19.88
	Rami	17.88	16.94	16.81	15.94	17.88	16.94	16.88	17.19
4	shaimaa	24.81	23.81	23.75	24.13	26.38	24.25	24.13	24.88
	warka	20.63	20.13	20.00	23.44	21.13	20.50	20.13	20.56
	Rami	19.00	17.31	17.06	17.19	19.69	17.50	17.31	18.13
L.S.D 5%		0.22			0.13	0.37			0.21
					Cultivars means				**Cultivars means**
Irrigations X	shaimaa	21.63	20.88	20.81	21.06	22.31	20.94	20.94	21.44
	warka	18.75	18.38	18.25	18.44	19.06	18.50	18.38	18.63

Cultivars	Rami	17.44	16.56	16.44	16.81	17.69	16.56	16.56	16.94
L.S.D 5 %		0.08			0.08	0.14			0.08
					Silicon means				**Silicon means**
Silicon X Irrigations	0	15.81	15.50	15.44	15.56	16.00	15.50	15.44	15.63
	2	20.50	19.88	19.81	20.06	20.69	19.88	19.88	20.19
	4	21.44	20.44	20.25	20.69	22.38	20.69	20.50	21.19
L.S.D 5%		0.13			0.05	0.21			0.14
Irrigations means		19.25	18.63	16.81		19.71	18.66	18.70	
L.S.D 5%		0.06				n.s			

Table 3. Effect Nano-Silicon Foliar Application and Irrigation Intervals on Soybean Cultivars and Their Interactions on the Nitrogen Concentration in Seeds (mg kg^{-1}) during the 2024 and 2025 Growing Seasons

2024						2025			
Nano-Silicon ml L^{-1}	**Cultivars**	**Irrigations / day**			**Silicon X Cultivars**	**Irrigations / day**			**Silicon X Cultivars**
		6	8	10		6	8	10	
0	shaimaa	4.38	4.33	4.23	5.54	4.40	4.33	4.23	4.32
	warka	4.32	4.24	4.21	5.45	4.33	4.25	4.21	4.26
	Rami	4.29	4.23	4.20	5.25	4.31	4.25	4.21	4.25
2	shaimaa	5.79	5.75	5.63	5.58	5.86	5.78	5.65	5.76
	warka	5.62	5.50	5.42	5.51	5.63	5.52	5.46	5.54
	Rami	5.50	5.44	5.40	4.25	5.54	5.45	5.44	5.48
4	shaimaa	6.01	5.83	5.70	5.85	6.17	5.88	5.73	5.93
	warka	5.73	5.55	5.50	5.72	5.77	5.57	5.51	5.62
	Rami	5.60	5.54	5.48	5.31	5.62	5.56	5.51	5.56
L.S.D 5%		0.04			0.03	0.04			0.02
					Cultivars means				**Cultivars means**
Irrigations X Cultivars	shaimaa	5.39	5.30	5.19	5.29	5.48	5.33	5.20	5.34
	warka	5.22	5.09	5.03	5.12	5.24	5.11	5.06	5.14
	Rami	5.13	5.07	5.04	5.08	5.16	5.09	5.05	5.10
L.S.D 5 %		0.02			0.01	0.03			0.02
					Silicon means				**Silicon means**
Silicon X Irrigations	0	4.33	4.27	4.22	4.27	4.34	4.27	4.21	4.28
	2	5.63	5.56	5.49	5.56	5.68	5.59	5.52	5.59
	4	5.78	5.64	5.56	5.66	5.85	5.67	5.58	5.70

L.S.D 5%	0.02			0.02	0.02			0.01
Irrigations means	5.25	5.16	5.09		5.29	5.18	5.10	
L.S.D 5%	0.01				0.01			

Table 4 .The effect of spraying with Nano- silicon and its additives on the yield of soybean and its average percentage of protein in the seeds for the agricultural seasons 2024-2025

2024						2025			
Nano-Silicon ml L^{-1}	**Cultivars**	**Irrigations / day**			**Silicon X Cultivars**	**Irrigations / day**			**Silicon X Cultivars**
		6	8	10		6	8	10	
0	shaimaa	27.38	27.06	26.44	28.94	27.50	27.06	26.44	27.00
	warka	27.00	26.50	26.31	26.60	27.06	26.56	26.31	26.63
	Rami	26.81	26.44	26.25	26.50	26.94	26.56	26.31	26.56
2	shaimaa	36.19	35.94	35.19	34.88	36.63	36.13	35.31	36.00
	warka	35.13	34.38	33.88	34.44	35.19	34.50	34.13	34.63
	Rami	34.38	34.00	33.75	26.56	34.63	34.06	34.00	34.25
4	shaimaa	37.56	36.44	35.63	36.56	38.56	36.75	35.81	37.06
	warka	35.81	34.69	34.38	35.75	36.06	34.81	34.44	35.13
	Rami	35.00	34.63	34.25	33.19	35.13	34.75	34.44	34.75
L.S.D 5%		0.30			0.18	0.27			0.17
					Cultivars means				**Cultivars means**
Irrigations X Cultivars	shaimaa	33.69	33.13	32.44	33.06	34.25	33.31	32.50	33.38
	warka	32.63	31.81	31.44	32.00	32.75	31.94	31.63	32.13
	Rami	32.06	31.69	31.50	31.75	32.25	31.81	31.56	31.88
L.S.D 5 %		0.18			0.10	0.19			0.13
					Silicon means				**Silicon means**
Silicon X Irrigations	0	27.06	26.69	26.38	26.69	27.13	26.69	26.31	26.75
	2	35.19	34.75	34.31	34.75	35.50	34.94	34.50	34.94
	4	36.13	35.25	34.75	35.38	36.56	35.44	34.88	35.63

L.S.D 5%	0.15			0.10	0.12			0.08
Irrigations means	32.81	32.25	31.81		33.10	32.38	31.93	
L.S.D 5%	0.06				0.05			

3.2. DISCUSSION

Leaf Nitrogen Concentration :

The results in Table 1 indicated that the cultivars differed in the percentage of leaf nitrogen concentration. The cultivar Shaimaa achieved the highest leaf nitrogen concentration, reaching 3.37 and 3.43 mg kg-1 for both seasons, respectively, compared to the cultivar Rami, which recorded the lowest concentration, reaching 2.69 and 2.71 mg kg-1 for both seasons, respectively. This difference in the response of genetic compositions to the available growth factors was reflected in their ability to absorb nutrients from the soil or via spraying. This result agrees with [12] in his study on mung bean , where he concluded that the studied cultivars differed in the percentage of leaf nitrogen concentration.

Regarding the effect of Nano-silicon, the table results showed that the treatment of 4 mL -1 surpassed the other treatments in the leaf nitrogen concentration trait, achieving 3.31 and 3.39 mg kg-1 for both seasons, respectively, compared to the control treatment, which gave 2.49 and 2.50 mg kg-1 for both seasons, respectively. The reason may be that silicon reduces the effect of water stress, which directs the plant's energy towards optimal growth and metabolism, and this, in turn, enhances the accumulation of proteins and organic nitrogen in the plant. These results was agreed with [11].

As for the effect of irrigation intervals, it was significant in the first season only. The 6day interval outperformed the other intervals, giving the highest average of 3.08 and 3.15 mg kg-1 for both seasons, respectively, while the 10 day irrigation interval gave the lowest average for the leaf nitrogen concentration trait, reaching 2.69 and 2.99 mg kg-1 for both seasons, respectively.

The reason may be that moderate irrigation management directly affects the efficiency of biological nitrogen fixation and its concentration in the leaves. This result agreed with [13].

Regarding the interaction between Nano-silicon spraying concentrations and the cultivars, the treatment of 4 mL-1 with the cultivar Shaimaa outperformed, giving the highest average of 3.86 and 3.98 mg kg-1 for both seasons, respectively, while the control treatment with the cultivar Rami gave the lowest average, reaching 2.11 and 2.48 mg kg-1 for both seasons, respectively.

Regarding the interaction between silicon and irrigation intervals, the concentration of 4mL-1 with the 6day irrigation interval gave the highest average, reaching 3.43 and 3.58 mg kg-1 for both seasons, respectively, compared to the control treatment at the 10 day irrigation interval, which gave the lowest average, reaching 2.47 and 2.47 mg kg-1 for both seasons, respectively.

The table results also showed significant differences between the cultivars and irrigation intervals, where the cultivar Shaimaa at the 6day irrigation interval gave the highest average of 3.46 and 3.57 mg kg-1 for both seasons, respectively, compared to the cultivar Rami at the 10day irrigation interval, which gave the lowest average of 2.63 and 2.65 mg kg-1 for both seasons, respectively.

The table results also indicated that the triple interaction between cultivars, Nano-silicon concentrations, and irrigation intervals had a significant effect, where the cultivar Shaimaa with the concentration 4 mL-1 and the 6day irrigation interval gave the highest average of 3.97 and 4.22 mg kg-1 for both seasons, respectively, compared to the control treatment with the cultivar Rami at the 10day irrigation interval, which gave the lowest average for the leaf nitrogen concentration trait, reaching 2.46 and 2.45 mg kg-1 for both seasons, respectively.

Leaf Protein Percentage:

The results in Table 2 showed significant differences among the cultivars in the leaf protein percentage trait. The Shaimaa cultivar surpassed the other cultivars, giving the highest average of 21.06 % and 21.44 % for both seasons, respectively, compared to the Rami cultivar which gave the lowest average of 16.81 % and 16.94 % for both seasons, respectively. This superiority is attributed to the higher nitrogen concentration in the leaves of the Shaimaa cultivar These, results agreed with the findings of [12]. in his study on mung bean cultivars.

Regarding the effect of Nano-silicon, the table results showed that the treatment of $4mL^{-1}$ surpassed the other treatments in the leaf protein percentage trait, achieving 20.69 % and 21.19\% for both seasons, respectively, compared to the control treatment which gave 15.56 % and 15.63 % for both seasons, respectively. This is attributed to the superiority of the $4mL^{-1}$ concentration in increasing nitrogen concentration in the leaves as well as table 1 ,These results agreed with [11].

As for the effect of irrigation intervals, it was significantly superior only in the first season. The table results showed that the 6 day interval surpassed the other intervals, giving the highest average of 19.25% and 19.71 % for both seasons, respectively, while the 10day irrigation interval gave the lowest average for the leaf protein percentage trait, which was 16.81 % and 18.70 % for both seasons, respectively. This is attributed to the superiority of the 6 day irrigation interval in increasing nitrogen concentration in the leaves as well as table 1 ,This result agreed with the findings of [13].

Concerning the interaction between Nano-silicon concentrations and cultivars, the treatment of 4 mL^{-1} with the Shaimaa cultivar was superior, giving the highest average of 24.13 % and 24.88 % for both seasons, respectively, while the control treatment with the Rami cultivar gave the lowest average of 13.19 % and 15.50 % for both seasons, respectively.

As for the interaction between silicon and irrigation intervals, the 4 mL^{-1} concentration with the 6 day irrigation interval gave the highest average of 21.44 % and 22.38 % for both seasons, respectively, compared to the control treatment at the 10 day irrigation interval which gave the lowest average of 15.44 % and 15.44 % for both seasons, respectively.

The table results also showed significant differences between cultivars and irrigation intervals, where the Shaimaa cultivar at the 6 day irrigation interval gave the highest average of 21.63 % and 22.31 % for both seasons, respectively, compared to the Rami cultivar and the 10 day irrigation interval which gave the lowest average of 16.44 % and 16.56 % for both seasons, respectively.

Furthermore, the table results also indicated a significant effect of the triple interaction between cultivars, Nano-silicon concentrations, and irrigation intervals. The Shaimaa cultivar at the 4mL^{-1} concentration and the 6day irrigation interval gave the highest average of 24.81 % and 26.38 % for both seasons, respectively, compared to the control treatment with the Rami cultivar at the 10day irrigation interval, which gave the lowest average for the leaf protein percentage trait of 15.31 % and 15.31 % for both seasons, respectively.

Seed Nitrogen Concentration :

Table 3 results indicated the superiority of the Shaimaa cultivar plants in seed nitrogen concentration, giving the highest nitrogen concentration in the seeds of this cultivar, which reached 5.29 and 5.34 mg kg^{-1} for both seasons, respectively. In contrast, the Rami cultivar gave the lowest average, reaching 5.08 and 5.10mg kg^{-1} for both seasons, respectively. the result agreement with the result of [6] [15]. which demonstrated, that superiority of the Shaimaa cultivar in this trait is attributed to its superiority in leaf nitrogen concentration, which was translocate to the seeds during the filling stage, in addition to the genetic nature of soybean cultivars' variability in response to growth factors, and consequently, the variability in growth, yield, and quality traits in soybean and the result agrees with [10][1] and [4]. in their studies on Mung bean.

The effect of Nano-silicon, the results showed the superiority of the 4 ml L^{-1} treatment over the other treatments in seed nitrogen percentage, achieving 5.66 and 5.70 mg kg^{-1} for both seasons, respectively, compared to the control treatment, which gave 4.27 and 4.28 mg kg^{-1} for both seasons, respectively. This is attributed to the superiority of the 4 ml L^{-1} concentration in leaf nitrogen concentration, as shown in Table 1, and its subsequent translocation to the seeds during the filling stage, These results agree with [9]. Regarding the effect of irrigation intervals, the superiority of the 6day interval over the other intervals, giving the highest average of 5.25 and 5.29 mg kg^{-1} for both seasons, respectively. In contrast, the 10 day irrigation interval gave the lowest average for seed nitrogen concentration, reaching 5.09 and 5.10 mg kg^{-1} for both seasons, respectively. This is attributed to the superiority of the 6 day irrigation interval in increasing leaf nitrogen concentration as in Table 1, and its subsequent translocation to the seeds. This result is agree with the findings of [13].

The interaction between spraying with Nano-silicon concentrations and cultivars, the 4ml L^{-1} treatment with the Shaimaa cultivar was superior, giving the highest average of 5.85 and 5.93 mg kg^{-1} for both seasons, respectively. In contrast, the control treatment with the Rami cultivar gave the lowest average of 5.25 and 4.25 mg kg^{-1} for both seasons, respectively. the interaction between silicon and irrigation intervals, the 4ml L^{-1}concentration with the 6day

irrigation interval gave the highest average of 5.78 and 5.85 mg kg^{-1}, respectively, for both seasons, compared to the control treatment at the 10 day irrigation interval, which gave the lowest average of 4.22 and 4.21 mg kg^{-1}, respectively, for both seasons. And there was significant differences between cultivars and irrigation intervals, Shaimaa cultivar at the 6 day irrigation interval gave the highest average of 5.39 and 5.48 mg kg^{-1} for both seasons, respectively, compared to the Rami cultivar at the 10 day irrigation interval, which gave the lowest average of 5.04 and 5.05 mg k^{-1} for both seasons, respectively, the triple interaction among cultivars, Nano-silicon concentrations, and irrigation intervals had a significant effect, Shaimaa cultivar with the 4 ml L^{-1} concentration and the 6 day irrigation interval gave the highest average of 6.01 and 6.17 mg kg^{-1} for both seasons, respectively, compared to the control treatment with the Rami cultivar at the 10 day irrigation interval, which gave the lowest average for seed nitrogen concentration, reaching 4.20 and 4.21mg kg^{-1} respectively for both seasons.

Seed Protein Percentage (%) :

Table 4 results showed significant differences among cultivars in seed protein percentage, Shaimaa cultivar was superior, giving the highest protein percentage of 33.06 and 33.38 % for both seasons, respectively. In contrast, the Rami cultivar gave the lowest average of 31.75 and 31.88 % for both seasons, respectively. This is attributed to the superiority of the same cultivars in seed nitrogen concentration (Table 3). These results agree with [5] [7] in their studies on soybean.

The effect of Nano-silicon showed the superiority of the 4 ml L^{-1} treatment over the other treatments In seeds protein percentage, achieving 35.38 and 35.63% for both seasons, respectively, compared to the control treatment, which gave 26.69 and 26.75 % for both seasons, respectively. This is attributed to the superiority of the 4 ml L^{-1} concentration in seed nitrogen concentration, as shown in Table 3 , These results agree with [11].

The effect of irrigation intervals results showed the superiority of the 6 day interval over the other intervals, giving the highest average of 32.81 and 33.10% for both seasons, respectively. In contrast, the 10 day irrigation interval gave the lowest average for seed protein percentage, reaching 31.81 and 31.93 % for both seasons, respectively. This is attributed to the superiority of the 6 day irrigation interval in increasing seed nitrogen concentration .This result agrees with the study of [13].

The interaction between spraying with Nano-silicon concentrations and cultivars, the treatment with the 4 ml L^{-1}concentration with the Shaimaa cultivar was superior, giving the highest average of 36.56 and 37.06 % for both seasons, respectively. In contrast, the control treatment with the Rami cultivar gave the lowest average of 26.50 and 26.56% for both seasons, respectively.

The interaction between silicon and irrigation intervals, the 4ml L^{-1}concentration with the 6 day irrigation interval gave the highest average of 36.13 and 36.56%, respectively, for both seasons, compared to the control treatment at the 10 day irrigation interval, which gave the lowest average of 26.38 and 26.31%, respectively, for both seasons. Also there was significant differences between cultivars and irrigation intervals, where the Shaimaa cultivar

at the 6 day irrigation interval gave the highest average of 33.69 and 34.25% for both seasons, respectively, compared to the Rami cultivar at the 10 day irrigation interval, which gave the lowest average of 31.50 and 31.56 % for both seasons, respectively. The table results also indicated that the triple interaction among cultivars, Nano-silicon concentrations, and irrigation intervals had a significant effect, where the Shaimaa cultivar with the 4 ml L^{-1} concentration and the 6 day irrigation interval gave the highest average of 37.56 and 38.56% for both seasons, respectively, compared to the control treatment with the Rami cultivar at the 10 day irrigation interval, which gave the lowest average for seed protein.

4. CONCLUSIONS

The Cultivers "Shaimaa," treated with a 6-day irrigation period and sprayed with 4 ml of Nano-Silicone, outperformed all other treatments in terms of nitrogen concentration and protein percentage in leaves and seeds. Therefore, we recommend that future researchers use other concentrations of nano-silicon and higher irrigation intervals than those currently used, and apply them to other cultivars .

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