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The effect of visible light ratio and amino acids in some biochemical growth parameters of *chrysanthemum indicum* plants under various irrigation periods

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Abstract

An experiment was conducted under plastic shades set up for this purpose in the almussaib city (45 km north of Babil province) During the period from April 1, 2023, to November 15, 2023 to improve biochemical indicators for chrysanthemum plants Minngopher variety with red flowers, the experiment include three factors the first factor different percentages of visible light blocking (50 ,75) % representation of the second factor treating plants with three Irrigation Intervals (daily, every 24 hours, and every 48 hours) as for the third factor spraying plants with many concentrations of free amino acids (0, 1.00, 1.50 and 2.00) mg L^{-1}, a factorial experiment applied using a Randomized Complete Blocks Design with three replicates per treatment. Each replicate contained three pots, with one plant. The results showed the study factors have significant impact of the studied qualities, the interaction (75% shading, daily irrigation, and a concentration of 150 mg L^{-1}) give significant impact in the chlorophyll content of the leaves (44.45 SPAD) while achieved the triple interaction treatment (75% shading, daily irrigation, and treatment with a concentration of 200 mg L^{-1}) significant impact in Nitrogen content of the leaves (3.050%) and phosphorus (0.9027%) and potassium (2.086%) and carbohydrates (29.88%) while for the proline content of the leaves the interactions treatment was impact (50% shading, irrigation every 48 hours and comparative treatment (0.9027 mg g^{-1}) from here we conclude that shading ratios play an important role in reducing the impact of stress intensity humidity and thermal associated with treating plants with free amino acids spraying on vegetative plant.

Keywords: chrysanthemum plants, blocking Percentage**,** amino acids**,** Irrigation Period

Introduction

chrysanthemum (*Chrysanthemum indicum* L.) a perennial herbaceous plant belonging to the Compositae family, originating from Asia and Northeast Europe, is one of the most important commercially harvested flowers for short-day plants, It ranks second globally claiming the top position in the United States and Japan, where it is considered a national flower, First cultivated in China, it later spread to Japan, Europe, and the United States, Its significance lies in its versatile uses, being a crucial cut flower that can be cultivated for landscaping purposes in gardens, It is marketed as potted flowering plants, offering a variety of flower shapes, sizes, and colors, Additionally, it boasts a prolonged flowering period when cut and arranged in vases [1 , 2].

The location of Iraq, influenced by the semi-tropical high-pressure system characterized by high radiation and excessive summer temperatures, coupled with a decrease in rainfall, has caused environmental problems and significant variations in weather conditions. These factors have led to clear stresses affecting the growth and spread of plants [3]. Therefore, it is more appropriate to explore methods to overcome issues related to extreme light intensity. These include selecting suitable shading ratios to reduce the impact of solar radiation, as well as spraying certain nutrients, such as amino acids, which may play a role in mitigating the damage from high light intensity and water scarcity. The current study aims to investigate the impact of light blocking percentage, irrigation periods, and free amino acids on the growth of Chrysanthemum plants.

Materials and Methods

An experiment was conducted under plastic houses set up for this purpose in the almussaib During the period from April 1, 2023, to November 15, 2023 the experiment aimed to study the impact of the quality of visible light by varying shading percentages using polyethylene and foliar amino acids sprayed on water-stressed Chrysanthemum plants. This was achieved by subjecting them to different irrigation intervals, Chrysanthemum plants of the Minngopher variety with red flowers were obtained from a private nursery in Karbala at the age of 18 months on March 15, 2023. Subsequently, the plants were propagated into two types: first, the formed shoots, which were selected as uniformly as possible, and second, the basal shoots. Various types (basal, lateral, and terminal) were planted, with lengths ranging from 10 to 15 cm after pruning on March 28–30, 2023. The plants were placed in plastic pots with a diameter of 22 cm and a volume of 3 kg, filled with river mix soil with specified physical and chemical characteristics as indicated in Table (1). One plant was placed per pot, and soil compaction was ensured during the planting of basal shoots and formed shoots to prevent seedling displacement. All necessary service operations were carried out, following the procedures applied during the study period [4]. Prior to this, a plastic greenhouse with an area of (2.5×3.5 m) for each shade was prepared independently, covered with two types of polyethylene (green Saran). The pots were arranged with a one-meter gap between the two shades.

Table (1): Some Physical and Chemical in Experiment Soil

Soil texture	Size distribution of soil particles			N. P. K. (mg Kg^{-1})			Organic material (100)%	E.C ds. m^{-1}	pH
Sandy mixture	Sand percentage	Alluvial percentage	Clay Per.	K	P	N			
	53	21	26	174.3	9.3	19.1	6.5	1.5	7.8

The research experiment involved the use of three factors divided according to the adopted experimental design, as follows:

1. **Light Shading Ratio**: This factor utilized green polyethylene at shading ratios of 50% and 75%.
2. **Irrigation Intervals:** Three irrigation intervals were implemented in the experiment (daily, every 24 hours, and every 48 hours). It was carried out using a hand sprayer throughout the experiment, starting on June 1, 2023, and continuing until the appearance of buds on November 5, 2023.
3. **Free Amino Acids:** Plants were treated with a free amino acids, was sprayed on the vegetative growth with three concentrations (1.00, 1.50 and 2.00) mg L^{-1}. Additionally, a control treatment was included, with three sprays at intervals of 21 days during the evening. The first spray was administered on June 1, 2023.

Study Parameters

1. Chlorophyll content of the leaves (SPAD): it was measured using a SPAD.
2. Nitrogen content of the leaves (%): It was measured in the laboratories of the Graduate Studies Department, Animal Production Technologies section, at Al-Mussayab Technical College. The total nitrogen percentage was calculated after adding sodium hydroxide (NaOH) using a Kjeldahl Micro Digestion Unit.
3. Phosphorus content of the leaves (%): it was measured using a spectrophotometer.
4. potassium content of the leaves (%): it was assessed at the soil and water Leboratories at the Mousayeb technical institute using the flame photometer
5. proline content of the Leaves (mg/g): the quantity of the amino acid (proline) was measured in the in the laboratories of the University of Babylon.
6. Carbohydrates content of the Leaves (%): it was measured in the laboratories of the University of Babylon.

Experimental Design

The experiment was statistically analyzed in a (2x3x4) factorial design using R.C.B.D. with three replicates per treatment. Each replicate contained three pots, each with one plan. Statistical analysis was performed using the GenStat2012 program. Mean comparisons were conducted to determine the significance level based on the Least Significant Difference (L.S.D.) at a 5% probability level [5].

Results and Discussion

First/ Chlorophyll content of the leaves(SPAD):

The statistical analysis results in Table (2) reveal significant differences caused by the shading percentage, 75% shading ratio demonstrated a significant superiority in chlorophyll content, yielding the highest average SPAD (42.37 SPAD) compared to the 50% shading treatment, which had a lower average of (41.37 SPAD). Similarly, irrigation periods showed significant differences, with daily irrigation achieving the highest average (42.84 SPAD), surpassing the 48-hour irrigation treatment with an average of (29.33 SPAD). Regarding free amino acid concentration, the sprayed treatment at a concentration of 2.00 mg L^{-1} exhibited a significant impact, recording the highest average (42.42 SPAD) compared to the control treatment with an average of (41.25 SPAD).

Interaction effects between experimental factors were evident, where the interaction of 75% shading and daily irrigation resulted in the highest average (43.60 SPAD), outperforming most other treatments additionally, the interaction of 75% shading with a concentration of 2.00 mg L^{-1} showed a higher average (43.09 SPAD) compared to the interaction of 50% shading for untreated plants (40.68 SPAD). The interaction of irrigation period with amino acid concentration also had a significant effect, with daily irrigation for plants treated with a concentration of 1.50 mg L^{-1} achieving a higher average (43.20 SPAD) compared to the untreated plants with an average of (40.52 SPAD).

The combined interaction of shading, irrigation periods, and free amino acids demonstrated a significant response in measuring chlorophyll content. The triple interaction of 75% shading, daily irrigation, and a concentration of 1.50 mg L^{-1} exhibited the highest average (44.45 SPAD), while the triple interaction of 50% shading, 48-hour irrigation, and a concentration of 1.00 mg L^{-1}recorded the lowest average (40.27 SPAD).

Table (2): Effect of light Ratio, irrigation period, and free amino acids, and their interactions, in the chlorophyll content in chrysanthemum plants (SPAD)

Blocking Percentage X irrigation period	Amino acid concentration, mg^{-1}				Irrigation Period (hour)	Blocking Ratio
	2.00	1.50	1.00	0.00		
42.08	41.83	42.01	42.64	41.85	daily	%50
41.36	42.43	41.23	40.77	41.00	Every 24	
40.68	40.96	41.06	40.27	40.41	Every 48	
43.60	44.33	44.45	43.57	42.06	daily	%75
42.38	43.86	42.15	41.90	41.58	Every 24	

41.12	41.07	41.78	40.99	40.62	**Every 48**	
0.910	**L.S.D. 0.05**				**L.S.D. 0.05**	
Blocking percentage	**Light blocking ratio × Amino acid concentration, mg**					
41.37	41.74	41.43	41.23	41.09	**%50**	
42.37	43.09	42.79	42.15	41.42	**%75**	
0.526	1.051				**L.S.D. 0.05**	
Irrigation period	**Irrigation period × Amino acid concentration**					
42.84	43.08	43.23	43.11	41.96	**daily**	
41.87	43.15	41.69	41.34	41.29	**Every 24**	
40.90	41.02	41.42	40.63	40.52	**Every 48**	
0.644	1.287				**L.S.D. 0.05**	
	42.42	42.11	41.69	41.25	**Amino acids**	
	0.743				**L.S.D. 0.05**	

Second/ Nitrogen content of the leaves (%)

The statistical analysis results in Table (3) indicate significant differences attributed to the shading percentage.75% shading ratio demonstrated a statistically significant superiority in nitrogen content, yielding the highest average of 2.683% compared to 2.599% for the 50% shading treatment. In terms of irrigation periods, daily irrigation showed the highest average of 2.683%, compared to the 48-hour irrigation treatment, which recorded the lowest average of 2.555%. Additionally, the treatment with a concentration of 200 mg L^{-1} of free amino acids applied to the plants had a significant effect on the same trait, recording the highest average of 2.722%, outperforming the control treatment that achieved the lowest average of 2.476%.

Interaction effects between experimental factors also resulted in significant differences. The interaction of 50% shading and daily irrigation recorded the highest average (2.719%), while the interaction of 75% shading with irrigation every 24 hours had the lowest average (2.537%). The interaction between shading percentage and free amino acid concentration had a significant effect on this trait, where the interaction of 50% shading for plants treated with a concentration of 2.00 mg/L had the highest average (2.784%), surpassing most other treatments. In contrast, the interaction of 75% shading for untreated plants achieved the lowest average (2.468%).

The interaction of irrigation period with free amino acid concentration also had a significant effect on the same trait. The interaction of daily irrigation for plants treated with a concentration of 2.00 mg/L had the highest average (2.868%), outperforming most other treatments, compared to the 48-hour irrigation treatment for untreated plants, which had an average of 2.455%. the results of the table indicate that the combined interaction of experimental factors (shading, irrigation periods, and free amino acids) had a significant response in measuring nitrogen content for chrysanthemum plants. The triple interaction of 50% shading, daily irrigation, and a concentration of 2.00 mg L^{-1} exhibited the highest average (3.050%), while the triple interaction of 75% shading, irrigation every 48 hours, and daily irrigation with a concentration of 0 mg L^{-1} recorded the lowest average (2.463%).

Table (3): Effect of visible light, irrigation period, and free amino acids, and their interactions, on the Nitrogen content in chrysanthemum plants (%)

Blocking Percentage X irrigation period	Amino acid concentration, mg^{-1}				Irrigation Period (hour)	Blocking Ratio
	2.00	1.50	1.00	0		
2.719	3.050	2.700	2.633	2.493	**daily**	**%50**
2,573	2.610	2.613	2.553	2.513	**Every 24**	
2.598	2.693	2.660	2.590	2.447	**Every 48**	
2.648	2.687	2.753	2.687	2.463	**daily**	**%75**
2.537	2.640	2.550	2.480	2.477	**Every 24**	
2.613	2.653	2.673	2.663	2.463	**Every 48**	
0.1636	0.3271				**L.S.D. 0.05**	
Blocking percentage	**Light blocking ratio × Amino acid concentration, mg**					
2.630	2.784	2.658	2.592	2.484	**%50**	
2.599	2.660	2.659	2.610	2.468	**%75**	
0.0944	0.1889				**L.S.D. 0.05**	
Irrigation period	**Irrigation period × Amino acid concentration**					
2.683	2.868	2.727	2.660	2.478	**daily**	
2.555	2.625	2.582	2.517	2.495	**Every 24**	
2.605	2.673	2.667	2.627	2.455	**Every 48**	
0.1157	0.2313				**L.S.D. 0.05**	
	2.722	2.658	2.601	2.476	**Amino acids**	
	0.1335				**L.S.D. 0.05**	

Third/ Phosphorus content of the leaves (%)

The statistical analysis results in Table (4) reveal significant differences attributed to the shading percentage.75% shading ratio demonstrated a statistically significant superiority in phosphorus content, yielding the highest average of 0.797% compared to 0.716% for the 50% shading treatment, which had the lowest average. In terms of irrigation periods, daily irrigation showed the highest average of 0.816%, compared to the 48-hour irrigation treatment, which recorded the lowest average of 0.670%.

Additionally, the treatment with a concentration of 2.00 mg L^{-1} of free amino acids applied to the plants had a significant effect on the same trait, recording the highest average of 0.843%, outperforming all other treatments, compared to the control treatment that achieved the lowest average of 0.687%.

Table (4): Effect of visible light, irrigation period, and free amino acids, and their interactions, on the Phosphorus content in chrysanthemum plants (%)

Blocking Percentage X irrigation period	Amino acid concentration, mg^{-1}				Irrigation Period (hour)	Blocking Ratio
	2.00	1.50	1.00	0.00		
0.747	0.937	0.583	0.797	0.670	daily	%50
0.737	0.823	0.760	0.710	0.657	Every 24	
0.662	0.723	0.670	0.640	0.617	Every 48	
0.885	0.950	0.943	0.913	0.733	daily	%75
0.812	0.877	0.783	0.790	0.800	Every 24	
0.695	0.747	0.713	0.673	0.647	Every 48	
0.1067	0.2134				L.S.D. 0.05	
Blocking percentage	Light blocking ratio × Amino acid concentration, mg					
0.716	0.828	0.671	0.716	0.648	%50	
0.797	0.858	0.813	0.792	0.727	%75	
0.0616	0.1232				L.S.D. 0.05	
Irrigation period	Irrigation period × Amino acid concentration					
0.816	0.943	0.763	0.855	0.702	daily	
0.775	0.850	0.772	0.750	0.728	Every 24	
0.679	0.735	0.692	0.657	0.623	Every 48	
0.0755	0.1509				L.S.D. 0.05	
	0.843	0.742	0.754	0.687	Amino acid	
	0.0871				L.S.D. 0.05	

Interaction effects between experimental factors also resulted in significant differences. The interaction of 75% shading with daily irrigation recorded the highest average (0.885%), outperforming most other treatments. In contrast, the interaction of 50% shading with irrigation every 48 hours had the lowest average (0.662%). The interaction between shading percentage and free amino acid concentration had a significant effect on this trait, where the interaction of 75% shading for plants treated with a concentration of 2.00 mg L^{-1} had the highest average (0.858%), surpassing most other treatments. In contrast, the interaction of 50% shading for untreated plants achieved the lowest average (0.648%). The interaction of irrigation period with free amino acid concentration also had a significant effect on the same trait. The interaction of daily irrigation for plants treated with a concentration of 2.00 mg L^{-1} had the highest average (0.943%), outperforming most other treatments, compared to the 48-hour irrigation treatment for untreated plants, which had an average of 0.623%.

The results of the table indicate that the combined interaction of experimental factors (shading, irrigation periods, and free amino acids) had a significant response in measuring phosphorus content for chrysanthemum plants. The triple interaction of 75% shading, daily irrigation, and a concentration of 2.00 mg L^{-1} exhibited the highest average (0.950%), while the triple interaction of 50% shading, daily irrigation, and a concentration of 1.50 mg L^{-1} recorded the lowest average (0.583%).

Forth/ potassium content of the leaves (%)

The statistical analysis results in Table (5) reveal significant differences attributed to the shading percentage.75% shading ratio demonstrated a statistically significant superiority in potassium content, yielding the highest average of 1.8925% compared to 1.8692% for the 50% shading treatment, which had the lowest average. In terms of irrigation periods, daily irrigation showed the highest average of 1.9775%, outperforming all other treatments. In contrast, the 48-hour irrigation treatment recorded the lowest average of 1.7329%. Additionally, the treatment with a concentration of 2.00 mg L^{-1} of free amino acids applied to the plants had a significant effect on the same trait, recording the highest average of 1.9217%, surpassing the control treatment that achieved the lowest average of 1.8350%, with no significant response for other concentrations.

Interaction effects between experimental factors also resulted in significant differences. The interaction of 75% shading with daily irrigation recorded the highest average (2.0283%), outperforming all other treatments. In contrast, the interaction of 75% shading with irrigation every 48 hours had the lowest average (1.7033%). The interaction between shading percentage and free amino acid concentration had a significant effect on this trait, where the interaction of 75% shading for plants treated with a concentration of 2.00 mg L^{-1} had the highest average (1.9344%), surpassing most other treatments. In contrast, the interaction of 50% shading for untreated plants achieved the lowest average (1.812%). the interaction of irrigation period with free amino acid concentration also had a significant effect on the same trait. The interaction of daily irrigation for plants treated with a concentration of 2.00 mg L^{-1} had the highest average (2.0250%), outperforming most other treatments, compared to the 48-hour irrigation treatment for untreated plants, which had an average of 1.6600%.

The results of the table indicate that the combined interaction of experimental factors (shading, irrigation periods, and free amino acids) had a significant response in measuring potassium content for chrysanthemum plants. The triple interaction of 75% shading, daily irrigation, and a concentration of 2.00 mg L^{-1} exhibited the highest average (2.0867%), while the triple interaction of 75% shading, irrigation every 48 hours, and a concentration of 0 mg L^{-1} recorded the lowest average (1.6567%

Table (5): Effect of visible light, irrigation period, and free amino acids, and their interactions, on the potassium content in chrysanthemum plants (%)

Blocking Percentage X irrigation period	Amino acid concentration, mg^{-1}				Irrigation Period (hour)	Blocking Ratio
	2.00	1.50	1.00	0.00		
1.9267	1.9633	1.9233	1.9133	1.9067	daily	%50
1.9183	1.9367	1.9333	1.9367	1.8667	Every 24	
1.7625	1.8267	1.7900	1.7700	1.6633	Every 48	
2.0283	2.0867	2.0333	2.0167	1.9767	daily	%75
1.9458	1.9567	1.9400	1.9467	1.9400	Every 24	
1.7033	1.7600	1.7200	1.6767	1.6567	Every 48	
0.0581	0.1163				$L.S.D._{0.05}$	
Blocking percentage	Light blocking ratio × Amino acid concentration, mg					
1.8692	1.9089	1.8822	1.8733	1.8122	%50	
1.8925	1.9344	1.8978	1.8800	1.8578	%75	
0.0336	0.0671				$L.S.D._{0.05}$	
Irrigation period	Irrigation period × Amino acid concentration					
1.9775	2.0250	1.9783	1.9650	1.9417	daily	
1.9321	1.9467	1.9367	1.9417	1.9033	Every 24	
1.7329	1.7933	1.7550	1.7233	1.6600	Every 48	
0.0411	0.0822				$L.S.D._{0.05}$	
	1.9217	1.8900	1.8767	1.8350	Amino acids	
	0.0475				$L.S.D._{0.05}$	

Fifth/ Carbohydrates content of the paper (%)

The statistical analysis results in Table (6) indicate significant differences attributed to the shading percentage.75% shading ratio demonstrated a statistically significant superiority in carbohydrate content, yielding the highest average of 20.96% compared to 17.64% for the 50% shading treatment, which had the lowest average. In terms of irrigation periods, daily irrigation showed the highest average of 22.86%, outperforming all other treatments. In contrast, the 48-hour irrigation treatment recorded the lowest average of 16.87%. Additionally, the treatment with a concentration of 2.00 mg L^{-1} of free amino acids applied to the plants had a significant effect on the same trait, recording the highest average of 24.97%, surpassing the control treatment that achieved the lowest average of 16.05%, outperforming all other treatments.

Table (6): Effect of visible light, irrigation period, and free amino acids, and their interactions, on the Carbohydrates content in chrysanthemum plants (%)

Blocking Percentage X irrigation period	Amino acid concentration, mg-1				Irrigation Period (hour)	Blocking Ratio
	2.00	1.50	1.00	0.00		
18.40	27.83	17.86	12.96	14.95	daily	%50
17.81	23.10	16.85	16.14	15.14	Every 24	
16.71	22.21	15.67	15.17	13.81	Every 48	
26.96	29.88	27.69	27.19	23.08	daily	%75
18.89	22.94	19.77	16.66	16.21	Every 24	
17.03	23.83	16.17	15.00	13.12	Every 48	
2.616	5.231				L.S.D. 0.05	
Blocking percentage	Light blocking ratio × Amino acid concentration, mg					
17.64	24.38	16.79	14.76	14.63	%50	
20.96	25.55	21.21	19.62	17.47	%75	
1.510	3.020				L.S.D. 0.05	
Irrigation period	Irrigation period × Amino acid concentration					
22.68	28.86	22.78	20.07	19.01	daily	
18.35	23.02	18.31	16.40	15.67	Every 24	
16.87	23.02	15.92	15.08	13.47	Every 48	
1.850	3.699				L.S.D. 0.05	
	24.97	19.00	17.19	16.05	Amino acids	
	2.136				L.S.D. 0.05	

Interaction effects between experimental factors also resulted in significant differences. The interaction of 75% shading with daily irrigation recorded the highest average (26.96%), outperforming all other treatments. In contrast, the interaction of 50% shading with irrigation every 48 hours had the lowest average (16.71%). The interaction between shading percentage and free amino acid concentration had a significant effect on this trait, where the interaction of 75% shading for plants treated with a concentration of 2.00 mg L^{-1} had the highest average (25.86%), surpassing most other treatments. In contrast, the interaction of 50% shading for untreated plants achieved the lowest average (14.63%). the interaction of irrigation period with free amino acid concentration also had a significant effect on the same trait. The interaction of daily irrigation for plants treated with a concentration of 2.00 mg L^{-1} had the highest average (28.86%), outperforming most other treatments, compared to the 48-hour irrigation treatment for untreated plants, which had an average of 13.47%.

The results of the table indicate that the combined interaction of experimental factors (shading, irrigation periods, and free amino acids) had a significant response in measuring carbohydrate content for chrysanthemum plants. The triple interaction of 75% shading, daily irrigation, and a concentration of 2.00 mg L^{-1} exhibited the highest average (29.88%), while the triple interaction of 75% shading, irrigation every 48 hours, and a concentration of 0 mg L^{-1} recorded the lowest average (12.96%).

Sixth / proline content of the paper (mg/g)

The statistical analysis results in Table (7) reveal significant differences attributed to the shading percentage.50% shading ratio demonstrated a statistically significant superiority in proline content, yielding the highest average of 0.7381 mg/g compared to 0.7013 mg/g for the 75% shading treatment, which had the lowest average. Concerning irrigation periods, the treatment with irrigation every 48 hours showed the highest average of 0.8760 mg/g, surpassing all other treatments. In contrast, the daily irrigation treatment recorded the lowest average of 0.5980 mg/g. Additionally, the control treatment without amino acid application had the highest average of 0.7569 mg/g, outperforming only the treatment with a concentration of 2.00 mg L^{-1}, which achieved the lowest average of 0.6903 mg/g, with no significant response observed for other concentrations.

Table (7): Effect of visible light, irrigation period, and free amino acids, and their interactions, on the proline content in chrysanthemum plants (mg/g)

Blocking Percentage X irrigation period	Amino acid concentration, mg^{-1}				Irrigation Period (hour)	Blocking Ratio
	2.00	1.50	1.00	0.00		
0.6327	0.5747	0.6113	0.6337	0.7110	daily	%50
0.7024	0.6903	0.7193	0.6900	0.7100	Every 24	
0.8792	0.8690	0.8647	0.8803	0.9027	Every 48	
0.5634	0.5220	0.538	0.5583	0.6353	daily	%75
0.6677	0.6603	0.6807	0.6493	0.6807	Every 24	
0.8728	0.8253	0.8750	0.8893	0.9017	Every 48	
0.05843	0.11686				L.S.D. 0.05	
Blocking percentage	Light blocking ratio × Amino acid concentration					
0.7381	0.7113	0.7318	0.7347	0.7746	%50	

0.7013	0.6692	0.6979	0.6990	0.7392	**%75**
0.03374	0.06747				**L.S.D. 0.05**
Irrigation period	**Irrigation period × Amino acid concentration**				
0.5980	0.5483	0.5747	0.5960	0.6732	**daily**
0.6851	0.6735	0.7000	0.6697	0.6953	**Every 24**
0.8760	0.8472	0.8689	0.8848	0.9022	**Every 48**
0.04132	0.08264				**L.S.D. 0.05**
	0.6903	0.7148	0.7168	0.7569	**Amino acid**
	0.04771				**L.S.D. 0.05**

Interaction effects between experimental factors also resulted in significant differences. The interaction of 50% shading with irrigation every 48 hours recorded the highest average (0.8792 mg/g), outperforming most other treatments. In contrast, the interaction of 75% shading with daily irrigation had the lowest average (0.5634 mg/g). The interaction between shading percentage and free amino acid concentration had a significant effect on this trait. The interaction of 75% shading for untreated plants recorded the highest average (0.7392 mg/g), contrary to the interaction of 75% shading for plants treated with a concentration of 2.00 mg L^{-1}, which achieved the lowest average (0.6692 mg/g). The interaction of irrigation period with free amino acid concentration also had a significant effect on the same trait. The interaction of irrigation every 48 hours for untreated plants recorded the highest average (0.9022 mg/g), outperforming most other treatments, compared to the daily irrigation treatment for plants treated with a concentration of 2.00 mg L^{-1}, which had an average of 0.5483 mg/g.

The results of the table indicate that the combined interaction of experimental factors (shading, irrigation periods, and free amino acids) had a significant response in measuring proline content for chrysanthemum plants. The triple interaction of 50% shading, irrigation every 48 hours, and untreated plants exhibited the highest average (0.9027 mg/g), while the triple interaction of 75% shading, daily irrigation, and a concentration of 2.00 mg L^{-1} recorded the lowest average (0.5220 mg/g).

The observed significant improvement in the studied traits, as indicated by the results in tables (2-6), may be attributed to the role of shading in providing suitable environmental conditions, including temperature, humidity, and light intensity. Environmental adaptation directs chloroplasts to change their position within the cell towards the light, under low light conditions, chloroplasts arrange themselves along the upper and lower surfaces of the leaf to capture the maximum amount of incident light necessary for photosynthesis on the other hand, the decrease in leaf proline content is linked to the shading effect, reducing environmental stress on plants. Proline acts by inducing genes responsible for plant stress tolerance [6 , 7].

Shortening daylight through 75% shading, in a positive role, increased carbohydrates and nitrogen content in plants [8]. The variation in values in the aforementioned tables could be attributed to daily irrigation providing somewhat high and sufficient humidity levels for growth. This continuous water availability positively reflects on improving and increasing the rates of photosynthetic activity, being the driving force or primary substance in this process, In contrast, reduced available water in agricultural soil due to water loss through drainage or evaporation weakens plant growth, leaf size, elongation, vital growth processes, cell division, cell expansion, reducing the rates of new leaf emergence. This accelerates the plant's life cycle by increasing aging and leaf shedding, unlike daily irrigation, which increases water and essential nutrient readiness for plant growth, enhancing absorption rates and subsequently increasing the rate of carbon assimilation and energy production for all essential processes [9 , 10].

The observed moral improvement resulting from plant spraying with free amino acids may be attributed to the increased leaf chlorophyll content with nitrogen released by amino acids. Nitrogen is involved in chlorophyll formation, and amino acids in green plastid formation, increasing leaf chlorophyll content [11]. The nitrogen included in amino acid formation is ready for plant absorption directly, leading to an increase in concentration in leaves treated with amino acids. Nitrogen then indirectly affects the absorption and transport rates of the remaining elements by entering chlorophyll formation [11]. The conversion of amino acids into proline serves as a defensive mechanism to limit the impact of acids, Additionally, during plant stress, proline moves freely within the plant, accumulating in high concentrations in leaves, providing amino groups to cells needed for protein synthesis. Proline acts as a source of energy production to alleviate stress and return to a natural state, as its oxidation process serves as an energy-producing process, water stress in plants causes chlorophyll reduction, leaf growth, and cell elongation reduction, thus decreasing the photosynthetic process due to stomatal closure. Also, there is a reduction in plant pigment production, which lowers carbohydrate production. Protein breakdown results in drought, leading to ammonia release, causing leaf aging and shedding, the addition of amino acids stimulates chlorophyll formation, plastid granule formation, and subsequently increases chlorophyll content [12 , 13].

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