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Evaluation of yield components, seed yield, and oil content of promising winter oilseed rape genotypes in response to the foliar application of essential amino acids in low-salinity lands around Lake Urmia

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Abstract
Objective: The present study was conducted in 2020-2021 cropping season to evaluate the response of promising winter oilseed rape genotypes to the application of essential amino acids in low-salinity lands.
Methods: It was performed at the East Azerbaijan Agricultural and Natural Resources Research and Education Center, Tabriz, Iran. The experiment was implemented as a split-plot design based on randomized complete blocks with three replications. The main plots included foliar application with a mixture of 17 essential amino acids at two conditions: without amino acids, and with amino acids. The subplots consisted of 24 promising oilseed rape genotypes that were developed through hybridization which were obtained from the Seed and Plant Improvement Institute, Karaj, Iran.
Results: The results demonstrated that the application of amino acids had a significant effect on seed yield and most yield components. There was also a significant difference among the genotypes concerning the measured variables. However, there was no significant interaction between these two factors. The combined application of amino acids improved the plant height, number of siliques per plant, silique growth rate, number of seeds per silique, seed yield, and oil yield of oilseed rape genotypes in the saline lands around Lake Urmia, Iran. On average, it increased the seed yield and the oil yield by 2470 and 1141 kilograms per hectare, respectively. Based on the cluster analysis, genotypes 7, 14, 19, and 24 (group 4) exhibited the highest number of seeds per silique, silique growth rate, seed yield, and oil yield. Path analysis revealed that the number of siliques per plant, silique growth rate, the number of seeds per silique, and 1000-seed weight were the main components of the seed yield in oilseed rape in the present study.
Conclusion: The foliar application of essential amino acids led to an increase in growth, yield components, seed yield, and oil yield under salinity stress. There was also a significant diversity in seed yield, its components, and oil yield among the oilseed rape genotypes studied. Based on the cluster analysis, the genotypes

in group 4 (7, 14, 24, and 19) demonstrated the highest values concerning seed yield and some yield components and may be recommended for planting in similar salinity areas, provided that further detailed experiments are conducted.

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Introduction

Edible oils are an essential component of human nutrition. Oilseeds are one of the major sources of oil production worldwide. Among these, oilseed rape ranks as the third-largest source of crop oils after soybean and sunflower. Oilseed rape seeds contain 40-45 percent oil. The most important fatty acids in oilseed rape oil include palmitic acid, stearic acid, oleic acid, linoleic acid, and linolenic acid (Carlsson 2009). Oilseed rape oil also contains tocopherols, carotenoids, and phytosterols, which play a significant role in preventing various chronic diseases such as heart disease, cancer, arthritis, and aging (Hollman *et al.* 2011). Additionally, oilseed rape meal contains phenolic compounds that can be utilized in the pharmaceutical industry (Laguna *et al.* 2018).

Salinity is recognized as one of the most significant abiotic stresses, constituting a major limiting factor for plant growth, reducing agricultural productivity, and serving as a serious barrier to meeting the world's food needs (El Shaer 2010). Excess salt in the soil decreases the germination percentage of crops such as oilseed rape, and its osmotic and ionic effects reduce the growth of these plants, adversely affecting yield components and disrupting their ability to produce desirable and even economical yields. In this context, Vujakovic *et al.* (2017) found that the germination percentage, seed vigor index, and seedling growth of oilseed rape decreased in saline lands. Salinity in oilseed rape reduces the levels of nutrients (iron, manganese, and zinc) in leaves, stems, and roots (Chakraborty *et al.* 2016). Kandil *et al.* (2017) reported that at the salinity stress, there was a reduction in plant height, leaf size, chlorophyll content, yield components, yield, and the seed quality of oilseed rape. EL Sabagh *et al.* (2019), in an experiment on two species, *B. napus* and *B. compestris*, identified that the cause of oilseed rape yield reduction in saline soil was a decrease in the number of siliques and the number of seeds per silique. Ashraf and McNeilly (2004) mentioned that the main reasons for the reduction in 1000-seed weight in oilseed rape were stomatal closure and a decrease in photosynthesis rate under saline conditions, leading to the production of smaller seeds.

Plants employ various mechanisms to combat salinity. One of these mechanisms involves using amino acids, especially during reductions in carbohydrate production. Under such conditions, amino acids enter the respiration process through pathways shared with carbohydrate catabolism, converting into alpha-keto acids and participating in energy production. Researchers have found that when crops are treated with aromatic amino acids such as tryptophan, phenylalanine, and tyrosine, they show resistance to various stresses (Batista-Silva *et al.* 2019). Zhang *et al.* (2025) stated that amino acids play an important role in increasing plants' tolerance to salinity. Alfosea-Simón *et al.* (2020) reported that treating tomatoes with methionine, a combination of proline and methionine, and a combination of tryptophan and methionine reduced the negative effects of salinity. Saddique *et al.* (2022) evaluated the possible potential of methionine, phenylalanine, tyrosine, and their combinations in enhancing the salinity tolerance in spinach and identified the probable underlying mechanisms. Khan *et al.* (2018) mentioned that exogenous application of both proline and glycine betaine reduced the effect of salinity in oilseed rape. Amino acids, by boosting chlorophyll concentration and consequently enhancing the rate of photosynthesis, play an effective role in maintaining dry matter production, growth, and high plant performance (El-Tanahy *et al*. 2024).

The significant population growth in Iran, the reduction of freshwater resources, and the increasing salinity of agricultural lands have led to severe limitations in Iranian agriculture in recent years (Sadeghi and Emam 2011). In this context, due to the excessive decrease in the water level of Lake Urmia as a result of prolonged droughts caused by climate change and the reduction of water in the catchment area by other factors, there is an ever-increasing salinity of the lands surrounding this lake (Aghaian Zadeh *et al.* 2013). In such conditions, one of the strategies proposed for more effective utilization of these lands, alongside using plants and varieties tolerant to salinity stress, is the external application of certain compounds, including amino acids (Glenn *et al.* 1998). Therefore, oilseed rape, being a strategic oilseed crop in the country, compatible with the climatic conditions of the region, and relatively tolerant to salinity, was selected for this study. Several promising genotypes of this plant were chosen and the impact of foliar application of a mixture of amino acids on these genotypes was examined, aiming to select high-yielding varieties suitable for cultivation under such conditions.

Materials and Methods

This study was conducted in 2020-2021 cropping season at the East Azarbaijan Agricultural and Natural Resources Research and Education Center, Tabriz, Iran. The station is located at 37˚ 58´ north latitude, 46˚ 2´ east longitude, and 1347 meters above sea level. The area is characterized by a cold semi-arid climate, with an annual maximum temperature of 16.5 degrees Celsius, an annual minimum temperature of 2.78 degrees Celsius, and an annual rainfall of 270 millimeters. The meteorological details of the site in the experiment are presented in Table 1. The soil in the experimental site was classified as clay loam, containing 1.5 percent organic matter, with a pH of 8.1 and electrical conductivity of 6.5 dS/m, as detailed in Table 2.

The experiment was conducted as a split-plot design based on randomized complete blocks with three replications. The amino acid factor, comprising a mixture of glycine, alanine, serine, threonine, valine, leucine, cysteine, methionine, phenylalanine, tyrosine, tryptophan, aspartic acid, glutamic acid, arginine, lysine, histidine, and proline at two levels (without foliar application and with foliar application), was arranged in main plots. The 24 promising oilseed rape genotypes, developed in the hybridization programs, were arranged in subplots.

Table 1. Meteorological characteristics of the experimental site during the study period.

Year	Month	Average Minimum Temperature (°C)	Average Maximum Temperature (°C)	Overall Average Temperature (°C)	Total Precipitation (mm)	Average Relative Humidity (%)	Total Evaporation (mm)
2021	September	18.1	26.7	23.3	2.4	38	264.9
	October	11.3	22.6	16.6	3.9	44.3	146.1
	November	5.1	17.3	11.2	54.8	58.4	54.7
	December	-0.1	7.9	2.7	23.8	79.3	-
2022	January	-6.9	7.5	-0.5	189.7	70.1	-
	February	-7.7	9.6	-2.8	32.2	66	-
	March	-9	12.2	4.4	16.8	39.4	-
	April	4.6	18.1	11.8	19.3	45.1	106.3
	May	14.2	24.1	18.8	33.3	47.9	207.6
	June	16	30.1	23.7	4.9	31.2	349.7
	July	22	30.5	27.5	11.7	32.8	376.5

Table 2. Soil physicochemical properties of the experimental site.

pH	EC (dS/m)	Organic matter (%)	Nitrogen (%)	Phosphorus (mg/kg)	Potassium (%)	Soil texture	Clay (%)	Silt (%)	Sand (%)
8.1	6.5	1.5	0.05	7.5	2.07	Clay loam	14	19	67

Bed preparation was carried out in early September. On September 11th, seeds were sown in 5-meter-long and 1.5-meter-wide plots. Sowing was performed at the planting rate of 8 kilograms per hectare using the wet planting method in the moistened furrows. The spacing between planting rows was 24 centimeters, and the spacing between plants within each row was seven centimeters. Irrigation was applied to the furrows at appropriate times. After the winter rosette stage, foliar application with a concentration of 0.2% was performed three times at two-week intervals from the beginning of stem growth until the start of flowering. Weeding was done manually throughout the growth period. To combat the mealybug infestation, the field was sprayed with chlorpyrifos at a concentration of 0.15% in the middle of the flowering period. Plants were harvested on July 1st.

At crop maturity, 10 plants from each plot were randomly selected to measure plant height and seed yield components. The seed yield for each experimental unit was determined by removing the borders and harvesting all the plants in the plot, then converted to Kg per hectare. The oil content in the seeds was determined using the Soxhlet method. The analysis of variance and subsequent mean comparisons by Duncan's multiple range test was performed using the MSTATC software. Cluster analysis was conducted by SPSS software.

Results and Discussion

The effect of foliar application with essential amino acids on plant height, number of siliques per plant, silique growth rate, number of seeds per silique, seed yield, and oil yield was significant (Tables 3 and 4). This indicates a positive effect of amino acids on the quantity and quality of oilseed rape produced in low-salinity lands. With the foliar application of oilseed rape using amino acids during vegetative and reproductive growth stages, it is possible to hope for a relative increase in the yield of seeds and oil. Batista-Silva *et al.* (2019) stated that the external use of amino acids significantly increased the height of oilseed rape plants. The positive effect of amino acid application, including lysine and tryptophan, on the number of siliques per plant as an important yield component was reported in oilseed rape by Wang *et al.* (2018). In a study, the application of 5-aminolevulinic enhanced growth characteristics, the amount of soluble solids, the level of photosynthetic pigments, and tolerance to salinity in oilseed rape plants (Naeem *et al.* 2010). The findings of Mirzapour and Gholipour *et al.* (2022) in oilseed rape showed that the application of amino acids in combination with some other plant growth biostimulants significantly increased seed yield, yield components, and oil in saline land.

The correlation coefficients among the measured traits are presented in Table 5. Although some statistically significant association was observed between the traits the correlations were either medium or low, except for the relationship of seed yield with oil yield. Plant height was only significantly and positively correlated with the rate of silique development. The number of seeds per silique correlated significantly and positively with the number of siliques per plant, silique growth rate, silique length, and oil content. Among the yield components, the number of siliques per plant,

Table 3. Analysis of variance of the effect of foliar application with essential amino acids on promising winter oilseed rape genotypes in the saline soil.

Sources of variation	df	Mean squares								
		PH	NSP	SGR	SL	NSS	TSW	SY	OC	OY
Replication	2	702.8*	125.7**	1.08*	8.10	15.36*	1.40	1570430*	2.46	256460**
Amino acid (A)	1	1314.1*	3660.3**	5.03**	22.67	151.99**	1.07	219726270**	30.73	46873752**
Error a	2	36.0	0.81	0.02	1.93	0.43	0.10	19616	1.89	723
Genotype (B)	23	538.5**	1014.5**	0.37**	1.52**	11.37**	0.43**	2209511**	4.03	465704**
A × B	23	14. 6	6.6	0.06	0.22	0.43	0.08	336084	0.92	71483
Error b	92	96.1	35.4	0.14	0.63	2.00	0.16	570753	2.90	131462
C.V. (%)	-	8.78	4.00	21.23	11.62	5.07	11.13	19.93	3.81	21.29

*, and **Significant at 5% and 1% probability levels, respectively; PH: Plant height, NSP: Number of siliques per plant, SGR: Silique growth rate, SL: Silique length, NSS: Number of seeds per silique, TSW: 1000-seed weight, SY: Seed yield, OC: Oil content, OY: Oil yield.

Table 4. Comparison of foliar application of essential amino acids with the control in the saline soil.

Foliar application	PH (cm)	NSP	SGR (g/day)	SL (cm)	NSS	TSW (g)	SY (kg/ha)	OC (%)	OY (kg/ha)
Without foliar application	108.7b	139.9b	0.70b	6.43a	26.91b	3.49a	2555.6b	44.27a	1132.8b
With foliar application	114.7a	150.0a	1.07a	7.22a	28.97a	3.76a	5026.1a	45.20a	2273.9a

Different letters in each column indicate significant differences based on the analysis of variance; PH: Plant height, NSP: Number of siliques per plant, SGR: Silique growth rate, SL: Silique length, NSS: Number of seeds per silique, TSW: 1000-seed weight, SY: Seed yield, OC: Oil content, OY: Oil yield.

Table 5. Correlation coefficients between traits of promising winter oilseed rape genotypes measured in the saline soil.

Trait	PH	NSP	SGR	SL	NSS	TSW	SY	OC
PH	-							
NSP	0.150	-						
SGR	0.252**	0.068	-					
SL	0.129	0.116	0.234**	-				
NSS	0.136	0.215**	0.215**	0.213*	-			
TSW	-0.047	0.041	0.074	0.259**	0.108	-		
SY	0.162	0.348**	0.351**	0.250**	0.461**	0.257**	-	
OC	0.092	0.103	0.103	0.074	0.194*	0.060	0.297**	-
OY	0.163	0.344**	0.346**	0.250**	0.465**	0.250**	0.995**	0.380

* and **Significant at the 0.05 and 0.01 probability levels, respectively; PH: Plant height, NSP: Number of siliques per plant, SGR: Silique growth rate, SL: Silique length, NSS: Number of seeds per silique, TSW: 1000-seed weight, SY: Seed yield, OC: Oil content, OY: Oil yield.

silique growth rate, silique length, number of seeds per silique, and 1000-seed weight were significantly and positively correlated with seed yield and oil yield.

The results of path analysis about the direct and indirect effects of variables affecting seed yield and oil yield are shown in Tables 6 and 7, respectively. According to Table 6, the number of siliques per plant, silique growth rate, the number of seeds per silique, and the weight of 1,000 seeds showed a positive direct effect on seed yield. The indirect effects were generally low. The highest indirect effect on seed yield belonged to the number of siliques per plant, silique growth rate, and 1,000-seed weight through the number of seeds per silique, and also to the number of seeds per silique through the number of siliques per plant and silique growth rate. Some of the results were similar to Sedaghat *et al.* (2021) who investigated the effects of drought stress on rapeseed. Based on the results of Table 7, seed yield had a high direct effect on oil yield. Oil content had a low direct effect on oil yield, but indirectly affected the oil through seed yield. According to Sharafi *et al.* (2015), a significant and robust relationship exists in oilseed rape between the number of siliques on a plant and its seed production. In comparative studies of spring and autumn varieties of oilseed rape, Ahmadi and Bahrani (2009) highlighted that seed yield was closely and positively linked with plant height, the number of secondary branches, the number of siliques per plant, and 1000-seed weight. Furthermore, seed yield was found to be significantly and positively associated with the oil content, and the oil

Table 6. Direct and indirect effects of yield components on seed yield of promising winter oilseed rape genotypes in the saline soil.

Trait	Indirect effect by				Direct effect	Correlation coefficient with seed yield
	X_1	X_2	X_3	X_4		
Number of siliques per plant (X_1)	-	0.0162	0.0703	0.0074	0.248	0.348
Silique growth rate (X_2)	0.0168	-	0.0703	0.0134	0.238	0.351
Seeds per silique (X_3)	0.0533	0.0511	-	0.0195	0.327	0.461
1000-seed weight (X_4)	0.0102	0.017	0.035	-	0.181	0.257

Table 7. Direct and indirect effects of seed yield and oil content on oil yield of promising winter oilseed rape genotypes in the saline soil.

Trait	Indirect effect by		Direct effect	Correlation coefficient with oil yield
	X_1	X_2		
Seed yield (X_1)	-	0.027	0.97	0.995
Oil content (X_2)	0.288	-	0.093	0.38

yield. Also, Sharafi *et al.* (2015) demonstrated a significant and positive relationship between the weight of seeds and seed yield, suggesting that enhancements in seed weight contribute to an increase in harvest index and seed yield.

The results of the analysis of variance (Table 3) and the means comparison (Table 8) indicated that significant differences existed among the evaluated genotypes concerning plant height, number of siliques per plant, silique growth rate, silique length, number of seeds per silique, 1000-seed weight, seed yield, and oil yield. Waraich *et al.* (2020) also showed significant variability in seed yield and oil yield in the oilseed rape varieties studied. The presence of diversity in physiological, morphological, and agronomic variables provides the opportunity to select high-yielding genotypes.

The dendrogram from the cluster analysis of 24 oilseed rape genotypes based on plant height, yield components, seed yield, and oil yield is displayed in Figure 3. The genotypes were divided into four groups. The first cluster included genotypes 11, 12, 18, 9, 23, and 17, which had a greater plant height and silique length than other groups. The second cluster consisted of genotypes 2, 10, 1, 4, 6, 20, 22, and 3, which didn’t show any advantage in the examined variables over the other groups and could be considered the poorest group. The third cluster included genotypes 5, 13, 15, 16, 8, and 21 which had higher siliques per plant and 1000-seed weight than other groups. The fourth cluster comprised genotypes 7, 14, 24, and 19. Genotypes in this group showed the highest values in terms of silique growth rate, number of seeds per silique, seed yield, and oil yield, indicating the superiority of the genotypes in this group over others and suggesting their suitability for cultivation in areas with similar climatic conditions.

Salinity, by increasing the soil's osmotic potential, leads to a reduction in water absorption, cell division, elongation, and development, and ultimately diminishes plant growth (Liang *et al.* 2018). Furthermore, salinity decreases plant growth through the ionic effects of salts, toxicity of certain ions, deficiency of other ions, oxidative stress, damage to the photosynthetic apparatus, reduction in chlorophyll content, decrease in photosynthesis rate, increase in respiration rate, and reduction in dry matter production (Geranpaye *et al.* 2017). Consequently, in varieties subjected to saline conditions, osmotic and ionic stresses caused by soil salinity lead to diminished growth, manifesting as shorter internodes, reduced stem height, and decreased silique lengths. Moreover, saline soil contributes to lower plant growth, including reductions in stem height, silique length, and dry matter, ultimately, resulting in decreased seed yield. Ashraf and McNeilly (2004), reported that the biomass of oilseed rape at the vegetative and reproductive stages declined under the saline soil conditions. In the research by Akhyani *et al.* (2010), salinity led to a decrease in plant height, dry matter quantity, and seed yield in oilseed rape varieties. In a study, exposure to high salt concentrations resulted in fewer siliques per

Table 8. Comparison of promising winter oilseed rape genotypes in the saline soil based on the measured traits.

Genotype	PH (cm)	NSP	SGR (g/day)	SL (cm)	NSS	TSW (g)	SY (kg/ha)	OC (%)	OY (kg/ha)
1	108.3d-h	130.5jk	0.63c-f	6.90c-f	27.07g-i	3.88a	3854a	44.29a	1723b-h
2	101.7f-h	129.3jk	0.46ef	6.63c-f	27.03g-i	3.55ab	4410a-d	44.57a	1989a-d
3	122.2a-c	125.2k	1.02a-d	6.91c-f	25.92i	3.58ab	3247fg	43.29a	1397f-h
4	101.8f-h	128.8jk	0.73b-f	6.92c-f	27.27f-i	3.58ab	3143fg	44.38a	1402f-h
5	113.2c-f	161.0a-c	0.87a-e	6.21d-f	26.42hi	2.85c	3670c-g	44.13a	1628c-h
6	110.3c-h	150.3ef	0.92a-d	7.00b-d	27.07g-i	3.35b	3016g	43.50a	1315h
7	97.8h	141.0gh	1.11ab	6.13ef	27.86e-h	3.51ab	4946a	44.78a	2236a
8	117.5b-e	158.0b-d	0.47ef	6.34c-f	29.13b-e	3.96a	4665ab	44.66a	2087ab
9	112.8c-f	155.0c-e	0.60d-f	7.07b-d	27.71e-h	3.28bc	3573d-g	45.67a	1637c-h
10	102.7f-h	138.5g-i	0.42f	6.90c-f	27.48f-i	3.33b	3852b-g	44.51a	1719b-h
11	114.7c-f	137.7hi	0.90a-e	6.97b-f	27.67e-h	3.70ab	3107g	44.28a	1388f-h
12	121.0a-d	137.3hi	0.92a-d	7.04b-e	28.72c-f	3.66ab	3358fg	44.83a	1519e-h
13	131.3a	162.2ab	0.99a-d	6.11f	26.84g-i	3.28bc	4310a-e	44.50a	1919a-e
14	98.3gh	134.2ij	1.26a	7.21a-c	30.53ab	3.70ab	4271a-e	45.78a	1964a-d
15	107.7d-h	152.2de	0.91a-d	6.60c-f	27.61e-h	3.95a	3986b-f	44.63a	1794b-f
16	99.0gh	166.7a	0.69b-f	6.57c-f	27.71e-h	3.90a	4528a-c	44.33a	2008a-c
17	111.3c-g	157.7b-d	0.97a-d	7.86ab	31.08a	3.55ab	3077g	44.42a	1365gh
18	112.8c-f	140.2g-i	1.19a	7.51bc	29.21b-e	3.28bc	3587d-g	44.38a	1598c-h
19	120.8a-d	125.2k	1.20a	6.19d-f	28.24d-g	3.91a	3521e-g	46.83a	1653c-h
20	105.5e-h	143.0gh	1.07a-c	7.19a-c	26.28hi	3.68ab	3169fg	44.79a	1416f-h
21	103.8f-h	165.2a	0.70b-f	6.42c-f	29.71a-d	3.71ab	3819b-g	45.92a	1762b-g
22	114.5c-f	155.3c-e	1.04a-d	8.10a	26.37hi	3.71ab	3571d-g	44.04a	1582d-h
23	123.2a-c	145.2fg	0.83a-f	6.83c-f	27.67e-h	3.55ab	3273fg	46.18a	1514e-h
24	128.2ab	139.8g-i	1.23a	6.36c-f	29.92a-c	3.40b	5032a	44.80a	2264a

Different letters in each column indicate significant differences based on Duncan's multiple range test at 0.05 probability level; PH: Plant height, NSP: Number of siliques per plant, SGR: Silique growth rate, SL: Silique length, NSS: Number of seeds per silique, TSW: 1000-seed weight, SY: Seed yield, OC: Oil content, OY: Oil yield.

plant, fewer seeds per plant, and smaller seeds in oilseed rape varieties (Waraich *et al.* 2020). The research by EL Sabagh *et al.* (2019) stated that 1000-seed weight is a decisive factor in the seed yield of oilseed rape genotypes, especially under saline conditions. The reduction in seed yield also leads to decreased oil yield. Chaghakaboodi *et al.* (2021) reported that oilseed rape cultivars differ greatly in terms of oil yield, and this difference is caused by the difference in seed weight and oil content.

Among these mechanisms, the sequestration of salt ions into vacuoles stands out as a strategy to mitigate their cytotoxic effects in the cytoplasm and enhance water absorption (Azizpour *et al.* 2010). Activation of antioxidant systems to scavenge free oxygen radicals represents another strategy to prevent damage to macromolecules, cells, and cellular functions, particularly the photosynthetic machinery in the resistant varieties (Zare and Pakniyat 2012).

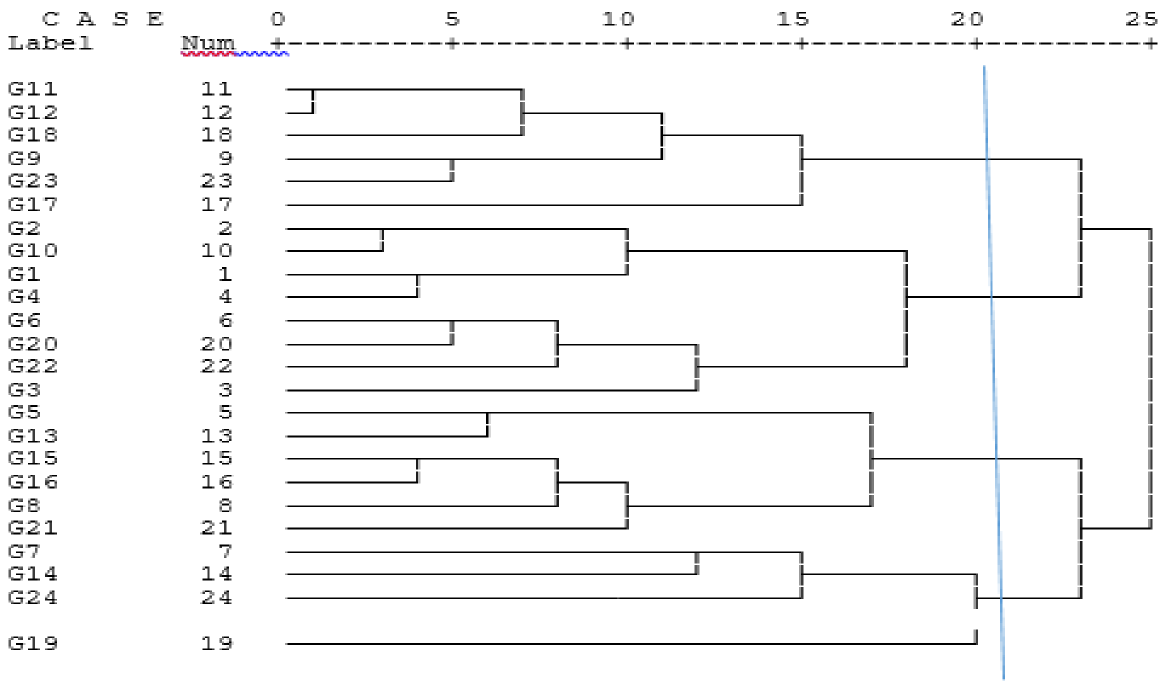

Figure 3. Clustering of promising winter oilseed rape genotypes.

Conclusion

In the present study, foliar application with amino acids led to an increase in plant height, number of siliques per plant, silique growth rate, number of seeds per silique, seed yield, and oil yield of oilseed rape compared to the absence of foliar application. Thus, foliar application of amino acids during the vegetative and reproductive growth stages can enhance the production of oilseed rape in the less fertile saline lands around Lake Urmia, Iran. Based on the path analysis, the number of siliques per plant, silique growth rate, the number of seeds per silique, and 1000-seed weight had significant and positive direct effects on seed yield. The results also showed a significant diversity among the 24 genotypes studied for yield components, seed yield, and oil yield. In addition, based on the results from cluster analysis, the genotypes were divided into four groups. Among these, genotypes 7, 14, 24, and 19 showed the highest values concerning silique growth rate, number of seeds per silique, seed yield, and oil yield. Consequently, this group can be considered as promising high-yielding genotypes suitable for saline lands. The remaining genotypes, which were categorized into two other groups, can be used for specific breeding objectives.

Conflict of Interest

The authors declare that they do not have any relevant competing interests.

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