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COMPARATIVE ANALYSIS AND EVALUATION OF MORPHOLOGICAL TRAITS OF *CHENOPODIUM ALBUM*

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Abstract *Chenopodium album is a widespread deleterious weed that affects crop productivity considerably. This work was conducted to examine the morphological traits of Chenopodium album. For this purpose, the Chenopodium album samples were collected from a maize field located at the University of Punjab, Faculty of Agricultural Sciences, Lahore, Pakistan, from three different locations. The samples were examined for eight morphological traits: fresh weight, dry weight, moisture content, leaf length, leaf width, leaf area, shoot height, and root length. Analysis of variance and correlation were used to study the importance and correlation of these traits. Our data showed that traits such as leaf length, leaf width, moisture content, dry weight, fresh weight, shoot height, and root length varied significantly among the three locations. These differences demonstrate that the growth and development of Chenopodium album are greatly affected by environmental factors (sunlight, shade, and distance from irrigation water). It was observed that the plants were highly adaptable to different agro-ecological environments. Additionally, regression analysis showed that the relationships between growth variables under evaluation were minimal. In looking for management strategies, this research provides useful information for understanding adaptability and emphasizes the role of environmental conditions in the morphological traits under study. The outcomes will be beneficial in designing management strategies for this invasive weed to reduce its impact on agricultural yield.* It was found from study that locations 1 and 3 were excellent locations for the growth and development of *Chenopodium album.*

Keywords*:* *Chenopodium album; noxious weed; morphological traits; crop productivity; analysis of variance; regression analysis*

Introduction

Chenopodium album (C. album) is one of the invasive weeds belong to the Amaranthaceae family. It is an annual herb, also known as lamb's quarters, goosefoot, or Bathua (Majumdar et al., 2025). Globally, it falls in the category of the widespread weeds (Tang et al., 2022). In European countries, it is one of the most extensively growing weeds, especially in the crops that are sown in the spring season (Schroeder et al., 1993). However, its worldwide spread, including both the northern and southern hemispheres, has been documented particularly in the Asian sub-continent, North and South America, the South African region, and Australia (Le et al., 2019). *C. album* is known to compete with almost 40 essential crop breeds globally (Asshleb, 2010). Furthermore, these harmful weeds were observed to grow extensively besides the highways and in distressed areas due to the overexploitation and pressure of grazing, together with other anthropogenic and wildlife activities (Eslami and Ward, 2021). As a result, a substantial reduction in the agricultural production has been observed due to the weed competition for useful resources with the crop plants, including irrigation water, soil nutrients, and the availability of sunlight (Bajwa et al., 2019; Monteiro and Santos, 2022). Due to early sprouting and rapid growth, it has an edge over the agricultural plants (Coleman et al., 2018). Therefore, *C. album* poses a significant agricultural and economic loss, developing the potential food security risk worldwide (Kupdhoni et al., 2023; Kurashige and Agrawal, 2005).

High temperatures, higher evaporation rate, high summer, deficient rainfall, and elevated salt at the surface of the soil are the factors responsible for its growth (Tang et al., 2022). All over the world, the invasive weed species *C. album* affects the growth of crops like sugar beet, potatoes, maize, grains, and vegetables and causes predominant loss (Cimmino et al., 2015). However, in some crops, including maize, it is extremely difficult to chemically control the weed growth due to the fact that *C. album* has shown aggressive resistance mechanisms to herbicides. While in the case of sugar beet, the usage of herbicides could be minimized by selective controlling of *C. album* (Scheepens et al., 1997). It has been observed that they are susceptible to competition after a few weeks of seeding due to canopy closure (Eslami and Ward, 2021). Interestingly, under the heavy infestation, it has the ability to produce up to 50 million seeds per hectare (Coleman et al., 2018). The dormant seeds of Black *C. album* can survive for 30-40 years. Under favorable conditions, it can thrive at a depth of more than 45 cm (Yerka et al., 2012). Even though it has the potential to grow in almost all types of soils, it thrives best in nitrogen-rich soils (Asshleb, 2010). In principle, allelopathic compounds are released by *C. album* into the soil, which inhibits the growth of nearby crops and adversely affects their germination potential (Bajwa et al., 2019). On the basis of cropping systems and weed infestation levels *C. album* has been effectively controlled by a numerous cultural, mechanical, and biological methods (Kupdhoni et al., 2023). Keeping in view that the environmental factors favorably affect the growth of *C. album*, the current study was designed to investigate the effect of environment on the morphological traits of *C. album* in the maize field.

Materials and Methods

In the present study, plant samples were collected from a maize field during the period from 1st March 2026 till 7th March 2026 from the University of the Punjab, Lahore. Three different locations were selected based on the availability of sunlight, shade, and distance from irrigation water. Plants were divided into three groups. Group A ($n = 3$) plants were selected from sunlight and close to the inlet of the irrigation water. Group B ($n = 3$) plants were collected from an area with sunlight but far from the inlet of irrigation water. Group C ($n = 3$) plants were collected from a shaded area. Plant samples included root, shoot, leaves, and whole plant. Samples were transported to the Seed Biotechnology Laboratory for measurement of morphological traits laboratory and morphological analysis was done by measuring fresh weight, dry weight, and moisture content of the whole plant. Measurements were done by using a standard manual measuring scale. To calculate dry weight, plants were sun-dried for two weeks. The data were noted for leaf length, leaf width, leaf area (Leaf area = leaf length × leaf width × 0.74), (Jordan, 1969) plant height, fresh weight, dry weight, and moisture percentage (Moisture% = [(FW − DW) / FW] × 100). All the statistical analysis was done by using software Statistix 8.1 (Steele and Torrie, 1960)

Results and Discussion

In the present study, *C. album* plants were collected from three different locations of the same field, located at the University of the Punjab, Lahore, Pakistan. The number of plants collected from three locations was 9, with 3 plants from each location (Hayat et al., 2025). Locations were divided into Group A, Group B, and Group C. After plant sampling of root, shoot, and leaves, samples were transported to the laboratory. In addition, the total weight of the fresh and dry plant was measured on a weighing balance. It was observed that the average total weight of fresh plant at three locations was 1.52gm, 1.616gm and 1.76gm respectively. On the other hand, the total weight of dry plant at three locations was 0.33gm, 0.916gm and 0.546gm respectively. Our results showed that the percentage of moisture weight was 78.28% ($n = 3$), 43.29% ($n = 3$), and 68.92% ($n = 3$) from three locations.

Next, we studied the characteristics of the plant with respect to the length and width measurements of the leaf and root, while the height of the shoot was measured. The average leaf length was 2.23cm, 2.63cm, and 3.16cm, respectively, while the leaf width was 0.03cm, 0.93cm, and 0.96cm from all three different locations. The leaf area was also recorded. It was found to be 0.054cm^2, 1.81 cm^2, and 2.269cm^2 with respect to all three locations. Furthermore, we recorded the root characteristics by measuring their average length, which was recorded as 4.33cm, 9.16cm, and 5.31cm, respectively, from three locations. In addition, shoot height was recorded. The average shoot height was 4.44cm, 10.13cm, and 9.01cm from all three locations. When all three groups were compared, highly significant results for all characteristics were obtained. Group A is highly significant for moisture content (< 0.0001), Group B is the best location for dry weight, root length, and shoot height (< 0.0001 each), and Group C is the best location for fresh weight and leaf area (0.00006 and 0.0002, respectively). The detailed results were given in Table 1.

Table 1: Analysis of morphological traits of *C. album*

Vegetation characteristics	**Group A**	**Group B**	**Group C**	***p*-value**
	mean ± SE			
FW (gm)	1.52 ± 0.02	1.62 ± 0.02	**1.76 ± 0.02**	0.00006
DW (gm)	0.33 ± 9.02	**0.9167 ± 9.02**	0.5467 ± 9.02	< 0.0001
MC (%)	**78.287 ± 0.59**	43.290 ± 0.59	68.927 ± 0.59	< 0.0001
LA (cm)	0.054 ± 0.09	1.813 ± 0.09	**2.2693 ± 0.09**	0.0002
RL (cm)	4.330 ± 0.11	**9.1600 ± 0.11**	5.3133 ± 0.11	< 0.0001
SH (cm)	4.447 ± 0.05	**10.133 ± 0.05**	9.013 ± 0.05	< 0.0001

Abbreviations: LA=Leaf area, SH=Shoot height, RL=Root length, FW=Fresh weight, DW=Dry weight, MC=Moisture content

Next, we examined the environmental influence on the morphological traits of *C. album* by ANNOVA analysis. Our data showed that the F-value for all the traits was high, while the low CV value was observed in the study groups (Al-Naggar et al., 2022). The detailed results were given in Table 2.

Table 2: Environmental Influence on morphological traits of *C. album*

Vegetation characteristics	F-values locations	Grand Mean	CV
FW (gm)	80.3	1.63	1.43
DW (gm)	1080.05	0.59	2.62
MC (%)	937.95	63.50	1.61
LA (cm)	160.98	1.37	11.58
RL (cm)	466.38	6.26	3.27
SH (cm)	2908.15	7.86	1.23

Genetic characteristics of the morphological traits were observed and analyzed. Coefficient of genetic variability (GCV%), heritability (h^2bs%), and genetic advance (GA%) showed that the DW, LA, LW, RL, and SH possessed higher percentages, while LL had lower percentages. These results demonstrated that the environmental influence on the LL was higher than on the other traits. Therefore, selection was less effective for LL. On the other hand, the selection was effective for other traits (Rehman et al., 2026). The detailed results were given in Table 3.

Table 3: Estimation of Genetic Variability, Heritability, and Genetic Advance for Morphological Traits in *C. album*

Traits	GV	GCV%	h^2bs %	GA%
FW	0.014	9.3928	96.386	12.667
DW	0.088	38.3507	99.728	86.932
MC %	327.919	227.2443	99.681	49.967
SH	9.0713	107.3998	99.896	67.177
RL	6.5014	101.847	99.359	71.166
LL	0.2033	27.5559	80.973	26.593
LW	0.279	65.8272	98.793	143.0439
LA	1.359	99.2817	98.159	147.009

Next, we performed the correlation analysis of the traits. Positive correlation was observed among LA: LW, DW: RL, LW: SH, LA: SH, FW: LA, FW: LL, while negative correlation was observed in the case of DW: MC, MC: RL, MC: SH, LW: MC. On the other hand, FW is not correlated with any of the observed traits. The detailed results were given in Table 4.

Table 4: Correlation Among Morphological Traits of *C. album*

Traits	DW	FW	LA	LL	LW	MC	RL
FW	0.2586						
LA	0.6351	0.8735*					
LL	0.2565	0.8694*	0.8641*				
LW	0.7584*	0.8052*	0.9787*	0.7490*			
MC	-0.9934*	-0.1405	-0.5479	-0.1632	-0.6814*		
RL	0.9801*	0.0841	0.4952	0.1230	0.6285	-0.9933*	
SH	0.8823*	0.6699*	0.9166*	0.6237	0.9738*	-0.8238*	0.7823*

*=Significant at 5% probability level

Furthermore, multiple linear regression analysis was performed between FW and other morphological traits to check their relation. Our data showed a higher coefficient of determination (R^2: 0.9991) and adjusted (R^2: 0.9929) values, indicating that the FW variation is correlated with all other traits, and our results were reliable (Hayat et al., 2025). The detailed results were given in Table 5. Figure 1 indicated that locations 1 and 3 were excellent locations for the growth and development of *Chenopodium album.*

Table 5: Stepwise Multiple Linear Regression for Fresh Weight of *C. album*

Traits	Coefficients	Standard error	t stat	*p*-value
DW	-7.70067	37.0766	-0.21	0.8696
FW	16.6807	18.3169	0.91	0.5297
LA	4.41833	3.97732	1.11	0.4666
LL	-2.33256	2.21462	-1.05	0.4835
LW	-8.80610	10.6879	-0.82	0.5613
MC	-0.38833	0.71076	-0.55	0.6817
RL	-0.81069	0.71076	-0.55	0.5121

Abbreviations: t= t-statistic p= probability level

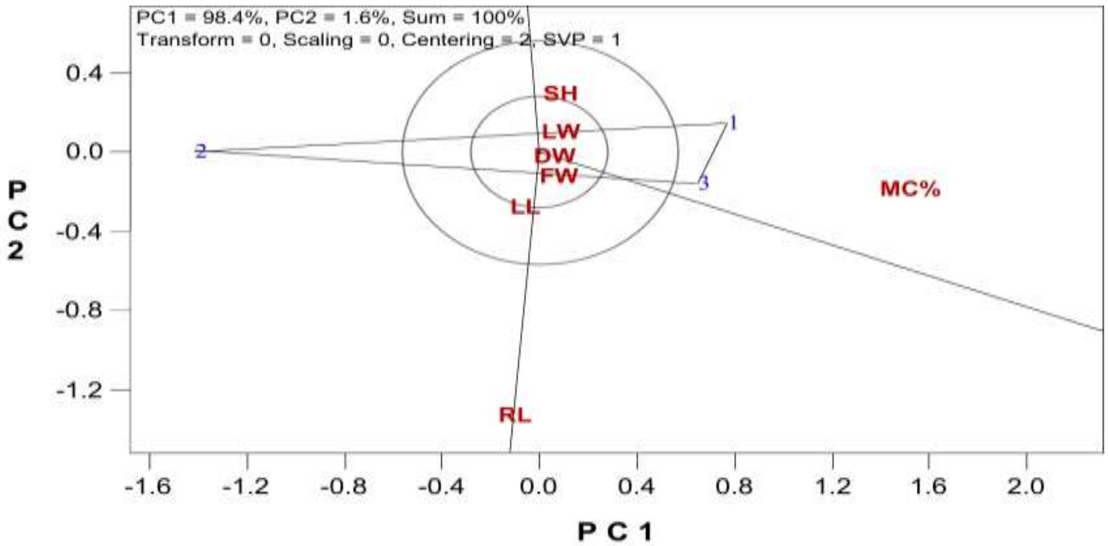

Figure 1. *Chenopodium album* morphological traits in a GGE biplot at three different locations

Conclusion

In order to reduce the yield losses, the plant population of *Chenopodium album* should be managed.

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Declaration

Data Availability statement

All authenticated data have been included in the manuscript.

Consent for publication

Not applicable

Declaration of Competing Interests

The authors declare that they have no conflict of interest.

Author Contribution Statement

AS collected data and conducted research and wrote article. Final editing was carried out and approved for final publication.

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Informed Consent

Not applicable.

Ethical Statement

Not applicable