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EXPLORING MORPHOLOGICAL TRAITS VARIATION IN *CHENOPODIUM MURALE*: A COMPREHENSIVE MULTIVARIATE ANALYSIS

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Abstract *Chenopodium murale, a significant weed in wheat, maize, rice, sugarcane, and cotton fields, poses a substantial threat to crop plants due to its competitive nature for water, minerals, and nutrients, leading to significant yield losses. To address this issue, a prescribed study was conducted to assess the morphological traits of Chenopodium murale under three different environmental locations. The results revealed a positive and significant correlation among several study traits: height, dry weight, fresh weight, inflorescence fresh weight, leaf area, leaf length, leaf width, and root length. Notably, plant leaf width emerged as the most influential trait contributing to the plant's height. Furthermore, the study identified location three as an exceptionally favorable environment for the robust growth and development of Chenopodium murale plants. To mitigate potential yield losses in crop plants, the study recommends the timely removal or control of Chenopodium murale, emphasizing the importance of managing its population effectively* .

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Keywords: *Chenopodium murale*, Nettle-leaved Goosefoot, morphological, weed, correlation, regression

Introduction

Chenopodium murale, is an annual herb commonly known as prickly Russian thistle, Nettle-leaved Goosefoot or feather geranium; it is a fast-growing annual plant that belongs to the Amaranthaceae family (Bajwa et al., 2019). This plant is native to Europe and Asia, but has become naturalized in many parts of the world, including North America, South America, Australia, and New Zealand (Zaman et al., 2020).

It has a slender stem that can grow up to two meters tall. The stem is typically reddish or green and is covered in small hairs. The leaves of this plant are triangular or diamond-shaped and have a serrated edge (Bajwa et al., 2019). They are also covered in small hairs that give them a fuzzy appearance. The leaves of *Chenopodium murale* are usually green but can turn reddish or yellowish under certain onditions (Naqvi et al., 2020). The flowers are small and inconspicuous, with male and female flowers on separate plants. The male flowers are clustered together in small spikes at the end of the stem, while the female flowers are solitary and develop in the axils of the leaves. The flowers of this plant are pollinated by wind or insects (Bana et al., 2022).

It produces small, black, round seeds enclosed in a papery husk. The seeds of this plant are highly nutritious and have been used as a food source by various cultures throughout history (Javaid et al., 2021). The seeds are rich in protein, fiber, and multiple minerals, including iron and calcium. The seeds can be ground into flour and used to make bread, cakes, and porridge (Abd-ElGawad et al., 2020). In addition to its use as a food source, *Chenopodium murale* has also been used for medicinal purposes. The plant has been used in traditional medicine to treat various ailments, including digestive disorders, respiratory problems, and skin diseases. The leaves of this plant can be made into a tea or poultice and applied topically to the affected area. The plant has also been used as a natural remedy for insect bites and stings (Naqvi et al., 2019).

Chenopodium murale is a widespread weed found in agricultural fields and gardens. It is known for its ability to grow rapidly and compete with crops for nutrients and water, making it a nuisance to farmers (Khan et al., 2021). The plant is known for its hardiness and adaptability to various soil types and environmental conditions, which makes it particularly challenging to control in agricultural fields. *Chenopodium murale* is a fascinating and versatile plant that has played an important role in human history. Its ability to adapt to different environments and provide a source of food and medicine has made it a valuable resource for many cultures throughout the world (Bana et al., 2022). However, its tendency to spread and compete with crops has also made it a problematic weed in many agricultural settings. As such, finding ways to control and manage *Chenopodium murale* will continue to be an important challenge for farmers and land managers (Zaman et al., 2020).

Weeding is an important cultural practice in crop management, and it is essential to control weeds in their early stages to prevent yield losses. In Pakistan, farmers use various weed control practices, including manual, mechanical, and chemical methods, to control *Chenopodium murale (*Alsherif, 2020*)*. Manual weed control methods include hand weeding, hoeing, and pulling, which are labor-intensive but effective in controlling small weeds. These methods suit small farms and are often used with other control measures. Mechanical weed control involves the use of implements such as harrows, cultivators, and rotary tillers, which are used to uproot and bury the weeds (Šoštarčić et al., 2021). Mechanical weed control is suitable for large farms but can cause soil compaction and damage crops if not done correctly. Chemical weed control involves the use of herbicides to control weeds. Farmers in Pakistan use various herbicides, including glyphosate, paraquat, and 2, 4-D, to control *Chenopodium murale*. Herbicides are effective and can save labor costs, but they can also have negative environmental and health impacts if not used correctly (Kashyap et al., 2022). Crop rotation involves alternating the crops planted in a field to disrupt the weed's life cycle, while intercropping involves planting two or more crops in the same field to suppress the growth of the weed. Cover cropping involves planting a non-crop plant to suppress weed growth and improve soil fertility (Kulan and Kaya, 2023).

Materials and Methods

This study's sample collection process involved gathering specimens of *Chenopodium murale* from three different locations from Punjab University, Lahore, Pakistan, each with three replications, resulting in nine replications. A representative sample was obtained by digging the soil and the weed plant.

Leaf Length (cm)

Three leaves were randomly selected from each plant to measure the leaf length, and their length was recorded using a cm scale. The average value of the three measurements was then calculated.

Leaf Width (cm)

Leaf width was measured at three points on each leaf: the base, center, and tip. Three leaves were randomly selected from each plant, and the width at each point was recorded. The average value of the three measurements was then calculated.

Leaf Area (cm^2)

The leaf area was calculated by multiplying the leaf length by the leaf width and a correction factor of 0.74 cm. The formula used to calculate the leaf area was as follows:

$$Leaf\ area = leaf\ width \times leaf\ length \times 0.74$$

Plant Height (cm)

To measure the plant height, the measurement process started from the point of attachment of the stem to the root (base of the stem), and the longest shoot on each plant was measured.

Fresh Weight (g)

The fresh weight was measured immediately after the weed sample was removed from the field to prevent the sample from drying out. The electronic weight balance was used to measure the weight of the sample, both with and without the inflorescence.

Dry Weight (g)

To obtain the dry weight, the sample was dried in an oven. Each sample was packed separately in envelopes and left them to dry for 8-13 hours. After the samples were drawn from the oven, each sample was weighed on a balance, both with and without the inflorescence.

Moisture Percentage (%)

The total plant moisture percentage both with and without the inflorescence was recorded using the following formula:

$$Moisture\ percentage = \frac{fresh\ plant\ weight - dry\ plant\ weight}{fresh\ plant\ weight} \times 100$$

Results and Discussions

The findings (from **Table 1**) indicate notable variations observed among all the locations and studied traits of *Chenopodium murale*. Specifically, the average plant height was measured to be approximately (50.667 ± 2.3094 cm), leave width (13.044 ± 0.7763 cm), leave length (19.511 ± 1.1796 cm), leave area (197.03 ± 22.398cm2), root length (24.111 ± 0.9623 cm), fresh weight (60.889 ± 2.9408g), dry weight (11.778 ± 0.8714g), moisture (80.533 ± 0.611%), inflorescence fresh weight (9.6556 ± 0.7712g), inflorescence dry weight (3.1889 ± 0.2502g), inflorescence moisture (66.278 ± 1.0324%) for *Chenopodium murale* plants collected from three different places. *Chenopodium murale* demonstrates a superior capacity to endure harsh climatic conditions, as evidenced by its higher plant weight and moisture percentage (Poonia and Upadhayay, 2015). However, removing these plants from crop fields is crucial due to their competitive nature. They consume essential resources such as food, minerals, water, and space, leading to reduced crop yield by out-competing the cultivated plants and causing them to dry out (Bajwa et al., 2019).

Table 1. Analysis of variance for morphological traits of *Chenopodium murale*

	Height	Leave Width	Leave Length	Leave Area	Root Length	Fresh Weight	Dry Weight	Moisture	Inflorescence Fresh Weight	Inflorescence Dry Weight	Inflorescence Moisture
Locations	379*	28.7078*	64.3611*	26530.2*	59.1111*	492.111*	8.77778*	4.36*	10.8344*	0.18778*	76.1678*
Error	16	1.8078	4.1744	1505	2.7778	25.944	2.27778	1.12	1.7844	0.18778	3.1978
Grand Mean	50.667	13.044	19.511	197.03	24.111	60.889	11.778	80.533	9.6556	3.1889	66.278
CV	7.89	10.31	10.47	19.69	6.91	8.37	12.81	1.31	13.83	13.59	2.7
Standard Error	2.3094	0.7763	1.1796	22.398	0.9623	2.9408	0.8714	0.611	0.7712	0.2502	1.0324

*=Significant at 5% probability level, CV = Coefficient of variance

A correlation analysis examined the relationship between various morphological traits of *Chenopodium murale* (**Table 2**). The results revealed that all studied traits exhibited significant and positive correlations with each other, indicating the plant's remarkable capacity to withstand harsh and hot environmental conditions. This resilience is likely attributed to the plant's higher photosynthetic rate and accumulation of organic compounds in its body, which promote robust growth and development (SAMI et al., 2023), (Chamkhi et al., 2022).

However, it is important to note that there were exceptions in the correlations between inflorescence dry weight and inflorescence moisture, inflorescence dry weight and overall moisture. These traits did not show a significant correlation, suggesting a more intricate relationship between them (Almas et al., 2023), (Chamkhi et al., 2022). To prevent potential yield losses in crop plants, controlling the growth of Chenopodium murale is imperative. Manual removal and the judicious use of chemicals can effectively manage these invasive plants. Alternatively, employing transgenic crop plants with glyphosate resistance can also be considered a strategy to control the growth of these weeds. Farmers can safeguard crops and enhance agricultural productivity (Chamkhi et al., 2022).

Table 2. Correlation among morphological traits of *Chenopodium murale*

	Dry Weight	Fresh Weight	Height	Inflorescence Dry Weight	Inflorescence Fresh Weight	Inflorescence Moisture	Leave Area	Leave Length	Leave Width	Root Length
Fresh Weight	0.9393*									
Height	0.9362*	0.9977*								
Inflorescence Dry Weight	0.7299*	0.5775*	0.5934*							
Inflorescence Fresh Weight	0.9757*	0.9565*	0.951*	0.6083*						
Inflorescence Moisture	0.602*	0.6909*	0.6668*	-0.0965	0.7282*					
Leave Area	0.9336*	0.9892*	0.991*	0.5809*	0.9643*	0.6905*				
Leave Length	0.9482*	0.9952*	0.9935*	0.5795*	0.9732*	0.7088*	0.9968*			
Leave Width	0.9503*	0.9966*	0.9957*	0.5864*	0.9688*	0.699*	0.9949*	0.999*		
Root Length	0.9399*	0.9984*	0.9998*	0.594*	0.9556*	0.6729*	0.9924*	0.9953*	0.9971*	
Moisture	0.2924	0.6009*	0.6024*	-0.0421	0.3814*	0.4675*	0.5763*	0.5593*	0.5607*	0.5947*

*=Significant at 5% probability level

Regression analysis revealed that a higher contribution for height was recorded for leave width (8.020) followed by root length (7.388), inflorescence fresh weight (3.320), and leave area (0.168), while negative contribution was found for leave length (-0.501), dry weight (-0.291), fresh weight (-0.002) and moisture (-0.153). The regression equation was predicted as (**Table 3**),

Y (FW) = -9.995 + 0.044(Leaf Width) - 0.501(Leave Length) + 3.114(Root Length) + 0.007 (Inflorescence Fresh Weight) - 0.291(Dry Weight) - 0.002(Fresh Weight) - 0.153(Moisture) + 0.003(Leaf Area).

Regression analysis is a valuable tool for plant researchers to identify the key plant traits that significantly influence crop yield. By analyzing a large dataset of various traits, researchers can pinpoint the most crucial factors contributing to higher crop plant yields (Bajwa et al., 2019).

Table 3. Stepwise multiple linear regression for fresh weight of *Chenopodium murale*

Traits	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Leave Width	0.044	0.628	0.070	0.956	-7.932	8.020

Leave Length	-0.501	0.654	-0.767	0.583	-8.809	7.806
Root Length	3.114	0.336	9.257	0.069	-1.160	7.388
Inflorescence Fresh Weight	0.007	0.261	0.027	0.983	-3.306	3.320
Dry Weight	-0.291	0.175	-1.666	0.344	-2.510	1.928
Fresh Weight	-0.002	0.111	-0.022	0.986	-1.411	1.406
Moisture	-0.153	0.040	-3.840	0.162	-0.658	0.353
Leave Area	0.003	0.013	0.234	0.854	-0.162	0.168

The Principal of Component Analysis (**Figure 1**) revealed that PC1 accounted for 97.7% of the observed variation in all studied morphological traits, indicating that the majority of the observed differences among the studied traits can be attributed to this single component common factor (Chamkhi et al., 2022), which is captured by this component, while PC2 only predicted 0.2% of the variation. Additionally, the analysis indicated that location 3 is particularly favorable for the growth and development of *Chenopodium murale* plants, as it showed the highest productivity. Based on these findings, it is recommended to implement plant population control measures specifically at location 3. Doing so makes it possible to mitigate potential yield losses in crop plants and ensure optimal growth conditions for *Chenopodium murale*. This approach would lead to more efficient agricultural practices and improved crop productivity.

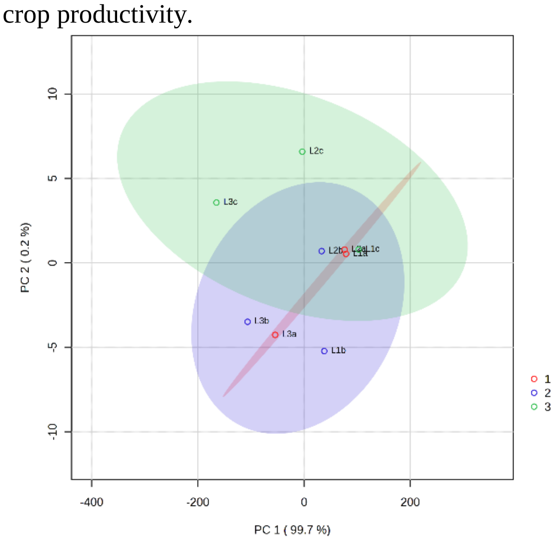

Figure 1: Scores Plot for morphological traits of Chenopodium murale under 3 different locations

Conclusion

Based on the study's findings, it is recommended to regulate the plant population of *Chenopodium murale* to reduce potential yield losses in crop plants.

Declarations .

Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

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Conflict of Interest

The authors affirm that the research was conducted without any involvement of commercial or financial relationships that could be perceived as a possible conflict of interest.

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