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MULTIVARIATE ANALYSIS FOR MORPHOLOGICAL TRAITS OF *MALVASTRUM COROMANDELIANUM* L.

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Abstract *Malvastrum coromandelianum L. particularly grows in tropical and subtropical regions. It is an invasive alien and poses a serious threat to agricultural production and is utilized by diverse ethnic groups for medicinal purposes. Multivariate statistical analysis was therefore conducted to describe the morphological characteristics of M. coromandelianum and assess its plasticity in different environmental conditions. Plant samples were randomly collected from the Faculty of Agricultural Sciences, University of the Punjab, Lahore, Pakistan, during the active growing season. From three locations, three independent replicates were collected. Data on their morphological and physiological traits, including leaf length, leaf width, leaf area, shoot height, root length, fresh weight, dry weight, and moisture content, were recorded. On the collected data, analysis of variance (ANOVA), Pearson's correlation, regression analysis, and GGE biplot techniques were applied. The study showed the significance (at a probability level of 5%) and interrelationship of these traits, indicating strong phenotypic adaptability under fluctuating environmental conditions. Correlation analysis revealed a positive association of dry weight with fresh weight and shoot height, while leaf area was positively related to leaf width and root length. Further, regression analysis indicated the strong interdependence among observed traits. GGE biplot analysis showed that plants collected from location three exhibited greater environmental stability and adaptability. These findings provide a scientific basis for developing sustainable long-term management approaches to mitigate the detrimental effects of this weed while protecting its beneficial value*.

Keywords: *Malvastrum coromandelianum; invasive; GGE biplot; regression; correlation*

Introduction

In tropical and subtropical climates, *Malvastrum coromandelianum L*. is recognized as an ecologically important invasive species in disturbed and managed habitats (Kaur et al. 2021; Dheer et al. 2023). Invasive species such as M. coromandelianum present a double-edged impact: they disturb native ecosystems by dominating local plant communities and restructuring ecological processes (Richardson and Pyšek 2006), yet they also serve as valuable models for studying adaptive traits and stress resilience in human-modified environments (Van Kleunen et al. 2010). As an understory plant, plays a significant role in maintaining biodiversity, nutrient cycling, and regeneration dynamics (Gilliam 2007; Xu et al. 2020). According to the author (Zhou et al. 2003), weeds may serve as an important intermediate host of plant viruses and contribute to the development of disease outbreaks; M.coromandelianum is a common host for Gemini virus, commonly found in Yunnan Province, China (Zhou et al. 2003). Currently, it is considered among the ten most competitive, persistent, and aggressive weeds affecting economically important horticultural and agronomic crops (Ali et al., 2016; Webster, 2001).

M.coromandelianum L. is widely identified by its common names as false mallow, broom weed, and clock plant. Commonly, it grows in tropical and subtropical regions and belongs to the Malvaceae family. It occurs across a wide range of habitats, including cultivated fields, wastelands, gardens, roadsides, and uncultivated lands (Dheer et al., 2023). Its growth is favored by minimal biotic disturbance, although it is also occasionally found in grassland and forest ecosystems (MONDIALE, 1967; Villasenor et al., 2002). Ethnobotanically, the crushed leaves of *M. coromandelianum* are used by Mexican Kickapoo Indians, mixed with salt and alcohol, to treat ringworm infections (Latorre and Latorre, 1977). Also, in the traditional Indian system of medicine, the plant is used as an analgesic, antidysenteric, and anti-inflammatory (Husain et al.). Pharmacological testing has reported various uses of this plant, such as antinociceptive (Reddy et al., 2001), anti-inflammatory, and analgesic activity (Khonsung et al., 2006)and antimicrobial activity (Pranay Jain et al., 2010). This paper presents a very comprehensive review of recent advancements made in the management of *M. coromandelianum* L. alongside the analysis of pertinent literature. The goal is to elucidate patterns of variation and their ecological significance.

Figure 1. Sample Collecting Places

Materials and Methods

Sample Retrieval

The study was conducted on *Malvastrum coromandelianum L*, collected from the vicinity of the Faculty of Agricultural Sciences, University of the Punjab, Lahore, Pakistan, as shown in Figure1. During the growing season of Malvastrum coromandelianum L, plant samples were collected totally randomly from the study area. Three independent replicates were collected, and within each replicate, three individual plants were selected, resulting in a total of 9 experimental units and 27 plants overall. Whole weed plants were carefully uprooted to preserve their root systems intact (Fuentes et al., 2010). Further analyses were carried out in the Plant Breeding and Genetics Laboratory-II.

Morphological Measurements

Various morphological traits were recorded. Shoot length, root length, leaf length, leaf width, and leaf area(Leaf area = leaf width × leaf length × 0.74); a standard correction factor is used for leaf area estimation (Pandey and Singh, 2011). Leaf dimensions were calculated using a digital caliper. Plant height was observed from the base of each plant to the apex.

Biomass Determination and Moisture Content

Fresh weight (FW) was calculated using an electronic balance immediately after collecting the sample. Plants were then dried to measure the dry weight (DW). Moisture content was calculated using the formula: $[(FW - DW) / FW] \times 100$ (Hunt, 2012; Poorter et al., 2012).

Statistical Analysis

To calculate the variation among replications, recorded data were subjected to the analysis of variance (ANOVA). Statistical analyses were calculated using Staistix-10.1 (Gomez and Gomez, 1984; Steel and Torrie, 1960).

Results and Discussions

The physiological and morphological traits of M. coromandelianum L. showed significant variation due to fluctuations in environmental parameters, indicating its adaptive potential and ecological plasticity (Chauhan et al., 2017). Spread of vegetation (SOV), plant height (PH), leaf area (LA), moisture percentage (MP), and fresh weight to dry weight ratio (FW/DW) were found to be statistically significant at the 5% probability level. These observed traits are strongly influenced by different environmental conditions, including soil nutrients, temperature fluctuations, light availability as well as humidity. Similar ecological adaptations have been reported in invasive and stress-tolerant weed species, where morphological plasticity plays a crucial role in survival and longevity (Ens et al., 2015). Secondary traits, such as fresh weight (FW), dry weight (DW), and root length (RL), showed high variability and were not consistently significant across replicates. This variability is due to micro-environmental heterogeneity. Such fluctuations are highly common in field-based weed studies that are due to short-term environmental influences rather than stable genetic traits. Collectively, these results indicate that *M. coromandelianum L.* shows considerable adaptability in morphological and physiological plasticity, enabling it to withstand environmental stressors (Zahra et al., 2025).

In the ANOVA table (Table1), most of the traits showed very high broad-sense heritability estimates (above 90%), indicating that these traits are highly governed by genetics and can be improved through selection. Genetic advances were particularly high for FW, DW, and RL, suggesting great genetic improvement through breeding.

Table 1. ANOVA for *Malvastrum coromandelianum (L.)*

SOV	SH	RL	FW	DW	LL	LW	LA	MC%
Location	10.8144	36.0175	2001.36	31.3071	0.48634	0.70908	1.44294	82.7674
Error	0.3053	0.1737	0.09	0.1171	0.00869	0.00199	0.04418	0.7822
Grand Mean	15.256	9.3333	33.18	5.7711	2.9978	2.3744	5.1858	80.573
CV	3.62	4.47	0.89	5.93	3.11	1.88	4.05	1.1
Standard Error	0.319	0.2407	0.1696	0.1976	0.0538	0.0258	0.1214	0.5106
Heritability	91.9834	98.567	99.9865	98.8862	94.8245	99.1628	91.3446	0.2174
Genetic advance	20.6497	64.5289	136.604	97.5065	22.7473	35.7334	22.0858	11.2271

*= Statistically significant at p<0.0 5%, CV = coefficient of variance LL=leaf length, LW= leaf width, LA=leaf area, SH= shoot height, FW=fresh weight, DW=dry weight, MC%=moisture content percentage, RL =root length

The results of regression analysis showed in Table2 that none of the predictors had statistically significant p-values ($p > 0.05$). Some of the predictors had positive regression coefficients while others showed negative. High VIF values showed high multicollinearity among predictor variables, indicating strong interdependence and less model stability (O'brien, 2007; Vatcheva et al., 2016).

Table 2.Multiple Regression Analysis of *Malvastrum coromandelianum (L.)*

Variables	Coefficient	Std Error	T	P	VIF
Constant	-80.4159	48.5973	-1.65	0.3461	
DW	0.474	1.58431	0.3	0.8149	887.8
FW	-0.08098	0.22583	-0.36	0.7808	1141.8
LA	-16.5514	10.9306	-1.51	0.3716	2068.1
LL	25.7658	16.1372	1.6	0.3562	1507.3
LW	33.7887	21.6505	1.56	0.3628	3749.9
MC	0.27123	0.50463	0.54	0.686	241.4
MC	0.22849	0.4407	0.52	0.6955	79.7

DW = dry weight, FW = fresh weight, LA = leaf area, LL = leaf length, LW = leaf width, MC = moisture content, RL = root length. Coefficient = regression estimate, Std Error = standard error, T = t-statistic, P = significance level, VIF = variance inflation factor, R^2= 0.9922, Adjusted R^2= 0.9378, Standard Deviation=0.42286

Pearson's correlation analysis showed that most measured weed traits had a significant relationship with one another at $p<0.05$ in Table 3. Dry weight had a strong positive correlation with FW (r = 0.909) and with SH (r = 0.976); as plant height increases, fresh weight as well as dry biomass will also increase. FW was also positively associated with SH or plant height (r = 0.916). Similar relationships have been widely reported in previous research about weed ecology (Chauhan and Johnson, 2010). Leaf area showed positive correlation with leaf width (r = 0.770) and root length (r = 0.718), indicating that an increase in leaf area enhances the root growth system (Poorter et al., 2012). Correlation analysis showed that some of the traits were negatively associated with each other: leaf length with leaf width and moisture content, and root length. Such relations are due to environmental stressors, so plants store resources in their selective organs (Grime, 2006). Leaf width had strong positive correlations with moisture content and root length, showing that plants having wider leaves maintained better water uptake and stronger root growth.

Table 3. *Malvastrum coromandelianum* Morphological and Physiological traits correlation

Traits	DW	FW	LA	LL	LW	MC	RL
FW	0.9094*						
LA	-0.7188*	-0.3963					
LL	-0.3671	-0.7006*	-0.2606				
LW	-0.1712	0.2405	0.7701*	-0.8148*			
MC	0.3914	0.7372*	0.2812	-0.9600*	0.8084*		
RL	-0.1031	0.3004	0.7176*	-0.8454*	0.9878*	0.8270*	
SH	0.9764*	0.9155*	-0.6487	-0.4102	-0.0961	0.4509	-0.0388

DW = Dry Weight, FW = Fresh Weight, LA = Leaf Area, LL = Leaf Length, LW = Leaf Width, MC = Moisture Content, RL = Root Length, and SH = Shoot Height or Plant Height. (*) denotes significant correlations at $P < 0.05$.

Still, further research is needed to understand this weed and its interaction with the environment to know about its effect on crop yield and other related factors (Leon et al., 2003; Mobeen et al., 2015; Qamar et al., 2015). The GGE biplot showed individual genotype performance and its interaction with the environment in Figure 2. PC1 represented performance of genotype, and PC2 demonstrated stability of weed with environment. The genotype present at location three showed higher environmental plasticity. So, at this location, growth of M. coromandelianum L.should be controlled to protect main crops (Afzal et al., 2016; Mahmood et al., 2016).

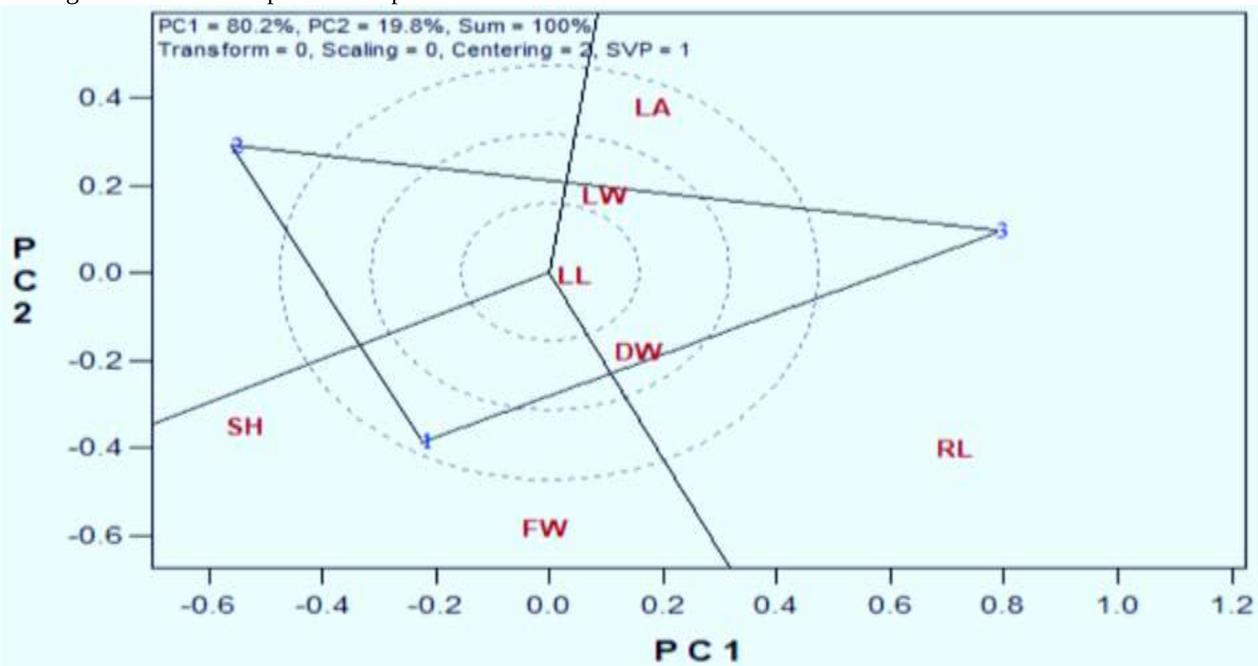

Figure 2. *Malvastrum coromandelianum* L. morphological and physiological traits in a GGE biplot at three different locations

Conclusion

M. coromandelianum exhibited considerable morphological variation, which is useful for characterization and population differentiation. Due to its invasive and resilient nature, *M. coromandelianum* should not be recommended for restoration. It may create competition with nearby crops. It has various pharmacological advantages utilized by researchers and health care providers. Therefore, appropriate management practices should be carried out to minimize yield loss while conserving its medicinal value.

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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

KT, EY, ST collected data and conducted research and wrote article. EY and Amna make final editing was carried out and approved for final publication.

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Informed Consent

Not applicable.

Ethical Statement

Not applicable