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MULTIVARIATE ANALYSIS FOR MORPHOLOGICAL TRAITS OF *RUMEX DENTATUS*

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Abstract *The study assessed the growth performance and morphological variation of Rumex dentatus taken from three distinct places within the University of Punjab, Lahore's Faculty of Agriculture Sciences. Nine plant samples were examined for characteristics such as fresh weight, dry weight, moisture content, leaf area, leaf width, leaf length, and root length. Statistical analyses of ANOVA, regression, correlation, and GGE biplot analyses were performed by Statistix software. All measured features showed notable variations between distinct regions. Strong positive correlations were found between leaf-related metrics, while negative correlations were found between leaf-related parameters and root length and shoot height. Regression analyses revealed strong interconnectedness between the variables. Location 1 was found to be relatively favorable for vegetative growth. The environmental influence on the growth of Rumex dentatus was highlighted through this study. As for management strategies, it was suggested to control the growing population of Rumex dentatus to minimize yield loss.*

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Keywords: *Rumex dentatus; morphological traits; correlation; regression; GGEbiplot*

Introduction

Commonly referred to as toothed dock **or** Aegean dock, *Rumex dentatus* is a flowering weed comprising more than 150 species across the globe. It is a member of the family Polygonaceae. The morphology of R. dentatus is characterized by a height of about 70 cm or more and comparatively smaller leaves.(Khalil et al., 2022).This species is widely distributed across Southeast Europe, North Africa, and warmer regions of Asia, exhibiting a variable morphology (Khalil et al., 2022). It flourishes best in subtropical as well as tropical regions of the Northern hemisphere (Khalil et al., 2022). Optimal growth of *R. dentatus* is well observed in valleys, hillsides, or levelled terrains to an elevation of around 3000 m(Anjen et al., 2003). Phytochemical studies of *R. dentatus* suggest the presence of major secondary metabolites such as quinones, particularly anthraquinone, as well as flavonoids (Midiwo and Rukunga, 1985). *R. dentatus* is now gaining attention in the pharmaceutical field for its various applications in traditional medicine (Saoudi et al., 2021). All of its plant organs(roots, stems, leaves, etc.) are used for the treatment of various ailments. For instance, the roots of R. dentatus are crushed and then used for the treatment of eczema and dysentery (Saleem et al., 2014). Its roots are the main sites of bioactive compounds such as quercetin, vitamin C, kaempferol, chlorogenic acid, and myricetin. These compounds make it a potent therapeutic agent against diseases (Saleem et al., 2014). Its leaves have diuretic and refrigerant properties (Ajaib et al., 2015) and are employed as coolants in pharmacology (Hussain et al., 2006). Some studies suggest that it could be a compelling agent against breast cancer, which is becoming a serious disease in women across the globe and in Pakistan (Batool et al., 2019). The nutritional content of *R. dentatus* differs in all organs, with protein being highest in the stem (15%), fat being highest in the root (14%), fiber being highest in the fruit (11%), and the carbohydrates being highest in the seeds of this species (54.40%) (Hameed and Dastagir, 2009). The mineral composition of *R. dentatus* suggests higher concentrations of carbon (52.02%) and oxygen (32.75%) along with minute quantities of Mg (0.53%), potassium (8.00%), calcium (0.21%), and iron (0.25%) (Ibrahim et al., 2021). It negatively impacts on agro-ecological systems since it competes with cultivated crops for nutrients and causes reduction in yield and deterioration of crop quality. It is mostly found in wheat fields of Pakistan (Siddiqui and Bajwa, 2001).Reports suggest yield losses of about 50% due to infestation of *R. dentatus* in wheat fields of Pakistan (Iffat Siddiqui et al., 2010). The chemical control for elimination of its negative impacts on cultivated crops such as wheat is possible by the application of chemical herbicides like Bromoxynil+ MCPA, fluroxypyr+ MCPA, and Traisulfuran+terbutryn (Abbas et al., 2009; Naseer-ud-Din et al., 2011)

Materials and Methods

Sampling and measurements

The study was conducted on *Rumex dentatus* weed from different locations within the Faculty of Agriculture Sciences, University of Punjab, Lahore, Pakistan. The plant was randomly sampled from three locations within the premises of the department. Sampling resulted in a total of 9 samples; 3 replicates from each location. To preserve the integrity of all organs, the whole plant was uprooted. For the measurement of morphological parameters like leaf length, leaf width, stem length, and root length, a measuring tape was used. Leaf area was determined by the multiplication of measured dimensions and a correction factor (leaf area =leaf width*leaf length*0.74). After sampling and measurements, fresh weight (FW) was recorded immediately in the laboratory by an electronic weighing machine. To obtain a constant dry weight (DW), plant samples were oven-dried at a controlled temperature. Moisture content was measured by using the formula of [(FW-DW)/FW]*100.

Statistics

The data from all these measurements were organized in an Excel sheet. Analysis of variance (ANOVA) was performed on this data to check the significant differences among these locations (Fuentes et al., 2010). Furthermore, correlation and regression analyses were also performed on Statistix for the determination of the relationships among measured variables and to assess the most suitable location for weed growth (Steel and Torrie, 1981).

Figure 1. Sample collection sites

Results and Discussions

In accordance with Table 1, the morphological traits of *Rumex dentatus* showed significant variation across three different locations. Morphological traits of dry weight (DW), leaf area (LA), and fresh weight (FW) showed high variability, indicating strong environmental influence contributing to plant vigor and biomass development. In this case, selection will be made on the basis of phenotype and will be highly effective. Whereas in the case of moisture content (MC) and root length (RL), comparatively low variability was observed, suggesting that these traits remained almost the same in all the locations, which makes them less responsive to direct selection and overall genetic improvement (Munir et al., 2016).

Table 1. ANOVA for morphological traits of *Rumex dentatus*

SOV	LA	FW	DW	MC	RL
Locations	845.042*	16.0669*	0.00001*	177.253*	5.40778*
Error	0.169	4.444E-05	0.00004	0.01458	0.00444
Grand mean	43.605	6.7422	0.7722	90.305	9.1556
Standard error	0.2554	3.849	3.849	0.0697	0.0385
CV	1.01	0.10	0.86	0.13	0.73
Heritability %	99.930	99.99	99.990	99.975	99.754
GA%	67.518	60.239	145.426	14.936	25.694

*=Statistically significant at 5% level of probability, CV= Coefficient of variance, LA= leaf area, FW=fresh weight, DW= dry weight, MC= moisture content, RL= root length, GA = Genetic advance

The Pearson correlation analysis revealed both positive and negative associations among the morphological traits of *Rumex dentatus*. Significant positive correlations were observed among leaf-related traits, which are leaf area(LA), leaf length(LL), and leaf width (LW), indicating that the greater the leaf dimensions, the greater the leaf area. Root length (RL) and shoot height (SH) were also positively correlated, suggesting a synchronized aboveground and underground vegetative growth. A negative correlation was observed between leaf-related parameters and root length(RL) and shoot height(SH), suggesting increased leaf expansion was associated with reduced root length(RL) and shoot height(SH). Fresh weight (FW) and moisture content (MC) were also negatively correlated. Overall, the analysis indicated that the leaf-related parameters were closely related, whereas other structural and physiological growth parameters showed limited dependency due to environmental influences (Babar et al., 2015).

Table 2. Correlation for morphological traits of *Rumex dentatus*

	DW	FW	LA	LL	LW	MC	RL
FW	1.0000*						
LA	-0.5143	-0.5179					
LL	-0.5181	-0.5217	0.9994*				
LW	-0.5005	-0.5039	0.9978*	0.9949*			
MC	1.0000*	-0.9999*	0.5158	0.5195	0.5020		
RL	0.4135	0.4174	-0.9840*	-0.98660*	-0.9786*	-0.4149	
SH	0.493	0.4968	-0.9974*	-0.9987*	-0.9923*	-0.4944	0.9925*

*=Statistically significant at 5% level of probability, CV= Coefficient of variance, DW= dry weight, FW= fresh weight, LA= leaf area, LL= leaf length, LW= leaf width, MC= moisture content, RL= root length, SH= shoot height

Table 3 shows the regression analysis of the morphological traits of *Rumex dentatus.* Morphological and physiological characteristics together accounted for a very high percentage of the variation in *Rumex dentatus* plant height, according to multiple linear regression analysis (R^2 = 96.40%, R = 98.18%). R2 (35.61%) shows a significantly reduced explanatory power, indicating potential predictor redundancy. Plant height was not significantly affected by any of the individual variables (DW, FW, LA, LL, LW, MC, and RL) at $p > 0.05$. Fresh weight and leaf area were positively correlated, whereas the other characteristics were negatively correlated. Overall, the model shows that features have a large combined influence (Sykes, 1993).

Table 3. Multiple linear regression for plant height of *Rumex dentatus*

Traits	Cofficient	Standard-errror	T-Stat	P-value
DW	-54.8422	31.7793	1.88	0.3113
FW	3.75024	3.58406	-1.73	0.3343
LA	11.8414	7.41264	1.05	0.4856
LL	-49.3583	29.8194	1.60	0.35614
LW	-76.5737	48.2346	-1.66	0.346021
MC	-3.41967	2.00648	-1.59	0.3579
RL	-2.19964	2.24761	-1.70	0.5069

LA= leaf area, LL= leaf length, LW= leaf width, MC= moisture content, RL= root length, DW= dry weight, FW= fresh weight, T stat= T statistic, p-value= probability level,

Standard error=0.869, multiple R=98.18%, R^2 =96.40%, Adjusted R^2 = 35.61%

Figure 2 showed that location 1 turned out to be a favourable growth area due to a strong association between growth-related parameters like leaf area(LA) and root length(RL), which contribute to biomass and plant vigor.

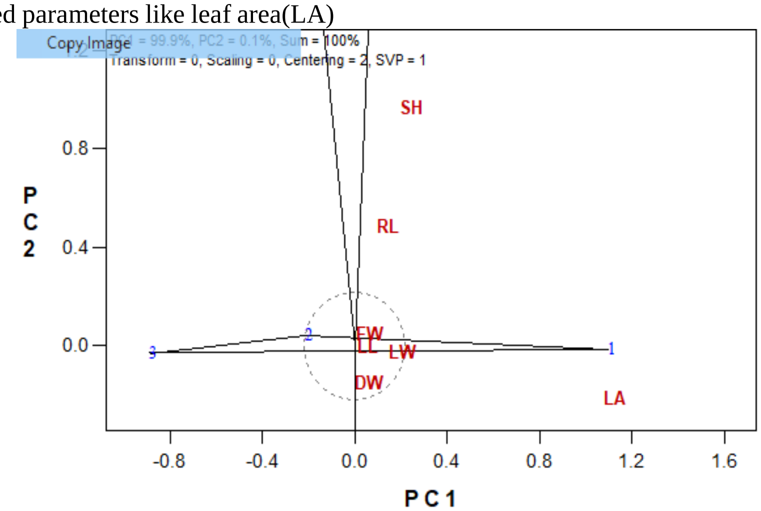

Figure 2. GGE biplot image for the morphological traits of *Rumex dentatus* at three different locations

Conclusion

Location 1 turned out to be the best for plant growth, so it was concluded that this location needs the most weed management to avoid crop yield losses.

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Statements and Declarations

Data Availability statement

All relevant data are within the manuscript file.

Author's Contribution Statement

EY, and Amna, collected data and wrote manuscript equally. All authors have read the final manuscript and approve its submission.

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Conflict of interest

The investigation was undertaken without any financial conflicts of interest or any other commercial relationships that could be seen as such by any of the authors.