Journal of Life and Social Sciences
eISSN: 3006-2675
www.bbasrjlifess.com
*J. Life Soc. Sci, 2025; Volume, **4**: 43*

Original Research Article ***Open Access***

MULTIVARIATE ANALYSIS FOR MORPHOLOGICAL TRAITS OF *CYPERUS ROTUNDUS*

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(Received, 25th August 2024 Accepted 4th September 2025, Published 17th September 2025)

Abstract *Cyperus rotundus is among the most damaging weed plants and a great threat to agricultural systems across the world. This work, therefore, sought to examine and describe the morphological characteristics of C. rotundus and assess its suitability in the various environments in ways that would explain its survival strategies. Samples were collected from three different locations of Pakistan's Punjab University's Faculty of Agriculture Sciences, Lahore. Specifically, the cross-sectional samples were rated according to seven morphological attributes: Leaf length, Leaf width, Area of leaf, stem height, fresh weight, dry weight, and moisture percent. Analysis of variance and correlation analysis were used to examine the significance of these traits. The study showed that characteristics such as leaf area, shoot height, fresh weight, and moisture percentage were significantly different, and this suggested that the plant had developed stress tolerance factors that enable it to cope with environmental stress factors. The morphological traits were also considered for their interconnectivity; moisture availability was positive with fresh weight. Further, using regression analysis, relationships with the growth factors under consideration were found to be rather low. As for management strategies, this research stresses that the density of C. rotundus should be managed more effectively, mainly due to its competitive abilities. The conclusion will be useful to design long-term control strategies for the management of this unpalatable weed to reduce its effect on improved agricultural production.*

*[Citation: Hayat, Q., Ali, Z., Awais, M., Shaheen, M.F. (2025). Multivariate analysis for morphological traits of Cyperus rotundus. J. Life Soc. Sci, **4**: 43]*
Keywords: *Cyperus rotundus; invasive weed; morphological traits; correlation; regression; GGE biplot*

Introduction

Cyperus rotundus is defined as the world's disaster and invasively colonizing weed, which adversely affects agro-ecological systems in several regions of the world (Holm et al., 1977). Traditional uses of the plant involve the use of the rhizomes and tubers in the treatment of different ailments among communities in China, India, Japan, and Iran (Srivastava et al., 2013). Therefore, little time has passed by, and today *C. rotundus* is termed as the most abundant, invasive, and economic weed of the tropical and sub-tropical world (Terry and Magambo, 1972). It is today ranked among the top 10 most competitive, persistent, and aggressive weeds that affect several economically valued Horticultural and agronomic crops (Ali et al., 2016; Webster, 2001). *Cyperus rotundus* is a smooth perennial nutsedge that belongs to the Cyperaceae family and is native to different edaphic conditions, more or less preferring moist conditions, but widely distributed in tracts, gardens, orchards, and wasteland(Khalid, 2014). This species is responsible for 23-89% yield loss in more than 50 crops and is present in 92 tropical and sub-tropical countries(Bendixen and Nandihalli, 1987). It is the major weed in cotton, maize, rice, sugarcane and most vegetables including bean, capsicum, carrot, chilli, cocoa, coffee, colza, cress, crocodile pine, cucumber, eggplant, emblem, fenugreek, fig, French bean, geranium, ginger, gold of pleasure, gooseberry, hemp, Indian relish, indigo, jute, lablab, lady's finger, apart from this, due to its various and very strong allelopathic effects, it may be a factor limiting the development and growth of several crops (Iqbal et al., 2007).

The dynamic morphological Characters, genotypes, competitive ability, storage capability of tubers, and several methods of vegetative reproduction make it imperative that this plant species be acknowledged as the world's worst weed (Fuentes et al., 2010). Additionally, this species has become especially aggressive and problematic in warmer nations due to the lack of a viable long-term control plan. In organic vegetable production systems, *Cyperus rotundus* has also been identified as a significant problem that is challenging to manage with conventional or organic weed control techniques (Peerzada, 2017). Using the

pertinent research, a thorough evaluation of recent developments in *C. rotundus* management was conducted. The objective was to raise knowledge and comprehension of *C. rotundus's* current condition to support better management choices(Iqbal et al., 2012). This article also identifies current gaps in the eco-biology of *C. rotundus* that must be filled in order to create long-term management plans for the species in different agricultural production systems. On the structure and variability of this plant, genetic polymorphism, competitiveness, durability of the tubers, and multiple ways of propagation, this species should be listed as the most toxic world's weed (Wahua and Abass, 2024). Consequently, this paper provides a comprehensive review of recent progress in the management of *C rotrundus* alongside the related literature. The goal was to increase the intensity and knowledge of the present state of *C. rotundus* to help with the alteration of the current decision-making processes.

Materials and Methods

Three replicates of each sample were drawn from the *Cyperus rotundus* population at Pakistan's Punjab University's Faculty of Agriculture Sciences, Lahore (Figure 1). Thus, there were a total of 9 replications in addition to three plants from each repeat (total samples were 27). By excavating the dirt alongside the weed plant, a sample of the entire weed was obtained. After collection, the samples were taken to a seed biotechnology facility for additional analysis. Various morphological characteristics were documented and surveyed for the data, and the analysis of variance was done to determine the significance of the results (Fuentes et al., 2010). The data were recorded for leaf length, leaf width, leaf area (Leaf area = leaf length × leaf width × 0.74), plant height, fresh weight, dry weight, and moisture percentage (Moisture% = [(FW - DW/FW) × 100]).

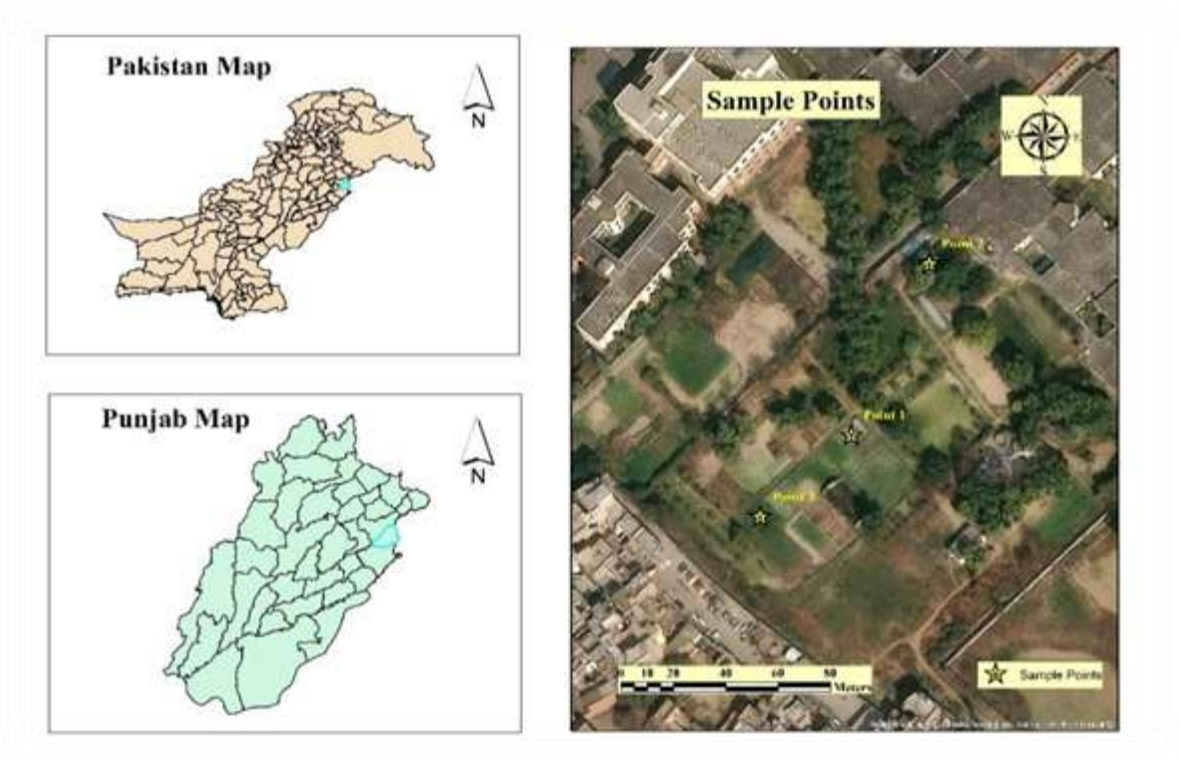

Figure 1. Sample collecting places

Results and discussions

The result from table 1 considering of morphology characteristics of *Cyperus rotundus* under different environments indicates various mechanisms that allow it to become invasive and survive. These characters were found to be significant at a probability level of 5%: Spread of Vegetation (SOV), Leaf area (LA), Plant height (PH), Fresh weight/Dry Weight Ratio (FW/DW), and moisture percentage (MP). These traits indicate responses to issues such as water and light, nutrients in the soil, as well as fluctuations in temperature. Secondary characters that are not always measurable, such as Fresh weight (FW), Dry weight (DW), and Root Length (RL), highly vary. This could be attributed to fluctuating environments or constraints in experiments. In general, *Cyperus rotundus* has shown good potential to adapt its vegetative and reproductive structures to deal with environmental stress factors; thus, there is a need to develop relevant control measures (dos Santos et al., 2015; Pena-Fronteras et al., 2009).

Table 1. ANOVA for morphological traits of *Cyperus rotundus*

SOV	LA	PH	FW	DW	FW/DW	MP	RL
Locations	4.81333*	675*	44.7778*	5.11*	0.18852*	577.744*	2.1111*
Error	2.877	0.778	0.004	0.007	0.789	74.380	1.611
Grand mean	8.500	3.889	0.914	0.291	3.254	59.558	5.778
Standard error	0.979	0.509	0.037	0.048	0.513	4.979	0.733
CV	19.950	22.680	6.980	28.280	27.300	14.480	21.970

*= Statistically significant at 5 % level of probability, CV = Coefficient of variance, LA=leaf area, PH= Plant height, FW=fresh weight, DW=dry weight, FW/DW=fresh weight and dry weight ratio, MP=moisture percentage, RL =root length

From Table 2, correlation analysis showed that there was a positive relationship between most of the morphological traits of *Cyperus rotundus*, except for a few. The fresh weight (FW) had a positive relationship with DW and a more powerful positive correlation with the FW/DW ratio. It was absolutely concluded that plants with high FW make better biomass. On the other hand, leaf area (LA) rose in the opposite direction to dry weight, which can imply that plants with larger leaves sacrifice biomass production. Moisture percentage (MP) = 3Parameters that manifested negative but very weak correlations with the moisture percentage are dry weight as a function of dry weight (DW) and the area of the leaves (LA). Other pairs, for example, plant height (PH) and the attributes in dry weight, were meaningfully positively correlated with PH. However, PH is not something that can be relied upon to greatly contribute to biomass accumulation in *Cyperus rotundus* (dos Santos et al., 2015; LAMIAA and Gazer, 2015; Peerzada et al., 2015). In general, the noticeable positive correlations of most of the traits are an indication that *Cyperus rotundus* is genetically fitted to cope with unfavourable environments for agriculture, within the context of its management in agricultural practice (Gianoli, 2004; Harrem et al., 2015; Mobeen et al., 2015).

Table 2. *Cyperus rotundus* morphological traits correlation

Traits	DW	FW/DW	LA	MP	RL	PH
FW/DW	-0.735*					
LA	-0.65	0.461				
MP	0.345	0.375	-0.191			
RL	-0.01	0.052	-0.287	-0.0023		
SH	-0.062	0.065	0.517	0.0703	-0.293	
FW	0.674*	-0.001	-0.41	0.925*	0.012	0.019

*= Statistically significant at 5 % level of probability, DW= dry weight, LA=leaf area PH=Plant height, FW=fresh weight, DW=dry weight, FW/DW=fresh weight and dry weight ratio, MP=moisture percentage, RL =root length

Using stepwise multiple regression on the variable Fresh Weight of *Cyperus rotundus* (purple nutsedge weed), it is shown that even though there is a correlation between the independent variables (LA, PH, DW, FW/DW, MP, and RL). The result showed that none of the predictors is statistically significant (P> 0.05), which means none of these traits affects the fresh weight of *C. rotundus* independently. The coefficient of determination R^2 was found to be very high 96.40% which indicated that the results from the study were highly reliable. It has implications for conceptualizing the impact of this weed on crop yields and the diminution of the crop-producing environment. *Cyperus rotundus* is a perennial weed that is known to interfere with crops for water, nutrients, and light, which in turn reduces crop yield. Still, the model underlines the necessity of future investigation of the other factors or interactions that may be more effective for understanding the impact on the crop yield and the environment (Leon et al., 2003; Mobeen et al., 2015; Qamar et al., 2015). From Figure 2, to determine the ideal site for *Cyperus rotundus* propagation under various environmental circumstances, a GGE biplot was created. The best and most favorable area for *Cyperus rotundus* to grow and flourish was discovered to be location 3. Now it was suggested that weed plants should be controlled from location 3 to reduce the yield loss of crop plants(Afzal et al., 2016; Mahmood et al., 2016).

Table 3. Stepwise multiple linear regression for fresh weight of *Cyperus rotundus*

Traits	**Coefficients**	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
LA	-0.119	0.469	-0.254	0.823	-2.137	1.899
SH	-0.487	0.413	-1.179	0.360	-2.263	1.290
DW	-67.667	86.072	-0.786	0.514	-438.005	302.670
FW/DW	-2.429	3.288	-0.739	0.537	-16.576	11.718

MP	-0.297	0.384	-0.775	0.520	-1.948	1.354
RL	0.011	0.301	0.035	0.975	-1.284	1.306

LA=leaf area, SH=stem height, FW=fresh weight, DW=dry weight, FW/DW=fresh weight and dry weight ratio, MP=moisture percentage, RL =root length, t= t-statistic p= probability level,
Standard error=0.869, multiple R=98.18%, R^2=96.40%, Adjusted R^2= 35.61%

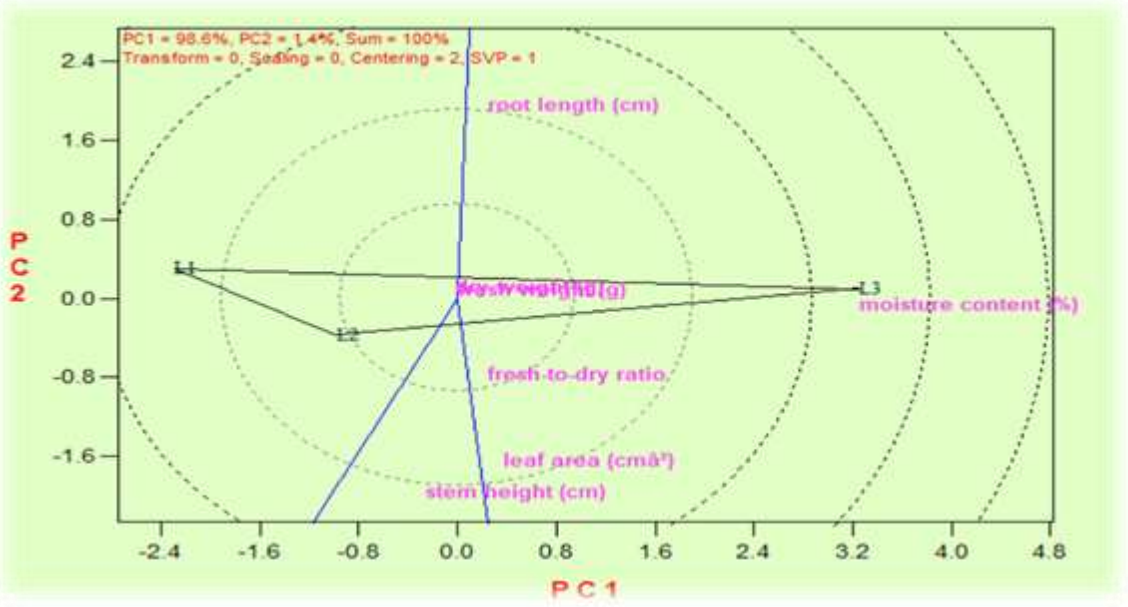

Figure 2. *Cyperus rotundus* morphological traits in a GGE biplot at three different locations

Conclusions

It was proposed that to reduce agricultural plant production losses, the *Cyperus rotundus* plant population should be managed.

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Declaration

Authors' Contributions

The corresponding author (QH) was involved in the conception, design, drafted the present manuscript and data analysis. All authors (ZA, MA, MFS) were involved in analysis and interpretation of data. QH and MA have been involved in critically revising the manuscript for important intellectual content.

Conflicts of Interest

The authors declare that they have no competing interests.

Ethics approval and consent to participate

Not applcable

Availability of data and materials

All the generated data in this article.

Funding

No funding was given to support this study