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MULTI-DIMENSIONAL ANALYSIS FOR MORPHOLOGICAL TRAITS OF *PARTHENIUM HYSTEROPHORUS* L.

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Abstract *Parthenium hysterophorus belongs to the family Asteraceae, which is an invasive, unwanted plant affecting agriculture, biodiversity, and human health in Asia, Africa, and Australia. This research intended to probe the morphological characteristics of P. hysterophorus and which of these attributes are linked to enable strategies for controlling the invasive spread of the plant. Several characteristics, such as leaf area, shoot height, fresh and dry weight, FW/DW ratio, amount of moisture, and root length, were assessed and compared. Variances were learned to have a close relation with environmental habits like the type of land in relation to soil, water, and nutrients. Multiple correlations, such as fresh mass and dry mass =0.899*, humidity level with the area of the leaf = 0.972*, and root length with shoot height = 0.965*, have pointed towards the fact that all these traits are interrelated. Multiple regression analysis by steps revealed that none of the recording traits of the first predictor had any effect on the fresh weight. These results re-emphasize that proper, targeted, and specialty management strategies for this site would be appropriate to combat P. hysterophorus. It is further suggested that integrated control measures, inclusive of mechanical, chemical, cultural, and biological means of pest control, are more sustainable. More studies are recommended in order to define specific antecedents of trait variations and refine local treatments.*

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Keywords: *Parthenium hysterophorus; invasive weed; morphological traits; correlation; regression; GGE biplot*

Introduction

Parthenium hysterophorus is an annual or perennial herb plant from the Flowering group, recognized as belonging to the family Asteraceae (Dhileepan and Strathie, 2009). Some of the popular other names used in the community are Santa-Maria, Santa Maria feverfew, white-top weed, and famine weed (Dheer et al., 2023). It is locally called carrot grass, congress grass, or sometimes gajar, ghas, or dhanura in India, an invasive species that has attracted attention on account of its prolific growth and effects. Originally grown in the Americas, tropical regions, this has become an emerging weed in the Asian, African, and Australia; pacific island states, among other areas(Goosem, 2009). The species is famous for its rapid growth, fruitful reproduction, and allelopathic characteristics to quickly grow and spread in the agricultural fields, pastures, and natural valleys (Ayele, 2007; Duguma et al., 2019; Zareen et al., 2021). The mentioned rapid increase in the distribution of *P. hysterophorus* can be explained by several factors. The plant has many small, viable seeds, which makes it easy for it to spread over huge distances, including aerial and waterborne movements, animal and human movements (Matzrafi et al., 2021; Zareen et al., 2021). Also, the germination potential of *P. hysterophorus* is very high, with a short generation time, and thus poses a high threat in terms of invasion and reproduction. This characteristic, which makes it so invasive, is also its ability to act as an allelopathic plant or organism; it secretes chemicals in the soil, which tend to slow or kill off other plants in the region to allow room for its own growth. These aspects, together with an absence of limber biocontrol agents in many of the invaded areas, make *P. hysterophorus* one of the most invasive weed species worldwide (Khan et al., 2020; Kriticos et al., 2015; Williams and Groves, 1980). As much as the effects are wide and serious, *P. hysterophorus* is equally as disastrous. In agriculture, the weed interferes with the crops for nutrients, water, and light, which results in reduced yields and high expenses on farming (Cowie, 2020; Khan and Fahad, 2020). In the pastoral regions, it has a direct negative effect on the quality and quantity of feed available to

the animals, thereby leading to low production and added expense on management. *P. hysterophorus* is also dangerous to human and animal health; the plant may cause skin rashes, skin reactions, and respiratory problems when people come into contact with it, and cattle die when they feed on the plant(Kaur et al., 2021; Safdar, 2015). Moreover, the existence of the weed in natural environments affects the usual plant associations and reduces the level of biological diversity. For these reasons, the biology, ecology, and management of this plant are important for the formulation of approaches that will help in the control of the plant (Temesgen et al.).

Current work has centred on many management approaches to mitigate the effects of *Parthenium hysterophorus.* Some of these methods include mechanical control, chemical control, cultural control, and biological control (Saini et al., 2014). Manual removal by hand-pulling or mowing can work, but it is rather slow, and may not fit well with large infestations(Cowie, 2020). Chemical herbicides offer short-term solutions, but some operations often affect the environment, which may also give rise to resistance breakthroughs. Some of the cultural measures that can curb the spread of the weed include: rotation of crops, mulching, and competition by planting other vegetation. Integrated control, the process of using such environmentally friendly methods as introducing natural enemies like insects and pathogens, has been partly successful in some parts(Dheer et al., 2023). According to the study, the best control option is comprised of more than one approach and considers the whole life cycle of *P.hysterophorus* since this way of controlling is effective and does not require increased amounts of chemicals due to possible resistance of plants. Further scientific investigation, together with interdisciplinary and regional approaches involving farmers and policymakers, is still required to come up with feasible and appropriate strategies to address the negative impact of this noxious weed(Abbas et al., 2018; Jayasuriya, 2021).

Materials and Methods

Three replicates of each sample were drawn from the population of *Parthenium hysterophorus* at the Faculty of Agriculture Sciences, University of the Punjab, Lahore, Pakistan. Thus, there were an overall 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 divergence was done to determine the significance of the consequences.

Leaf Dimension (cm)

Blade dimension was deliberate by utilizing a millimeter ruler. For this objective, three leaves were taken from each plant, and their dimension and mean result were documented.

Leaf Width (cm)

Leaf breadth was assessed at three locations at the leaf apex, middle, and bottom and the mean value is computed as done in leaf dimension.

Leaf Area (cm^2)

Leaf surface area is the cross product of leaf dimension and leaf breadth and an adjustment coefficient.

Protocol is as follows:

Leaf Area = Leaf dimension x Leaf breadth x cf

Stem Height (cm)

Plant height (length) was quantified beginning from the point of attachment of the stem to the root (base of the stem). The tallest sprout was taken on each plant to measure plant length.

Fresh Weight (g)

Fresh organic mass was measured promptly after taking the weed specimen from the field to avoid drying of the sample with the help of an electronic weight balance.

Dry Weight (g)

Before determining the desiccated mass, the initial phase is to dry the sample in a thermal dryer or via solar exposure. The sample was dried in an oven because it is a quick and efficient way to dry. Sunlight requires a lot of hours to dry. So, for this purpose, the sample was secured in packets separately. After 2-4 After hours, the sample was drawn from the oven. Then each sample was weighed on a scale balance.

Moisture Percentage (%)

Water content was calculated by using the subsequent equation:

Moisture Percentage = [(Plant fresh mass– Plant dry mass/ Plant freshmass) x 100]

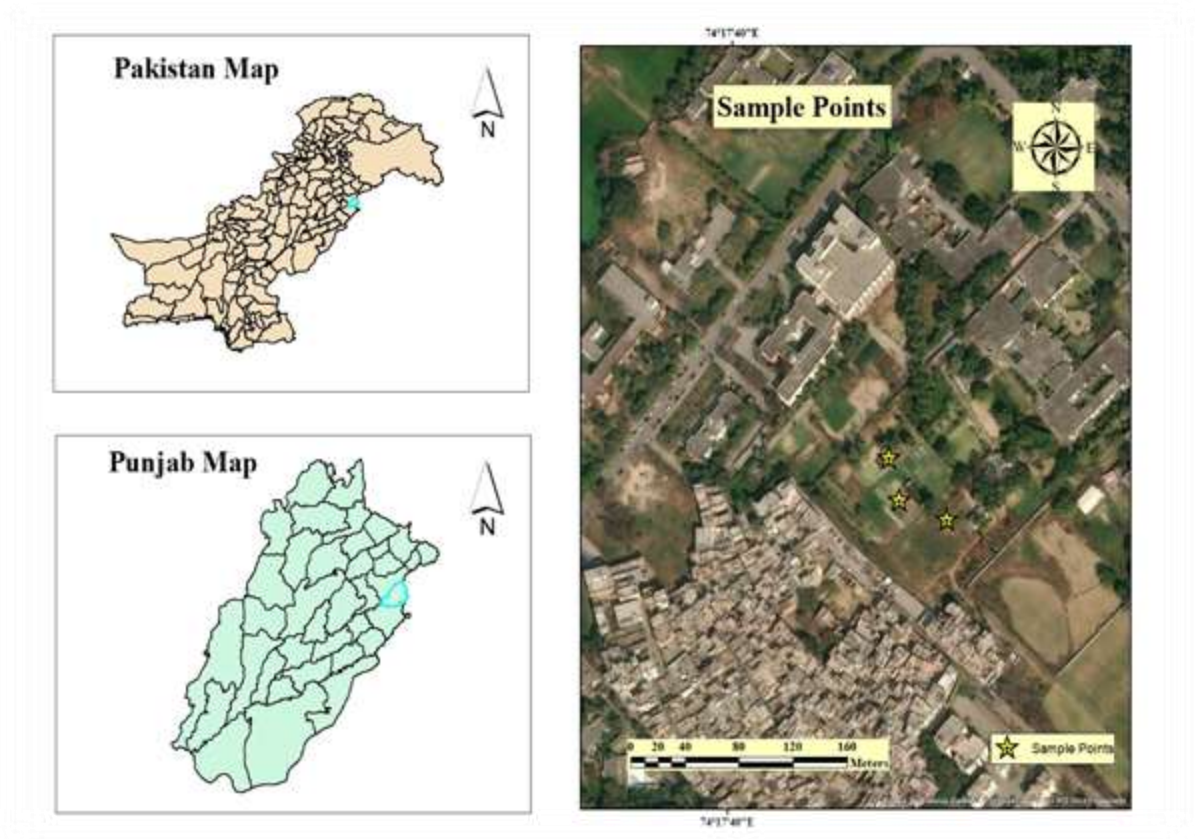

Figure 1 Sample collecting locations

Results and discussion

From Table 1 for *Parthenium hysterophorus,* the efficiency of the growth parameters abstracted by surface analysis of variance shows considerable variation when compared across different locations. Some of the differences that were observed at the 0.05 level include the leaf area, shoot height, fresh weight, dry weight, FW/DW ratio, moisture percentage, and root length; factors such as the location differences in the type of soil, moisture, and nutrients likely caused the differences seen on the two plantlets (AJMAL et al., 2026). The coefficients of variation of the FW/DW ratio and dry weight, for instance, show large variability at different locations. These results imply that since the management of rose-ringed parakeet weed is successful locally, further efforts should be made towards devising specific site-specific management techniques that aim at controlling this invasive weed(Hayat et al., 2025; Hayyat et al., 2025). Future work should aim at identifying specific factors responsible for these differences and creating accurate, targeted local interventions(Cowie et al., 2020; Kaur et al., 2019; Rathee et al., 2021).

Table 1. ANOVA for morphological traits of *Parthenium hysterophorus*

SOV	LA	SH	FW	DW	FW/DW	MP	RL
Locations	0.39*	29.7778*	2.76333*	0.13043*	20.0297*	76.247*	0.01333*
Error	2.323	49.444	0.158	0.179	59.346	199.232	0.077
Grand mean	8.367	20.556	3.233	0.690	7.018	77.764	1.433
Standard error	0.880	4.060	12.310	0.245	4.4477	8.149	0.160
CV	18.220	34.210	0.230	61.390	109.770	18.150	19.320

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

From Table 2 the study of the coefficient correlation of traits of *Parthenium hysterophorus* according to the results and findings, food and thousand seed weight had positive and highly significant correlation coefficients among the various parameters. FW and DW are strongly positive correlated (r = 0.899*), which implies that plants having higher FW also possess greater DW. To compare, the FW-DW ratio correlates with the actual FW at 0.726 * P, and the LA at 0.692 * P, indicating that tissues with high H 2 O content may be larger. The results of biologically repeats of this investigation are presented in Table 2, these show the positive correlation in moisture percentage (MP) with FW (Pearson coefficient = 0.948*), FW/DW (Pearson coefficient = 0.835*), largest leaf area (LA) (Pearson coefficient = 0.972*),

root length (RL) (Pearson coefficient = 0.973*), shoots height (Another interesting and strong relationship was observed between root length (RL) and shoot height (SH) and all the other traits, which are critical for the support and growth of plant and its invasiveness. These interconnected traits imply that if the environmental moisture and biomass of *P. hysterophorus* are well regulated, then this species might be well contained(Cowie et al., 2020; Rathee et al., 2021).

Table 2. *Parthenium hysterophorus* morphological traits correlation

Trait	DW	FW	FW/DW	LA	MP	RL
FW	0.899*					
FW/DW	0.457	0.726*				
LA	0.921*	0.9361*	0.692*			
MP	0.843*	0.948*	0.835*	0.972*		
RL	0.919*	0.936*	0.722*	0.995*	0.973*	
SH	0.883*	0.941*	0.73*	0.956*	0.954*	0.965*

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

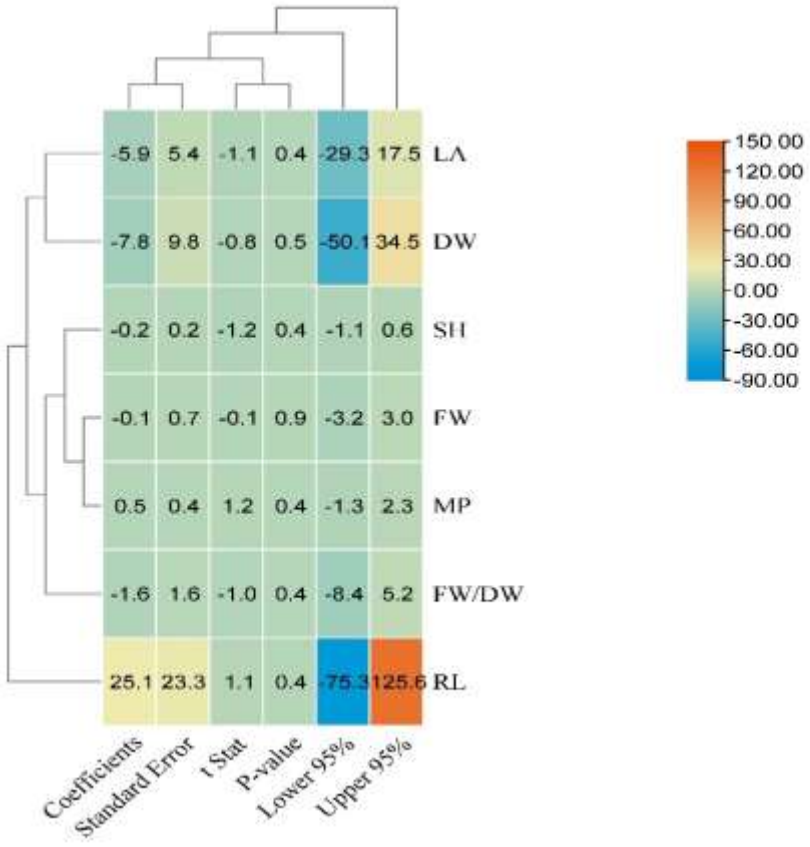

Figure 2 Sequential multiple linear regression for fresh mass of *Parthenium hysterophorus*

From Fig 2 for fresh weight in *Parthenium hysterophoru*, none of the predictor traits, LA, SH, DW, FW/DW ratio, moisture percentage, and RL are significant at the 0.05 level as indicated by stepwise multiple regression analysis for fresh weight in the plant. The coefficients for these traits are, respectively, negative or positive but have high p-values, which are non-significant. The presented standard errors and the huge confidence intervals point to a large variability and significant uncertainty of these measurements. This makes it clear that the predictor traits do not make much impact on fresh weight directly and that other factors could be more decisive as far as this particular trait is concerned. Exploratory research using larger sample size or including other other possible factors might be required in an effort to establish better correlation. From figure 2 to determine the ideal site for *Parthenium hysterophoru* propagation under various environmental circumstances, a GGE biplot was created. The best and most favorable area for *Parthenium hysterophoru* to grow and flourish was

discovered to be location 3. Now it was recommended that weed plants should be restrained from location 3 to reduce yield loss of crops plants(Afzal et al., 2016; Ali et al., 2016; Bajwa et al., 2020; Rathee et al., 2021).

Standard error=1.032, multiple R= 97.43%, R^2=94.92%, adjusted R^2= 29.69%

LA=leaf area, SH=stem height, FW=fresh weight, DW=dry weight, FW/DW=fresh weight and dry LA weight ratio, MP=moisture percentage, RL =root length, t= t statistic p= probability level,

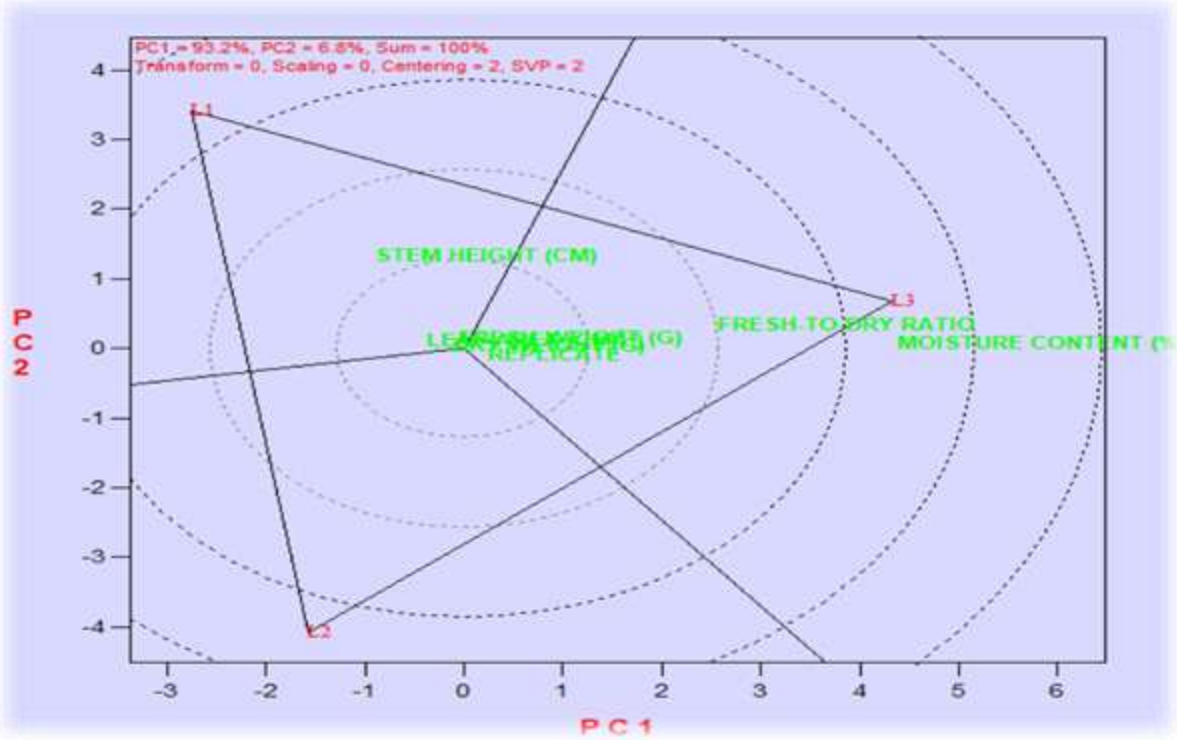

Figure 3 *Parthenium hysterophorus* morphological traits in a GGE biplot at three different locations

Conclusions

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

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Statements and Declarations

Data Availability statement

All relevant data are within the manuscript file.

Author's Contribution Statement

MT, MUR, and QH collected data and wrote manuscript equally. All authors have read the final manuscript and approve its submission.

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Ethical Statement

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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.