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Indicator species analysis and assessment of ornamental plants using multivariate statistical techniques in the home gardens of Rustam Valley, Pakistan

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Abstract

Ornamental plant species are mostly grown for aesthetic purposes, for their fruits, vegetables, flowers, and medicinal value. Houses are decorated with various annual and perennial plants. The present study was performed to assess the ornamental plant composition, abundance, and distribution pattern with a special reference to gardening practices/environmental variables in the Rustam Valley, Pakistan. Using quantitative ecological methods, different home gardens were observed at arbitrary intervals. The frequency, relative frequency, density, relative density, and importance values were measured to determine the most frequent and least frequent ornamental plant species in each type of habitat. The initial results showed a total of 43 ornamental plant species belonging to 30 families. Presence-absence data (1, 0) for the 43 ornamental species and 50 stations were analysed using cluster and two-way cluster analyses using the PC-ORD version 5, which resulted in the identification of four different ornamental plant communities. The CANOCO version 4.5 was used to evaluate the environmental and cultural gradients of ornamental plants through the canonical correspondence analysis (CCA). The positions of characteristic plant species in a particular community were confirmed using data attribute plots. The CCA plots of the ornamental and questionnaire data show that irrigation, home size, purpose of cultivation and the use of artificial fertilizers were the main factors affecting various ornamental plant communities. Additionally, further studies should be conducted to examine, conserve, and manage the ornamental plant species diversity and contributions of such species to livelihoods in the study area.

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Two-way cluster analysis;
Canonical correspondence analyses

Abbreviations

CCA (Canonical Correspondence Analysis), ISA (Indicator Species Analysis), P (Phosphorus), K (Potassium), K_2O (Potassium oxide)

Introduction

Ornamental plant species are mainly grown for aesthetics purposes, but they have other benefits, such as fruit, vegetable, flower production and medicinal value. Houses are decorated with various mixtures of annual and perennial plants (Paumgarten et al., 2005). Fernandes and Nair (1986) described a system concerning the planned management of multi-used trees and shrubs in relation to annual and perennial rural crops and domestic animals within the yard of a focal house. A garden is a confined location that is possibly composed of medicinal, ornamental, and vegetable plants, lawns, ponds and transitory buildings (Orme et al., 2005; Roy, 2008; Perveen et al., 2010; Rajalakshmi et al., 2018). Home

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gardens contain various items within a small region and play an important role in our daily lives. They increase the beautification of an environment, are used as a sign of sentiment, and are vital components of spiritual and social ceremonies. The significance of home gardens in providing food, drugs and additional benefits helpful for human beings is broadly acknowledged (Polegri and Negri, 2010; Sher and Al-yemeni, 2011). Home gardens are used for the continuation of agriculture and the profitable production of food crops (Guitart et al., 2012). Pakistan has a diverse flora due to its favourable climate and ecological and soil conditions. More than 6,000 different varieties of higher plants, of which 2,000 being medicinal, grow here. Pakistan has attempted to sell ornamental flowers and buds to various countries around the globe, and thus it can benefit from a trade of billions of U.S. dollars by exporting flowers and buds. Home gardens receive a significant attention from researchers due to their well-organized plant diversity, nutrient cycling, use of exterior inputs and soil maintenance potential (Hylander et al., 2008; Galhena et al., 2013). They provide more varied and steady contributions to socioeconomic foodstuffs and profits for families that maintain them compared to other agricultural ecosystems.

The present study was conducted to identify ornamental plant indicator species and their abundance and rareness in particular habitats. The main objectives of this work were to examine the effects of gardening practices on ornamental plant species diversity, distribution and management to explore potential preservation sites for home garden ornamental plants.

Materials and Methods

Sampling

Rustam Valley is located in Mardan district of Khyber Pakhtunkhwa Province, Pakistan, at an altitude of 369 m. It is surrounded by the Chengay Baba, Shabaz Ghara, Sarma Lang and Kashmir Smasta mountains. Rustam is famous for its agricultural products, i.e., fruits and vegetables, with oranges, plums, peaches, apricots, pears, and mangoes and apples being rare fruits. The present study was conducted to determine the effects of gardening practices and environmental variables on the ornamental plant species in the study area. Different sampling sites were established at random intervals and varying distances. Quantitative ecological methods using quadrats were used to assess the environmental variability and distribution in home gardens (Khan et al., 2013; Khan et al., 2014; Ahmad et al., 2016). Data from a total of 50 home gardens were collected. At each station, the density, frequency, relative density, relative frequency, and importance values of ornamental plant species were recorded. Ornamental plant specimens were collected, labeled, disinfected and attached upon herbarium sheets. Finally, the specimens were identified using the available literature (Nasir et al., 1972).

Data analyses

The data matrices for the ornamental species and questionnaires were analyzed using the CANOCO version 4.5 to determine the effects of various gardening practices on ornamental plant species distribution, diversity, and composition. The data for the 50 home gardens were added to MS EXCEL to prepare a presence-absence data sheet (1, 0) for cluster analysis and two-way cluster analysis (Ter Braak and Prentice, 1988; Dufrêne and Legendre, 1997; Ahmed et al., 2018; Anteneh et al., 2018). The PC-ORD version 5 was used for a two-way cluster analysis for the 50 home gardens (Greig-Smith, 1983; Ahmad et al., 2016; Khan et al., 2016). The ornamental plant species data file was transposed in such a way that species were arranged in rows, while quadrats arranged in columns, which is a requirement for the PC-ORD version 5 software.

Results

A total of 43 ornamental plant species belonging to 30 families were reported. Family Rosaceae was the predominant one, with 5 ornamental plant species (12%), followed by Moraceae, Myrtaceae, Poaceae and Rutaceae, each having 3 species (7%), and Cupressaceae had 2 different species (4.65%). *Rosa indica* was the most frequent ornamental plant species, with a frequency of 28 and a relative frequency of 6.23. Other frequent species included *Morus nigra, Cupressus sempervirens, Thuja occidentalis, Duranta dombeyana, Prunus armeniaca, Jasminum humile, Ziziphus nummularia, Mangifera indica* and *Psidium guajava*, all with frequencies over 14. The least frequent ornamental plant species in the study area were *Arundinaria gigantea, Alpinia zerumbet, Vitis vinifera, Platanus orientalis, Bambusa papyrifera, Diospyros lotus, Mentha longifolia, Epipremnum aureum, Musa paradisiacal* and *Pelargonium hirsutum*, which were present in fewer than six home gardens in the study area.

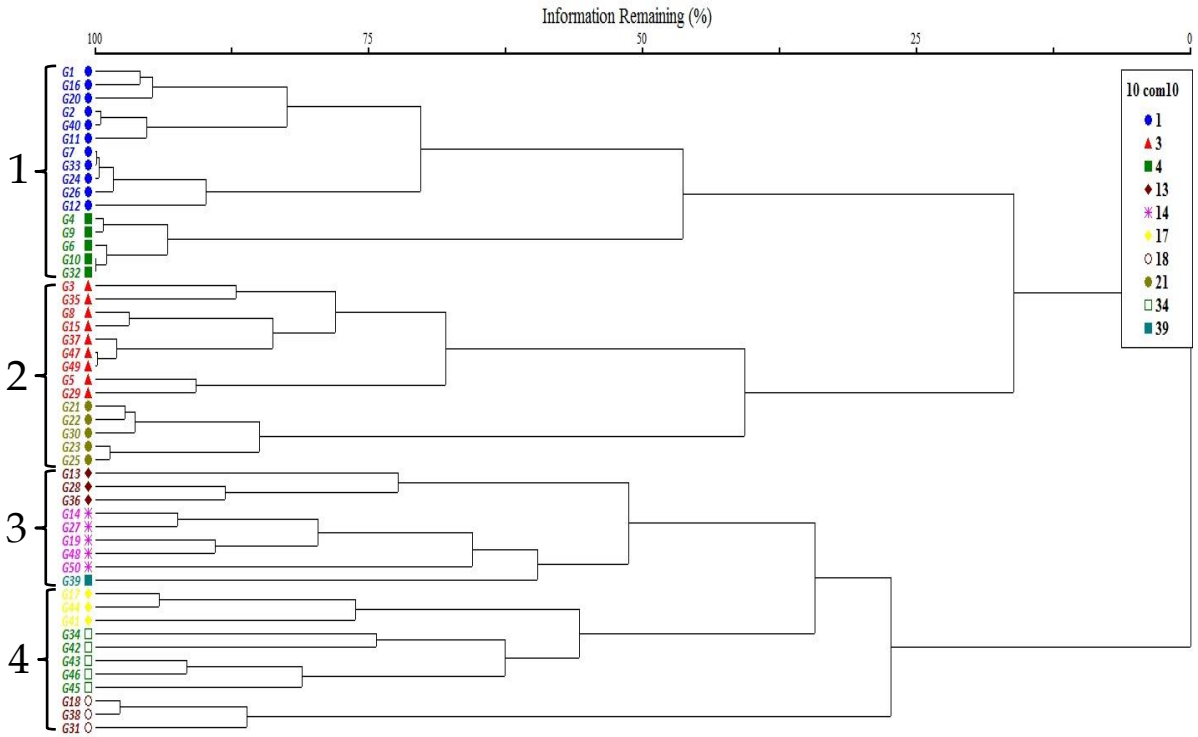

Figure 1. Cluster analysis of 50 home gardens based on Sorensen measures showing 4 ornamental plant communities via PCORD software.

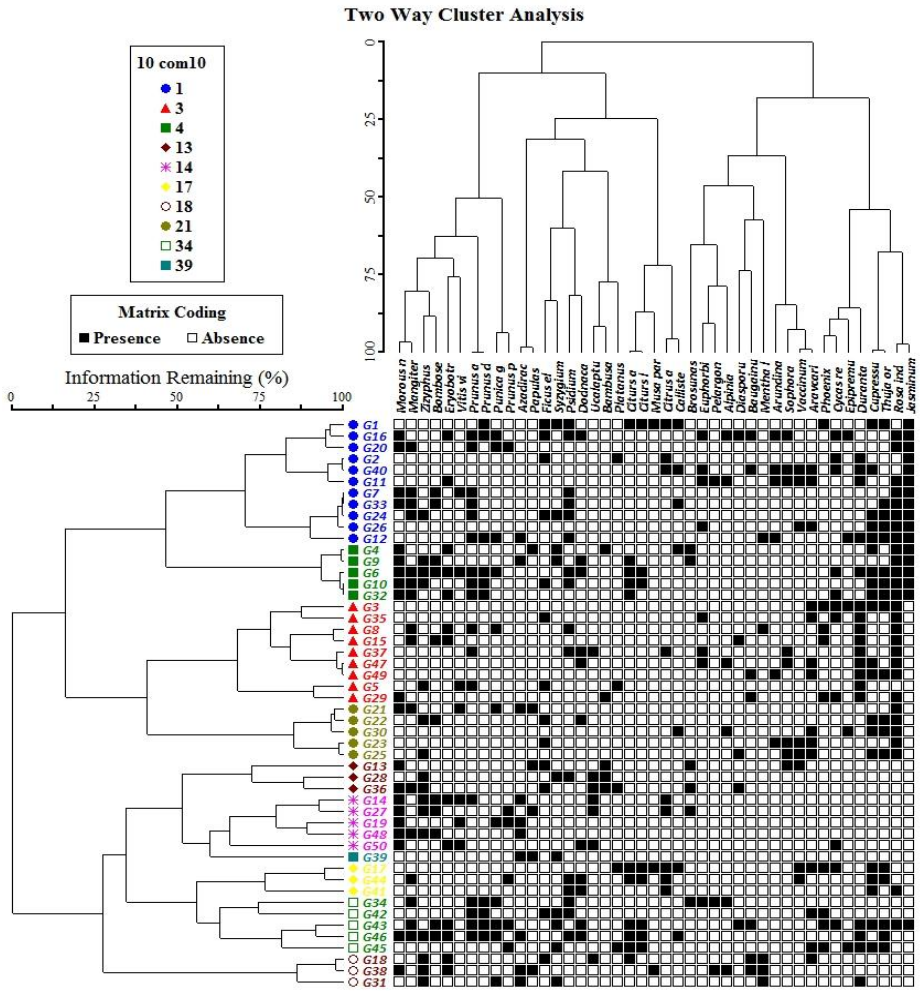

Figure 2. A plot showing distribution of 43 ornamental plant species among 50 home gardens using a two-way cluster analysis

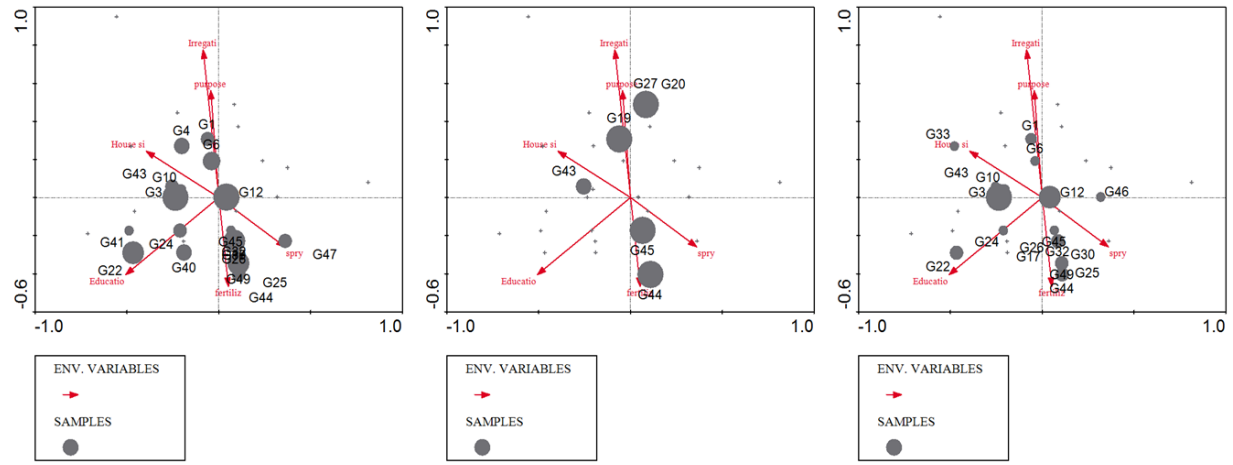

Figure 3. Data attribute plots for indicator species *Cupressus sempervirens*, *Prunus persica* and *Thuja occidentalis* of the first community

Results of the cluster analysis and two-way cluster analysis

The cluster analysis using the PCORD version 5 software clustered the 50 home gardens into 4 different ornamental plant communities (Fig. 1). In the results of the two-way cluster analysis, the black dots represent the presence of plant species, while the white dots indicate the absence of ornamental plant species in the site (Fig. 2).

The detailed descriptions based on the analysis of the individual communities in relation to the various environmental variables are as follows:

Cupressus–Prunus–Thuja community

This community name was given based on an indicator species analysis (ISA). The most frequent ornamental plant species in the first community included *Jasminum humile, Rosa indica, Duranta dombeyana, Mentha longifolia* and *Cupressus sempervirens*, while *Platanus orientalis, Phoenix dactylifera, Prunus persica, Vitis vinifera* and *Bambusa papyrifera* were the least frequent ornamental plant species recorded. Considering the CCA plot, it was concluded that gardening using irrigation, a large home size and cultivation for multiple purposes were the main significant variables for this community. *Cupressus sempervirens, Prunus persica* and *Thuja occidentalis* were the top three indicator species of this community. Data attribute plots using CCA for the top 3 indicator species of this community, i.e., *Cupressus sempervirens, Prunus persica* and *Thuja occidentalis*, showed indicator values of 20, 42 and 40, respectively, in the case of gardening using irrigation, and 17, 48 and 41 in the case of different purposes of cultivation (Fig. 3).

Araucaria–Cycas–Rosa community

The most frequent species in this community were *Duranta dombeyana, Rosa indica, Cupressus sempervirens, Araucaria araucana* and *Euphorbia milii*, with frequencies greater than 20. The least frequent ornamental plant species were *Punica granatum, Bougainvillea glabra, Vitis vinifera, Azadirachta indica* and *Platanus orientalis.* The environmental data for community 2 analyzed with the help of the CCA bi-plot showed that the main significant variables were the use of artificial fertilizers and the use of spraying while gardening. The three primary indicator species of the community based on the CCA attribute plots were *Araucaria araucana, Cycas revoluta* and *Rosa indica*, with indicator values of 49, 23 and 57, respectively, in the case of artificial fertilizers, and 41, 32 and 43 in the case of gardening using spraying (Fig. 4).

Bambusa–Broussonetia–Morus ornamental community

The most abundant ornamental plant species of this community were *Bambusa* species, *Populus alba*, *Azadirachta indica*, *Morus nigra* and *Eucalyptus obliqua*, which had high frequencies. *Mangifera indica*, *Vitis vinifera*, *Syzygium cumini*, *Diospyros lotus* and *Cycas revoluta* were recorded less frequently. The most significant variables for community 3 were irrigation and multiple purposes of cultivation based on the CCA bi-plot. *Bambusa bambos*, *Broussonetia papyrifera* and *Morus nigra* were the top indicator species of this community, with indicator values of 31, 28 and 57, respectively. The indicator species *Morus nigra* had an importance value of 51 in the case of multipurpose cultivation (Fig. 5).

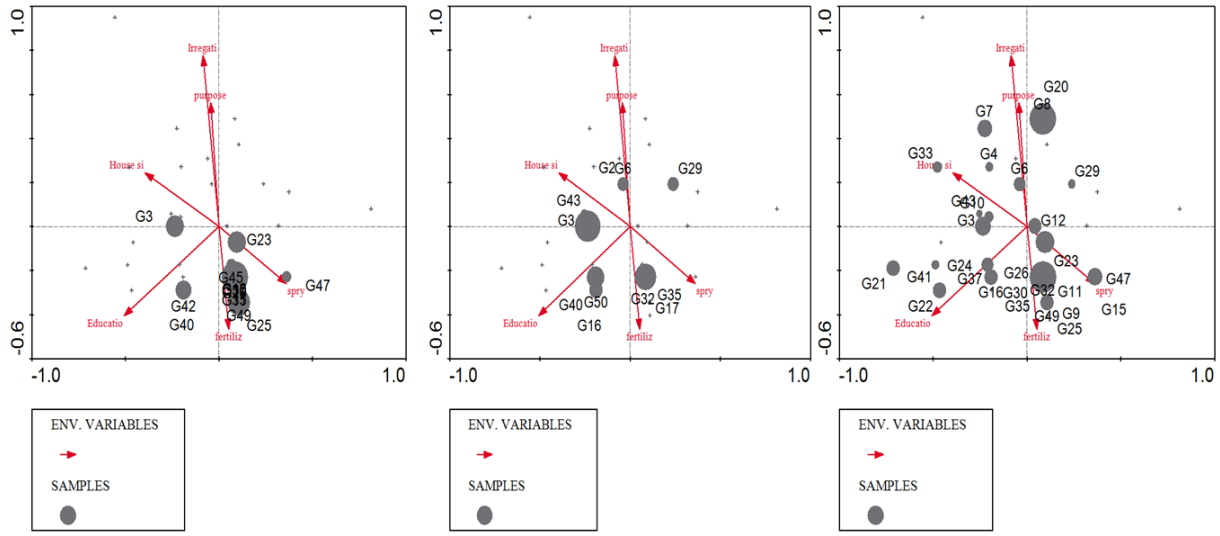

Fig. 4. Data attribute plots for indicator species of community 2 with respect to associated environmental variables

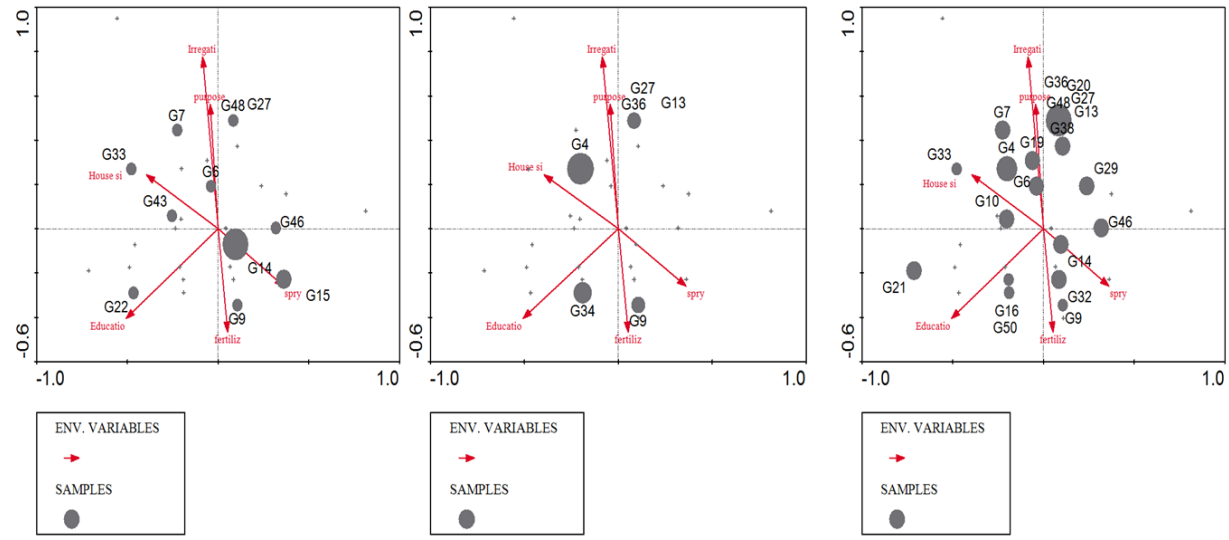

Fig. 5. Data attribute plot for *Bambusa bambos*, *Broussonetia papyrifera* and *Morus nigra* indicators of community 3

Azadirachta–Duranta–Epipremnum ornamental community

The most frequent ornamental plant species of community 4 were *Mentha longifolia*, *Duranta dombeyana*, *Dodonaea viscosa*, *Citrus decumana* and *Euphorbia milii*, with frequencies greater than 14. *Broussonetia papyrifera*, *Bambusa bambos*, *Populus alba*, *Epipremnum aureum* and *Diospyros lotus* were the least abundant ornamental plant species in this region. Considering the CCA plot, it was concluded that gardener education and the application of fertilizers and sprays were the main significant variables for this community. The top 3 indicator species of this community were *Azadirachta indica*, *Duranta dombeyana* and *Epipremnum aureum*, with indicator values of 15, 22 and 52, respectively, in the case of irrigation, while in the case of the use of spraying, *Duranta dombeyana* showed an indicator value (IV) of 44 (Fig. 6).

Environmental gradient

All the ornamental plant species and environmental data showed significant effects of all the environmental variables on ornamental plant species composition, diversity and indicator species. The CCA of all quadrats resulted in the negative side of axis 1 having most of the quadrats assembled under the influence of fertilizers and spray. In terms of axis 2, it appeared that most quadrats clustered near the negative side, indicate the strong influence of irrigated gardeners. The quadrats clustered on the positive side of axis 2, indicate the impacts of large house size, irrigation, and multiple purposes of growing of ornamental plants (Table 1 & Fig. 7).

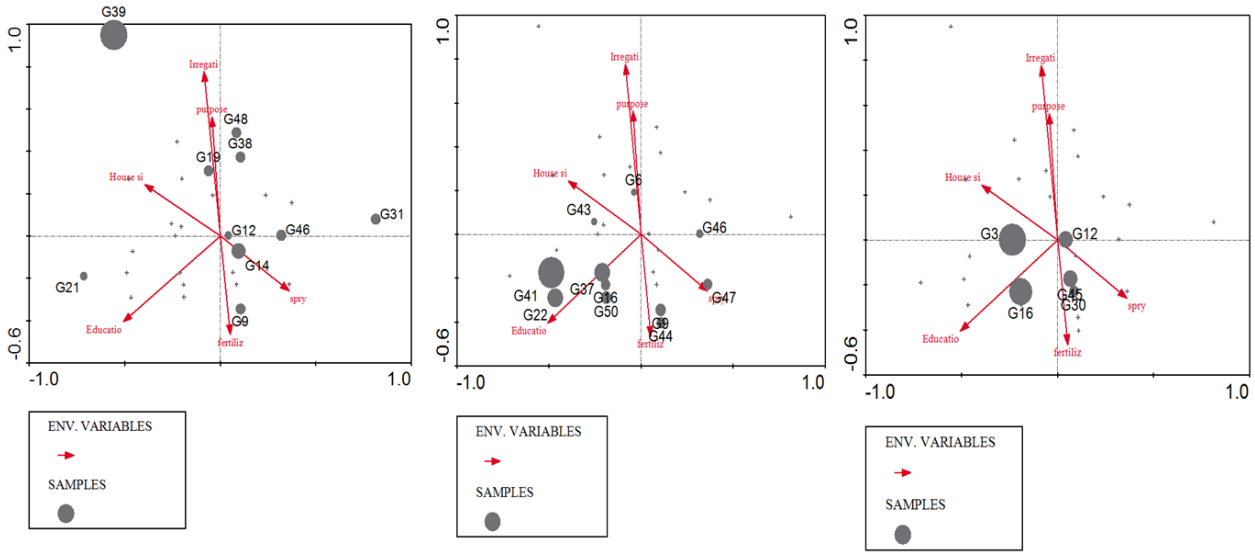

Fig. 6. Data attribute plots for the indicator species *Azadirachta indica*, *Duranta dombeyana* and *Epipremnum aureum* in community 4

Table 1: Canonical Corresponding Analysis summary of all 43 species with all 10 environmental variables

Axes	1	2	3	4	Total inertia
Eigen values	0.253	0.199	0.121	0.092	4.682
Species-environment correlations	0.646	0.670	0.568	0.617	
Cumulative percentage variance of species data	5.40	9.70	12.2	14.2	
Species-environment relation	33.6	60.0	76.0	88.3	
Summary of Monte Carlo test (499 permutations under reduced model)					
Test of significance of first canonical axis		Test of significance of all canonical axes			
Eigen value	0.253	Trace			0.754
F-ratio	2.458	*F*-ratio			1.375
P-value	0.162	*P*-value			0.046

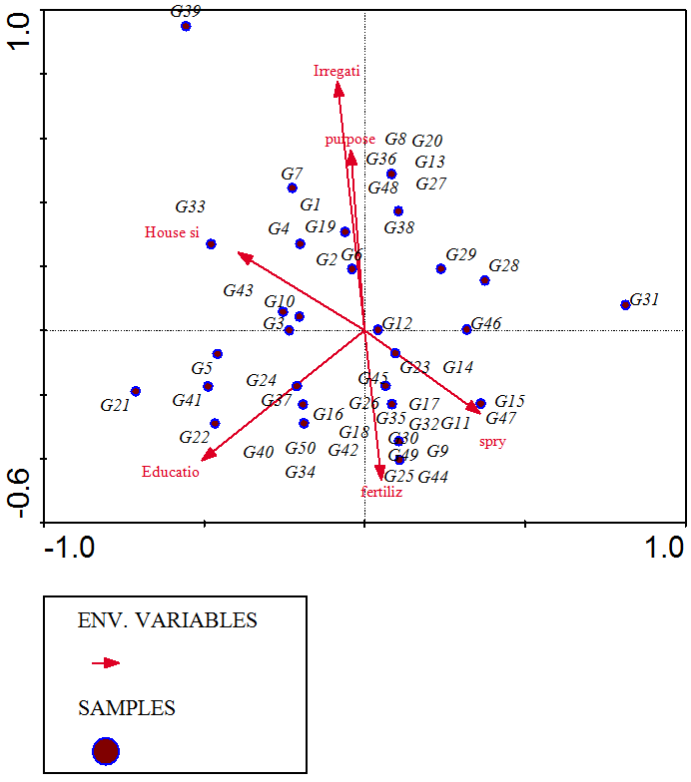

Fig. 7. Distribution of 50 home gardens in relation to various environmental variables after CCA through CANOCO software

Discussion

Of 50 home gardens, a total of 43 ornamental plant species belonging to 30 families were collected. Family Rosaceae was the leading family, whereas *Rosa indica* was the most frequent ornamental plant, followed by *Morus nigra* and *Cupressus sempervirens.* At the same time, the least frequent ornamental plant species included *Arundinaria gigantea, Alpinia zerumbet* and *Vitis vinifera.* The ornamental plant species *Euphorbia milii* is cosmopolitan. It mainly grows on granite rocks, but different varieties grow in various habitats (Eggli and Hartmann, 2002). The present study shows that *Euphorbia milii* was frequently present in areas where higher doses of different fertilizers were used. For example, foliar spray of inorganic fertilizers is highly recommended to augment the nutritional and aesthetic values of fruits, vegetables, and flowers. For example, Yaseen and Ahmad (2010), while applying fertilizers through foliar spray, reported that citrus fruit had high nutritional value and it fetched reasonably high price in the market. Similarly, our research shows that *Citrus decumana* and *Dodonaea viscosa* grow in areas where the application of fertilizers either through foliar spray or as soil application is practiced. In addition, both plants were cultivated by well-trained gardeners.

In the present study, it was observed that *Mentha longifolia* plants were present in areas where higher concentrations of fertilizers, irrigation and chemicals were regularly applied. Moreover, the plants of *M. longifolia* showed vigorous growth. Likewise, while conducting a filed study, Alsafar and Al-Hassan (2009) determined the effects of P and N fertilizers applied at various time periods on the growth and production of important *Mentha longifolia* oil products. The leaves were found to be significantly increased in size in response to increased fertilizer application rate. In addition, the application of the fertilizers at different growth stages did not significantly influence the essential oil yield of this plant. However, different rates significantly affected the growth and yield of mint.

Another important ornamental plant of the study site was *Jasminum sambac*; it was found growing in those places wherein there was a sufficient supply of water. In a previous study with this plant, Sengar et al. (2015) also reported that water is essential in the period of root establishment and for quick plant growth of this ornamental plant. The present study showed that the ornamental plant species *Jasminum humile* and *Mentha longifolia* were cultivated in places with more irrigation and that underwent multipurpose cultivation. Similarly, Waikar and Jadhav (2012) showed that a 60% increase in supply of excess K_2O to *Rosa indica* plants caused superior growth in number of branches per plant, leaf area, diameter and weight of flowers, and number of flowers when compared to other treatments. The present study also shows that gardeners gave chemical fertilizers to *Rosa indica* to facilitate its growth and to obtain good results and that *Rosa indica* frequently grows in places where fertilizers, irrigation and spray are applied to optimum levels. Likewise, Maroyi (2013) studied qualitative and quantitative data collected from 31 home gardens in the Zvishavane district (Zimbabwe) between March and December 2009. This study documented 73 plant species growing in home gardens and their numbers, composition, and different uses, i.e., vegetable, fruit, ornamental, and medicinal plants were the most important categories.

Our study showed 43 ornamental plant species, which are also grown as fruit, vegetable, and medicinal plants. Das and Das (2005) also reported a total of 92 species (38 trees, 10 shrubs, and 44 herbs) in 36 home gardens in the Rajubari village in the Cachar district, southern Assam, India. The present study revealed 43 ornamental plant species in 50 home gardens in the Rustam tehsil, Mardan district. However, our study showed that *Rosa indica* was the leading ornamental plant species, with a frequency of 28 and a relative frequency of 6.23, while *Musa paradisiacal* was rarely found. Bhat et al. (2014) conducted a study in 50 selected home gardens in Karwar, Karnataka, India, to document their floristic diversity and composition regarding life forms and use. Their study revealed 210 species of flowering plants belonging to 69 families. Thirty-eight percent of the plant species were grown mainly for ornamental and aesthetic purposes, while 33% of the species were used for obtaining food products, such as fruits and vegetables, and 22% of the plants were mainly used for medicinal purposes. Similarly, our study showed that in different gardens various types of ornamental plants are generally cultivated for different purposes. Tynsong and Tiwari (2010) reported 197 plant species, with an average of 89 plant species per home garden, in Meghalaya, India, and revealed that 35% of home garden products were used for self-consumption, while 65% was sold in the local markets. The important plant species contributing to household incomes were *Piper betle* (24%), *Mangifera indica* (19%), *Litchi chinensis* (15%) and *Areca catechu* (11%). The present study showed the ornamental plant species *Mangifera indica* having a frequency of 16 and a relative frequency of 3.56, since that habitat is not appropriate for the mango tree.

Conclusion

The CCA plots of ornamental plant species and environmental data show that irrigation, home size, purpose of cultivation and the use of artificial fertilizers were the main factors affecting the vigour of ornamental plant communities. Additionally, further studies should be conducted to explore the judicious means to conserve and manage the ornamental plant species diversity and the contributions of such species to the livelihoods in the study area.

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