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Assessment of horticultural crops biodiversity in Kermanshah Province

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Abstract

Biodiversity is one of the important indices for assessment of agroecosystems sustainability. Unfortunately, the benefits of biodiversity are ignored in the agroecosystems. Therefore, the present study was conducted for evaluating horticultural crops biodiversity of Kermanshah province in the Campus of Agriculture and Natural Resources of Razi University during 2012. Data were collected by the Ministry of Agriculture of Iran. The results of biodiversity criteria indicated high diversity among the fruits species cultivated in the province. The number of cultivated species was estimated 24. Among the cities, Dalahoo, Paveh, Harsin ,Salas-e-Babajani and Ravansar had the most Shannon index while Qasr-e-Shirin exhibited the least species, Shannon index, diversity evenness and Sorensen's similarity index. Long-term mutual effects of different climatic elements on living organisms create fixed and specific biologic conditions so that in each climate we find certain plants with particular adaptations which have similar and specific growth and developmental characteristics and of a predefined tolerance against environmental factors. With the increase of altitude and the environment becoming mountainous, the cultivation of horticultural crops increased. Kermanshah Province, due to the territorial diversity of species diversity was sufficient for horticultural crops.

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Introduction

Each agricultural system is a complex and interdependent bed of soil, plants, animals, agricultural equipment, labor and capital. These systems are continuously introduced to the world as a result of removing trade barriers, globalization, introduction of modern agricultural technologies, changing social demands and climate changes. There are strong interactions between policy-makings and adoption of agricultural modern technologies which necessitates the assessment of the strengths and weaknesses of these relationships to adopt policies which pursue sustainable development (Van Ittersum *et al*., 2008). Management decisions are largely influenced by the type of agricultural system and its conditions. Different reasons have been expressed for the diversity of agricultural systems from one place to another (Thapa and Rasul, 2005). Distance to markets, access to water for irrigation (Blaikie, 1971), the availability of inputs, overpopulation and land scarcity (Ruthenberg, 1980), knowledge and skills of farmers (Binswanger and McIntire 1987), access to institutions and technology centers (McMillan, 1998), access infrastructures and transportation system, security of land ownership (Reardon *et al*., 2001) and physical limitations (Turner II and Brush1987) are among the being influential on this diversity. In a viewpoint, Boserup (1965) see the various intensities present in agriculture expansion as a result of numerous biological, physical and social - economic factors. In agriculture, sustainability involves the same set of physical, biological, economic and social factors (Goncalves-Gomes *et al*, 2009). Evidences show that biodiversity loss of agroecosystem is directly related to the type of agricultural systems (Benton *et al*., 2003). Biodiversity indicators can be used as a powerful tool for assessing the sustainability of agricultural systems (Biala *et al*., 2003).

Plant and animal biodiversity are considered as factors which affect the functions of agricultural and natural ecosystems (Altieri, 1999). Thus a biodiversity decline is deemed as a serious threat to the survival of those ecosystems (Tscharntke *et al*., 2012).

Biodiversity is one of the important indices for assessment of agroecosystems sustainability (Thompson, 1998). Biodiversity enhancement plays a critical role in maintaining ecosystems and this has raised its importance. This holds true as an increase in the number of the species of a region. On the one hand, it augments the structural complexities and on the other hand promotes the ecosystems' ability in responding to the occurrence of any environmental change (Jenkins and Parker, 1998). The role of the ecological biodiversity is clearly apparent in food production, pest management, weeds and diseases science, soil fertility and biodiversity enhancement of soil organisms, decreasing dependency on external items and energy conservation (Jackson *et al*., 2009; Altieri, 1999; Tscharntke *et al*., 2012; Power, 2010). Therefore, studying agricultural biodiversity and protecting it has been at the center of ecologists attentions, especially in recent years (Pimentel *et al*, 1993).

Koocheki *et al*. (2005) found that the diversity of horticultural crops and vegetables of various provinces of the country are in a relatively fair range. Further in assessing agricultural ecosystems, they argued that the species diversity of agriculture in Iran is relatively poor (Koocheki *et al*., 2005).

Among Iran's provinces, Kermanshah has devoted a great share of the agricultural products due to its continental conditions. The total agricultural land areas of the province is 933,000 hectares (excluding fallow land) of which 228,000 (equivalent to 23.3%) and 663,500 (equivalent to 71%) hectares is allocated to irrigated and rainfed lands, respectively and 33,200 hectares to horticultural products (irrigated and rainfed/ equivalent to 3.6%) (www.kermanshah.agri-jahad.ir).

Koocheki *et al*. (2005) in evaluating the species diversity of horticultural crops and vegetables of Iran reported desirable species diversity for this province. However, in order to better understand the importance of species diversity, it is necessary to

conduct such studies more carefully and at the county level of province. Therefore, given the importance of the subject, this study was conducted with the aim of evaluating the diversity of horticultural crops in Kermanshah province in the crop year 2012 and separately for each county of the province.

Materials and method

This study was carried out during 2012 in Kermanshah, western Iran. Kermanshah province with an area over 2,339,000 hectares is geographically located at 31°33' to 17°35'N and 23°35' to 50°38'E. Its average annual precipitation is around 537 mm, i.e. 270 mm higher than the mean annual precipitation of Iran. The average annual temperature is about 13.2°C (www.kermanshahmet.ir). The characteristic of Kermanshah Province is having four climates of cold, subtropical, temperate and tropical which distinguishes it from rest of the provinces. Therefore ecotone features are evident in many parts of the province. The geographical characteristics of the province are presented in Table 1.

Table 1. Some geo characteristics of Kermanshah province.

City	Climate	Altitude (m)	Topography	The annual average Precipitation (mm)	The annual average Temperatur el (°C)
Kermanshah	Semi-arid & cold	1320	Plain- hilly area	444.7	14.3
Ravansar	Mediterranean & cold	1380	Plain- hilly area	532	14.9
Sarpol-e-Zahab	Semi-arid & warm	545	Plain- hilly area	421.3	19.9
Eslamabad-e-Ghrab	Mediterranean & cold	1350	Plain- hilly area	479.8	13.7
Kangavar	Semi-arid & cold	1470	Plain- hilly area	395.1	13.3
Qasr shirin	Arid & warm	376	Plain- hilly	375.4	22
Sonqor	Semi-arid & cold	1700	Mountainous area	535.5	12.8
Gilan-e-Ghrab	Semi-arid & warm	816	Plain- hilly area	429	20.3
Paveh	Humid &moderate	1485	Mountainous area	755.5	15.1
Javanrod	Semi humid &moderate	1375	Mountainous area	608	15
Harsin	Mediterranean & cold	1382	Plain- hilly area	489	13.8
Sahneh	Semi-arid & cold	1580	Mountainous area	369	13.9

To perform this study the required agricultural products information has been collected from 14 counties of Kermanshah province over 2012. Data were collected by the Ministry of Agriculture of Iran also case interview with relevant authorities.

All the horticultural crops were classified into tropical and subtropical fruits, dried fruits, granule fruits, nucifer fruit and fruit with seeds.

Biodiversity Indices of Products

Species richness is a determinant presence of various species and is obtained through the enumeration of plant species in a region (Ghorbani, 2010).

Shannon species diversity index (H) is in fact a hybrid indicator of species richness and uniformity (Barnes, 1998; Magurran, 1988).

Formulae (1) $H = -\sum Pi \times Ln\ Pi$

Where, $= \frac{ni}{N}$, n_i is the number of the individuals (biomass) of each species (species i) and N accounts for the total number of the individuals (total biomass) of a given region. $\frac{ni}{N}$ represents the ratio or the relative species abundance. To calculate Shannon index, $\frac{ni}{N}$ is set as the cultivation area of each county divided by the cultivation area of the province.

Evenness index was calculated by below formula (Barnes, 1998; Magurran, 1988):

Formulae (2) $J = \frac{H}{Ln S}$

Here, horticultural is Shannon's index of diversity and species represents the number of species (or the

area under cultivation). The value of this indicator is equal to or smaller than 1. The value of J equal to 1 indicates the evenness of the area under cultivation (or the number) for a species and shows non-evenness in the distribution of the varieties of a crop species.

Sorenson similarity index is obtained as (Ghorbani, 2010):

Formulae (3) $S = \frac{2a}{2a+b+c}$

a: indicator of the number of common species present in both regions A and B

b: indicator of the number of species being present in region A which are not present in region B

c: indicator of the number of species present in region B which are not present in region A

Sorenson similarity index varies between 0 (full non-similarity) and 1 (full similarity).

Results and discussion

Species Richness

The results of this study revealed that there are 24 horticultural crop species being cultivated in Kermanshah province (Table 2).

Table 2. Different groups of fruits and the number of cultivated species in Kermanshah province.

Tropical and subtropical fruits	Dried fruits	Granule fruits	Nucifer fruits	Fruit with seeds
Date	Pistachio	Grapes	BlackCherry	Apple
Fig	Almonds	Mulberry Tree	Cherry	Pears
Citrus	Walnut	Strawberry	GreenTomate	Quince
Pomegranate	Hazelnut		Plum	
Olive	Sea-buckthorn		Peach	
Persimmon			Apricots	
			Nectarine	
Total 6	5	3	7	3

Regardless of the cultivation area, the share of nucifer fruits and fruit with seeds were higher than of other fruits in most counties of the province and cultivation of tropical and subtropical fruits such as dates were given consideration in few counties of the province, particularly the city of Qasr-e Shirin. City of Qasr-e Shirin has the highest latitude in Iran and therefore is the only place having the possibility of palm cultivation. Species richness is among the simplest indicators and evaluative measures of species diversity which its basis is the number if species cultivated (Meff and Carroll 1997).

Table 3 shows the species richness (the number of species being cultivated) of horticultural crops in each county of the province. The findings depict different species richness for different counties. Amongst, Kermanshah city with a species richness of 20 has dedicated about 83% of all horticultural species to itself, while Islamabad-e-gharb, Qasr-e-Shirin and Sonqor have dedicated just 54% of horticultural crops to themselves with a species richness of 13.

Table 3. Species richness and cultivated area of Horticultural crops from 2011-2012 seprarately for each city.

City	Species richness	Cultivated area of city to province
Kermanshah	20	0.17
Harsin	18	0.05
Sahneh	17	0.16
Ravansar	17	0.03
Paveh	17	0.08
Javanrod	16	0.05
Salas-e-Babajani	16	0.06
Gilan-e-gharb	15	0.04
Kangavar	15	0.04
Dalahoo	15	0.08
Sarpol-e-Zahab	14	0.03
Qasr-e-Shirin	13	0.07
Sonqor	13	0.04
Eslamabad-e-Gharb	13	0.02

Shannon Species Diversity Index

Shannon diversity index (H) is in fact a combination of species richness and evenness (Barnes, 1998; Magurran, 1988). The greatest Shannon diversity indexes were seen for the counties of Dalahoo, Solas-e-Babajani, Ravansar and Paveh while Qasr-e-Shirin devoted the least one to itself. As discernable from Tables 4 and 5, Shannon's index changes in different cities do not follow the trend of the number of species. The value of Shannon's index is equal to or greater than zero which its higher values indicate more diversity among horticultural species (Barnes, 1998; Magurran, 1988).

Table 4. Shannon index and Evenness index of Horticultural crops in Kermanshah province for 2011-2012

City	Shannon index	Evenness index
Dalahoo	2	0.23
Salas-e-Babajani	1.99	0.24
Paveh	1.94	0.22
Ravansar	1.92	0.25
Gilan-e-Gharb	1.89	0.24
Sahneh	1.86	0.2
Kermanshah	1.82	0.19
Harsin	1.8	0.22
Sonqor	1.75	0.22
Eslamabad-e-Gharb	1.75	0.24
Kangavar	1.62	0.21
Sarepol-e-Zahab	1.59	0.2
Javanrod	1.36	0.17
Qasr-e-Shirin	1.06	0.12

Table 5. Sorensen's similarity index of Horticultural crops from 2011-2012 seprarately for each city.

	Eslam	Paveh	Salas	Java-nrod	Dala-hoo	Rava-nsar	Sarpol	Sonqor	Sah-neh	Qasr	Kerm-anshah	Kang-avar	Gilan	Harsin
Eslam	1													
Paveh	0.80	1												
Salas	0.89	0.90	1											
Javanrod	0.82	0.90	0.81	1										
Dalahoo	0.88	0.75	0.83	0.77	1									
Ravansar	0.80	0.93	0.83	0.96	0.75	1								
Sarpol	0.73	0.70	0.80	0.66	0.82	0.72	1							
Sonqor	0.92	0.86	0.82	0.89	0.78	0.86	0.66	1						
Sahneh	0.80	0.88	0.83	0.90	0.75	0.93	0.70	0.86	1					
Qasr-e-Shirin	0.61	0.66	0.68	0.55	0.71	0.60	0.81	0.53	0.53	1				
Kermanshah	0.78	0.91	0.88	0.88	0.80	0.91	0.76	0.78	0.91	0.66	1			
Kangavar	0.92	0.81	0.83	0.83	0.80	0.76	0.68	0.85	0.76	0.63	0.85	1		
Gilan	0.78	0.75	0.83	0.70	0.80	0.75	0.96	0.71	0.75	0.78	0.80	0.73	1	
Harsin	0.83	0.85	0.93	0.82	0.83	0.85	0.81	0.77	0.91	0.63	0.93	0.83	0.83	1

Counties such as Harsin and Ravansar by respectively having 17 and 18 species of horticultural crops have a lower Shannon index in comparison with counties like Dalahoo and Solas-e-Babajani, while the number of the horticultural species present in these counties were much less than that of Harsin and Ravansar counties. Considering the cultivation area of horticultural crops, again comparison of Shannon indices would be considerable. Despite having higher cultivation area relative to Islamabad-e-gharb and Sonqor counties, the number of the cultivated horticultural crops was the same in these three counties. The non-evenness of the cultivation area of the horticultural crops of this county led to a lower Shannon index relative to Islamabad-e-gharb and Sonqor counties. The low Shannon diversity index seems to be related to the dominance of dates' cultivation due to the special climate conditions of this region. In addition to the number of species, the diversity of an ecosystem also depends on the abundance of species. In fact species diversity consists of two components, namely species richness and species evenness, which the latter point to the evenness of individuals within different species (NasiriMahallati *et al.*, 2002). Koocheki *et al.*, (2005) have found that provinces such as Bushehr and Khuzestan in comparison with other provinces of Iran have a lower Shannon diversity index due to their climate conditions being favorable for the cultivation of palms, and this was so despite their great number of species and because of the higher share of the cultivation area for dates, also in another study have reported that due to the dominance of the cultivation of rice in Gilan province, the lowest Shannon index

regarding wheat is devoted to Gilan (Koocheki *et al.*, 2005).

Evenness Index

Evenness index (J) demonstrates the diffusion and distribution pattern of the species population (Barnes, 1998; Magurran, 1988). The results of this study depicted that there is unevenness in the distribution of horticultural species among the counties of the province (Table 4). The highest evenness index was observed for Ravansar county and the lowest one for Qasr-e-Shirin county. The results derived from evenness index alongside the results derived from similarity index confirm this fact that the similarity index for Q is the lowest one compared with of other counties. The more even the distribution of species, the more stability and sustainability we see and thus more species diversity is observed (Barnes, 1998; Magurran, 1988).

Sorensen Similarity Index

Similarity index shows the differences in species composition and the changes of diversity in different habitats. One of the easiest methods of measuring habitat diversity is to use similarity coefficients. There are various similarity coefficients which the most common one is Sorensen similarity index (S) (Ghorbani, 2010).

The counties of the province showed a relatively high similarity index (Table 5). All the counties of the province had the highest similarity in the cultivation of pome and stone fruits, and it is the cultivation area of small, dry, tropical and temperate fruits which accounted for the difference among the counties. This confirms the high species richness for pome and stone fruits relative to other fruits. The similarity indices of the counties were close to each other and the similarity of adjacent ones were higher. As Table 4 demonstrates, the highest similarity indices were obtained by the pairs of Kermanshah with Harsin, Ravansar with Paveh, Ravansar with Javanrod, and Gilan-e-Ghrab with Sarpol-e-Zahab. This similarity was higher among the adjacent counties having relatively similar climate conditions. On the other side, Qasr-e-Shirin County had the lowest similarity with other counties of the province due to the cultivation of specific crops which in turn is an attest on its lower evenness index (Table 4). Climate conditions and physical and chemical characteristics of soil, which themselves are a function of the climate of region, are the basis of the formation and diversity present in agricultural ecosystems throughout the world (Stocking, 1999). The findings of previous studies revealed that in regions being poor in terms of climate and soil's fertility (Gonabad county), there is less number of vegetable species cultivated and the cultivation area is distributed unevenly among the species which in turn causes the dominance of a few number of species (Koocheki *et al.*, 2005). Koocheki *et al.* also found that there is much similarity between the provinces of the country in terms of varieties of the wheat under cultivation and that this similarity was seen more between the provinces having similar climate characteristics (Koocheki *et al.*, 2005).

Discussion

The consequences of climate changes have put a new approach into attention for the discussion of species diversity in agriculture. Today the reduction in species diversity especially at a very wide range is mostly resulted from the change in agricultural operations and manufacturing systems. Climate change is one of the most important threats and in words of some scholars it is considered as the most serious threat in the twenty-first century (B. Yanga, 2011) so that The UN Secretary-General Ban Ki-moon labeled it in 2009 as the greatest collective challenge that all we humans as the members of a single family face it (B. Yanga, 2011). Among the very important climate changes being influential in species diversity of plants and animals, we could point to temperature rise, change in the patterns of rainfall and distribution and diffusion of water, rising sea levels, extreme climatic disasters and increase of greenhouse gases (Malhi and Meir 2002). Global warming of the Earth is a climatic phenomenon of foremost importance. Since 1861 average temperature have

been annually increased 0.6 °C and the concentration of carbon dioxide experienced an increase of 32% per year which this outstanding increase of the concentration is unprecedented during the last 20 million years (Malhi and Meir 2002). Scientists estimate that temperature increases 1 to 5 °C annually depending on the geographical location and the highest value is expected to be in tropical and subtropical areas (Caldera *et al*, 2003). Among the consequences of temperature rise we could point to the reduction in species diversity (both plant and animal), intense evaporation from the soil surface, increasing decomposition of organic matter, and the incidence of diseases and pests (Pimentel, 1992). The problems associated with water supply are one of the most important challenging concerns. In the last century, subtropical regions had less than 3% rainfall and were faced with drought. In contrast, the northern hemisphere accounted for the highest rainfall of 5 to 10%. However, to deal with drought, it is suggested to use varieties which are resistant against dehydration (Oxfam, 2002). In addition to temperature rise and changes in altitude is also an important geographic factor in the development of diversity. By increasing altitude and having mountainous conditions, conditions are provided for gardening activities and the species richness of horticultural products increases (Hashemi *et al*, 2011). Kermanshah Province has a desirable species richness regarding its horticultural crops due to having a diverse climate. According to Table 1 and the geographical location of the counties, the effects of climate consequences are clearly evident in the species diversity of horticultural crops. The type and the extent of substrate preparation, type of constraints associated with the cultivation time, and management of chemical fertilizers including their use, split, type and cultivation method are affected by climate in various ways. Evapotranspiration potential is a very important component of climate which determines the need of plants to water and the effectiveness of rainfall (Khagepoor, 2007).In humid climates, access to irrigation water is higher and requires less irrigation water and hence crop rotation is largely determined by climate. These potentials and limitations determine the compatibility of the plant species and their varieties and specify the type and specifications of different agricultural operations. Therefore, we could explain all the agricultural decisions related to the production of any crop or group of similar products for each climate (Khagepoor, 2007). Kermanshah province is divided into different groups based on the distribution of temperature, precipitation and altitude. The Southern East, West and South West of the province including Harsin, Kermanshah, Kangavar, Sarpol-e-Zahab and Qasr-e Shirin had the lowest rainfall while Ravansar, Javanrud and Islamabad-e-gharb had good condition in terms of rainfall. The possibility of having suitable temperature for germination was also divided into the four categories of poor, average, good and very good. In the central part of the province, there is a possibility of 71% to have temperatures suitable for germination (very good group) and Sarpol-e-Zahab County placed in poor group, and east, northern east, west and southern west areas placed in average group. Counties like Harsin, Sahneh, Paveh, Javanrud and Kangavar were rich for the cultivation of horticultural crops due to having the right temperature for growing crops, being mountainous, and of good rainfall compared to other counties. Long-term mutual effects of different climatic elements on living organisms create fixed and specific biologic conditions so that in each climate we find certain plants with particular adaptations which have similar and specific growth and developmental characteristics and of a predefined tolerance against environmental factors (Bladocchi, 2005).

The ground and its altitude are influential on crop yield. As a general rule, with an increase in altitude, rainfall increases. Western part of the province is the best place in terms of altitude. With the increase of altitude and the environment becoming mountainous, the cultivation of horticultural crops increased. Such a situation is typical for Paveh County. On the other side, higher temperature and less rainfall of the county of Qasr-e Shirin relative to other counties

proved that the possibility of cultivating horticultural crops is very low there.

Conclusion

Dalahoo, Solas-e-Babajani, Ravansar and Paveh counties devoted the highest species diversity index among the counties of the province and Qasr-e-Shirin County was of the least Shannon diversity index, evenness index and similarity index. But in general, the results indicate that in the production systems of horticultural crops in Kermanshah province, despite having high species richness, the Shannon diversity index do not follow species richness but further a function of the cultivation area of horticultural crops. Of course the effect of climatic factors and their consequences on the cultivation of crops should not be ignored. Understanding the effects of the species diversity of horticultural crops on these systems, as well as the impacts of the species diversity on agricultural production systems and on their surrounding natural environment requires collecting comprehensive data about different species and varieties under cultivation in all counties, about the distribution of these crops in local and provincial levels, as well as evaluating climatic parameters. Unfortunately, due to the lack of access to detailed statistics and that the name of the varieties were unknown for most of the horticultural crops, assessment of species diversity at the variety-level was impossible.

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