UDC (UDK): UDK 634.1.076(496.5)

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GEO-INFORMATION ANALYSIS OF FRUIT TREES SPECIES IN ALBANIA

SUMMARY

The geographic distribution of some fruit trees species in Albania using a database of 515 geo-referenced observations, including all 21 currently known fruit trees species, was analyzed. Geo-referenced observations of fruit tree species occur in 11 Counties of Albania, but 54% of the observations are from Elbasan, Tirana and Dibra Counties. A grid of 25 × 25 km cells was used to asses' diversity and richness of species. To include all species at least once, 33 grid cells were selected.

Spatial analysis of species richness clearly shows that Elbasan, Tirana and Dibra counties were areas of high diversity. In these counties the highest number of species (respectively 14; 13 and 12 species) was observed. For all grid cells selected the summarized results on diversity indices and richness estimators were: Richness (S) 21, Margalef index 3,20; Menhinick 0,93; Shannon 2,62; Simpson index of diversity 0,91; Brillouin index 2,54.

Grid cells situated in Elbasan, Tirana and Berat counties appears to be the areas with the highest potential fruit trees species diversity and with the most potential priority areas for in situ conservation. New alleles were also contributed by additional areas (Berat and Tirana) that contain respectivelly 3 and 4 new species (or alleles).

Most delimitated factors to the potential distribution of each species seems to be precipitation of driest month in north-eastern part of Albania, and maximum temperature of warmest month for central Albania, and precipitation of driest month for south part of Albania.

Keywords: GIS tools; geographic distribution; species richness, diversity indices

INTRODUCTION

Plant genetic resources (PGR) play a key role in contributing to the sustainable development of agriculture, and in our days the preservation of genetic resources is regarded as an important need for human society. The gene banks offer the main means to explore, collect, store, and protect genetic materials, providing the raw material for the improvement of crops.

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Albania is one of the Balkan countries with high level of diversity for many cultivated and wild species including fruit tree crops. Fruit tree crops and especially wild species provide an invaluable source of genes for the improvement of cultivated fruit crops. Genetic resources of fruit trees crops have a major contribution to the growth of agricultural food products in all regions of Albania. Fruit trees are economically, socially and culturally important crops grown over a wide range of ecological habitats in the country, in the range of 10,190 million trees, MAFCP (2010).

Ecogeographic studies provide critical information about the diversity present in specific geographic areas (Maxted *et al.*, 1995), which, can be used for the assessment of the current conservation status of PGR and to prioritize areas for in situ conservation. Geographic information systems (GIS) are useful tools for ecogeographic analysis (Guarino *et al.*, 2002). GIS tools allow complex analyses to be done, as well as visualizing results of geographic distributions of biodiversity in clear maps, which are effective for genebank management, identification of collection gaps, formulation and implementation of more targeted and more effective conservation strategies for PGR (Guarino *et al.*, 2005).

Today documentation of PGR is considered an integral part of the conservation of germplasm resources. To increase usage value of the plant genetic resources of fruit tree species in ex situ (field collection) and in situ /on farm status of conservation, for the present and the future, it is necessary to have PGR information in a well-organized documentation system. Good database on genetic materials conserved in the gene-bank leads to enhanced utilization of germplasm by farmers and ensure that "tomorrow's plant breeders will have today's genetic resources for use in their plant breeding programs", (Engels *et al.*, 2003).

Since ex situ collections aim to cover the maximum amount of genetic variation and the entire range of environmental adaptation of the target species, nowadays the objective in collecting expeditions is frequently to fill gaps in representativeness. The origin of these gaps or biases in plant genetic resources collecting is described in detail by Hijmans *et al.* (2000).

Application of GIS tools to improve genetic representativeness (GR) of gene-bank collections, to detect areas of higher diversity (alpha diversity), to understand differences in the diversity between areas (beta diversity), to identify prioritized collecting sites and gaps in current conservation and the development of a more systematic conservation strategy and a good database for the PGR, were the purposes of this study. Geographic distribution and diversity analysis of fruit trees species in Albania was realized using geographic, taxonomic, ecological and conservation information registered in PGR database of Albania Gene Bank (AGB).

MATERIAL AND METHODS

Description of the study area: The analysis of geographic distribution and fruit tree species diversity was conducted in all principal growing zones of fruit trees crops in Albania. The geographic areas where the geo-referenced observations were carried out include 11 counties of Albania: Berat (BR), Diber (DI), Durres (DR), Elbasan (EL), Fier (FR), Gjirokaster (GJ), Korce (KO), Kukes (KU), Shkoder (SH), Tirana (TR) and Vlora (VL).

The geographic observed areas are separated into low resolution grid square cells. A grid square cell of 25 × 25 km was used to asses' distribution, richness and diversity indices of fruit tree species. To include all species at least once, 33 grid cells were selected.

Analysis of species occurrence data in combination with climatic data, was realized using more higher resolution grid square cells. In this case the geographic observed areas are separated into a grid of 5 × 5 km (2.5 minutes), (Hijmans *et al.*, 2005). In addition to the geographic separation, the soil and climate differences, which vary widely in space and in time, between the south, the central, and the north-eastern part of Albania. In this study free GIS World Environmental data, were used (Hijmans, *et al*. 2005).

Data sampling criteria: Collecting expeditions during their collecting activities used some specific priority criteria as: age of species (preferred aged fruit trees species); usage value of fruit trees (preferred old local landraces grown successfully 40 – 60 years ago); fruits quality (preferred local landraces selected by farmers for quality and value of their fruits); priority for fruit tree species in risk and rare exemplars; resistance against parasites or tolerance especially against disfavor climate conditions. So collecting sites result randomly distributed.

Geographic data: Each individual plant or species (or the group of individuals) represents a georefernced observation, which supposes presence of a fruit tree individual known as presence point. Presence points include basic passport data (at least four elements) of an individual plant or of a group of individuals in a specific geographic unit: an identification code (ID), the taxonomic name, longitude and latitude coordinates, Alercia *et al.*, (2001). All georeferenced observations, chosen to carry out spatial analysis, were entered into the GIS analysis, as *presence points,* Hijmans *et al.*, (2001).

Diversity distribution: The analysis focuses solely on the study of diversity at the species levels (unit of alpha diversity). Magurran (1988) define species diversity as consisting of two components: the number of species (richness-R) and how equally abundant the species are (evenness-E).

Diversity indices: During GIS analysis several diversity indexes and richness estimators have been used to assess diversity taking into account the respective proportions of each species in the study area. *Species richness* (S) and species diversity was calculated as simplest account of the number of different species in a given area and the species evenness as the relative abundance of individuals among the species. Diversity indices: *Shannon's diversity index* (H), *Brillouin index* (B), *Simpson's index* (D), *Simpso diversity index* (1-D), *Margalef's index* (D_{MG}) and richness estimators (E abundance and evenness) as *Chao-1* and 2; *Jacknife-1* and 2, abundance coverage estimation (ACE) were calculated using DIVA-GIS tools.

Richness in species is used for prioritizing conservation areas of either plant communities – based on number and uniqueness of observed species (Gotelli *et al.*, 2001). Distinction of the minimum number of areas (grid cells) necessary to conserve a given number of species, varieties or alleles of the gene pool under study Hijmans *et al.* (2001), was realized using *reserve selection* modelling, developed by Rebelo *et al.* (1992).

Cluster analysis method using Group-Average clustering was used to measure (Bray-Curtis) similarity (McAleece *et al.*, 1997), between species presence/absence in different observed areas (grid cells).

Modeling of potential richness: Combination of species occurrence data with climatic data that allows the modeling of potential richness at the district level (Rebelo *et al*., 1992) was used to assess the influence of bioclimatic factors that delimitates the potential distribution of each species.

RESULTS AND DISCUSSION

During collecting expeditions, conducted in Albania from 2008 to 2012, only a small fraction of the diversity has been collected and maintained as an ex-situ (field repository) germplasm, and at the same time a large range of information for each tree species collected was recorded.

The measurement of diversity and distribution of fruit tree species was realized in several ways. Firstly, the number of observations was tabulated per species and per counties. Secondly, the area of occupancy, as the total area occupied by a specific taxon, was selected as an indicator of abundance or rarity of a particular species. Data quality including the accuracy and precision of geographic coordinates and documenting farmer-named species and knowledge's is important for the genetic resources conservation, utilization and GIS analysis. For this purpose geo-referenced data points (*presence points*) were checked for inconsistencies. Data points with incorrect coordinates on the administrative unit (county) were assigned coordinates where possible while duplicate or doubtful data were removed (Scheldeman *et al.,* 2010). Data points without coordinates were removed. All tree species were also screened carefully to resolve any scientific name conflicts (Chapman, 2005a, 2005b).

Geographic distribution: After checking the data included in the plant tree species database with partial or complete information for a total of 686 presence points (32 species), and autocorrelation of present points, only 515 geo-referenced observations (in total 21 species) were used to assess the geographic distribution and diversity of fruit trees species/crops grown in Albania. Study results for geographic distribution and richness of fruit species are given in table 1. Geographic distribution of 515 geo-referenced fruit tree species observations, and species richness grid cells, given in richness maps (Fig 1), show the presence of diversity between areas and counties analyzed.

Study results show the presence of variability between observed geographic areas related to distribution, number and kind of fruit tree species collected. Species richness and diversity indices values proved the presence of this important variability in the study areas (grid cells) analyzed. Some species were very rare (*Prunus mahaleb*, *Pyrus amygdaliformis*, *Prunus cerasus*) and some other species as *Pyrus communis*, *Prunus domestica*, *Malus domestica* were observed in high frequency of present point (Table 1).

Table 1. Fruit tree species (taxons) collected according to observed counties.

Taxon / County	BR	DI	DR	EL	FR	GJ	KO	KU	SH	TR	VL
Amygdalus communis	1				5	2	1		1	2	6
Castanea sativa		3		2			2	2	12		
Cornus mas	1		10	2							
Corylus avellana		2		1	1		1		1	7	1
Cydonia oblonga		1		4	2	4				2	3
Ficus carica	1	2		7	2	6	4			4	
Juglans regia	2	10	2	5			8	6	5	1	4
Malus domestica		5	4	21	2	4	9	1	7	9	4
Malus sylvestris				3							
Morus alba	2	7		6			1		1		
Prunus armeniaca	2	1		6	4	2				5	4
Prunus avium	4	7	1	8	1	5	7		3	4	
Prunus cerasus		3									
Prunus domestica		3	6	36		3	7		6	21	1
Prunus mahaleb	1										
Prunus myrabolana				15					2	3	
Prunus persica				1		2	1			11	2
Punica granatum					1					5	2
Pyrus amygdaliformis	1										
Pyrus communis	5	3	5	22	5	8	7		10	5	7
Sorbus domestica			2	1	1						

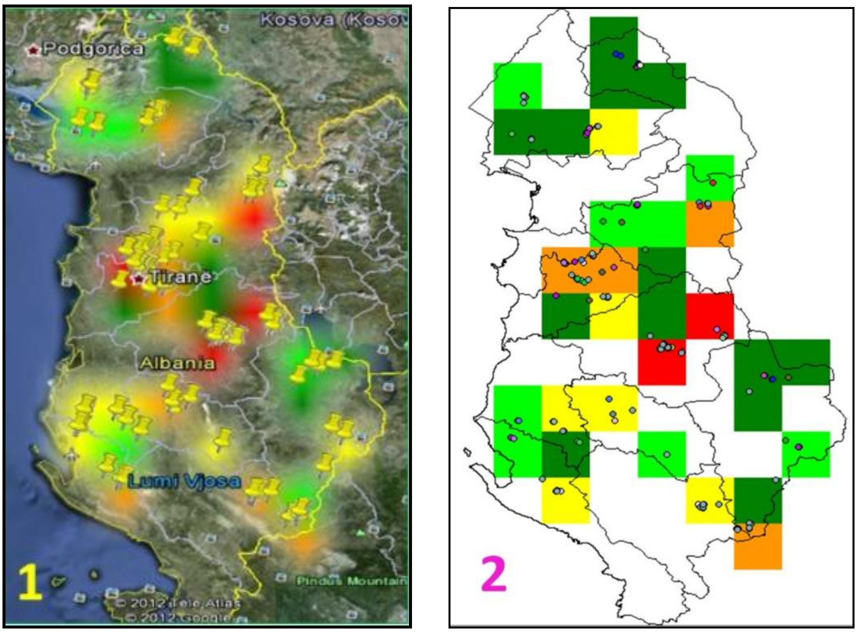


Fig 1: Geographic distribution (1) and richness map of fruit tree species (2).

Analysis of Diversity indices (D- group) and Richness Estimators (E-group) used to assess diversity is given on the table 2.

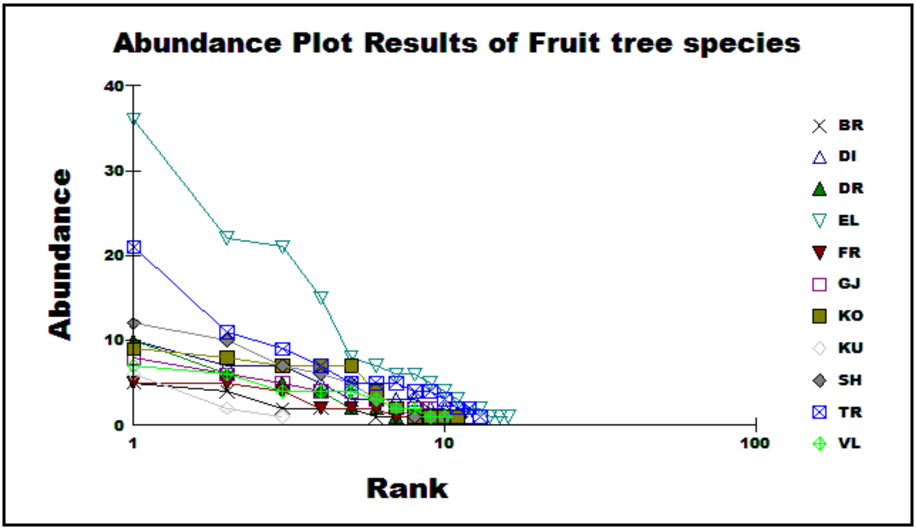
Diversity indices results: *Margalef index* values (M > 2.70) show presence of higher species diversity in the areas of EL, BR, DI, FR and TR counties. At the KO and VL counties (M > 2.50) there were also areas (grid cells) of high diversity level. *Shannon index* values (H > 2.20) show the presence of higher diversity in areas of EL, TR and DI counties. *Simpson index* of diversity (1 - D ≥ 0.90) shows presence of higher diversity in counties of BR, DI, FR and VL counties. *Brillouin index* values (B > 2.00) clearly shows that high species diversity occurs in EL and TR counties.

Table 2. Diversity indices (D) and Richness Estimators (E) of fruit tree species according to areas (grid cells) observed in different counties in Albania.

		BR	**DI**	**DR**	**EL**	**FR**	**GJ**	**KO**	**KU**	**SH**	**TR**	**VL**
Diversity (D)	Observations	20	47	30	140	24	36	48	9	48	79	34
	Richness	10	12	7	16	10	9	11	3	10	13	10
	Margalef	3.00	2.86	1.76	3.04	2.83	2.23	2.58	0.91	2.3	2.75	2.55
	Mechanic	2.24	1.75	1.28	1.35	2.04	1.50	1.59	1.00	1.4	1.46	1.72
	Shannon	2.11	2.27	1.73	2.28	2.10	2.08	2.12	0.85	2.0	2.28	2.14
	Simpson	0.90	0.90	0.82	0.87	0.90	0.89	0.88	0.56	0.8	0.88	0.90
	Brillouin	1.62	1.49	1.45	2.10	1.67	1.76	1.83	0.61	1.7	2.04	1.79
Estimators (E)	Observ.	20	47	30	140	24	36	48	9	48	79	34
	Richness	10	12	7	16	10	9	11	3	10	13	10
	Chao-1	14.2	13.0	7.25	18.2	12.7	9.00	19.0	3.50	14	13.25	11.00
	Chao-2	12.6	12.4	7.06	17.1	11.6	9.00	14.5	3.13	11.8	13.06	10.44
	Jacknife-1	14.50	13.83	7.86	18.81	13.60	9.00	14.64	3.67	12.70	13.92	11.80
	Jacknife-2	18.23	15.35	8.33	21.23	16.53	8.71	17.83	3.83	15.01	14.63	13.22
	ACE	13.33	12.53	7.37	16.62	12.00	9.00	12.00	4.50	11.17	13.19	10.63

Richness estimators (E): *Species richness* (S): Spatial analysis detects areas of different high diversity (alpha diversity) levels. Analysis clearly shows that high species richness occurs in observed areas (grid cells) of EL, TR, DI and KO counties. In these areas the highest number of species was observed, and species richness (S) values were respectively 16, 13, 12 and 11 species. At the second range the areas (grid cells) with highest number of species richness (S = 10 species) there were BR, FR, SH and VL counties. Less species richness occurs in KU and DR counties (respectively 3 and 7 species).

In term of richness (abundance and evenness) richness estimators as *Chao-1* and 2; and *Jacknife-1* and 2 (Table 2), show that the areas of EL, TR, DI and KO counties seems to be the more richness areas in fruit tree species in Albania. GIS analysis proved that Albania is a very rich country in plant tree species diversity and in plant genetic resources. Abundance-based coverage estimator of species richness (*ACE*) ranked the fruit tree species collected in different position for each county. There is *Pyrus communis* species ranked the first (5 observations) for BR county, *Juglans regia* (10 observations) for DI, Cornus mas (10 observation) for DR, Prunus domestica (36 observations) for EL and (21 observation) for TR, and so on (Graph 1). It is shown that increasing the number of species the relative abundance of each species goes down.



Graph 1. Abundance plot results of fruit tree species collected.

Reserve selection: Results of *reserve selection* method, developed by Rebelo *et al*. (1992), ranked the minimum grid cells that should be given priority for conservation and modeled richness maps were designed. Ranking and mapping gave the first priority to the grid cells with the highest alpha diversity (EL, TR and BR areas).

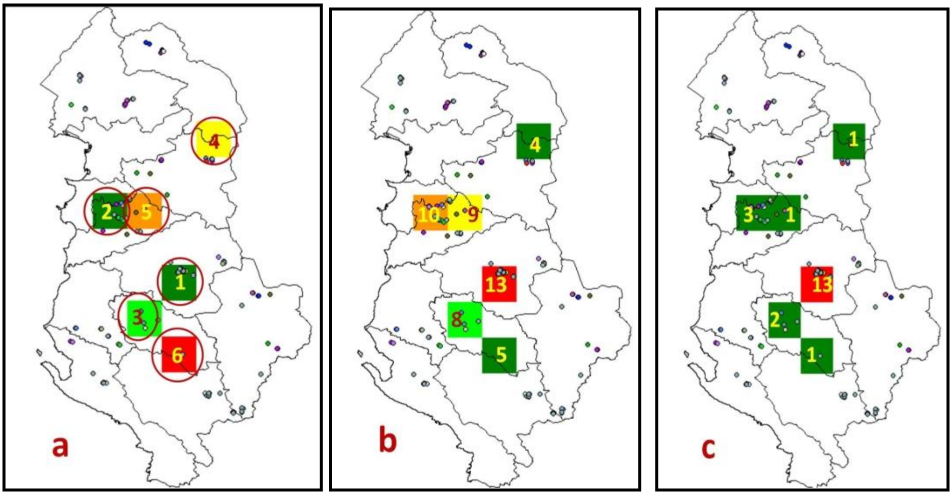


Fig 2: Reserve selection: the grid cell with
a) the most potential priority areas for in situ conservation;
b) the highest alpha diversity; c) the highest number of new species (alleles).

Based on the modeled richness maps, EL and TR counties appear to be the most potential priority areas (grid cells) for in situ conservation of fruit tree species (Fig. 2: a), and with the highest potential fruit trees species diversity (alpha diversity) (Fig. 2, b). GIS analysis gave the subsequent priority to the additional areas (BR, DI and TR counties) those grid cells that best complement the initial ones because they contain the highest number of new species, varieties or alleles that were not found in the previously selected grid cells (beta diversity), Scheldeman *et al*. (2010). Confrontation of grid cells shows the highest number of new species (alleles) was found in BR county (3 new species), in TR observed grid cells (4 other new species) and in DI county (one new species) (Fig 2, c).

Cluster analysis: Study results for analysis of distances and similarities between areas (grid cells) where it was collected are given in table 3 and dendrogram of Fig. 3.

Table 3. Cluster distances and Similarities of fruit species in observed areas (grid cells).

Steps	Cluster number	Matrix		Cluster		County	
		Distance	Similarity	Joiner 1	Joiner 2	Joiner 1	Joiner 2
1	10	31.03448	68.96552	5	11	FR	VL
2	9	31.25	68.75000	7	9	KO	SH
3	8	32.63158	67.36842	2	7	DI	KO
4	7	40	60.00000	5	6	FR	GJ
5	6	40.47619	59.52381	2	5	DI	FR
6	5	48.03150	51.96850	2	10	DI	TR
7	4	48.85845	51.14155	2	4	DI	EL
8	3	53.57143	46.42857	1	2	BR	DI
9	2	53.84615	46.15385	1	3	BR	DR
10	1	67.85714	32.14286	1	8	BR	KU

According to distance or similarity measures between each areas (grid cells), fruit tree species diversity and species richness of each observed areas were classified in different clusters. In this study Bray-Curtis similarity (Clarke *et al.*, 2006), between species presence or absence in different observed areas (grid cells), using group-average clustering method, gave a useful hierarchy of clusters shown in dendrogram (Fig. 3) Cluster analysis dendrogram and matrix data (Table 3) show clearly the presence of similarity (68.96552) between FR (joiner 1) and VL (joiner 2) grid cells or observed areas; and similarity (68.75000) between KO and SH counties; and similarity (67.36842) between DI and KO areas; and so on.

Richness modeling results: Combining fruit tree species occurrence data with climatic data in this analysis were identified outliers (Fig 3, b) using GIS tools (Scheldeman *et al.*, 2007) and assessed the influence of bioclimatic factors that delimitates the potential distribution of each species at the district level (Fig 3, c), using the modeling of potential richness, developed by Rebelo et al. (1992).

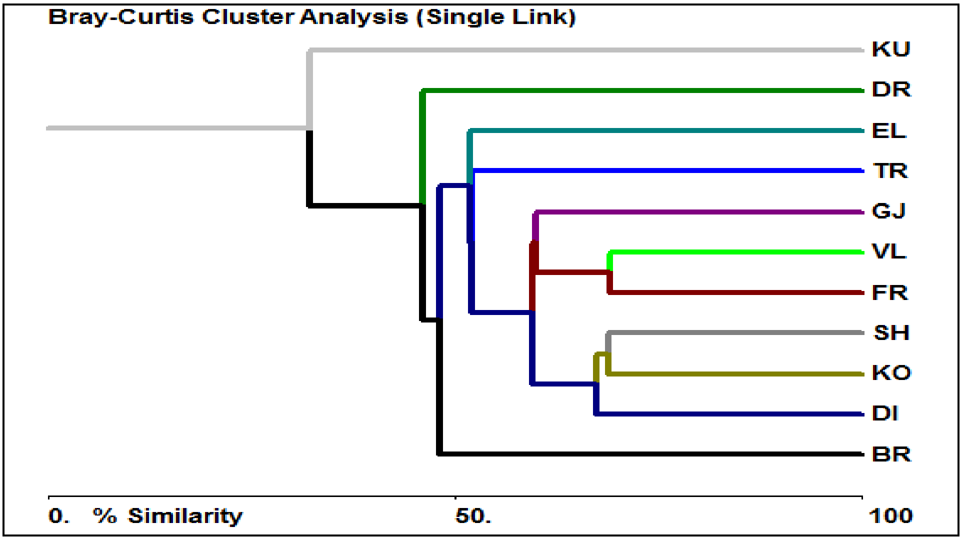


Fig 3: Cluster similarity dendrogram (single linkage) of collected grid cells areas.

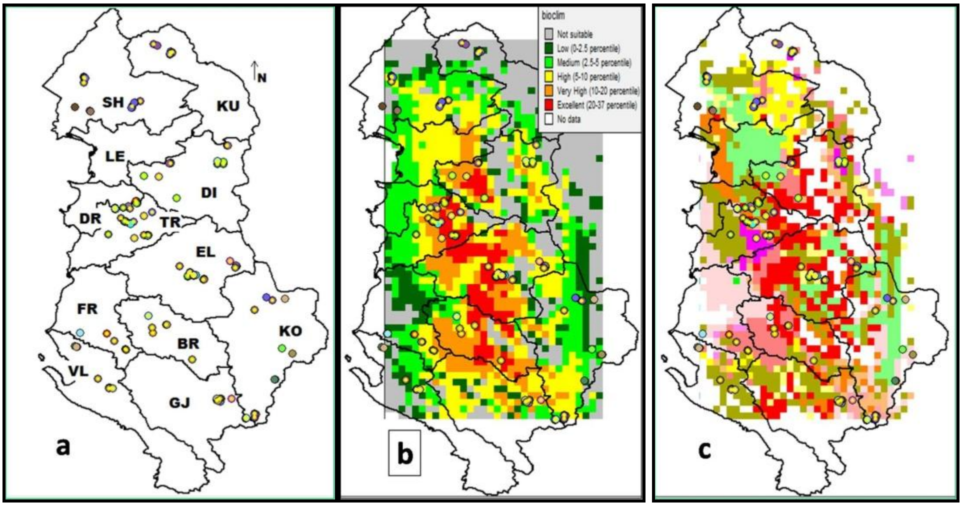


Fig 3: Fruit tree species occurrence in combination with climatic data (a), potential distribution of fruit tree species (b) and most limiting bio-climatic factors that influence species occurrence data (c).

Study results show that the great number of grid cells where it was collected was situated into excellent (from 20 to 30%), very high (from 10 to 20%), and high (from 5 to 10%) suitable areas (grid cells in red, brown and yellow color). There were also present points or collected point situated out of areas (grid cells) considered not suitable or low suitable for fruit tree species distribution (Fig 3, b).

Analysis of fruits tree data and 19 bioclimatic factors that delimitates the potential distribution of each fruit tree species at the district level demonstrate precipitation of driest month and precipitation seasonality seems to be the most limiting factors for the distribution of fruit tree species in north-eastern part of Albania (grid cells in yellow and green colors); and mean monthly temperature range and maximum temperature of warmest month for central part of Albania (grid cells in red and green dark colors), and low precipitation of driest month and temperature seasonality seems to be the most limiting factors for south-western part of Albania (grid cells in yellow and red orange colors), (Fig. 3, c).

CONCLUSIONS

GIS analysis show the presence of variability between geographic areas related to number and kind of fruit tree species collected. Diversity indices and richness estimators values show that Albania is a very rich country in tree species diversity.

Modeled richness maps identified Elbasan, Tirana and Berat counties as the areas with the highest potential fruit trees species diversity and with the most potential priority areas for in situ conservation. Confrontation of grid cells gave the subsequent priority to the additional areas (Berati, Tirana and Dibra counties) that contain the highest number of new species (or alleles) respectivelly 3, 4 and one new species.

Cluster analysis identified the similarity between collecting (grid cells) areas: Fieri and Vlora counties show similarity between them, also Korca and Shkodra counties, and Dibra and Korca counties; etc.

Most delimitated factors to the potential distribution of each species seems to be precipitation of driest month for the north-eastern part of Albania, and maximum temperature of warmest month for central Albania, and precipitation of driest month for south-western part of Albania.

Application of GIS tools identified presence of gaps in current conservation of fruit tree species (great parts of some counties were not included in collecting activities, fig. 1 and 3); identified prioritized collecting sites and potential priority areas for in situ conservation; improved representativeness of gene-bank collections and the development of a more systematic conservation strategy.

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ANALIZA GEOGRAFSKE DISTRIBUCIJE POJEDINIH VOĆNIH VRSTA U ALBANIJI

SAŽETAK

Analizirana je geografska distribucija pojedinih voćnih vrsta u Albaniji korišćenjem baze podataka od 515 georeferentnih zapažanja, kojim je obuhvaćena 21 do sada poznata voćna vrsta. Georeferentna zapažanja stabala voćnih vrsta odnose se na 11 okruga u Albaniji, ali 54% zapažanja se odnosi na Elbasan, Tiranu i Diberu.

GIS alatima su urađene karte zastupljenosti, a Elbasan, Tirana i Berat identifikovani kao oblasti sa najvećim potencijalom različitih voćnih vrsta i sa najviše potencijalnih prioritetnih oblasti za očuvanje *in situ*. Kao oblasti drugog prioriteta definisane su dodatne oblasti (Berati, Tirana i Dibra) koji sadrže najveći broj novih vrsta (alelomorfa), tj. pojedinačno, u navedenim oblastima su prepoznate 3, 4 i jedna nova vrsta.

Najizraženiji ograničavajući faktori za potencijalnu distribuciju pomenutih voćnih vrsta predstavljaju količina padavina u najsušnijem mjesecu u sjevero-istočnom dijelu Albanije, zatim maksimalna temperatura najtoplijeg mjeseca za centralnu Albaniju, i količina padavina u najsušnijem mjesecu u južnom dijelu Albanije.

Ključne riječi: GIS alati, geografska distribucija, zastupljenost vrsta, indeksi diverziteta.