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The role of trees in urban thermal comfort and SkyView Factor

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- Determination of comfortable places in urban areas is one key issue for urban planning or design processes.
- In order to determine comfortable places of Erzurum in this study, measurements are made for six different types of tree in the city.
- Relationships between air temperature, human thermal comfort and different types of trees have been determined for the city of Erzurum.

- In the context of this study, SVF analysis were made with fisheye photos
- Fish-eye photographs at 1.5 m above ground are taken for the calculation of Sky View Factor (SVF).
- Meteorological measurements were made three times in one day for summer months and RayMan model was used.
- Trees used in this study were *Fraxinus americana* L. (1), *Pinus sylvestris* L. (2), *Salix babylonica* L. (3), *Ulmus glabra Huds*. (4), *Betula pendula Roth*. (5), *Malus hybrida* (6).
- The relationship between the air temperature under trees and SVF was investigated.

AIM OF THE STUDY

- Aim of this study is to create an inventory of scientific resources by determining the choice of plant type at the urban scale considering their location at the landscape applications and effects of trees for a more liveable urban climate.

CLIMATE DATA

From the data obtained at the station in the airbase between 1988 and 2003,

- the mean daily temperature is 5.2 0C,
- diurnal temperature range is 15.1 0C,
- the maximum temperature measured so far is 35.6 0C and the minimum is -37.2 0C.
- annual rainfall is 401.6 mm and
- mean relative humidity is 63.3(%).
- Mean vapor pressure is 6.0Mb.
- Mean daily wind speed is 2.7 m/s and
- prevalent wind direction is ENE in summer and WSW in winter due to frontal Systems

METHOD

Stations in Study Area and Measurements

- Study was realized in 6 different locations in Ataturk University Campus area.
- Six different plant species has been chosen,
- Fish-eye photos were taken about 1.5 m above root collar of each plant by high-definition camera integrated with fisheye lens by three repetition in different three days and different times.
- Due to different dates and shooting times of the days, solar incidence angle were obtained by data from Directorate of State Meteorological for each shooting dates and hours.

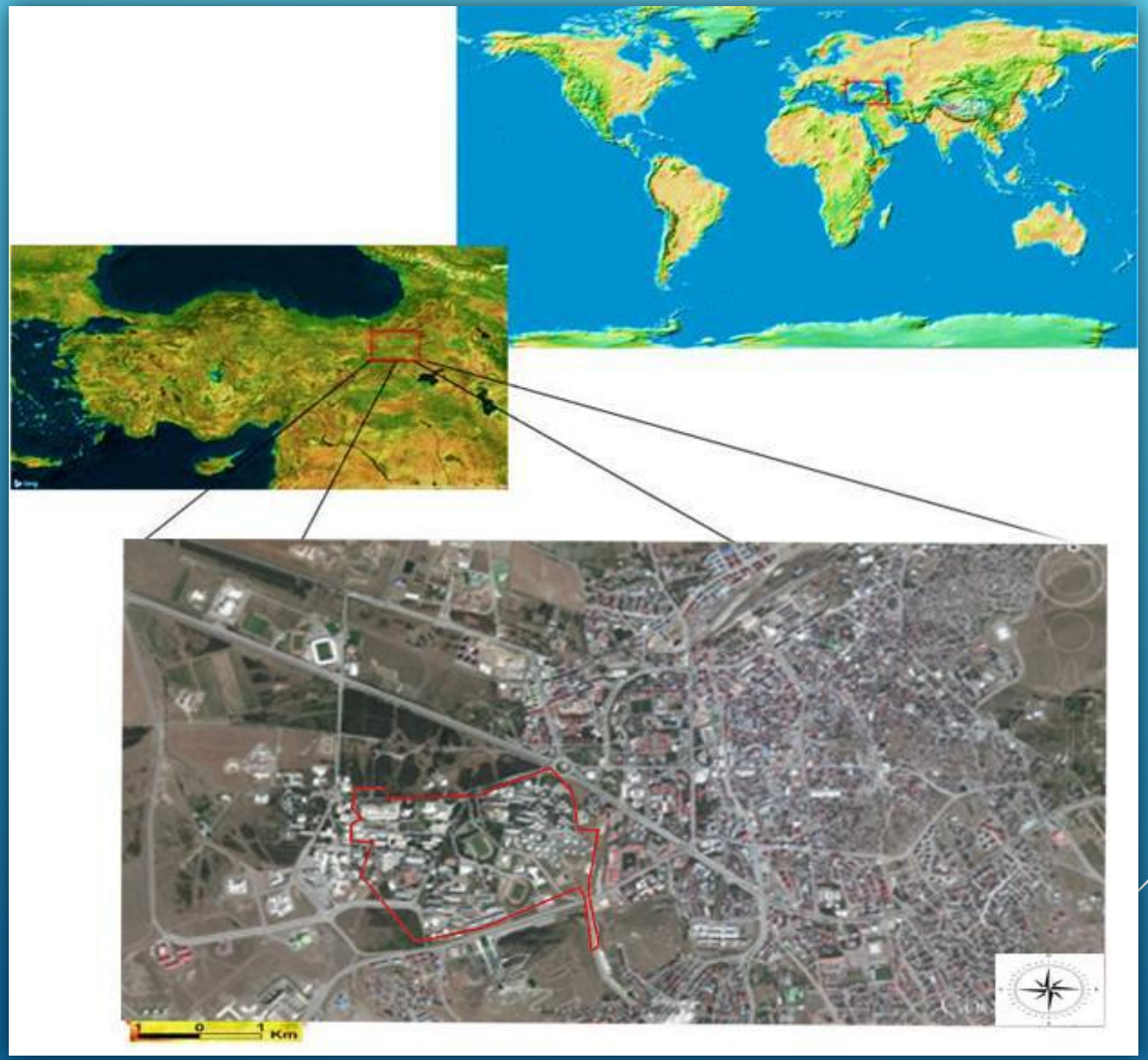

Fig 1. Map showing the location of Erzurum and The study area in the city

MATERIAL

In this study, the city center of Erzurum is located at coordinates of 39°54′35″N, 41°16′32″E are discussed as material.

Plants which

- *Fraxinus americana* L. (1),
- *Pinus sylvestris* L. (2),
- *Salix babylonica* L. (3),
- *Ulmus glabra* Huds. (4),
- *Betula pendula* Roth. (5),
- *Malus hybrida* (6) are adapted in six different locations in the city centre are tackled.

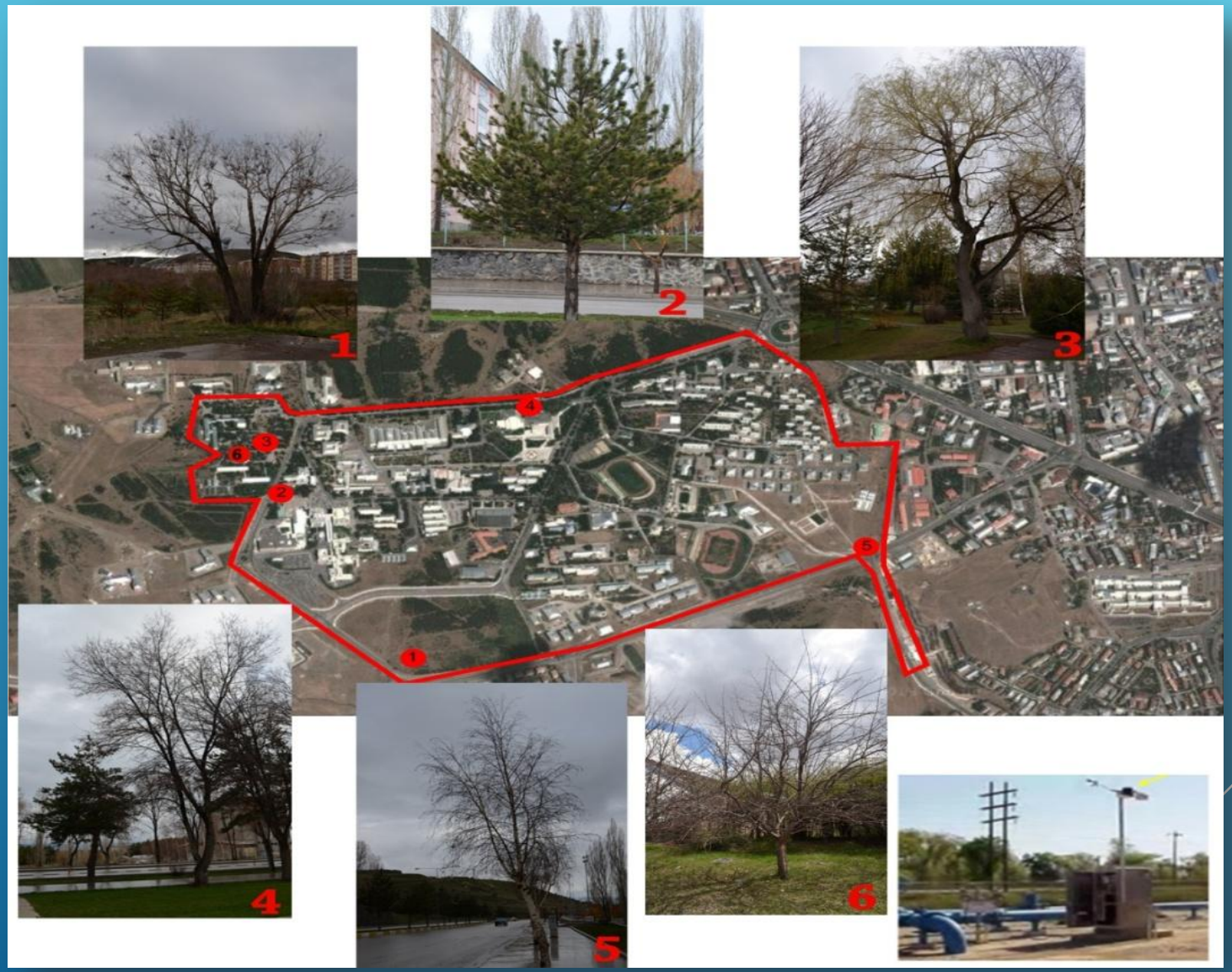

Fig 2. The study area in Erzurum and six different tree species:

- Fraxinus americana L. (1),
- Pinus sylvestris L. (2),
- Salix babylonica L. (3),
- Ulmus glabra Huds. (4),
- Betula pendula Roth. (5),
- Malus hybrida (6)

APPLICATION OF RAYMAN MODEL AND STATISTICAL METHODS

- RayMan model were used to calculate Physiologically Equivalent Temperature (PET) and Sky view Factors (SVF).
- PET thermal index is described in and PET values were calculated by considering the reference range for an individual based 35 of age, 1.75 m of height and 75 kg of weight.
- The relation between the variables was evaluated by the method of ordination analysis via the computer program CANOCO version 4.5.
- The relation between Sky view factors (SVF) and data for height and diameter of plant trends near-linear.
- When there is such this trend, RDE (Redundancy Analysis) analysis method is preferred in the ordination analysis, so these techniques were used in this study

Table 1.

PET (ºC)	Thermal perception	Grade of physiological stress
< 4	Very cold	Extreme cold stress
4,1 - 8,0	Cold	Strong cold stress
8,1 - 13,0	Cool	Moderate cold stress
13,1 - 18,0	Slightly cool	Slight cold stress
18,1 - 23,0	Comfortable	No thermal stress
23,1 - 29,0	Slightly warm	Slight heat stress
29,1 - 35,0	Warm	Moderate heat stress
35,1 - 41,0	Hot	Strong heat stress
>41,0	Very hot	Extreme heat stress

PET Value Gaps (Matzarakis et al. 1999)

RESULTS

Fraxinus americana L. (1) which located in the study area, has 3,38 m of corolla and 4,12 m of height, were examined with 3 different azimuth angle in different times and 3 different days

- SVF values were calculated to be 0.305, 0.304 and 0.288, respectively.
- Mean daily PET values on the study days obtained from the meteorological data are 20.8; 21.8; 20.2 °C.
- these values are accompanied by comfortable days during the year.

Pinus sylvestris L. (2) has 3,8 m of corolla and 5,5 m of height

- SVF values were calculated to be 0.950, 0.134 and 0.131.
- It is also accompanied by comfortable days during the year.

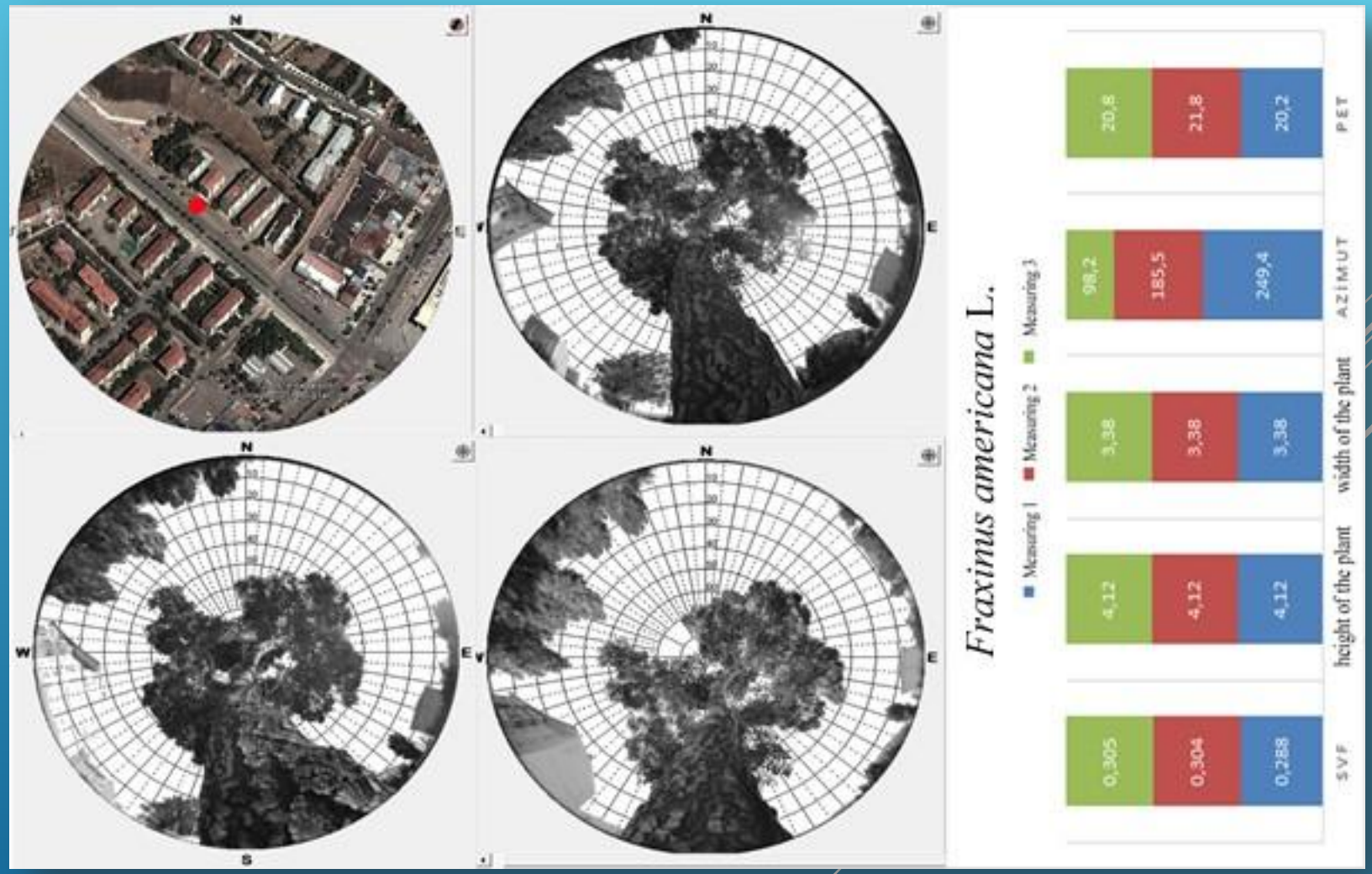

Fig 3. Values of SVF and PET belong to Fraxinus americana L.

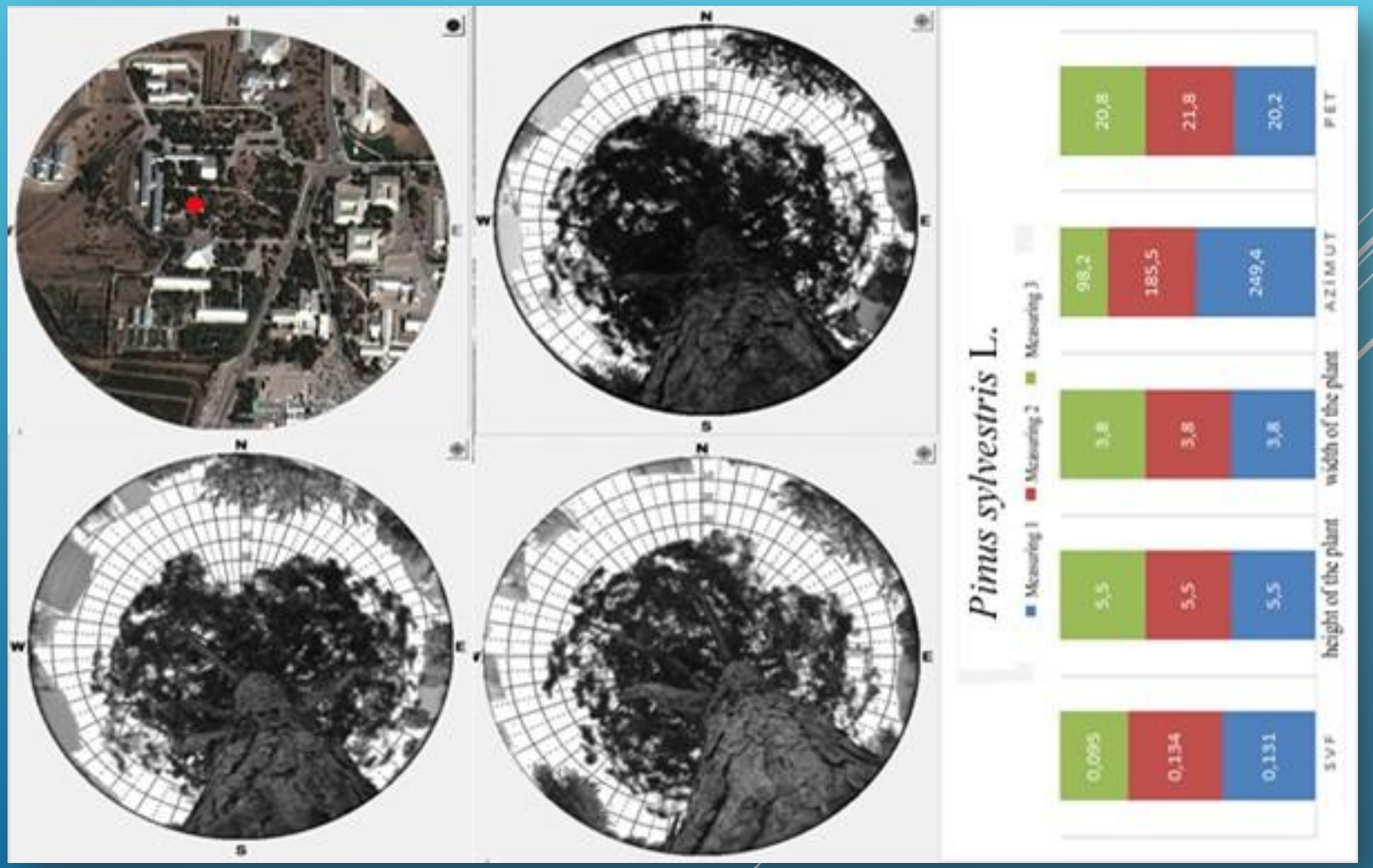

Fig 4. Values of SVF and PET belong to Pinus sylvestris L.

Salix babylonica L. (3) has 4,5 m of corolla and 11 m of height

- SVF values were calculated to be 0.810, 0.690 and 0.790, respectively.
- these values are accompanied by comfortable days during the year.

Ulmus glabra Huds. (4) has 7m of corolla and 13m of height.

- SVF values were calculated to be 0.540, 0.560 and 0.410.
- PET values calculated are 20.8, 21.8 and 20.2 on study days.

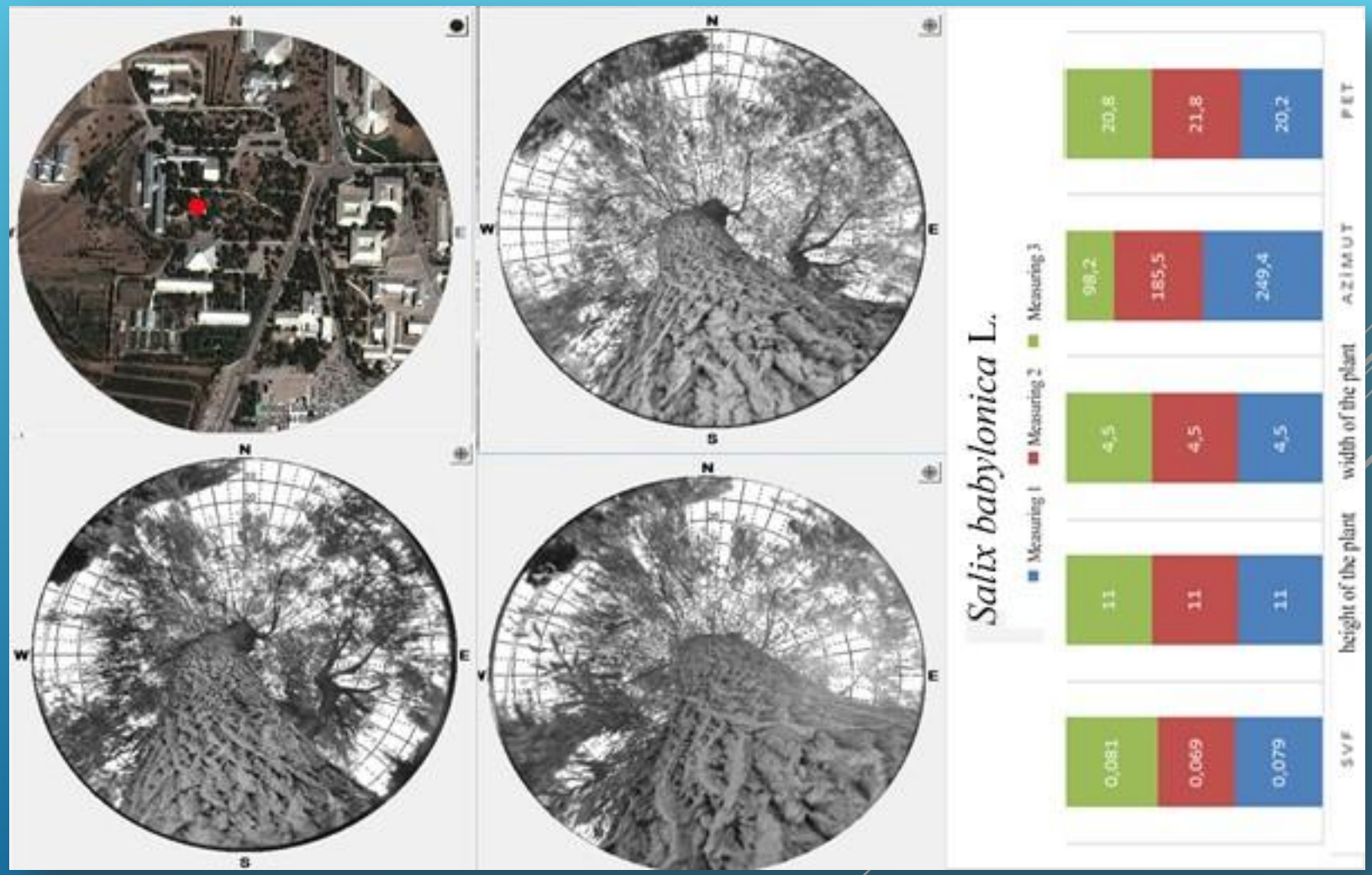

Fig 5. Values of SVF and PET belong to Salix babylonica L.

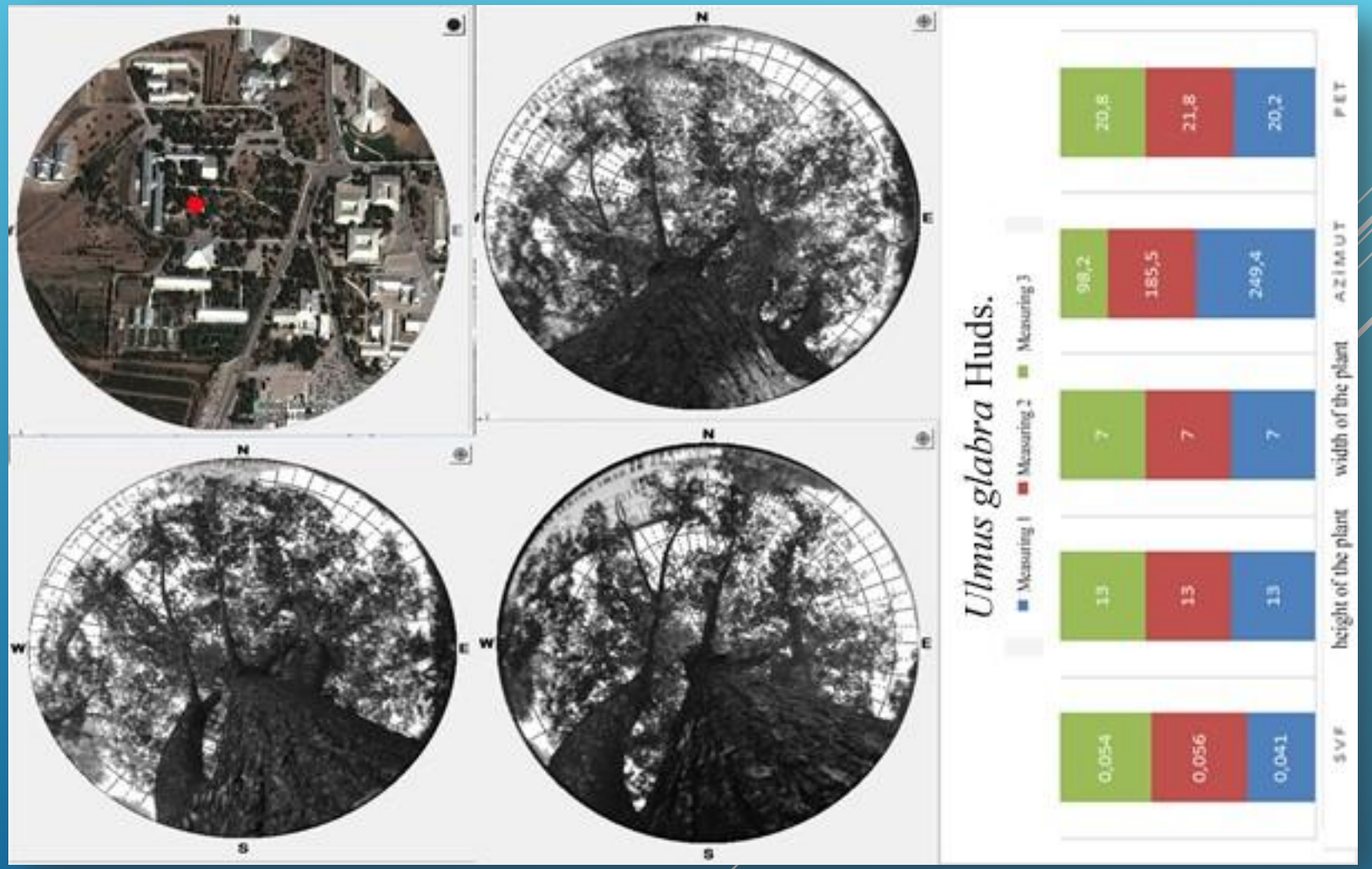

Fig 6. Values of SVF and PET belong to Ulmus glabra Huds.

***Betula pendula* Roth. (5),** has 3,3 m of corolla and 2,2 m of height.

- SVF values were calculated to be 0.407, 0.228 and 0.235.
- PET values calculated are 20.8, 21.8 and 20.2 on study days.

***Malus hybrida* L. (6)** has 3,38 m of corolla and 4,12 m of height.

- SVF values were calculated to be 0.125, 0.730 and 0.810.
- these values are also accompanied by comfortable days during the year.

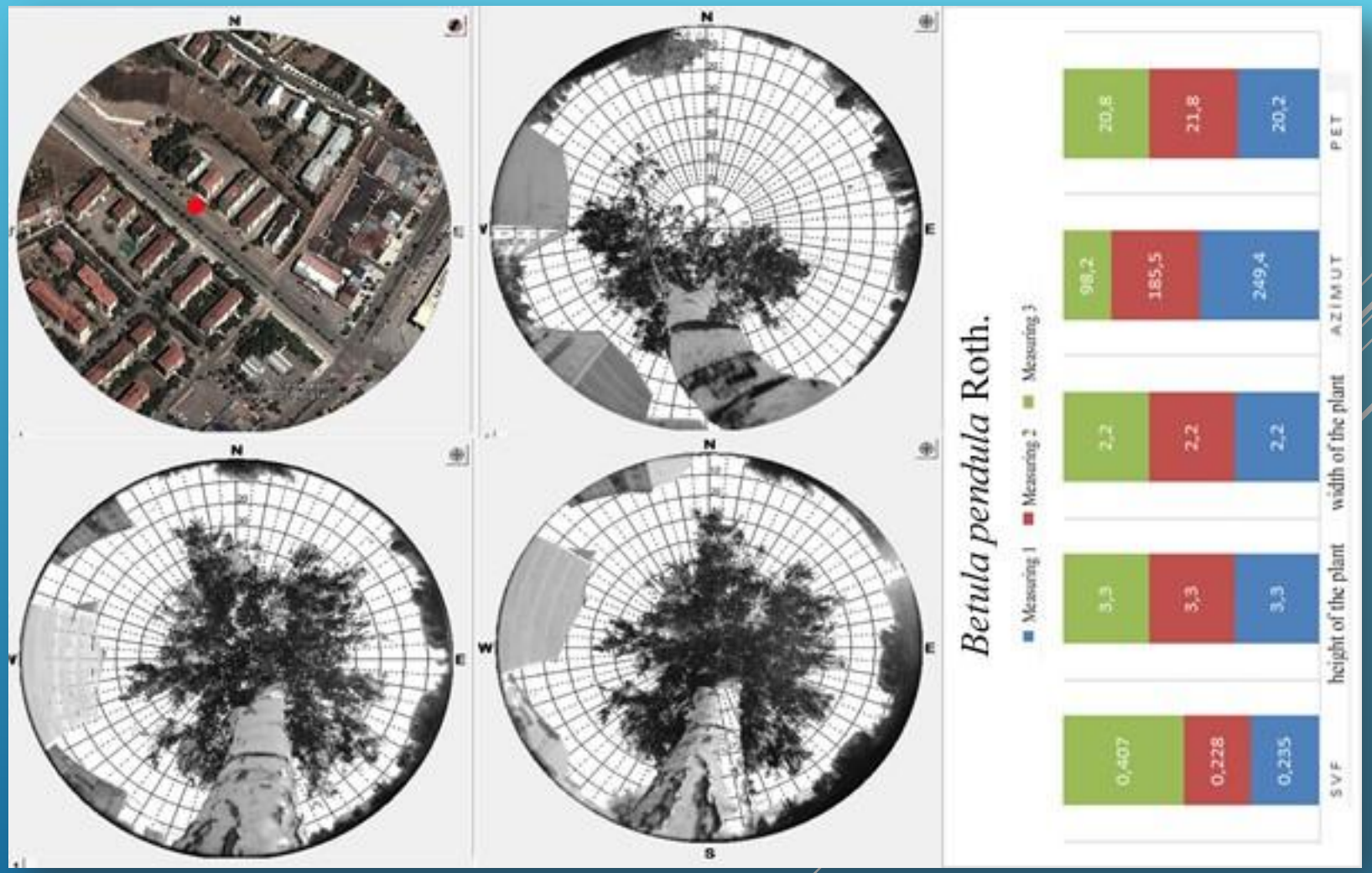

Fig 7. Values of SVF and PET belong to Betula pendula Roth.

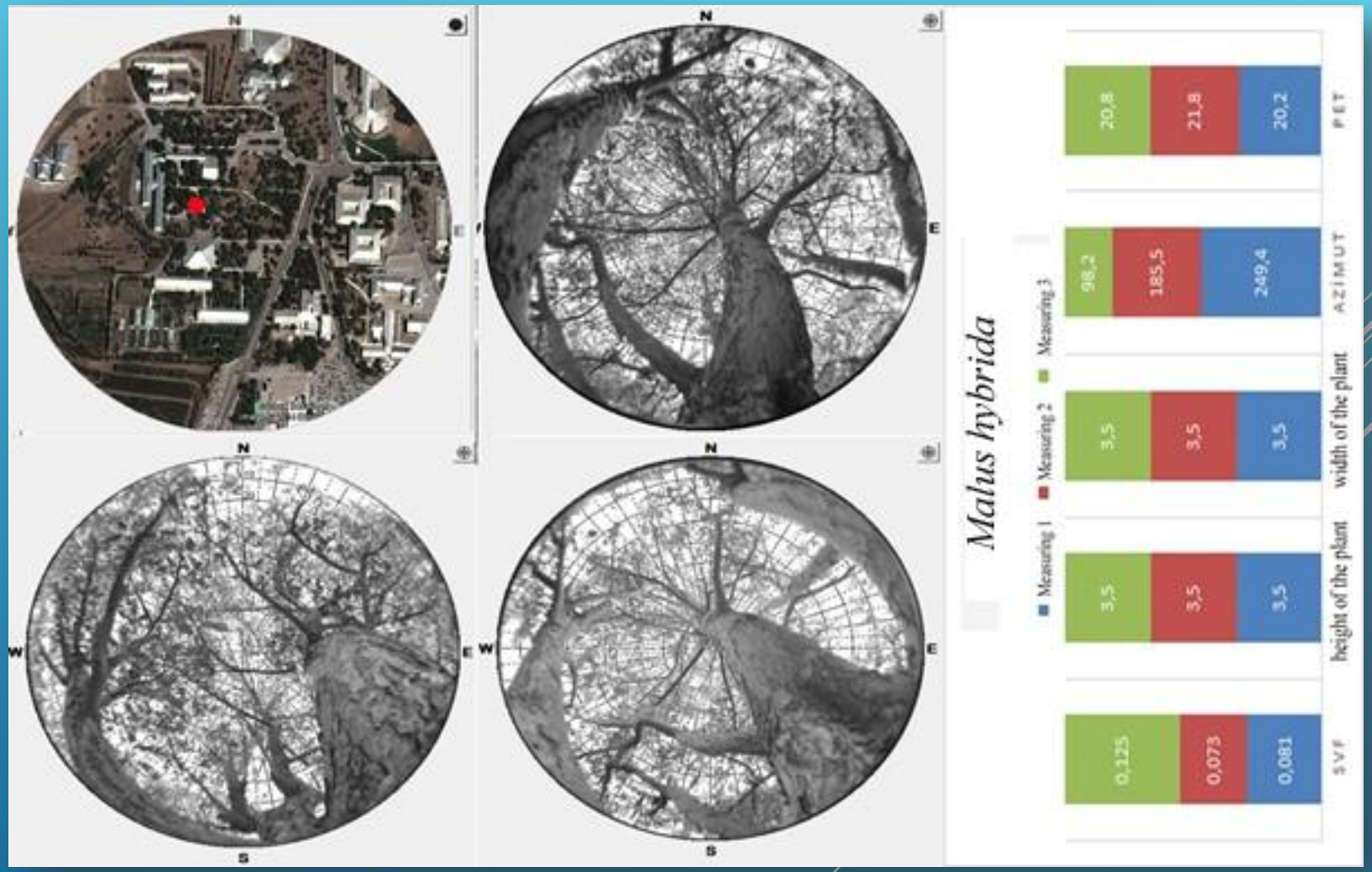

Fig 8. Values of SVF and PET belong to Malus hybrida L.

- 18 separate data were obtained by making three replications in 6 sample plants.
- Ordination analysis were applied to examine the relation between fixed data such as height of plant, plant corolla, azimuth value and PET values.

- Ordination orders objects that are characterized by values on multiple variables (i.e., multivariate objects) so that similar objects are near each other and dissimilar objects are farther from each other.

- These relationships between the objects, on each of several axes (one for each variable), are then characterized numerically and/or graphically.

DISCUSSION AND RESULTS

- It is clear in terms of ordination analysis that values of Sky view factor (SVF) are independent from azimuth and PET, which must strongly be related to Tmrt and was made in accordance with all data.
- Also at the previous study it was expressed that variability of Sky view factor (SVF) values caused by the lens factor although measurement made by different techniques in the same spot on the street where there are plants in the form of tree.

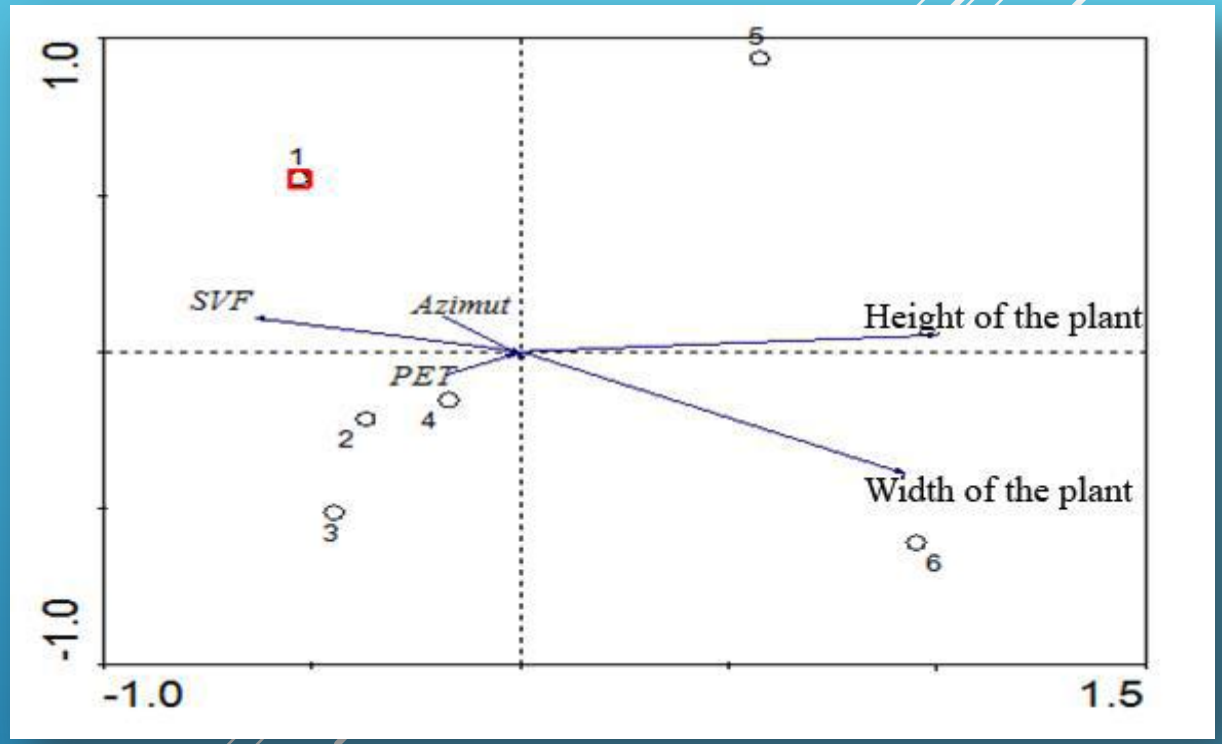

Fig 9. Ordination analysis

- Results of ordination analysis show that Sky view factor (SVF) values are proportional to width of corolla and height of plant.
- When width of corolla and height of plant increase, Sky view factor (SVF) value decreases.
- The sky is less apparent when viewed from the ground, so the shadow of plants is enhanced on the environment which are located and it is one of the factors that occur in bio-climatic areas.

- It can be seen from the results of the analysis in the study that width of plant corolla have a linear relationship with SVF.
- Six different plant species samples truly showed this situation.
- As the plant width and height increase, SVF also increases.
- It can clearly be seen in ordination analysis that principle variable SVF is independent of azimuth angle of the sun.

THANK YOU VERY MUCH