Science, Engineering & Education, 10, (1), 2025, 3-10

Proposal for Automatic Processing of Data Generated by Agrometeorological Station

Anton Sotirov[1*], Krasimir Sotirov[2]

[1]*Institute of Agriculture-Kyustendil, Agricultural Academy, Bulgaria*
[2]*Language School "Dr. Petar Beron" - Kyustendil*
Received 18 August 2025, Accepted 30 October 2025
DOI: 10.59957/see.v10.i1.2025.1

ABSTRACT

The study proposes optimization of the meteorological system Meteobot® and its eponymous software version 1.6. by additionally installing the XLStat mathematical statistics application to Microsoft Excel spreadsheets. The application will optimize the operation of the automatic meteorological and soil monitoring system through a wide range of statistical analyses, such as cluster analysis, dendrograms by similarities and differences of data, factor analysis, variations, determination of correlation coefficient, correlation matrix, scattering indicators, dispersion, correlation analysis, extrapolation and interpolation, etc.

Keywords: agriculture, meteorology, meteo- station, optimization, statistics.

INTRODUCTION

Modern smart agriculture is associated with the use of automatic meteorological stations that inform about weather conditions and soil conditions in real time. Such is the Meteobot® system, with the same name software for the Android and Windows systems, which is in the experimental fields of the Institute of Agriculture - Kyustendil, which is a part of the Agricultural Academy-Sofia, Bulgaria. The system has a Wi-Fi internet connection to mobile devices. It presents the data in the form of an Excel spreadsheet for the Windows operating system, and the data is easily transformed into the standard for this type of spreadsheet charts, graphs, histograms, maps, etc. All these Fig.s can be transferred, together with the database tables, after subsequent commands to different mobile devices via e-mail.

The aim of the study is to propose optimization of the automatic meteorological station Meteobot® and its software Meteobot®, version 1.6. by additionally installing the XLStat mathematical statistics application to Microsoft Excel spreadsheets, which is used free of charge against registration for two weeks, after which it can be purchased in different versions, depending on the degree of professional level of use, with the versions for the low professional levels having lower prices [1, 2]. The application

**Correspondence to: Anton Sotirov, Institute of Agriculture-Kyustendil, 1 Sofijsko Shose St., Kyustendil 2500, Bulgaria, e-mail: a_sotir@iz-kyustendil.org*

covers a wide range of statistical analyses, such as cluster analysis, dendrograms of similarity and dissimilarity, factor analysis, variations, correlation coefficient, correlation matrix, scattering indicators, dispersion, correlation analysis, extrapolation and interpolation, etc. There was not information has been found in the literature and on the Internet about the use of the XLSTat application in the automatic meteorological monitoring system Meteobot®, but these methods are widely used in science and professional practice, incl. and related to agriculture and food [3 - 7]. Statistical approaches in foods are described also by [8 - 10].

EXPERIMENTAL

The optimization of the data from the Meteobot® weather station can be achieved by installing the XLStat application to Excel spreadsheets, in which the mobile application for Android and Windows wirelessly sends the data collected by stationary or mobile sensors to establish environmental parameters - air, soil, water and weather to various mobile and stationary devices. Databases are used, automatically generated by the Meteobot® system, which is in the experimental fields of the Institute of Agriculture - Sofia, presented in Excel spreadsheets with charts, graphs, histograms, maps. In addition, standard statistical processing of the data directly from Meteobot in the spreadsheet is shown, and various results of statistical analyses in the field of agriculture, cluster analysis, dendrograms by similarities and differences of data, factor analysis, variations, determination of correlation coefficient, correlation matrix are applied for illustration. Meteobot® Pro has a data logger with a Sentek TriScan soil probe connected to it (30, 60, 90 or 120 cm). It measures at several depths depending on its length the following three parameters:

- Volumetric water content in the soil (L m^{-2});
- Soil temperature t(C);
- Soil Volume Ion Content (VIC), which includes all dissolved salts in the soil. Electrical conductivity is calculated on this basis;
- Measurements are sent via SIM card every 10 min s.

RESULTS AND DISCUSSION

Table 1 and Table 2 show the data on weather conditions and soil conditions for a given period of time by day, as the Meteobot station currently sends them to the registered SIM cards every 10 min.

Fig. 1 shows a graph of precipitation for a certain period, which is set by the user or automatically from the station to the users of the registered SIM cards. There is a lot of information about average moisture of the air and the leaves, dew point, soil moisture and temperature, precipitations. The very important data is about temperature and moisture.

Fig. 2a presents how Meteobot® generates and sends a satellite image of the monitored territory in real time and Fig. 2b automatically boundaries of the area and soil profiles are drawn. Fig. 3 and Fig. 4 show a real-time histogram of most measured values of active acidity pH of soils, that the meteo-station is currently able to send to users on-line. This information helps for visualization of the studied soil profiles and about planning of next area for investigations.

Fig. 2b presents the proposal of this paper to additionally install the XL Stat computer application to the operating system of the weather station and thus directly without additional computer processing on the SIM cards to directly obtain the contours of the measured area (white lines in the Fig.) and the data on soil parameters to be indicated by longitudinal profiles (yellow lines in the Fig.).

Table 3 gives a project for the automatic calculation of agglomerative hierarchical clustering (AHC) similarity using a correlation matrix. This information is a core of the statistical data and gives us the relation between the studied

parameters. Summary statistics (Table 4) is very useful for proving of the statistical importance of the received data. Data shown in the table summary statistics is automatic generated and it present to us information about number of observations, minimum and maximum measured values and average-mean value. Also standard deviation is a very important information to know the reliability of the data.

Automatic graphic presentation of the soil acidity pH on profiles 1, 2, and 3 is drawn on Fig. 4.

Table 1. Weather data automatically generated by Meteobot® in a spreadsheet.

Date	Air temperature min., °C	Air temperature max., °C	Air temperature average, °C	Air humidity min., %	Air humidity max., %	Air humidity average, %
1.3.24	6.88	14.34	10.6	53.76	96.68	73.1
2.3.24	3.36	15.97	8.4	61.11	98.37	90.5
3.3.24	3.46	16.61	6.9	62.20	98.83	89.2
4.3.24	-0.41	18.42	8.6	43.38	97.59	77.3
5.3.24	2.95	16.68	8.9	44.71	95.18	74.5
6.3.24	-1.17	16.18	7.3	44.88	96.01	78.8
7.3.24	1.42	13.62	6.6	56.17	97.75	88.1
8.3.24	0.37	13.80	5.9	46.38	97.58	79.8
9.3.24	-1.72	15.38	5.5	50.67	97.29	80.8
10.3.24	2.59	21.07	11.0	41.45	95.34	72.7
11.3.24	7.45	19.67	12.5	49.82	90.35	70.7
12.3.24	5.55	15.29	8.5	67.83	96.96	88.0
13.3.24	5.98	14.44	8.5	51.06	98.00	82.2
14.3.24	3.41	13.14	7.6	52.92	97.25	80.0
15.3.24	-0.39	12.33	5.8	53.83	94.70	80.3

Table 2. Meteorological and soil data automatically generated by Meteobot® in a spreadsheet.

Atmospheric pressure (hPa)	Dew point, °C	Precipitation, L m^{-2}	Wind speed, /s	Soil moisture 30 cm, %	Soil temperature 30 cm, °C	Leaf moisture, %
1013.8	5.7	3.25	2.3	94.2	8.4	7.8
1012.1	6.8	5.25	0.4	93.9	8.3	17.2
1013.3	5.1	0.25	1.1	94.8	8.5	9.7
1011.4	4.2	0.00	2.0	95.3	8.4	8.1
1009.1	4.2	0.00	2.4	95.3	8.5	1.4
1015.8	3.6	1.25	1.3	95.3	8.3	9.0
1015.6	4.7	10.50	1.4	95.6	8.5	16.5
1018.9	2.3	0.00	1.1	96.1	8.3	8.9
1019.2	2.1	0.00	1.2	96.1	8.2	7.8
1017.5	5.7	0.00	2.8	96.2	8.4	5.1
1013.0	7.1	1.25	3.7	96.5	9.1	3.4
1010.1	6.5	5.00	1.4	96.5	9.3	13.8
1012.5	5.3	2.00	1.6	96.5	9.5	9.4
1016.0	4.1	0.25	2.1	96.6	9.5	9.5
1017.9	2.4	0.00	0.3	96.6	9.1	3.8

Fig. 5 shows a proposal from the authors for automatic spatial distribution of parameters, for example, for salt content in the soil. after optimizing the data, measured by the automatic weather station.

Fig. 6 is a proposal for submission of

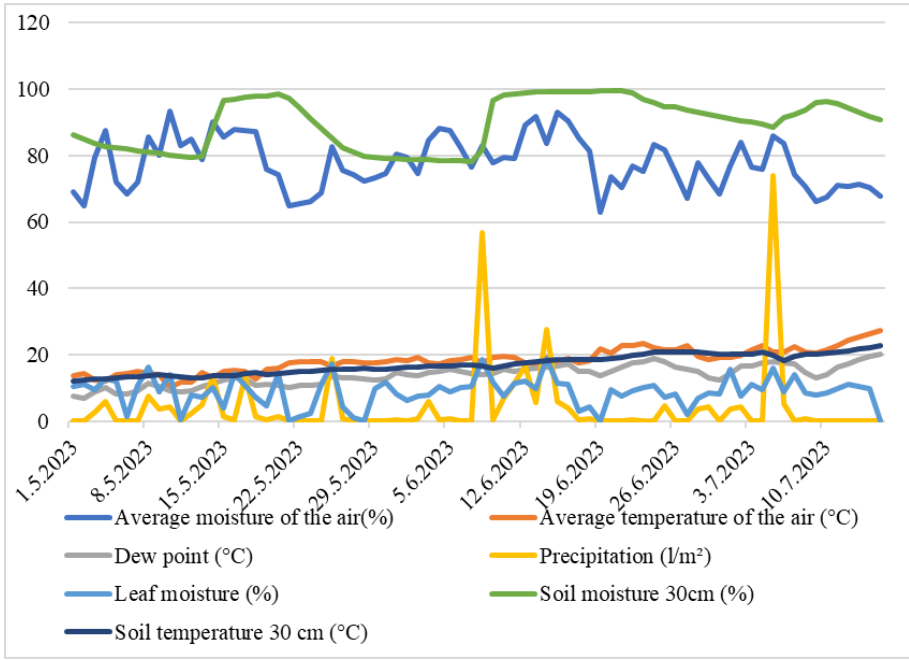

Fig. 1. Schedule of precipitation for a certain period of time, automatically generated by Meteobot®.

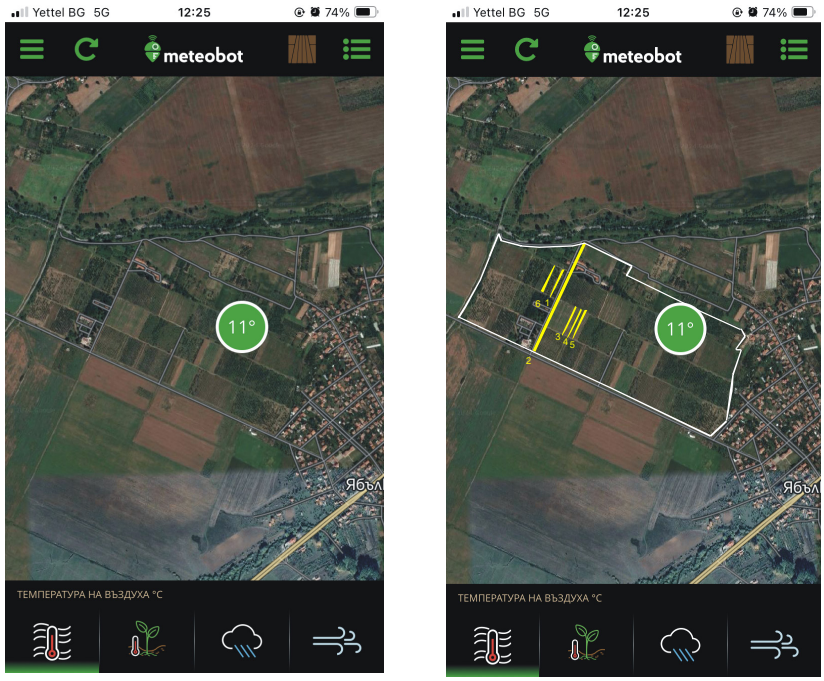

Fig. 2. Satellite image automatically generated by Meteobot® of the monitored area on the left (a) and a proposal for automatic drawing of contours and longitudinal soil profiles by interpolation and extrapolation to the right (b).

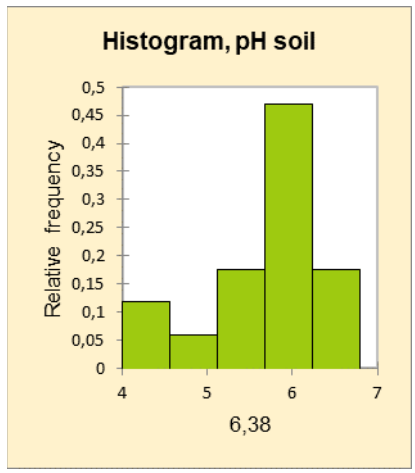

Fig. 3. Histogram of measured soil pH automatically generated by the agrometeo station.

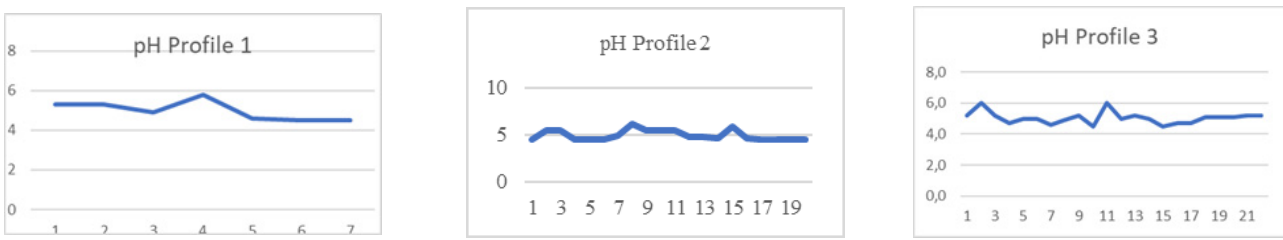

Fig. 4. Profile of active acidity pH of soils horizon 30 cm depth, distance between samples 20 m - automatically generated by the agro-meteo station.

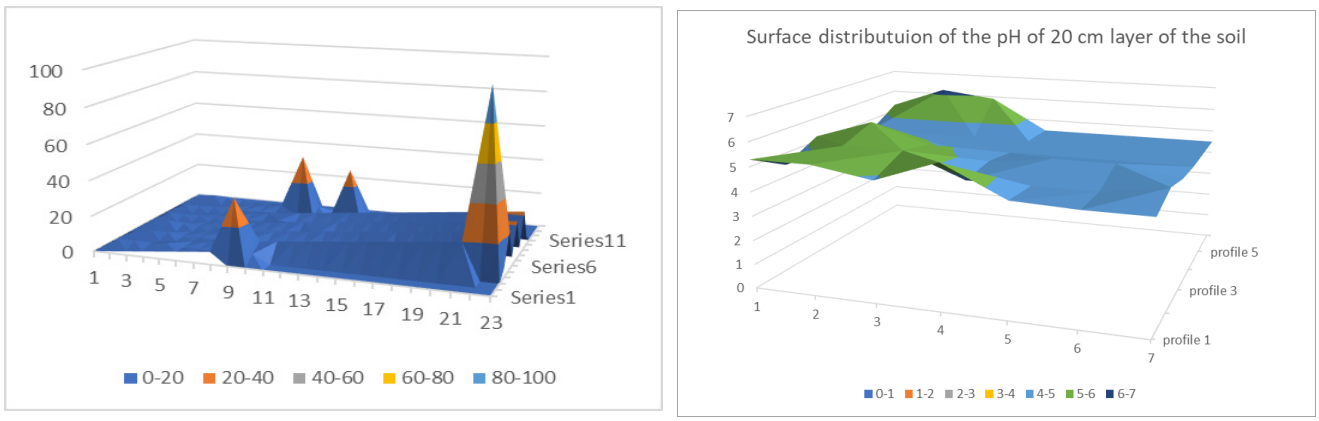

Fig. 5. Proposal for a spatial distribution of parameters, e.g. for salt content in the soil, after optimizing the data, measured by the automatic weather station.

Table 3. Agglomerative Hierarchical Clustering (AHC) Similarity, Correlation Matrix:

from \ to	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1	-0,635	-0,354	-0,425	-0,434	0,957	0,270	0,957	0,177	0,384	0,364
X2	-0,635	1	0,474	0,523	0,509	-0,800	-0,435	-0,800	-0,236	-0,317	-0,383
X3	-0,354	0,474	1	0,765	0,735	-0,421	0,018	-0,421	0,158	-0,521	-0,150
X4	-0,425	0,523	0,765	1	0,989	-0,480	0,086	-0,480	-0,457	-0,532	-0,699
X5	-0,434	0,509	0,735	0,989	1	-0,478	0,152	-0,478	-0,443	-0,615	-0,730
X6	0,957	-0,800	-0,421	-0,480	-0,478	1	0,358	1,000	0,188	0,391	0,379
X7	0,270	-0,435	0,018	0,086	0,152	0,358	1	0,358	0,115	-0,389	-0,111
X8	0,957	-0,800	-0,421	-0,480	-0,478	1,000	0,358	1	0,188	0,391	0,379
X9	0,177	-0,236	0,158	-0,457	-0,443	0,188	0,115	0,188	1	-0,117	0,839
X10	0,384	-0,317	-0,521	-0,532	-0,615	0,391	-0,389	0,391	-0,117	1	0,437
X11	0,364	-0,383	-0,150	-0,699	-0,730	0,379	-0,111	0,379	0,839	0,437	1

Table 4. Summary statistics.

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
12,8	4	0	4	5.80	216.00	93.50	88.28
10,7	4	0	4	6.80	218.00	92.55	89.33
9,4	4	0	4	6.00	210.00	90.97	85.69
12,3	4	0	4	7.10	157.00	75.50	61.69
8	4	0	4	7.40	199.00	87.60	80.29

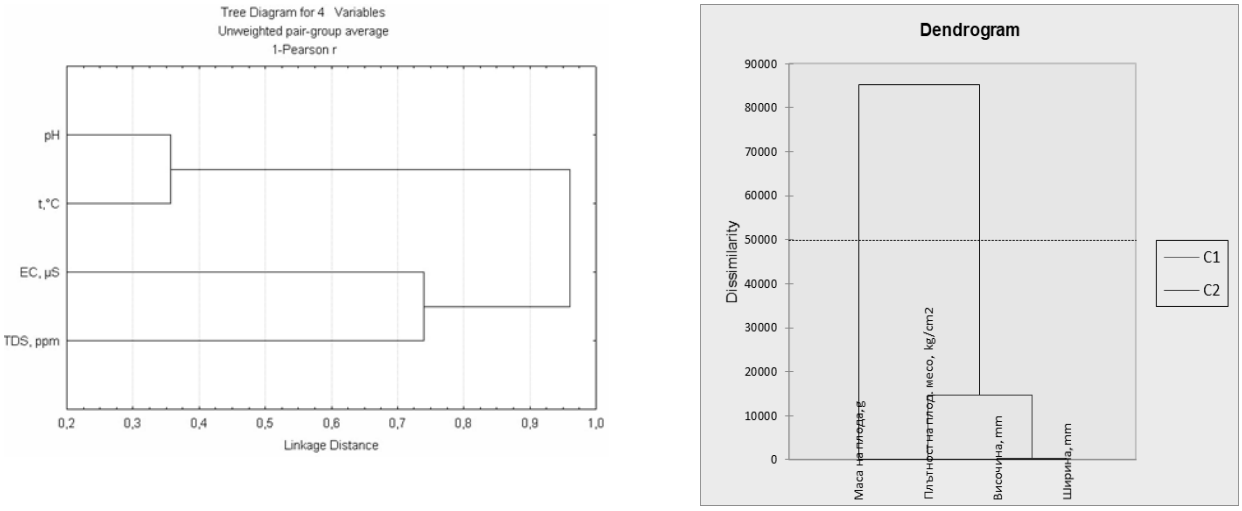

Fig. 6. (a) Agglomerative Hierarchical Clustering (AHC) Similarity/correlation coefficient is 0.40; Number of clusters 1, association pH-temperature; (b) Dissimilarity between fruit mass, fruit density, height and width of the tree.

information through an automatically synthesized graph for agglomerative hierarchical clustering (AHC) - cluster analysis of the measured data to the users of the registered SIM cards and a diagram of the variables (variations) of the measurement data to be delivered automatically as well, and not after additional processing on a computer (Fig. 6 -10). All these Figs reveal data to the scientist by very different way immediately and a lot of invisible natural phenomenon appear for the investigator. Fig. 6 gives us information how all studied parameters are dependent each other. The statistical program groups the data by similarities or by dissimilarities. By this way we may see connected phenomenon or chemical contents. Fig. 7 presents variables (variations) of measured data. Fig. 8 shows box plots, results of the processing of the statistical data as visualize the ranges of the values of the measurements. Evolution of the inertia of the data is given on Fig. 9. The bar chart uses bars to represent the frequency or count for each of these levels, with the height or length of the bar corresponding to that frequency (Fig. 10).

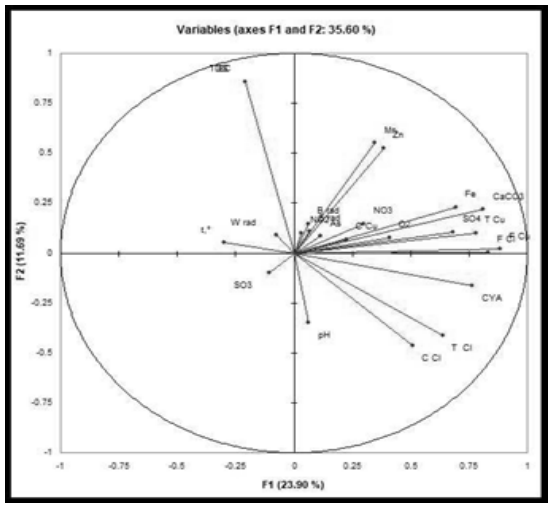

Fig. 7. Variables (variations) of measured data.

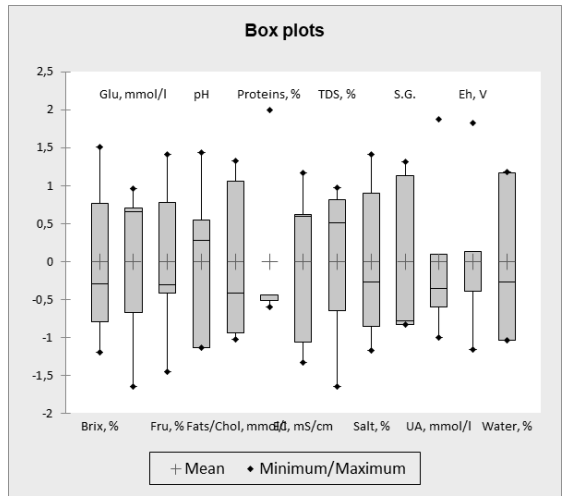

Fig. 8. Box plots, results of the processing of the statistical data.

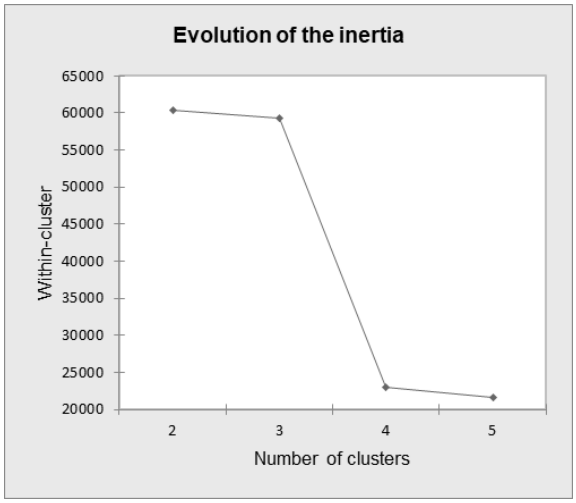

Fig. 9. Evolution of the inertia of the data.

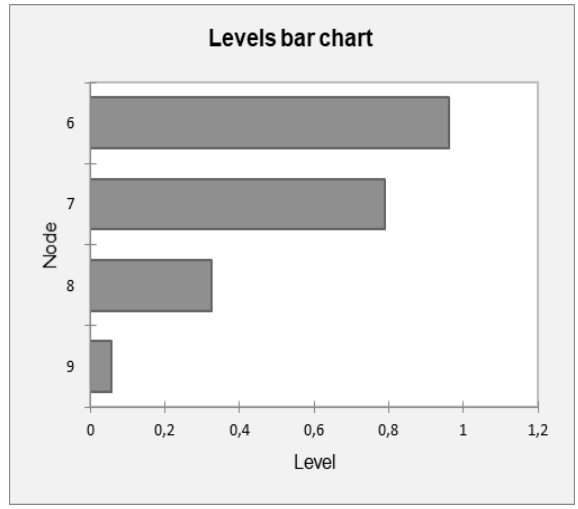

Fig. 10. Levels bars chart.

CONCLUSIONS

The result of this survey is a proposal for improving and optimizing the operation of the Meteobot® automatic agrometeorological station. by installing an advanced mathematical statistics application XLStat to the Excel spreadsheet program. where data is automatically sent to abundant devices. It is necessary to specify a command for presetting the statistical method and its graphic images to mobile devices without further processing of the data.

REFERENCES

1. Lumovero, XLSTAT, Statistical and data analysis solution, 2025. https://www.xlstat.com/en.
2. XLSTAT - PRO, User's guide. Addinsoft, New York, USA, Version 7.5, 2005, 104.
3. T. Dahl, T. Naes, Outlier and group detection in sensory panels using hierarchical cluster analysis with the procrustes distance, Food Quality and Preference, Barking, 15, 3, 2004, 195-208.
4. P.S. Henrique, A.R. Mota, G.A. Maia, E.S. Brito, D.S. Garruti, R.W. Figueiredo, Comparison of acceptability of tropical fruit mixed nectars by mean test and multivariate statistical analysis, Cincias Agrarias, Londrina, 34, 5, 2013, 2307-2316. DOI: 10.5433/1679-0359.2013v34n5p2307
5. R.A. Johnson, D.W. Wichern, Applied multivariate statistical analysis. 5th ed. Prentice Hall: Englewood Cliffs, 2002, p. 767.
6. E.M. Qannari, Vigneau, E.P. Luscan, A.C. Lefebvre, F. Vey, Clustering of variables, application in consumer and sensory studies. Food Quality and Preference. Barking, 8, 5-6, 1997, 423-428.
7. A. Sotirov, Statistical Approach in Juice Technology. International Journal of Scientific Development and Research, 9, 2, 2024. 761-770, DOI: 10.6084/m9.figshare.24874002.l
8. A.M. Simunaniemi, M. Nydahl, A. Andersson, Cluster analysis of fruit and vegetable-related perceptions: an alternative approach of consumer segmentation. Journal of Hum. Nutr. Diet., 26, 1, 2013, 38-47. doi: 10.1111/j.1365-277X.2012.01272
9. J.H. Ward, Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association, New York, 58, 301, 1963, 236-244.
10. L. Ying, A. Jaspreet, R. Bahadur, P. Pehrsson, Cluster Analysis of Micronutrients in Raw and Minimally Processe, Plant Foods (P24-049-19). Current Developments in Nutrition, 3, 1, 2019. https://doi.org/10.1093/cdn/nzz044.P24-049-19