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TOPOGRAPHIC TECHNIQUES APPLIED TO THE OUTLINE OF EXPERIMENTAL FIELDS WITH FORAGE PLANTS INCLUDED IN FIELD ASSOCIATIONS

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Abstract. *The topographic survey (detailed topographic survey) presents the real situation on the ground, measured in national coordinates, in the case of Romania in the Stereographic 1970 system. Practically speaking, we are talking about measurements or a set of works necessary to document the real situation on the ground. Or, even more concisely, the determination of level elevations relative to the level of the Black Sea. Plotting represents the topographical operation through which certain points in a project are materialized in the field by staking out. The purpose of this paper is to present the workflow for the mapping by modern methods of experimental fields with fodder plants included in field combinations. The tracing was performed with GNSS technology, the marking accuracy being ± 2.3 cm. In the case study presented below, a current orthophoto plan of the studied area was made using the eBee AG drone, after which a topographic survey was made using the South Galaxy S7 GNSS equipment. On the basis of the orthophoto plane and the data obtained from the topographic survey, the plan was drawn up for the plotting of the experimental fields, which was carried out with the help of the Leica Viva GS07 GNSS equipment. In this way, precise and reproducible results can be obtained in agricultural experiments, being a more expeditious method than the classical method.*

Keywords: *topographic survey, plotting, experimental field, GNSS*

INTRODUCTION

The experimental technique includes a wide range of issues related to the experimental objectives to be studied and the establishment of their priority (NEDELEA, MADOȘA, 2004), the working methodology necessary for obtaining and processing data (CIULCĂ, 2002; SAVATTI ET AL, 2004), as well as the evaluation of the obtained results and their interpretation.

In the field of plant culture, with the accumulation of new knowledge and theories, the farmer was and still is concerned with progress: new cultivated forms (varieties, hybrids), new technologies (DAVID ET AL, 2010; IMBREA, 2014) and new managerial methods, more efficient (IMBREA, 2011).

Scientific research in the field of plant culture is very complex due to the multitude of problems, as a result of the existing biodiversity within species and genera (KÖTELES, PEREȘ, 2013; IACOB ET AL, 2015), of specific culture technologies (COJOCARIU, 2005), of environment and ecological habitat. In any scientific research, soil and soil life play an important role (BOROZAN ET AL, 2013), along with the environmental conditions specific to the area. As such, establishing crop rotation, crop rotation (WIJNANDS ET AL, 2002; MATEI ET AL, 2010) and land preparation (COJOCARIU, 2005) are basic elements in scientific experimentation, so that the experimental results are real and repeatable.

In order to contribute to the development of the dynamic applied biological sciences (in the present case of forage plant culture), scientific research in the field must expand its methods of experimentation and take into account new, modern methods that are based on the UAV technique (SIMON ET AL, 2018; SIMON ET AL, 2020), GIS (HERBEI, SALA, 2016) and GNSS (ŞMULEAC ET AL, 2017; ŞMULEAC ET AL, 2019; COJOCARIU ET AL, 2022; MIKULINA, 2022). Thus, numerous knowledge, methods and techniques regarding the application of geomatic instruments for plotting and investigating the land were outlined and subsequently developed. One of these techniques is the detailed topographic elevation which can be defined as a high precision graphic representation of the terrain (KWEON, KANADE, 1994; LOFGREN, 2014; GROVES ET AL, 2015; LIAN ET AL, 2020), obtained by means of some specialized equipment.

Considering the fact that topographic mapping (or detailed topographic surveying) is the process of measuring and marking on the ground the positions and sizes of plots (CALINA ET AL, 2015; BARLIBA ET AL, 2018; SESTRAS, 2021), this procedure lends itself to to be applied in the "dimensioning" of the experimental fields.

In this context, the aim of the work is to apply the specific workflow of topographic mapping, by GNSS methods, for the "parceling" of experimental fields with forage plants included in field plots, as an alternative to the classic picketing techniques.

MATERIALS AND METHODS

Study area

The research presented in this paper - case study - was carried out in the western part of Romania, on the grounds of the Experimental Didactic Station (EDS) of ULS Timişoara (Figure 1). The resort has a number of facilities and infrastructure for research, such as farmland and pastures, laboratories and experimental fields.

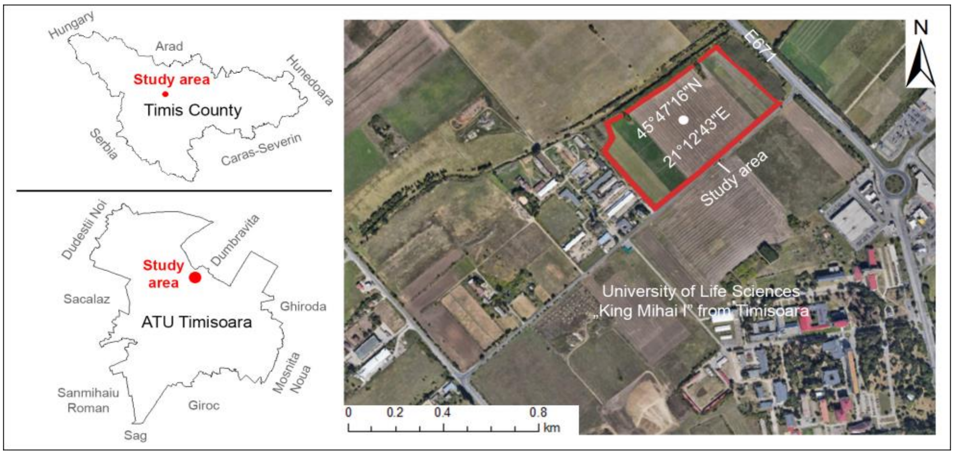

Figure 1. Location of the study area (processing after GEOSPATIAL, 2022)

Research methodology

The work methodology applied in the research involved the completion of several stages, presented synthetically in Figure 2.

During the research, the following stages were completed:

a. Identification and delimitation of the area of interest - was carried out both in the field and in the office, on the orthophoto plane; in this stage, the surface, the shape of the plots, the outer limits were established, in general terms;

Figure 2. Work methodology

b. Marking the initial structure of the experimental field - office stage in which the plots were delimited and the existing crops noted, in October 2022; the orthophoto plane obtained with photogrammetric equipment was used;
c. The topographic survey for the reorganization of the experimental field - field stage in which GNSS (Global Navigation Satellite System) equipment was used, the limits of the experimental field being established and with approximation, the position and dimensions of the new plots inside;
d. Drawing up the plotting plan - office stage that involved the design of the plots and the location of the x,y points, necessary in the plotting process;
e. Topographic mapping – field stage in which the boundaries of the component parcels were marked, with topographical precision, thus replacing picketing.

Equipment used

In a research stage prior to this study, the eBee Ag drone, specialized for agriculture, developed by the Swiss company senseFly, equipped with cameras and sensors that capture aerial images of high spatial resolution (ROUMENINA ET AL, 2016), necessary to generate the orthophotoplane (GHAZALI ET AL. 2022), from the area of interest (Figure 3).

Figure 3. The eBee AG drone together with the orthophoto plan of the studied area

The South Galaxy G7 GNSS equipment (Figure 4) is a precision receiver used in the field of topography and mapping.

Figure 4. South Galaxy G7

The South Galaxy G7 GNSS receiver is designed to work with a wide range of satellite signals, including GPS, GLONASS, BeiDou and Galileo, making it ideal for fieldwork in any region of the world (SALEM, 2022).

The Leica Viva GS07 GNSS equipment (Figure 5) was used in the field to plot the experimental fields (SZMAGLINSKI ET AL. 2022).

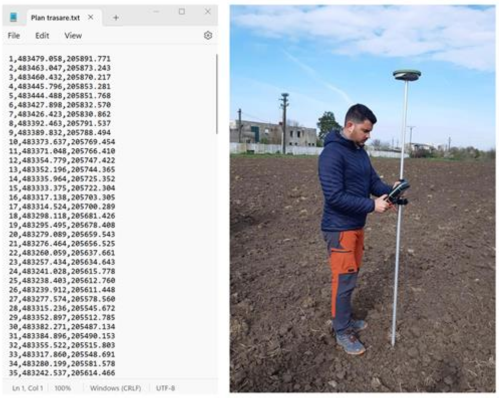

Figure 5 Leica Viva GS07 GNSS equipment

RESULTS AND DISCUSSION

The topographic survey can provide a very detailed image of the terrain and can be used to create a topographic plan (ŞMULEAC ET AL, 2017), but to obtain a 2D image of the terrain, it is necessary to create an orthophotoplan, which combines topographic information with aerial photographs (SIMON ET AL. 2020). In other words, the orthophoto plane is necessary to obtain a clear and precise image of the terrain (SIMON ET AL. 2018), which can be used to identify and delimit grasslands or agricultural crops (COJOCARIU ET AL, 2022), while the topographic elevation is necessary to obtain detailed information about the shape and elevation of the terrain.

Identification of the initial structure of the experimental field

The experimental field of fodder plants, with an area of 74,643 m^2, is located along the length of the road (368 m) connecting Calea Aradului and Torontalului. The experimental field has the shape of a rectangle oriented in the NE – SW direction (Figure 6).

For the identification and analysis of the structure of the experimental field, an orthophotoplan was used, made in October 2022. The area of interest contains two sub-areas:

a. - the area that was cultivated in 2022 with *Triticum aestivum* (an experimental plot), *Dactilys glomerata* (an experimental plot) and 2 plots with *Medicago sativa*, in the 4th year to be abolished as early as autumn;

b. - on the orthophoto plane you can see a green area containing perennial fodder plants (from *Festuca arundinacea*), plants still maintained.

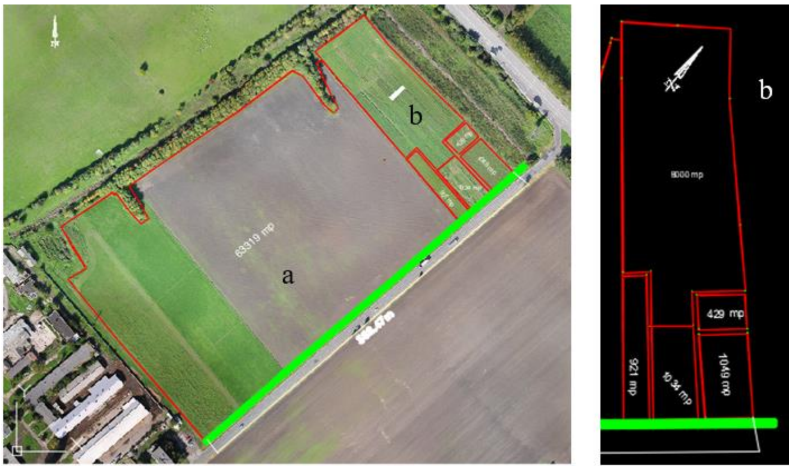

Figure 6 Representation of the experimental field on the orthophotoplane

Detailed topographical survey for the reorganization of the experimental field

As it was mentioned before, for part of the experimental field, namely subzone a, it was necessary to reorganize the structure of crops and implicitly the parceling of this subzone was imposed. The classic method involves picketing, respectively measuring with a roulette and delimiting by fixing the inflection points with pegs. In the case of this study, the "picketing" was done by topographical techniques, based on GNSS equipment, which involved, in the first stage, detailed topographical surveying. In the field, the corners of the plots, the roads between the plots, but also the outline of the entire experimental field were marked with GPS points.

According to the measurements in the field, in the office stage, the topographic plan was created (Figure 7), for which the following stages were completed:

- import of points raised in the field, in AutoCAD;
- adding additional information (property boundaries, buildings, roads and other features relevant to the project);
- labeling points of interest on the plan;
- calculation of coordinates, surfaces and distances.

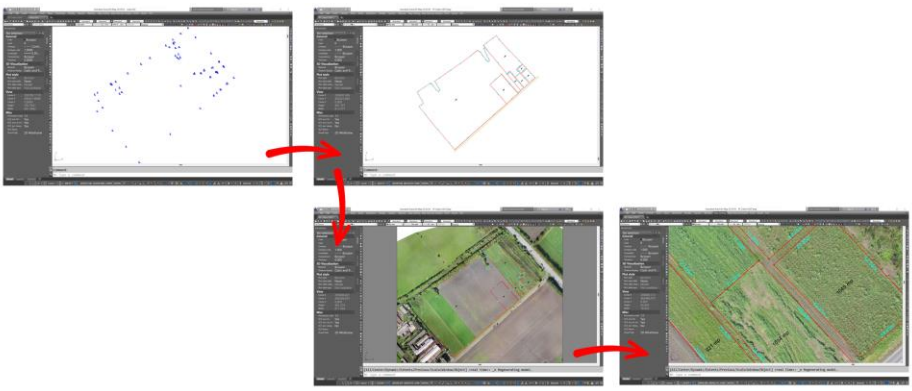

Figure 7. Creation of the topographic plan

Preparation of the layout plan

In order to create a layout plan (Figure 8), for the experimental fields, based on the topographic survey made in the previous stage, the following steps were taken:
- topographic data processing using AutoCAD software;
- drawing the layout plan based on topographical data; the exact dimensions and position of each element are recorded;
- for orientation in the field and to facilitate the marking of the points to be drawn, a grid of points with known coordinates was designed.

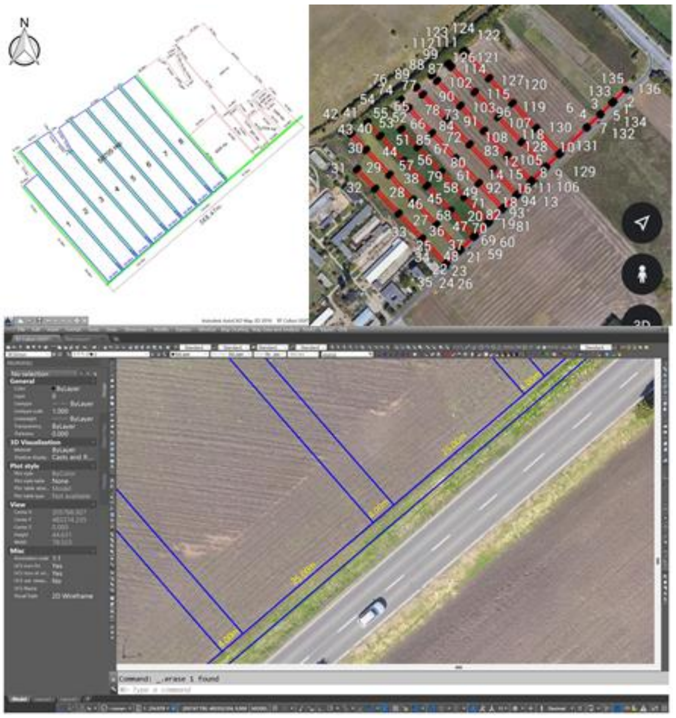

Figure 8. The design of the plotting plan

Based on the layout plan drawn up in the office stage, the corresponding points in the field were marked with GPS equipment.

The topographical plot

In order to plot the experimental plots with the Leica Viva GS07 GNSS equipment, the following steps were taken:
- preparing the GNSS device and ensuring the quality and correctness of the measurements (capturing the satellite signal to be able to determine the position precisely);
- initiation of the Leica Captivate application for collecting GPS points;
- the actual plotting of the experimental plots in accordance with the topographical plan, using the coordinates and altitude obtained by GNSS.

Following the topographic mapping, in sub-area "a" of the experimental device, the following were created, depending on the crops to be established:

- 8 large plots (marked 1 – 8), with the surface of each plot of approximately 5000 m^2, depending on the variation in the length of the land; each plot is 25 m wide, and 4 m roads were drawn between the plots, to facilitate access by mechanical means; the structure of the crops followed in the research will be the following: fodder beet (after alfalfa), fleshy clover, various annual mixtures according to the experiences with fodder grasses from the previous year (2022);
- a plot of 4505 m^2, with the purpose of setting up an experiment with various research variants of the Ryegrass aristat; the surface difference of 8361 m^2 is to be re-parceled for other experiments with fodder plants (Figure 9).

Figure 9. Planting some fodder species

Finally, in the research fields, the placement of the cultures is done according to some well-established rules (experimental technique) according to the clearly established objectives for each individual culture.

The proposed method, using the GNSS technique, can help the improver through precision and reduction of working time.

CONCLUSIONS

Following the research, the plotting of the experimental fields with the help of GNSS technology, proved to be effective in terms of the following aspects:
- high precision: GNSS technology can provide precise positions and exact coordinates of the plotted points, with a precision of up to a few millimeters;
- speed and therefore saving time and resources, tracing with the help of GNSS being much faster than classic methods;
- easy updating of data; in the event that adjustments to the plot are necessary, i.e. updating the data according to needs during the same year or in the following years.

Without minimizing the importance and efficiency of classic picketing methods, following our own research, we support the use of modern topographical techniques, namely GNSS technology, for the parcelling of experimental fields.

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