DATA ACQUISITION PROTOCOL FOR MONOIC HEMP EXPERIMENTAL FIELD

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Abstract. *Research developed in recent years underlines the importance of monoic hemp crops, both for economic values, in the agricultural field, and as an integrated substance in medical treatments. As in the case of other agricultural crops, for the analysis of the dynamics during a vegetation cycle of hemp crops, it is necessary to apply a well-established work flow, within an experimental device. In this context, through this study, a work protocol is presented through which the "classic" experimental technique is completed by geomatic means. The proposed work protocol involves a field stage, in which the experimental field is marked with GPS points and the sampling points are located with centimeter precision, which ensures the possibility of sampling from the same plant, in different phenophases. The second stage, the office one, involves: the graphic representation of the experimental site, based on the contour points marked in the field, and therefore the verification and validation of the necessary dimensions (dimensions between rows, free spaces, cultivated spaces, etc.); overlaying the experimental field with other thematic maps of environmental factors and thus extracting geospatial information (geology, climate data, soil, etc.) that complements the information collected directly from the field. To position the points in the field, GNSS equipment with a South receiver was used, with centimeter precision, and for data processing, AutoCAD Map 3D 2012 and ArcGIS 10.4 software were used. To extract the geospatial information, thematic maps in raster and vector format, taken from the specialized platforms, were used. The advantages of this working protocol consist in: locating with topographical precision the experimental device and the sampling points; the extraction of environmental data, point by point; the possibility of computerized comparison of the results obtained in different phenophases; spatialization of results and analysis of crop dynamics, both in a vegetation cycle and in different years; cartographic representation of the experimental field.*

Keywords: *monoic hemp, geomatic techniques, experimental site.*

INTRODUCTION

The depletion of ecological resources, climate changes and the increased attention for people's health, brings hemp culture back to the fore in the creation of a green economy (KARCHE, SINGH, 2019); the multitude of products resulting from processing hemp being biodegradable, recyclable and reusable (SALENTIJN ET AL., 2015, BALDINI ET AL., 2020, PANDA ET AL., 2021).

Cannabis sativa L. (hemp) is a versatile plant with multiple uses in the textile industry (ZIMNIEWSKA, 2022), food, pharmaceutical, paper, construction, energy, etc. Hemp fibers are obtained from the stems, which have a high resistance to torsion, breaking, are elastic, hygroscopic and thermally conductive, extremely important attributes for the quality of the products obtained from hemp: thread and string of many types, fishing materials, coarse cloths for bags, shoes and various water-resistant packaging, fine cloths resulting from the mixture of cottonized hemp fibers, cotton or silk.

The seeds are used in animal feed and for human food preparations, for cosmetic and pharmacological products due to its therapeutic properties (BAKER ET AL., 2013, CARUS ET AL., 2013).

From an agricultural point of view, hemp is an income-generating technical plant (STRUIK ET AL., 2000). It is an excellent shade plant that significantly reduces the degree of weeding.

Experiences with technological links, in the present situation how the distance between rows and between plants in a row (nutrition space) influences the development of hemp plants (DELEURAN ET AL., 2006, DI BARI ET AL., 2004), respectively the composition and quantity bioactive compounds in hemp (AMAR, 2006, SIKORA ET AL., 2011).

The scheme of the experimental field refers to the experimental objectives to be studied and the establishment of their priorities, the working methodology necessary for obtaining and processing the experimental data, evaluating the obtained results and their interpretation.

The operation of transposing the experience into the field involves the existence of a detailed sketch of the experience and the overall sketch of the experimental field or the position that the respective experience must occupy within the soil in the event that it has a singular placement (SĂULESCU, SĂULESCU, 1967, SĂNDOIU, 2020).

In the last decades, agriculture, in all its segments, has undergone significant transformations, both conceptually and in terms of practical applicability, through the introduction and use of geomatic techniques (Geographic Information Systems - GIS, satellite technologies, etc.), which has meant the localization, spatialization and cartographic representation of specific elements, all of which are part of precision agriculture (VIKRAM ET AL, 2017; LANGE, PEAKE, 2020, SHARMA, ET AL, 2020, SHARMA, ET AL, 2021).

Geographic Information Systems, in agriculture, in general, have produced major changes (ZHU ET AL, 2009, BILL ET AL, 2012). Thus, GIS methods and techniques can be applied, in agriculture, in different segments, such as: evaluation of crops and land, sustainable development of agriculture, analysis of productive potential, quantitative monitoring and analysis of changes, analysis of agro-ecosystems, land planning and management, and so on (CHELARU ET AL, 2011, OSHUNSANYA ET AL, 2017, SINGH, 2018, ZHANG, CAO, 2019).

The use of satellite navigation technologies (GNSS - *Global Navigation Satellite Systems*) allows the positioning and/or guidance of agricultural machinery, the location of sampling points for analysis or the spatio-temporal "lay-out" of various phenomena and components of the agricultural field (GREWAL ET AL, 2011, PÉREZ RUIZ, UPADHYAYA, 2012, YOUSEFI, RAZDARI, 2015, TAYARI. ET AL, 2015).

In accordance with the general changes in agriculture, the objectives of agro-biological research in hemp are in a continuous dynamic, and demand new precision methods, reduction of working time and fast and efficient data collection.

In this context, the aim of the work was to create a working protocol through which we can obtain two essential components of the experimental research: (1) the precise design of the **experimental device**, in the office and later its tracing in the field; (2) **crop monitoring** throughout the vegetative cycle, through a computerized and spatialized work algorithm, with precise location of observation points in the field.

MATERIALS AND METHODS

1. Study area

The experimental site is located at the Young Naturalists Station within the "King Mihai I" University of Life Sciences in Timişoara, located in the eastern part of the Municipality of Timişoara (Figure 1).

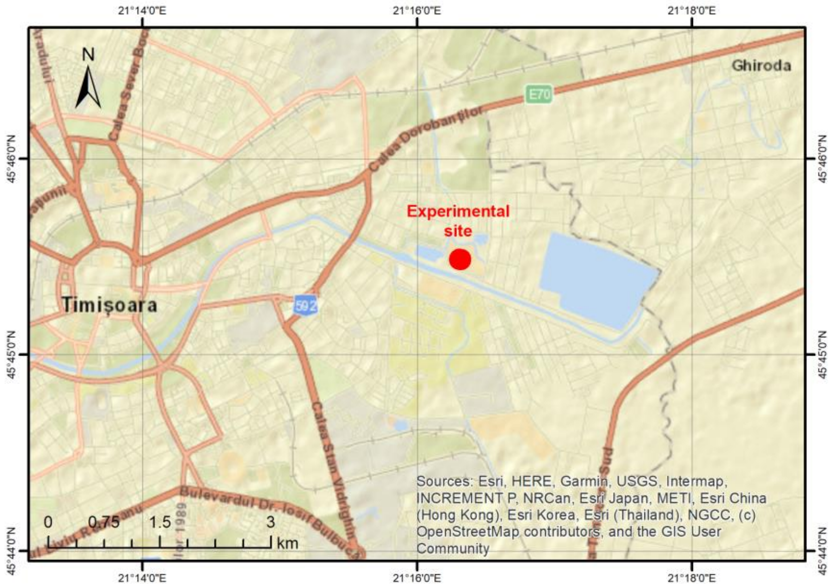

Figure 1 Location of the experimental site

The environmental conditions are those specific to the low plains in the Banat area, with a monotonous relief, with an altitude of approx. 91 m and very low slopes, with multi-year average temperatures above 10°C and annual precipitation amounts around 630 mm, with high groundwater levels and soils with high natural fertility.

2. Research methodology

The work protocol is shown schematically in figure 2.

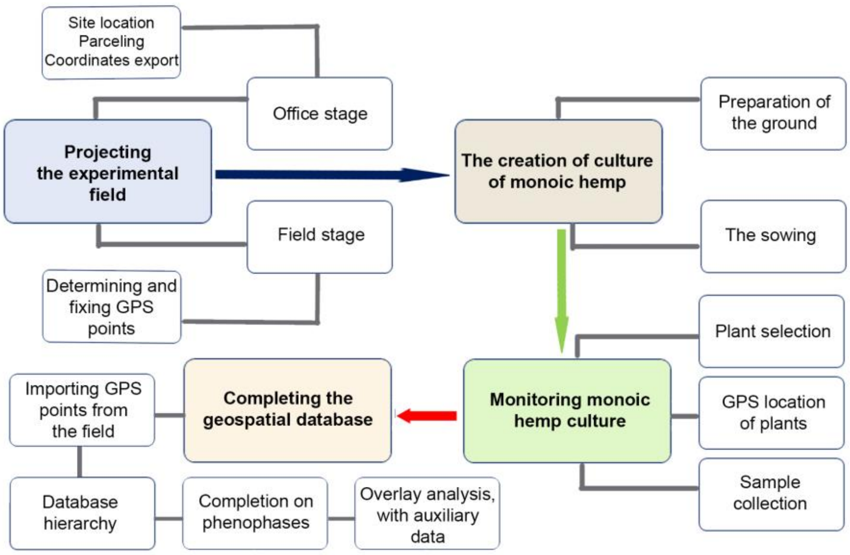

Figure 2 The work protocol

Considering the methodological nature of the study, each stage of the work protocol will be presented in the Results and discussions section.

3. Equipment and software used

The following were used for creating the experimental device:

- the Google Earth platform - for identifying the location of the experimental field and its rough "sketching";
- the Autocad 3D Map 2012 software – for accurately "drawing" the experimental site and extracting the stereographic coordinates of the points at the end of the rows;
- ArcGIS 10.4 – for exporting the coordinate file in ASCII format for import into the GNSS equipment.

To determine the points in the field, the GNSS positioning technique was used, with the South Galaxy G7 receiver, which allows determining the spatial position of the points using the RTK (*Real Time Kinematic*) method, with an accuracy of up to 2 cm, depending on the number of visible satellites, GSM signal and corrections from ROMPOS (Romanian Position Determination System). The South Galaxy G7 receiver has a GNSS board with 1598 channels. As the receiver supports Galileo, BDS (Beidou), GPS-NAVSTAR, Glonass, SBAS, IRNSS and QZSS satellite constellations, it can provide a high level of GNSS accuracy, even in restrictive conditions.

Figure 3 South Galaxy G7 equipment (left) for marking GPS points in the field (right)

ArcGIS 10.4 software was used to create databases, in order to monitor culture, as well as for overlay analysis (overlapping and extracting information from other geospatial data sets) (ARCGIS DOCUMENTATION, 2022).

The establishment of monoic hemp culture

The experiment was arranged in three blocks (A, B, C), in three variants: 1. - at a distance of 12.5 cm between rows, 2. - at a distance of 1 m between rows and 1 m between plants per row and 3. - at a distance of 1.5 m between rows and 1 m between plants per row.

As biological material, the Mara 21 variety of monoic hemp was used. It is an early variety, with good tolerance to drought, diseases and pests.

The operations in the field consisted in the preparation of the land and the sowing of the hemp crop, according to the proposed scheme. After the emergence of the plants and throughout the vegetation period, maintenance work was carried out whenever necessary.

For biometric measurements and sampling, 10 plants (localized by GPS) were selected and followed throughout the vegetation, until the formation of seeds.

RESULTS AND DISCUSSIONS

Design of the experimental device

The design of the experimental device, according to the work methodology, was initially done in the office stage, in which, in the Google Earth platform and the Autocad 3D Map 2012 software, the layout of the experimental field was identified and the corners of the plots were marked.

In the case of the monoic hemp culture that is the subject of this study, the culture in three blocks was chosen, each with three variants, differentiated by the nutritional space available to the plants. The distances between rows and between plants per row were calculated as follows: variant 1, at 12.5 cm, variant 2, at 100 cm and variant 3, at 150 cm (Figure 4). For example, one of the three experimental blocks will be presented, the work procedures being similar in the case of the other two locations.

Figure 4 The design of the experimental device in the office stage (processed after ANCPI, 2022)

After establishing the distances between the rows, the experimental field was "plotted", starting from the point in the northwest towards the one in the southwest, for each row coordinate points (x, y) were placed. The procedure was repeated for the division of the opposite side.

For subsequent plotting in the field, the points were coded as follows: V1, V2, V3 (variant), -1- (row start), -2 (row end), -1, -2, -3, -4 (row number within each variant).

In the field stage, the file with the coordinate points established in the office was inserted into the GPS receiver and thus these points were identified and marked with wooden stakes. By uniting the pairs of points "face to face", the location of the rows on which the monoic hemp culture was established, resulted in the field. Since the length of the plot was 20 m, constant for all rows, the joining of their two ends was done with string.

Hemp culture monitoring

To monitor the hemp culture, throughout the entire vegetative cycle, the scheme of the experimental device (exemplified for a single block) was used, spatialized in the Stereographic projection system 1970, a scheme designed in the previous stage.

In the field, the plants selected for laboratory analysis were marked by GPS points, which were later superimposed on the scheme of the experimental field (Figure 5).

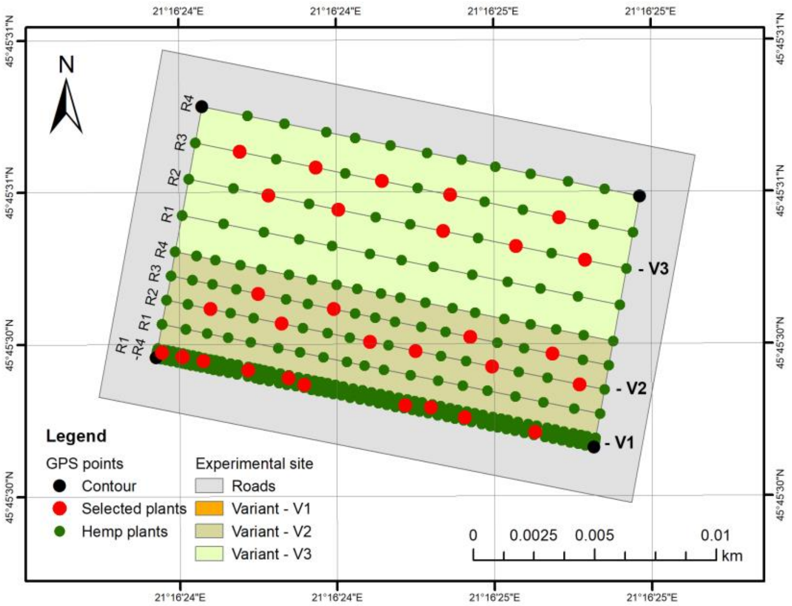

Figure 5 Location of plants selected for laboratory analysis

From each variant, ten plants were selected from the inner rows, to benefit from similar nutritional conditions (GARCÍA-TEJERO ET AL, 2014, CAMPIGLIA ET AL, 2017).

The geographic and stereographic coordinates of the thirty plants selected for analysis and monitoring are summarized in table 1. These coordinates are used to locate the plants, which means that it is possible to return to the same location for sampling in each phenophase.

Completing the geospatial database

Based on the GPS points determined in the field for each selected plant, the graphic and descriptive database (*Attribute Table*) was created and ranked in the ArcGIS software. Initially, in addition to the implicitly generated fields (*FID, Shape, Entity*), the plant identifier (the point number, coded for recognition in the previous stages) and the stereographic coordinates, x (latitude), y (longitude) and z (elevation). Through the automated calculation procedure, the geographic coordinates were also determined for the same points (figure 6). Later, fields were generated in the database for biometric measurements and laboratory analyses, for each plant, in different phenophases.

Table 1

Coordinates of the selected plants

Selected plants	Stereographic coordinates (m)		Geographical coordinates		Elevation (m)
	X	Y	Latitudine	Longitudine	
P1	479921.72920	210202.18630	45°45'30.284"N	21°16'24.641"E	91.765
P2	479923.07541	210196.88144	45°45'30.319"N	21°16'24.393"E	91.754
P3	479924.40907	210192.13417	45°45'30.355"N	21°16'24.170"E	91.806
P4	479924.82437	210190.49763	45°45'30.366"N	21°16'24.094"E	91.744
P5	479924.11689	210192.77737	45°45'30.347"N	21°16'24.201"E	91.795
P6	479932.22728	210196.38601	45°45'30.614"N	21°16'24.350"E	91.728
P7	479931.52155	210199.16693	45°45'30.596"N	21°16'24.480"E	91.781
P8	479922.45776	210199.31536	45°45'30.303"N	21°16'24.506"E	91.723
P9	479922.93508	210197.94256	45°45'30.316"N	21°16'24.442"E	91.754
P10	479925.28889	210188.66713	45°45'30.378"N	21°16'24.008"E	91.785
P11	479925.50390	210187.81989	45°45'30.384"N	21°16'23.969"E	91.714
P12	479925.71695	210186.98032	45°45'30.390"N	21°16'23.929"E	91.785
P13	479927.38117	210189.06035	45°45'30.447"N	21°16'24.022"E	91.803
P14	479927.12420	210194.13790	45°45'30.446"N	21°16'24.257"E	91.784
P15	479925.25767	210197.42818	45°45'30.391"N	21°16'24.413"E	91.812
P16	479924.86383	210203.04505	45°45'30.386"N	21°16'24.674"E	91.759
P17	479924.46720	210200.54309	45°45'30.370"N	21°16'24.559"E	91.792
P18	479926.64632	210191.95611	45°45'30.427"N	21°16'24.157"E	91.783
P19	479927.90387	210191.06555	45°45'30.467"N	21°16'24.113"E	91.699
P20	479925.71369	210199.69615	45°45'30.409"N	21°16'24.517"E	91.741
P21	479923.56432	210204.10095	45°45'30.346"N	21°16'24.725"E	91.801
P22	479925.72873	210195.57193	45°45'30.403"N	21°16'24.326"E	91.738
P23	479931.87378	210191.68161	45°45'30.596"N	21°16'24.133"E	91.751
P24	479932.91379	210193.68078	45°45'30.633"N	21°16'24.223"E	91.814
P25	479931.15175	210194.52680	45°45'30.577"N	21°16'24.266"E	91.768
P26	479929.31484	210201.76524	45°45'30.528"N	21°16'24.605"E	91.778
P27	479930.06853	210198.79529	45°45'30.548"N	21°16'24.466"E	91.794
P28	479930.39695	210203.59848	45°45'30.566"N	21°16'24.687"E	91.793
P29	479928.60246	210204.57241	45°45'30.510"N	21°16'24.736"E	91.749
P30	479933.69987	210190.58320	45°45'30.653"N	21°16'24.079"E	91.788

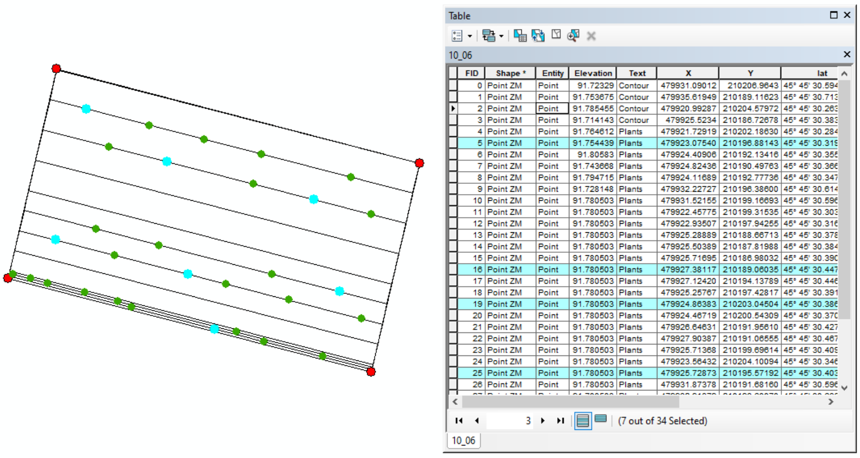

Figure 6 Graphical and descriptive database for the experimental site

Having the graphic, georeferenced representation of the experimental site, it was overlaid with pre-existing geospatial data sets: geological map, climate maps (air temperature and atmospheric precipitation) and pedological map; in this way, through the multilayer analysis, it was possible to frame the area of interest in a physical-geographical context, the subject of further research.

CONCLUSIONS

The case study presented in this paper supports the opportunity of using geomatics techniques in the representation and monitoring of monoic hemp culture.

The application of GNSS technology allowed the localization and spatialization of the experimental device and the sampling points of plant samples, with topographical precision, which ensures the possibility of returning to the same locations, in subsequent observation campaigns.

The use of GIS methods in the representation and spatialization of the experimental device, both as graphic and non-graphical data, has a number of advantages, such as: the possibility of computerized comparison of the results obtained in different phenophases; analysis of crop dynamics, both in a vegetation cycle and in different years, extraction of environmental data from the experimental site (geology, climate data, pedological data, etc.) and cartographic representation of the results.

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