# INFLUENCE OF SOIL AND CLIMATIC CONDITIONON, NUTRITIONAL QUALITY OF SORGHUM (Sorghum bicolor (L.) Moench) VARIETY GROWN IN BUZIAS MICRO- AREA OF ROMANIA

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***Abstract.*** *The study covers the behaviour of sorghum crop cultivated under the soil and climatic conditions of Buzias microzone. The soil type on which sorghum was grown was clay soil. To characterize the climatic conditions with the recorded monthly mean temperatures, data obtained from the Buzias Meteorological Station from 2021-2022 were used compared with the multi-year averages. Method of analysis Sorghum nutritional seed results are as follows: dry substance (92.41-90.33 %), crude protein, (10.97-10.10 %), crude cellulose (5.59-5.69 %), fats (4.87-4.66 %), mineral substances (2.19-2.31 %), carbohydrates rate (66.16-66.89 %), energetic value kcal (352.35-349.9 %). While that of humidity is (10.22-11.35 %). The grain yield achieved was between 2000-3500 kg/ha. Vegetation index values were also recorded by NDVI value ranges from -1 to 1 and shows the vigor of the crop, Misiunea Copernicus SENTINEL-2. Values close to 1: the more intense the green, the more vigorous the vegetation and vegetation cover. From a climatic point of view, the year 2021 was a dry year, with very little rainfall between May and June, which reduced grain production by 50%, although sorghum is a drought-resistant crop. Sorghum for grain is suitable for cultivation on heavy clay and loamy-clay soils, in the conditions of the Buzias area, the crop being a disease-resistant is an added advantage, thus thrive well in the location.*

***Keywords****: Grain sorghum production, chemical composition, vegetation indices, soil and climatic conditions, applied technology*

## INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is cereal crops belonging to the Poaceae family, which is native to Africa, thereafter, spread all over the world. It was then domesticated between thousands years at about 3000 to 5000 years ago (DE MORAIS CARDOSO, *et al.*, 2017). The crop (Sorghum) after wheat, rice, maize, and barley, is set to be the most widely produced grains on the planet (DEVI, *ET AL.*, 2014) and (SAXENA, *ET AL.*, 2018). It provides 329 kcal and 8-16 g protein per 100 g, serves as dual purpose crop providing staple food for human consumption (35%) and the rest as a fodder for livestock, alcohol production and more of industrial products (AWIKA, *ET AL.*, 2014). Sorghum can endure a variety of environmental conditions, including low soil fertility, high temperatures, as well as insufficient rainfall. It is a key staple food crop particularly in arid, hence, the unique plant is a promising crop with a high potential for cultivation in the tropics and semi-arid regions especially in a drought-prone and marginal locations and saline lands, where other crops might fail to thrive, similarly, the crop has the productive response and nutritional value similar to maize (CONTRERAS, *ET AL.*, 2011; Mihut C. et al 2018; REBORA, *ET AL.*, 2018).

World populations keep on increasing with changing diets, therefore, more nutritious foods should be a vital issue. Global food security, intensely focusing on how to grow sufficient food to feed current population. However, world's population is expected to grow to about 10 billion by 2050, boosting agricultural demand in a scenario of modest economic growth rates by 50 percent in comparison with the years 2013 (FAO, 2017). In one way or the other, food is linked with a host of sustainability challenges (BRANCA, *ET AL.*, 2019), (DEKEYSER, *ET AL.*, 2020) and (WILLETT, *ET AL.*, 2019). Thus, serious attention must be given to develop the crop in order to increase the current demand as well as the productivity per unit area and this can be achieved through the use of modern and scientific measures that would have impact on the growth and yield. Therefore, appropriate cultivar system, mineral fertilization, plant density, planting and sowing date etc., All the effect of these factors combined determines the quantity and quality of sorghum yield in addition to its important role in the formation and strengthening of the vegetative and root system of the crop (CHEN, *ET AL.*, 2020).

## MATERIALS AND METHODS

Field trials were carried out during 2021 and 2022 wet seasons at the experimental farm, located in Buzias micro- area of Timișoara, Romania; latitude 45º.65' North and the longitude 21º.60' East. Land preparation included clearing the land from weeds and some of the existing vegetation followed by harrowed twice to break big clods and ensure fine tilth. The land was then marked, demarcated into plots and blocks, and replicated.

The plant materials used were, two different sorghum varieties viz; 105/1 - sorghum variety 1 (red) and 105/2 - sorghum variety 2 (white). Sowing of seed was done on the 25$^{th}$ May, 2021 for the first year, and 4$^{th}$ May, 2022 for the second year of the trial, with a spacing of 75 x 50 cm, and density 100,000 /ha (150-200,000/ha) method of sowing was by dibbling, 3 seeds per hole, the emerged seedlings were later thinned down to 2 plants per stand at 2 weeks after sowing. Inorganic fertilizer was applied at the recommended rate of 300 s.a.kg N, 50 kg $P_2O_5$ and 50 kg $K_2O$ ha$^{-1}$.

The study area was also analyzed based on a remote sensing scene from the Sentinel 2 system taken from the www.planet.com portal (Planet Team (2017). Sentinel 2 images are composed of 13 spectral bands at spatial resolutions between 10 -60m

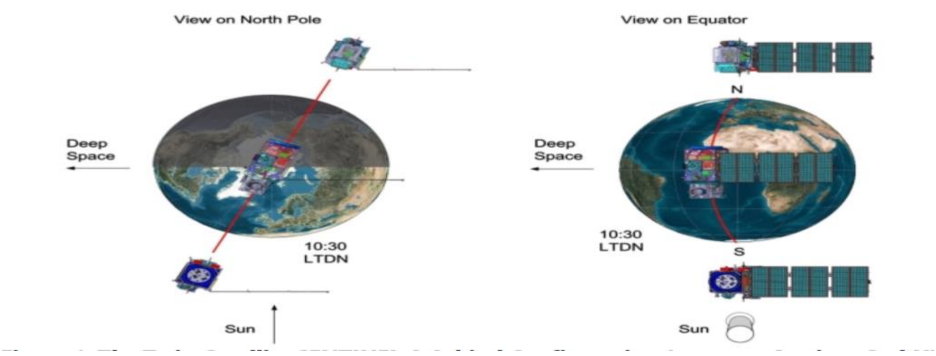


Fig. 1: Sateliții Sentinel 2

| Band | Resolution | Central Wavelength | Description |
|---|---|---|---|
| B1 | 60 m | 443 nm | Ultra Blue (Coastal and Aerosol) |
| B2 | 10 m | 490 nm | Blue |
| B3 | 10 m | 560 nm | Green |
| B4 | 10 m | 665 nm | Red |
| B5 | 20 m | 705 nm | Visible and Near Infrared (VNIR) |
| B6 | 20 m | 740 nm | Visible and Near Infrared (VNIR) |
| B7 | 20 m | 783 nm | Visible and Near Infrared (VNIR) |
| B8 | 10 m | 842 nm | Visible and Near Infrared (VNIR) |
| B8a | 20 m | 865 nm | Visible and Near Infrared (VNIR) |
| B9 | 60 m | 940 nm | Short Wave Infrared (SWIR) |
| B10 | 60 m | 1375 nm | Short Wave Infrared (SWIR) |
| B11 | 20 m | 1610 nm | Short Wave Infrared (SWIR) |
| B12 | 20 m | 2190 nm | Short Wave Infrared (SWIR) |

Fig. 2: Specification of spectral bands for the Sentinel-2 sensor

Based on the spectral bands, 2 indicators were calculated that are specific to the process of precision agriculture and agricultural crop monitoring. These indicators are NDVI (Rouse et al., 1974) and NDMI (Gai, 1996):

- Normalized Difference Vegetation Index (NDVI). This index is a standardized way of measuring healthy vegetation. When there are high NDVI values, the vegetation is healthier, and when the values are low in the land, the vegetation is affected by certain factor

$$NDVI = (\mathrm{NIR} - \mathrm{Red}) / (\mathrm{NIR} + \mathrm{Red}) \qquad (1)$$

-Normalized Difference Moisture Index (NDMI). This index is used to determine the water content of vegetation. It is calculated as the ratio between NIR and SWIR values in the traditional way. The SWIR band reflects changes in both vegetation water content and spongy mesophyll structure in the vegetation canopy, while NIR reflectance is affected by internal leaf structure and leaf dry matter content, but not water content.

$$NDMI = (\mathrm{NIR} - \mathrm{SWIR}) / (\mathrm{NIR} + \mathrm{SWIR}) \qquad (2)$$

The graphical distribution of the NDVI and NDMI indices for the studied area is presented in figure 3.

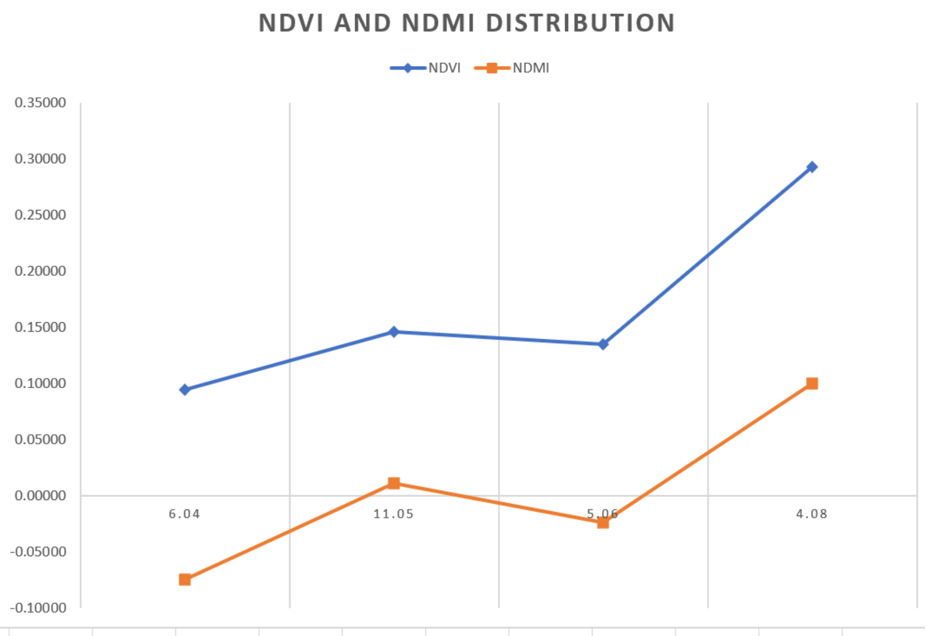


Fig. 3: Graphical distribution of NDVI and NDMI indices.

Fig. 4: Geographical area of the experimental field and crop at Buzias micro- area of Timișoara.

## RESULTS AND DISCUSSION

The samples collected from the research trial were subjected to analytical tests to determine, the nutritional values of the crop, the test was carried out at the university laboratory, Research platform at University of Life Sciences “King Mihai I” from Timișoara, Romania. Moreover, soil samples were analyzed for its physical and chemical properties, using standard procedures. The data of the climatic conditions for the period of the trials were collected from Meteorological service station, Buzias micro- area of Timișoara, Romania. The data obtained from the years 2021-2022 were compared with the multi-year averages (Tables 1& 2). Similarly, the analyzed nutrient composition of the different sorghum varieties is shown in Table 5. Dry substance (92.41-90.33 %), crude protein, (10.97-10.10%), crude cellulose (5.59-5.69%), fats (4.87-4.66 %), mineral substances (2.19-2.31%), carbohydrates rate (66.16-66.89%), energetic value kcal (352.35-349.9%), while that of humidity is (10.22-11.35%). Most of the higher nutrients values were found in white variety than the red varieties. The variations could be associated with the differences in the genetic make-up of the seed thereby exploring its potential after subjected to same soil and climatic condition. Similar observation was also found by (SHEN, *ET AL.*, 2018) who reported that, dry matter content of sorghum, which is an important factor in producing high-nutritional quality for usage. Thus, white sorghum variety, could be the better candidate for silage production, although the white sorghum varieties are more suitable for human consumption. OSMAN, *ET AL.* (2022) also reported that the Fermentation of different hybrids of sorghum in the same cultivated region varied mostly in pH value and protein content without any impact on the laboratory count or L-lactic acid content.

*Table 1.*

Average monthly temperatures recorded in Buzias during 2021-2022 compared to multi-year averages.

| Year | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2021** | -2.3 | -0.8 | 4.9 | 11.7 | 17.0 | 20.2 | 22.8 | 22.3 | 17.5 | 11.2 | 4.6 | -0.7 |
| **2022** | -2.1 | -2.8 | 5.3 | 11.9 | 16.5 | 20.4 | 22.5 | 22.1 | 17.4 | 10.9 | 4.3 | -1.0 |
| **Annual averages** | -2.20 | -1.80 | 5.10 | 11.80 | 16.75 | 20.30 | 22.65 | 22.20 | 17.45 | 11.05 | 4.45 | -0.85 |

*Table 2.*

Average monthly precipitation recorded at Buzias Meteorological Station in the period 2021-2022 compared to multi-year averages

| Year | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2021 | 36.6 | 41.2 | 39.8 | 52.1 | 64.3 | 68.5 | 47.6 | 42.3 | 41.6 | 39.8 | 40.7 | 50.9 |
| 2022 | 42.5 | 32.7 | 42.8 | 53.6 | 63.2 | 63.4 | 42.1 | 43.7 | 38.9 | 41.5 | 49.8 | 45.6 |
| Annual averages | 39.55 | 36.25 | 41.30 | 52.85 | 63.75 | 65.95 | 44.85 | 43.00 | 40.25 | 40.65 | 45.25 | 48.25 |

*Table 3.*

The physical-chemical analysis (physico-chemical exam - relative to air-dried soil)

| Internal sample code | **Sample code HARVEST | Determination of pH - in aqueous suspension soil: water ratio 1:2.5 | | Determination of humus | Determination of total nitrogen | Determination of mobile phosphorus in Al (P) | Determination of mobile potassium in Al (K) |
|---|---|---|---|---|---|---|---|
| | | Wave, object, | Tempe | | | Recalculation in fact, pH | |
| Unit of measurement | | Unit.pH | C _ | % | % | ppm | Ppm |
| 7061 | Pleșa 2- dam | 6.17 | 19.5 | 2.62 | 0.13 | 6.98 | 185 |
| 7062 | Baldness 4 | 5.52 | 19.5 | 2.74 | 0.15 | 3.70 | 127 |
| The reference document | | MR 7184-13:2001/PS-03 | | STAYS 7184/21-82/ PS-01 | STAYS 7184/2-85/PS-08 | STAYS 71824/19-82/PS-02 | STAYS 7184/18-80/PS-06 |

***Source:*** *"OSPA-USAMVBT" laboratory - Timișoara (BA 5065/22.11.2022)*
*Note1: "Tests marked (*) are **NOT** covered by RENAR accreditation, for additional details please request the accreditation certificate at ospatim@gmail,com_".*
*Note 2: ** Information provided by the customer.*

*Table 4.*

Nutritional composition of sorghum and other cereals (per 100 g)

| Commodities | Moisture (%) | Protein (%) | Fat (%) | Carbohydrate (%) | Ash (%) | Energy (Kcal) |
|---|---|---|---|---|---|---|
| Milled rice | 11.5 | 8.4 | 1.7 | 77.1 | 1.3 | 357 |
| Yellow corn | 11.4 | 9.8 | 7.3 | 69.1 | 2.4 | 366 |
| Millet | 11.9 | 9.7 | 3.5 | 73.4 | 1.5 | 364 |
| Wheat | 11.8 | 9.0 | 1.0 | 77.2 | 1.0 | 333 |
| **Sorghum** | **11.0** | **11.0** | **3.3** | **73.0** | **1.7** | **366** |

*Source: Nutricheck (2021), To cite the article: S Widowati and P Luna 2022 IOP Conf. Ser.: Earth Environ. Sci. 1024 012031*

*Table 5.*

Analyzed nutrient composition of the different sorghum varieties

| Sample | Humidity (%) | Dry substance (%) | Crude protein (%) | Crude cellulose (%) | Fats (%) | Mineral substances (%) | Carbohydrates (%) | Energetic value Kcal (%) |
|---|---|---|---|---|---|---|---|---|
| Method | SR EN ISO 712:2010 | From the calculation | | SR ISO 2171:2002 | SR EN ISO 11085:2016 | SR EN ISO 20483:2007 | From the calculation | From the calculation |
| 105c/1 | 10.22 | 92.41 | 10.97 | 5.59 | 4.87 | 2.19 | 66.16 | 352.35 |
| 105c/2 | 11.35 | 90.33 | 10.10 | 4.69 | 4.66 | 2.31 | 66.89 | 349.9 |

*Source: University laboratory Research platform, at University of Life Sciences "King Mihai I" from Timişoara, Romania.*

Sorghum is a promising crop with a high potential for cultivation in southern arid, marginal, and saline lands. The studied varieties reacted differently to the type of soil of the environment. Similarly, varieties of sorghum quite actively indicating the favorable conditions for plant growth. Moreover, according to the accumulation of biomass in the aboveground organs, the used of this varieties (105c 1 and 105c 2) were productive, where the grain yield achieved was between 2000-3500 kg/ha. The findings are similar to the research conducted (NEMUKONDENI, *ET AL.*, 2022) who reported that a substantial amount of nutritional elements, amino acids, minerals and possess nutraceutical potentials as demonstrated by the content of valuable phenolic compounds. However, there are limitation in the development of sorghum as a food product due to tannins. These tannin content causes a slightly bitter taste and less desirable colour, sometimes it's less preferred by consumers. WIDOWATI, *ET AL.* (2020) and DERIBE, *ET AL.* (2020). Tannins also have anti-nutritional properties because they can inhibit the digestibility of protein and carbohydrates (SUARNI *ET AL.*, 2012).

## CONCLUSIONS

Based on the results obtained from the study, it concluded that, sorghum is a genetically diverse crop; this variety includes nutrient levels and composition, the red sorghum variety (105c 1) and performed similar to that of the white sorghum variety (105c2), although, both possess good potentials for nutritional value in sorghum grain. The research supports the continued strategy of evaluating sorghum for additional nutritional properties, minerals and some essentials elements. The study also provides an opportunity for future research to be explored concerning sorghum variety. Similarly, soil and meteorological conditions, and off course the stage of plant maturity at harvest could all have an impact on the variations in nutrition, amino acid content between locations.

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