EXPERIMENTAL RESEARCHES ON THE WORKING QUALITATIVE INDEXES OF TECHNICAL EQUIPMENT FOR HARVESTING MISCANTHUS RHIZOMES

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ABSTRACT

The article presents the results of experimental research of the technical equipment for harvesting Miscanthus rhizomes, in order to determine the following working qualitative indexes: the percentage of extractedrhizomes, the degree of rhizome damage, rhizome losses at harvesting, the content of impurities in the mass of rhizomes and the degree of separation of extracted rhizomes. The results obtained in the experimental researches help improving the equipment for harvesting Miscanthus rhizomes in order to meet the quality requirements of the work.

Experimental researches were carried out under field conditions, on the experimental plot of INMA Bucharest, the development stage of energy plant Miscanthus being in the 7th year of growing.

INTRODUCTION

Within the renewable energy sources, energy cultures represent one of the most attractive options to replace fossil fuels. Currently, energy from biomass represents 10-12% of total energy consumption for heating and cooking food.

Miscanthus culture plays an important role for the production of heat and bioethanol. A hectare of Miscanthus can produce an average amount of 23 ... 25 tons of biomass with a humidity of 10 ... 16% and a calorific value equivalent to 14 tons of coal and 10 tons of oil. Miscanthus is one of the most efficient cultures. Net calorific value, relative to the dry biomass is 17 MJ/kg or 4.75 kWh/ kg. [1]

Energy plant Miscanthus has a significant potential for our country, taking into account that Romania has an agricultural potential that is not totally exploited and in rural areas the main source of heating during winter is the woody biomass, coming from forest areas under extinction. Rhizome harvesting is a determining factor in terms of quality of the seedling material used for the establishment of a new culture. [1, 3, 5] This operation must ensure obtaining a biological material without mechanical damage for maintaining viability during its transport and storage.

Brown rhizomes (Fig. 1) are irregularly shaped, with protuberances and even pronounced branches, their thickness varying between 7 and 12 mm.

Fig. 1 – Miscanthus rhizomes

In most cases, for harvesting the seedling material are used other machines destined to harvest other crops such as potatoes and onions by adapting various constructive solutions with less satisfying results in terms of seedling material quality and energy consumption for the harvesting work. However, there are specialized machines to extract the seedlings or other plants that can be successfully used to extract Miscanthus rhizomes. Worldwide, a well-known company is Egedal (Denmark); it produces displacement equipment of RR and SR-2 range, adapted for Miscanthus plant. [1]

MATERIAL AND METHOD

The experiments under field conditions, to determine working qualitative indexes of the technical equipment for harvesting Miscanthus rhizomes, were performed on the experimental plot of INMA Bucharest (fig. 2).

Fig. 2 – ERR equipment used in experiments **[3]**

ERR technical equipment for harvesting Miscanthus rhizomes (fig. 3) is used within the technology of Miscanthus rhizomes capitalization and works in aggregate with 70 ... 80 HP tractor, consisting of: frame, eccentric separator, displacement ploughshare, two wheels (left and right) and hydraulic motor.

The displacement process consists in deep loosening of soil without turning it over, destruction of the links between soil and rhizomes and pushing them upward toward the oscillating grates which, by sieving, separate the rhizomes of impurities and dirt and leave them on the ground in furrow to be loaded into the transportation means. [2, 3, 4]

Fig. 3 – Technical equipment for harvesting Miscanthus rhizomes ERR

Characteristics of Miscanthus culture where the tests were performed are listed in Table 1.

Table 1 [3]

Characteristics of Miscanthus culture	UM	Value
Stage of development	-	Miscanthus after the 7th year of growing
Distance between rows when culture is established	cm	80
Height of vegetable remains after harvesting	cm	15...20
Maximum depth at the bottom of rhizomes	cm	15

Measuring equipment and devices used for testing

Measuring and control equipment and devices used to determine the work qualitative indexes of the technical equipment for harvesting Miscanthus rhizomes are the following:

- for size: 3m measuring tape, 8m measuring tape, 60m measuring tape;
- for weight: METTLER PM 6000 electronic balance (fig. 4), mechanical balance with measuring range from 1 to 150 kg (fig. 5);

Fig. 4 – Precision electronic balance METTLER PM 6000

Fig. 5 – Mechanical balance with measuring range from 1 to 150 kg;

- digital electronic penetrometer with FIELDSCOUT SC 900 cone (fig. 6) measures the resistance force at cone penetration in soil layers (expressed in pressure units kPa) with the help of an electronic force transducer and the depth (position) of cone penetration in the soil by using a position sensor (level sensor) with ultrasound generator.

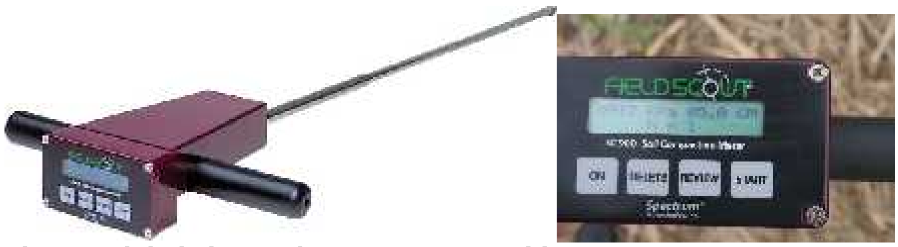

Fig. 6 – Digital electronic penetrometer with FIELDSCOUT SC 900 cone

- soil capacitive humidometer FIELDSCOUT TDR 300 (fig. 7) is designed for monitoring and recording soil humidity and includes “data logger” functions (storage/data processing). It can be used for any type of soil, in any climate conditions.

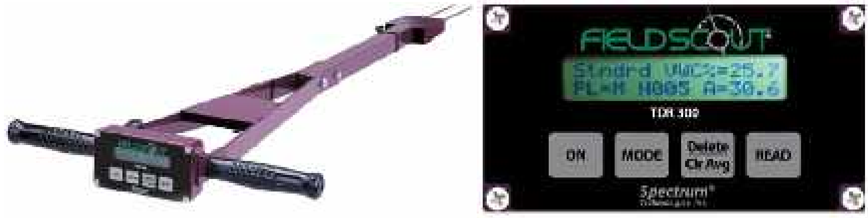

Fig. 7 – Soil capacitive humidometer FIELDSCOUT TDR 300

RESULTS AND DISCUSSIONS

Following the experimental researches to determine soil characteristics and working qualitative indexes, the following results were obtained:

- *soil humidity* (Table 2)

Table 2

Characteristic	**Tests**			**Average**
Soil humidity at different depths, %	**Test 1**	**Test 2**	**Test 3**	
0 - 5 cm	23.3	23.9	22.8	23.33
5 – 10 cm	33.2	31.3	31.7	32.06
10 – 15 cm	39.9	32.5	37.3	36.56
15 – 20 cm	42.1	35.9	40.6	39.53
20 – 25 cm	41.9	36.2	40.4	39.50

- *soil resistance to penetration* – penetration tension values, determined by penetrometer, are listed in kPa. Thus, to express penetration resistance force, the following formula is used:

$$F = \pm \cdot S$$

where F is the penetration resistance force, in N;

σ – penetration tension, MPa;

S – the area of cone base section mounted at the top of the penetrometer rod, mm^2.

(cone base area d=12.7 mm, $S = \frac{® \cdot d^2}{4}$)

This way the values of penetration resistance force are obtained. They are illustrated in table 3.

Table 3

Characteristic	**Tests**			**Average**
Soil penetration resistance force at different depths, N	**Test 1**	**Test 2**	**Test 3**	
5 cm	145.58	115.52	124.52	128.54
10 cm	240.17	249.04	204.58	231.26
15 cm	271.21	244.61	273.42	263.08
20 cm	204.58	177.85	185.55	189.32
25 cm	293.89	301.49	275.64	290.34

- *percentage of extracted rhizomes* – after one pass of the machine, on a surface of 1 m^2 the total displaced mass is collected, containing the mass of extracted rhizomes (cleaned rhizomes and impurities) and earth, stones, vegetable remains harvested together with the rhizomes. On the same surface, the rhizomes remained in the soil are harvested manually. Total displaced mass, the mass of extracted rhizomes (cleaned rhizomes and impurities) and the rhizomes that remained in the soil are weighed.

Total displaced mass is formed of extracted rhizomes mass and the mass of earth, stones and vegetable remains harvested together with the rhizomes

$$m_{td} = m_{rd} + m_p$$

where m_{rd} is extracted rhizomes mass;

m_p – mass of earth, stones and vegetable remains harvested together with the rhizomes.

$$m_{rd} = m_{rc} + m_i$$

where m_{rc} is cleaned rhizomes mass;

m_i – impurities mass.

The percentage of extracted rhizomes was determined using the following formula:

$$P_d = \frac{m_{rc}}{m_{rc} + m_s} \cdot 100 \ [\%]$$

where m_s is the mass of rhizomes that remained in the soil;

- *damage degree* (G_V) - was determined using the formula:

$$G_V = \frac{m_V}{m_{rc}} \cdot 100 \ [\%]$$, where m_V – damaged rhizomes mass

while the percentage of seriously damaged rhizomes was determined using the formula:

$$P_{GV} = \frac{m_{GV}}{m_{rc}} \cdot 100 \ [\%]$$

- *rhizomes losses at harvest (P)* – of the total rhizome production (extracted rhizomes m_{rd} and rhizomes that remained in the soil m_s) were considered as losses the un-extracted rhizomes (remained in the soil) and those seriously damaged during the harvesting process, according to the formula:

$$P = (100 - P_d) + \frac{m_{GV}}{m_{rc} + m_S} \cdot 100 \qquad [\%]$$

- *content of impurities in harvested rhizomes mass (C_i)* – to determine it, clean rhizomes and the impurities mass (earth, stones and the vegetable remains harvested together with the rhizomes) were weighed. To establish the content of impurities, the test displaced mass (cleaned rhizomes mass and impurities mass) represent 100% and separate fractions report to it.

$$C_i = \frac{m_i}{m_{rd}} \cdot 100 = \frac{m_i}{m_{rc} + m_i} \cdot 100 \ [\%]$$

- *extracted rhizomes separation degree (G_s)*

$$G_s = \frac{m_{rc}}{m_{rd}} \cdot 100 = \frac{m_{rc}}{m_{rc} + m_i} \cdot 100 \ [\%]$$

Values obtained from measurements are presented in Table 4.

Table 4

Working depth, cm	**Working speed [Km/h]**	**Total displaced mass m_{td} [kg]**	**Extracted rhizomes mass m_{rd} [kg]**	**Mass of earth, stones and vegetable remains m_p [kg]**	**Cleaned rhizomes mass m_{rc} [kg]**	**Impurities mass m_i [kg]**	**Damaged rhizomes mass m_v [kg]**	**Seriously damaged mass m_{gv} [kg]**	**Mass of rhizomes that remained in the soil m_s [kg]**
15 cm	3.2	120.9	12.9	108	6.8	6.1	0.12	0.03	0.1

Working qualitative indexes are presented in Table 5.

Table 5

Working depth, cm	Working speed [Km/h]	Percentage of extracted rhizomes P_d [%]	Damage degree G_V [%]	Percentage of seriously damaged rhizomes, P_{GV} [%]	Rhizomes losses at harvest P [%]	Content of impurities in extracted rhizomes mass C_i [%]	Separation degree of extracted rhizomes G_s [%]
15 cm	3.2	98.55	1.76	0.44	1.88	47.28	52.71

CONCLUSIONS

For obtaining a well-established culture, a high quality seedling material is a must. Rhizomes must be taken from the fields cultivated with Miscanthus especially aimed to obtain biologic material and young plants must be harvested, not plants coming from a late, aged crop.

Using specialised harvesting machines reduces rhizomes mechanical damage degree this way ensuring their increased viability.

Natural compaction of field and plants' root system expanding due to culture mature stage, identified at crops longer than 3 years make the harvest slower, leading to lower qualitative indexes, increased fuel consumption and accelerated wear of active parts of rhizomes harvesting machines. This shortcoming was noticed during the experimental researches, mostly due to the fact that the crops, cultivated on the experimental plot research were performed on, were in their 7th year of growing.

Plants' root system expanding did not allow a higher working speed during the trialswhich led to a worsening of the separation process during technical equipment technological flow.

BIBLIOGRAPHY

1. **Postelnicu, E., Sorică, C., Grigore, I., Ludig, M., Niţu, M.**, 2012 - *Methods for obtaining seedling material in order to promote energy plant Miscanthus*, Annals of University of Craiova, series Agriculture – Mountain Agriculture – Lands and Surveys, Volume XLII 2012/2, page 419-423, Craiova,*http://cis01.central.ucv.ro/analele_universitatii*;

2. **Sorică, C., Voicu, E., Manea, D.**, 2009 –*Technology for promotion in Romania of energy crop Miscanthus, as renewable resource to increase energy competitiveness in independence purposes*– in INMATEH Journal. No. 29 (2009-III), page 19-26, Bucharest, ISSN 1583-1019, *http://www.inma.ro/inmateh*;

3. **Sorică, E.**, (2015), *Experimental research on technical equipment for harvesting Miscanthus rhizomes,* Papernr. 5, Doctoral School.

4. **Voicu, E.**, et al., 2009 - *Alternative energies based on superior capitalization of Miscanthus plant and of biomass in Austria*,AGRICULTURE MECHANIZATION Journal, No. 1, Bucharest;

5.**Voicu, E., Pirnă, I., Ciurel, G., Chiţoiu, M., Brkic, M.**, 2010 - *Researches on harvesting of Miscanthus crop with the forage harvester*, in INMATEH Journal, No. 32 (2010-III), page 37-42, Bucharest, ISSN 1583-1019, *http://www.inma.ro/inmateh*.