

## INFLUENCE OF SOME TECHNOLOGICAL FACTORS ON GRAIN SORGHUM (*Sorghum bicolor* (L.) MOENCH VAR. *Eusorghum*) YIELD GROWN UNDER THE CONDITIONS OF SOUTHEASTERN ROMANIA

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### Abstract

Our research was aimed to analyse the behavior of the grain sorghum (*Sorghum bicolor* L. Moench var. *Eusorghum*) grown under the ecological conditions of Southeastern Romania (Moara Domneasca, Ilfov county), and to assess its yield potential.

Research was based on a split plot experiment where the following factors were analyzed: Factor A – grain sorghum hybrids with three graduations - Alize, Aquilon, Arack, Factor B - distance between rows with two graduations – at 70 cm and 50 cm, Factor C - fertilization treatments with 10 graduations –  $N_0P_0K_0$  (Control),  $N_{60}P_0K_0$ ,  $N_{90}P_0K_0$ ,  $N_{120}P_0K_0$ ,  $N_{90}P_{60}K_0$ ,  $N_{90}P_{60}K_0$ +foliar fertilization,  $N_{90}P_{60}K_{60}$ ,  $N_{90}P_{60}K_{60}$ +foliar fertilization,  $N_{120}P_{60}K_0$ ,  $N_{120}P_{60}K_{60}$ .

In the field conditions of the 2013-2014 agricultural year, grain sorghum crop produced a total average biomass (September, 2014) that varied from 26.59 t/ha in the hybrid Arack to 26.70 t/ha in the hybrid Alize at 70 cm distance between rows, and between 26.71 t/ha in the hybrid Alize and 27.75 t/ha in the hybrid Arack at the distance of 50 cm between rows. Depending on the fertilization rates, the total biomass at 70 cm between rows ranged from 19.18 t/ha in the hybrid Arack unfertilized to 31.69 t/ha in the hybrid Aquilon fertilized  $N_{120}P_{60}K_{60}$ +fertilization during the vegetative period. At the distance of 50 cm between rows the total biomass according to the fertilization rates varied between 19.14 t/ha in the hybrid Alize unfertilized and 31.77 t/ha in the hybrid Aquilon fertilized  $N_{120}P_{60}K_{60}$ +fertilization during the vegetative period.

The average grain yield for the three hybrids, depending on the fertilization rates, varied from 6 t/ha (Ct) to 10.6 t/ha ( $N_{120}P_{60}K_{60}$ +fertilization during the vegetative period) for the distance of 70 cm between rows and from 6.2 t/ha (Ct) and 10.4 t/ha ( $N_{120}P_{60}K_{60}$ +fertilization during the vegetative period) for the distance of 50 cm between rows.

**Key words:** *Sorghum bicolor* L. Moench, hybrid, fertilization, total biomass, grain yield.

### INTRODUCTION

Sorghum is a species with a good ecological plasticity, being grown worldwide in the semi-arid areas of Southeastern Asia, India and Australia, but also in areas with a warm temperate climate like Central America and Europe where sorghum crop is common in countries like Italy and France. According to FAO (Food and Agriculture Organization of the United Nations), in 2013 sorghum was cultivated on an area of approximately 42.2 million ha worldwide, the recorded yield being 62.3 million tones. In Europe, in 2013 sorghum yield was approximately 1.3 million tones, while the area harvested was almost 393 thousand ha. Sorghum crops are important owing to both the plant's tolerance to drought

and higher temperatures (Kebede, 2001; Wenzel, 2001) and its multiple usage, ranking fifth among the cultivated global grains (Dahlberg, 2011). Worldwide sorghum is used mostly as fodder in USA and Australia, as food in Africa, India, China, and Central America and in the food and light industry (starch production, alcohol and beer production).

In the Romanian agricultural conditions sorghum crop is important due to the plants efficiency in using natural resources. Sorghum has high yields in ecological conditions less favourable to other grain crops, characterized by poor soils and in areas affected by drought and intense heat (Antohe, 1981; Antohe, 2002; Draghici, 2007). In Romania sorghum grains

may be used as fodder and in different branches of food industry (Racolța, 2006).

Research conducted in USA demonstrated that production technology factors – crop rotation and fertilization (Varvel, 2000; Espinoza, 2005; Kaye, 2007), plant density (Schatz, 1990) and the distance between rows (Fernandez, 2012) – have a significant influence on sorghum yields.

In Romania, previous research attempted to ascertain grain sorghum hybrids yield (*Sorghum bicolor* (L.) Moench var. *Eusorghum*) considering the influence of the restrictive climatic and soil conditions (Mureșan, 1962; Antohe, 2002; Drăghici, 2007; Matei, 2011) and the results obtained varied under the influence of the testing factors (fertilization, crop rotation, distance between rows, plants density).

## MATERIALS AND METHODS

Our research was aimed to analyse the yield potential for certain grain sorghum hybrids (*Sorghum bicolor* (L.) Moench var. *Eusorghum*) cultivated in the climatic and soil conditions of Southeastern Romania, under the influence of different fertilizers rates and different row spacing distances.

The paper comprises results of the research conducted in the 2013-2014 agricultural year, at the Experimental Field of Moara Domnească Didactic Farm (Ilfov County), belonging to the University of Agronomic Sciences and Veterinary Medicine of Bucharest; the soil was chromic luvisol.

The experimental design was based on the split plot method with four replications. In the study area the following factors were tested:

- Factor A - grain sorghum hybrids, with three graduations: Alize (FAO group 380-400), Aquilon (FAO group 390-400), Arack (FAO group 400-420).
- Factor B - sowing distances between rows with two graduations: 70 cm and 50 cm;
- Factor C - fertilization treatment with ten graduations:  $N_0P_0K_0$  (Control),  $N_{60}P_0K_0$ ,  $N_{90}P_0K_0$ ,  $N_{120}P_0K_0$ ,  $N_{90}P_{60}K_0$ ,  $N_{90}P_{60}K_0 + Hortifor$ ,  $N_{90}P_{60}K_{60}$ ,  $N_{90}P_{60}K_{60} + Hortifor$ ,  $N_{120}P_{60}K_0$ ,  $N_{120}P_{60}K_{60}$ .

Wheat (*Triticum aestivum* L.) was the previous crop grown before the grain sorghum (*Sorghum*

*bicolor* L. Moench var. *Eusorghum*) crop. Tillage consisted in a 20 cm deep plowing in autumn, and bedding one day before sowing at 5-6 cm depth, using a pre-sowing combinator.

Grain sorghum hybrids were sown on the 2<sup>nd</sup> of May and harvested on the 16<sup>th</sup> of September, 136 days after sowing. The sowing-machine SPC 6 was used for sowing sorghum hybrids at 70 cm distance between rows and the sowing-machine SPC 7 was used for the 50 cm rows spacing distance. Plant density at sowing was 270 thousand sprouting seeds/ha.

Weeds were controlled pre-emergence using the herbicide Dual Gold (1.5 l/ha) and after emergence using Dicopur (1 l/ha). The control of *Tanymecus dilacotillis* was done using the insecticide Calypso in a dose of 150 ml/ha. During the vegetative stage sorghum crop was mechanically hoed twice. Fertilizers doses were applied when preparing the research field for sowing and during the vegetative stages (36 days after sowing) at the treatment with 120 kg/ha N (90 kg/ha at bedding + 30 kg/ha during the vegetative stages). Foliar fertilization was done by applying two treatments with the commercial product Hortifor, using a dose of 2.5 kg/ha. The foliar fertilization treatments were applied at 36 day after sowing and 67 days after sowing.

## RESULTS AND DISCUSSIONS

### *Climatic conditions, Moara Domnească, 2014*

Climatic conditions of the 2013-2014 agricultural year (Table 1) varied compared to the normal climatic conditions of the area.

Table 1. Climatic conditions at Moara Domnească, Ilfov County in the 2013-2014 agricultural year

| Month                   | Temperature (°C) |        | Rainfall (mm) |        |
|-------------------------|------------------|--------|---------------|--------|
|                         | 2013-2014        | Normal | 2013-2014     | Normal |
| October                 | 14.0             | 11.0   | 81.7          | 35.8   |
| November                | 8.3              | 5.3    | 17.6          | 40.6   |
| December                | -0.2             | 0.4    | 1.2           | 36.7   |
| January                 | -0.5             | -3.0   | 33.2          | 30.0   |
| February                | 1.2              | -0.9   | 7.6           | 32.1   |
| March                   | 8.9              | 4.4    | 37.3          | 31.6   |
| April                   | 13.4             | 11.2   | 116           | 48.1   |
| May                     | 19.3             | 16.5   | 88.0          | 67.7   |
| June                    | 19.9             | 20.2   | 113.0         | 86.3   |
| July                    | 22.8             | 22.1   | 38.0          | 63.1   |
| August                  | 24.1             | 21.1   | 26.2          | 50.5   |
| September               | 18.4             | 17.5   | 60.6          | 33.6   |
| Avg/Sum Oct. – Sept.    | 12.5             | 10.5   | 620.4         | 556.1  |
| Avg/Sum 02 May-15 Sept. | 21.3             | 20.0   | 291.0         | 284.4  |

Between May and August rainfall values were close to the normal standard of the area but recorded a different distribution.

The average temperatures registered between the 02<sup>nd</sup> of May and the 15<sup>th</sup> of September (Figure 1) exceeded the average multiannual values by 1.3°C and ensured the required useful thermal units ( $t > 6^{\circ}\text{C}$ ) of 1850°C for the grain sorghum hybrids, the amount of temperature degrees ( $t > 6^{\circ}\text{C}$ ) during the vegetative stages being 2083.9°C.

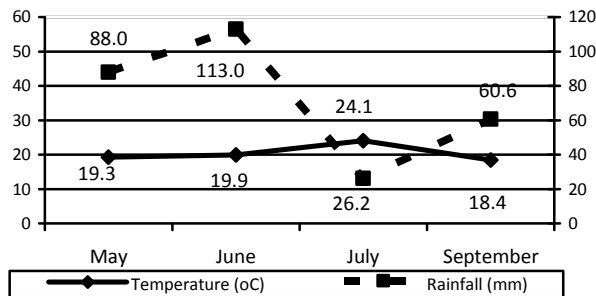


Figure 1. Climatic conditions between 02 May and 15 September 2014, Moara Domneasca

### Total fresh biomass yield

Data regarding the total fresh biomass yield for the three analyzed grain sorghum hybrids sown at 70 cm distances between rows are presented in Table 2. Total fresh biomass yield varied from 19.18 t/ha for in the unfertilized hybrid Arack to 31.69 t/ha for the hybrid Aquilon fertilized  $\text{N}_{120}\text{P}_{60}\text{K}_{60}$ . On average for the three grain sorghum hybrids, grain yield represented between 29.7% and 35.7% of the total fresh biomass yield, and the secondary fresh biomass yield represented between 64.3% and 70.3% of the total fresh biomass yield.

The hybrid Alize, grown both at 70 cm between rows sowing distance (Table 2) and at 50 cm between rows sowing distance (Table 3), recorded the highest share of secondary fresh biomass in the total fresh biomass yield at harvest and by default the lowest share of the grain yield.

Table 2. Total fresh biomass yield (TFB t/ha) at 70 cm sowing distance between rows, Moara Domneasca, September 2014

| Treatment   | Alize        |              |             |             | Aquilon      |              |             |             | Arack        |              |             |             | Average hybrids |              |             |             |
|---|--------------|--------------|-------------|-------------|--------------|--------------|-------------|-------------|--------------|--------------|-------------|-------------|-----------------|--------------|-------------|-------------|
|   | TFB t/ha     | TFB %        | SFB %       | GY %        | TFB t/ha     | TFB %        | SFB %       | GY %        | TFB t/ha     | TFB %        | SFB %       | GY %        | TFB t/ha        | TFB %        | SFB %       | GY %        |
| $\text{N}_0\text{P}_0\text{K}_0$                            | 20.76        | 100.0        | 70.1        | 29.9        | 20.72        | 100.0        | 70.1        | 29.9        | 19.18        | 100.0        | 70.8        | 29.2        | 20.22           | 100.0        | 70.3        | 29.7        |
| $\text{N}_{60}\text{P}_0\text{K}_0$                         | 23.70        | 100.0        | 67.4        | 32.6        | 24.08        | 100.0        | 67.3        | 32.7        | 22.82        | 100.0        | 68.0        | 32.0        | 23.53           | 100.0        | 67.6        | 32.4        |
| $\text{N}_{90}\text{P}_0\text{K}_0$                         | 24.88        | 100.0        | 64.9        | 35.1        | 25.87        | 100.0        | 64.5        | 35.5        | 24.63        | 100.0        | 64.5        | 35.5        | 25.12           | 100.0        | 64.6        | 35.4        |
| $\text{N}_{120}\text{P}_0\text{K}_0$                        | 25.69        | 100.0        | 64.9        | 35.1        | 26.55        | 100.0        | 64.3        | 35.7        | 25.98        | 100.0        | 64.1        | 35.9        | 26.07           | 100.0        | 64.4        | 35.6        |
| $\text{N}_{90}\text{P}_{60}\text{K}_0$                      | 26.40        | 100.0        | 65.1        | 34.9        | 27.56        | 100.0        | 63.2        | 36.8        | 26.55        | 100.0        | 64.5        | 35.5        | 26.84           | 100.0        | 64.3        | 35.7        |
| $\text{N}_{90}\text{P}_{60}\text{K}_0 + \text{Hortifor}$    | 27.35        | 100.0        | 65.7        | 34.3        | 28.19        | 100.0        | 63.7        | 36.3        | 26.99        | 100.0        | 64.7        | 35.3        | 27.51           | 100.0        | 64.7        | 35.3        |
| $\text{N}_{90}\text{P}_{60}\text{K}_{60}$                   | 28.29        | 100.0        | 66.4        | 33.6        | 28.71        | 100.0        | 64.0        | 36.0        | 27.98        | 100.0        | 65.1        | 34.9        | 28.33           | 100.0        | 65.2        | 34.8        |
| $\text{N}_{90}\text{P}_{60}\text{K}_{60} + \text{Hortifor}$ | 29.14        | 100.0        | 66.2        | 33.8        | 30.15        | 100.0        | 65.0        | 35.0        | 29.42        | 100.0        | 65.3        | 34.7        | 29.57           | 100.0        | 65.5        | 34.5        |
| $\text{N}_{120}\text{P}_{60}\text{K}_0$                     | 30.24        | 100.0        | 67.3        | 32.7        | 31.00        | 100.0        | 65.5        | 34.5        | 30.79        | 100.0        | 66.0        | 34.0        | 30.68           | 100.0        | 66.3        | 33.7        |
| $\text{N}_{120}\text{P}_{60}\text{K}_{60}$                  | 30.58        | 100.0        | 67.5        | 32.5        | 31.69        | 100.0        | 64.9        | 35.1        | 31.59        | 100.0        | 65.9        | 34.1        | 31.29           | 100.0        | 66.1        | 33.9        |
| <b>Average</b>  | <b>26.70</b> | <b>100.0</b> | <b>66.5</b> | <b>33.5</b> | <b>27.45</b> | <b>100.0</b> | <b>65.2</b> | <b>34.8</b> | <b>26.59</b> | <b>100.0</b> | <b>65.9</b> | <b>34.1</b> | <b>26.92</b>    | <b>100.0</b> | <b>65.9</b> | <b>34.1</b> |

TFB – Total Fresh Biomass = Secondary Fresh Biomass at harvest (SFB) + Grain Yield (GY) at STAS humidity (14%)

The average secondary fresh biomass yield of the three grain sorghum hybrids (Figure 2),

ranged between 14.21 t/ha for the control and 20.67 t/ha for the treatment  $\text{N}_{120}\text{P}_{60}\text{K}_{60}$ .

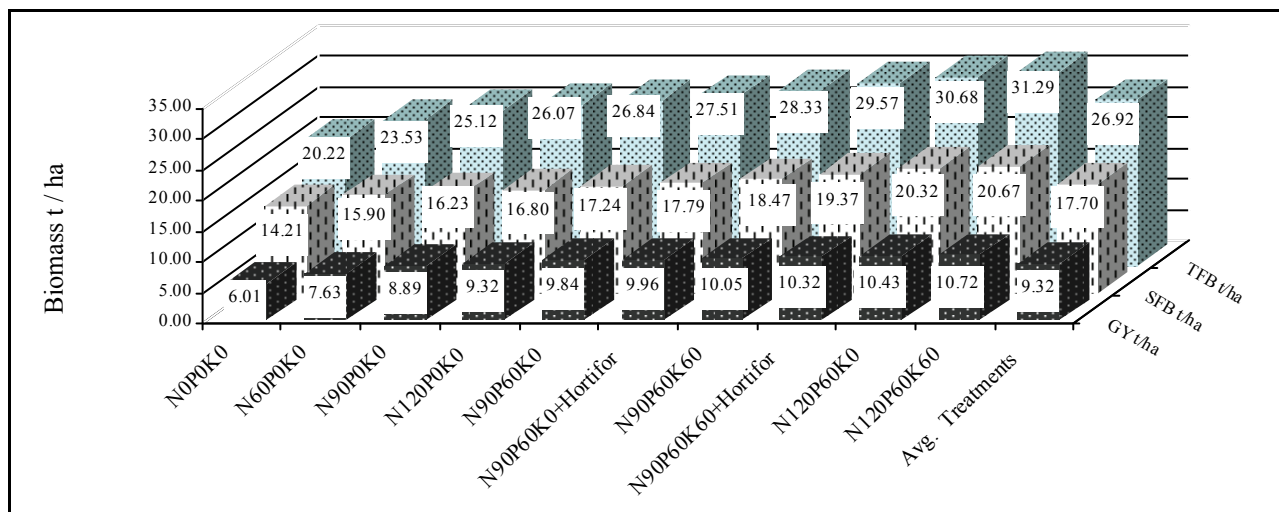


Figure 2. Total fresh biomass (TFB t/ha) production structure, average of three sorghum hybrids sown at 70 cm between rows, Moara Domnească, 2014

For the sowing distance of 50 cm between rows (Table 3), the hybrid Alize recorded the lowest total fresh biomass yield of 19.14 t/ha at Control treatment, while Aquilon fertilized N<sub>120</sub>P<sub>60</sub>K<sub>60</sub> had the highest total fresh biomass yield of 31.77 t/ha, of which grain yield had a share of 32.9%.

The average grain yield of sorghum hybrids sown at the distance of 50 cm between rows varied between 31.4% and 33.1% of the average total fresh biomass yield. The average secondary fresh biomass yield had shares in the total fresh biomass yield that varied from 66.9% to 68.6%.

Table 3. Total fresh biomass yield (TFB t/ha) at 50 cm sowing distance between rows, Moara Domnească, September 2014

| Treatment   | Alize    |       |       |      | Aquilon  |       |       |      | Arack    |       |       |      | Average hybrids |       |       |      |
|---|----------|-------|-------|------|----------|-------|-------|------|----------|-------|-------|------|-----------------|-------|-------|------|
|   | TFB t/ha | TFB % | SFB % | GY % | TFB t/ha | TFB % | SFB % | GY % | TFB t/ha | TFB % | SFB % | GY % | TFB t/ha        | TFB % | SFB % | GY % |
| N <sub>0</sub> P <sub>0</sub> K <sub>0</sub>              | 19.14    | 100.0 | 68.7  | 31.3 | 19.22    | 100.0 | 68.5  | 31.5 | 19.46    | 100.0 | 68.7  | 31.3 | 19.27           | 100.0 | 68.6  | 31.4 |
| N <sub>60</sub> P <sub>0</sub> K <sub>0</sub>             | 23.59    | 100.0 | 68.5  | 31.5 | 24.56    | 100.0 | 68.2  | 31.8 | 23.69    | 100.0 | 68.6  | 31.4 | 23.95           | 100.0 | 68.4  | 31.6 |
| N <sub>90</sub> P <sub>0</sub> K <sub>0</sub>             | 25.12    | 100.0 | 68.5  | 31.5 | 26.23    | 100.0 | 67.3  | 32.7 | 26.08    | 100.0 | 66.9  | 33.1 | 25.81           | 100.0 | 67.6  | 32.4 |
| N <sub>120</sub> P <sub>0</sub> K <sub>0</sub>            | 26.28    | 100.0 | 67.1  | 32.9 | 27.15    | 100.0 | 66.7  | 33.3 | 27.63    | 100.0 | 67.0  | 33.0 | 27.02           | 100.0 | 66.9  | 33.1 |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub>            | 27.03    | 100.0 | 67.3  | 32.7 | 27.94    | 100.0 | 67.6  | 32.4 | 28.35    | 100.0 | 65.8  | 34.2 | 27.77           | 100.0 | 66.9  | 33.1 |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub> +Hortifor  | 27.24    | 100.0 | 67.3  | 32.7 | 28.18    | 100.0 | 67.2  | 32.8 | 29.22    | 100.0 | 66.3  | 33.7 | 28.21           | 100.0 | 67.0  | 33.0 |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub>           | 28.42    | 100.0 | 67.0  | 33.0 | 29.53    | 100.0 | 67.5  | 32.5 | 29.73    | 100.0 | 66.3  | 33.7 | 29.23           | 100.0 | 66.9  | 33.1 |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> +Hortifor | 28.85    | 100.0 | 67.3  | 32.7 | 29.79    | 100.0 | 67.5  | 32.5 | 30.15    | 100.0 | 66.4  | 33.6 | 29.59           | 100.0 | 67.1  | 32.9 |
| N <sub>120</sub> P <sub>60</sub> K <sub>0</sub>           | 30.56    | 100.0 | 68.2  | 32.7 | 30.64    | 100.0 | 67.5  | 32.5 | 30.94    | 100.0 | 66.7  | 33.3 | 30.71           | 100.0 | 67.4  | 32.6 |
| N <sub>120</sub> P <sub>60</sub> K <sub>60</sub>          | 31.64    | 100.0 | 67.6  | 32.4 | 31.77    | 100.0 | 67.1  | 32.9 | 31.62    | 100.0 | 66.6  | 33.4 | 31.68           | 100.0 | 67.1  | 32.9 |
| Average   | 26.79    | 100.0 | 67.8  | 32.3 | 27.50    | 100.0 | 67.5  | 32.5 | 27.68    | 100.0 | 66.9  | 33.1 | 27.32           | 100.0 | 67.4  | 32.6 |

TFB – Total Fresh Biomass = Secondary Fresh Biomass at harvest (SFB) + Grain Yield (GY) at STAS humidity (14%)

Secondary fresh biomass yield at harvest (Figure 3) had an average value of 18.40 t/ha, varying from 13.23 t/ha, the minimum value

registered at the Control treatment, to 21.27 t/ha, the maximum yield value obtained for the treatment N<sub>120</sub>P<sub>60</sub>K<sub>60</sub>.

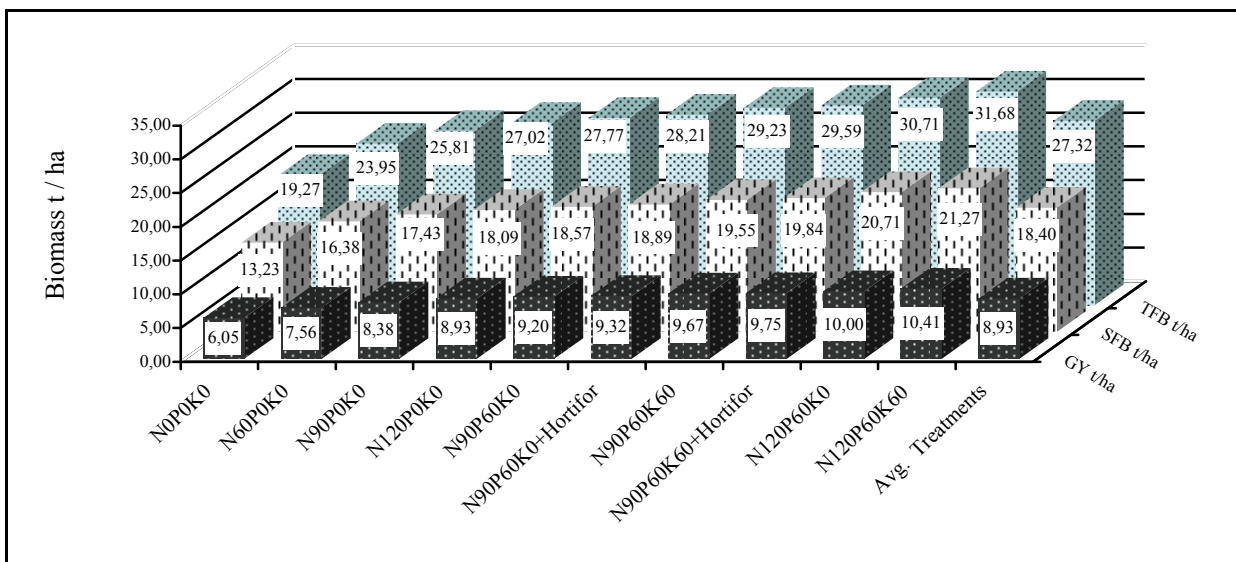


Figure 3. Total fresh biomass (TFB t/ha) yield structure, average of three sorghum hybrids sown at 50 cm between rows, Moara Domnească, 2014

The data in Table 4 highlights that in the field conditions of Moara Domnească in the agricultural year 2013-2014, the sowing distance between rows had no significant influence on the total fresh biomass average yield of the three cultivated grain sorghum hybrids. The total fresh biomass average yield obtained for the sowing distance of 50 cm between rows was 1.52% higher, i.e. 0.41 t/ha, than the total fresh biomass average yield obtained at the distance of 70 cm between rows.

### Grain yield

The hybrid influence on the grain yield was low both for the sowing distance of 70 cm between rows (Table 5) and 50 cm between rows (Table 6), regardless of the fertilization treatment, the differences between hybrids varying from -0.79 t/ha to +0.50 t/ha. Applying fertilizers had a favourable influence on the grain yield of sorghum hybrids. The average grain yield of the three analyzed grain sorghum hybrids sown at the distance of 70 cm between rows recorded a distinctly significant increase for the treatment N<sub>60</sub>P<sub>0</sub>K<sub>0</sub> compared to the control treatment (Table 7). Fertilization with nitrogen doses of 90 and 120 kg/ha, the usage of NPK complex fertilizers and foliar fertilizers had a very significant positive

influence on the grain yield, generating yield increases between 48.0% (N<sub>90</sub>P<sub>0</sub>K<sub>0</sub>) and 76.6% (N<sub>120</sub>P<sub>60</sub>K<sub>60</sub>). The highest grain yield of 11.12 t/ha was obtained in the hybrid Aquilon fertilized N<sub>120</sub>P<sub>60</sub>K<sub>60</sub>. On average fertilization treatments increased the grain yield of the three sorghum hybrids studied in the field conditions of Moara Domnească by 53.4%.

Table 4. Total fresh biomass yield (TFB t/ha) average of three sorghum hybrids, depending on the sowing distance between rows

| Treatment   | Sowing distance between rows |              |            |              |               |             |
|---|------------------------------|--------------|------------|--------------|---------------|-------------|
|   | 70 cm                        |              |            | 50 cm        |               |             |
|   | TFB t/ha                     | %            | Diff. t/ha | TFB t/ha     | %             | Diff. t/ha  |
| N <sub>0</sub> P <sub>0</sub> K <sub>0</sub>              | 20.22                        | 100.0        | Ct         | 19.27        | 95.31         | -0.95       |
| N <sub>60</sub> P <sub>0</sub> K <sub>0</sub>             | 23.53                        | 100.0        | Ct         | 23.95        | 101.77        | 0.42        |
| N <sub>90</sub> P <sub>0</sub> K <sub>0</sub>             | 25.12                        | 100.0        | Ct         | 25.81        | 102.72        | 0.68        |
| N <sub>120</sub> P <sub>0</sub> K <sub>0</sub>            | 26.07                        | 100.0        | Ct         | 27.02        | 103.62        | 0.95        |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub>            | 26.84                        | 100.0        | Ct         | 27.77        | 103.48        | 0.93        |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub> +Hortifor  | 27.51                        | 100.0        | Ct         | 28.21        | 102.55        | 0.70        |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub>           | 28.33                        | 100.0        | Ct         | 29.23        | 103.18        | 0.90        |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> +Hortifor | 29.57                        | 100.0        | Ct         | 29.59        | 100.08        | 0.02        |
| N <sub>120</sub> P <sub>60</sub> K <sub>0</sub>           | 30.68                        | 100.0        | Ct         | 30.71        | 100.11        | 0.03        |
| N <sub>120</sub> P <sub>60</sub> K <sub>60</sub>          | 31.29                        | 100.0        | Ct         | 31.68        | 101.26        | 0.39        |
| <b>Average Treatments</b>                                 | <b>26.92</b>                 | <b>100.0</b> | <b>Ct</b>  | <b>27.32</b> | <b>101.52</b> | <b>0.41</b> |

LSD 5% = 1.49 t/ha; LSD 1% = 2.10 t/ha; LSD 0.1% = 3.10 t/ha

TFB – Total Fresh Biomass = Secondary fresh biomass at harvest (SFB) + Grain Yield (GY) at STAS humidity (14%); Ct = Control



Table 5. Hybrid influence on grain yield (GY t/ha) for 70 cm between rows sowing distance, Moara Domnească, September 2014

| Treatment   | Alize       |             |              | Aquilon     |              |             | Arack       |              |             | Average hybrids |              |            |
|---|-------------|-------------|--------------|-------------|--------------|-------------|-------------|--------------|-------------|-----------------|--------------|------------|
|   | GY t/ha     | %           | Diff. t/ha   | GY t/ha     | %            | Diff. t/ha  | GY t/ha     | %            | Diff. t/ha  | GY t/ha         | %            | Diff. t/ha |
| N <sub>0</sub> P <sub>0</sub> K <sub>0</sub>              | 6.22        | 103.5       | 0.21         | 6.20        | 103.3        | 0.20        | 5.60        | 93.2         | -0.41       | <b>6.01</b>     | <b>100.0</b> | Ct         |
| N <sub>60</sub> P <sub>0</sub> K <sub>0</sub>             | 7.73        | 101.3       | 0.10         | 7.87        | 103.1        | 0.23        | 7.29        | 95.6         | -0.34       | <b>7.63</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>0</sub> K <sub>0</sub>             | 8.74        | 98.3        | -0.15        | 9.18        | 103.3        | 0.29        | 8.75        | 98.4         | -0.14       | <b>8.89</b>     | <b>100.0</b> | Ct         |
| N <sub>120</sub> P <sub>0</sub> K <sub>0</sub>            | 9.02        | 96.8        | -0.30        | 9.47        | 101.6        | 0.15        | 9.33        | 101.6        | 0.15        | <b>9.27</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub>            | 9.22        | 93.7        | -0.62        | 10.15       | 103.2        | 0.31        | 9.42        | 103.2        | 0.31        | <b>9.84</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub> +Hortifor  | 9.39        | 94.3        | -0.57        | 10.25       | 102.9        | 0.29        | 9.53        | 102.9        | 0.29        | <b>9.96</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub>           | 9.49        | 94.5        | -0.56        | 10.33       | 102.8        | 0.28        | 9.75        | 102.8        | 0.28        | <b>10.05</b>    | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> +Hortifor | 9.83        | 95.3        | -0.48        | 10.56       | 102.3        | 0.24        | 10.20       | 102.3        | 0.24        | <b>10.32</b>    | <b>100.0</b> | Ct         |
| N <sub>120</sub> P <sub>60</sub> K <sub>0</sub>           | 9.89        | 94.8        | -0.54        | 10.70       | 102.6        | 0.27        | 10.46       | 102.6        | 0.27        | <b>10.43</b>    | <b>100.0</b> | Ct         |
| N <sub>120</sub> P <sub>60</sub> K <sub>60</sub>          | 9.93        | 92.6        | -0.79        | 11.12       | 103.7        | 0.40        | 10.79       | 103.7        | 0.40        | <b>10.72</b>    | <b>100.0</b> | Ct         |
| <b>Average treatments</b>                                 | <b>8.95</b> | <b>96.0</b> | <b>-0.37</b> | <b>9.58</b> | <b>102.8</b> | <b>0.27</b> | <b>9.11</b> | <b>101.1</b> | <b>0.10</b> | <b>9.21</b>     | <b>100.0</b> | <b>Ct</b>  |

LSD 5% = 0.66 t/ha; LSD 1% = 0.90 t/ha; LSD 0.1% = 1.20 t/ha

GY = Grain Yield at STAS humidity (14%); Ct = Control

Table 6. Hybrid influence on grain yield (GY t/ha) for 50 cm between rows sowing distance, Moara Domnească, September 2014

| Treatment   | Alize       |             |              | Aquilon     |              |             | Arack       |              |             | Average hybrids |              |            |
|---|-------------|-------------|--------------|-------------|--------------|-------------|-------------|--------------|-------------|-----------------|--------------|------------|
|   | GY t/ha     | %           | Diff. t/ha   | GY t/ha     | %            | Diff. t/ha  | GY t/ha     | %            | Diff. t/ha  | GY t/ha         | %            | Diff. t/ha |
| N <sub>0</sub> P <sub>0</sub> K <sub>0</sub>              | 5.99        | 99.0        | -0.06        | 6.06        | 100.2        | 0.01        | 6.09        | 100.8        | 0.05        | <b>6.05</b>     | <b>100.0</b> | Ct         |
| N <sub>60</sub> P <sub>0</sub> K <sub>0</sub>             | 7.43        | 98.3        | -0.13        | 7.82        | 103.4        | 0.25        | 7.44        | 98.4         | -0.12       | <b>7.56</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>0</sub> K <sub>0</sub>             | 7.92        | 94.5        | -0.46        | 8.57        | 102.3        | 0.19        | 8.64        | 103.2        | 0.27        | <b>8.38</b>     | <b>100.0</b> | Ct         |
| N <sub>120</sub> P <sub>0</sub> K <sub>0</sub>            | 8.64        | 96.7        | -0.29        | 9.03        | 101.1        | 0.10        | 9.12        | 102.1        | 0.19        | <b>8.93</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub>            | 8.84        | 96.1        | -0.36        | 9.06        | 98.4         | -0.14       | 9.70        | 105.5        | 0.50        | <b>9.20</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub> +Hortifor  | 8.90        | 95.4        | -0.43        | 9.23        | 99.0         | -0.09       | 9.84        | 105.6        | 0.52        | <b>9.32</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub>           | 9.38        | 97.0        | -0.29        | 9.61        | 99.3         | -0.06       | 10.02       | 103.6        | 0.35        | <b>9.67</b>     | <b>100.0</b> | Ct         |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> +Hortifor | 9.44        | 96.9        | -0.31        | 9.67        | 99.2         | -0.08       | 10.14       | 104.0        | 0.39        | <b>9.75</b>     | <b>100.0</b> | Ct         |
| N <sub>120</sub> P <sub>60</sub> K <sub>0</sub>           | 9.72        | 97.2        | -0.28        | 9.97        | 99.7         | -0.03       | 10.31       | 103.1        | 0.31        | <b>10.00</b>    | <b>100.0</b> | Ct         |
| N <sub>120</sub> P <sub>60</sub> K <sub>60</sub>          | 10.24       | 98.3        | -0.17        | 10.45       | 100.3        | 0.03        | 10.55       | 101.3        | 0.14        | <b>10.41</b>    | <b>100.0</b> | Ct         |
| <b>Average treatments</b>                                 | <b>8.65</b> | <b>96.9</b> | <b>-0.28</b> | <b>8.95</b> | <b>100.2</b> | <b>0.02</b> | <b>9.19</b> | <b>102.9</b> | <b>0.26</b> | <b>8.93</b>     | <b>100.0</b> | <b>Ct</b>  |

LSD 5% = 0.85 t/ha; LSD 1% = 1.13 t/ha; LSD 0.1% = 1.48 t/ha

GY = Grain Yield at STAS humidity (14%); Ct = Control

Table 7. Treatment influence on grain yield (GY t/ha) for 70 cm between rows sowing distance, Moara Domnească, September 2014

| Treatment   | Alize       |              |             | Aquilon     |              |             | Arack       |              |             | Average hybrids |              |             |
|---|-------------|--------------|-------------|-------------|--------------|-------------|-------------|--------------|-------------|-----------------|--------------|-------------|
|   | GY t/ha     | %            | Diff. t/ha  | GY t/ha     | %            | Diff. t/ha  | GY t/ha     | %            | Diff. t/ha  | GY t/ha         | %            | Diff. t/ha  |
| N <sub>0</sub> P <sub>0</sub> K <sub>0</sub>              | <b>6.22</b> | <b>100.0</b> | Ct          | <b>6.20</b> | <b>100.0</b> | Ct          | <b>5.60</b> | <b>100.0</b> | Ct          | <b>6.01</b>     | <b>100.0</b> | Ct          |
| N <sub>60</sub> P <sub>0</sub> K <sub>0</sub>             | 7.73        | 124.4        | 1.52        | 7.87        | 126.8        | 1.66        | 7.29        | 130.2        | 1.69        | 7.63            | 127.0        | 1.62        |
| N <sub>90</sub> P <sub>0</sub> K <sub>0</sub>             | 8.74        | 140.5        | 2.52        | 9.18        | 148.0        | 2.98        | 8.75        | 156.2        | 3.15        | 8.89            | 148.0        | 2.88        |
| N <sub>120</sub> P <sub>0</sub> K <sub>0</sub>            | 9.02        | 145.1        | 2.81        | 9.47        | 152.7        | 3.27        | 9.33        | 166.5        | 3.73        | 9.27            | 154.4        | 3.27        |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub>            | 9.22        | 148.3        | 3.00        | 10.15       | 163.6        | 3.95        | 9.42        | 168.1        | 3.82        | 9.60            | 159.7        | 3.59        |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub> +Hortifor  | 9.39        | 151.0        | 3.17        | 10.25       | 165.2        | 4.04        | 9.53        | 170.2        | 3.93        | 9.72            | 161.8        | 3.72        |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub>           | 9.49        | 152.7        | 3.28        | 10.33       | 166.5        | 4.13        | 9.75        | 174.1        | 4.15        | 9.86            | 164.1        | 3.85        |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> +Hortifor | 9.83        | 158.2        | 3.62        | 10.56       | 170.2        | 4.36        | 10.20       | 182.0        | 4.60        | 10.20           | 169.7        | 4.19        |
| N <sub>120</sub> P <sub>60</sub> K <sub>0</sub>           | 9.89        | 159.1        | 3.68        | 10.70       | 172.5        | 4.50        | 10.46       | 186.8        | 4.86        | 10.35           | 172.3        | 4.34        |
| N <sub>120</sub> P <sub>60</sub> K <sub>60</sub>          | 9.93        | 159.7        | 3.71        | 11.12       | 179.2        | 4.91        | 10.79       | 192.6        | 5.19        | 10.61           | 176.6        | 4.60        |
| <b>Average treatments</b>                                 | <b>8.95</b> | <b>143.9</b> | <b>2.73</b> | <b>9.58</b> | <b>154.5</b> | <b>3.38</b> | <b>9.11</b> | <b>162.7</b> | <b>3.51</b> | <b>9.21</b>     | <b>153.4</b> | <b>3.21</b> |

LSD 5% = 1.15 t/ha; LSD 1% = 1.53 t/ha; LSD 0.1% = 1.98 t/ha

GY = Grain Yield at STAS humidity (14%); Ct = Control

For the grain sorghum hybrids sown at the distance of 50 cm between rows (Table 8), a distinctly significant increase of the average grain yield was observed for the fertilization with nitrogen doses of 90 and 120 kg/ha compared to the Control treatment. Regarding the treatments N<sub>90</sub>P<sub>60</sub>K<sub>0</sub>, N<sub>90</sub>P<sub>60</sub>K<sub>0</sub> + Hortifor, N<sub>90</sub>P<sub>60</sub>K<sub>60</sub>, N<sub>90</sub>P<sub>60</sub>K<sub>60</sub>+Hortifor, N<sub>120</sub>P<sub>60</sub>K<sub>0</sub>,

N<sub>120</sub>P<sub>60</sub>K<sub>60</sub>, they generated yield increases from 52.2% to 72.2% that were statistically assured compared to the control treatment. On average, the ten fertilization treatments generated a yield increase distinctly significant compared to the control treatment, the average yield for the three sorghum hybrids being 47.7% higher compared to the control.

Table 8. Treatment influence on grain yield (GY t/ha) for 50 cm between rows sowing distance, Moara Domneasca, September 2014

| Treatment   | Alize       |               |             | Aquilon     |               |             | Arack       |              |             | Average hybrids |              |             |
|---|-------------|---------------|-------------|-------------|---------------|-------------|-------------|--------------|-------------|-----------------|--------------|-------------|
|   | GY t/ha     | %             | Diff. t/ha  | GY t/ha     | %             | Diff. t/ha  | GY t/ha     | %            | Diff. t/ha  | GY t/ha         | %            | Diff. t/ha  |
| N <sub>0</sub> P <sub>0</sub> K <sub>0</sub>              | <b>5.99</b> | <b>100.00</b> | <b>Ct</b>   | <b>6.06</b> | <b>100.00</b> | <b>Ct</b>   | <b>6.09</b> | <b>100.0</b> | <b>Ct</b>   | <b>6.05</b>     | <b>100.0</b> | <b>Ct</b>   |
| N <sub>60</sub> P <sub>0</sub> K <sub>0</sub>             | 7.43        | 124.1         | 1.45        | 7.82        | 129.1         | 1.76        | 7.44        | 122.1        | 1.35        | 7.56            | 125.1        | 1.52        |
| N <sub>90</sub> P <sub>0</sub> K <sub>0</sub>             | 7.92        | 132.2         | 1.93        | 8.57        | 141.5         | 2.51        | 8.64        | 141.8        | 2.55        | 8.38            | 138.5        | 2.33        |
| N <sub>120</sub> P <sub>0</sub> K <sub>0</sub>            | 8.64        | 144.2         | 2.65        | 9.03        | 149.2         | 2.98        | 9.12        | 149.7        | 3.03        | 8.93            | 147.7        | 2.88        |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub>            | 8.84        | 147.6         | 2.85        | 9.06        | 149.6         | 3.00        | 9.70        | 159.2        | 3.61        | 9.20            | 152.2        | 3.15        |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub> +Hortifor  | 8.90        | 148.6         | 2.91        | 9.23        | 152.5         | 3.18        | 9.84        | 161.5        | 3.75        | 9.32            | 154.2        | 3.28        |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub>           | 9.38        | 156.7         | 3.39        | 9.61        | 158.7         | 3.55        | 10.02       | 164.5        | 3.93        | 9.67            | 160.0        | 3.63        |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> +Hortifor | 9.44        | 157.7         | 3.46        | 9.67        | 159.7         | 3.62        | 10.14       | 166.3        | 4.04        | 9.75            | 161.3        | 3.70        |
| N <sub>120</sub> P <sub>60</sub> K <sub>0</sub>           | 9.72        | 162.3         | 3.73        | 9.97        | 164.7         | 3.92        | 10.31       | 169.1        | 4.21        | 10.00           | 165.4        | 3.95        |
| N <sub>120</sub> P <sub>60</sub> K <sub>60</sub>          | 10.24       | 171.0         | 4.25        | 10.45       | 172.5         | 4.39        | 10.55       | 173.1        | 4.46        | 10.41           | 172.2        | 4.37        |
| <b>Average treatments</b>                                 | <b>8.65</b> | <b>144.5</b>  | <b>2.66</b> | <b>8.95</b> | <b>147.7</b>  | <b>2.89</b> | <b>9.19</b> | <b>150.7</b> | <b>3.09</b> | <b>8.93</b>     | <b>147.7</b> | <b>2.88</b> |

LSD 5% = 1.75 t/ha; LSD 1% = 2.32 t/ha; LSD 0.1% = 3.00 t/ha

GY = Grain Yield at STAS humidity (14%); Ct = Control

### Influence of the sowing distance on the grain yield of sorghum

The analysis of the data presented in Table 9 points out that in 2014 the grain yield of sorghum hybrids was lower for the distance of 50 cm between rows. The grain yield of sorghum hybrids at the sowing distance of 50 cm between rows represented between 94.2% and 99.1% of the grain yield of sorghum hybrids sown at the distance of 70 cm between rows. The yield differences obtained for the 50 cm sowing distance, compared to sowing distance of 70 cm between rows, were statistically negatively assured for the treatment N<sub>90</sub>P<sub>0</sub>K<sub>0</sub> (-0.51 t/ha).

The grain yield of the three sorghum hybrids recorded a very significantly positive influence of the amount of active substance fertilizers applied. The correlation coefficient between the fertilizers doses (active substance kg/ha) and the grain yield at 70 cm between rows sowing distance (Figure 4) was  $r = 0.9486$ , and at 50 cm between rows sowing distance (Figure 5) was  $r = 0.9642$ .

Table 9. Influence of the sowing distance on the average grain yield (GY t/ha) for different fertilization treatments

| Treatment   | Sowing distance between rows |              |            |             |       |            |
|---|------------------------------|--------------|------------|-------------|-------|------------|
|   | 70 cm                        |              |            | 50 cm       |       |            |
|   | GY t/ha                      | %            | Diff. t/ha | GY t/ha     | %     | Diff. t/ha |
| N <sub>0</sub> P <sub>0</sub> K <sub>0</sub>              | <b>6.01</b>                  | <b>100.0</b> | <b>Ct</b>  | <b>6.05</b> | 100.6 | 0.04       |
| N <sub>60</sub> P <sub>0</sub> K <sub>0</sub>             | <b>7.63</b>                  | <b>100.0</b> | <b>Ct</b>  | 7.56        | 99.1  | -0.07      |
| N <sub>90</sub> P <sub>0</sub> K <sub>0</sub>             | <b>8.89</b>                  | <b>100.0</b> | <b>Ct</b>  | 8.38        | 94.2  | -0.51      |
| N <sub>120</sub> P <sub>0</sub> K <sub>0</sub>            | <b>9.27</b>                  | <b>100.0</b> | <b>Ct</b>  | 8.93        | 96.3  | -0.34      |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub>            | <b>9.60</b>                  | <b>100.0</b> | <b>Ct</b>  | 9.20        | 95.9  | -0.40      |
| N <sub>90</sub> P <sub>60</sub> K <sub>0</sub> +Hortifor  | <b>9.72</b>                  | <b>100.0</b> | <b>Ct</b>  | 9.32        | 95.9  | -0.40      |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub>           | <b>9.86</b>                  | <b>100.0</b> | <b>Ct</b>  | 9.67        | 98.1  | -0.19      |
| N <sub>90</sub> P <sub>60</sub> K <sub>60</sub> +Hortifor | <b>10.20</b>                 | <b>100.0</b> | <b>Ct</b>  | 9.75        | 95.6  | -0.45      |
| N <sub>120</sub> P <sub>60</sub> K <sub>0</sub>           | <b>10.35</b>                 | <b>100.0</b> | <b>Ct</b>  | 10.00       | 96.6  | -0.35      |
| N <sub>120</sub> P <sub>60</sub> K <sub>60</sub>          | <b>10.61</b>                 | <b>100.0</b> | <b>Ct</b>  | 10.41       | 98.1  | -0.20      |
| <b>Average</b>  | <b>9.21</b>                  | <b>100.0</b> | <b>Ct</b>  | <b>8.93</b> | 96.9  | -0.29      |

LSD 5% = 0.44 t/ha; LSD 1% = 0.60 t/ha; LSD 0.1% = 0.80 t/ha

GY = Grain Yield at STAS humidity (14%); Ct = Control

## CONCLUSIONS

Fertilizer application influenced the total fresh biomass production of grain sorghum hybrids. In the conditions of the agricultural year 2013-2014, the grain sorghum hybrids grown in the

Southeastern area of Romania (Moara Domnească, Ilfov County) had a high total fresh biomass yield, varying at the sowing distance of 70 cm between rows from 23.53 t/ha to 31.29 t/ha, and at the sowing distance of 50 cm between rows from 23.95 t/ha to 31.68 t/ha.

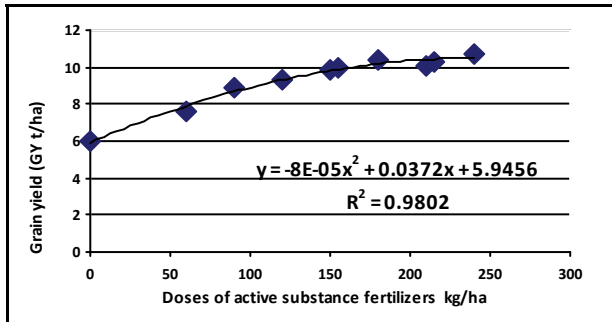


Figure 4. Correlation between the grain yield (GY t/ha) of the sorghum hybrids sown at 70 cm between rows and the doses of active substance fertilizers applied (kg/ha)

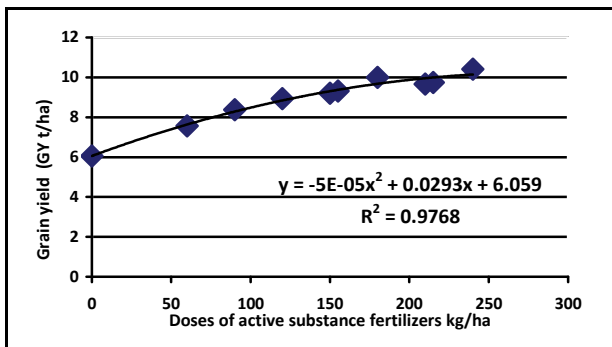


Figure 5. Correlation between the grain yield (GY t/ha) of the sorghum hybrids sown at 50 cm between rows and the doses of active substance fertilizers applied (kg/ha)

The lowest grain yield at 70 cm sowing distance between rows was recorded in the unfertilized hybrid Arack (5.60 t/ha), and the highest grain yield in the hybrid Aquilon (11.12 t/ha) fertilized  $N_{120}P_{60}K_{60}$ .

For the sowing distance of 50 cm between rows the minimum grain yield was recorded in the unfertilized hybrid Alize (5.99 t/ha) and the maximum grain yield in the hybrid Arack (10.55 t/ha) fertilized  $N_{120}P_{60}K_{60}$ .

The average grain yield of the three sorghum hybrids did not vary significantly under the influence of the sowing distance between rows. Depending on the fertilization treatment, the average grain yield for the sowing distance of 70 cm rows was higher by 0.9-5.8% than the average grain yield at the distance of 50 cm between rows.

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