Acta regionalia et environmentalica 2
Nitra, Slovaca Universitas Agriculturae Nitriae, 2013, p. 42–45

COMPARISON OF PRODUCTION AND GROWTH CHARACTERISTICS OF SORGHUM WITH OTHER CROPS AND THEIR GROWING ECONOMY

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The experiments aimed at the comparison of the growth and production parameters of sorghum with other field crops were established in the experimental workplaces CVRV-VÚA in Milhostov. In the course of favourable meteorological factors, the slowest initial development of vegetation height and dynamics of biomass accretion was observed in sorghum. From 15th August, however, sorghum accretion intensity significantly exceeded all the monitored field crops. The total cost of the cultivation of sorghum for silage accounted for 870.34 € ha^{-1} and of maize for silage 861.36 € ha^{-1}. The difference resulted from different levels of material costs. In the experiment, the harvested amount reached 62.70 t ha^{-1} for sorghum silage and 54.20 t ha^{-1} for maize (33% moisture). At these yield and silage costs 33 € t^{-1}, sorghum achieved a profit of 1198.76 € ha^{-1} without subsidy, while maize achieved a profit of 927.24 € ha^{-1}. The yields exceeding 26.37 t ha^{-1} for sorghum and 26.10 t ha^{-1} for maize would be sufficient to achieve profits.

Keywords: *Sorghum* ssp., yield, costs, profit

Grain sorghum was examined in experiments in Milhostov. From the climate point of view, it is a thermophile plant (type C4), and in terms of its use, it can be used in the energy sector as well. According to Jureková and Marišová (2008), only type C4 plants, such as sorghum, are more resistant to heat and drought, have a good economy of water regime and low photorespiration. In addition to biomass production, sorghum is used to produce grain, useful in the food sector, as well as in animal production. According to Berényi (2002), in very dry regions of Serbia it is preferable to grow grain sorghum rather than maize. From this perspective, the verification of the suitability of growing grain sorghum began in warm and dry regions of Slovakia, too. The aim of this article was to compare the phenological and growth characteristics and final product of sorghum with other field crops. Calculation of economy parameters of grain maize and silage sorghum for biogas stations was performed, too.

Material and methods

In 2011, the experimental base PPRC – Agroecology Research Institute in Milhostov carried out experiments focused on the comparison of phenology and growth characteristics, dynamics of accretion and production of biomass and production of the main product in sorghum and other field crops: maize, sunflower, spring barley, and soybean. The experiments were based upon conventional soil preparation. There were used Yami variety for sorghum, DK 315for maize, hybrid PR64H42for sunflower, variety Levan for spring barley, and Cardiff variety for soybean. During the vegetation period, phenological observations and measurements in the stand were made, and the plant material was removed in order to determine the accretion of biomass. For sorghum and maize, during the waxy stage of maturity, the samples of plant material were taken to determine the production of silage per hectare in order to use it in the biogas plant. For all crops, the harvest of the main product was set after maturation.

For maize and sorghum, the economic parameters of production for the biogas plant were calculated. In economic evaluations, the costs from basic soil preparation to the transport of materials from the stand are included in the calculation. To evaluate the cost of machine and work operation, there were used norms by Kavka et al. (2006) and by Abrhám et al. (2007), recalculated into the terms of heavy soils of the Eastern lowland. The economic efficiency of cultivation technologies of maize and sorghum was evaluated according to the methodology (Poláčková et al., 2010).

Results and discussion

Figure 1 lists the temperature and rainfall conditions in the experimental field in Milhostov in 2011. During the first five months of the year, rainfall was subnormal, which can be considered as a positive indicator in the agro-climatic conditions characterized by the frequent spring subsoil irrigation. Higher values of June and July rainfall positively influenced the growth and production parameters, especially in maize and sorghum. The production of these crops was positively impacted by a temperature exceeding the long term average.

Selected phenological observations are given in Table 1. The table shows that the period from sowing to the technological maturity of seeds took the highest number of days, exactly 165 for sorghum, 153 days for sunflower and 144 days for soybean. Due to the later date of sowing, maize grew 135 days.

In 2011, at specified time periods, the growth characteristics and dynamics of sorghum biomass accretion

Table 1 Selected phenological observations in plantations of crops in 2011

Crop	Indicator	Sowing	Emergence	Ears creation	Flowering	Technological maturity	Harvest
Grain sorghum	date	10. 5.	21. 5.	28. 6.	16. 7.	22. 10.	25. 10.
	days from sowing	–	11	49	67	165	167
Maize	date	13. 5.	20. 5.	20. 7.	23. 7.	2. 10.	4. 10.
	days from sowing	–	7	61	64	135	137
Sunflower	date	19. 4.	2. 5.	20. 6.	6. 7.	18. 9.	20. 9.
	days from sowing	–	14	63	79	153	155
Spring barley	date	1. 4.	11. 4.	31. 5.	10. 6.	12. 7.	14. 7.
	days from sowing	–	11	61	71	103	105
Soybean	date	26. 4.	9. 5.	14. 6.	21. 6.	16. 9.	22. 9.
	days from sowing	–	14	50	57	144	150

Table 2 Comparison of the growing dynamics of height and biomass accretion of sorghum grain with selected crops in 2011

Date	Height in mm					Biomass in g m²				
	sorghum	maize	sunflower	barley	soybean	sorghum	maize	sunflower	barley	soybean
16. 5.	–	–	170	32	90	–	–	14	237	30
31. 5.	–	100	310	57	150	–	4	66	594	41
16. 6.	460	610	980	58	470	126	171	560	570	142
30. 6.	720	1010	1560	60	550	553	298	773	878	241
12. 7.	920	1430	1700	61	870	1074	409	1454	245	416
15. 8.	1330	2080	1780	–	940	3192	1999	1429	–	1140
12. 9.	1420	2350	2000	–	1170	3801	1443	1478	–	414
12. 10.	1510	–	–	–	–	5373	–	–	–	–

were evaluated in relation to the parameters of other field crops (Table 2). Tracking was done in two weeks and then at monthly intervals. The crop of sorghum had the slowest initial development and therefore, the first complete measurement of products for the entire crop was carried out on 16th of June. Slow initial growth of sorghum is connected with the fact that it first develops its root system and only then starts the growth of the above-ground parts (Abraham, 2010; Hancock, 2009; Sarvar, 2011).

The fastest initial development was recorded in sunflower. Sunflower was the highest until the sixth measure, which was on 15th of August and when it was overgrown by maize, which at that time exceeded 2000 mm. On 12th of July, the crop height of sorghum exceeded the height of soybean. Grain sorghum grew to a height of 1510 mm. Height of sorghum exceeded other 11-grain sorghum growths in an experiment in Kiskundorozsma (Hungary), which Pál and Rajki (2010) indicate. Throughout that experiment, the height of grain sorghum ranged from 900 to 1350 mm.

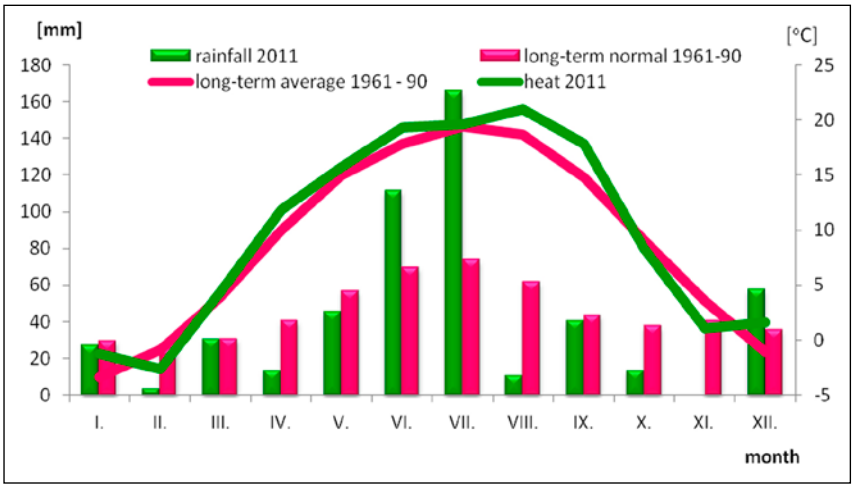

Figure 1 The overview of meteorological factors in 2011

The increase of sorghum biomass during a slow initial development was slow, too. A significant increase in biomass occurred in the month of July. Sorghum biomass accretion intensity significantly exceeded not only soybeans, but also maize and sunflower. When examining the samples of 15th August, 2011, the sorghum biomass of 1 m² exceeded 3000 g, while for sunflower, it was less than a half, and for maize, it exceeded 2000 g. Overall sorghum biomass production reached 5373 g m². For maize, the highest values of biomass were achieved on

15th August. On 12th of September, the weight of biomass decreased due to aging plantations. Least biomass was produced by spring barley preceded by soya bean.

Seed crops are evaluated in Table 3. The highest production, nearly 12 t ha^{-1}, was recorded for maize, which was by 2.4 t ha^{-1} higher than sorghum yield. Other crops marked significantly lower values.

Technology of sorghum production for silage is practically identical with the technology of growing corn for silage. The costs for particular working operations in

Table 3 Harvest seeds of field crops in 2011

Crop	Main product yield in t ha^{-1}	Energy production of main product in GJ ha^{-1}
Grain sorghum	9.58	173.49
Maize	11.98	216.96
Sunflower	3.52	88.52
Spring barley	3.91	68.27
Soybean	4.03	80.08

Table 4 Costs of working operations at sorghum and maize

Operation	Amount of operation	Consumption		Variable costs in € ha^{-1}				Fixed costs in € ha^{-1}	Variable and fixed costs of machines in € ha^{-1}
		work in h ha^{-1}	diesel in l ha^{-1}	work	fuel, oils	repairs, maintenance	SUM		
Stubble	1	0.45	7.50	1.53	8.48	9.81	19.82	7.26	27.08
Medium tillage	1	1.00	25.00	3.40	28.25	26.14	57.79	16.94	74.73
Preparation of soil-loosening shallow.	2	1.00	20.00	3.40	22.60	24.02	50.02	14.61	64.63
Transport, handling and spreading of mineral fertilizers to 200 kg ha^{-1}	1	0.35	2.00	1.19	2.26	2.38	5.83	4.18	10.01
Transport, handling and spreading of mineral fertilizers of 300 kg ha^{-1}	1	0.45	2.80	1.53	3.16	2.77	7.47	5.72	13.19
Seeding	1	0.63	10.00	2.14	11.30	12.50	25.94	15.62	41.56
Cold rolling after sowing	1	0.37	3.50	1.26	3.96	2.86	8.07	3.17	11,24
spraying the surface	2	0.90	3.60	3.06	4.07	3.61	10.74	31.42	42.15
Harvesting with self-propelled cutter	1	1.80	25.00	6.12	28.25	10.08	44.45	21.76	66.21
Transport of biomass	1	14.30	0.60	48.62	0.68	0.48	49.78	1.32	51.10
Summary	12	21.25	100.00	72.25	113.00	94.64	279.89	121.99	401.89

Table 5 Material costs of sorghum and maize cultivation

Type of material		Unit	Sorghum		Maize	
			dose on 1 ha	sum in € ha^{-1}	dose on 1 ha	sum in € ha^{-1}
Seeds		VJ	1	75.00	1	74.00
SUM seeds				75.00	74.00	
Mineral fertilizers	PRP Sol	kg	200	144.00	200	144.00
	LAV	kg	111	19.98	333	103.23
	NPK	kg	400	144.00	0	0
SUM Mineral fertilizers				307.98	247.23	
Pesticides	Pledge	g	80	59.20	0	0
	Roundup Akt	l	3	26.27	0	0
	Wing P	l	0	0	4	59.04
	Laudis	l	0	0	2,2	79.20
SUM pesticides				85.47	138.24	
Summary				468.45	459.47	

Table 6 Total cost of sorghum and maize growing in € ha^{-1}

Indicator	Sorghum	Maize
Material costs	468.45	459.47
Cost of mechanical works	279.89	279.90
Variable costs	748.35	739.37
Fixed costs	121.99	121.99
Total costs	870.34	861.36

Table 7 Economy of sorghum and maize cultivation without subsidies

Indicator	Unit	Sorghum	Maize
Yield	t ha^{-1}	62.70	54.20
Price per unit	€ t^{-1}	33.00	33.00
Total production	€ ha^{-1}	2069.10	1788.6
Economic result per ha	€ ha^{-1}	1198.76	927.24
Economic result per t	€ t^{-1}	19.12	17.11
Profitability per ha	%	137.73	107.65
Profitability per t	%	2.20	1.99
The income threshold for zero profitability	t ha^{-1}	26.37	26.10

conventional cultivation methods are shown in Table 4. From stubble to removal of biomass from the area, the cultivation of sorghum and maize consumed 100.0 litres of diesel per hectare, and the necessary work makes 21.25 hours. Variable costs account for almost 280 € ha^{-1} and fixed costs almost 122 € ha^{-1}. The total costs for particular operations are 401.89 € ha^{-1}.

When evaluating material costs, sorghum spent higher costs with mineral fertilizers (about 60.75 € ha^{-1}) and maize with the pesticides (about 52.77 € ha^{-1}). For both crops, soil conditioner PRP sol was applied, combined with NPK fertilizer in sorghum, and for maize it was LAV at doses shown in Table 5.

The total costs in the production of both crops are shown in Table 6 and the difference 8.98 € ha^{-1} shows different levels of material costs. The total cost for sorghum are 870.34 € ha^{-1} and for maize 861.36 € ha^{-1}.

In the experiment with sorghum, silage harvest reached 62.70 t ha^{-1} and for maize it was 54.20 t ha^{-1} (33% moisture). With a price 33 € t^{-1} of silage, a profit for sorghum without subsidies reached 1,198.76 € ha^{-1} and for maize 927.24 € ha^{-1}. The profit per ton for the sorghum crop was 19.11 € and 17.11 € for maize. The both crops profitability per hectare exceeded 100%. For profitable cultivation, the sufficient yield should exceed 26.37 t ha^{-1} for sorghum and 26.10 t ha^{-1} for maize.

Conclusions

The comparative experiments of sorghum with other crops brings following conclusions:

1. Temperature and rainfall conditions at the experimental station favourably influenced the growth and production processes of the selected field crops.
2. The slowest initial amount of crop development was observed in sorghum and the fastest in sunflower.
3. After an initial slow accretion of biomass, from 15th of August, sorghum significantly exceeded all monitored field crops by accretion intensity.
4. The highest seed yield 11.98 t ha^{-1} was achieved for maize, the sorghum yield was 9.58 t ha^{-1} and it was by 2.4 t ha^{-1} lower than yield of maize. Other crops marked significantly lower values.
5. Costs for particular operations in the conventional method of cultivation of sorghum and maize silage were identical and amounted to 401.89 € ha^{-1}.
6. The difference in the total costs of cultivation of sorghum and sunflower silage was 8.98 € ha^{-1} and it resulted from different levels of material costs. The total costs for sorghum accounted for 870.34 € ha^{-1} and for maize 861.36 € ha^{-1}.
7. The profit 1,198.76 € ha^{-1} was achieved in the experiment with sorghum, and for maize, it made 927.24 € ha^{-1}. A sorghum harvest at over 26.37 t ha^{-1}, would be sufficient to achieve a profit, and for maize, it would be 26.10 t ha^{-1}.

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