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REACTION OF SELECTED ORCHARD GRASS (*Dactylis glomerata* L.) CULTIVARS TO SOIL MOISTURE

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ABSTRACT

The paper presents the results of 3-year pot experiment, aimed at defining the impact of soil moisture on selected biometric characteristics, dry matter yield and yield quality. The research covered four orchard grass cultivars, ‘Amera’, ‘Astera’, ‘Bepro’, ‘Potomac’, different in earliness, cultivated under four field water capacities (80%, 65%, 50% and 35% FWC). Tillering, leaf blade area and dry matter yield were most considerably enhanced by moderate soil moistures, 65% and 50% FWC. However the reaction to soil moisture differed across cultivars. ‘Amera’ yielded significantly highest under 50% FWC, ‘Astera’ yielded similarly under 65% and 80% FWC, ‘Bepro’ under 65% and 50%, while the highest yield of ‘Potomac’ was obtained under 65% FWC. ‘Astera’ was

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most prolific, developed the greatest number of shoots and the greatest leaf blade assimilation area. The soil moistures affected the contents of crude protein and water-soluble carbohydrates; the grater the soil moisture the lower the content of protein and the higher content of carbohydrates. Early cultivars, 'Amera' and 'Bepro', accumulated more protein and less carbohydrates than the late cultivar 'Astera'.

Key words: orchard grass, cultivars, soil moisture, plant morphology, dry matter yield, nutritive value

INTRODUCTION

Grasses show a high coefficient of transpiration and, therefore, in central Poland a shortage of rainfall reduces meadow and pastureland yielding due to limited assimilation and transpiration. Water intake and give-off by plants depend on various factors, including air temperature, soil water availability, plant assimilation area and development phase. Soil moisture affects nutrient metabolism. Water relations in soil regulate not only yielding but also yield quality. Yield qualitative characteristics are significantly modified by habitat conditions [2,9,12,14,18,21].

Currently grass species especially unaffected by a growing water deficit in agroecosystem are becoming more and more required. Orchard grass is one of them due to its high productivity and considerable resistance to periodical semi-draughts as well as its high adaptability to various habitat conditions. The literature [9,11,12,13,16,20] shows that orchard grass yield variability over successive years is very much affected by climate, rainfall in specific, which could point to varied water requirements across cultivars.

The present research aimed at defining the effect of soil moisture on dry matter yield and quality and morphological characteristics of selected orchard grass cultivars different in earliness.

MATERIAL AND METHODS

The experiment, set up in the spring of 1997 and completed in the autumn of 1999, was carried out by the Bydgoszcz University of Technology and Agriculture in 20 cm-in-diameter pots filled with 6 kg of muck and peat soil whose pH in KC1 was 6.8 and which showed a high total N content (2.11%), a medium P content (8.84 mg·100 g^{-1} of soil) and a low content of available K (14.9 mg·100 g^{-1} of soil).

The research covered three Polish orchard grass cultivars different in earliness: early 'Amera' and 'Bepro', late 'Astera' and 'Potomac' Canadian cultivar and four soil moistures: 80%, 65%, 50% and 35% of field water capacity (FWC) which were controlled by supplementing pots with water to a fixed weight throughout the vegetation period.

'Amera' cultivar was entered in the Cultivar Register in 1983. 'Amera' plants are very high, do not lodge and overwinter well. It is especially applicable to field cultivation in pure stand or as a spring cereal intercrop. 'Astera' cultivar was entered in the Cultivar Register in 1993. 'Astera' yields in meadow-and-pasture farming are very high, plants do not lodge and show a favourable first-cut nutritive value. 'Bepro' cultivar, entered in the Cultivar Register in 1981, shows an early and rapid growth. It regrows and overwinters well generating high fresh and dry matter yields. The plants do not lodge and are resistant to diseases and pests. 'Bepro' is applicable to meadow and pasture farming [1].

All the cultivars were fertilised with 0.5 g of N (per sward) in the form of ammonium nitrate and 0.3 g of P in superphosphate and 0.4 g of K in potassium chloride per pot per 1st sward, only. Four cuts were harvested each year, the 1st one over the mowing maturity and the following after 5-6 weeks. The number and weight of shoots per pot, leaf blade area, dry matter yield and quality were defined. An average leaf blade area was obtained by measuring all the blades of 10 randomly sampled shoots from the second sward. The leaf blade area was calculated with the Kemp [8] formula: $p = a \cdot b \cdot 0.905$, where p = leaf blade area, a – leaf blade length, b – leaf blade width. The pot plant dry matter yield was defined following an earlier drying with air desiccator at 105 ^{o}C to the fixed weight.

Chemical analysis covered the contents of crude protein, crude fibre and water-soluble carbohydrates and was carried out with InfraAnalyzer 450 near-infrared spectroscopy. The results were verified with the completely randomised variance analysis and with the Tukey test at α=0.05. Figures 1-3 present LSD for the interaction between cultivar and soil moisture.

RESULTS AND DISCUSSION

The temperature over 1997-1999 was changeable (Table 1). In the first year of study (1997) mean air temperature April through September was lower than and in 1998 equalled the multi-year mean. In 1999 vegetation period mean air temperature was much higher. Changeable temperature conditions over years affected the orchard grass tillering. According to Garwood [5], orchard grass requires high tillering temperature of about 20°C.

Table 1. Mean daily air temperature distribution over 1997-1999 vegetation periods, °C

Years	April	May	June	July	August	September	April - September
1997	4.7	11.5	16.0	17.7	19.9	13.2	13.8
1998	9.3	13.8	16.6	16.7	15.5	12.7	14.1
1999	8.6	12.2	16.5	20.0	17.4	15.6	15.0
1949-1995	7.2	12.7	16.2	17.8	17.4	13.2	14.1

The number of shoots developed by orchard grass cultivars when exposed to varied soil moistures ranged from 48.1 to 75.4 per pot (Fig. 1); the greatest was recorded for ‘Astera’ (75.4), then ‘Amera’ (68.7), ‘Bepro’ (66.4) and ‘Potomac’ (57.8). ‘Astera’ was also among the most tillering orchard grass cultivars studied by Łyszczarz et al. [13]. The present research showed that moderate soil moisture (65% and 50% FWC) was the most favourable for orchard grass tillering. A significantly lower number of shoots was recorded under extreme moistures, both highest (80% FWC) and lowest (35% FWC). There was observed an interaction between cultivars and soil moistures studied. ‘Amera’ and ‘Bepro’ developed fewer shoots under 80% and 35% FWC, ‘Astera’ reduced tillering under draught (35% FWC) significantly, while ‘Potomac’ produced more shoots under a higher soil moisture (65% and 80% FWC). Also Rutkowska [19] confirms unfavourable effect of draught on orchard grass tillering.

The mean dry matter weight of a single ‘Amera’, ‘Astera’ and ‘Bepro’ shoot differed slightly and ranged from 11.6 to 11.9 mg (Fig. 2), while ‘Potomac’ single shoot dry matter weight was much lower and amounted to 9.8 mg. 65% and 80% FWC enhanced the single shoot weight of most cultivars, except ‘Potomac’, while 50% and 35% FWC decreased mean shoot weight by an average of about 9%.

Fig. 1. Impact of soil moisture on the mean number of shoots in orchard grass cultivars

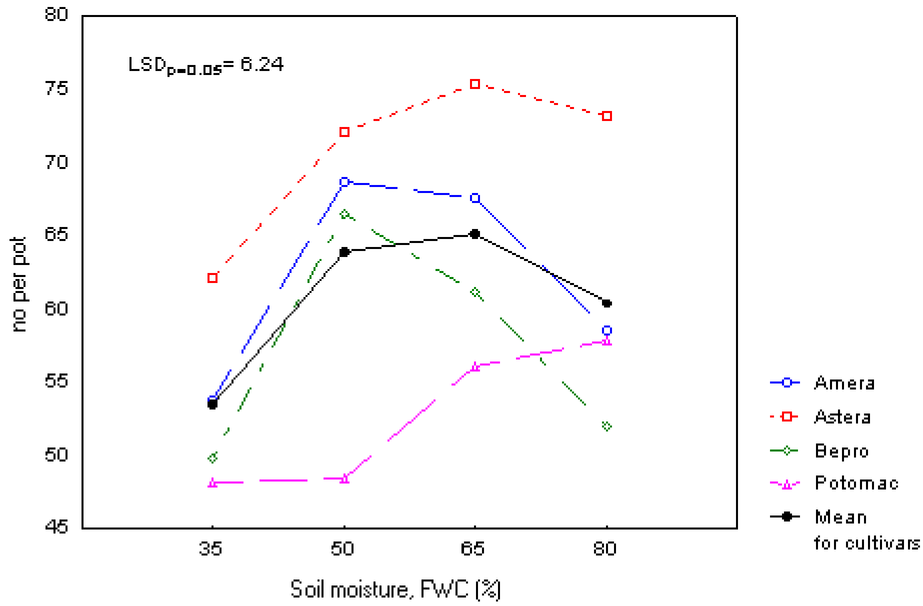
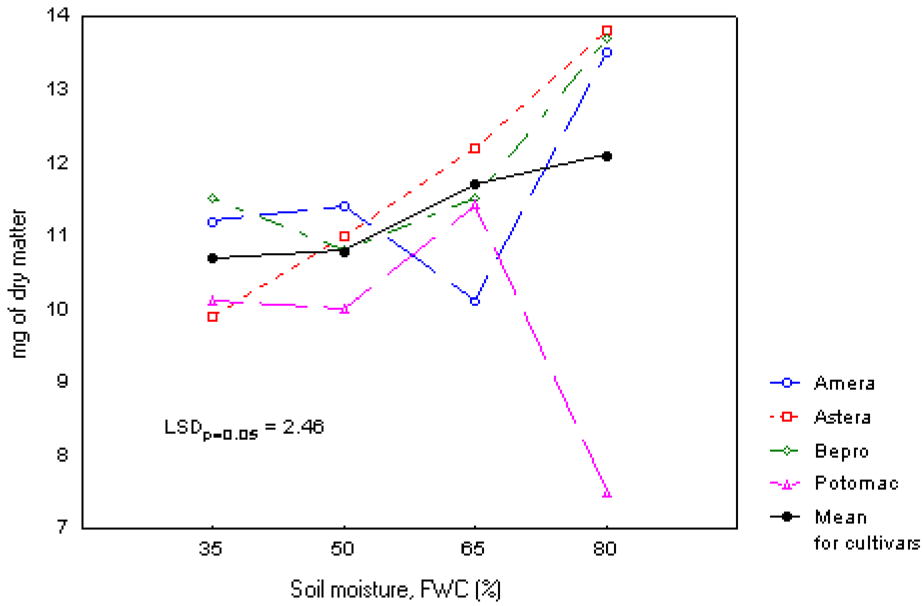


Fig. 2. Impact of soil moisture on the mean shoot weight in orchard grass cultivars



An average leaf assimilation area was cultivar and soil moisture specific (Fig. 3). The biggest orchard grass leaf blades were developed under 50% and 65% FWC, 50% FWC for 'Amera' and 'Potomac' and 65% for 'Bepro' and the biggest 'Astera' leaf blade area was noted for 80% FWC; all of which points to varied water requirements of orchard grass cultivars. In the present research 35% FWC limited the leaf blade area and leaf length of all cultivars. Nelson and Sleper [17] claim that grass leaf area depends mainly on leaf length. Mikołajczak [15] showed an increase in orchard grass leaf blade area along with an increase in soil moisture from 40% to 80% FWC.

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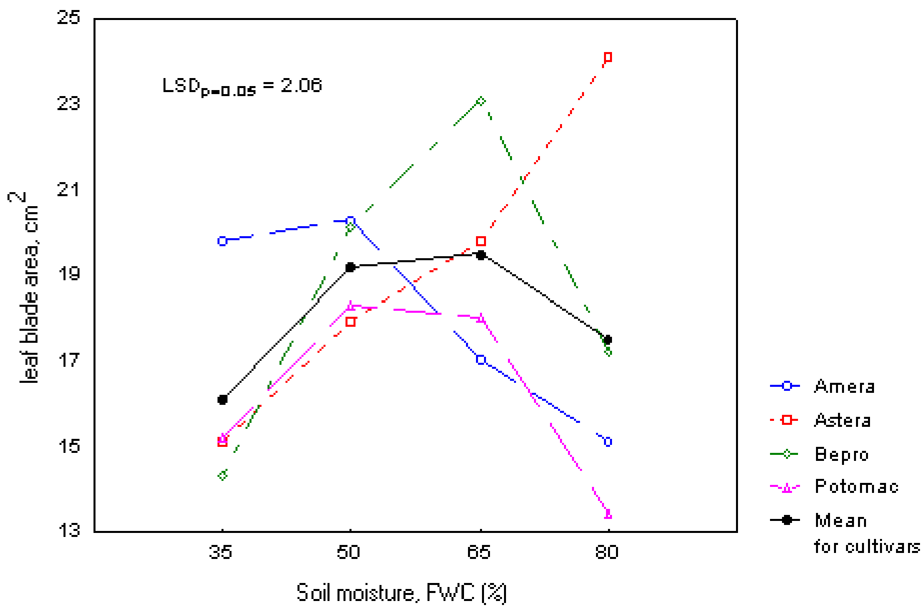
Fig. 3. Impact of soil moisture on the mean leaf blade area in orchard grass cultivars



Dry matter yields over successive cuts differed significantly; the highest was obtained in the 1st cut (Table 2). ‘Astera’ turned out to be the most productive of all the cultivars studied and its dry matter yield was 75% higher than that of the lowest yielding ‘Potomac’. Other cultivars e.g. ‘Amera’ and ‘Bepro’ yielded similarly. On average, the highest orchard grass dry matter yields were obtained under 65% and 50% FWC while increasing FWC to 80% resulted in a significant decrease in yield, whereas lowering to 35% - an even significantly lower yield than the latter. Kasperczyk and Szewczyk [7], Moraczewski et al. [16] as well as Rutkowska and Lewicka [20] claim that moderate soil moisture is most favourable for orchard grass yielding as both shortage and excessive amount of water are responsible for poor soil nutrient consumption [6,20]. The present research showed a varied orchard grass cultivars yielding due to a varied soil moisture. The ‘Amera’ annual mean dry matter yield was significantly higher under 50% FWC and ‘Astera’ yielded similarly under 80% and 65% FWC while ‘Bepro’ under 65% and 50%. The highest ‘Potomac’ dry matter yield was recorded under 65% FWC. Łyszczarz et al. [13] also reported on early orchard grass cultivars yielding higher over drier years and on late ‘Astera’ yielding higher under higher rainfall.

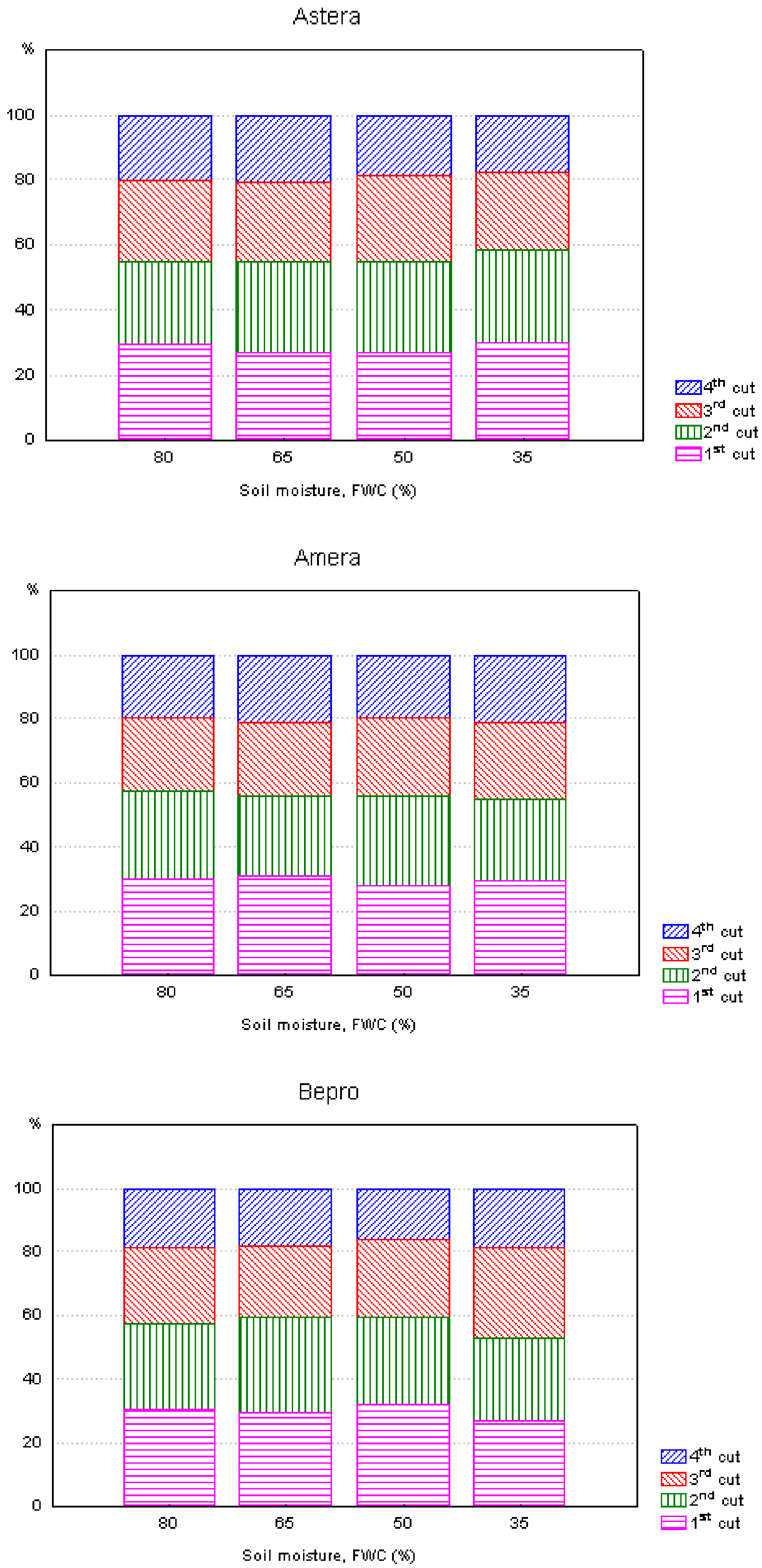
Table 2. Impact of soil moisture on the mean orchard grass cultivar dry matter yield, g per pot

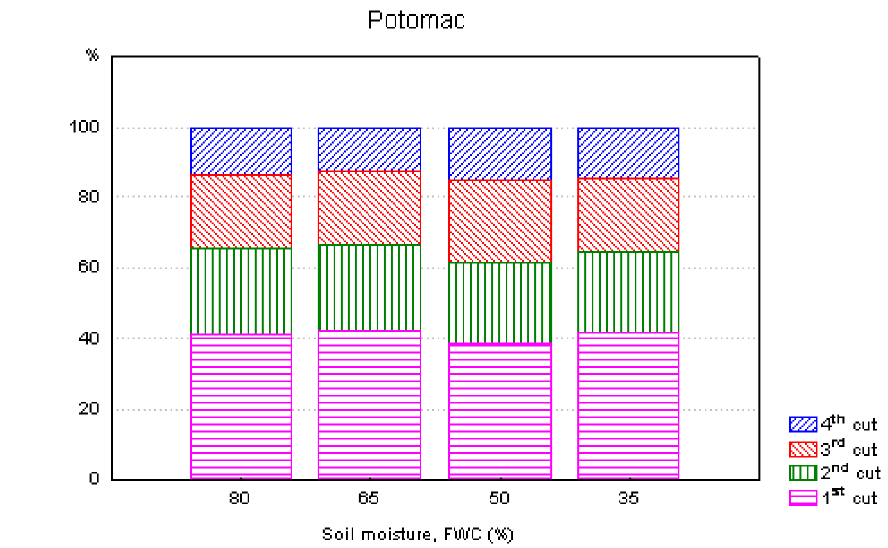
Cultivar	FWC, %	Cuts				Mean for cut
		I	II	III	IV	
Amera	80	6.38	5.87	4.81	4.17	5.31
	65	6.68	5.33	5.09	4.48	5.40
	50	6.56	6.38	5.83	4.55	5.83
	35	5.78	4.93	4.84	4.08	4.91
	Mean	6.35	5.62	5.14	4.32	5.36
Astera	80	8.28	7.15	7.20	5.70	7.08
	65	7.92	8.25	7.41	6.03	7.40

	50	7.20	7.43	7.09	4.93	6.66
	35	7.24	6.97	5.87	4.24	6.08
	Mean	7.66	7.45	6.89	5.23	6.81
Bepro	80	6.12	5.59	4.81	3.73	5.06
	65	6.65	6.88	4.98	4.02	5.63
	50	6.97	5.99	5.32	3.45	5.43
	35	4.70	4.59	5.05	3.23	4.39
	Mean	6.11	5.76	5.04	3.61	5.13
Potomac	80	5.85	3.51	3.01	1.90	3.57
	65	7.65	4.53	3.88	2.20	4.57
	50	6.30	3.83	3.84	2.45	4.11
	35	5.50	3.14	2.73	1.95	3.33
	Mean	6.33	3.75	3.36	2.13	3.90
Mean for FWC:						
	80%	6.66	5.53	4.96	3.88	5.26
	65%	7.23	6.25	5.34	4.18	5.74
	50%	6.76	5.91	5.52	3.85	5.50
	35%	5.81	4.90	4.62	3.38	4.68
Mean		6.62	5.65	5.11	3.82	5.30
$LSD_{0.05}$ for:						
	Cultivars	0.51	0.38	0.45	0.37	0.33
	Soil moisture	0.51	0.38	0.45	0.37	0.33
	Interaction between cultivars and soil moisture	1.02	0.96	0.90	0.74	0.66

Generally, the soil moisture did not affect the orchard grass dry matter yield distribution over the vegetation period, however there was observed a varied yield distribution across the cultivars (Fig. 4). The 1st cut yield in ‘Amera, ‘Astera’ and ‘Bepro’ accounted for about 29% while in ‘Potomac’ more than 40% of the annual dry matter yield. The share of the 2nd and 3rd cut dry matter yield of all the cultivars ranged from 22% to 28%, on average. The 4th cut dry matter yields were lower, especially in ‘Potomac’ (over three times lower than in 1st cut). In conclusion, ‘Amera’ and ‘Bepro’, early orchard grass cultivars, developed better under moderate soil moisture (50% and 65% FWC) and must have consumed less water for dry matter production due to a lower leaf blade area and hence a lower transpiration area, whereas a higher soil moisture, 65% and 80% FWC, were more favourable for mid-early ‘Astera’.

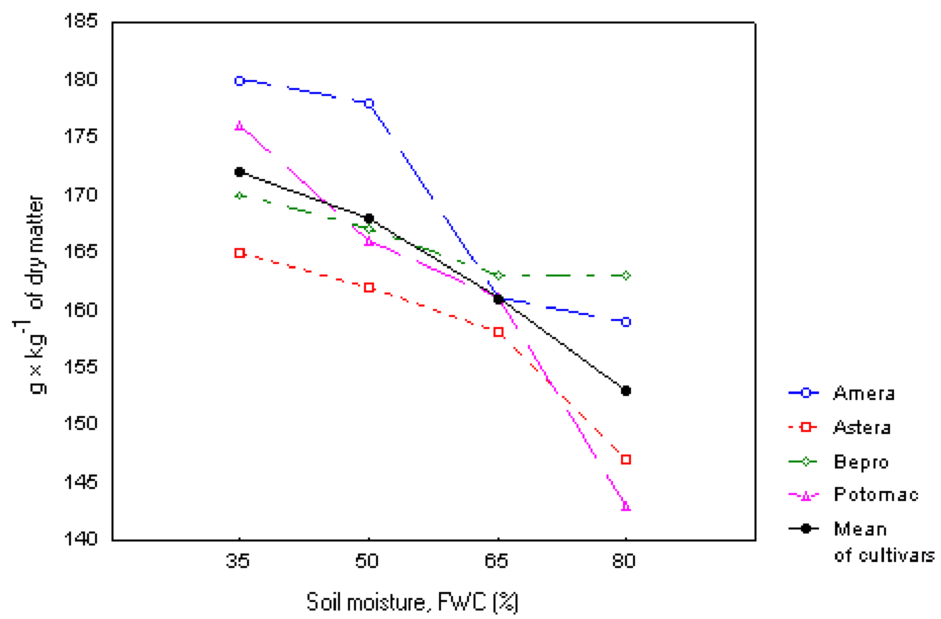
Fig. 4. Impact of soil moisture on the share of dry matter yield from subsequent cuts in annual yield of orchard grass cultivars





Plant nutritive value is made up of contents of crude protein, crude fibre and water-soluble carbohydrates. Generally, the cultivars studied contained enough protein and crude fibre and showed a low content of carbohydrates [4]. The crude protein content in orchard grass dry matter ranged from 143 to 180 g·kg^{-1} (Fig. 5). Early cultivars, 'Amera' and 'Bepro', accumulated most, 'Potomac' less and late 'Astera' the least protein.

Fig. 5. Impact of soil moisture on the mean content of crude protein in orchard grass cultivar dry matter



The highest accumulation of water-soluble carbohydrates was observed in 'Astera' (60.4 g kg^{-1}) while the lowest – 'Bepro' (52.5 g·kg^{-1} of dry matter) (Fig. 6). Reports by Kozłowski et al. [10] show a considerable variation in the sugar content across orchard grass cultivars and classify 'Bepro' as a low sugar content cultivar. Soil moistures researched were responsible for different crude protein and water-soluble carbohydrate contents. 80% FWC resulted in a lower crude protein content and in a higher carbohydrates content as compared with 35%

FWC. However crude fibre content was not affected by soil moistures and ranged across cultivars from 202 to 228 g·kg^{-1} of dry matter (Fig. 7). The results obtained only partially coincide with the literature data. According to Prończuk [18], early grass species show a higher protein and fibre contents than the late ones. Dębska-Kalinowska [2] observes higher contents of both protein and sugars when exposed to dry soil conditions, which was not found in the present research. Neither did the present research record an impact of soil moisture on orchard grass crude fibre content. However Dębska-Kalinowska [2] and Martyniak and Szymczak [14] show that the fibre content in grass is considerably affected by soil moisture. A high ground water level, and hence adequate soil moisture in rhizosphere, makes a lower crude fibre content possible. Thorvaldsson and Fagerberg [21], on the other hand, say that soil moisture affects more the protein content than the crude fibre content since water shortage delays shoot development and plant ageing, which enhances the nutritive value of animal feed.

Fig. 6. Impact of soil moisture on the mean content of water-soluble carbohydrates in orchard grass cultivar dry matter

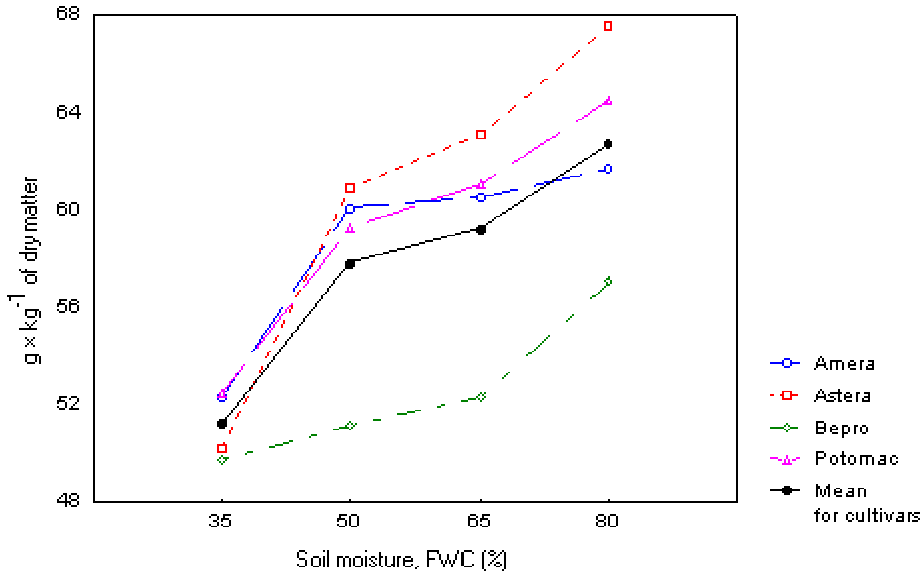
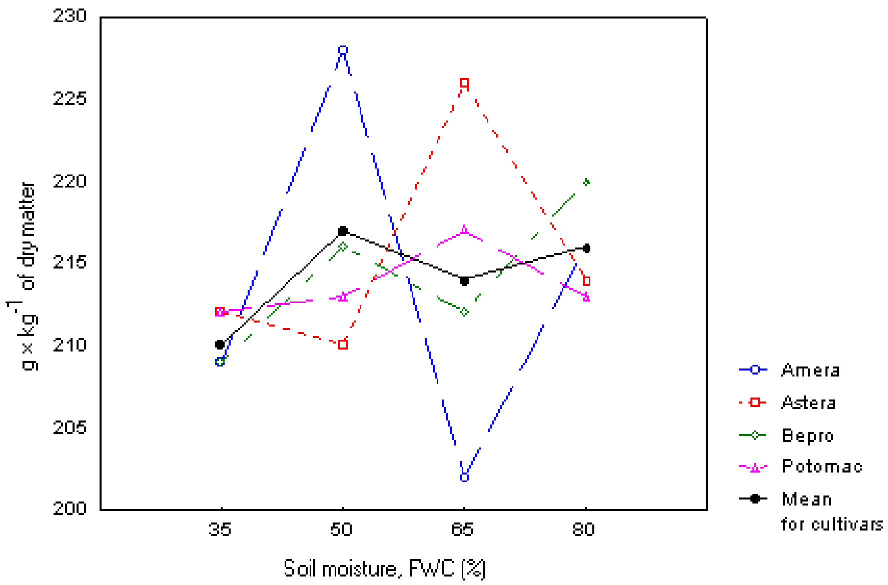


Fig. 7. Impact of soil moisture on the mean content of crude fibre in orchard grass cultivar dry matter



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Generally, ‘Amera’ and Bepro’, early orchard grass cultivars, developed better under moderate soil moisture (50% and 65% FWC); even though the leaf assimilation area was smaller, the transpiration area was also smaller, and, therefore, plants could have consumed less water. Higher soil moisture was more favourable for development of the later ‘Astera’ cultivar. One shall stress that the highest yielding ‘Astera’ cultivar yielded higher under semi-draught conditions than the other cultivars studied. The contents of crude protein and crude fibre were sufficient while the content of water-soluble carbohydrates was low as compared with Falkowski et al. [4]. Varied soil moistures affected only the contents of crude protein and of water-soluble carbohydrates in feed.

CONCLUSIONS

1. Soil moisture affected orchard grass tillering, leaf blade assimilation area, yielding and yield quality across cultivars.
2. ‘Amera’ and ‘Bepro’, early orchard grass cultivars yielded higher under moderate soil moisture (50% and 65% FWC), while late ‘Astera’ yielded similarly under 65% and 80% FWC. The highest ‘Potomac’ dry matter yield was obtained under 65% FWC.
3. Out of all the orchard grass cultivars studied, it was ‘Astera’ which yielded highest, developed leaf blades of the greatest area and showed a higher water-soluble carbohydrates content.
4. An increase in soil moisture coincided with crude protein decrease and water-soluble carbohydrates increase in dry matter. ‘Amera’ and ‘Bepro’ showed a higher crude protein content and a lower water-soluble carbohydrate content than those observed in late ‘Astera’ cultivar.

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