Evaluation of the suitability of grass species for dry conditions

MICHAL KVASNOVSKY, IVA KLUSONOVA, LUCIA HODULIKOVA, PAVEL KNOT
Department of Animal Nutrition and Forage Production
Faculty of Agronomy
Mendel University in Brno
Zemedelska 1, 613 00 Brno
CZECH REPUBLIC

michal.kvasnovsky@mendelu.cz

Abstract: The main aim of this study was to evaluate the response of the production types of grasses to stress-induced reduction of normal precipitation in relation to their production characteristics and the structure of biological phytomass. The covers were established by planting of pre-grown plants of the individual grass species in the spring of 2009 in the form of a small-plot experiment in two blocks. Block A - normal precipitation mode, Block B - reduced precipitation mode consisting in roofing of 50% of the experimental area coverage by a special film with a minimum reduction of light conditions in order to drain a half of rainfall out of the area. In the crop year 2011 the annual total Rainfall was relatively lower by 14.0% (632.8 mm) than the long-term average, i.e. 736 mm. In relation to production formation, it is necessary to take into account that in 2011, the precipitation amount for vegetation ranged between 71% and 75% of the annual total. Highest weight of dry matter is in the hybrid Festulolium Fojtan (average 132.6 $g.pc^{-1}$).The effect of reduced precipitation is manifested in a relatively lower weight of the plant Festulolium Fojtan (77.5 $g.pc^{-1}$). The effect of drought on decrease in production and number of pseudostems (offsets) has not been completely proved.

Key-Words: grass, drought, utilization, production, number of offsets.

Introduction

Climate change (rising temperatures, lengthening of the growing season, increasing evaporation) significantly affects agricultural production in traditional production areas, as illustrated by example better results in growing of corn on its northern or upper height limit. Also, the turf can be observed in recent years more and more often occurrence of grass species in group C4 [5]. The important factor that often limits the yield and dry matter grass in drought reflects the significant decrease in soil water content. Water shortage has reflected worse nutrient uptake and thus lower yield [1]. In dry years, yields at higher altitudes are above the average and that compensates short falls in production in major producing areas. These changes of the water balance can significantly influence the possibility of growing crops in our area [6]. However, not only worse nutrient uptake is the cause of reduced yield. Many species respond to drought by maintaining high water potential by reducing water losses or better adsorption. Limitation of water losses can be reduced in the development of water stress by rolling the leaves or fast closing stomata. The plants, however, not only reduce transpiration, but also reduce photosynthesis and thus growth and development [8].

Interaction of drought stress with high temperature has a greater effect than the damaging effects of each stressor separately. There is a loss of water by transpiration required for cooling and thus faster drying [3].

Almost a third of the fresh water that is consumed in Europe is used in agriculture, mostly for irrigation [2]. Although most of the production limits of field crops and grasslands are largely drought [3], the overwhelming majority of agricultural land in the Czech Republic there is not used irrigation. Also grassland in the summer months, when water consumption is highest, on grounds the lack of irrigation possibility is greatly limited. At such situation stands react with deterioration in appearance and functionality. In the Czech Republic during the summer season (April to September), a significant reduction in available water content in the upper soil layer [4]and even in the areas with relatively high rainfall at higher altitudes. Lack of water in the soil is often compounded by the fact that part of the precipitation comes in summer as torrential rains that causes surface runoff, and only part of the total sum increases soil water retention.

Breeding for drought tolerance thus becomes a major objective of breeding programs. Whereas, that the root system of plants is the organ responsible for the uptake of water and nutrients, in addition to anchoring the plants in the soil. The roots are seen as essential for improving the resistance of plants to drought stress [7].Soil heterogeneity and dynamic availability of nutrients in the soil represents a challenging environment in which the plants efficiently receive nutrients to maintain their internal nutrient homeostasis throughout their growth. They are mathematical models that help to understand the strategy of plant growth and root characteristics associated.

The main aim of the study was to evaluate the response production types of grasses to stress-induced reduction of normal precipitation in relation to their production characteristics and the structure of biological phytomass.

Material and Methods

Characterization of growing locality and experimental design

Experimental studies are conducted at the experimental site of the Mendel University in Brno, in the Fodder Research Station of Vatín. From a geographical point of view it is a potato-growing region, with altitude of 535 m. Weather conditions: average annual temperature 6.9°C of which for vegetation 12.6°Cannual amount of precipitation 736 mm of which for vegetation 440 mm. The covers were established by planting of pre-grown plants of the individual grass species in the spring of 2009 in the form of a small-plot experiment in two blocks. Block A - normal precipitation mode, Block B - reduced precipitation mode consisting in roofing of 50% of the experimental area coverage by a special film with a minimum reduction of light conditions so as to drain a half of rainfall out of the area. The mode of precipitation regulation was applied only in the second year after planting for the reason of allowing the same conditions for initial growth and development of plants.

Growing Variants

The subject matter of monitoring and evaluation was a total of 2 grass species (*Festuca arundinacea* variety Prolate and Festulolium Fojtan) and their suitable varieties for grazing character. Fojtan is the result of a crossing between Italian Ryegrass and Tall Fescue.Each variant consisted of planting 25 pcs of individuals grown in layouts of 200 x 200 mm in triplicate (a, b, c). Planting was carried out in June 2009. In the first year, clearing the covers of weeds was done manually. Harvest of the covers (individual plants) was carried out 2x a year only in the year of establishment. From 2010 was subjected to a "model" 5-fold mowing grazing utilization. Before planting was applied to the surface of the NPK fertilizer (dose of N 50 kg.ha^{-1}). In the next year's crop fertilization was 150 kg N.ha^{-1}, of which 1/3 NPK after hibernation and 2 more doses after mowing LAV 27.5%.

Harvesting of individual plants was performed manually by cutting the whole plant at stubble height of 60 mm. For each harvested plant, its weight in dry state was determined by weighing after drying in a drying room. Also the number of stalk (a leaf) offsets, further the plant height, taken as the maximum length of the stalk, was determined. Rated characteristics:

- number of stalk (a leaf) pseudostems
- Weight in dry matter.

Evaluation of inter-species differences in production and differences in production among the water mode were subjected to the ANOVA test. Results were evaluated with Tukey's test. Differences were declared to be statistically significant when $P \leq 0.05$.

Results and Discussion

Evaluating the Level and Course of Rainfall and Temperature

In crop year of 2011 the annual total Rainfall was relatively lower by 14.0% (632.8 mm) than the long-term average, i.e. 736 mm. In relation to production formation, it is necessary to take into account that in 2011, the precipitation amount for vegetation ranged between 71% and 75% of the annual total. Another unusual feature of the year 2011 is a very low level of precipitation in the period of the major production harvests, i.e. the 1st and 2nd mowing. Their share in the annual total is 15% at the maximum, and in relation to the long-term average in the same season it is lower by 1/3 (Table 5).

From the point of view of temperature, average temperature in 2011 was 7.4 °C, which is above the long-term average (6.9 °C).

Weight of Plants in Dry State

Highest weight of dry matter is in the hybrid Festulolium Fojtan (average 132.6 g.pc^{-1}). A statistically significant difference between two monitored species was the 4th and 5th mowing in reduced precipitation mode (Table 1).

The effect of reduced precipitation is manifested in a relatively lower weight plant. However, the differences are not conclusive in any year. Despite the overall lower fodder production, utilization of multiple mowing may be related to better adaptation to an uneven course of precipitation during the growing season. Between two precipitation modes, there is significant difference at *Festuca arundinacea* in 3rd mowing and Festulolium in 2nd and 4th mowing (Table 3).

Table 1 Weight of dry matter, difference between two monitored species (g/1 piece)

Species		1st cut	2nd cut	3rd cut	4th cut	5th cut	Average
Festuca arundinacea	R	32.72 a	21.58 a	8.32 a	15.26 b	26.64 b	122.46 b
Festulolium	R	25.48 a	13.82 a	6.2 a	33.2 a	16.7 a	77.46 a
Festuca arundinacea	N	33.26 a	26.7 a	13.54 a	28.44 a	23.42 a	131.54 a
Festulolium	N	35.82 a	28.08 a	13.78 a	31.48 a	29.6 a	132.58 a

N - Normal precipitation mode, R - Reduced precipitation mode

Table 2 Number of stalk (a leaf) pseudostems, difference between two monitored species (pc/1 piece)

Species		1st cut	2nd cut	3rd cut	4th cut	5th cut	Average
Festuca arundinacea	R	91.93 a	58.53 a	38.00 a	107.07 b	68.73 a	72.85 b
Festulolium	R	74.93 a	38.13 a	25.00 a	57.67 a	47.80 a	48.71 a
Festuca arundinacea	N	77.8 a	59.73 a	44.13 a	96.86 a	88.4 a	73.39 a
Festulolium	N	97.40 a	63.47	39.67 a	82.20 a	82.27 a	73.00 a

Table 3 Weight of dry matter, difference between two blocks precipitation mode (g/1 piece)

Species		1st cut	2nd cut	3rd cut	4th cut	5th cut	Average
Festuca arundinacea	N	33.3a	26.7a	13.5b	28.4a	29.6a	131.5a
	R	32.7a	21.6a	8.3a	33.2a	26.6a	122.5a
Festulolium	N	35.8a	28.1b	13.8a	31.5b	23.4a	132.6b
	R	25.5a	13.8a	6.2a	15.3a	16.7a	77.5a

Table 4 Number of stalk (a leaf) pseudostems, difference between two blocks precipitation mode (pc/1 piece)

Species		1st cut	2nd cut	3rd cut	4th cut	5th cut	Average
Festuca arundinacea	N	77.80 a	59.73 a	44.13 a	96.87 a	88.40 a	73.39 a
	R	91.93 a	58.53 a	38.00 a	107.07 a	68.73 a	72.85 a
Festulolium	N	97.40 a	63.47 b	39.67 a	82.20 a	82.27 a	73.00 a
	R	74.93 a	38.13 a	25.00 a	57.67 a	47.80 a	48.71 a

Table 5 Precipitation in year 2011 (distribution in each mowing)

	Spring 1.1.-1.3.	1st mowing	2nd mowing	3rd mowing	4th mowing	5th mowing	Autumn	Total
mm	78.8	47.5	49.5	71.9	190.7	107.4	86.8	623.8
%	12.4	7.5	7.8	11.4	30.1	17	13.7	100

Explanation of the decline in production in the situation of reduced rainfall can be related to the species differences in evapotranspiration of grasses [10] and also to a slowdown in growth of the root system and the associated decrease in production [11].

Number of stalk (a leaf) pseudostems

A statistically significant difference in the number of pseudostems between the monitored species was the 4th mowing in reduced precipitation mode. *Festuca arundinacea* had more pseudostems compared to Festulolium (57.67 pc). At normal precipitation mode there has not been detected significant difference in the number of pseudostems between a species (Table 2).

The effect of drought on number of pseudostems is not conclusive. Only the second mowing at Festulolium is significant difference, between two precipitation mode (Table 4).

The results further confirm a lower fodder production and a higher formation of offsets in all species at the 5-fold mowing utilization of covers. Generally, this fact is expressed in connection with the lower weight and massiveness of the root system. The proof of the results is reported in high-mowed, i.e. less often mowed, and in short-mowed, i.e. very often mowed lawn species [12].

Conclusion

The effect of reduced precipitation is manifested in a relatively lower weight plant. However, the differences are not conclusive in any year. Despite the overall lower fodder production, utilization of multiple mowing may be related to better adaptation to an uneven course of precipitation during the growing season.
The effect of drought on number of pseudostems was not detected statistically significant differences. As it is evident from the results of connection to findings exactly the grazing type variety could be the reason of overall lower production of fodder in grazing utilization on the one hand, but on the other hand, also of a more favorable yield response to drought than in varieties of the meadow character.
The effect of drought on decrease in production and number of pseudostems has not been wholly proved.

Acknowledgement

The paper was prepared under the support from Grant no. IGA TP 3/14 Effect of specifically positive aditives in animal nutrition on animal products quality and environment preservation during forage production.

References:

[1] Fiala K, Tůma I, a Holub P, Interannual Variation in Root Production in Grasslands Affected by Artificially Modified Amount of Rainfall, *The Scientific World Journal*.2012.

[2] Flörke M, Alcamo J, European outlook on water use. Final report, Centre for Environmental Systems Research. Kassel, 2004 83 p.

[3] Jiang Y, Huang B, Drought and Heat Stress Injury to Two Cool-Season Turfgrasses in Relation to Antioxidant Metabolism and Lipid Peroxidation, *Crop Science*, 2001. 41:436–442.

[4] Možný M, Monitoring zásoby využitelné vody v povrchové vrstvě půdy pod travním porostem. Meteorologické zprávy, 2006. 59: 118-121.

[5] Trnka M, *Využití agroklimatických metod při posuzování biofyzikálních předpokladů udržitelného hospodaření*, Habilitační práce MZLU v Brně, 2008. 249 s.

[6] Trnka M, Dubrovský M, Svoboda M, Semerádová D, Haynes M, Žalud Z, Wilhite D, Developing a regional drought climatology for the Czech Republic. *International Journal of Climatology*, 2008. 1745 (10), p. 1-21.

[7] Vadez V, Root hydraulics: The forgotten side of roots in drought adaptation. *Field Crops Research* 2014. Volume 165, p. 15–24.

[8] Xu BF, Li L, Shan Y, Ma N, Ichizen, and Huang J, Gas exchange, biomass partition, and water relationships of three grass seedlings under water stress. *Weed Biology and Management,* 2006. 6:79–88.

[9] Petr J, *et al*. Počasí a výnosy, 1987. SZN Praha, 365 s.

[10] Rychnovská M, et.al. Structure and Functioning of Seminatural meadows. Praha, Academia (et.Elsevier), 1993, 385.s.

[11] Svačina D, Středa T, Chloupek O, Uncommon Selection by Root System Size Increases Barley, Agronomy for Sustainable Development. Seiens des productions vegetales et de l'environnement. 2014. Vol. 34, No. 2, pp. 545-551.

[12] Knot P, Hrabě F, Vrzalová J, Succesion and structure of a mulched and cut lawn, *Alternative functions of grassland. Proc. of the EGF*, 2009, Brno, Czech Republic, 7.-9. 2009, Grassland Science in Europe, Vol.14, p. 452-455.