doi: 10.17221/134/2016-CJGPB

Characterization of the First Czech Sorghum Variety Ruzrok Tested in the Czech Republic

*Jiří HERMUTH and Klára KOSOVÁ**

Department of Plant Genetics, Breeding and Product Quality,
Crop Research Institute, Prague, Czech Republic
**Corresponding author: kosova@vurv.cz*

Abstract

Hermuth J., Kosová K. (2017): Characterization of the first Czech sorghum variety Ruzrok tested in Czech Republic. Czech J. Genet. Plant Breed., 53: 37–44.

Ruzrok, the first sorghum cultivar of Czech provenance, was selected as a multiline cultivar from sorghum collected in the Bílé Karpaty region in Moravia, Czech Republic. In the present paper, basic plant morphological and yield-related characteristics as well as characteristics related to plant resistance to major abiotic and biotic stress factors are described. The major advantages of Ruzrok consists in its earliness, plant height and high growth rate of plants leading to high biomass production. Ruzrok was registered for its high biomass yield; however, its grains can also be used for flour production and food purposes after the technological removal of tannin-rich outer layers of grains. Recommendations for basic cultural practices such as sowing date, fertilization and protection against pests and diseases are given. In conclusion, potential utilization of the novel sorghum variety as both biomass and fodder crop is discussed.

Keywords: central Europe; earliness; growth- and yield-related characteristics; minority cereals; yield

The global climate change brings a lot of undesirable impacts which will influence the agricultural production in the Czech Republic in future. Nowadays, drought risks and their impact have increasingly begun to affect agricultural production. One of the main solutions might be the breeding and selection of more resistant species and varieties which are more adaptable to lower water availability and which are more resistant to the new climate change as well as an introduction of novel crops including minority cereals (Hermuth *et al.* 2016).

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the oldest crops grown by mankind. Presently, it is one of the five most commonly cultivated cereals in the world for human nutrition. Sorghum is also suitable as a high-quality feeding product due to high content of sugars, revealing very good digestibility, and high content of green silage masses.

The novel sorghum variety Ruzrok was bred from a landrace collected by Dr. V. Holubec in the Bílé Karpaty region in Moravia, Czech Republic. For sorghum breeding, a series of positive and negative selections from the population collected within 7 years was used. Plant self-pollination was used as a method of variety production.

The aim of the study was to compare the first Czech sorghum variety Ruzrok with selected sorghum genotypes Friggo, Farmsorgho 180, Niagara 2, Sweet Caroline, Sweet Susana and ZSG-006 grown at five locations (Čáslav, Chrlice, Lednice, Uherský Ostroh, Žatec) of the Central Institute for Supervising and Testing in Agriculture during the two growing seasons, 2012 and 2013. Basic plant growth- and yield-related characteristics including relative growth rate of plants, heading date, plant height, relative dry mass, yield and thousand grain weight were assessed in order to evaluate the suitability of the new sorghum variety Ruzrok for growth in conditions of the Czech Republic.

Plant material. In field experiments in 2012, the following five sorghum genotypes were assessed:

doi: 10.17221/134/2016-CJGPB

Sweet Caroline, Sweet Susana, Farmsorgho 180, Friggo and Ruzrok. In 2013, the following four sorghum cultivars were assessed: Niagara 2, ZSG-006, Friggo and Ruzrok. Basic morphological characteristics of the Ruzrok sorghum cultivar are provided in Table 1. Except for Ruzrok which is a line cultivar, the other

Table 1. Morphological and yield-related characteristics of Ruzrok sorghum variety

Characteristic	State of expression	Scale
Seedling: anthocyanin coloration of coleoptile	medium	5
Seedling: anthocyanin coloration of dorsal side of first leaf	absent or very weak	1
Seedling: anthocyanin coloration of sheath of first leaf	absent or very weak	1
Leaf: anthocyanin coloration of blade (at five leaf stage)	absent or very weak	1
Plant: time of panicle emergence (50% of plants with a panicle)	very early	1
Plant: natural height of foliage at panicle emergence	medium	5
Leaf: green colour of blade (at panicle emergence)	medium	5
Flag leaf: extension of discoloration of midrib	weak	3
Flag leaf: intensity of green coloration of midrib compared to blade	paler	1
Flag leaf: yellow coloration of midrib	weak	3
Glume: colour at flowering	green yellow	4
Glume: anthocyanin coloration (at flowering)	weak	3
Glume: anthocyanin coloration of pubescence	absent or very weak	1
Lemma: arista formation	medium	5
Stigma: anthocyanin coloration	absent or very weak	1
Stigma: yellow coloration	medium to strong	6
Stigma: length	short to medium	4
Flower with pedicel: length of flower	long	7
Panicle: density at end of flowering	medium	5
Dry stamen: colour (after end of flowering)	orange	3
Plant: total height (at maturity)	medium to high	6
Stem: diameter (one third of height of plant, at maturity)	small to medium	4
Leaf: length of blade of the third leaf from top	short	3
Leaf: width of blade of the third leaf from top	narrow	3
Panicle: lenght without neck	medium	5
Panicle: length of branches (middle-third of panicle)	short to medium	4
Panicle: density at maturity	sparse to medium	4
Panicle: shape	panicle broader in lower part	4
Neck of panicle: visible length above sheath	medium to long	6
Glume: colour at maturity	black	7
Glume: length	very long	9
Caryopsis: colour after threshing	pale brown	7
Grain: Weight of 1000 grams	low to medium	4
Grain: shape in dorsal view	elliptic	5
Grain: shape in profile view	elliptic	5
Grain: size of mark of germ	small to medium	4
Grain: content of tannin	high	7
Grain: texture of endosperm (in longitudinal section)	¾ farinaceous	7
Grain: colour of vitreous albumen	orange	4

Characteristics included in the CPVO Technical Protocol, UPOV Test Guidelines or National Guidelines; the scale 1 to 9 represents quantitative and qualitative values: 1 means the lowest value while 9 means the highest value of a given character

doi: 10.17221/134/2016-CJGPB

Table 2. A list of sorghum varieties used for testing in 2012 and 2013 by the Central Institute of Testing and Supervising in Agriculture; all tested varieties can be grown for grain as well as silage in the Czech Republic; Friggo variety was used a control variety (*)

Variety	Char	Company	Company (CZ)	Testing (year)	Grain	Silage
Sweet Caroline	H	MMR Research	Ing. Karel Kokaisl	2012	yes	yes
Sweet Susana	H	MMR Research	Ing. Karel Kokaisl	2012	yes	yes
Farmsorgho 180	H	Gabonkutató Nonprofit Közhasznú	AgriSem GmbH	2012	yes	yes
Niagara 2	H	Semillas Biscayart S.A.	OSEVA PRO s.r.o.	2013	yes	no
ZSG-006	H	Semillas Biscayart S.A.	OSEVA PRO s.r.o.	2013	yes	no
Friggo*	H	RAGT	VP AGRO, s.r.o.	2012/13	yes	yes
Ruzrok	L	CRI Prague	CRI Prague	2012/13	yes	yes

Char – variety character; H – hybrid variety; L – line variety; company – breeding company; company (CZ) – Czech branch of the breeding company

Table 3. Basic characteristics of locations used for the testing of sorghum varieties in 2012 by the Central Institute for Testing and Supervising in Agriculture; locations used for sorghum variety testing were Čáslav (CAS), Chrlice (CHR), Lednice (LED), Uherský Ostroh (UHO) and Žatec (ZAT) which belong to either maize (1) or sugar beet (2)production regions

Location	Code	Production region	Altitude (m a.s.l.)	Temperature mean (°C)	Rainfall (mm)	Soil type
Čáslav	CAS	2	260	8.9	555	CH
Chrlice	CHR	1	190	9.0	451	FE
Lednice	LED	1	171	9.6	461	CH
Uherský Ostroh	UHO	1	196	9.1	521	CE
Žatec	ZAT	2	285	9.0	439	CH

CE – Eutric Cambisol; CH – Haplic Chernozem; FE – Eutric Fluvisol

sorghum materials used in the assessments are hybrids. Basic characteristics of sorghum varieties including their origin are shown in Table 2.

Field trials. Field assessments of sorghum cultivars were carried out at five stations of the Central Institute for Supervising and Testing in Agriculture (CISTA): Čáslav (CAS), Chrlice (CHR), Lednice (LED), Uherský Ostroh (UHO), and Žatec (ZAT). Basic agrometeorological characteristics of the stations including production region, altitude, mean temperature, rainfall and soil type are shown in Table 3. Basic cultural practices including the date of sowing, date of harvest, and previous crop used in the two growing seasons (2012 and 2013) are documented in Table 4. Fertilization and chemical treatment were applied according to manuals of the Central Institute for Supervising and Testing in Agriculture (CISTA 2012, 2013).

Table 4. Basic cultural practices including date of sowing, date of harvest, and previous crop used in Čáslav (CAS), Chrlice (CHR), Lednice (LED), Uherský Ostroh (UHO) and Žatec (ZAT) locations in 2012 and 2013

		Location				
		CAS	CHR	LED	UHO	ZAT
Date of sowing	2012	22/05	14/05	14/05	15/05	23/05
	2013	20/05	27/05	23/05	21/05	21/05
Date of harvest*	2012	8/11	23/10	31/10	23/10	24/10
	2013	10/10	10/10	1/11	7/10	24/10
Previous crop	2012	spring barley	spring barley	spring barley	winter wheat	spring barley
	2013	winter wheat	spring barley	winter wheat	winter wheat	spring barley

*Date of harvest for Friggo and Ruzrok varieties only

doi: 10.17221/134/2016-CJGPB

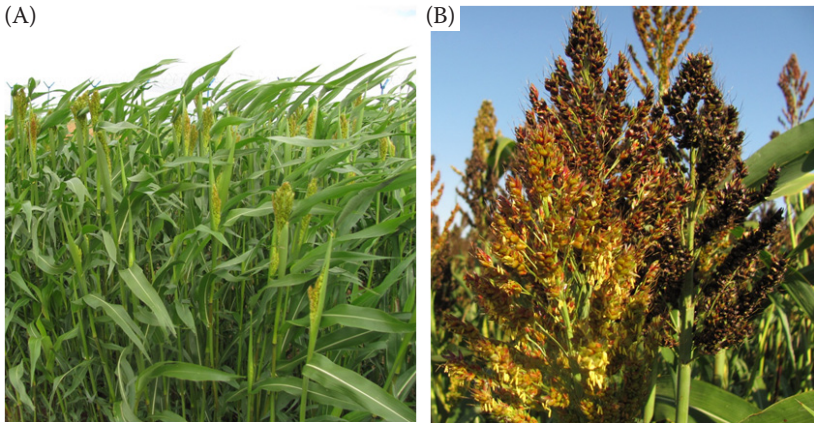

Figure 1. Ruzrok sorghum variety grown for biomass production in the field (A) and a representative panicle with mature grains (B) grown in the field (experimental plots of the Crop Research Institute, Prague-Ruzyně)

The following growth- and yield-related characteristics were assessed: relative growth rate of plants, heading date (number of days to heading), plant height, relative dry mass of grain (%), yield, and thousand grain weight.

The relative growth rate of plants was evaluated using a 9-point scale where 1 means the lowest relative growth rate while 9 means the fastest relative growth rate.

Statistical analysis of the data was performed using Student's *t*-test at a 0.05 significance level, one-way ANOVA analysis, multiple comparisons, and principal component analysis (PCA) were done using STATISTICA version 11 (StatSoft Inc., Tulsa, OK, USA).

Variety description. Ruzrok represents the first sorghum multi-line cultivar of Czech provenance bred by Ing. Jiří Hermuth in Crop Research Institute (CRI), Prague. It is a line cultivar bred by a series of positive and negative selections from a population collected in the Bílé Karpaty region in Moravia, Czech Republic. In CRI, maintenance breeding of the cultivar is also carried out. Ruzrok can be grown as an energy crop for biomass production as well as feed and fodder crop for polygastric (ruminant) animals. The major advantages of Ruzrok are high relative growth rate, high final plant height and high amount of plant biomass produced during the plant vegetative period (Figure 1A). However, Ruzrok can also be grown for grain in the Czech Republic since it is able to produce mature seeds in the temperate climate of Central Europe (Figure 1B). Basic morphological and yield-related characteristics of the sorghum variety Ruzrok are provided in Table 1.

Basic cultural practices for Ruzrok. The Ruzrok sorghum variety is a chilling-sensitive crop damaged by low above-zero temperatures similarly like other sorghum genotypes. Seeds need a minimum temperature of 12–15°C for germination. However, sorghum can be grown for biomass also at those areas where maize provides insufficient yield. Sorghum has similar requirements for growth conditions like maize. Sorghum needs the well-fertilized soil devoid of weeds in order to diminish canopy damage at a seedling stage when the sorghum growth rate is quite low. In regions with sufficiently high mean annual temperatures, sorghum can be grown after

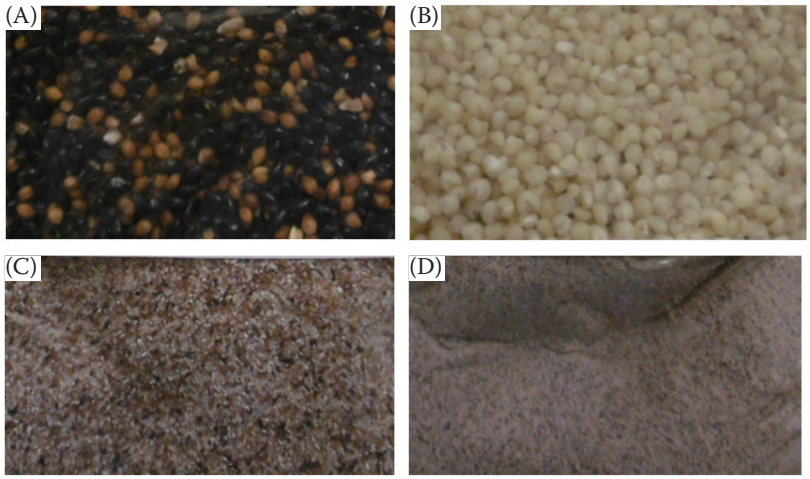

Figure 2. Naked grains (A) and dehulled grains without outer layers (B) of Ruzrok sorghum, and their final products semolina (C) and flour (D) with reduced tannin content

doi: 10.17221/134/2016-CJGPB

Table 5. Recommended doses of nutrients used for fertilization of the Ruzrok sorghum variety grown in the Czech Republic

	N	P_2O_5	K_2O	Ca	Mg
Fertilizer rate (kg/ha)	140–160	60–80	120–150	30–50	15–30

Table 6. Chemical composition of grain (%) in Ruzrok variety

Crude protein content	Lipid	BNLV	Fibrous	Crude ash
12.62	2.89	69.15	5.61	1.31

BNLV – nitrogen-free extract

root (tuber) crops, legumes or cereals. Ruzrok can be grown under both conventional and ecological agricultural systems. Further details about recommended cultural practices for Ruzrok cultivation were described in Hermuth *et al.* (2012).

Proper timing of sowing is very important in marginal regions of sorghum cultivation. Recommended interlinear sowing distance should be 30 cm and recommended seeding amount should range from 10 to 15 kg/ha. Optimum sowing depth should be 3–5 cm. Sorghum requirements for soil mineral contents can be satisfied in the form of organic fertilizers (cattle manure, compost) applied during the preceding crop cultivation. An optimum dose of organic fertilizers

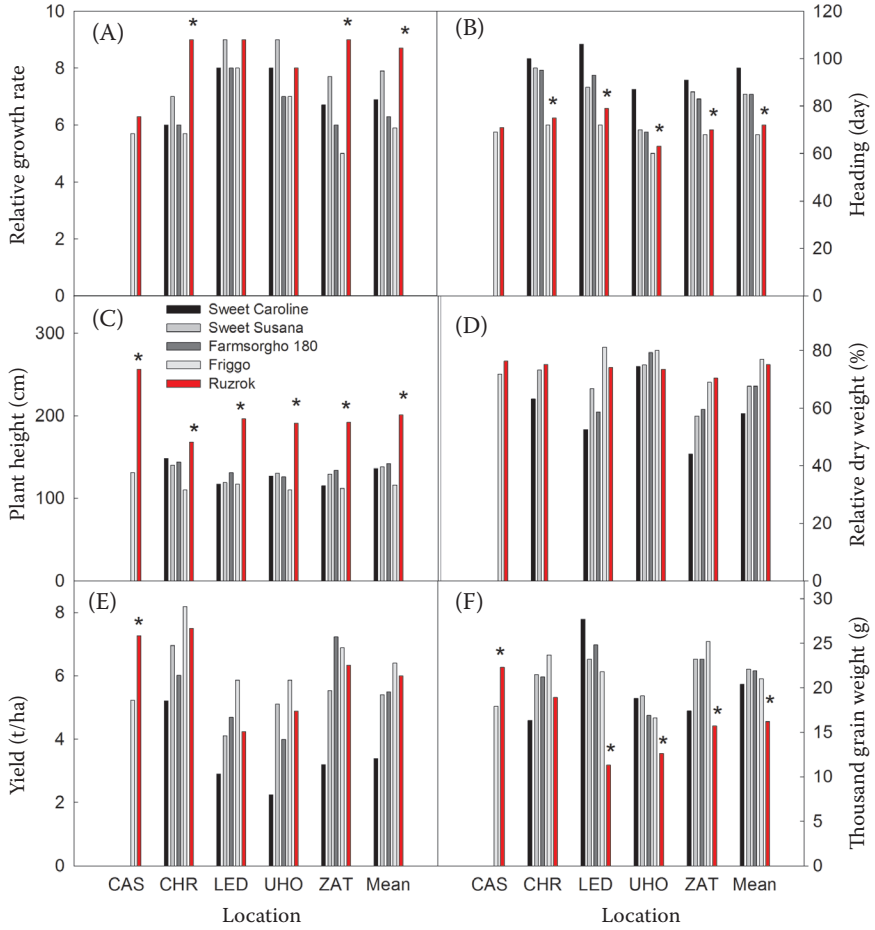

Figure 3. Basic growth- and yield-related characteristics of the sorghum varieties Sweet Caroline, Sweet Susana, Farmsorgho 180, Friggo and Ruzrok determined in 2012 at Čáslav (CAS), Chrlice (CHR), Lednice (LED), Uherský Ostroh (UHO) and Žatec (ZAT) locations as well as the mean values based on the data from all five locations of the Central Institute for Supervising and Testing in Agriculture; the following plant characteristics were assessed: relative growth rate (A), heading date (B), plant height (C), plant dry weight in percent (D), yield (E) and thousand grain weight (TGW; F); the data for Ruzrok are shown in red colour; *indicates significant differences between Ruzrok and the other genotypes determined by Student's *t*-test at a 0.05 significance level

doi: 10.17221/134/2016-CJGPB

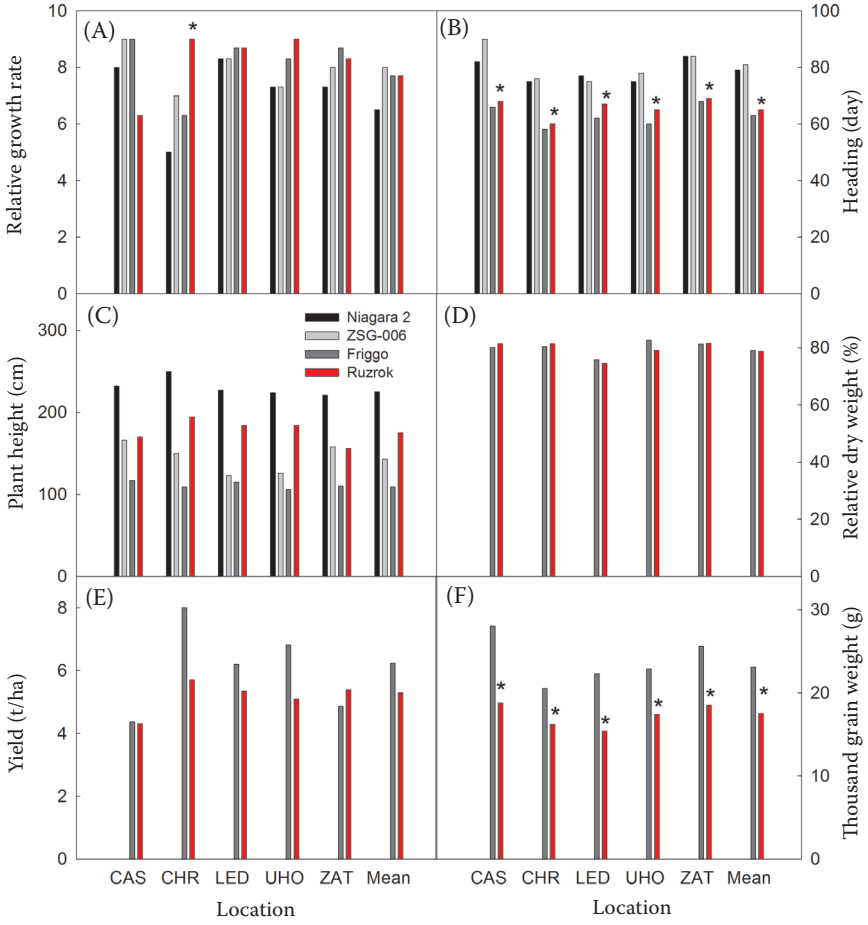

Figure 4. Basic growth- and yield-related characteristics of the sorghum varieties Niagara 2, ZSG-006, Friggo and Ruzrok determined in 2013 at Čáslav (CAS), Chrlice (CHR), Lednice (LED), Uherský Ostroh (UHO) and Žatec (ZAT) locations as well as the mean values based on the data from all five locations of the Central Institute for Supervising and Testing in Agriculture; the following plant characteristics were assessed: relative growth rate (A), heading date (B), plant height (C), plant dry weight in percent (D), yield (E) and thousand grain weight (TGW; F); the data for Ruzrok are shown in red colour; *indicates significant differences between Ruzrok and the other genotypes determined by Student's *t*-test at a 0.05 significance level

should range from 25 to 35 t/ha. The dynamics of nutrient uptake by sorghum corresponds well with the dynamics of sorghum growth with a maximum demand in July and August. Sorghum can be grown on the same plot for 2–3 growing seasons if adequate doses of nutrients and herbicides are applied. Further details about recommended doses of mineral nutrients are provided in Table 5.

The Ruzrok sorghum cultivar was registered for biomass production. However, Ruzrok is also able to produce mature grains under climatic conditions in the Czech Republic. Basic data on grain chemical composition are provided in Table 6. However, its grains can also be used for food purposes despite the high tannin content in outer layers of grains. The PRO-BIO Company has applied a technology leading to an efficient removal of outer layers of grains, which resulted in the efficient elimination of tannin in sorghum grains and final products (Figure 2, Table 7). The final semolina and flour can be then used for food preparation.

Comparison of Ruzrok with other sorghum varieties grown in the Czech Republic. The Ruzrok sorghum variety was compared with other sorghum varieties Sweet Caroline, Sweet Susana, Farmsorgho 180, Niagara 2, ZSG-006 and Friggo which served as a control variety in tests conducted by the Central Institute for Testing and Supervising in Agriculture in 2012 and 2013 at five different locations: Čáslav (CAS), Chrlice (CHR), Lednice (LED), Uherský Os-

doi: 10.17221/134/2016-CJGPB

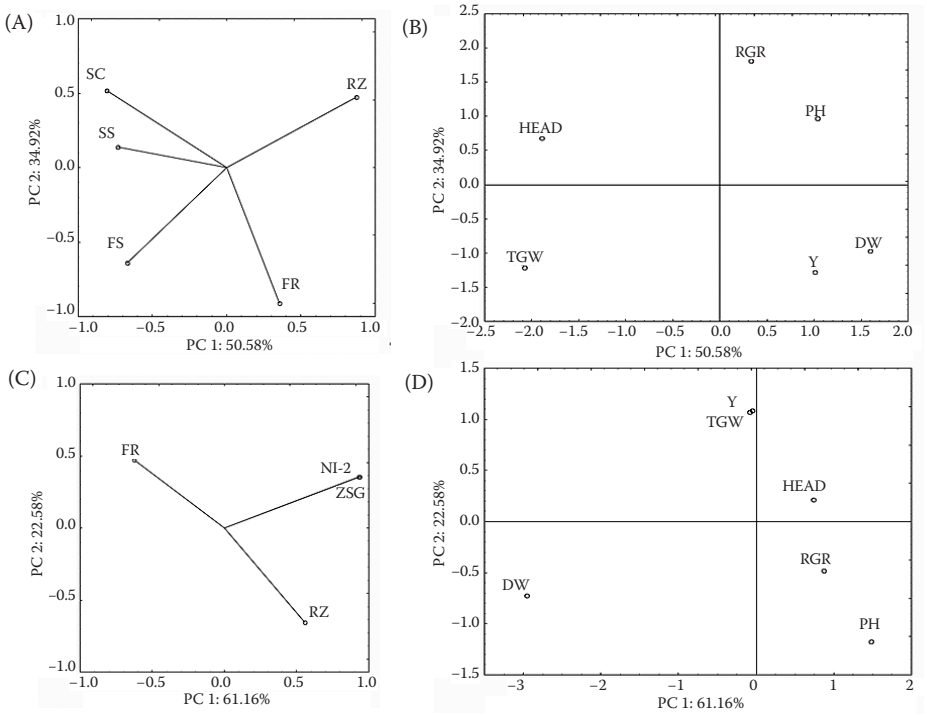

Figure 5. Results of principal component analysis (PCA) showing the results of the analysis of sorghum genotypes (A) and plant growth- and yield-related characteristics (B) as evaluated by the Central Institute for Testing and Supervising in Agriculture (CISTA) in 2012 season and results of PCA analysis showing the results of the analysis of sorghum genotypes (C) and plant growth- and yield-related characteristics (D) as evaluated by CISTA in 2013 season
FR – Friggo; FS – Farmsorgho; NI-2 – Niagara 2; RZ – Ruzrok; SC – Sweet Caroline; SS – Sweet Susana; ZSG – ZSG-006; DW – dry weight; HEAD – heading date; PH – plant height; RGR – relative growth rate; TGW – thousand grain weight; Y – yield

troh (UHO) and Žatec (ZAT). Basic characteristics of all tested sorghum varieties are shown in Table 2. Ruzrok was the only line variety while the other tested sorghum varieties were hybrids. The Friggo sorghum variety was used as a control.

Basic meteorological, pedological and agricultural characteristics of locations used for sorghum variety testing are given in Table 3. Dates of basic cultural practices and previous crops used at the individual locations in both seasons 2012 and 2013 are shown in Table 4.

Basic plant growth and yield-related characteristics were assessed in both seasons. The characteristics include relative growth rate of plants (Figure 3A, 4A), heading date (Figure 3B, 4B), plant height (Figure 3C, 4C), plant dry weight in percent (Figure 3D, 4D), yield (Figure 3E, 4E) and thousand grain weight (TGW; Figure 3F, 4F). A comparison of the individual sorghum varieties has revealed that Ruzrok showed a higher relative growth rate of plants than the other varieties tested. This characteristic is associated with the earliness of Ruzrok variety. Yield-related characteristics of Ruzrok were similar to those of the other tested sorghum varieties despite the hybrid nature of the other sorghum varieties. Further data on other evaluated morphological and yield-related characteristics are provided in publications of the Central Institute for Supervising and Testing in Agriculture (2012, 2013).

Table 7. Tannin content expressed as percentage of dry weight (mean ± SD; n = 4) in various products from grains of Ruzrok sorghum variety

Sorghum product	Tannin content (%; mean ± SD)
Sorghum grain	1.00 ± 0.04[a]
Dehulled sorghum grain	0.00 ± 0.01[c]
Sorghum semolina	0.67 ± 0.01[b]
Sorghum flour	1.00 ± 0.01[a]

Different letters indicate significant differences obtained by one-way ANOVA, Duncan's multiple range test at 0.05 significance level; SD – standard deviation

doi: 10.17221/134/2016-CJGPB

A comparison of Ruzrok with the other assessed sorghum varieties has revealed that Ruzrok showed a high relative growth rate, earliness of heading date as well as tall plant height and high relative dry mass of seeds. The fact that Ruzrok produced relatively lower grain yield and thousand grain weight compared to the other tested sorghum varieties can be explained by hybrid nature and associated heterosis effects in the other sorghum varieties (Rooney *et al.* 2007).

A principal component analysis (PCA) was carried out on the selected sorghum growth- and yield-related characteristics obtained in 2012 and 2013 seasons as presented in Figures 3 and 4. PCA results showed different behaviour of the Ruzrok variety from the other sorghum varieties (Figure 5A, C) as well as similar patterns in the dynamics of plant height (PH) and relative growth rate (RGR), and dry weight (DW) and yield (Y) characteristics (Figure 5B, D).

Maintainer of the variety and holder of breeders' rights: Výzkumný ústav rostlinné výroby, v.v.i., Drnovská 507, 161 06 Praha 6-Ruzyně.

Acknowledgements. This work was supported by National Programme on Conservation and Utilization of Plant, Animal and Microbial Genetic Resources (Project No. 206553/2011-MZE-17253) and Ministry of Agriculture of the Czech Republic (Project No. RO0415). The authors thank Dr. M. Povolný and Dr. B. Hampl from the Central Institute for Supervising and Testing in Agriculture (ÚKZÚZ) for providing the data from selected locations of ÚKZÚZ as well as for their assistance with the manuscript preparation. The authors also thank the PRO-BIO Company, a.s., for providing products with reduced tannin content, and Dr. V. Dvořáček from the Crop Research Institute, Prague, for providing data on tannin content in sorghum grain products.

References

CISTA (2012): Assessment of sorghum. Brno, Central Institute for Supervising and Testing in Agriculture.

CISTA (2013): Assessment of sorghum. Brno, Central Institute for Supervising and Testing in Agriculture.

Hermuth J., Janovská D., Strašil Z., Usťak S., Hýsek J. (2012): *Sorghum Bicolor* (L.) Moench, possibilities of its growth and utilization in the climatic conditions of the Czech Republic. Metodika pro praxi. Prague, CRI. (In Czech)

Hermuth J., Janovská D., Hlásná Čepková P., Usťak S., Strašil Z., Dvořáková Z. (2016): Sorghum and Foxtail Millet – promising crops for the changing climate in Central Europe. In: Konvalina P. (ed.): Alternative Crops and Cropping Systems. Intech Open Science/Open Minds: 5–27. Available at http://dx.doi.org/10.5772/62642

Rooney W.L., Blumenthal J., Bean B., Mullet J.E. (2007): Designing sorghum as a dedicated bioenergy feedstock. Biofuels, Bioproducts and Biorefining, 1: 147–157.

Received for publication August 11, 2016
Accepted after corrections January 12, 2017