ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 62 100 Number 5, 2014
http://dx.doi.org/10.11118/actaun201462050971

THE STUDY OF SIMILARITIES AMONG CZECH ALFALFA (*MEDICAGO SATIVA* L.) VARIETIES

Daniela Knotová[1], Jiří Skládanka[2], Jan Pelikán[3]

[1] Department of Genetic Resources, Agricultural Research, Ltd., Zahradní 400/1, 664 41, Troubsko, Czech Republic
[2] Department of Animal Nutrition and Forage Production, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic
[3] Department of Genetic Resources, Research Institute for Fodder Crops, Ltd. Troubsko, Zahradní 400/1, 664 41, Troubsko, Czech Republic

Abstract

KNOTOVÁ DANIELA, SKLÁDANKA JIŘÍ, PELIKÁN JAN. 2014. The study of similarities among Czech alfalfa (*Medicago sativa* L.) varieties. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 62(5): 971–977.

Within the period of 2010–2011, a set of 14 Czech alfalfa cultivars was evaluated in the research locality Troubsko. On small plots and also in the individual plantations altogether 51 descriptors were evaluated. Statistical differences existing among cultivars in individual trait sunder study were analysed using the method of point and interval estimations of average values. Intraspecific variability was studied on the base of estimation of variation coefficients. A high degree of intraspecific uniformity was found in cultivars 'Jarka' and 'Holyna' while the lowest one was registered in the cultivar 'Litava'. Green matter yields ranged from 66.3 t.ha^{-1} ('Jitka') to 77.2 t.ha^{-1} ('Holyna'), hay yields from 11.71 t.ha^{-1} ('Jitka') to 15.43 t.ha^{-1} ('Jarka'), and yields of seed from 0.19 t.ha^{-1} ('Jitka') to 0.35 t.ha^{-1} ('Kamila'). As far as the descriptor "Alfalfa tuft dry matter" was concerned, cultivars 'Oslava' and 'Holyna' were statistically highly significantly ($P < 0.01$) better than than cultivars 'Jitka' and 'Vlasta'. As far as the descriptor "Width of the terminal leaflet" was concerned, the cultivar 'Palava' was statistically highly significantly better ($P < 0.01$) than cultivars 'Vlasta', 'Litava', and 'Denisa'. The existence of similarity of cultivars under study was determined by means of cluster analysis. It was found out that the highest degree of similarity existed between cultivars 'Morava' and 'Niva'.

Keywords: Cluster analyses, *Medicago sativa* L., variability, yields

INTRODUCTION

In the Czech Republic, altogether 18 alfalfa cultivars are registered at present. Of them, 14 are of the Czech origin. Altogether 13 cultivars were selected in the Breeding Station Želešice, company Agrogen, spol. s r. o. Troubsko and 1 in the Breeding Station Čejč (Knotová *et al*., 2013).

Within the framework of breeding programmes a good knowledge of similarity of individual cultivars is very appreciated. For example, studies on genetic similarity in alfalfa were performed by Wang *et al*. (2011), Julier (2010), and Tucak (2008) while Benabderrahim *et al*. (2009) and some other authors studied similarity of morphological traits. Lakić and Vojin (2010) monitored variability of economic traits in four genotypes of red clover (*Trifolium pratense* L.); they also evaluated seed yields and qualitative characteristics of 18 genotypes of alfalfa (*Medicago sativa* L.). Lugic *et al*. (2010) analysed variability and correlation relationships in red clover because a good knowledge of the breeding material is indispensable from the breeder's point of view. Variability of agronomic and fodder traits encourages plant breeders to use and evaluate breeding and genetic materials in research and breeding programmes. Bender and Annamaa (2007) studied the yield potential and the fodder quality in Estonian natural alfalfa populations. In the Czech Republic, the evaluation of plant genetic resources is performed within the framework of the "National Programme of Preservation and Use of Plant Genetic Resources and Agrobiodiversity". Obtained results are used for example when choosing individual

cultivars for breeding programmes and when creating the so-called "core" collections of plant genetic resources (Pelikán *et al.*, 2009).

The aim of this study was to identify statistic differences existing between tested cultivars in individual traits, to describe the intra-varietal variability, to evaluate yield characteristics and to compare similarity of individual Czech cultivars of alfalfa.

MATERIAL AND METHODS

In April of 2009, a field experiment with 14 Czech cultivars of alfalfa was established in the locality Troubsko. The locality Troubsko is situated in warm and moderately dry sugar-beet-growing region. Its altitude is about 270 m above sea level and the long-term average annual sum of precipitation is 547 mm (of this 344 mm have been recorded in the growing season). The long-term average annual temperature is 8.6 ^{0}C (14.8 ^{0}C in the growing season). The parent rock consists of weathered tertiary rocks dating back to the neogene; in this locality, soils are predominantly degraded gray brown luvisols with a loamy to clay-loam texture. The soil reaction is neutral or slightly acid.

The experiment was established using the method of randomized blocks with three replications for production of fodder and three replications for production of seed. The area of individual plots was 10m^2. At the same time, individual plantations of these cultivars were also established. In 2010 and 2011, the evaluation was performed both on experimental plots and in individual plantations (in this case, only ten plants were evaluated). The total number of evaluated descriptors was 51: "Shape of the leaf rosette in the autumn", "Density of the leaf rosette", "Number of stems per clump", "Length of stems", "Thickness of stems", "Shape of the stem intersection", "Stem hollowness", "Stem colour", "Number of internodes", "Length of the central internode", "Number of lateral branches", "Shape of the terminal leaflet", "Margin of the terminal leaflet", "Tip of the terminal leaflet", "Length of the terminal leaflet", "Width of the terminal leaflet", "Area of the terminal leaflet", "Leaf colour", "Leaf hairness (pubescence)", "Leaf size", "Occurrence of multiple leaves", "Shape of the inflorescence", "Length of the inflorescence", "Number of flowers per stem", "Number of flowers per inflorescence", "Colour of the inflorescence", "Number of infructescences per stem", "Number of pods per infructescence", "Number of pods per 100 flowers", "Pod shape", "Pod colour", "Height of the pod spiral", "Width of the pod spiral", "Number of seeds per pod", "Seed shape", "Seed colour", "Weight of thousand seeds", "Frost resistance", "Crop height at the beginning of flowering", "Crop height in the period of full blossom", "Crop height 20 days after the first cut", "Stand regrowth", "Number of cuts per year", "Total production of green biomass", "Total weight of green biomass", "Total yield of hay", "Ratio between the yield at the first cut and the total annual biomass production", "Seed yield", "Weight of seeds per plant", "Content of N-substances", and "Content of fibre". Weighed, calculated, and measured traits were converted to a nine-point scale while other traits were compared directly with values of the classificator (Vacek *et al.*, 1985). Weighed, calculated, and measured traits were evaluated by means of methods of point and interval estimation of the average value and of estimation of the variation coefficient. The point matrix was used for the evaluation of results by means of the cluster analysis. Statistic differences among cultivars under study were determined on the base of interval estimates of average values of individual cultivars at the significance level $P < 0.05$ (Zapletalová, 1983).

RESULTS AND DISCUSSION

The determination of point and interval estimates of average values represented the first step in the process of evaluation of an experimental collection of Czech alfalfa cultivars. Point estimates of average values and their bottom and upper limits for descriptors of individual cultivars are presented in Tab. I. The highest number of maximum values of point intervals was recorded in the cultivar 'Oslava' in 5 descriptors ("Length of the terminal leaflet", "Leaf size", "Yield of green matter per plant", "Number of stems per plant", and "Yield of dry matter per plant"). This variety also produced the highest yields of hay both per plant and per plot (this was surely correlated with the size of the leaf area and the number of stems per plant). The second position was occupied by the cultivar 'Litava' with 3 descriptors ("Number of pods per stem", "Number of seeds per stem", "Yield of seeds per plant"). These positive properties could be used when selecting plants with the emphasis on the seed yield. Cultivars 'Palava' and 'Tereza' reached maxima in two descriptors ('Palava': "Width of the leaf terminal", and "Lenght of the pod spiral"; Tereza': "Inflorescence length", and "Width of the pod spiral"), 'Holyna', 'Morava', 'Vlasta', 'Jarka', 'Niva', and 'Magda' reached maxima in one descriptor. On the other hand, minimum values of point estimates of the average value were recorded in seven descriptors of the cultivar 'Litava' (viz. "Length of the leaf terminal", "Width of the leaf terminal", "Leaf area", "Terminal leaflet area", "Stem thickness", and "Number of lateral branches per stem") and in four descriptors of the cultivar 'Palava' ("Stem length", "Number of stems per plant", "Number of inflorescences per stem", and "Number of pods per stem"). Minimum values of two descriptors were recorded in cultivars 'Morava' ("Width of the pod spiral", and "Number of seeds per pod"), 'Jitka' ("Yield of green matter per plant", and "Yield of dry matter production per plant"), and 'Denisa' ("Inflorescence length", "Height

of the pod spiral"). Finally, in cultivars 'Oslava', 'Holyna', 'Vlasta' and 'Zuzana' minimum values of one descriptor were found out.

Statistical differences between individual traits of cultivars under study were estimated on the base of interval estimates of average values at the significance level of $P < 0.01$. There were no differences between cultivars in the following traits: "Length of the terminal leaflet", "Stem thickness", "Green matter of the tuft", "Number of stems", "Number of flowers per inflorescence", "Number of infructescences per stem", "Number of pods per infructescence", "Width of the pod spiral", "Number of seeds per pod", and "Weight of seeds per plant". As far as the descriptor "Width of the terminal leaflet" was concerned, the cultivar 'Palava' was statistically highly significantly better ($P < 0.01$) than cultivars 'Vlasta', 'Litava', and 'Denisa'. In the descriptor "Size of leaf area" the cultivar 'Palava' was also statistically highly significantly better than cultivars 'Litava' and 'Vlasta'. As far as the descriptor "Area of the terminal leaflet" was concerned, the cultivar 'Oslava' was statistically highly significantly better than cultivars 'Litava' a 'Vlasta'. Cultivars 'Zuzana', 'Kamila', 'Magda', 'Morava', 'Holyna', and 'Tereza' showed statistically highly significantly better values of the descriptor "Length of the stem" than the cultivar 'Palava'. As far as the descriptor "Number of internodes" was concerned, the cultivar 'Morava' was better than cultivars 'Palava', 'Jitka', 'Litava', 'Vlasta', and 'Denisa'" and cultivars 'Oslava', 'Tereza', 'Niva', 'Zuzana', 'Kamila', and 'Magda' were better than cultivars 'Litava', 'Vlasta', and 'Denisa'. The cultivar 'Litava' showed better values of the descriptor "Length of the central internode" than cultivars 'Zuzana' and 'Morava'. The descriptor "Number of lateral branches" was better in the cultivar 'Morava' than in cultivars 'Palava', 'Litava', and 'Denisa'; further, cultivars 'Kamila', 'Oslava', 'Niva', and 'Jarka' showed better values of this trait than the cultivar 'Denisa'. Values of the descriptor "Tuft dry matter" of cultivars 'Oslava' and 'Holyna' were better than those of cultivars 'Jitka' and 'Vlasta'. The cultivar 'Tereza' showed a better value of the descriptor "Length of the inflorescence" than cultivars 'Palava', 'Litava', and 'Morava'. In the "Number of inflorescences per stem" the cultivar 'Palava' was surpassed by cultivars 'Jarka', 'Kamila', 'Morava', 'Niva', and 'Denisa'. Cultivars 'Magda', 'Jitka', and 'Jarka' showed better values of the descriptor "Number of pods per 1000 flowers" than the cultivar 'Zuzana' and, finally, the cultivar 'Palava' showed better values of the descriptor "Height of the pod spiral" than cultivars 'Holyna' and 'Denisa'.

Tab. I contains also values of variation coefficients that indicate the degree of uniformity of corresponding descriptors. The lowest values of variation coefficients were found out for traits "Length of the terminal leaflet", "Number of pods per 100 flowers", and "Width of the terminal leaflet" while values of descriptors "Yield of green matter per plant", "Yield of dry matter per plant", "Number of stems per plant", "Number of inflorescences per stem", "Number of pods per stem", "Number of pods per inflorescence", "Number of seeds per pod", and "Yield of seeds per plant" were the highest ones. A low intra-varietal variability (a high uniformity of evaluated descriptors) was found out in cultivars 'Jarka' and 'Holyna' (in both, 3 descriptors showed the lowest values of the variation coefficient and there was no maximal value). The cultivar 'Morava' showed minimal and maximal values of 3 and 1 descriptors, respectively). On the other hand, however, the cultivar 'Litava' showed a high degree of imbalance (1 and 4 descriptors showed the minimal and the maximal values of the variation coefficient, respectively).

Evaluation of yield characteristics of the crop was a further step in the process of evaluation of Czech alfalfa cultivars. Within two subsequent years, altogether four cuts of fresh fodder were harvested, and yields of hay as well as seed yields were recorded in each year. Yields of green biomass were already published (Knotová *et al.*, 2013). For the purpose of a description within the framework of the information system EVIGEZ pursuant provisions of the classificator and also for the determination of similarities, descriptors "Yield of biomass harvested in all four cuts per year"; "Hay yield in all four cuts", "Share of the first yield in the annual production of biomass", and "Seed yield" were used and compared with those of the standard cultivar 'Palava' (Control). Recorded values of these descriptors are presented in Tab. II. As compared with the standard cultivar 'Palava', higher hay yields gave cultivars 'Jarka', 'Litava', 'Magda', 'Morava', 'Niva', 'Oslava', 'Holyna', and 'Tereza'. As far as the descriptor "Seed yield" was concerned, all tested cultivars excepting 'Zuzana' and 'Jitka' gave better yield than the control cultivar 'Palava'. In the first year under study, seed yields ranging from 66.30 $t.ha^{-1}$ to77.20 $t.ha^{-1}$were recorded while Lamb *et al.* (2003) mentioned seed yields ranging from 84.7 $t.ha^{-1}$ to 122.8 $t.ha^{-1}$. For the first year of production, Avci *et al.* (2013) reported the range of yields of alfalfa green matter 59.88 $t.ha^{-1}$–67.09 $t.ha^{-1}$. Yields of green biomass (Harratt *et al.*, 1986) are dependent on the environment and the genotype, the yield of hay depends on the environment (Sharratt *et al.*, 1986), date of harvest and height of plants (Ottman and Rogers, 2000). Pelikán *et al.* (2007) mentioned that in the first year of production, cultivars 'Zuzana' and 'Jarka' gave higher yields of green biomass and hay than Palava'. In our study, however, only yields of the cultivar 'Jarka' were better so that it could be concluded that 'Jarka' was a plastic cultivar and responded better to the effect of the year.

The conversion of all measured, weighed and calculated variables to points of the classificator and the supplementation of point-evaluated descriptors was the last step in this process. The developed matrix for 14 cultivars and 51

I: *Survey of point estimates of the interval average values with their upper and bottom limits plus coefficients of variation of individual descriptors (%)*

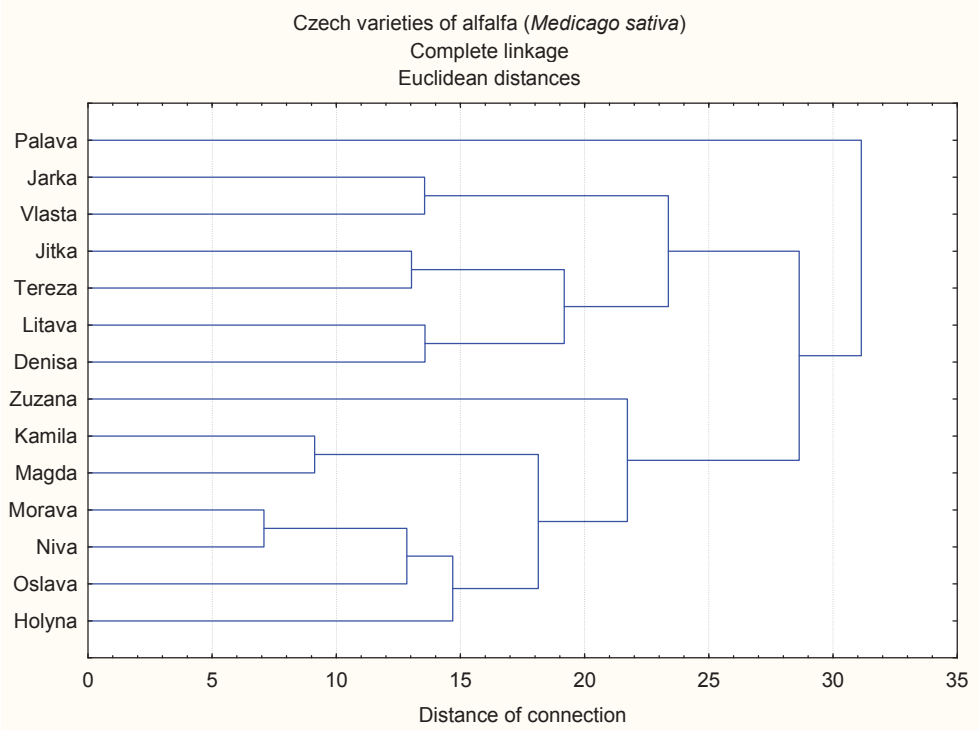
	A		B		C		D		E		F		G		H		I		J	
	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)
Palava	32.9 (±4.32)	14.71	19.1 (±2.12)	12.45	14.22 (±1.91)	15.09	4.89 (±0.99)	22.67	57.57 (±5.30)	10.33	4.18 (±0.79)	21.18	8.8 (±2.05)	26.13	0.29 (±0.09)	36.18	27.9 (±6.26)	25.14	0.07 (±0.02)	35.43
Jarka	31.4 (±5.60)	19.98	16.1 (±1.71)	11.88	10.27 (±2.71)	29.54	3.67 (±0.84)	25.78	59.02 (±16.65)	31.61	4.28 (±0.78)	20.46	10.6 (±1.84)	19.49	0.41 (±0.12)	33.16	29.5 (±6.04)	22.95	0.09 (±0.03)	34.86
Zuzana	34.3 (±4.04)	13.19	16.9 (±2.28)	15.14	11.87 (±2.69)	25.43	4.26 (±1.00)	26.26	70.19 (±3.81)	6.09	3.65 (±0.33)	10.08	11.5 (±1.35)	13.12	0.36 (±0.13)	41.54	34.8 (±7.87)	25.34	0.08 (±0.03)	40.42
Jitka	31.1 (±4.28)	15.42	15.9 (±2.74)	19.32	11.58 (±3.54)	34.23	4.14 (±1.15)	31.03	66.39 (±6.95)	11.74	3.79 (±0.72)	21.39	9.3 (±1.88)	22.70	0.28 (±0.10)	39.47	27.1 (±7.45)	30.8	0.06 (±0.02)	42.40
Kamila	32.2 (±1.87)	6.51	15.2 (±2.22)	16.35	11.66 (±2.01)	19.36	4.12 (±0.84)	20.17	77.20 (±12.48)	18.12	4.35 (±0.68)	17.46	11.9 (±1.81)	17.02	0.38 (±0.11)	31.70	39.8 (±12.45)	35.07	0.09 (±0.02)	30.68
Litava	28.7 (±2.11)	8.22	14.3 (±2.49)	19.52	9.27 (±1.89)	22.8	3.35 (±0.70)	23.36	65.19 (±13.43)	23.09	3.49 (±1.05)	33.60	8.4 (±1.47)	19.60	0.39 (±0.21)	61.15	42.6 (±18.85)	50.06	0.09 (±0.05)	58.32
Magda	34.2 (±4.03)	13.21	16.2 (±3.25)	22.5	12.64 (±2.74)	24.33	4.57 (±1.10)	26.95	73.70 (±9.52)	14.47	3.71 (±0.44)	13.43	11.1 (±1.07)	10.79	0.30 (±0.07)	27.38	34.9 (±8.40)	26.96	0.07 (±0.02)	25.57
Morava	35.3 (±3.18)	10.09	16.0 (±3.06)	21.45	13.23 (±2.66)	22.57	4.66 (±0.93)	22.4	71.95 (±6.93)	10.80	4.23 (±0.39)	10.33	12.7 (±1.03)	9.13	0.39 (±0.09)	27.22	39.5 (±11.76)	33.36	0.09 (±0.02)	27.15
Niva	35.1 (±2.99)	9.54	15.3 (±2.56)	18.75	12.34 (±2.92)	26.56	4.34 (±1.07)	27.67	72.65 (±15.16)	23.34	3.92 (±0.40)	11.53	11.7 (±1.52)	14.56	0.35 (±0.07)	23.10	40.5 (±14.30)	39.56	0.09 (±0.02)	21.91
Oslava	36.7 (±2.69)	8.23	16.6 (±2.42)	16.36	14.34 (±2.28)	17.85	5.04 (±0.85)	18.94	72.15 (±11.87)	18.44	4.04 (±0.83)	22.92	11.6 (±0.86)	8.33	0.50 (±0.13)	29.80	45.5 (±15.33)	37.77	0.12 (±0.03)	29.59
Vlasta	32.0 (±2.52)	8.84	14.4 (±1.84)	14.34	10.64 (±1.66)	17.52	3.73 (±0.42)	12.75	67.00 (±6.66)	11.14	3.99 (±0.54)	15.04	8.7 (±1.19)	15.37	0.30 (±0.10)	37.34	30.9 (±7.94)	28.8	0.06 (±0.02)	39.61
Holyna	34.0 (±3.88)	12.78	17.8 (±2.05)	12.92	14.04 (±2.78)	22.16	5.01 (±1.02)	22.92	72.75 (±7.01)	10.80	3.85 (±0.69)	20.05	10.7 (±1.58)	16.51	0.42 (±0.06)	17.07	35.8 (±7.71)	24.13	0.10 (±0.01)	16.54
Tereza	30.6 (±2.73)	10.01	14.3 (±3.47)	27.19	10.19 (±2.35)	25.86	3.54 (±0.76)	24.17	68.75 (±4.53)	7.39	4.03 (±0.43)	11.93	11.8 (±1.56)	14.84	0.39 (±0.11)	30.54	30.0 (±8.78)	32.81	0.08 (±0.02)	33.14
Denisa	31.8 (±3.46)	12.21	14.7 (±1.84)	14.00	10.62 (±1.87)	19.74	3.90 (±0.96)	19.06	60.05 (±7.80)	14.57	3.60 (±0.81)	25.13	9.0 (±0.84)	10.48	0.37 (±0.13)	38.47	35.6 (±11.10)	34.94	0.08 (±0.03)	37.78

	K		L		M		N		O		P		Q		R		S		T	
	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)	average value	V_x(%)
Palava	2.35 (±0.43)	20.38	14.9 (±6.27)	47.19	20.1 (±6.38)	35.60	31.9 (±28.92)	81.62	9.7 (±3.64)	42.10	61.11 (±12.11)	22.21	5.11 (±0.61)	13.38	4.13 (±0.38)	10.53	4.9 (±1.42)	32.55	2.46 (±1.67)	75.92
Jarka	3.31 (±1.15)	38.91	39.1 (±11.48)	32.9	28.3 (±13.05)	51.67	43.3 (±17.44)	45.14	9.0 (±3.18)	39.55	61.65 (±8.47)	15.40	4.58 (±0.75)	18.41	4.16 (±0.77)	20.62	5.3 (±1.12)	23.62	3.19 (±1.97)	69.10
Zuzana	2.78 (±0.74)	29.75	21.9 (±7.97)	40.81	20.7 (±6.10)	33.00	42.4 (±16.67)	44.06	10.4 (±2.23)	24.07	44.71 (±8.27)	20.73	4.49 (±1.29)	32.22	3.98 (±0.60)	14.93	3.6 (±1.47)	45.74	4.26 (±1.73)	45.59
Jitka	3.08 (±0.57)	20.86	19.6 (±8.30)	47.45	23.8 (±7.63)	35.92	46.3 (±13.41)	32.47	12.4 (±2.46)	22.23	60.80 (±3.63)	6.69	4.59 (±1.29)	31.56	4.10 (±0.35)	9.66	5.4 (±1.64)	34.04	2.27 (±1.31)	64.77
Kamila	4.07 (±1.60)	44.00	29.0 (±5.24)	20.24	20.3 (±7.23)	36.81	45.5 (±12.05)	29.67	12.9 (±3.89)	33.78	60.25 (±9.19)	17.09	4.75 (±1.01)	23.81	4.21 (±0.47)	12.46	3.4 (±1.28)	42.05	2.90 (±1.34)	51.69
Litava	2.64 (±0.76)	26.29	26.8 (±9.79)	40.94	24.8 (±8.76)	39.59	49.4 (±10.92)	24.78	8.8 (±2.41)	30.68	59.96 (±9.22)	17.24	4.35 (±0.69)	17.84	4.47 (±0.53)	13.21	5.5 (±1.85)	37.61	4.18 (±2.49)	66.85
Magda	3.07 (±0.80)	29.22	30.4 (±11.33)	41.76	20.2 (±5.06)	28.08	49.0 (±14.80)	33.86	12.1 (±3.13)	29.01	62.70 (±5.31)	9.49	4.09 (±0.75)	20.42	4.58 (±0.35)	8.56	5.0 (±2.02)	45.22	3.45 (±2.18)	70.82
Morava	2.75 (±0.36)	14.77	34.4 (±13.20)	43.01	25.9 (±6.16)	26.65	36.6 (±12.21)	37.38	10.3 (±3.47)	37.76	58.59 (±8.89)	17.02	4.17 (±1.49)	39.95	3.88 (±0.65)	18.87	3.1 (±1.36)	49.16	3.08 (±1.06)	38.73
Niva	3.10 (±0.70)	25.40	32.2 (±9.23)	32.13	24.9 (±9.54)	42.94	38.0 (±9.06)	26.72	15.3 (±4.23)	30.97	59.29 (±8.25)	15.59	4.38 (±1.10)	28.20	4.36 (±0.46)	11.88	4.4 (±1.79)	45.71	4.00 (±2.50)	69.99
Oslava	3.08 (±1.21)	43.88	29.5 (±15.22)	57.82	21.3 (±10.14)	53.35	38.3 (±15.14)	44.31	14.3 (±5.22)	40.92	58.46 (±7.51)	14.39	3.99 (±0.97)	27.21	4.07 (±0.49)	13.60	5.4 (±1.69)	35.14	1.80 (±1.28)	79.87
Vlasta	2.89 (±0.55)	21.48	39.7 (±26.34)	74.36	22.8 (±7.25)	35.62	37.2 (±16.89)	50.88	10.4 (±5.55)	59.83	56.88 (±5.96)	11.74	4.66 (±0.81)	19.58	4.11 (±0.40)	10.93	3.5 (±1.70)	54.29	2.50 (±1.39)	62.12
Holyna	2.81 (±0.82)	32.59	25.8 (±11.04)	47.95	17.8 (±5.38)	33.90	32.3 (±12.96)	44.99	10.7 (±2.11)	22.05	59.46 (±7.02)	13.23	3.74 (±0.62)	18.67	4.22 (±0.53)	14.16	4.9 (±1.95)	44.56	3.15 (±1.77)	63.12
Tereza	5.11 (±1.90)	41.76	25.8 (±7.56)	32.83	25.5 (±7.43)	32.67	37.7 (±12.93)	38.44	10.5 (±2.98)	31.83	57.07 (±7.29)	14.32	4.68 (±1.13)	27.06	4.63 (±0.63)	15.24	4.0 (±1.63)	45.64	2.92 (±1.78)	68.30
Denisa	2.26 (±1.01)	50.03	30.5 (±6.53)	24.01	20.5 (±6.82)	37.31	42.6 (±15.42)	40.57	12.0 (±3.79)	35.36	59.85 (±8.46)	15.84	3.60 (±0.89)	27.71	4.29 (±0.49)	12.78	5.3 (±1.03)	21.88	3.44 (±3.63)	88.43

A: Leaflet terminal – length (mm), B: Leaflet terminal – width (mm), C: Leaf – area (cm2), D: Leaflet terminal – area (cm2), E: Stem – length (cm), F: Stem – thickness (mm), G: Stem – number of lateral branches, H: Yield of green matter – plant (kg), I: Stem – number on plant, J: Yield of dry matter – plant (kg), K: Inflorescence – length (cm), L: Number of inflorescence on stem, M: Inflorescence – number of flowers, N: Inflorescence – number of pods per stem, O: Inflorescence – number of pods, P: Pod – number per 100 flowers, Q: Pod – height of spiral (mm), R: Pod – width of spiral (mm), S: Pod – number of seeds, T: Yield of seeds – plant (g)

II: *A survey of yield characteristics*

	Green matter				Hay yield		Seed yield	
	In the first cut ($t.ha^{-1}$)	Total production ($t.ha^{-1}$)	Percent of control	Share of the first cut yield in the whole annual yield	The first year of utilisation ($t.ha^{-1}$)	Percent of control	The first year of utilisation ($t.ha^{-1}$)	Percent of control
Palava	22.63	73.90	100.00	30.62	13.41	100.00	0.23	100.00
Jarka	22.97	76.50	103.52	30.02	15.43	115.06	0.26	113.05
Zuzana	23.63	72.33	97.88	32.67	13.07	97.46	0.22	95.65
Jitka	21.27	66.30	89.72	32.08	11.71	87.32	0.19	82.61
Kamila	22.53	69.80	94.45	32.28	12.87	95.97	0.35	152.17
Litava	23.17	76.37	103.34	30.34	14.29	106.56	0.28	121.74
Magda	23.77	76.63	103.69	31.02	15.08	112.45	0.28	121.74
Morava	25.87	76.10	102.98	33.99	13.73	102.39	0.25	108.70
Niva	21.97	73.73	99.77	29.80	13.78	102.76	0.29	126.09
Oslava	22.30	72.80	98.51	30.63	14.58	108.72	0.25	108.70
Vlasta	23.90	71.20	96.35	33.57	13.00	96.94	0.26	113.04
Holyna	24.70	77.20	104.46	31.99	14.14	105.44	0.34	147.83
Tereza	20.73	66.77	90.35	31.05	13.64	101.72	0.34	147.83
Denisa	22.03	71.13	96.25	30.97	12.70	94.71	0.28	121.74



1: *Results of cluster analysis of a collection of Czech alfalfa cultivars*

descriptors was used when processing obtained data by the method of cluster analysis (Fig. 1). Cultivars 'Morava' and 'Niva' showed the highest degree of similarity; their pedigrees involved clones of regional varieties 'Hodonínka', 'Kašťická' and 'Přerovská'. Today, only 'Hodonínka' and 'Přerovská are available for plant breeders. They can be obtained from the Gene Bank in the Crop Research Institute in Praha-Ruzyně (http://genbank.vurv.cz/genetic/resources/asp2/default_c.htm).

Regional varieties exist within and are bond to a certain region; they are not homogeneous and for that reason they represent a rich source of genes that are very valuable in the field of plant breeding. Cultivars 'Holyna' and 'Oslava' (that also

had three aforementioned regional varieties in their pedigree) were rather similar to cultivars 'Morava' and 'Niva'. Another pair showing a great similarity consisted of cultivars 'Kamila' and 'Magda'. Also in this case it was possible to find out a kinship in their pedigree. Just the cultivar 'Magda' represented one of components of the combination crossing that resulted in the existence of the cultivar 'Kamila'. The cultivar 'Zuzana', the pedigree of which also involved regional varieties 'Hodonínka' and 'Flandria' ('Flandria' can be found also in pedigrees of cultivars 'Morava', 'Niva' and 'Oslava'), was similar to all the aforementioned cultivars. A relatively high degree of similarity was identified also in pairs 'Litava' and 'Denisa', 'Jitka' and 'Tereza' and, finally also 'Jarka' and 'Vlasta'. The cultivar 'Pálava' showed to be the most distant to this set of cultivars. Evaluated Czech alfalfa cultivars were selected in the Breeding Station Želešice. The only exception was the oldest Czech cultivar 'Palava' that originated from the Breeding Station Čejč. In spite of the fact that they contained the same original breeding material in their pedigrees, it was possible to carry out the selection for certain specific properties and traits, e.g. for increased capacity to fix nitrogen in cultivars 'Niva' and 'Oslava', resistance against the vascular wilt disease ('Vlasta' and 'Litava'), and higher seed yields and production of N-substances ('Litava'). The only exception representeds the cultivar 'Palava'; although its pedigree involved also such varieties as 'Hodonínka' and 'Flandria' that occurred also in pedigrees of other Czech cultivars. Annicchiarico (2006) used cluster analysis when evaluating the genetic similarity of 11 regional alfalfa varieties and 7 registered cultivars in Italy. In his experiments, the method of cluster analysis was based on 12 yield and biological traits (descriptors). In our experiment, however, the whole set was subdivided into two larger clusters that were compared with a quite unique cultivar 'Palava'. Basing on obtained results, it could be concluded that in future quite different original material should be used for further breeding and selection.

CONCLUSIONS

For the time being, the assortment of registered cultivars can be used as a basic source of breeding material in the field of alfalfa breeding and selection. A high level of intra-varietal homogeneity was found out in cultivars 'Jarka' and 'Holyna' while the cultivar 'Litava' showed quite contradictory properties. Nevertheless, it can be concluded from the viewpoint of the plant breeder that also in this case it is possible to carry out selection also within the framework of this cultivar (just because of its high intra-varietal variability). The evaluation of yield characteristics demonstrated that all Czech cultivars are able to produce satisfactory yields even in the first year of production (although in this case only the choice of cultivars suitable for growing within a certain region is important). In this context it is necessary to highlight that the cultivar 'Palava' was registered already in 1967 and still maintains a high performance standard. Similarities existing among cultivars under study were evaluated on the base of detailed descriptions and by the method of cluster analysis. The highest degree of similarity was found out between cultivars 'Morava' and 'Niva'. In case that the grower uses very similar cultivars, it is possible to substitute one cultivar by another and/or to choose cultivars that have some added properties, e.g. those that show an increased resistance to some diseases ('Zuzana') or the capability to fix higher amounts of nitrogen ('Oslava', 'Niva') etc. Cultivars showing the lowest degree of similarity (e.g. 'Litava') are very appreciated in the so-called "core" collections of plant genetic resources with a limited set of items; another possibility represent cultivars (and/or wild forms) that show the maximum genetic diversity.

SUMMARY

In years 2010 and 2011, altogether fourteen Czech cultivars of alfalfa (*Medicago sativa* L.) were evaluated. The experiment was established using the method of randomized blocks with three replications for the fodder production and three replications for production of seed. Individual plantations consisting of 30 plants were established at the same time. Ten plants of each cultivar were used for the evaluation of individual traits. Weighing, measuring and calculation concerning cultivars under study were performed pursuant instructions published in a classificator (Vacek *et al.*, 1985). Individual traits were evaluated using methods of point and interval estimates of average values and of the estimate of variation coefficient. Point matrix was used as a base for the processing of results by the cluster analysis.

In the cultivar 'Oslava', maximum values of five point estimates of the average value were identified in five yield-forming descriptors. This cultivar also produced the highest yields of hay per experimental plot. A low intra-varietal variability was demonstrated in cultivars 'Jarka' and 'Holyna' while the highest one was found out in the cultivar 'Litava'. As far as hay yields were concerned, cultivars 'Jarka', 'Litava', 'Magda', 'Morava', 'Niva', 'Oslava', 'Holyna', and 'Tereza' produced more hay the the control cultivar 'Palava'. Excepting cultivars 'Zuzana' and 'Jitka' all other cultivars under study gave better seed yields than the cultivar 'Palava'. Using the method of cluster analysis, the whole set of experimental data was subdivided into two larger clusters and these were compared with a unique cultivar 'Palava'. The highest degree of similarity was detected in cultivars 'Morava' and 'Niva'.

Acknowledgement

The work was supported by the Ministry of Agriculture of the Czech Republic (National Programme on Conservation and Utilization of Plant Genetic Resources and Agro-biodiversity) and Ministry of Education, Youth and Sports (Institutional research project No. MSM 2629608001).

REFERENCES

ANNICCHIARICO, P. 2006. Diversity, genetic structure, distinctness and agronomic value of Italian lucerne (*Medicago sativa* L.) landraces. *Euphytica*, 148(3): 269–282.

AVCI, A. A., OZKOSE, A., TAMKOC, A. 2013. Determination of yield and quality characteristics of alfalfa (*Medicago sativa* L.) varieties grown in different locations. *Journal of Animal and Veterinary Advances*, 12(4): 487–490.

BENABDERRAHIM, M. A., MANSOUR, H., ALI, F. 2009. Diversity of lucerne (*Medicago sativa* L.) populations in south Tunisia. *Pakistan journal of botany*, 41(6): 2851–2861.

BENDER, A., ANNAMAA, K. 2007. Yield Potential and Herbage Quality of Estonian Natural Alfalfa Populations. In: *Book of Abstracts, 18th Eucarpia Genetic Resources Section Meeting*. Piešťany, 23rd–26th May 2007, 115.

CHLOUPEK, O. 2008. *Genetická diverzita, šlechtění a semenářství*. Praha: Academia ČMT.

EVIGEZ. 2014. *Evidence genových zdrojů*. Available online: URL: http://genbank.vurv.cz/genetic/resources/asp2/default_c.htm.

JULIER, B., SEMIANI, Y., LAOUAR, M. 2010. Genetic Diversity in a Collection of Lucerne Populations from the Mediterranean Basin Evaluated by SSR Markers. In: *Sustainable use of genetic diversity in forage and turf breeding*. 107–112.

KNOTOVÁ, D., KOZOVÁ, Z., PELIKÁN, J., RAAB. S. 2013. Výkonnost českých odrůd vojtěšky seté. *Pícninářské listy*, XIX: 28–30.

LAKIĆ Ž., VOJIN, S. 2010. Variability of agronomic traits of red clover genotypes (*Trifolium pratense* L.). In: *Biotechnology in animal husbandry*. Kruševac – Serbia, 26–28 May 2010. 35–40.

LAMB, J. F. S., SHEAFFER, S. C., SAMAC, D. A. 2003. Population density and harvest maturity effects on leaf and stem yield in Alfalfa. *Agron. J.*, 95: 635–641.

LUGIC, Z., RADOVIC, J., SOKOLOVIC, D., JEVTIC, G., MILENKOVIC, J. 2010. Variability and Correlative Relations of Important Traits for Red Clover (*Trifolium pratense* L.) Half Sib progenies. In: *Sustainable use of genetic diversity in forage and turf breeding*. 313–318.

OTTMAN, M. J., ROGERS, M. T. 2000. *Alfalfa yield response to cutting height and cutting at dawn and dusk*. [Online]. Available online: http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az11851a.pdf.

PELIKÁN, J., VYMYSLICKÝ, T., HUTYROVÁ, H., KNOTOVÁ, D., MINJARÍKOVÁ, P., CHOLASTOVÁ, T., NEDĚLNÍK, J. 2009. *Metodika tvorby „core collection" u motýlokvětých pícnin*. Troubsko: VÚP a ZV.

PELIKÁN, J., VYMYSLICKÝ, T., GOTTWALDOVÁ, P. 2007. *Zhodnocení výnosového potenciálu odrůd vojtěšky. Aktuální poznatky v pěstování, šlechtění, ochraně rostlin a zpracování produktů*. VUPT.

SHARRATT, B. S., BAKER, D. G., SHEAFFER, C. C. 1986. Climatic effect on alfalfa dry matter production. Part I. *Agric. Forest Meteorol.*, 37: 123–131.

TUCAK, M., POPOVIC, S., CUPIC, T., GRLJUSIC, S., BOLARIC, S., KOZUMPLIK, V. 2008. Genetic diversity of alfalfa (*Medicago* spp.) estimated by molecular markers and morphological characters. *Periodicum biologorum*, 110(3): 243–249.

VACEK, V., MRÁZKOVÁ, V., SESTRIENKA, A., SEHNALOVÁ, J., BAREŠ, I., HÁJEK, D. 1985. *Klasifikátor genus Medicago* L. Praha: VÚRV.

WANG, X., YANG, X., CHEN, L., FENG, G., ZHANG, J., JIN, L. 2011. Genetic diversity among alfalfa (*Medicago sativa* L.) cultivars in Northwest China. *Acta Agriculturae scandinavica: section B-Soil and Plant Science*, 61(1): 60–66.

ZAPLETALOVÁ, I. 1983. Variabilita a interakce znaků podmiňujících výnosy píce odrůd jetele plazivého (*Trifolium repens* L.). *Sborník vědeckých prací VŠÚP Troubsko*, 8: 129–138.

Contact information

Daniela Knotová: knotova@vupt.cz
Jiří Skládanka: jiri.skladanka@mendelu.cz
Jan Pelikán: pelikan@vupt.cz