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THE FORAGE UTILIZATION OF WINTER PEA-CEREAL MIXTURE IN AGRICULTURE LOW-INPUT SYSTEM

J. Hakl, V. Brant, K. Mášková, K. Neckář, J. Pivec

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Abstract

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The aim of this paper is to evaluate the forage utilization of winter catch crop in relation to yield and mixture composition. In 2006–2009, the plot experiment with winter pea in mixtures with rye and triticale was conducted under completely randomized design with four replicates. The productivity of mixture was above 10 $t.ha^{-1}$ whilst the significantly lowest value was observed for pea monoculture. The rye represented the most productive component in mixture but it achieved lower forage quality in comparison with triticale. The ratio of pea varied from 7 to 38% in dependence on year and companion cereal. The triticale mixture provided higher ratio in comparison with rye and significant differences between rye varieties were also detected. The quality of mixture was depended mainly on ratio of crops in the mixture. The ratio of pea significantly increased crude protein content in mixture according to linear regression where crude protein = 9.56 + 0.11* weight percentage pea ratio ($P < 0.000$, $R^2 = 0.89$). Quality of pea forage was also influenced by companion crop where pea in mixture with rye achieved significantly lower quality. The amount of weeds was highest in the pea monoculture and lowest in mixture with rye.

yield, quality, triticale, rye

Grain legumes generally provide many benefits including positive effect on soil structure, nitrogen fixation, high-quality biomass etc. According to NAUDIN *et al.* (2008), cereal-legume intercrops are a promising way to combine high productivity and several ecological benefits in temperate agro-ecosystems. For forage production, they can be mainly used as a winter catch crop (HAKL, 2008), rarely as a main crop in a farm crop rotation. Because of lower quality, these forages could be used for less intensive plant and animal production, for example in organic farming. The main advantages of winter catch crops are yield stability and early maturing for forage use (URBAN and ŠARAPATKA, 2003) but removal of water and nutrients from the soil connected with soil tillage could be a reason of lower yield of following crops (HALVA, 1978).

In the past, the most common winter catch crops were cereals, brassicas, and some grass species. From leguminous crops, a wetch (*Vicia* ssp.) and crimson clover (*Trifolium incarnatum* L.) were used (HALVA, 1978). Winter form of field pea (*Pisum arvense* L.) was later introduced leguminous crop for our condition. This crop is one of the oldest cultivated crops with origin near the Mediterranean and could be used as forage as well as grain crop (TEKELI and ATES, 2003). According to ARSLAN *et al.* (2008), forage mixture usually results in better forage production and animal performance than a single species grown alone. As noted by URBAN and ŠARAPATKA (2003), one of the mixture advantages is better ratio between protein and energy in forage in comparison to monoculture. The species with lodged stems are more suitable for mixture with cereals than in monoculture (URBAN and ŠARAPATKA, 2003). The legume-cereal mixtures are generally also recommended in organic farming.

As mentioned above, these mixtures could be widely used for forage production. According to FLOHROVÁ (1998), the catch crops are used

for direct feeding most of the time, sporadic for conservation. The mixture composition for forage use should not be focused only on yield but also on quality of harvested forage. The aim of this paper is to evaluate the utilization of winter catch crop including cereal and winter field pea in relation to forage yield and mixture composition in the Czech Republic.

MATERIAL AND METHODS

In 2006–2009, the plot experiment with cereal-legume mixtures was conducted in the experimental field of the Research Station of the Czech University of Agriculture in Červený Újezd. The experimental area altitude is 405 m. The mean annual temperature at this location is 7.7 °C and the long-term annual sum of precipitation is 493 mm. The soil type is clay loam luvisol with the neutral soil reaction.

The plot experiment was of completely randomized design with four replicates with plot size 15 m^2. The fertilizers and herbicides were not used. The field pea (*Pisum arvense* L., Arkta variety) was grown in monoculture with seeding rate 100 $kg.ha^{-1}$ or in mixture with triticale (*Triticale* WITTMARC, Ticino variety) and rye (*Secale cereale* L., hybrid varieties Picasso and Pollino). In these mixtures, the seeding rate was 50 and 100 $kg.ha^{-1}$ for pea and cereal, respectively. The terms of seeding and sampling are presented in Table I. The samples were taken from area 0.1 m^2 in each plot with height of stubble 20 mm and were oven-dried at 60 °C. The pea and cereal yield and weight of weeds (W) were measured for each sample. The total dry matter yield (T) and weight percentage ratio of pea (P%) were calculated. The samples from last sampling date in each year except for variety Picasso were homogenised to a particle size of 1 mm and analysed for crude protein (CP) and crude fiber (CF) content. CP was quantified using the Dumas procedure for N determination (% CP = % N x 6.25) and CF contents were determined according to modified Scharrer method (ČSN ISO 6541). The forage mean of qualitative traits was calculated based on forage quality of mixture components and their weight percentage ratio. Precipitation totals (P, mm) were collected by tipping bucket rain gauge RS03 (Fiedler, CZ) within a 1 h interval and air temperature (t, °C) was measured by datalogger Minikin TH (EMS Brno, CZ) every 10 min.

The effect of variant and year on yield and forage quality was statistically evaluated by two-way ANOVA. The simple linear regression was used for prediction of forage quality in the mixture. All statistical analyses were performed using Statistica 9.0 (STATSOFT, 2003).

I: *Stand establishment and sampling dates and developmental stages of mixture component in evaluated years*

seeding date	sampling date					
	I.		II.		III.	
stage	pea	cereal	pea	cereal	pea	cereal
30. 9. 2006	3. 5. 2007		15. 5. 2007		30. 5. 2007	
	4 branches	BBCH 30	7 branches	BBCH 55	flowering	BBCH 69
9. 10. 2007	6. 5. 2008		20. 5. 2008		3. 6. 2008	
	2 branches	BBCH 24	5 branches	BBCH 51	flowering	BBCH 71
7. 10. 2008	5. 5. 2009		18. 5. 2009		8. 6. 2009	
	4 branches	BBCH 26	7 branches	BBCH 49	flowering	BBCH 69

II: *Total dry matter yield of mixture component (T, $g.m^{-2}$), weight ratio of pea (P%, %), and weight of weeds (W, $g.m^{-2}$) for evaluated variants and years (P = pea, T = Triticale, S Pi = Secale Piccasso, S Po = Secale Pollino)*

	I.			II.			III.		
	T	P%	W	T	P%	W	T	P%	W
P	260^{a}	-	15^{a}	460^{a}	-	34^{a}	710^{a}	-	21^{a}
P-T	450^{b}	26^{a}	3^{b}	590^{a}	24^{a}	12^{b}	1090^{b}	38^{a}	11^{ab}
P-S Pi	540^{b}	15^{b}	4^{b}	840^{b}	18^{a}	9^{b}	1330^{bc}	25^{b}	11^{ab}
P-S Po	560^{b}	13^{b}	3^{b}	970^{b}	7^{b}	8^{b}	1450^{c}	16^{c}	4^{b}
p-value	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	0.031
2007	630^{a}	30^{a}	11^{a}	800^{a}	21^{a}	6^{a}	1060	20^{a}	3^{a}
2008	350^{b}	11^{b}	3^{b}	680^{b}	13^{b}	29^{b}	1260	41^{b}	11^{ab}
2009	380^{b}	13^{b}	4^{b}	660^{b}	15^{ab}	10^{b}	1120	18^{a}	21^{b}
p-value	< 0.000	< 0.000	< 0.000	0.014	0.034	<0.000	0.064	<0.000	0.003

Different letters document statistical differences between variants or years within sampling dates for Tukey HSD, $\alpha = 0.05$)

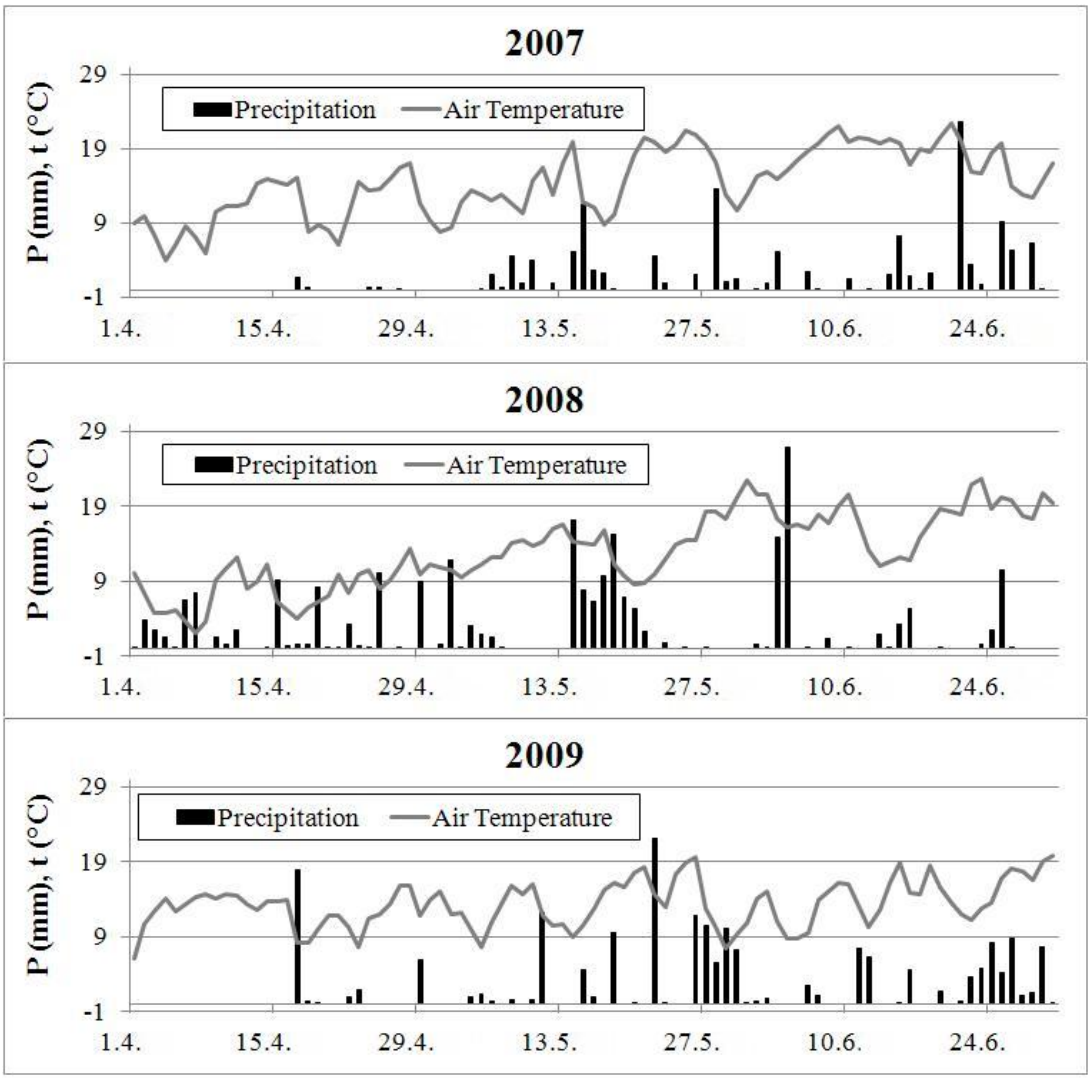
RESULTS AND DISCUSSION

Productivity

Achieved forage yield, percentage ratio of pea, and weed production are presented in Table II. In last term of sampling, the productivity of mixture was above 10 t.ha^{-1} whilst the significantly lowest value was observed for pea monoculture. Mixture with rye was more productive than with triticale. The level and stability of acquired yield within three year experiment showed that the winter catch crops are stable forage source in accordance with HAKL (2008).

According to NAUDIN *et al.* (2010), the proportion of each species in the mixture in the harvest is highly variable. In our experiment, the ratio of pea varied from 7 to 38%. The differences were detected between triticale and rye as well as between rye varieties. Triticale mixture provided higher ratio of pea in comparison with rye. The variety Pollino showed higher competitive ability than variety Piccasso which resulted in significant differences in pea ratio. In relation to yield, the seeding rates 50 kg.ha^{-1} for pea and 100 kg.ha^{-1} for triticale were more suitable than 65 and 150 kg.ha^{-1}, respectively (BRANT *et al.*, 2008). Weed infestation was generally low in all stands and did not exceed 7%. The amount of weeds was highest in the pea monoculture and lowest in mixture with rye. It is in accordance with results of HAUGGAARD-NIELSEN *et al.* (2008) that the intercropping was particularly effective at suppressing weeds, capturing a greater share of available resources than monocultures.

The year effect was significant in all evaluated traits. Due to dry conditions in 2007 (Fig. 1.), the productivity of stands was reduced in last term of sampling in spite of significantly higher productivity in the first and second term. The pea ratio was also modified by year when the highest value was observed in 2008, probably in accordance with higher sum of precipitation in this year. Temperature could also play a role because there was significantly lower pea ratio under acceptable



1: *Daily sum of precipitation (P, mm) and daily average temperature (t, °C) from 1 April to 30 June in 2007–2009*

precipitation but lower temperature from the end of May to the end of June in 2009. In dry year 2007, the ratio was reduced during vegetation period whilst in 2008 was highly and in 2009 slightly increased. Also N fertilization could be used as a tool to enhance the contribution of wheat in the intercrop biomass but may reduce the nitrogen fixation in the intercrop by decreasing pea biomass (NAUDIN *et al*., 2010).

Forage quality

The results of forage analyses are showed in Table III. According to expectation, the pea achieved the highest forage quality which was represented by the highest CP and the lowest CF content. The quality of pea forage was influenced by companion crop where pea in mixture with rye achieved significantly lower quality. In contrast to rye, triticale provided significantly higher CP content but differences in CF were not significant.

The achieved forage quality of mixtures generally did not correspond with demand for highly performed milk cow in accordance with HAKL (2008). The quality of mixture was dependent mainly on ratio of crops in the mixture. The ratio of pea significantly increased CP content in mixture forage according to linear regression where CP = 9.56 + 0.11* percentage pea ratio ($P < 0.000$, $R^2 = 0.89$). It is in accordance with ARSLAN *et al.* (2008) about positive effect of pea ratio in mixture on CP content in the harvested biomass. In our experiment, the effect of pea ratio was also recorded for CF content when CF (%) = 30.91 – 0.06* percentage pea ratio ($P = 0.001$) but with lower R^2 0.28. The mixture with triticale provided better forage value of harvested biomass therefore could be recommended as more suitable in comparison with rye mixture. The higher content of pea in this mixture and better quality of triticale is possible to conclude as the main reason.

As regard forage quality, the year has significant effect only on CF content in relation to dry matter yield. The interaction between variant and year was significant ($P = 0.003$) when CF content in triticale was significantly lower than in rye in 2008. The differences in CP content of forage mean among years were connected with highest pea ratio in 2008.

CONCLUSION

The productivity of mixtures exceeds 10 $t.ha^{-1}$ at the beginning of the June what could be considering as a satisfactory level. Also the amount of weeds was strongly reduced in the mixtures. The percentage ratio of pea in the mixture highly varied in relation to companion crop as well as weather condition in the year. The higher ratio of pea improved forage quality of the mixture when increased crude protein and decreased crude fibre content. For forage production, the mixture of winter pea and triticale could be recommended because of higher yield than pea monoculture and better quality in comparison with rye mixture.

III: *Crude protein (CP, %) and crude fiber (CF, %) content in components and forage mean (based on weight percentage ratio) of evaluated variants (P = pea, T = Triticale, S = Secale Pollino) and years in the last term of sampling*

		Pea		Cereal		Forage mean	
		CP	**CF**	**CP**	**CF**	**CP**	**CF**
variant	P	20.2 [a]	24.0 [a]	-	-	20.2 [a]	24.0 [a]
	P-T	19.3 [a]	24.4 [a]	11.5 [a]	30.9	14.6 [b]	28.7 [b]
	P-S	17.1 [b]	21.6 [b]	9.1 [b]	32.0	10.6 [c]	30.2 [c]
year	p-value	0.003	0.009	< 0.000	0.218	< 0.000	< 0.000
	2007	18.8	21.2 [a]	10.0	26.6 [a]	14.8 [a]	23.7 [a]
	2008	19.8	27.4 [b]	10.4	33.8 [b]	16.3 [b]	30.5 [b]
	2009	18.0	21.4 [a]	10.5	33.9 [b]	14.2 [a]	28.8 [c]
	p-value	0.114	< 0.000	0.798	< 0.000	0.001	< 0.000

Different letters document statistical differences between variants or years within mixture components and mean of forage for Tukey HSD, $\alpha = 0.05$)

SUMMARY

Grain legumes generally provide many benefits including positive effect on soil structure, nitrogen fixation and high-quality biomass. The aim of this paper is to evaluate the forage utilization of a winter catch crop including cereal and winter field pea in the Czech Republic in relation to yield and mixture composition. In 2006–2008, the plot experiment was periodically established under completely randomized design with four replicates. The field pea (*Pisum arvense* L., Arkta variety) was grown in monoculture or in mixture with triticale and rye. The pea and cereal yield and weight of weeds were measured for each sample in three terms from May to June. The total dry matter yield and weight percentage ratio of pea were calculated. The samples from last term of sampling were analysed on crude protein and crude fiber. In last term of sampling, the productivity of mixture was above 10

t.ha^{-1} whilst the significantly lowest value was observed for pea monoculture. The pea ratio in the mixture was significantly influenced by year where higher precipitation and temperature increased this ratio. Also rye as a companion crop significantly reduced the pea ratio mainly in 2nd and 3rd term of sampling. In this trait, the significant differences between rye varieties were also detected. The rye provided the most productive component in mixture but achieved lower forage quality in comparison with triticale. The quality of mixture was depended mainly on ratio of crops in the mixture. The ratio of pea significantly increased CP content in mixture according to regression where CP (%) = 9.56 + 0.11* percentage pea ratio (R^2 = 0.89). Quality of pea forage was also influenced by companion crop where pea in mixture with rye achieved significantly lower quality. The amount of weeds was highest in the pea monoculture and lowest in mixture with rye. For forage production, the mixture of winter pea and triticale could be recommended because of higher yield than pea monoculture and better quality in comparison with rye mixture.

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Address

Ing. Josef Hakl, Ph.D., Ing. Kamila Mášková, Katedra pícninářství a trávníkářství, Ing. Václav Brant, Ph.D., Ing. Karel Neckář, Ph.D., Jan Pivec, Ph.D., Katedra agroekologie a biometeorologie, Česká zemědělská univerzita v Praze, Kamýcká 129, 165 21 Praha 6 –Suchdol, Česká republika, e-mail: hakl@af.czu.cz