Intercropping pea with eight cereals for forage production

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Introduction

Pea *(Pisum sativum* L.) is widely distributed in both wild and agricultural flora of Serbia and other Southeast European countries. *P. sativum* subsp. *sativum* var. *arvcnsc* (L.) Poir., appears as a weed in cereals, especially fall-sown wheat in southeastern Serbia (1). it is also cultivated for forage production and has been successfully used for developing fall-sown cultivars of forage pea highly resistant to low temperatures (2).

Cultivated area of forage pea in Serbia has been about 4000 ha for several decades (3). Forage pea is traditionally used in fall-sown mixtures with cereals (4) such as common wheat *(Triticum aestivum* L. subsp. *aestivum),* barley *(Hordeumvulgare*L.), oat *(Avenasativa* L.) and triticale (*Triticosecale* spp.). The seed mixture of forage pea and cereals depends on local recommendations and is 50:50 in Lithuania (5) and France (6) and 75:25 (pea:cereal) in Serbia (7) and Bulgaria (8).

The goal of this research was to assess the potential of pea intercrops with various cereals for forage production in temperate regions of Serbia.

Materials and methods

A small-plot trial was carried out at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Sancevi during the growing seasons of 2009/2010 and 2010/2011 (Table 1) and on a chernozem

Table 1. Average monthly temperatures (°C) and monthly rainfall (mmm) during the 2009/2010and2010/2011growing seaso

Temperature	Oct.	Nov.	Dec.		Feb.	Mar.	Apr.	May	June	Average
2009/2010	12	9	3	0	2	7	13	17	20	9
2010/2011	10	10	1	0	0	6	13	17	18	8
Long-term	12	6	2	-1	2	6	11	17	20	8
Rainfall	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Sum
2009/2010	83	64	96	73	65	38	71	95	174	605
2010/2011	67	44	66	29	35	28	23	65	61	375
Long-term	43	50	48	37	32	38	47	59	85	374

soil (Table 2). it included intercrops of forage pea with eight cereals, namely einkorn *(Triticum monococcum* L.), emmer *(Triticum turgidum* L. subsp. *dicoccon* (Schrank) Thell.), spelt *(Triticum aestivum* L. subsp. *spelta* (L.) Thell.), durum wheat *(Triticum turgidum* L. subsp. *durum* (Desf.) Husn.), common wheat, barley, oat and triticale. The sole crops of each intercrop species were also included in the trial.

Table 2. Chemical composition of the chernozem soil at Rimski Sancevi in 2009.

pH (H2O)	pH (KCl)	N (%)	P2O5 (mg 100g-1)	K2O (mg 100g-1)	CaCO3 (%)	Humus (%)
7.9	7.41	0.196	17.99	21	5.61	2.97

in both trial years, all sole crops and their intercrops were sown in the second half of October, with plot size of 5 m^2 and three replicates. All sole crop treatments were harvested at full bloom or first pod formation in pea and in the full flag leaf stage for the cereal crops. The intercrop treatments were harvested when the first crop of the mixture reached the desired stage (9). in the majority of treatments both component crops reached the desired stage concurrently.

The green forage yield in all intercrops and sole crops was measured directly after cutting. Forage dry matter yield was determined after allowing the harvested samples to dry to a constant mass in a drier at 105 °C. The agronomic and economic reliability of green forage yield and forage dry matter production in each intercrop was determined by calculating their Land Equivalent Ratio (LER_{GFY} and LER_{FDMY}) according to (10):

LERGFY = GFY(p)ic / GFY(p)sc + GFY(c)c / GFY(C)SC,

where GFY(p)ic is the green forage yield of pea in the intercrop, GFY(p)sc is the green forage yield of pea in its sole crop, $GFY(c)_{IC}$ is the green forage yield of a cereal in the intercrop and $GFY(c)_{SC}$ is the green forage yield of a cereal in its sole crop. Similarly, LER_{FDMY} was calculated.

The results were analyzed using Statistica 8.0 software, with analysis of variance (ANOVA) performed and a Fisher's Least Significant Difference (LSD) calculated at $P = 0.05$.

Results and discussion

There were significant differences in the two-year average green forage yield among both sole crops of pea and cereals and their intercrops (Table 3).

Table 3. Average green forage yield (t ha^{-1}) in sole crop (GFYsc) and intercrop (GFY_{cc}) treatments of peea (GFYp) and cereals (GFYc) in 2009/2010and2010/2011at Rimski Sancevi.

Sole crop	GFYSC	Intercropping	GFYP	GFYC	GFYIC	LERGFY
Pea	43.5	-	-	-	-	-
Einkorn	34.5	Pea + einkorn	19.5	18.0	37.5	0.97
Emmer	51.0	Pea + emmer	9.0	37.5	46.5	0.94
Spelt	52.5	Pea + spelt	7.5	43.5	51.0	1.00
Durum wheat	34.5	Pea + durum wheat	28.5	12.0	40.5	1.00
Common wheat	42.0	Pea + common wheat	13.5	34.5	48.0	1.13
Barley	55.5	Pea + barley	7.5	48.0	55.5	1.04
Oat	36.0	Pea + oat	13.5	34.5	48.0	1.27
Triticale	45.0	Pea + triticale	16.5	30.0	46.5	1.05
C.V.						
LSD0.05	4.8	LSD0.05	4.8	0.09		

The average green forage yield in the intercrops ranged from 37.5 t ha^{-1} in pea + einkorn to 55.5 t ha^{-1} in pea + barley, confirming that in temperate conditions barley produces the highest forage yields, although with poorer quality (11). The largest proportion of pea was in its intercrop with durum wheat (28.5 t ha^{-1}), followed by einkorn (19.5 t ha^{-1}). The two-year average green forage yield in pea sole crop treatments was comparable to previous data under the same conditions (12). The intercrops of pea with einkorn, emmer, spelt and durum were not economically justified with LER_{GFY} values either lower or equal to 1.0. The intercrop of pea with oat had a significantly higher LER_{GFY} value (1.27) than the other seven intercrops.

In general, the two-year average forage dry matter yield (Table 4) followed similar trends as the two-year average forage dry matter yield. In sole crops, barley (11.2 t ha^{-1}), spelt (11.1 t ha^{-1}), emmer (11.0 t ha^{-1}) and pea (10.7 t ha^{-1}) had significantly higher forage dry matter yield in comparison to the remaining four cereals. The two-year average forage dry matter yield in the intercrops varied between 8.5 t ha^{-1} in pea + einkorn and 11.5 t ha^{-1} in pea + barley, the latter being lower than at the same pea and barley ratio in the temperate regions of North America (13). The forage dry matter proportion of each crop may differ slightly in a pure stand compared to an intercrop. For this reason, the values of LER_{FDMY} were slightly different than LER_{GFY}, with a maximum in the pea + oat intercrop (1.23) and a minimum in the pea + spelt intercrop (0.97).

Table 4. Average forage dry matter yield (thai') in sole crop ($FDMY_{sc}$) and intercrop ($FDMY_{cc}$) treatments ofpea (FDMYp) and cereals (FDMY) hi 2009/2010 and2010/2011at Rimski Sancevi.

Sole crop	FDMYSC	Intercropping	FDMYp	FDMYc	FDMYIC	LERFDMY
Pea	10.7	-	-	-	-	-
Einkorn	7.1	Pea + einkorn	4.6	3.9	8.5	0.98
Emmer	11.0	Pea + emmer	2.1	8.8	10.9	1.00
Spelt	11.1	Pea + spelt	1.8	8.9	10.7	0.97
Durum wheat	7.0	Pea + durum wheat	6.7	2.6	9.3	1.00
Common wheat	9.5	Pea + common wheat	3.2	7.7	10.8	1.11
Barley	11.2	Pea + barley	1.8	9.7	11.5	1.03
Oat	7.7	Pea + oat	3.2	7.2	10.4	1.23
Triticale	9.2	Pea + triticale	3.9	6.3	10.2	1.05
C.V.						
LSD0.05	0.9	LSD0.05	0.9	0.10		

Conclusions

This study confirmed that the traditional practice of intercropping pea with common wheat, barley, oat and triticale have the greatest potential for forage production in comparison to less traditional or forgotten crops such as durum wheat, spelt, einkorn and emmer. However, this study should be continued with a more detailed study on forage dry matter quality, with emphasis on crude protein and crude fiber as well as with all important underground aspects of intercropping, primarily plant-microbial interactions and nutrient availability.

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