Potential of the intercrops of normal-leafed and semi-leafless pea cultivars for forage production

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Pea *(Pisum sativum* L.) is one of the most ancient food and feed crops in the Balkan Peninsula. Its traditional use in animal husbandry on the territory of modern Serbia has been in the form of forage, either fresh or dry, as well as in mixtures with small grains or as a pure stand (1). The first Serbian forage pea cultivars were autumn-sown, with excellent winter-hardiness and delayed flowering resulting in high quality and stable forage yields (2). The semi-leafless types of pea entered the Serbian market and breeding programs during the last decade of the last century and are exclusively associated with dry grain production. Recently, it was demonstrated that it is possible to develop autumn-sown semi-leafless dry pea cultivars for the conditions of Serbia (3), and that the semi-leafless cultivars may provide high quality forage yields with enhanced seed production due to their prominent lodging tolerance (4).

Numerous contemporary systems involving monocultures require chemical fertilizers and pesticides, and result in decreased soil and water quality and reduced biodiversity. On the other hand, intercropping systems with carefully and appropriately selected species where legumes serve a prominent role provide many advantages in contrasting environments (5). Along with the traditional intercropping of legumes with small grains in many European regions (6, 7), attempts have been made recently to examine intercrops of perennial and annual legumes, such as field pea in establishing red clover (8), as well as mutual intercropping of annual legumes for forage production (9). The goal of this research was to assess the potential of the mutual intercrops of pea cultivars with different leaf types for forage production.

Materials and Methods

A small-plot trial was established during the 2008-2009 and 2009-2010 growing seasons at Rimski Sancevi, near Novi Sad (45°20' N, 19°51' E and 84 masl) on a slightly carbonated chernozem soil (Table 1). Compared to the long term average (1964-2010), the growing season of 2008/09 was much warmer and much drier, while the growing season of 2009/10 was slightly warmer and significantly wetter (Table 2).

Table 1. Basic chemicalproperties of a chernozem soil at Rimski Sancevi

Depth (cm)	pH KCl	pH	CaCO3	Humus	Ntotal	Al-P_2O_5 (mg $100g^{-1}$)	Al-K2O (mg $100g^{-1}$)
0-30	7.41	7.90	5.61	2.97	0.196	17.99	20.00

Table 2. Average monthly temperatures (°C) and monthly precipitation (mmm) for the growing period of autumn-sown cool season annual forage legumes in 2008/2009 and20X09/2010.

Month / Year	Oct	Nov	Dec		Feb	Mar	Apr	May	Mean
Average monthly temperature (°C)									
2008/2009	14	9	4	2	6	7	15	18	9.4
2009/2010	12	9	3	0	2	7	13	17	7.9
Long term	12	6	2	-1	2	6	11	17	6.9
Monthly precipitation sum (mm)									Total
2008/2009	17	58	45	23	7	36	2	48	236
2009/2010	83	64	96	73	65	38	71	95	585
Long term	43	50	48	37	32	38	47	59	354

The trial included four dry pea cultivars in total, namely the autumn-sown semi-leafless cultivar 'Dove' (France), the autumn-sown normal-leafed cultivar 'Frijaune' (France), the spring-sown semi-leafless cultivar 'Jezero' (Serbia) and the spring-sown normal-leafed cultivar 'Javor' (Serbia). These four cultivars were grown in pure stand and intercropped with the complementary genotype within the same crop type such that one had good standing ability (supporting crop, Dove and Jezero) while the other was lodging-susceptible (supported crop, Frijaune and Javor). There were six treatments in total: four pure stands and two intercropped treatments, i.e. Dove with Frijaune and Jezero with Javor.

The trial was set up as a randomized complete block design, with four replicates, and plot size of 10 m^2 and a row spacing of 20 cm. The pure stands were sown with 120 viable seeds m^{-2}. The intercropped treatments were composed of 50% of each variety. The autumn treatments were sown on October 11, 2008, and October 15, 2009, while the spring treatments were sown on March 14, 2009, and March 22, 2010.

Pure stands were cut at full bloom, while the intercrops were cut when the first of the two components reached full bloom. The varieties in the combined treatments flowered at similar times. The autumn-sown treatments were cut on April 17, 2009, and April 25, 2010, while the spring-sown treatments were cut on May 7, 2009, and May 17, 2010. Green forage yield (t ha^{-1}) and forage dry matter yield (t ha^{-1}) were monitored. The Land Equivalent Ratio (LER) was calculated as (10):

$$LER = Sdic / Sdps + Sgic / Sgps$$

, where Sd_{IC} is the supported component forage yield in the intercrop, Sd_{PS} is the supported component forage yield in its pure stand, Sg_{IC} is the supporting component forage yield in the intercrop and Sg_{PS} is the supporting component forage yield in its pure stand. The values for both green forage yield (LER_{GFY}) and forage dry matter yield (LER_{FDMY}) were calculated separately.

The analysis of variance was performed using Statistica 8.0 software, with a Fisher's LSD test used at P = 0.05.

Results and Discussion

There were statistically significant differences at the p = 0.05 level between green forage yield among treatments (Table 3). On average, green forage yields were higher in the 2009/10 growing season compared to the 2008/09 growing season. Pure stand green forage yield varied from 28.5 t ha^{-1} for the normal-leafed spring-sown Javor in 2008/09 to 34.0 t ha^{-1} for the spring-sown semi-leafless Jezero also in 2008/09. In the 2008/09 growing season, the autumn-sown and the spring-sown intercrops produced similar total green forage yield (33.9 t ha^{-1} and 33.8 t ha^{-1}), while, in the 2009/10 growing season, the autumn-sown intercrops produced higher yields (34.5 t ha^{-1}) than the spring-sown intercrops (33.9 t ha^{-1}). The supported component of the autumn-sown intercrops benefitted much more than the supporting crop in both years, while in the spring-sown intercrops the two component varieties were more balanced in their contribution to the total green forage yield. These results suggest that semi-leafless pea cultivars may have great potential for forage production (11).

Both autumn-sown and spring-sown intercrops had two-year LER_{GFY} average values greater than 1 (1.09 and 1.11) suggesting that intercropping the two varieties was economically justified for green forage production.

Table 3. Green forage yield (t ha-1) and LER$_{GFY}$ in mutual intercrops ofpea cultivars with different leaf types at Rimski Sancevi during the 2008/09 and2009/10growing seasons.

Year	Season	Treatment	Green forage yield of supported component	Green forage yield of supporting component	Total green forage yield	LERGFY
2008/ 2009	Winter	Dove, pure stand	31.6	0.0	31.6	1.00
		Frijaune, pure stand	0.0	30.4	30.4	1.00
		Dove +Frijaune	22.2	11.7	33.9	1.10
	Spring	Jezero, pure stand	34.0	0.0	34.0	1.00
		Javor, pure stand	0.0	28.5	28.5	1.00
		Jezero + Javor	18.3	15.5	33.8	1.10
2009/ 2010	Winter	Dove, pure stand	33.2	0.0	33.2	1.00
		Frijaune, pure stand	0.0	31.2	31.2	1.00
		Dove +Frijaune	24.1	10.4	34.5	1.09
	Spring	Jezero, pure stand	28.6	0.0	28.6	1.00
		Javor, pure stand	0.0	32.0	32.0	1.00
		Jezero + Javor	14.4	19.5	33.9	1.13
Average 2008/ 2010	Winter	Dove, pure stand	32.4	0.0	32.4	1.00
		Frijaune, pure stand	0.0	30.8	30.8	1.00
		Dove +Frijaune	23.2	11.0	34.2	1.09
	Spring	Jezero, pure stand	31.3	0.0	31.3	1.00
		Javor, pure stand	0.0	30.3	30.3	1.00
		Jezero + Javor	16.4	17.5	33.8	1.11
$P < 0.05$				3.7		0.08

Average forage dry matter yields in pure stands were statistically significant (Table 4). Yield ranged from 5.5 t ha^{-1} in the spring-sown semi-leafless Jezero in 2008/09 and 8.0 t ha^{-1} in the autumn-sown, normal-leafed Frijaune in 2009/10. The trend of forage dry matter yield was not the same as green forage yield due to different forage dry matter proportion in individual cultivars and individual years.

In 2008/09, forage dry matter yield in the autumn-sown intercrop (7.7 t ha^{-1}) was significantly greater compared to the forage dry matter yield in the spring-sown intercrop (6.4 t ha^{-1}). In 2009/10, the autumn-sown intercrop was significantly more productive (8.4 t ha^{-1}) than the spring-sown intercrop (6.5 t ha^{-1}). Similar to the case of green forage yield, there was a balance between the two components in the spring-sown intercrop, while the supported component had much greater contribution in the autumn-sown intercrop.

The LER_{FDMY} values suggest that both autumn-sown and spring-sown intercrops were economically justified, although the former was significantly more productive (1.13) than the latter (1.03).

Conclusions

The obtained results give a solid basis for further research on intercropping legume varieties with contrasting leaf types for forage production. One of the advantages the mutual dry pea intercropping may have in comparison to the traditional annual forage legume cultivation is a prominent earliness, especially in the autumn-sown treatments, allowing the possibility of sowing a succeeding crop in a regular sowing term. Future research in the mutual pea and other annual legume intercropping must include evaluation of additional above and below ground characteristics.

Table 4. Forage dry matter yield (t ha') and $LEER_{FDMY}$ for mutual intercrops of pea cultivars with different leaf types at Rimski Sancevi during the20088/09 and2009/10growing seasons.

Year	Season	Treatment	Forage dry matter yield of supported component	Forage dry matter yield of supporting component	Total forage dry matter yield	LERFDMY
2008/ 2009	Winter	Dove, pure stand	6.7	0.0	6.7	1.00
		Frijaune, pure stand	0.0	7.6	7.6	1.00
		Dove +Frijaune	4.9	2.8	7.7	1.10
	Spring	Jezero, pure stand	6.3	0.0	6.3	1.00
		Javor, pure stand	0.0	5.5	5.5	1.00
		Jezero + Javor	3.0	3.4	6.4	1.09
2009/ 2010	Winter	Dove, pure stand	6.9	0.0	6.9	1.00
		Frijaune, pure stand	0.0	8.0	8.0	1.00
		Dove +Frijaune	5.3	3.1	8.4	1.16
	Spring	Jezero, pure stand	7.1	0.0	7.1	1.00
		Javor, pure stand	0.0	6.5	6.5	1.00
		Jezero + Javor	2.7	3.8	6.5	0.96
Average 2008/ 2010	Winter	Dove, pure stand	6.8	0.0	6.8	1.00
		Frijaune, pure stand	0.0	7.8	7.8	1.00
		Dove +Frijaune	5.1	3.0	8.1	1.13
	Spring	Jezero, pure stand	6.3	0.0	6.3	1.00
		Javor, pure stand	0.0	6.4	6.4	1.00
		Jezero + Javor	2.9	3.6	6.5	1.03
$P < 0.05$				0.8		0.08

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