Forage yields in the intercrops of pea with other cool season annual legumes

Krstic, D.[1], Mikic, A.[2], Cupina, B.[1], Antanasovic, S.[1], Mihailovic, V.[2], Eric, P.[1] and Pejic, B.
University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia
[2]Institute of Field and Vegetable Crops, Novi Sad, Serbia

Introduction

Pea *(Pisumsativum* L.) is an economically important plant species worldwide, especially in temperate regions. It is used in both human diets and animal feeding in the form of green forage, forage dry matter, forage meal, silage, haylage, immature pods, immature grains, mature grains and straw (1) and also plays a significant agronomic role through green manure and mulch. Pea is traditionally intercropped with cereals in many regions of Europe and the world, but also as a companion crop in establishing a perennial forage crop such as red clover *(Trifolium pratense* L.), alfalfa *(Medicago sativa* L.) or sainfoin *(Onobrychis viciifolia* Scop.), where it acts as a bioherbicide (2).

Today, pea is one of the most important annual forage legumes in Serbia and other Balkan and South East European countries. Recently, attempts have been made in Serbia to re-introduce neglected and underutilized annual legume crops such as faba bean *(Viciafaba* L.) (3), grass pea *(Lathyrus sativus* L.) (4), lentil *(Lens culinaris* Medik.) and bitter vetch *(Vicia ervilia* (L.) Willd.), as well as to introduce novel annual legume crops such as white lupin *(Lupinus albus* L.) (5), that could serve as supplements in providing animal husbandry with quality plant protein.

The aim of this study was to assess the possibility of intercropping pea with other temperate annual legumes for forage production.

Materials and methods

A small-plot trial was carried out during two pea growing seasons, from the fall 2009 to the spring 2011 on a chernozem soil at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Sancevi near Novi Sad. Treatments comprised several intercrop combinations of pea with other cool season annual legumes, as well as the intercrop of pea with contrasting leaf morphology. All treatments were designed according to the four basic principles of the mutual annual legume intercropping (6): 1) same time of sowing; 2) similar growth habit; 3) similar cutting time; and 4) combinations of crops with good standing ability (supporting crop) with others that are susceptible to lodging (supported crop). Seven treatments involving pea were included in the trials: 1) fall-sown forage pea + faba bean, 2) fall-sown semi-leafless dry pea + normal-leafed dry pea, 3) fall-sown semi-leafless dry pea + bitter vetch, 4) spring-sown forage pea + faba bean, 5) spring-sown forage pea + white lupin, 6) spring-sown semi-leafless dry pea + normal-leafed dry pea and 7) spring-sown semi-leafless dry pea + lentil (Figure 1). Each component of the treatments was also included in the trial as a pure stand.

Figure 1. Intercrops involving pea and other cool season annual legumes 2010 and 2011 at Rimski Sancevi: (fall-sowing) forage pea + faba bean (firstrow, left), semi-leafless drypea + normal-leafed drypea (firstrow, righ t) semi-leafless dry pea + bitter vetch (second row), (spring-sown) forage pea + faba bean (third row, left), forage pea + white lupin (third row, right), semi-leafless drypea + normal-leafed drypea (fourth row, left) and semi-leafless drypea + lentil (fourth row, right).

All fall intercrops and sole crops were sown on 8 October 2009 and 15 October 2010, while all spring intercrops were sown on 2 March 2010 and 6 March 2011. Plot size was 5 m^2 and the experimental design was a split-plot with three replicates. The seeding rates in sole crops were 75 viable seeds m^{-2} for fall- and spring-sown faba bean and white lupin, 120 viable seeds m^{-2} for fall- and spring-sown forage and dry pea and 180 viable seeds m^{-2} for bitter vetch and lentil. In all the intercrops, the seeding rates of each component in its sole crop were reduced by 50%. No rhizobia or inorganic fertilizers were added and no weed control was done. All the plots with sole crops were cut at the full bloom or early pod stage, while the intercrops were cut when the first intercrop component reached the full bloom or early pod stage.

The green forage yield in all intercrops was measured immediately after cutting. The forage dry matter yield in each was determined on the basis of forage dry matter proportion in the green forage samples taken after the cutting and dried until constant mass at a room temperature. The reliability of green forage yield in each intercrop was determined by calculating its Land Equivalent Ratio (LER_{GFY}) as (6):

LERGFY = GFY(sg)ic / GFY(sg)sc + GFY(sd)$_{IC}$ / GFY(sd)sc,

where $GFY(sg)_{IC}$ is the green forage yield of the supporting component in the intercrop, $GFY(sg)_{SC}$ is the green forage yield of the supporting component in its sole crop, $GFY(sd)_{IC}$ is the green forage yield of the supported component in the intercrop and $GFY(sd)_{SC}$ is the green forage yield of the supported component in its sole crop. In an analogous way, the LER for forage dry matter yield (LER_{FDMY}) was calculated.

The results were analyzed using Statistica 8.0 software. Analysis of variance (ANOVA) was performed and means were separated using Fisher's Least Significant Difference (LSD) test at $P = 0.05$.

Results and discussion

The seedling emergence in all the treatments was regular and provided the projected stand density. Average green forage yields in the pure stands of fall-sown forage pea (46.1 t ha^{-1}) and spring-sown faba bean (45.6 t ha^{-1}) were significantly higher compared to the other treatments, especially the spring-sown normal leaf dry pea (27.9 t ha^{-1}) and lentil (23.3 t ha^{-1}) (Table 1). Among the fall-sown treatments, the

Table 1. A verage values ofggreen forage yield (t ha^{-1}) and its Land Equivalent Ratio (LER_{GFY}) in the intercrops of pea with other cool season annual legumes for 2010 and 2011 at Rimski Sancevi

Season	Treatment	Green forage yield Supporting crop	Supported crop	Total	LERGFY
Fall	Faba bean	38.3	-	38.3	1.00
Fall	Forage pea	-	46.1	46.1	1.00
Fall	Faba bean + forage pea	16.5	32.0	48.5	1.12
Fall	Semi-leafless dry pea	33.5	-	33.5	1.00
Fall	Normal-leafed dry pea	-	29.6	29.6	1.00
Fall	Bitter vetch	-	35.6	35.6	1.00
Fall	Semi-leafless dry pea + normal-leafed dry pea	22.1	17.9	40.0	1.26
Fall	Semi-leafless dry pea + bitter vetch	24.1	22.5	46.6	1.35
Spring	Faba bean	45.6	-	45.6	1.00
Spring	White lupin	41.2	-	41.2	1.00
Spring	Forage pea	-	39.2	39.2	1.00
Spring	Faba bean + forage pea	19.2	23.4	42.6	1.02
Spring	White lupin + forage pea	17.3	26.9	44.2	1.11
Spring	Semi-leafless dry pea dry pea	30.1	-	30.1	1.00
Spring	Normal-leafed dry pea	-	27.9	27.9	1.00
Spring	Lentil	-	23.3	23.3	1.00
Spring	Semi-leafless dry pea + normal-leafed dry pea	17.4	15.6	33.0	1.14
Spring	Semi-leafless dry pea + lentil	19.5	14.8	34.3	1.28
LSD0.05			4.1		0.10

average two-year green forage yield ranged from 40.0 t ha^{-1} in the intercrop of semi-leafless and normal-leafed peas to 48.5 t ha^{-1} in the intercrop of faba bean and forage pea. In the spring-sown treatments, the highest green forage yield was in the intercrop of white lupin and forage pea (44.2 t ha^{-1}), while the lowest green forage yield was in the intercrop of semi-leafless and normal-leafed peas (33.0 t ha^{-1}).

The intercrops of semi-leafless pea, both fall-sown and spring-sown, had significantly higher two-year average values than all other intercrops, especially 1.35 in the intercrop with bitter vetch and 1.28 in the intercrop with lentil. In comparison to some other cool season annual legumes that also may play the role of supported crop, such as grass pea, spring-sown forage pea had higher forage yields in the intercrops with faba bean and white lupin, as well as much lower values of LER_{GFY} when intercropped with both (7).

Overall, the two-year average forage dry matter yield (Table 2) followed the same trend as the green forage matter yield. Among the sole crop treatments, the average green forage yields in spring-sown faba bean (13.2 t ha^{-1}) were significantly higher compared to the other treatments, especially lentil (5.6 t ha^{-1}). In the fall-sown intercrops, the average two-year green forage yield ranged from 9.8 t ha^{-1} in the intercrop of semi-leafless and normal-leafed peas to 12.5 t ha^{-1} in the intercrop of faba bean and forage pea. Among the spring-sown intercrops, the intercrops of forage pea with faba bean and white lupin produced the highest green forage yield (both 11.0 t ha^{-}), while the intercrop of semi-leafless and normal-leafed peas produced the lowest green forage yield (7.7 t ha^{-1}).

Table 2. Average values of forage dry matter yield (t ha^{-1}) and its Land Equivalent Ratio (LERPDMY) in the intercrop of p with other cool season annual legumes for 2010 and 2011 at Rimski Sancevi.

Season	Treatment	Forage dry matter yield: Supporting crop	Supported crop	Total	LERFDMY
Fall	Faba bean	11.1	-	11.1	1.00
Fall	Forage pea	-	11.3	11.3	1.00
Fall	Faba bean + forage pea	4.6	7.8	12.5	1.11
Fall	Semi-leafless dry pea	8.5	-	8.5	1.00
Fall	Normal-leafed dry pea	-	7.3	7.3	1.00
Fall	Bitter vetch	-	8.9	8.9	1.00
Fall	Semi-leafless dry pea + normal-leafed dry pea	5.4	4.4	9.8	1.24
Fall	Semi-leafless dry pea + bitter vetch	5.9	5.6	11.5	1.32
Spring	Faba bean	13.2	-	13.2	1.00
Spring	White lupin	11.5	-	11.5	1.00
Spring	Forage pea	-	9.4	9.4	1.00
Spring	Faba bean + forage pea	5.4	5.6	11.0	1.00
Spring	White lupin + forage pea	4.5	6.5	11.0	1.08
Spring	Semi-leafless dry pea dry pea	7.2	-	7.2	1.00
Spring	Normal-leafed dry pea	-	6.6	6.6	1.00
Spring	Lentil	-	5.6	5.6	1.00
Spring	Semi-leafless dry pea + normal-leafed dry pea	4.0	3.7	7.7	1.11
Spring	Semi-leafless dry pea + lentil	4.5	3.6	8.0	1.26
LSD0.05			0.8		0.11

The intercrops of semi-leafless pea, both fall-sown and spring-sown, had significantly greater two-year average values compared to the other intercrops, namely 1.32 in the intercrop with bitter vetch and 1.26 in the intercrop with lentil. In comparison to the results of other trials with mutual annual legume intercrops, such as those including warm-season legumes such as soybean *(Glycinemax* (L.) Merr.) and few *Vigna* species, the intercrops of pea with other cool season annual legumes had higher values of ^{LER}FDMY (8).

Conclusions

Depending on individual cases, intercropping various types of pea, such as forage pea and dry pea with afila and normal leaves, with other cool season annual legumes may lead to higher forage yields and an economical justification by high LER values and better utilization of natural resources. In comparison to the traditional intercropping pea and other annual legumes with cereals for forage production, the mutual intercropping of annual forage legumes provides farmers with high quality forage richer in protein. Further research on the same subject will focus on forage quality aspects, such as the crude protein and crude fiber content in forage dry matter and other less examined issues such as forage yield components and crop physiology.

Acknowledgements

This research is a part of the project TR-31016 of the Ministry of Education and Science of the Republic of Serbia.

References

1. Mihailovic, V., Mikic, A., Eric, P., Vasiljevic, S., Cupina, B. and Katic S. 2005. Biotechnology in Animal Husbandry 21:5-6:1: 281-285.
2. Cupina, B., Mikic, A. and Krstic, D. 2009. Grain Legumes 52: 9.
3. Mihailovic, V., Mikic, A., Vasic, M., Cupina, B., Duric, B., Duc, G., Stoddard, F.L. and Hauptvogel, P. 2010. Ratarstvo i povrtarstvo / Field and Vegetable Crops Research 47: 27-32.
4. Mikic, A., Mihailovic, V., Cupina, B., Duric, B., Krstic, D., Vasic, M., Vasiljevic, S., Karagic, D. and Dordevic, V. 2011. Food and Chemical Toxicology 49: 650-654.
5. Mikic, A., Mihailovic, V., Cupina, B., Dordevic, V. and Stoddard, F.L. 2010. Ratarstvo i povrtarstvo / Field and Vegetable crops Research 47: 21-26.
6. Cupina, B., Mikic, A., Stoddard, F.L., Krstic, D., Justes, E., Bedoussac, L., Fustec, J. and Pejic, B. 2011. In: Lichtfouse, E. (ed), Sustainable Agriculture Reviews 7: Genetics, Biofuels and Local Farming Systems. Springer, Dordrecht, 347-365.
7. Cupina, B., Mikic, A., Mihailovic, V., Krstic, D. and Duric, B. 2009. Grain Legumes 54: 32.
8. Mikic, A., Dordevic, V., Peric, V., Cupina, B., Mihailovic, V., Srebric, M. and Krstic, D. 2010. Proceedings, XII International Symposium on Forage Crops of Republic of Serbia, Krusevac, Serbia, 26-28 May 2010, 2, 269-275.