Some agronomic aspects of the intercrops of semi-leafless and normal-leafed dry pea cultivars

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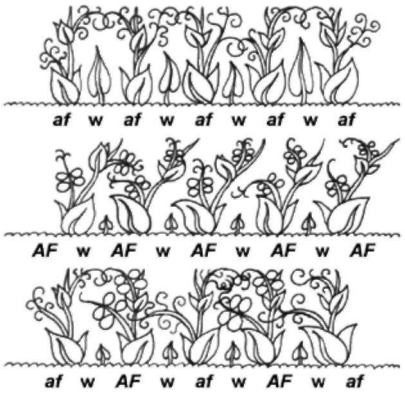
Introduction

Pea *(Pisum sativum* L.) is present in both wild and agricultural floras of Serbia and other Balkan countries. The subspecies *arvense* is traditionally cultivated as a forage crop, while the subspecies *sativum* is a widespread garden plant. During the last two decades of the last century, the first dry pea cultivars, mostly of Canadian and Czechoslovakian origin, were introduced in the then Yugoslav, and now Serbian, agriculture. Today, dry pea, usually known among the Serbian farmers as *protein* pea, is grown mostly for feed, with an average harvested area of between 20,000 ha and 25,000 ha (1). The only institution involved in dry pea breeding in Serbia today is the Institute of Field and Vegetable Crops in Novi Sad (2), with nearly 20 cultivars registered in the country and a moderately large pea collection (3).

Dry pea shows good agronomic performance when used as a companion crop in the establishment of a perennial forage legume such as red clover (4). Especially suitable are 'semi-leafless' cultivars, with all leaflets of the compound pea leaf transformed into tendrils. There are many advantages in comparison with normal-leafed dry pea cultivars. Among these is better penetration of sunlight into a pea stand and all green parts of a plant are included in photosynthesis. Additionally, there is enhanced airflow and which results in less favorable conditions for developing pea diseases and pests (5). Recently, an idea was developed to attempt intercropping semi-leafless *(af)* and normal-leafed (AF) pea cultivars for both forage and dry grain production, with a possible reduction of weeds (W) in the former and lodging in the latter (Figure 1), resulting in better utilization of both stand area and volume.

The initial objective of this research is to assess the agronomic performance of the intercrops of semi-leafless and normal-leafed dry pea cultivars as affected by stand density and their proportion in the mixture.

Figure 1. Theoretical aspects of intercropping semi-leafless and normal-leafedpea cultivars.



Materials and methods

Small-plot trials were carried out during 2010 and 2011 at the Experimental Field of the Institute of Field and Vegetable Crops at Rimski Sancevi, in the vicinity of Novi Sad on a slightly carbonated chernozem soil. The trial included three stand densities, namely 80 plants m^{-2}, 100 plants m^{-2} and 120 plants m^{-2}. Within each stand density, there were five proportions of one semi-leafless *(af)* : one normal-leafed (AF) cultivars: 100% : 0%; 75% : 25%; 50% : 50%; 25 % : 75% and 0% : 100%. The semi-leafless cultivar 'Partner' and the normal-leafed cultivar 'Dukat' were both developed at the Institute of Field and Vegetable Crops and registered in Serbia in 2007. Both cultivars are characterized by a short vine length, on average from 45 cm to 60 cm in both. The two cultivars mature at approximately the same time and have very uniform maturity. The size of a trial plot was 5 m^2, with three replicates. The weeds were controlled by the application of 1 l ha^{-1} an appropriate post-sowing and pre-emergence herbicide, Prometrin®. The plots

were not inoculated with rhizobia, since chernozem is rich in its strain specialized for pea. Inorganic fertilizer containing 45 kg ha^{-1} of phosphorus (P) and potassium (K) each was applied in the preceding fall.

In both trial years, all intercrops were sown in mid-March, as soon as the field conditions allowed, and harvested during the second half of June when the seeds in the first pods had reached full maturity. Since the determinate stem growth in both cultivars and a prominent maturing infirmity, there were no green pods at this stage. Each plot was harvested by hand. Each cultivar was separated from the other and they were combined separately with a Wintersteiger Nurserymaster. The grain yield of all intercrops was measured at a seed moisture content of 14%.

The economic reliability of grain yield in each intercrop was determined by calculating the Land Equivalent Ratio (LER) as (6):

$$LER = afic / afsc + AFIC / AFSC,$$

where af_{ic} is the grain yield of the semi-leafless cultivar in the intercrop, af_{sc} is the grain yield of the semi-leafless cultivar in its sole crop, AF_{ic} is the grain yield of the normal-leafed cultivar in the intercrop and AF_{sc} is the grain yield of the normal-leafed cultivar in its sole crop.

The analysis of variance (ANOVA) of the results was performed using Statistica 8.0 software. Means were separated using Fisher's Least Significant Difference (LSD), $P = 0.05$, for a combined analysis of the two sole crops and the intercrop.

Results and discussion

There were significant differences in grain yields, both between different stand densities and different proportions of individual dry pea cultivars (Table 1). In general, both cultivars reacted positively to

Table 1. A verge values of grain yield (kg ha^{1}) and Land Equivalent Ratio in the intercrops of semi-leafless and

Stand density (plants m^{-2})	Treatment	*GYaf*	GYAF	GYIC	LER
80	100% *af* + 0% *AF*	3438	0	3438	1.00
	75% *af* + 25% *AF*	2700	1050	3750	1.17
	50% *af* + 50% *AF*	2100	1300	3400	1.09
	25% *af* + 75% *AF*	1525	1675	3200	1.06
	0% *af* + 100% *AF*	0	2700	2700	1.00
100	100% *af* + 0% *AF*	4625	0	4625	1.00
	75% *af* + 25% *AF*	3350	1225	4575	1.27
	50% *af* + 50% *AF*	2325	1575	3900	1.20
	25% *af* + 75% *AF*	1425	1788	3213	1.10
	0% *af* + 100% *AF*	0	2250	2250	1.00
120	100% *af* + 0% *AF*	4975	0	4975	1.00
	75% *af* + 25% *AF*	3475	1275	4750	1.14
	50% *af* + 50% *AF*	2525	1513	4038	1.04
	25% *af* + 75% *AF*	1925	2113	4038	1.12
	0% *af* + 100% *AF*	0	2863	2863	1.00
Average	100% *af* + 0% *AF*	4346	0	4346	1.00
	75% *af* + 25% *AF*	3175	1183	4358	1.18
	50% *af* + 50% *AF*	2317	1463	3779	1.09
	25% *af* + 75% *AF*	1625	1858	3483	1.09
	0% *af* + 100% *AF*	0	2604	2604	1.00
LSD0.05			778		0.07

increasing their stand densities in both intercrops and their sole crops, from 80 plant m^{-} to 120 plant m^{-}.

The two-year average grain yield in the sole crops of the semi-leafless cultivar ranged from 3438 kg ha^{-1} at 80 plants m^{-2} to 4975 kg ha^{-} at 120 plants m^{-2}. The two-year average grain yield in the sole crops of the normal-leafed cultivar ranged from 2250 kg ha^{-1} at 80 plants m^{-2} to 2863 kg ha^{-1} at 120 plants m^{-2}. In a two-year average, the semi-leafless cultivar had significantly higher yield than the normal-leafed cultivar. This agrees with previous research in the same conditions (7) and may be basically explained as the consequence of a better balance between grain yield components in comparison to those in the normal-leafed cultivar.

In all intercrops, the semi-leafless cultivar had significantly higher proportion in the total dry grain yield than the normal-leafed one. The averages ranged from 3175 kg ha^{-1} to 1183 kg ha^{-1} at 75% : 25% and from 2317 kg ha^{-1} to 1463 kg ha^{-1} at 50% : 50%. The normal-leafed cultivar had a higher proportion in the total dry grain yield when planted as 75% of the intercrop (1858 kg ha^{-1}), but not significant in comparison to the remaining 25% of the semi-leafless cultivar (1625 kg ha^{-1}).

The LER values were higher than 1 in all intercrops, regardless of the stand density and the proportion of individual components with different leaf types. However, the highest LER values, as affected by crop density, were in the intercrops of 75% of the semi-leafless and 25% of the normal-leafed cultivars, with 1.17, 1.27 and 1.14, respectively (Figure 2). This proportion proved economically most reliable in average as well, with its LER value of 1.18 significantly higher than 1.09 in both other proportions. It is noteworthy that the intercrops of semi-leafless and normal-leafed pea cultivars are reliable in forage production, as documented by another pioneer study in the same conditions (8).

Figure 2. An intercrop of the serai-leafless and normal-leafed dryp

These results pose opportunities for further research. These two cultivars were intentionally chosen for intercropping due to similar growing habit and developmental stages. However, future research could provide a more stringent evaluation of intercropping by developing F5- or F6-derived near isogenic semi-leafless and normal-leafed varieties (9).

Conclusions

This initial study needs to be repeated over years and in diverse environments. However, this study documents the intercropping of semi-leafless and normal-leafed dry pea cultivars as an alternative solution for enhanced grain production in temperate regions such as serbia. Future research will target more detailed analysis of grain yield components in the intercrops and diverse physiological parameters, as well as numerous underground aspects such as plant-microbial interactions and nutrient dynamics.

Acknowledgements

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