THE INFLUENCE OF WINTER WHEAT AND WINTER PEA INTERCROP ON GRAIN YIELD AND PROFITABILITY

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Abstract. *In Hungary sowing structure was simplified in the last 2 decades, which causes problems from an agronomic aspect in crop rotation, plant protection and tillage. Futhermore from economic aspect this increasing process makes vulnerable our plant production. It was required the sowing structure diversification in a gradual form. A possible way to increase the sown area of protein plants is plant association. Our investigations were made in Szeged-Öthalom, in 2018-2019 year, where the experimental plots were 10m^2, in 4 repeats, with 2 winter wheat varieties (GK Szilárd, Cellule) and 2 field pea varieties (Aviron, Enduro). We use 2-2 different seed density (winter wheat 3 and 5 million seed ha^{-1}, winter pea 0,6 and 1 million seed ha^{-1}) in every varieties in every combination. As a result of the comparison of winter wheat and field pea sowing together or alone, both of these 2 varieties grain yield were significantly less in plant association. This yield depression was observed when we were used 100-100% winter wheat and pea seed density together. However there were combinations, which gave higher yield, and income than pure stands. We have noticed that for either wheat or pea, grain yield is determined not only the seed density, but also the choice of the varieties and their combinability.*

Keywords*: winter wheat, field pea, intercrop, yield, profitability*

INTRODUCTION

In Hungary 85% of the total arable land were sown only five crops: maize, wheat, sunflower, barley, oil seed rape (PEPÓ and SÁRVÁRI 2011). Single-crop production is beneficial for exploitation of machinery or partially the aspect of agronomy, but in long term it causes problems in crop rotation, plant protection and tillage (ANTAL, 2005a). The cultivation of only a few crops makes our country vulnerable to market demands, just like in other developing countries (PEPÓ and SÁRVÁRI, 2011).

It was necessary to modify gradually our sowing structure, primarily increase the sown area of oilseeds, legumes and fodder crops. In order to reduce quantity of protein import, it has become an important task to increase the sowing area and yield of legumes. Soybean has the largest proportion of protein crops both in the world and in Hungary, but filed pea is also attracting for farmers. Field pea is the second largest crop of legumes in the world (ANTAL, 2005b), the average yield is 1.5-2.3t ha^{-1} in Hungary, the crop area is changing from 20,000 to 35,000 hectares. Due to its high protein content, field pea is one of the main components of feed mixtures, feed ingredients and is also a valuable plant for green fodder. Because of the excellent preceding crop effect of pea has an important role in sowing structure of Hungary. It has a gentle effect on soil water balance, stimulates the microbiological life of the soil (GOLLNER ET AL., 2019), reduces the fungal disease of cereals and the potential of soil pollution (RADICS 2002).

Plant association is a special method of crop production when two or more plants are sown, grown and harvested together to utilize their advantageous properties. In plant association, cereals have a supporting role, and legumes are a symbiotic nitrogen fixing ability supplying N for cereals.

Until the beginning of the 20th century, intercrop of cereals and peas was widespread method in Hungary (CSERHÁTI 1901), but the increase of machinery park, chemical plant protection and breeding of tendril pea varieties resulted the increase of pure sowings in crop production (BOCZ, 1996). Today farmers have almost forgot intercrop of cereals and peas in Hungary. In international literature, numerous publications have been published about intercropping. MURRAY and SWENSEN (1985) used different proportions of mixtures in their experiments. He found that winter peas has 27% more yield using the ratio of 3:1 peas: grain, but the cereal yield decreases 60% in the rate of 3:1 grains : peas. He observed that these two crops compatible in terms of sowing and harvesting, and sieving was solvable too. FUJITA ET AL. (1992) also emphasized that cereals and legumes in intercrop has higher values by dry matter content and yield than in monocrop. In contrast, KRISTÓ ET AL. (2007a, 2007b, 2011a, 2011b) observed in the case of high sowing density of winter wheat, that overdensity makes yield depression, which can be appear in intercrop production. LITHOURGIDIS ET AL. (2011) compared to wheat, rye, and triticale in intercrop with pea and in monocrop. Although he was examined less growth vigor in mixtures, the dry matter content and the protein content increased significantly. HAUGGAARD-NIELSEN ET AL. (2006) noticed protein content, GOODING ET AL. (2007) defined to increase nitrogen and sulphur in winter wheat in intercrop. According to FUJITA ET AL. (1990, 1992), HARDASON and ATKINS (2003), GHALEY ET AL. (2005), TOSTI and GUIDUCCI (2010) intercrop is advantageous for improve nitrogen fixation and pest control. URBATZKA ET. AL. (2011) determined that cereals and legumes in mixed cropping system reduce weed suppression and give high yield stability, moreover WILLEY (1990), MORRIS and GARRITY (1993), LI ET AL. (2003) added resources such as nutrients and light are usually utilised better in mixed stands.

We suppose that cereals and legumes in intercrop not just increase the sowing area of legumes, but also increase the number of cultivated crops, allows lower inputs through reduce fertilizer and maintain inner content values and quantitative parameters of the cereals in high level. This theme generates qustions of nutrient supply, crop rotation, species and variety use, germ count, sowing time and weed control.

The aim of our experiment is to get answers to the following questions based on our experience as a small plot in Hungary:

- Is it possible to grow winter wheat and peas together?
- What kind of yield of winter wheat and peas we get in pure and intercrop?
- Is it worth economically for farmers to change crop pruduction from monocrop to intercrop?

MATERIAL AND METHODS

Our investigations were made in Hungary, on the research station of Szeged-Öthalom. The experimental plots were 10m^2, in 4 repeats, with 2 winter wheat varieties (GK Szilárd, Cellule) and 2 pea varieties (Aviron, Enduro).

All winter wheat and pea varieties are sown with 2 seed density (*Table 1.*). In the case of winter wheat, the sowing density of 5 million seed ha^{-1} was considered to be 100%, and in the case of winter peas, 1 million seed ha^{-1}. In our experiment, the 60% seed quantity of winter wheat was 3 million seed ha^{-1} and it was 600 thousand seeds on the winter peas. In order to find out the optimal sowing rate of the wheat-pea plant association, we set all variations of the 100% and 60 % sowing standards in our study.

Table 1

Number of seed used in plant associations and their relative ratio

		seed density of winter pea		
		0 million seed ha^{-1}	0,6 million seed ha^{-1}	1 million seed ha^{-1}
seed density of winter wheat	0 million seed ha^{-1}	-	0:60	0:100
	3 million seed ha^{-1}	60:0	60:60	60:100
	5 million seed ha^{-1}	100:0	100:60	100:100

Yields were analyzed and evaluated by one-way analysis of variance. In the case of yields, crop prices, support and production costs, we have calculated profitability per hectare for economic comparability of intercrop technologies.

RESULTS AND DISCUSSIONS

The yield of winter wheat with different seed density in the treatments of pure and mixed, can be studied in *Table 2*. For seeding density of 3 million seed ha^{-1}, GK Szilárd achieved a yield of 6.07t ha^{-1}. Compared to the pure sowing of GK Szilárd at 3 million seed ha^{-1}, significantly harvested less winter wheat from all mixed crop treatments. The 600 thousand seed ha^{-1} sowing density of Aviron and Enduro pea varieties reduced the yield of GK Szilárd by 3 million seed ha^{-1} by what was almost 18%. We achieved the lowest yield of the mixture of GK Szilárd 3 million seed ha^{-1} and Aviron 1 million seed ha^{-1}. In this case, we observed 22% less yield compared to pure sowing.

In the case of pure sowing of Cellule with 3 million seed ha^{-1}, harvested 6.87 t ha^{-1} of wheat. However, if we sow this wheat together with 600 thousand seed ha^{-1} of Enduro peas, our wheat yield will be less at 1.15 t ha^{-1}. If we combine the same with Aviron peas at a seed rate of 600 thousand seed ha^{-1}, our result will be 1.5 t ha^{-1} less than in pure sowing. If Enduro is sown at 1 million seed ha^{-1} with Cellule, the yield is 26% lower than pure sowing. When we associated Aviron with Cellule at 1 million seed ha^{-1}, then we achieved the lowest quantity of yield compared to pure sowing, as we can talk only 69% of yield compared to the pure sowing. A significant difference can be defined for all four mixed sowings compared to pure sowing. There is no significant difference between Cellule 3 million seed ha^{-1} + Aviron 600 thousand seed ha^{-1} and Cellule 3 million seed ha^{-1} + Enduro 1 million seed ha^{-1} and Cellule 3 million seed ha^{-1} + Aviron 1 million seed ha^{-1}, however There was a statistical difference between Cellule 3 million seed ha^{-1} + Enduro 600 thousand seed ha^{-1} and Cellule 3 million seed ha^{-1} + Aviron 1 million seed ha^{-1}.

At the time of harvesting the 5 millions seed ha^{-1} pure stands of GK Szilard, we achieved a yield of 6,38t ha^{-1}. In contrast, wheat yields were only 87% when we associated with Enduro of 600 thausand seed ha^{-1}, which is 0.85t/ha less than in pure sowing. When we associated GK Szilárd with 5 million seed ha^{-1} with 600 thausand seed ha^{-1} Aviron, we harvested 1.09t ha^{-1}, when we sow it with 1 million seed ha^{-1} Enduro, we harvested 1.07t ha^{-1} less crops than in pure sowing. If 1 million seed ha^{-1} were applied on Aviron with GK Szilárd with a seed quantity of 5 million seed ha^{-1}, we harvested 1.22 t ha^{-1} less crops than the pure yield, which is a 19% wheat loss. The winter wheat yields of all 4 crop mixtures from pure sowing are significantly lower, but we can also see that the wheat yields of the crop associations do not show a significant difference *(Table 2)*.

When Cellule is sowing purely in 5 million seed ha^{-1}, the yield has reached 7.19t/ha *(Table 2)*. However, when the same sowing density was associated with peas, none of the results from the plant mixtures achieved this wheat yield, which was proved statistically. When we put 600 thousand seed ha^{-1} of Enduro in the seed mixture, our wheat yield was 6.09 t ha^{-1}, which is 1.1 t ha^{-1} less than the pure stands. If the 5 million seed ha^{-1} Cellule was associated

with the Aviron pea variety in 600 thousand seed ha^{-1}, we harvested 17% less produce than pure wheat. When Enduro was added to Cellule in the quantity of 1 million seed ha^{-1}, the yield was 5.95 t ha^{-1}, which was 1.6 t ha^{-1} (22 %) less than the pure sowing. On the other hand, when Aviron was added to the plant association in quantities of 1 million seed ha^{-1}, we had a yield of 1.5 t ha^{-1} less than wheat yields from pure sowing. Compared to pure sowing, the associated treatment of Cellule 5 million seed ha^{-1} sowing yielded significantly less winter wheat yields, but the wheat yields of each crop association did not differ statistically.

Table 2

Yields of winter wheat (t ha^{-1}) according to the varieties and seed numbers

			seed density of winter pea				
			0 million seed ha^{-1}	0,6 million seed ha^{-1}		1 million seed ha^{-1}	
				Enduro	Aviron	Enduro	Aviron
seed density of winter wheat	3 millin seed ha^{-1}	GK Szilárd	6.07^{a}	4.98^{b}	4.98^{b}	4.85^{b}	4.75^{b}
		Cellule	6.87^{a}	5.72^{b}	5.37^{bc}	5.11^{bc}	4.80^{c}
	5 million seed ha^{-1}	GK Szilárd	6.38^{a}	5.53^{b}	5.29^{b}	5.31^{b}	5.16^{b}
		Cellule	7.19^{a}	6.09^{b}	5.98^{b}	5.59^{b}	5.69^{b}

(Within each line, the values marked with different letters differ significantly at the p< 0.05.)

During the pure sowing of 600 thousand seed ha^{-1} of the Enduro pea variety, a yield of 1.36 t ha^{-1} was harvested (*Table 3*). However, if we associated the GK Szilárd wheat cultivar with a seed yield of 3 million seed ha^{-1}, the yield of peas was 0.99t ha^{-1}, which is 0.37t ha^{-1} less, so a loss of 27% was recorded. When the Cellule wheat variety was added to the seed mixture in the amount of 3 million seed ha^{-1}, we measured 1.07 t ha^{-1} yield of pea, which is 0.29 t ha^{-1} less compared to pure sowing, so we can talk about 21% yield reduction. In the case of intercrop with GK Szilárd of 5 million seed ha^{-1}, the yield of peas was only 0.62 t ha^{-1}, which means 0.74 t ha^{-1} less than pure sowing. However, when Cellule was applied at 5 million seed ha^{-1}, we already harvested 0.56 t ha^{-1} less than in pure sowing, which means 41% yield loss. A significant difference in the yield of peas can be observed during the intercrop with 600 thousand seed ha^{-1} of pure Enduro and 5 million seed ha^{-1} with GK Szilárd.

When Aviron was sown at 600 thousand seed ha^{-1}, the yield reached 1.99 t ha^{-1} (*Table 3*). However, when we sow 3 million seed ha^{-1} in association with the GK Szilárd wheat variety, only 1.03 t ha^{-1} of peas were harvested, it was 48% crop loss. If the Cellule variety was added to the seed mixture at 3 million seed ha^{-1}, the pea yield was 0.84 t ha^{-1} lower, which is a 43% yield loss. When GK Szilárd with 5 million seed ha^{-1} and Aviron with 600 thousand seed ha^{-1} were combined, the pea yield was 1.22 t ha^{-1} less than in pure sowing (61% yield loss). When sowing Aviron 600 thousand seed ha^{-1} + Cellule 5 million seed ha^{-1}, we observed a yield of 1.55 t ha^{-1}. We determined significant difference between pea yield of pure sowing and all mixed parcels, but there were no statistical difference in the results of the four plant associations.

The yield of the Enduro variety was 1.52 t ha^{-1} when pure sowing was 1 million seed ha^{-1}. If Enduro was sown with the GK Szilárd variety with a seed density of 3 million seed ha^{-1}, the yield was 1.24 t ha^{-1}, which means a yield level of 82% and 0.28 t ha^{-1} less peas. When this amount was increased to 5 million seed ha^{-1}, 0.91 t ha^{-1} of peas was harvested, which represents a yield of 60%, i.e. a loss of 0.61 t ha^{-1}. On the other hand, when Enduro was associated with 3 million seed ha^{-1}with the Cellule variety, our yield was 1.54 t ha^{-1}, which is 0.02 t ha^{-1} or 1.3% more than pure sowing. When the amount of Cellule seed in the mixture was increased to 5 million seed ha^{-1}, the yield was reduced to 1.16 t ha^{-1}, giving a loss of 23% compared to the pea

yield of pure sowing. There was no significant difference between the results in either case. At a seed density of 1 million seed ha^{-1} in Aviron, the yield was 2.29 t ha^{-1} of pea. When the GK Szilárd variety with a seed rate of 3 million seed ha^{-1} was grown in the seed mixtue, the yield of peas was 0.9 t ha^{-1} lower and the yield loss was 39% compared to pure sowing. In the case of Cellule, when 3 million seed ha^{-1} were applied together with the 1 million seed ha^{-1} variety Aviron, the pea yield less was 0.37 t ha^{-1}. When the GK Szilárd seed density was increased to 5 million seed ha^{-1} in the seed mixture, our pea yield was 0.95t / ha, which resulted in 1.34 t ha^{-1}, (69%) less yield than pure sowing. When Cellule seed density was applied at 5 million seed ha^{-1}, our yield was 1.3 t ha^{-1}, which is 0.99 t ha^{-1} less than pure sowing. Compared to the pure sowing of Aviron at 1 million seed ha^{-1}, a significant yield loss was observed of the seed mixtures when GK Szilárd was applied with a sowing rate of 3 and 5 million and Cellule with a sowing rate of 5 million seed ha^{-1}.

Table 3

Yields of winter pea (t ha^{-1}) according to the varieties and seed numbers

			seed density of winter pea			
			0,6 million seed ha^{-1}		1 million seed ha^{-1}	
			Enduro	Aviron	Enduro	Aviron
seed density of winter wheat	0 million seed ha^{-1}		1.36^{a}	1.99^{a}	1.52^{a}	2.29^{a}
	3 million seed ha^{-1}	GK Szilárd	0.99^{ab}	1.03^{b}	1.24^{a}	1.39^{bcd}
		Cellule	1.07^{ab}	1.15^{b}	1.54^{a}	1.92^{ab}
	1 million seed ha^{-1}	GK Szilárd	0.62^{b}	0.77^{b}	0.91^{a}	0.95^{d}
		Cellule	0.80^{ab}	0.4^{b}	1.16^{a}	1.30^{cd}

(Within each column, the values marked with different letters differ significantly at the $p< 0.05$)

Figure 1 shows the average yield of pure-sown wheat and pea varieties with different seed count, as well as the yield per hectare in plant association. The yield of 3 million seed ha^{-1} of pure wheat was 6.47 t ha^{-1}, while at 5 million seed ha^{-1}, harvested 6.78 t ha^{-1}. The average yield of 600 thousand seed ha^{-1}of peas was 1.67 t ha^{-1}, while the yield of 1 million seed ha^{-1} was 1.90 t ha^{-1}. Increase of the seed count of winter wheat and winter peas, yields increased too. In the case of plant association, we have the most prominent yield when we sow wheat 5 million seed ha^{-1} + peas 1 million seed ha^{-1}. Yield of wheat was 5.43 t ha^{-1} and yield of pea was 1.07 t ha^{-1}. Then 5 million seed ha^{-1} of wheat + 600 thousand seed ha^{-1} of pea gave 5.71 t ha^{-1} for wheat and 0.75 t ha^{-1}for peas. Then wheat 3 million seed ha^{-1} + peas 1 million seed ha^{-1}, where wheat yield was 4.8 t ha^{-1} and pea 1.51 t ha^{-1}. In the case of the association of wheat 3 million seed ha^{-1} + peas 600 thousand seed ha^{-1}, the yield of wheat was 5.26 t ha^{-1} and the yield of pea was 1.05 t ha^{-1}. If we see figure1, the higher seed count of pea results higher yield when wheat is associated with 3 million seed ha^{-1} and 5 million seed ha^{-1}. The same can be observed for wheat: in the case of 5 million seed ha^{-1} application we measured a higher yield, so it gave a higher yield than the 3 million seed ha^{-1} seed dose.

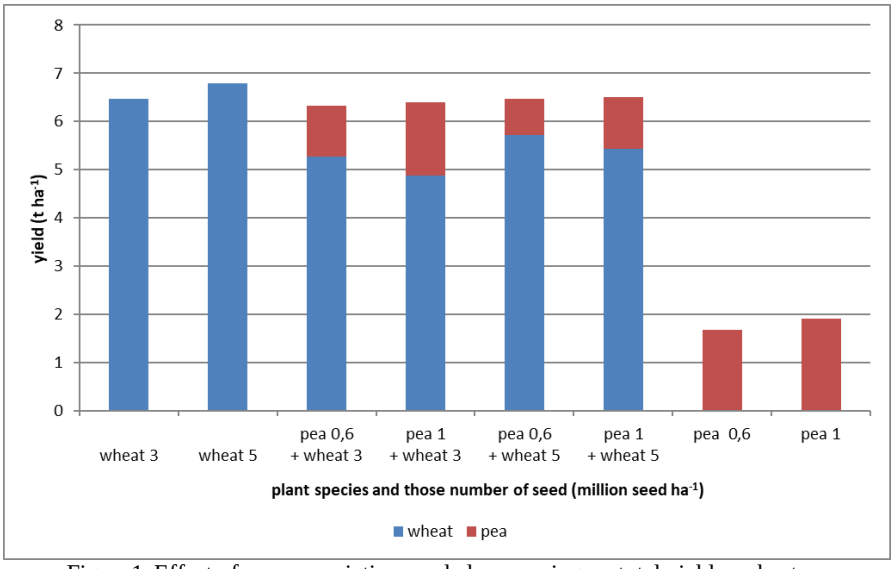

Figure 1. Effect of crop associations and clean sowing on total yield per hectare

Table 4

Profitability of plant associations (euro ha^{-1}) by varieties and seed counts included in the study

			seed density of winter pea				
			0 million seed ha^{-1}	0 million seed ha^{-1}		0 million seed ha^{-1}	
				Enduro	Aviron	Enduro	Aviron
seed density of winter wheat	0 million seed ha^{-1}		-	93,58	251,12	83,24	284,64
	3 million seed ha^{-1}	GK Szilárd	457,26	515,08	531,01	517,88	551,12
		Cellule	544,97	616,20	601,96	619,55	688,83
	1 million seed ha^{-1}	GK Szilárd	467,32	458,94	475,14	462,29	461,73
		Cellule	555,87	563,97	567,88	553,07	607,26

We considered the costs (tillage, nutrient supply, sowing, seed, plant protection, harvest) as well as incomes (crop price, supports), the profitability of crop associations was also calculated (*Table 4*). The results of pure sowing show that the farmer's income is largely determined by the cultivated crop, the choice of variety and sowing density. When we examined the results of crop associations, we can see that in some cases crop associations offer a higher income to the farmers than pure wheat sowing. At the same time, GK Szilárd's 5 million seed ha^{-1} seed dose combined with Enduro's 600,000 or 1 million germ count and Aviron's 1 million seed ha^{-1} count and the 5 million Cellule + 1 million Enduro seed ha^{-1} combination resulted in lower income than pure wheat.

CONCLUSIONS

The Hungarian sowing structure cereals plays a dominant role. For farmers, the world market price of export-oriented cereals determines the profitability of farming, which causes a high degree of economic exposure not only for farmers but also for the country. At the same time the lack of protein source and uneconomical production are limited the expansion of our animal population. It would be important from an economic and agronomic point of view to change the sowing structure, increase the sown area of protein crops and produce them economically. The recent years have shown that soybeans, as the main protein crop, cannot be

produced always and everywhere, even with the support of the government. Therefore, it would be worth to research with protein crops that are still grown on a small area, to develop "new" technologies with them. One of the protein crop is field pea, which is perfect to associate with winter wheat in terms of sowing, harvesting time and mechanization demand, and currently grown in the largest area (KNOTT and BELCHER, 1998).

Based on the results of our experiments about associated cultivation of winter wheat and field peas, and in agreement with MURRAY and SWENSEN (1985), it can be determine that the two crops are compatible in terms of sowing and harvesting, and with an appropriate technology can be increase the sowing area of field pea. We could see that compared to the pure sowing of wheat and pea with the yield of both varieties in the plant association were lower in single form, what we could prove statistically. we can say crop depression when the overcompensated 100-100% seed quantities were used together. KRISTÓ ET AL emphasized that crop depression caused by high plant density in the case of winter wheat (2007a, 2007b, 2011a, 2011b). We have also observed for both of wheat or peas, yield is determined not only by sowing density but also the choice of variety and their combinability with each other. Our results are promising way to cultivate winter wheat and filed pea in intercrop in terms of their total yield per hectare and profitability. Therefore, we would like to continue our research and develop the technology that can be used in practice.

BIBLIOGRAPHY

ANTAL, J., (2005a): Növénytermesztéstan 1. Mezőgazda Kiadó, Budapest.

ANTAL, J., (2005b): Növénytermesztéstan 2. Mezőgazda Kiadó, Budapest.

BOCZ, E., (1996): Szántóföldi növénytermesztés. Mezőgazda Kiadó, Budapest.

CSERHÁTI, S., (1901): Általános és különleges növénytermesztés. Czéh Sándor-féle Könyvnyomda, Magyar-óvár

FUJITA, K, OGATA, S, MATSUMOTO, K, MASUDA, T, GODFRED, K, OFOSU-BUDU, KG, KUWATA, K (1990): Nitrogen transfer and dry matter production in soybean and sorghum mixed cropping system at different population densities. Soil Sci. Plant Nutrition 36: 233-241.

FUJITA, K., OFOSU-BUDU, K. G., OGATA, S. (1992): Biological nitrogen fixation in mixed legume-cereal cropping systems, Plant and Soil, 141: 155-175.

GHALEY, B. B., HAUGGAARD-NIELSEN, H., HØGH-JENSEN, H., JENSEN, E. S. (2005): Intercropping of wheat and pea as influenced by nitrogen fertilization, Nutrient Cycling in Agroecosystems (2005) 73:201–212.

GOLLNER, G., STARZ, W., FRIEDEL, J. K. (2019): Crop performance, biological N fixation and pre-crop effectof pea ideotypes in an organic farming system. Nutr Cycl Agroecosyst, 115:391–405.

GOODING, M. J., KASYANOVA, E., RUSKE, R., HAUGGAARD-NIELSEN, H., JENSEN, E. S., DAHLMANN, C., FRAGSTEIN, P., DIBET, A.,CORRE-HELLOU, G., CROZAT, Y, PRISTERI, A. ,ROMEO, M., MONTI, M., LAUNAY, M. (2007): Intercropping with pulses to concentrate nitrogenand sulphur in wheat, Journal of Agricultural Science(2007),145, 469–479

HAUGGAARD-NIELSEN, H., TRYDEMAN KNUDSEN, M., RAVN JORGENSEN, J., STEEN JENSEN, E. (2006): Intercropping wheat with pea for improved wheat baking quality. Poster at: Joint Organic Congress, Odense, Denmark, May 30-31, 2006.

KNOTT, C. M., BELCHER, S. J. (1998): Optimum sowing dates and plant populations forwinter peas (Pisum sativum), Journal of Agricultural Science,Cambridge, 131, 449-454.

KRISTÓ, I., GYURIS, K.; TORMA, M., HÓDI SZÉL, M., PETRÓCZI, I. M. (2007b): Investigation of sowing date and seeding rate on the yield of winter wheat, Cereal Research Communications 35 : 2 pp. 685-688.

KRISTÓ, I., HÓDI SZÉL, M., GYAPJAS, J., SZEKERES, A. (2007a): Effect of sowing date and seeding rate on different winter wheat cultivars, Research Journal of Agricultural Science 39 : 1 pp. 61-64.

KRISTÓ, I., JOLÁNKAI, M., PETRÓCZI, I. M. (2011a): Csíraszám és vetésidő hatása néhány őszi búzafajta terméselemeinek relatív fejlődésére. Növénytermelés 60 : 3 pp. 91-110.

KRISTÓ, I., JOLÁNKAI, M., PETRÓCZI, I. M. (2011b): Csíraszám és vetésidő hatása az őszi búza terméselemeire. Növénytermelés 60 : 3 pp. 67-89

LI, L., ZHANG, F. S, LI, X. L., CHRISTIE, P., SUN, J. H., YANG, S. C., TANG, C. (2003). Interspecific facilitation of nutrient uptake by intercropped maize and faba bean. Nutrient Cycling in Agroecosystems 68: 61-71.

LITHOURGIDIS, A. S., VLACHOSTERGIOS, D. N., DORDAS, C. A., DAMALAS, C. A., (2011): Dry matter yield, nitrogen content, and competition in pea-cereal intercropping systems, European Journal of Agronomy, 34 (4): 287-294.

MORRIS, RA, GARRITY, DP. (1993). Resource capture and utilization in intercropping: non-nitrogen nutrients. Field Crops Res. 34: 319-334.

MURRAY, G. A., SWENSEN, J. B. (1985): Seed yield of austrian winter field peas intercropped with winter cereals, Agronomy Journal, 77 (6): 913-916.

PEPÓ, P., SÁRVÁRI, M. (2011): Gabonanövények termesztése. TÁMOP-4.1.2-08/1/A-2009-0010. Debreceni Egyetem. 143.

RADICS, L. (2002): Alternatív növények termesztése II., Szaktudás Kiadó Ház, Budapest.

TOSTI, G., GUIDUCCI, M. (2010): Durum wheat-faba bean temporary intercropping: Effects on nitrogen supply and wheat quality, European Journal of Agronomy, 33 (3): 157-165.

URBATZKA, P., GRAß, R., HAASE, T., SCHÜLER, C.,TRAUTZ, D., HEß, J. (2011): Grain yield and quality characteristics of differentgenotypes of winter pea in comparison to spring peafor organic farming in pure and mixed stands, Org. Agr. (2011) 1:187–202.

WILLEY, RW. (1990): Resource uses in intercropping systems. Agric. Water Management 17: 215-231.