PRODUCTION CAPABILITIES OF CATCH CROPS AND THEIR IMPACT ON THE GRAIN YIELD OF SPRING BARLEY

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Abstract: Catch crops are grown between two main crops, their significance is multifaceted. Catch crops may affect the subsequent crop. The aim of this study was to evaluate the production capabilities of catch crops in the years 2011–2014 and their impact on the grain yield of spring barley in the years 2012–2015. The field experiment was set up in an experimental field station in Žabčice, South Moravia, Czech Republic. The experiment included ten kinds of catch crops: *Sinapis alba, Raphanus sativus v. oleifera, Phacelia tanacetifolia, Fagopyrum esculentum, Secale cereale v. multicaule, Panicum miliaceum, Crambe abyssinica, Malva verticillata, Phalaris canariensis, Carthamus tinctorius*. The experiment also included a control variant - without catch crops. Catch crop growths were set up after winter wheat. Catch crops were left on the lot until spring. The subsequent crop after catch crop was spring barley. Weather conditions affected the production capabilities of catch crops. From the point of view of securing the purpose of growing catch crops, it is necessary to include *Sinapis alba*, *Raphanus sativus v. oleifera*, *Crambe abyssinica* and *Phacelia tanacetifolia*, which reached regularly the highest yields. When there is enough water in the winter and spring, catch crops have no negative impact on yields of spring barley.

Key Words: dry matter of catch crops, weather conditions, competition for water

INTRODUCTION

The high proportion of cereals in the structure of crops leads to soil degradation. Catch crops might be the solution. Catch crops are crops grown between two main crops. In addition to the beneficial effect on the environment as far as the nutrients and soil and water conservation are concerned, catch crops can also serve as a protection against weeds, diseases, and pests (Leskovšek et al. 2013, Campliglia et al. 2015, Larkin et al. 2011). The yield of catch crops biomass depends on weather conditions during the autumn (Satkus, Velykis 2014). Many authors study the influence of catch crops on subsequent crops. Chen et al. (1993) reported that catch crops have improved growth and development as well as increased the yield of subsequent crops such as corn, wheat, and rice. *Sinapis alba* did not have a negative impact on productivity of corn (Romaneckas et al. 2012). *Sinapis alba*, *Phacelia tanacetifolia* did not change dramatically the yield of spring barley (Gaweda 2011). However, some authors point out negative effects of catch crops on the yield of subsequent crops (Balnytè et al. 2009). *Sinapis alba* were the least beneficial to the productivity of spring barley in a drier beginning of the year (Gaweda 2011). Saptoka et al. (2012) reported that catch crops decreased the yield of spring barley, probably due to competition between the catch crop and cereal for nitrogen, water, and light. The aim of this study was to evaluate the production capabilities of catch crops and their impact on the yield of spring barley.

MATERIAL AND METHODS

The small-plot field experiment was set up in an experimental field station in Žabčice (South Moravia, Czech Republic; 49° 1' 19" N, 16° 36' 52" E). The experiment included ten kinds of catch crops. The experiment also included a control variant - without catch crops. Catch crop growths were set up after winter wheat. Pre-sowing preparation of soil and sowing catch crops with residue-free seeder

(OYORD) was carried out after the harvest of winter wheat. Kind of catch crops and seed amounts were as follows: *Sinapis alba* (25 kg · ha^{-1}), *Raphanus sativus v. oleifera* (25 kg · ha^{-1}), *Phacelia tanacetifolia* (15 kg · ha^{-1}), *Fagopyrum esculentum* (70 kg · ha^{-1}), *Secale cereale v. multicaule* (150 kg · ha^{-1}), *Panicum miliaceum* (20 kg · ha^{-1}), *Crambe abyssinica* (25 kg · ha^{-1}), *Malva verticillata* (15 kg · ha^{-1}), *Phalaris canariensis* (25 kg · ha^{-1}), *Carthamus tinctorius* (30 kg · ha^{-1}). To determine the amount of biomass, traditional sampling of fresh vegetable matter of catch crops was used in October surface and then it was dried to a constant value. Catch crops were left on the lot until spring. Sowing of spring barley was carried out by sowing combination (in a single operation is pre-sowing preparation of soil and sowing). Nitrogen fertilization at 60 kg · ha^{-1} N was carried out in the spring. The subsequent crop after catch crop was spring barley. Spring barley harvest was carried out in full maturity and the yield was recalculated at 14% moisture. The experiment took place on clay-loam gleyic fluvisols, with 2.97 per cent humus content and pH/KCl 6.8. Average annual rainfall is 480 mm and the average annual temperature is 9.2°C. Table 1 shows rainfall and average temperature in individual years. During the 2011 growing season of catch crops, there was lower rainfall than the long-time average. During the beginning of the growing season of spring barley, higher than the long-time average rainfall occurred only in 2013. The lack of water was during the spring in 2012. The results were statistically processed using the Statsoft Statistica 12 software package.

Table 1 Rainfall and temperature from Žabčice in the years 2011–2015

Year	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Rainfall (mm)											
2011	21.4	4.6	39.3	33.2	46.2	42.9	79.8	42.4	31.1	22.6	1.6	14.6
2012	27.2	7.4	2.4	19.8	21.4	101.2	64.6	43.0	40.2	49.2	19.4	35.6
2013	20.2	42.1	40.8	20.2	109.0	147.4	4.7	43.6	63.2	35.2	20.4	6.2
2014	22.0	12.6	5.6	11.2	62.8	43.4	85.0	113.6	116.2	46.4	29.2	28.7
2015	20.0	7.4	28.0	9.4	33.8	22.4	-	-	-	-	-	-
norm. 61–90	24.8	24.9	23.9	33.2	62.8	68.6	57.1	54.3	35.5	31.8	36.8	26.3
	Temperature (°C)											
2011	-0.4	-0.9	5.4	12.4	15.3	19.4	19.2	20.5	17.1	9.3	2.5	2.2
2012	1.0	-3.4	7.0	10.8	16.9	19.8	21.4	21.1	16.2	9.4	6.5	-1.2
2013	-1.0	0.7	1.8	10.6	14.7	18.3	21.9	20.3	13.9	10.1	5.3	2.1
2014	1.1	2.7	8.5	11.8	14.5	18.8	21.5	17.9	15.6	11.5	7.5	2.4
2015	1.8	1.6	5.5	10.1	14.7	19.1	-	-	-	-	-	-
norm. 61–90	-2.0	0.2	4.3	9.6	14.6	17.7	19.3	18.6	14.7	9.5	4.1	0.0

RESULTS AND DISCUSSION

Table 2 shows the results of production capabilities of catch crops. The lowest average dry matter yields of catch crops were reported in 2011. In all the monitored years, the catch crops that regularly produced the highest yields included *Sinapis alba* (1.13 to 3.16 t · ha^{-1}), *Phacelia tanacetifolia* (1.22 to 2.80 t · ha^{-1}), *Crambe abyssinica* (1.19 to 2.90 t · ha^{-1}), and *Raphanus sativus v. oleifera* (1.33 to 2.25 t · ha^{-1}). Variable and above all lower dry matter yields were achieved with *Fagopyrum esculentum* (0.64 to 3.65 t · ha^{-1}), *Secale cereale v. multicaule* (0.54 to 1.92 t · ha^{-1}), *Panicum miliaceum* (0.22 to 1.98 t · ha^{-1}), *Malva verticillata* (0.81 to 2.25 t · ha^{-1}), *Phalaris canariensis* (0.14 to 1.16 t · ha^{-1}), and *Carthamus tinctorius* (0.63 to 3.70 t · ha^{-1}).

Table 2 Dry matter yields of catch crops in the years 2011–2014

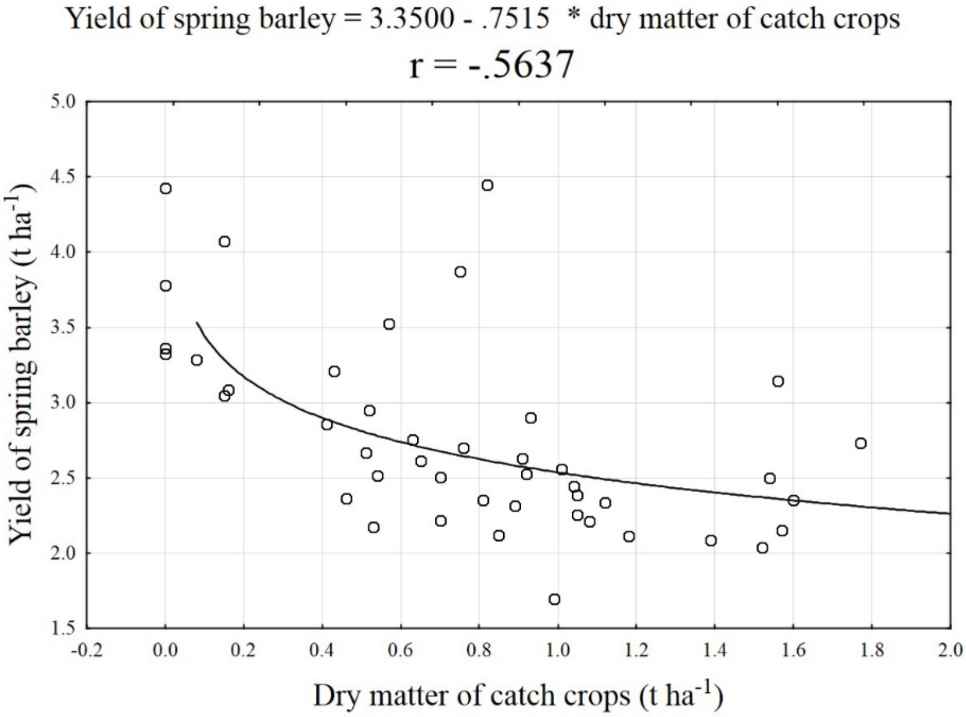
Dry matter yields of catch crops (t · ha^{-1})	2011	2012	2013	2014
Sinapis alba	1.13	2.50	3.16	2.04
Raphanus sativus v. oleifera	1.33	2.25	2.09	1.70
Phacelia tanacetifolia	1.22	2.80	2.49	1.87
Fagopyrum esculentum	0.64	3.65	1.09	1.98
Secale cereale v. multicaule	0.54	1.40	1.92	1.13
Panicum miliaceum	0.89	1.98	0.22	0.31
Crambe abyssinica	1.19	2.90	2.59	1.76
Malva verticillata	0.88	2.25	1.33	0.81
Phalaris canariensis	0.14	0.78	1.16	0.61
Carthamus tinctorius	0.63	1.53	3.70	1.45
Average	0.86	2.20	1.98	1.37

Table 3 and Figure 1 show the yield results of spring barley after catch crops. In 2012, spring barley yields ranged from 2.09 to 3.72 t · ha^{-1}. Yields less than 2.5 t · ha^{-1} of spring barley were reached after *Sinapis alba*, *Raphanus sativus v. oleifera*, *Phacelia tanacetifolia*, and *Malva verticillata*. In 2013, yields of spring barley (ranging from 5.27 to 7.07 t · ha^{-1}) was higher for the majority of crops than the variant without catch crops (6.43 t · ha^{-1}). Lower yields of spring barley than in the variant without catch crops were only after *Secale cereale v. multicaule*. The highest yield was after *Crambe abyssinica*. In 2014, the yields of spring barley ranged from 4.25 to 7.74 t · ha^{-1}, with the lowest yields being after *Secale cereale v. multicaule* and *Phalaris canariensis*. The highest yields were obtained after *Malva verticillata*, the variant without catch crops, and *Crambe abyssinica*. In 2015, spring barley yields ranged from 6.59 to 8.54 t · ha^{-1}. Yields less than 7 t · ha^{-1} of spring barley have occurred after *Phalaris canariensis*, *Secale cereale v. multicaule*, and *Phacelia tanacetifolia*. The highest yields were in the variant without catch crops, *Panicum miliaceum*, *Crambe abyssinica*, and *Malva verticillata*.

Table 3 Grain yield of spring barley after catch crops in the years 2012–2015

Grain yield of spring barley (t · ha^{-1})	2012	2013	2014	2015
Sinapis alba	2.09	6.83	6.65	7.59
Raphanus sativus v. oleifera	2.19	6.97	6.65	7.66
Phacelia tanacetifolia	2.37	6.67	6.03	6.90
Fagopyrum esculentum	2.92	6.43	6.95	7.17
Secale cereale v. multicaule	2.54	5.27	4.25	6.76
Panicum miliaceum	3.67	6.80	6.92	8.31
Crambe abyssinica	2.55	7.07	7.20	8.29
Malva verticillata	2.31	6.90	7.74	8.20
Phalaris canariensis	3.37	6.43	5.71	6.59
Carthamus tinctorius	2.67	6.77	7.16	7.39
Control variant – without catch crops	3.72	6.43	7.21	8.54

Figure 1 Example of regression analysis between the yield of biomass crops and spring barley in 2012 (lack of water in winter 2011 and spring 2012)



Weather conditions also affected production capabilities of catch crops. Satkus, Velykis (2014) also state that the yield of catch crops biomass is dependent on weather conditions during the autumn. Catch crops may affect yields of subsequent spring barley. Yields of spring barley after catch crops higher than the variant without catch crops were in 2013, when there was enough water during the sowing and growth of spring barley. In other years, spring barley yields were similar or significantly lower, especially after catch crops with higher amounts of biomass. Decline in yields of spring barley occurred during increasing deficit of water in the winter and spring. Saptoka et al. (2012) also mentioned competition for water between the remnants of catch crops and subsequent crop, stating that the cause may also include competition for light and nitrogen. Regular, secure yields were achieved in crops from the family *Brassicaceae* including *Sinapis alba*, *Raphanus sativus v. oleifera*, and *Crambe abyssinica*, as well as *Phacelia tanacetifolia*. It was found that *Sinapis alba*, *Raphanus sativus v. oleifera*, and *Phacelia tanacetifolia* did not change significantly the yield of spring barley, as Gaweda (2011) also found for *Sinapis alba* and *Phacelia tanacetifolia*. However, in a drier year (e.g. 2012), there was a risk of significant yield reduction of spring barley after *Sinapis alba*, *Raphanus sativus v. oleifera*, and *Phacelia tanacetifolia*. For example, Gaweda (2011) also reported that for *Sinapis alba*. An interesting catch crop could be *Crambe abyssinica*, which despite its amount of produced biomass had no negative impact on yields of spring barley. It turned out that *Secale cereale v. multicaule* is not a suitable catch crop before spring barley.

CONCLUSION

Weather conditions affected the production capabilities of catch crops. From the point of view of securing the purpose of growing catch crops, it is necessary to include *Sinapis alba*, *Raphanus sativus v. oleifera*, *Crambe abyssinica* and *Phacelia tanacetifolia*. These catch crops produced regular, high yields of biomass, more so than *Fagopyrum esculentum, Secale cereale v. multicaule, Panicum miliaceum, Malva verticillata, Phalaris canariensis,* and *Carthamus tinctorius*. In the dry beginning of the year, growing catch crops from the family *Brassicaceae* and *Phacelia tanacetifolia* as well as and other crops with more biomass, could be risky for spring barley. An exception could be *Crambe abyssinica*, which did not have so negative impact on yields of spring barley. The study showed that *Secale cereale v. multicaule* is not suitable catch crop before spring barley. When there is enough water in the winter and spring, catch crops have no negative impact on yields of spring barley.

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