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THE POTENTIAL OF WINTER COVER CROPS FOR EARLY SPRING FODDER

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The use of cover crops is a recognized and well known method for soil tilth, soil nutrients conservation and weed suppression, whereas the utilization of winter cover crops for early spring fodder is not sufficiently investigated, especially in organic agriculture, where special rules have been applied. The experimental set up near Valpovo, Croatia, at the eutric brown cambisol soil type, during the years of 2007 and 2008, aimed toward effects of different cover crops and their mixtures on the biomass production and cover crops potential for early spring fodder. The experimental set-up was CRBD in four repetitions, with eight cover crop treatments after soybean (*Glycine max* L.) and pop-corn maize (*Zea mays* L. var. *everta*): WW – winter wheat (*Triticum aestivum* L.), RY – winter rye (*Secale cereale* L.) FP – field pea (*Pisum arvense* L.); HV – hairy vetch (*Vicia vilosa* L.); WF – mixture of WW and FP; WH – mixture of WW and HV; RF – mixture of RY and FP; and RH – mixture of RY and HV. The highest dry biomass production treatments were WW and RY after soybean with 3123 and 2987 kg of dry matter per ha, and RY and WW after maize, with 1656 and 1399 kg of dry matter ha^{-1}, respectively. Regarding protein production potential, WW and RY treatments after soybean yielded 226 and 183 kg of proteins, whereas HV and WH treatments after maize produced 155 and 143 kg of proteins, respectively.

Key words: winter wheat; winter rye; field pea; hairy vetch; dry biomass; protein

ПОТЕНЦИЈАЛ НА ЗИМСКИТЕ ЗРНЕСТИ КРМИ КАКО РАНА ПРОЛЕТНА ХРАНА

Употребата на зрнестите крми е признат и добро познат начин за култивирање на почвата, конзервирање на хранливите материи во неа и задржување влага во неа. Меѓутоа прифаќањето на зимските зрнести крми како рана пролетна храна не е соодветно истражувано, посебно во органското земјоделие каде што мора да бидат аплицирани специјални правила. Експериментот беше изведен во близина на Валпово, Хрватска, на еутричен кафеав камбисол во 2007 и 2008 година со цел да се утврдат ефектите од различни зрнести крми и нивни смески во продукцијата на биомаса, како и нивниот потенцијал како рана пролетна крма. Експерименталниот план беше CRBD во 4 повторувања со 8 зрнести третмани по соја (*Glycine max* L.) и пченка (*Zea mays* L. var. *everta*): WW – зимска пченица (*Triticum aestivum* L.), RY – зимска 'рж (*Secale cereale* L.), FP – полски граор (*Pisum arvense* L.); HV – класеста ливадарка (*Vicia vilosa* L.); WF – смеска од WW и FP; WH – смеска од WW и HV; RF – смеска од RY и FP; RH – смеска од RY и HV. Највисока продукција на сува биомаса има кај третманот со WW и RY по соја со 3123 и 2987 kg на сува материја по хектар и со RY и WW по пченка со 1656 и 1399 kg на сува материја по хектар, соодветно. Производството на протеинскиот потенцијал при третманот со WW и RY по соја изнесува 226 и 183 kg протеини, додека при третманот со HV и WH по пченка се продуцираат 155 и 143 kg протеини, соодветно.

Клучни зборови: зимска пченица; зимска 'рж; полски граор; класеста ливадарка; сува биомаса; протеин

1. INTRODUCTION

The organic crop production, besides numerous advantages, still has concerns for sustainability, both environmental and financial, thus making farmers reluctant to convert their conventional production into the organic production, due to possibility of lower yields in the transitional period (Liebhardt et al., 1989; MacRae et al., 1990). Certain agricultural methods, such as cover crop use, can alleviate some problems regarding soil tilth, erosion prevention, nutrients availability and weed control (Raimbault et al., 1990; De Bruin et al., 2005; Khanh et al., 2005). Due to shoot and root growth of the cover crop, soil physical properties can also be considerably improved. Different cover crops, both cereals and legumes, have been found to improve soil aggregation for a wide range of soil types, as was shown by different authors (Stamatov, 1979; McVay et al., 1989; Roberson et al., 1991, 1995; Zebarth et al., 1993; Basso and Reinert, 1998; Kabir and Koide, 2000). Other authors found lower soil bulk density and soil compaction after cover crop growth (Jackson et al., 1987; Scott et al., 1990; Arevalo et al., 1998; Calkins and Swanson, 1998; Raper et al., 2000), although not always (Wagger and Denton, 1989; Burmester et al., 1995).

Through improved aggregation, reduced compaction and greater porosity, cover crops were also found to improve infiltration and saturated hydraulic conductivity (Davidoff and Selim, 1986; McVay et al., 1989; Scott et al., 1990; Bruce et al., 1992; Stirzaker and White, 1995). Greater water infiltration, water retention (Scott et al., 1990) and soil water content through the cover crop mulching effect (Layton et al., 1993; Teasdale and Mohler, 1993; Yoo et al., 1995; Clark et al., 1997) can provide advantageous soil moisture for the following cash crop in cases of serious water stresses during the summer period of growth, whose occurrence is more emphasized during the last decade, as observed by Birkas et al. (2007).

But under certain conditions, cover crops can also be detrimental for the cash crop growth through their large biomass growth. In dry springs, some authors (Helsel et al., 1991; Unger and Vigil, 1997) found that cover crops depleted soil moisture needed for the following cash crop. Furthermore, in wet springs cover crops may cause higher soil moisture content that can, in combination with lower soil temperature, cause delays in early cash crop development for temperature-sensitive crops, as was found by Teasdale and Mohler (1993), Johns (1994) and Drury et al. (1999).

Based on the previously reviewed literature and other sources, some of them even hundred years old (NN, 2007), there are certain possibilities for organic maize production and higher sustainability by cover crop management, which can also be used as an early spring fodder, thus substantially improving the organic animal production potential by the use of the winter cover crops.

2, MATERIAL AND METHODS

In order to test the hypothesis that the use of cover crops can contribute toward the sustainability of organically grown maize after soybean as a previous crop in the crop rotation, the experimental site was established in Valpovo, Croatia, at the eutric brown soil type, during the years of 2007 and 2008. The used maize was the pop-corn maize hybrid "OSSK 605 pc" due to the substantially higher financial turnover than regular hybrids. The experimental design was set up as a complete randomized block design in four repetitions, with the basic experimental plot size of 5×30 m^2. The eight cover crop (CC) treatments were used: WW – winter wheat (*Triticum aestivum* L.) cover crop, cultivar "Žitarka", with the aimed population of 700 plants per m^2 and seeding rate of 300 kg ha^{-1}; RY – rye (*Secale cereale* L.) cover crop, cultivar "Eho Kurz", with the aimed population of 400 plants per m^2 and seeding rate of 150 kg ha^{-1}; FP – fodder pea (*Pisum arvense* L.) cover crop, cultivar "Osječki zeleni", with aimed population of 100 plants per m^2 and seeding rate of 125 kg ha^{-1}; HV – hairy vetch (*Vicia vilosa* L.) cover crop, cultivar "Poppelsdorf", with aimed population of 250 plants per m^2 and seeding rate of 120 kg ha^{-1};WP – mixture of the WW and FP, sown in the 50% : 50% ratio of sole winter wheat and fodder pea cover crops; RP – mixture of RY and FP, sown in the 50% : 50% ratio of sole winter rye and fodder pea cover crops; WV – mixture of the WW and HV, sown in the 50% : 50% ratio of sole winter wheat and hairy vetch cover crops; and RV – mixture of RY and HV, sown in the 50% : 50% ratio of sole winter rye and hairy vetch cover crops. The cover crop seed was planted by broadcasting method after soil preparation by singe heavy-duty diskharrowing after the previous main crop harvest. The cover crop biomass was collected before mouldboard ploughing within the week prior to the main crop planting (the first week in May), by cutting all plants 1–2 cm above ground level from four ¼ m^2 frames on each experimental plot. Collected biomass has been drying at 60ºC during 24 hours and weighted after being cooled down at room temperature. The nitrogen extraction has been done by the Kjeldahl method, and nitrogen concentration has been determined by boron acid titration. The recalculations of plant N concentration into theoretical protein content has been done by the conversion factor of 5.70 for WW, 5.83 for RY and 5.52 for both legumes, according to IDF (2006). The conversion factor of fodder proteins into the milk proteins of 0.63 has been used, after Metcalf et al. (2008). The split-plot ANOVA was performed by the SAS statistic package (V 8.02, SAS Institute, Cary, NC, USA, 1999) with the Year as the main level, Main Crop as the sub-level and Cover Crop as the sub-sub-level. The Fisher protected LSD means comparisons were performed for P = 0.05 significance levels.

3. RESULTS AND DISCUSSION

The cover crops dry biomass yield was in average higher after soybean as the previous crop than after maize (Table 1), which was expected due to higher N content in soybean residues, available for cover crops. It is especially visible from the cereal cover crop biomasses after soybean (WW and RY, 3123 and 2987 kg ha^{-1}, respectively), which shows higher biomass accumulation than after maize (WW=1399 and RY=1656 kg ha^{-1}), which residues are not rich with N for subsequent cover crop N uptake. Both legume cover crops, FP and HV, failed to produce substantial dry biomass before the biomass sampling, and after both pre-crops the collected biomasses were not higher than 1000 kg ha^{-1}. The reason of these low biomasses was slower growth rate in comparison with cereals, especially during the early spring period. Regarding cover crop mixtures, the cereal cover crops were prevailing within the total biomass, but lower cereal plant population in comparison with the full seeding rate cereal treatment gave consequently lower biomasses. The best biomass yielding treatment was RF (1655 kg ha^{-1}), followed by WH (1480 kg ha^{-1}), WF (1426 kg ha^{-1}) and RH (1241 kg ha^{-1}). These results are confirming some previous experiments with grasses-legumes mixtures in comparison with sole legume crops where grasses can be benefiting on numerous ways for the forage biomass (Barnett and Posler, 1983).

Table 1

The cover crop treatments dry biomass (kg ha^{-1}) after soybean (S) and maize (M) main crops, Valpovo site, years 2007 and 2008

	WW	RY	FP	HV	WF	WH	RF	RH	x
S	3123a*	2987a	350e	584e	1721bc	1561c	1991b	1159d	1685A**
M	1399ab	1656a	403d	912c	1130b	1399ab	1319b	1324b	1193B
x	2261A	2321A	376C	748C	1426B	1480B	1655B	1241B	1439

*The means within the same main crop row, labeled by the same lowercase letter, are not significantly different by P>0.05 significance level according to Fisher protected LSD means comparisons.
**The cover crop and main crop means labeled by the same uppercase letter are not significantly different by P>0.05 significance level according to Fisher protected LSD means comparisons.

The results of cover crop treatments recalculaed for the protein mass of each cover crop from the N concentration are showed in the Table 2. Different nitrogen:protein ratios, which are ranging from 5.52 in FP and HV to 5.70 for WW and 5.83 for RY, showed somewhat different relations among treatments. As in the dry biomass case, cover crops grown after soybean had higher protein mass in comparison with cover crops grown after maize (139 and 110 kg ha^{-1}, respectively). Regarding cover crop treatments, in spite of low N concentration, WW treatment showed again the highest values of the observed matter (169 kg of proteins per ha), purely due to the largest biomass production, which is also true for RY treatment (136 kg of proteins). But, higher N concentration, in spite of lower dry biomass production, showed that HV and WH had statistically same protein mass per ha (128 and 145 kg, respectively). Other cover crop mixtures showed similar results as WH, and in all cases higher than FP treatment alone (only 61 kg of proteins).

Table 2

The cover crop treatments protein mass (kg ha^{-1}) after soybean (S) and maize (M), Valpovo site, years 2007 and 2008

	WW	RY	FP	HV	WF	WH	RF	RH	x
S	226.1a*	182.8b	62.3e	102.2d	140.2c	147.5c	145.0c	106.9d	139.1A**
M	111.6ab	88.8bc	59.2c	154.6a	100.7b	143.3a	83.0bc	139.0a	110.0B
x	168.8A	135.8AB	60.8C	128.4AB	120.4B	145.4AB	114.0B	123.0B	124.6

* The means within the same main crop row, labeled by the same lowercase letter, are not significantly different by P>0.05 significance level according to Fisher protected LSD means comparisons.
** The cover crop and main crop means labeled by the same uppercase letter are not significantly different by P>0.05 significance level according to Fisher protected LSD means comparisons.

The cover crop treatments potential for the milk production is given in Table 3, where cover crop proteins are converted into the true milk proteins by the factor 0.63. Further conversion from milk proteins into the milk, if taken into consideration that 35–40 g of milk proteins are in 1 liter of milk (Fox and McSweeney, 2003), gives the cover crop potential for the range of milk production of 1100 to 3100 l (for FP and WW, respectively). If taking into consideration that this can be produced in accordance within the organic agricultural production legislations, which is suffering from the inadequate amounts of organic fodder, advantage of winter cover crop uses is clearly visible.

Table 3

The cover crop treatments true milk protein mass (kg) after soybean (S) and maize (M), Valpovo site, years 2007 and 2008

	WW	RY	FP	HV	WF	WH	RF	RH	x
S	142.4	115.2	39.3	64.4	88.3	92.9	91.3	67.4	87.6
M	70.3	56.0	37.3	97.4	63.4	90.3	52.3	87.6	69.3
x	106.4	85.6	38.3	80.9	75.9	91.6	71.8	77.5	78.5

4. CONCLUSIONS

Based on this research of winter cover crops, following conclusions can be stated:

– soybean as a previous crop yields with higher dry biomass production and with higher protein mass than maize;

– the highest dry biomass, and consequently, protein mass, can be obtained by WW as a winter cover crop;

– dry biomass of cereal mixtures with legumes yields more than legume cover crops alone;

– winter cover crops can be substantial resource for animal production.

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