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WINTER-HARDY VS. FREEZE-KILLED COVER CROP MIXTURES BEFORE MAIZE ON AN ORGANIC FARM WITH REDUCED SOIL CULTIVATION

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Abstract: The advantages and disadvantages of a winter-hardy vs. a freeze-killed cover crop (CC) mixture were studied on an organic farm in Lower Austria in two consecutive experiments. Effects on soil inorganic nitrogen contents, weed density and the yield of a following maize crop were assessed. The winter-hardy compared to freeze-killed CC mixture, both consisting of legumes and non-legumes, reduced soil nitrate contents over winter, leading to a reduced nitrate leaching risk, whereas the yield of a following grain maize crop was not significantly affected. Weed density was high in both CC treatments, presumably due to a reduced, non-inverting soil cultivation before maize, and higher in the winter-hardy CC treatment at one of the assessment dates. Combined with an adapted soil cultivation, both winter-hardy and freeze-killed CC mixtures were suitable CCs before grain maize.

Introduction: Cover crop mixtures have multiple advantages compared to bare soil. Mixtures of legumes and non-legumes reduce erosion by covering the soil, fix nitrogen from the air and reduce nitrate leaching, add organic matter to the soil, increase soil biological activity and improve soil structure, can mobilise nutrients like potassium or phosphorus, can reduce weed density by competing the weeds, and can increase the yield of following main crops by providing nutrients from their biomass (e.g. Rinnofner et al. 2008). However, the advantages and disadvantages of winter-hardy vs. freeze-killed cover crop (CC) mixtures have not been studied systematically. The objectives of our study were to test if a winter-hardy CC mixture terminated with a rotary cultivator compared to freeze-killed CC mixture worked into the soil with a chisel (i) reduces soil nitrate contents over winter, (ii) decreases or increases weed density, and (iii) increases the yield of the following crop, i.e. a following maize crop in this study.

Material and methods: Two field experiments (FE1 and FE2) with two CC / soil cultivation treatments in four replicates (randomized complete block design) were conducted on farmer´s fields in Raipoltenbach, Lower Austria, in two consecutive years. The soil was an orthic Luvisol. The topsoil had a silty clay (FE1) and silty loam (FE2) texture, a pH_{CaCl2} value of 7,4 (FE1) and 6,7 (FE2), a sufficient level of available phosphorus (P) and a low (FE1) to sufficient (FE2) level of available potassium (K). No livestock has been on the farm since 1998. The farm was converted to organic farming in

2008, soil management has been mainly non-inverting with a rotary cultivator or a chisel since then. Average air temperature during the experimental period was 10.5 °C, average annual precipitation was 850 mm (FE1) and 710 mm (FE2).

The winter-hardy CC mixture was “Landsberger Gemenge” (seeding rate in kg ha^{-1} in brackets) consisting of winter vetch (102.5), crimson clover (11.3) and Italian ryegrass (11.3). The freeze-killed CC mixture consisted of fodder pea (142.0), common vetch (58.0), chickling vetch (50.0), buckwheat (12.0), phacelia (8.5) and fodder radish (8.5). CCs were sown on 9 August 2016 / 22 August 2017 in FE1 and FE2, respectively. The winter-hardy catch crop mixture was terminated with a rotary cultivator and the freeze-killed CC was worked into the soil with a chisel on 4 April 2017 / 19 April 2018. After chiseling the soil (only in FE1), maize, cv “Connexxion RZ 340”, was sown on 4. May 2017 / 7. May 2018. In both treatments, soil was harrowed once in May and hoed twice in June. Only in the winter-hardy CC treatment, an underseed of Egyptian clover, squarrose clover, linseed, phacelia, Persian clover, serradella, white clover and ryegrass was established on 24 June 2017 / 18 July 2018.

Soil inorganic nitrogen (N_{in}) was analysed as nitrate + ammonium content in 0.0125 M $CaCl_2$ extracts.

Results: The winter-hardy CC developed slower than the freeze-killed CC. In November (2016 FE1 / 2017 FE2), the dry matter biomass of the winter-hardy CC was lower compared to the one of freeze-killed CC (Table 1). In April (2017 FE1 / 2018 FE2), the biomass dry matter of the winter-hardy CC equaled the November-values of the freeze-killed CC. The biomass N content and C-to-N ratio (ca. 13 in FE1 / 10 in FE2) did not differ between both CC treatments.

N_{in} values in 0-90 cm soil depth in spring (2017 FE1 / 2018 FE2) were almost doubled in the freeze-killed CC treatment compared to the winter-hardy CC treatment (Table 1). An assessment in June (FE1) and May (FE2) showed no differences in the number of maize plants per m^2. The undersown crop mixture in the winter-hardy CC treatment developed well in 2017 (FE1) and poorly in 2018 (FE2) due to little precipitation and high temperatures in spring 2018. Main weeds were creeping thistle, chickweed, red dead-nettle and white goosefoot (*Chenopodium album*). Weed density was moderate in June, but in July to September weeds covered 30 to 80 % of the area in FE2 in 2018. Weed density did not differ between the treatments, with one exception: on 3 July 2018, weed density was higher in the winter-hardy CC treatment than in the freeze-killed CC (data not shown).

Maize grain dry matter yield was 7.8 t ha^{-1} in FE1 and 7.0 t ha^{-1} in FE2 on average and did not differ between treatments. Also maize nitrogen yield did not differ (Table 1).

Table 1: Cover crop above-ground dry matter (CC DM), soil inorganic N content (N_{in}) in 0-90 cm in spring (March 2017 / April 2018), maize grain dry matter yield (Maize DM) and maize N yield (Maize N yield) in both field experiments.

		CC DM November	CC DM April	N_{in} spring	Maize DM	Maize N yield
		(t ha^{-1})	(t ha^{-1})	(kg ha^{-1})	(t ha^{-1})	(kg ha^{-1})
Winter-	FE1	1.90 a	3.24	33 a	7.29 a	91.9 a
hardy	FE2	1.73 α	2.34	47 α	7.32 α	100.4 α
CC	Averag e	1.82 A	2.79	40 A	7.31 A	96.1 A
Freeze-	FE1	3.27 b	-	71 b	8.33 a	101.9 a
killed	FE2	2.92 β	-	82 β	6.58 α	92.4 α
CC	Averag	3.10 B	-	77 B	7.46 A	97.2 A

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FE1: field experiment 1; FE2: field experiment 2. The same (lowercase / Greek / capital) letters in one column are not significantly different (Tukey-test, $P < 0.05$).

Discussion: The winter-hardy “Landsberger Gemenge” cover crop mixture reached an above-ground biomass of 2.3 to 3.2 t DM ha^{-1} in FE1 and FE2. Although this biomass was equal to (FE1) or slightly less (FE2) than the biomass of freeze-killed CC mixture, in spring the rooting density was higher and N_{in} contents were significantly lower in the winter-hardy CC treatment in both experiments. Moreover, in a study by Rüegg et al. (1998), winter-hardy rye achieved lower N_{in} values in spring compared to a freeze-killed mixture consisting of phacelia and white mustard. Nitrogen mineralisation from the residues of the freeze-killed CC mixture may already increase N_{in} contents during winter. In contrast, the winter-hardy CC mixture in our study took up soil nitrogen until termination in April, thus reducing N_{in} contents after winter and the risk of nitrate leaching during winter, saving nitrogen for the following main crop.

Otherwise, sowing maize without inverting soil cultivation was more difficult in the winter-hardy CC treatment than in the treatment where the CC mixture was freeze-killed. But mainly due to the effective CC termination with the rotary cultivator, weed density was not higher in this treatments except for one assessment date in July 2018 in FE2, and did not affect maize grain yield significantly. Similar to our results, Rüegg et al. (1998) found no differences in the number of maize plants per m^2 between a freeze-killed CC mixture and a winter-hardy rye CC.

Maize grain DM yield was lower in FE2 than in FE1 in the freeze-killed CC treatment. This corresponds to less precipitation and hot weather in spring 2018 in FE2. Rüegg et al. (1998) found lower silage maize dry matter yields after a winter-hardy rye CC compared to a freeze-killed CC mixture consisting of phacelia and white mustard, both cultivated under minimum tillage. On the contrary, silage maize DM yield was higher after winter-hardy Landsberger Gemenge (12.90 t ha^{-1}) than after a freeze-killed CC mixture (11.99 t ha^{-1}) in the study of Schließer et al. (2010). Kramberger et al. (2014) found lower maize yields following pure Italian ryegrass stands or non-legume dominated mixtures compared to CC mixtures with a high legume content. Kolbe (2007) concluded that CC mixtures consisting of legumes and non-legumes lead to decreased maize grain DM yields compared to pure legume CC mixtures. Obviously, the legume content of CC mixtures is more relevant for the N release and consequent maize grain yield than the cold hardiness of the CC mixture.

In our study, both freeze-killed and winter-hardy CC mixtures consisted of a legume-dominated legume-non-legume mixture. This resulted in a narrow C-to-N ratio (10 to 13) in the CC biomass as a basis for a swift N mineralization from the CC residues in both treatments. Accordingly, maize grain DM yield and maize grain N yield did not differ between the CC treatments in our study.

References: Kramberger B, Gselman A, Kristl J, Lesnik M, Sustar V, Mursec M & Podvrsnik M (2014): Winter cover crop: the effects of grass–clover mixture proportion and biomass management on maize and the apparent residual N in the soil. EUR J AGRON, 55**,** 63-71.

Kolbe H (2004) Zwischenfrüchte im Ökologischen Landbau, Sächsische Landesanstalt für Landwirtschaft.

Rinnofner T, Friedel JK, de Kruijff R, Pietsch G & Freyer B (2008) Effect of catch crops on N dynamics and following crops in organic farming. AGRON SUSTAIN DEV 28, 551-558.

Rüegg WT, Richtner W, Stam, P & Feil B (1998) Accumulation of dry matter and nitrogen by minimum-tillage silage maize planted into winter cover crop residues. EUR J AGRON, 8, 59-69.

Schließer I, Schuster M & Kolbe H (2010) Einfluss verschiedener Zwischenfrüchte als Vorfrüchte für die Ertrags- und Qualitätsleistung von Silomais und Kartoffeln. Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie.

Disclosure of Interest: None Declared

Keywords: catch crops, grain maize, legumes, non-inverting cultivation, weed density