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Original Research

The Effect of Direct Covering with Biodegradable Nonwoven Film on the Physical and Chemical Properties of Soil

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Abstract

It is well known that plastic mulch film increases the yield of many vegetables, in particular the early season yield, most likely by increasing soil temperature and moisture, and inhibiting weed growth. Soil surface covering decreases erosion, reduces evaporation, protects against raindrop impact, and increases aggregate stability. The following field experiment was carried out at the experimental farm in Mydlniki in Krakow, Poland in 2008/09 and 2009/10. Winter leek and onion covered by biodegradable nonwoven (Bionnole 100 $g \cdot m^{-2}$ and IBWCH 75 $g \cdot m^{-2}$) film were assessed to estimate the changes in several physical and chemical soil properties. The experiment revealed the interaction between treatments and wet-aggregate content in soil. The biofilm covering slightly increased the amount of large aggregates (4.0-2.5 mm) and decreased the percentage of small sized macroaggregates (0.50-0.25 mm). We also observed a trend in the increase of water capacity in soils following treatments. The obtained results suggest that the use of biodegradable film as covering could be an alternative to the traditional plastic films widely used in the world.

Keywords: biofilm, leek, onion, soil organic matter, soil structure, water-stable aggregates

Introduction

Soil management affects the physical and chemical parameters of the soil. Mulching and direct soil covering are important agricultural practices used to improve crop productivity [1-5]. Under cool soil conditions, covering warms the soil and advances harvest maturity, preserves moisture, and decreases nutrient leaching. Mulch with plastic materials covers soils and creates a physical barrier to soil water evaporation, preserves a beneficial soil structure, controls weeds, and protects plants from soil contamination. After harvest, plastic mulches should be removed from the field and disposed of properly according to directives on incineration. Biodegradable mulch films are alternatives to removing plastic from fields [6, 7]. In the early 1960s, photo- or biodegradable materials were recognized as one solution to the disposal problem associated with plastic mulches [8, 9]. At the end of the growing season, biofilms can degrade into biologically rich soil, broken down by microorganisms or under ultraviolet sunlight [10].

Soil surface covering decreases erosion, reduces evaporation, protects against raindrop impact, and increases aggregate stability [11]. Mulches, particularly from organic materials, improve soil structure by favorable conditions for soil aggregation, e.g. through higher soil water content and temperature and the mineralization of organic matter in the soil. The soil structure consists of an aggregate formed by the arrangement of soil particles, and depends on interactions between primary particles and organic constituents to form stable aggregates [12, 13]. Soil aggregates, which

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have significant influence on physical and chemical soil properties, are the most basic units of soil structure and an important component of the soil [14]. Thus, the recognition of soil aggregate size distribution and soil aggregate stability is important to properly interpret soil structure [15].

The water economy achieved by plastic mulching is significant. Water reserves are available for plants and, consequently, the nutrient supply is also more constant. Plastic film mulch reduces N leaching. On the other hand, higher microbial biomass and intense nitrification favour higher moisture, temperature, and better aeration of the soil [16]. Moreover, the bioavailability of trace elements is strongly affected by bio-factors in addition to the physical-chemical condition of soils. The benefits of plastic mulch in crop production are well documented and also include greater root growth and nutrient uptake, and the more efficient use of soil nutrients due to higher yield [17].

Little is known about how biofilm covering affects physical and chemical soil parameters. Additional information on the biochemistry and decomposition of biodegradable films and their interaction with soil type and environment condition to promote aggregation would allow for the identification of more effective management practices [18].

In this study, biodegradable nonwoven film covered winter leek and onion were tested to evaluate changes in several physical and chemical soil properties: bulk density, water retention, wet soil aggregate stability, and nutrient and heavy metal content.

Material and Methods

Soil Sampling and Analysis

The field experiment was carried out at the experimental farm of the Agricultural University of Krakow in Mydlniki in 2008/09 and 2009/10. The effect of onion and leek film covering on the physical and chemical properties of the soil was studied. The trials consisted of a randomized complete block design with four treatments: biodegradable films – Bionnole 100 g/m^2 and IBWCH 75 g/m^2, and bare soil (control). Transplants of the frost-resistant 'Kenton' winter leek cultivar were planted in the field on 22 July 2008 and 3 July 2009, respectively, at a distance of 75×15 cm and a depth of 13-15 cm. The experimental fields were established with four replications with 20 plants in each. Nonwovens were stretched over leek when the air temperature decreased and before expected snow (on 22 November 2008 and 11 December 2009, respectively). In the case of leek, covers were kept until the spring and then removed a few days before harvest (6 April 2009 and 25 March 2010, respectively). Plants cultivated without covers were the control. Leek was harvested only once each year: on 17 April 2009 and 30 March 2010.

Seeds of the frost-resistant 'Glacier' onion cultivar were sown into the field on 21 August 2008 and 17 August 2009. The experimental fields were established with four replications with dimensions of 1.2×3 m. Nonwovens were stretched over and kept through the same dates as leeks. Onion was harvested only once each year: on 14 May 2009 and 1 June 2010.

Soil samples were collected from the plots divided into sections differentiated by cover films. In each section, the soil samples were taken at a depth of 0-20 cm after leek and onion cropping. The soil samples were air-dried at room temperature and sieved.

Intact soil cores (250 cm^3) were sampled in triplicate to measure soil bulk density (BD) and water retention parameters. The undisturbed soil samples for determining the soil bulk density were oven-dried at 105ºC to a constant weight. Volumetric (%vw) and weight (%ww) water content of the soil was determined by a Kopecky-type procedure [19]. Granulometric analysis was made using the Casagrande aerometric method modified by Prószyński [20]. This procedure is regulated by the PN-R-04032 [21] standard published mostly for agricultural soil analysis in Poland.

Soil aggregates were separated by wet-sieving using Yoder's procedures [22]. Previously separated out by dry sieving, a single size soil fraction (<5 mm) was disrupted under water. For measurements, 40 grams of air-dried aggregates in five replications were placed onto the top sieve and immersed in water for a period of time (5 min.) before beginning the mechanical sieving process for 20 minutes. There were five size classes used: 0.25, 0.5, 1.0, 1.5, and 2.5 mm. The amount of soil retained on each sieve was determined by drying and weighing. The stability index based on the wet soil fragmentation procedure was calculated as a sum of five size classes of aggregates.

Soil pH was measured in water and 1 mol·dm^{-3} KCl at a soil-to-solution ratio of 1:2. Soil organic carbon (SOC) was determined using the dichromate oxidation method [20]. The available forms of nitrogen ($N\text{-}NO_3$ and $N\text{-}NH_4$), phosphorus, potassium, magnesium, and calcium were determined using the universal method as described by Nowosielski [23]. The extractable forms of metals were measured in 1 mol·dm^{-3} HCl extractant [20]. This soil extractant and procedure is currently used to estimate the availability and critical levels for soil micronutrient cations in Poland. Available N was detected using flow injection analysis (FIA) with spectrometric detection [24], and P, K, Mg, and Ca were determined using the inductively coupled argon plasma atomic emission spectroscopy ICP-OES technique (ICP-OES Teledyne Prodigy, Leeman Labs spectrophotometer).

Statistical Analysis

Data collected from the study were analyzed using the one-way analysis of variance test based on the ANOVA module in Statistica 8.0. Means for each treatment were separated using the Fisher test at the p = 0.05 level of significance.

Results and Discussion

Soil texture has a significant influence on aggregation. Clay content affects aggregation through swelling and dispersion. In temperate climate zones, an increasing clay con-

Table 1. Physical and chemical properties of soils from leek plantations covered with biodegradable films, 2009-10.

Treatment	Bulk density (g·cm^{-3})	Water capacity (% ww)	Water capacity (% vw)	%C
2009				
Control	1.41 a	29.3 a	41.4 a	1.48
Bionolle 100	1.44 a	30.8 a	44.3 b	1.54
IBWCH 75	1.43 a	31.6 a	45.2 b	1.28
2010				
Control	1.31 a	36.3 a	47.5 a	1.48
Bionolle 100	1.26 a	37.1 a	48.0 a	1.31
IBWCH 75	1.30 a	36.8 a	47.9 a	1.38

p=0.05. Fisher test; the same letter indicates no significant differences between means.

Table 2. Physical and chemical properties of soils from onion plantations covered with biodegradable films, 2009-10.

Treatment	Bulk density (g·cm^{-3})	Water capacity (% ww)	Water capacity (% vw)	%C
2009				
Control	1.49 a	29.5 a	43.9 a	1.37
Bionolle 100	1.41 a	32.4 a	45.6 a	1.44
IBWCH 75	1.46 a	30.8 a	44.9 a	1.35
2010				
Control	1.45 a	29.5 a	42.8 a	1.16
Bionolle 100	1.44 a	28.2 a	41.5 a	1.25
IBWCH 75	1.43 a	30.4 a	43.6 a	1.24

p=0.05. Fisher test; the same letter indicates no significant differences between means.

centration is usually associated with increased organic content in soil [11]. In the present study, the particle size analysis showed a silty clay texture of the soil (14% of size particles 1.0-0.1 mm, 45% of 0.1-0.02 mm, and 41% of <0.02 mm) classified as heavy alluvial soil.

Soil Bulk Density and Water Capacity

High bulk density levels can result from poor structural stability or from compaction by intensive tillage. Increased density is usually associated with a decrease in mainly structural porosity [14, 25]. The soil under plastic mulch remains loose, friable, and well-aerated. Roots have access to adequate oxygen, and microbial activity is enhanced. Mulching decreases soil compaction.

A minor effect of the treatments on soil bulk density was observed. In 2009, in the leek treatment, the bulk density (BD) measured for the control soil was 1.40 g·cm^{-3}. Results showed no significant differences between the control and treatments (Table 1). The soil bulk density found for biofilm covering was similar and ranged between 1.43-1.44 g·cm^{-3} for Bionolle and IBWCH films, respectively. In the 2010 season, the average BD for the control soil was 1.31 g·cm^{-3}. There was no impact of film covering on soil bulk density, although soil collected from the Bionolle covering demonstrated a relatively low value (1.26 g·cm^{-3}) as compared to the other treatments.

In both leek cropping seasons, the use of covering films did not affect water capacity expressed as a per cent of mass units (% ww). In 2009, weighed water capacity ranged from 29.3 (control) to 31.6% ww (IBWCH), and in 2010, varied between 36.3% (control) to 37.1% ww (Bionolle). In the 2009 leek cropping season, the volumetric water capacity (% vw) was significantly higher in soil covered with Bionolle (44.3% vw) and IBWCH (45.2% vw) biodegradable films as compared to bare soil (41.4% vw) (Table 1). Results from a study by Ndubuisi [26] showed that plastic film mulches improved physical soil properties such as the soil water content and the temperature in topsoil layers, prompting the emergence of seedlings and greater root distribution in soil. Martin-Closas [18], Moreno and Moreno [3], and Moreno et al. [4] found similar results.

At the onion plantation in 2009-10, soil bulk density ranged between 1.45-1.49 g·cm^{-3} for the control treatments (Table 2). In 2009 a statistically significant effect of covering films on BD was recorded.

In all of the onion cropping seasons, no significant effect of treatments on water retention parameters were demon-

Table 3. Percent of soil water stable aggregates (means and standard deviation, p=0.05) in soil from leek plantation covered with biodegradable films, 2009-10.

Treatment	Aggregates in diameter of mm					
	4.0-2.5	2.5-1.5	1.5-1.0	1.0-0.50	0.50-0.25	∑ 0.25-5.0
2009						
Control	38.6±2.1 a	10.2±0.82 b	19.2±0.63 a	21.3±0.67 a	7.69±0.62 a	96.9
Bionolle 100	39.5±8.0 a	8.5±1.1 a	17.7±1.7 a	19.8±4.5 a	7.3±2.2 a	92.8
IBWCH 75	38.1±2.6 a	9.8±0.52 ab	19.1±0.48 a	24.4±2.1 a	7.4±0.61 a	98.8
Mean	38.7	9.5	18.7	21.8	7.5	
2010						
Control	33.1±2.8 a	6.75±0.83 a	14.8±0.84 a	29.0±1.6 a	11.0±0.57 b	94.2
Bionolle 100	35.2±1.2 a	7.20±0.87 ab	17.7±0.54 b	27.8±1.2 a	8.62±0.15 a	96.3
IBWCH 75	32.8±2.7 a	8.27±0.38 b	17.1±1.1 b	27.8±1.5 a	10.3±0.57 b	96.3
Mean	33.7	7.4	16.5	28.2	10.0	

Table 4. Percent of soil water stable aggregates (means and standard deviation, p=0.05) in soil from onion plantation covered with biodegradable films, 2009-10.

Treatment	Aggregates in diameter of mm					
	4.0-2.5	2.5-1.5	1.5-1.0	1.0-0.50	0.50-0.25	∑ 0.25-5.0
2009						
Control	31.2±5.1 a	7.6±1.3 a	16.2±3.4 a	25.5±2.8 a	10.4±2.2 a	91.1
Bionolle 100	35.9±8.0 a	8.7±0.63 a	17.6±2.4 a	23.8±5.2 a	8.1±1.2 a	94.1
IBWCH 75	30.2±6.9 a	8.0±0.58 a	18.5±5.0 a	27.2±2.2 a	9.7±0.99 a	93.7
Mean	32.4	8.1	17.2	25.5	9.4	
2010						
Control	34.9±3.4 a	8.17±1.18 a	16.9±1.9 b	24.9±1.43 c	9.87±0.74 b	94.8
Bionolle 100	46.3±2.4 b	6.82±0.90 a	13.4±0.94 a	19.7±0.94 b	9.17±1.17 b	95.4
IBWCH 75	56.5±1.4 c	12.1±2.62 b	15.1±2.20 b	8.50±0.96 a	4.77±0.71 a	97.0
Mean	38.9	22.0	14.7	8.47	7.47	

strated. However, in 2009 a slight trend to increase water capacity under biofilm covering was observed (Table 2). It was associated with better wet soil structure in combinations with biofilm usage. The mean values for the parameter varied between 29.5 (control) and 32.4% ww (Bionolle).

Soil Water-Stable Aggregates

High soil aggregate stability is an important factor for improving soil fertility and increasing agronomic productivity. Aggregate analysis may help explain most aspects of soil water properties, including runoff, infiltration, aeration, and root growth [27]. Aggregates are susceptible to disruption by physical disturbances such as clay swelling, tillage and rainfall impact [11]. Mulching and covering improve soil structure and enhance soil water-stable aggregate contents by decreasing soil erosion, reducing raindrop impact, and increasing the magnitude of the organic carbon pool of the soil.

In the 2009-10 leek season there were no significant differences between wet stability structure indexes expressed as a sum of the water stable aggregate fractions ∅ 0.25-4.0 mm under the different treatments used (Table 3). In 2009 the mean measured values for this physical soil parameter were high and ranged between 92.8% (Bionnole) and 98.8% (IBWCH). In 2010, the structure stability indexes varied from 94.2% (control) to 96.3% (degradable films). A slight tendency to increase the percentage of water stable aggregates under biofilms was observed, but the differences were not statistically verified. In 2009 the results of leek

Table 5. Acidity (pH), electrical conductivity (EC mS·cm^{-1}), and available forms of macronutrients (mg·dm^{-3}) in soil from leek plantation covered with biodegradable films, 2009-10.

Treatment	pH_{H_2O}	pH_{KCl}	EC	$N\text{-}NH_4$	$N\text{-}NO_3$	P	K	Mg	Ca
2009									
Control	7.07	6.21	0.12	3.7	4.2	63.0	162	131	1468
Bionolle 100	7.12	6.15	0.11	2.6	5.2	56.8	142	120	1233
IBWCH 75	7.18	6.23	0.09	8.0	5.1	45.8	118	126	1690
2010									
Control	7.44	6.52	0.14	0.14	1.6	82.5	159	214	2058
Bionolle 100	7.52	6.65	0.15	0.79	1.3	53.5	76	140	1287
IBWCH 75	7.52	6.57	0.10	0.00	0.8	45.3	131	135	1371

Table 6. Acidity (pH), electrical conductivity (EC mS·cm^{-1}), and available form of macronutrients (mg·dm^{-3}) in soil from onion plantation covered with biodegradable films, 2009-10.

Treatment	pH_{H_2O}	pH_{KCl}	EC	$N\text{-}NH_4$	$N\text{-}NO_3$	P	K	Mg	Ca
2009									
Control	7.02	5.95	0.08	4.3	3.1	44.6	127	113	1107
Bionolle 100	7.16	6.09	0.08	3.6	4.1	39.0	141	109	1040
IBWCH 75	6.88	5.83	0.12	3.3	3.1	46.2	131	117	1119
2010									
Control	7.09	5.94	0.04	trace	0.8	11.8	17.6	102	796
Bionolle 100	6.99	5.93	0.05	trace	1.9	12.2	24.4	112	879
IBWCH 75	7.05	5.86	0.04	trace	0.5	12.8	20.3	112	933

soils showed the highest content of large water-stable aggregates in diameter 4.0-2.5 mm (37.7%) and 1.0-0.5 mm (21.9%) (Table 3). A similar effect was observed in 2010 (33.7 and 28.1%, respectively). In 2010, the number of small wet stable aggregates (∅ 1.0-0.5 and 0.5-0.25 mm) decreased in soils with biofilm treatments in relation to the control. A reverse effect in the case of aggregates of 1.5-1.0 mm in diameter was found

In both years of onion cropping, a slight trend to increase the water aggregate stability indicators for biodegradable films in comparison to the control treatment was observed (Table 4). However, the differences were not statistically significant. In 2009 the highest content of water-stable aggregates in onion soils was measured for diameters of 4.0-2.5 mm (33.3%) and 1.0-0.5 mm (24.7%). In 2010 the highest number of water-stable aggregates was found in diameters of 4.0-2.5 mm (44.1%). In 2010, similar to the leek treatment, Bionolle and IBWCH biofilms significantly increased the percentage of large aggregates of 4.0-2.5 mm in diameter in relation to the control treatment (Table 4). For aggregates 2.5-1.5 mm in diameter, the best results were obtained for IBWCH biofilm. Consequently, the percentage of small wet stable aggregates (∅ 1.0-0.5 mm and 0.5-0.25 mm) decreased in those covered soils. The uncovered soil was directly exposed to the destructive effects of rain (raindrop splash), wind, and solar radiation. The film covering (physical protection) showed a beneficial effect on the number of large soil water-stable aggregates. It is generally considered that large aggregates are more indicative of good structure for most agricultural purposes (availability of O_2, water and resistance to penetration by roots and shoots in seedbeds created by tillage) than small aggregates [11]. The process of soil aggregate stabilization is complex and involves a variety of binding mechanisms. Jastrov et al. [28] demonstrated the importance of fine roots and mycorrhizal hyphae as driving factors for macroaggregate stabilization. Under biofilms, in favorable conditions for rooting and intense soil microbial activity, more stable aggregates were probably formed.

Generally, the high wet-aggregate stability of the analyzed soils resulted in the weak influence of covering films on soil structure.

Soil Organic Carbon

Clay and soil organic matter (SOM) are the key factors that influenced the total water-stable aggregates. Soil organic matter forms complexes with primary mineral par-

Table 7. Micronutrient and heavy metal content (mg·kg^{-1}) in soil from leek plantation covered with biodegradable films, 2009-10.

Treatment	Zn	Cu	Mn	Fe	B	Cd	Pb	Cr	Ni
2009									
Control	49.9	6.34	201	1734	1.77	0.94	26.1	1.38	2.58
Bionolle 100	45.5	6.26	166	1578	1.70	0.92	25.0	0.28	2.35
IBWCH 75	47.8	6.56	196	1690	1.84	0.98	26.2	1.31	2.45
2010									
Control	60.0	5.87	230	1868	2.20	1.07	30.4	1.55	2.60
Bionolle 100	67.8	6.76	270	2179	2.20	1.18	33.2	1.68	2.97
IBWCH 75	61.5	5.80	240	1925	2.18	1.09	30.7	1.60	2.66

ticles and secondary structural units [11]. The consequence of high SOM content will yield a desired soil structure and high strength in wet conditions [29]. The activities of soil organisms influence C-retention, which influences aggregation and soil structure [14]. The decomposition of SOM was a result of the activity of soil organisms, soil properties, and environmental factors such as temperature and moisture gradient. Management practices include film covering and mulching at moderate moisture and temperature regime in soil [4, 30]. This can influence soil carbon retention. Moreno and Moreno [3] indicated that biodegradable mulches have a lower impact on soil temperature regime than synthetic ones. Biofilm material permits increased gas exchange with the open air as a result of its higher permeability to water vapor.

The soil organic carbon content in the analyzed leek soils ranged from 1.28% (IBWCH) to 1.54% (Bionolle) in 2009, and 1.31% (Bionolle) to 1.48% C (control) in 2010 (Table 1). At the onion plantation we determined an organic carbon content from 1.35% (IBWCH) to 1.44% C (Bionolle) in 2009, and from 1.16% (control) to 1.25% C (Bionolle) in 2010. The results do not point out clear differences between treatments. However, under Bionolle-treated soils, a slightly higher organic carbon was determined. High organic matter and clay content could explain the high wet aggregate stability in arable silty clay soils from leek and onion plantations.

Chemical Soil Analyses

Soil pH affects plant growth, availability of nutrients, microbial activity, and clay dispersion. A high pH raises negative surface charge on clay particles and flocculate dispersive clays [31]. An elevated pH often results in increased microbial activity and higher SOM, which encourages aggregation [32]. In both leek and onion cropping seasons the soil pH was near 7.0 or above, and differences among the treatments were not observed (Tables 5 and 6). Neutral pH and high levels of bivalent cations (Ca and Mg) encouraged high water-stable aggregate content for all treatments. Bivalent cations improve soil structure through binding clay particles and SOM [32, 33].

The results of chemical soil analysis demonstrated no impact of treatments on pH, EC, macro and microelement concentration measured after leek and onion cropping. However, in 2010 the biofilm covered soil in the leek plantation was characterized by lower amounts of phosphorus, potassium, and magnesium as compared to bare soil. The most probable explanation of these results is a depletion of available forms of nutrients. Better plant growth and higher plant biomass in the trials where moisture, oxygen, and temperature were most favorable resulted in higher nutrient uptake. Root zone temperature strongly influences the growth and uptake of nutrients [34]. Mulching is known to contribute to enhanced mineral nutrient availability to enhance nitrification. Mulching also improves soil aeration, creates better biological activates, and thus has a consequent beneficial effect on soil fertility [16]. One of the advantages of using plastic mulches is also reduced fertilizer leaching. Many plant nutrients are not held tightly in the soil, and rainfall or excessive irrigation may leach them below the roots zone. A plastic mulch covering prevents rainfall from percolating through the soil and moving nutrients. Preventing leaching improves the efficiency of plant nutrition and production [17]. Li et al. [16] compared soil CO_2 concentrations and soil surface CO_2 fluxes between traditional and plastic mulch systems during the cotton-growing season. Higher CO_2 concentrations in the soil profile in the plastic mulch than in the conventional system were determined. Microbial activity and diversity of microbial community in soil can be significantly altered by CO_2 enrichment. It can increase carbonate weathering, differ the rhizospheric exudation and enhance the amount of available C in soil. The elevated concentration of CO_2 can influence the transformation and bioavailability of heavy metals in soils.

In the present study, in both leek and onion cropping seasons, plant covering did not affect heavy metal concentrations in soils (Tables 7 and 8). Heavy metals are in soil minerals as well as bound to different phases of soil particles by a variety of mechanisms, mainly absorption, ion exchange, coprecipitation, and complexation. Moreover, soil properties such as content of organic matter, carbonates, oxides, and soil structure influence heavy metal

Table 8. Micronutrient and heavy metal content (mg·kg^{-1}) in soil from onion plantation covered with biodegradable films, 2009-10.

Treatment	Zn	Cu	Mn	Fe	B	Cd	Pb	Cr	Ni
2009									
Control	46.6	6.87	178	1679	1.63	0.93	26.2	1.22	2.54
Bionolle 100	52.9	7.00	202	1710	1.60	0.99	27.9	1.26	2.62
IBWCH 75	50.3	7.31	178	1640	1.68	0.98	28.0	1.15	2.52
2010									
Control	51.7	5.02	107.4	1329	1.26	0.99	25.5	1.02	2.19
Bionolle 100	52.6	5.17	133.4	1314	1.45	1.93	26.3	1.08	2.33
IBWCH 75	54.4	5.07	139.0	1287	1.38	1.14	26.6	1.01	2.39

mobility. Li et al. [34] studied the effect of plastic mulching on copper and zinc bioavailability in the soil in Chinese cabbage. Results showed that the mulched field had lower soil pH and SO_4^{2-} contents. However, plastic mulching didn't have a significant effect on the distribution and translocation characteristic of Cu, while it affected those of Zn.

Conclusion

The soils in our study had high clay and organic carbon content, neutral or slight alkaline pH, and high levels of available Ca and Mg. These parameters in general develop the desired soil structure (wet stable). This is most probably the main factor in the explanation of our results. Generally, biofilm covering results in merely small differences between treatments and the bare soil.

The experiment revealed the interactions between treatments and wet-aggregate content in soil. Biofilm covering with Bionolle and IBWCH slightly increased the amount of large aggregates and decreased the percentage of the smallest sized aggregates in soils. We also observe a trend in the increase of water capacity in soils with covering treatments.

This study only addressed arable silty clay soil in a conventional tilled system. We observed a slight tendency to encourage some physical soil parameters with biofilm treatments. The obtained results suggest that biodegradable film used as covers could be an alternative to the traditional plastic films widely used in the world. More studies are needed to evaluate changes in physical and chemical soil properties after using biofilm covering. We suggest that future investigations should include soils with contrast texture and weak soil structure.

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