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BIOGRATEX

Biodegradowalne wyroby włókniste

BIODEGRADABLE SPUN-BOND NON-WOVENS AS MATERIALS FOR MULCHES, NURSERY POTS AND DIRECT COVERS OF PLANTS

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BACKGROUND

Plastic covers for the soil and plants have been used in agriculture and horticulture production since the middle of the last century. These are mainly polyethylene films and polypropylene nonwovens, which can be applied in the cultivation of many plants[1]. A problem with most covers and mulches used in agriculture is the durability of these materials. Their usability ranges from one to 2-4 years, and they take many years to decompose in a temperate climate.

In recent years attention has focused on biodegradable polymers which can be converted to desirable fibrous products. Much of this attention is focused on polylactide (PLA) and polybutylene succinate (Bionolle)[2].

Poly(lactic acid) or polylactide (PLA) is an aliphatic polyester that can be produced from renewable materials such as corn, sugar or vegetables[3,4]. Compared with classical polyesters such as polyethylene terephthalate (PET), PLA products are characterised by a higher water sorption of 0.4-0.6% and better resistance to UV radiation. The latter feature, in combination with biodegradability, makes polylactide non-woven particularly useful materials or in agriculture.

Bionolle is biodegradable aliphatic polyesters produced by Showa Highpolymer. Bionolle is manufactured through a polycondensation of glycols with aliphatic dicarboxylic acids and additional chemical reactions.

These materials can be incorporated into the soil at the end of the crop season and undergo biodegradation by soil microorganisms. Recently biodegradable spun-bond non-wovens, besides mulches and covers [5, 6] are also used as materials for the production of biodegradable nursery pots.

Herein results of investigation carried out at the Experimental Station at Mydlniki by Krakow concerned the effect of mulches, direct covers and nursery pots made from PLA and Bionolle on microclimatic conditions and subsequent yield of vegetables.

AIM OF WORK

Evaluation of the applicability of a biodegradable spun-bonded non-wovens (in the form of mulches, direct covers and nursery pots) in the cultivation of vegetables.

MATERIALS AND METHODS

Raw material

Non-woven fabrics were manufactured from commercially available PLA and Bionolle.

- PLA 6251D (Nature Works LLC, USA) specifically designed for the spun-bonded technology. A molar mass of PLA 6251D M_n of 45 800 g mol^{-1} and a polydispersity M_w/M_n of 1.29 were determined by size-exclusion chromatography (SEC) with a multi-angle light scattering (MALLS) detector in methylene chloride. The glass transition temperature (T_g) and melting temperature (T_m), determined by differential scanning calorimetry (DSC), were equal to 61°C and 169°C, respectively.
- Bionolle (two grades) poly(butylene) succinate (PBS) and poly(butylene) succinate/adipate (PBSA), the copolymer of 1,4-butandiol and succinic acid/adipic acid, also known as 1000 series and 3000 series, respectively.

Spun-bonded technology

Prior to spinning, the polimers were dried for at least 4 h at 50-80°C (dew point -30°C) in a Piovan dryer that is part of the laboratory setup for studying non-woven fabrics manufacturing with the spun-bonded technique. The moisture content in the polymer was measured by the Karl Fischer coulometric method using the DL39X apparatus produced by Mettler Toledo (acceptable moisture content below 50 ppm).

The non-woven fabrics were formed by a spun-bond technique on a laboratory line designed and constructed by the Research and Development Centre of Textile Machinery Polmatex-Cenaro, Poland. The process parameters were as follows: a temperature in the range from 205°C to 216°C and a polymer throughput in the range of 0.10-0.43 g/min/hole can be used. The calender temperature was varied from 60°C to 130°C.

Parameter	Unit	PLA non-wovens	Bionolle non-wovens
Mass per unit area	g/m^2	20 – 100	50 – 100
Thickness	mm	0.12 – 0,40	0.20 – 0,40
Fibre diameter	μm	5 – 12	11 – 8
Tenacity in the machine direction	N	40 – 80	10 – 50
Tenacity in the transverse direction	N	20 – 40	10 – 55
Elongation at break in the machine direction	%	2 – 25	13 – 144
Elongation at break in the transverse direction	%	2 – 21	15 -113
Shrinkage in hot air 80 °C (60 °C)	%	0 – 60 (-)	- (0 – 4)
Time of biodegradation in laboratory conditions	week	4-16 (-)	- (0 – 4)

Tabele 1. Parameters of PLA and Bionolle non-wovens

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RESULTS

Kind of cover	Total yield. [kg m^{-2}]	Dry matter [%]	Soluble sugars [% f. m.]	Chlorophyll 'a' [mg g-1 f.m.]	Chlorophyll 'b' [mg g-1 f.m.]
PLA 20 g m^{-2}	4,64 b*	6,30 b	1,62 b	0,45 a	0,25 a
PLA 50 g m^{-2}	4,37 b	6,17 b	1,55 b	0,49 ab	0,27 ab
Control without cover	3,28 a	5,63 a	1,02 a	0,52 b	0,28 b

*Mean values marked with the same letters do not differ significantly at p = 0.05

Tabele 2. The effect of biodegradable nonwoven direct covers on total yield and quality of butterhead lettuce.

Total yield of butterhead lettuce cultivated under biobegradable covers is 40% higher in comparison with control (without covers).

Kind of cover	Early yield kg m^{-2}	Total yield kg m^{-2}
PLA 50 g m^{-2}	10,78 a	11,46 a
PLA NOVA 50 g m^{-2}	12,21 a	13,72 ab
Control without cover	11,10 a	11,91 a

Yield of tomato fruit harvested from plants grown in mulched soil was higher in comparison with control (without covers). *After 4.5 months biodegradable mulches can be incorporated into the soil.*

Tabele 3. Yield of tomato fruit harvested from plants grown in mulched soil.

AGRICULTURE APPLICATIONS OF BIODEGRADABLE NON-WOVENS

PLA non-wovens as a mulches in the cultivation of cucumbers.

PLA non-woven as a direct covers in the cultivation of leeks

PLA non-woven as a direct covers in the cultivation of cucumbers

Nursery pots made from Bionolle non-woven

Nursery pots made from Bionolle non-woven after five weeks in the soil

SUMMARY

Biodegradable mulches and direct covers had positive effect on the yield of vegetables. For this reason the use of biodegradable plastic materials in agriculture may be more ecological alternative to the polyethylene films, Biodegradable and direct mulches and direct covers fulfill successfully all the functions of the traditional plastic mulches.

Biodegradable nursery pots made from Biollolle degrade in a short time, instead of being left or burnt without any control, and reduce the contamination of the soil.

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