Biodegradable twines in horticulture

Greenhouse test tomato - contact with dealers and composters

Barbara Eveleens and Chris Blok

Report WPR-979

WAGENINGEN
UNIVERSITY & RESEARCH

Referaat
Lenzing fabriceert Lyocell touw van houtafval uit hernieuwbare gecertificeerde bossen in Europa. In een semi-commercieel kasexperiment was er geen breuk van het touw bij 162 planten met zware trossen. Dit biologisch afbreekbare touw behoudt zijn sterkte in een vochtige kas en kan een gewicht tot 18 kg dragen als de belasting langzaam wordt verhoogd. In dit experiment, was het gewicht van de plantstelen met 9 trossen fruit hangend aan het touw maximaal 6,5 kg. De biologische afbreekbaarheid bleek uit het binnen 4-6 weken uiteenvallen van het touw in vrij water in de kas. Verkleuring van het touw heeft geen invloed op de sterkte, aangezien het touw na 10 maanden telen een vergelijkbare breeksterkte had als nieuw touw. Door het gebruik van biologisch afbreekbaar touw tijdens het composteringsproces wordt de kwaliteit en verwerkbaarheid van de compost sterk verbeterd. Er is een toenemende belangstelling voor het gebruik van plasticvrije materialen, zowel vanuit economisch als ecologisch oogpunt.

Abstract
Lenzing produces Lyocell twine from wood residuals from renewable certified forests in Europe. In a semi-commercial greenhouse experiment there was no breakage of the twine in 162 plants with heavy trusses. This biodegradable twine keeps its strength in a moist greenhouse and can support a weight of up to 18 kg when the load is slowly increased. In this experiment, the weight of the plant stems with 9 trusses of fruit actually hanging on the twine was maximal 6.5 kg. The biodegradability is apparent as twines resting in free water disintegrate within 4-6 weeks in a greenhouse situation. Discolouration of the twines does not affect the strength as twines in a 10 month crop had a similar breaking strength as new twines. The use of biodegradable twines during the composting process creates a great improvement in the processing and quality of the compost. There is increasing interest in the use of plastic free materials both from an economic and environmental standpoint.

Reportinfo

Report WPR-979
Projectnumber: 3742281600
DOI-nummer: 10.18174/534525
Theme: Water and nutrients

Disclaimer

Address

Wageningen University & Research, BU Greenhouse Horticulture
Violierenweg 1, 2665 MV Bleiswijk
P.O. Box 20, 2665 ZG Bleiswijk
The Netherlands
T +31 (0) 317 - 48 56 06
F +31 (0) 10 - 522 51 93
glastuinbouw@wur.nl
www.wur.eu/greenhousehorticulture

Table of contents

	Summary		**5**
1	**Introduction**		**7**
	1.1	Background	7
	1.2	Aim	7
	1.3	Approach	7
	1.4	Personnel involved	7
2	**Material and methods**		**9**
	2.1	Greenhouse experiment	9
	2.2	Tests for strength and load	10
	2.3	Moisture	10
	2.4	Market orientation for the biodegradable twines	10
3	**Results**		**11**
	3.1	Greenhouse experiments	11
	3.2	Tests on strength of the twines	11
	3.3	Moisture	13
	3.4	Marketing	13
	3.4.1	Visit to Renewi (Hoek van Holland, Johan van Paassen, 2nd March).	13
	3.4.2	Visit to Brinkman ('s Gravenzande Martin Meuldijk (preparatory meeting February) and Steven Timmer (product manager, 3rd March))	14
4	**Conclusion**		**15**

Summary

Lenzing A.G. in Austria is interested in marketing biodegradable twines for commercial horticultural use. In a semi commercial 10 month truss tomato crop in Bleiswijk, the Netherlands, 162 twines showed promising results. There was no breakage during the crop and twines that were removed during and at the end of the crop showed no reduction in strength. The biodegradable twines broke at approx. 18 kg after a gradually increasing weight was applied. This maximum of approx. 18 kg was also reached if the twines were subjected to a sudden force. The weight of the truss tomato plants hanging on the twines was at maximum 6 kg in a greenhouse with a 5 m high gutter and 3.75 m free fall for the stem. The lower part of the plant stem and twine that were laying on the gutters in a horizontal position did not contribute to the weight of the plant (see illustrations). This extra strength is necessary for any unforeseen problems with the crop harvesting or crop care equipment.

The twines did discolour in contact with the plants, but this did not affect their strength. The complete twine had a moisture content of 13%. The twine consisted of 100% organic matter after treatment in a muffle oven. When the twines came into permanent contact with free water they disintegrated after 4-6 weeks. This is a positive property of the twines and makes them of interest for commercial composting companies.

The biodegradable twine is as easy to use as the standard synthetic twine except that the stringing of the plants at the start of the crop is slightly more difficult because of the suppler nature of the twine when compared to synthetic twine.

During a visit by representatives from Lenzing to the Netherlands we discussed the properties of the twine with Brinkman, Gravenzande, NL, a supplier of the whole range of horticultural sundries. Contact was established with Brinkman and the representatives of Lenzing and interest was shown in the twines. A visit to a waste material processing and recycling company, Renewi, Hoek van Holland, NL, showed that the costs of waste disposal are reduced if all the crop waste together with the supporting material can be composted. The use of biodegradable twines during the composting process creates a great improvement in the quality of the compost and also facilitates the processing of the mass in sieves and cutting equipment. This is an advantage of the biodegradable twines from Lenzing.

1 Introduction

1.1 Background

Lenzing AG, Austria is producer of among others biodegradable twines. The Lyocell twine is made from wood pulp from renewable certified forests in Europe.To encourage market developments, Lenzing asked Wageningen University & Research, Greenhouse Horticulture to test a product series for the stringing of greenhouse crops in high wire cultivation systems.

1.2 Aim

The aim of the experiments was to establish the load performance over time of the Lenzing twines in a practical greenhouse setting. Apart from the experiment, Wageningen University & Research assisted in contacting and visiting potential partners to accelerate market introduction of the twines.

1.3 Approach

It was decided to use tomato plants in a semi-commercial setting at the Wageningen University and Research Unit in Bleiswijk as tomato crops on commercial nurseries could not be used because of the incidence of the Tomato brown rugose fruit virus (ToBRFV). The test in Bleiswijk was on a trial of large truss tomatoes for a period of 10 months and on a trial of snack tomatoes for 5 months (the snack tomato crop was removed before the twines could be tested for maximum strength). The following points were used to draft this project:

1. Use the twine in research greenhouses in semi-commercial setting on approx. 300 tomato plant stems in the guard rows of greenhouse compartments.
2. Test the twines on strength and on whiteness before and after the cultivation period.
3. Deliver names of potential dealers and visit these dealers.
4. Deliver names of composters with an interest in biodegradable twine and visit these companies.

1.4 Personnel involved

The original contact via Lenzing was with Nicole Schram and Marina Crnoja-Cosic. In March 2020 Marina Cronja-Cosic and Robert Malinowsky from Lenzing visited the experiment at WPR in Bleiswijk, the Netherlands. Together with Chris Blok and Barbara Eveleens from Wageningen University & Research (WUR) Marina and Robert visited Brinkman (‘s Gravenzande, NL) and Renewi (Hoek van Holland, NL). The research in Bleiswijk was done by Barbara Eveleens and Aat van Winkel. Chris Blok (WPR) was the project leader.

2 Material and methods

2.1 Greenhouse experiment

Lenzing supplied Wageningen University and Research with 298 biodegradable twines on metal spools for two types of tomato crop grown under semi-commercial conditions at the research premises in Bleiswijk, the Netherlands. The unused twines were tested for breakage at the start of the trial. The ease of use of the twines was discussed with greenhouse personnel.

On 15th October 2019 136 twines were used to bind 4 rows of young tomato plants in a snack tomato crop in a 144 m^2 compartment (Figure 1).

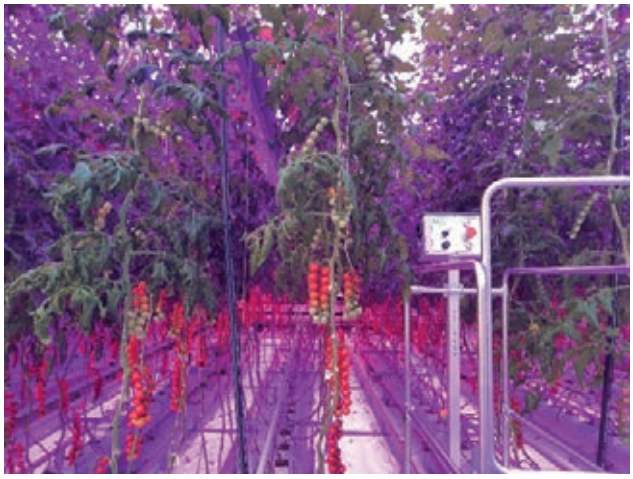

Figure 1 *8th January. Impression of the greenhouse with, in total 4 rows of 34 plants. The purple colour is caused by the LED-lighting in the greenhouse.*

On 17th December 2019 162 biodegradable twines were used to bind 6 guard rows divided over 3 greenhouses (each 144 m^2) of young tomato plants in a truss tomato crop (Figure 2). These twines were 14 m (11 m plus 3 m free fall).

Figure 2 *8th January. Impression of one of the three greenhouses with, in total 6 rows of 27 plants.*

The synthetic Biovalent twines show an interconnected pattern between the strands when opened out (Figure 3). The biodegradable twines show 10 separate strands (Figure 4).

Figure 3 *Synthetic twine biovalent.*

Figure 4 *Lenzing biodegradable twine.*

2.2 Tests for strength and load

In the greenhouse compartments the twines were regularly inspected for breakage. In the greenhouse the weight of the plant hanging on the twine was measured (Figure 5) using the crane scale (Figure 6). The strength of the twine was measured by connecting the twines to a crane scale and loading the twine using a lashing strap with a ratchet. The loading was done gradually as in the greenhouse situation but also with a sudden force as if something hit the twine. This test was carried out on new twines (synthetic Biovalent and biodegradable Lenzing) and repeated in June and September.

Figure 5 *Measurement weight of stem.*

Figure 6 *Crane scale.*

2.3 Moisture

The twines were observed for discolouration and degradability and the moisture level of the twines was measured. The twines were also measured for the organic matter component in a muffle oven at 450^{o}C. This removes all organic matter leaving mineral matter in the sample.

2.4 Market orientation for the biodegradable twines

To encourage market developments, representatives from Lenzing and WUR visited Renewi, a waste material processing and recycling company at the beginning of March 2020. This was to observe the effect of plastic twines in the waste crop residue and to discuss the advantages of biodegradable twines. Renewi collects waste and recycles this into useful products. We visited the premises in Hoek van Holland in the Westland area of the Netherlands where horticultural waste is the main waste product.

To learn the vision of important horticultural supply companies, representatives from Lenzing and WUR visited Brinkman (‘s Gravenzande). This meeting was preceded by a preparatory meeting with Brinkman and WUR at the end of February 2020. Brinkman is a horticultural sundries supplier and interested in biodegradable products for use in the international horticultural industry.

3 Results

3.1 Greenhouse experiments

The greenhouse with the snack tomatoes had been emptied before we could test the strength of the biological twines at the end of the crop. This was not our intention but the average weight per plant of the snack tomato crop was only 1.8 kg per plant at the end of the 7 months (measured using a crane scale). This relative low weight per plant will in our opinion not be a problem for the biological twine as the twine breaks at approx. 18 kg. There were no breakages of the twine in this crop.

The remaining 3 greenhouse compartments with biological twines in a truss tomato crop was followed until October, a crop of in total 10 month. The average plant stem weight with 9 trusses resting on the twines in these greenhouses was 4.7 kg in April and 5.6 kg in May and 4.7 kg in September. The lower value in September was due to the fact that the maximum truss weight fell from 1 kg in the summer to 0.8 kg in the late summer. There was no breakage of the twines in these compartments. The height of the wire on which the twines are hanging is approximately 3.75 m and the greenhouse gutter is 5 m. Even if the greenhouses have a higher gutter 3.75 m is normally the maximum height of the wire. A higher wire would make crop care more difficult and even dangerous.

Figure 7 *Work on high wire crop at 3.75 m.*

The biodegradable twine is as easy to use as the standard synthetic twine except that the stringing of the plants at the start of the crop is slightly more difficult because of the suppler nature of the twine when compared to synthetic twine. A film has been made of this step to show what is meant. A treatment of the first meter of the twine to make it less flexible could alleviate this problem.

3.2 Tests on strength of the twines

The strength of the twines in the 3 greenhouse compartments with truss tomatoes was measured with a crane scale. A twine was hung from a crane scale and the force was increased both gradually and quickly using a lashing strap and ratchet. This was done at the start of the experiment in December, in June and in September at the end of the experiment. The results show that there is no reduction in the strength of the twines between the new state at the start of the experiment and after contact with the plants for 6 and 9 months (Table 1). The maximum weight in this crop was approx. 6 kg and this twine was suitable for this type of coarse truss tomatoes as the total strength of up to 18 kg was sufficient. We do advise this extra strength (=12 kg) in case the harvesting or crop care machinery does catch or come into contact with the twines.

Table 1

Breakage of the twines as tested on a crane scale using a lashing strap and ratchet.

	breakage synthetic	Breakage biodegradable
	kg	kg
start	25*	18*
June	25*	18*
September	25*	18*

* The values are rounded off to kg because a more accurate reading using the crane scale was disputable.

The synthetic twine showed an uneven breakage of the individual strands while the Lenzing twine showed an equal breakage of the individual strands (Figure 8).

Figure 8 *Left breakage synthetic twine and right breakage Lenzing twine.*

The twine is discoloured after contact with the lower part of the plant (Figures 9 and 10) but this does not affect the strength of the twine. In this experiment clips (Figure 11) were used in both the synthetic twines and the biodegradable twines because in the spring the stem at the top of plants was thin (plants were generative) and when the plants were wrapped around the twine for support, the twines could damage the stems. This is applicable for all types of twine. The twine was therefore not in contact with the plants from April onwards but at the start of the crop the twine was wrapped around the stems (Figure 9). Measurement of the strength of the twine was done over the whole length of the twine including this lower end that had been in contact (wrapped around the stem) with the plants for 10 months.

Figure 9 *Discolouration of twine*

Figure 10 *Discolouration of lower twine*

Figure 11 *to illustrate the clips used in the trial.*

3.3 Moisture

In this greenhouse with truss tomatoes the moisture levels were up to 90% RV during the night. The moisture of the biodegradable twines from the greenhouse was measured in September. The complete twine had a moisture content of 13%. The twine consisted of 100% organic matter after treatment in a muffle oven. The twines became wet if they were trailing in the gutter at the start of the experiment (Figure 12). Degradability was observed within 4 to 6 weeks if the twines came into permanent contact with free water as is shown in Figure 13. These loose ends of twine are from the attachment of the twines to the plants (simple knot, left in Figure 13). These remaining free ends after the knot should not be too long. Once the plants are lowered the twines that lay in a horizontal position do not need to hold a plant upright (Figure 14). Any discolouration of the horizontal part is irrelevant but free water could cause disintegration of the twines and could damage the stem of the plant. No free water or disintegration was observed. Later clips were used and the twine remained clean.

Figure 12 *Water absorption of twine.*

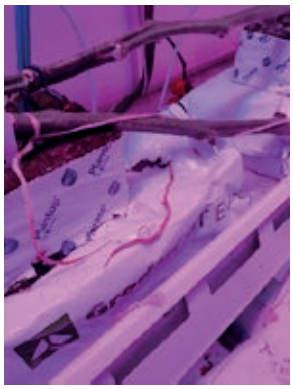

Figure 13 *Disintegration of twine.*

Figure 14 *The twines in horizontal position without function.*

3.4 Marketing

3.4.1 Visit to Renewi (Hoek van Holland, Johan van Paassen, 2nd March).

Plastic twines are the main source of plastic in 270000 ton plant residue (55000 horticulture, remainder public green, gardening companies and roadside maintenance). The price is recently differentiated depending on the absence of synthetic twine and plastic clips. Cost range from 72 Euro/m^3 to 32 Euro/m^3. In November, most horticultural material is delivered and composted in 2 weeks (in covered cells with oxygen and moisture control) then outside storage until March. Therefore, degradation in 4 months is acceptable. Iron rings from clips are not much of a problem as they are harmless in open fields and removable anyway. A Renewi special is the wet, sticky product from tomato and pepper leaves to cover bulb fields as a mulch to consolidate the sand that would blow away in the winter if not fixed. For this product plastic is a problem, as the microplastics of partial degradation accumulate in the top layer (Figure 15).

Figure 15 *Small strands of plastic in compost.*

Tomato and plastic truss holders.

Piles of compost at Renewi.

3.4.2 Visit to Brinkman ('s Gravenzande Martin Meuldijk (preparatory meeting February) and Steven Timmer (product manager, 3rd March))

Brinkman offers organic PLA (poly lactic acid) twine, Viscose twine and brownish jute twine as biodegradable twine. All twines are more expensive and technically inferior to the standard synthetic twines. PLA is produced from plant sugars (maize, tapioca) but this could as well be milk residue or household waste derived PLA. The twine is made in the same way as 'normal' polypropylene twine. It is spun and then several twines are twisted together (tiers), to improve strength. The twine, dependent on the circumstances, breaks down in industrial compost in 5 to 8 weeks into an unrecognizable, humus like substance. PLA, for tomato as the most demanding crop, breaks at 44 kg and is not sensitive to UV. The twine can also be supplied in an O-configuration (customized delivery); i.e. with a per grower defined free length for fast release of the first wire to slab distance. Weight of this twine is 2 times heavier than PP; weight is important parameter for shipping. Certificates mentioned were TUV-Austria and Vincotte.

Lenzing makes Lyocell twine from wood pulp from renewable certified forests in Europe (close to source). This wood pulp is waste (beech) wood from the furniture industry. Even waste cotton could be used, and this is added to the pulp. The wood is broken down into single molecular units and then re-assembled. Chemically the result is similar to viscose. However, viscose is produced in a chemical process requiring substantial amounts of debatable chemicals. Lyocell is produced by using temperature and pressure steps. The twine is very compostable which was affirmed by observations in these greenhouse trials in Bleiswijk.

Problems could be storage (up to two years is common), higher RH in greenhouse (problematic for cotton and viscose) and sulphur vapours used to suppress fungal disease. Stretching of the twine is a problem with peppers and aubergines i.e. rigidity is favoured.

4 Conclusion

The Lyocell twine from wood pulp from renewable certified forests in Europe made by Lenzing shows promising results in a truss tomato crop of 10 months. There was no breakage of the twine in a crop with heavy trusses under semi-commercial conditions. This biodegradable twine keeps its strength in a moist greenhouse and can support a weight of up to 18 kg when the load is both slowly or suddenly increased. In this experiment, the weight of the plant stems with 9 trusses of fruit actually hanging on the twine was maximal 6 kg. The extra strength of the twine (12kg) is necessary for any accidents with crop harvesting or crop care machines.

The biodegradability is apparent as twines resting in free water disintegrate within 4-6 weeks in a greenhouse situation. Free water is present in gutters and on the top of the stone wool blocks in which the plants stand. Discolouration of the twines does not affect the strength as twines in a 10 month crop had a similar breaking strength as new twines. In this experiment the twines were placed in a clip after 3 months and so the twine did not touch the plant. When the strength of the twine was tested the whole twine was used including the part that had been in contact with the stems from the start of the 10 month experiment. The clips were added in April to protect the thin growing tips. The use of clips is common in high value growing as the clips prevent the wire from pressing into the soft stem during growth, which is thought to hamper the flow of water and nutrients through the stem. In low production countries, clips are less common because of the related costs.

The biodegradable twine is as easy to use as the standard synthetic twine except that the stringing of the plants at the start of the crop is slightly more difficult because of the suppler nature of the twine when compared to synthetic twine.

The use of biodegradable twines during the composting process creates a great improvement in the quality of the compost and also facilitates the processing of the mass in sieves and cutting equipment. There is increasing interest in the use of plastic free materials both from an economic and environmental standpoint.

To explore the potential of nature to improve the quality of life

Wageningen University & Research,
BU Greenhouse Horticulture
P.O. Box 20
2665 ZG Bleiswijk
Violierenweg 1
2665 MV Bleiswijk
The Netherlands
T +31 (0)317 48 56 06
www.wur.nl/glastuinbouw

Report WPR-979

The mission of Wageningen University and Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 5,000 employees and 12,000 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.