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Research Update

Welcome to the PBS International Research Update

In this edition, we share research about our pollination control tents for large-scale field projects, introduce new studies to understand pollination control in cannabis, and follow up on research highlighted in previous Research Update.

The papers featured show how our state-of-the-art **dura**web® materials can support plant breeding efforts reliably and economically by:

- reducing the risk of pollen contamination.
- increasing seed production.
- promoting favourable growing conditions.

Our innovative pollination control bags and tents are developed to meet the needs of the plant breeders and seed producers we serve, so our customers' needs guide our research investments.

If you have pollination control challenges, get in touch!

Stay in touch

Contact us at **enquiries@pbsinternational.com** to share your thoughts about research in this update or suggest future research ideas. Follow us on **Instagram** and **LinkedIn** for the latest news, product information and research updates.

Key findings

PBS International duraweb® pollination control tents (PCTs):

- ✔ Yield up to 36% more fescue seed than open pollinated controls.
- ✔ Prevent pollen cross-contamination in anemophilous crops.
- ✔ Control pollination over larger areas and with multiple plants without sacrificing genetic purity.

PBS International duraweb® pollination control bags (PCBs):

- ✔ Increase loblolly pine cone survival, with 35% less labour and an estimated 60% more seeds per bag
- ✔ Outperform paper and cellophane for pollination control and seed set in many species.
- ✔ Eliminate bird damage, prevent pollen contamination and result in less grain mould in sorghum.

Pollination control tents deliver pollen proofing & improved seed yield

Two research studies with our pollination control tents reveal positive results for large-scale breeding projects in anemophilous crops.

Grass seed yield boosted by up to 36%

A study carried out in collaboration with the Noble Research Institute at field sites in Oklahoma evaluated the feasibility of using various sizes of novel nonwoven fabric Pollination Control Tents (PCTs) to replace the standard isolation plots typically used in grass breeding programmes.

Over two years researchers studied the impact of two different fabric types 'DWB10' and 'DWB24', on the seed yield and genetic integrity of tall fescue lines, using two sizes of tents.

Key findings from the research include:

- The smaller DWB10 tent showed up to a **36% increase in seed yield** over open pollinated control plots.
- There was **no evidence of pollen contamination** in any of the tent fabrics tested.
- The microclimate inside tents may contribute to **high-yield and disease-free seeds**.

Overall, tents of both fabrics generally resulted in slightly taller plants with higher seed yield versus the open pollinated control. There was **no evidence of pollen contamination** – as assessed by two methods. There was little difference among treatments and locations for the final seed germination at 21 days after sowing. This data suggests that **seed produced in PCTs is as viable as seed sourced from open-pollinated fields.**

The average temperature within tents was higher with lower average humidity than the control, producing a **microclimate that may contribute to high-yield and disease-free seeds**.

This promising research demonstrates that PCTs made of novel nonwoven fabrics could help support breeding efforts in grasses. This study's results catalyzed a plan to improve the PCT design and test the novel materials in different crops to assess the production and economic considerations for plant breeding programmes.

Read the research paper

Source: Trammell M, Pittman D, Virk DS, Senior H. (2020). Assessing the effectiveness of nonwoven fabric pollination tents for improved grass breeding. J. Plant Breed. Crop Sci. 12(3):200-218.

Key findings about PCTs

- support larger-scale breeding efforts, with excellent pollen-proofing.
- produce seed quantities similar to or better than open-pollinated controls.
- maintain favourable microclimates.
- provide a reusable, economical and flexible solution for hybridising, scaling up or crossing an anemophilous crop.

Maintaining genetic integrity in sugar beet

A study, conducted in 2019 in collaboration with the Lion Seeds' UK research station, was developed to test the effectiveness of the PCT fabrics PBS International had developed for keeping wind-borne sugar beet pollen away from cytoplasmically male sterile plants. These plants were covered by mini tents made from several different **dura**web® trial materials.

The work found that there was **no contamination by foreign pollen** in the fabrics despite a pollen rich environment surrounding the structures apart from those which developed damage causing pollen ingress. The **dura**web® fabrics' physical complexity creates a tortuous path that makes entry of foreign pollen difficult, and is credited for keeping genetic contamination at bay.

The research also demonstrated **that none of the tested fabrics caused a significant deviation in the micro-climate** that could adversely affect the plants' performance. The open-pore material makes PCTs more air permeable for better temperature and humidity control, and it allows for more light transmission, which is essential for optimal seed production. The data suggest that PCTs do not alter the plant growing environment so much as to affect sugar beets' production potential.

These data remain provisional, based on limited data from one season at one location, although the trial is being repeated in 2021.

The authors suggest the preliminary results may indicate that PCT materials **can maintain genetic integrity** in breeding operations such as crosses, generation advance of progenies, seed increases for multi-locational testing and for maximizing isolations with limited space in a single season.

Read the research paper

Source: Townson P, Virk DS, Senior H (2020). Evaluating the pollen proofing of nonwoven synthetic fabric pollination control tents for sugar beet. J. Plant Breed. Crop Sci. 12(2):228-236.

PBS International pollination bags lead to CMP success in loblolly pine

In 2014 PBS International began work with the North Carolina State University Tree Improvement Program (NCSU-TIP) to identify a favourable alternative to the kraft paper bags used by loblolly pine seed producers in their Controlled Mass Pollination process. After years of development and study, results show that the bags now known as PBS CMP.55 produce two benefits over kraft paper: increased seed production and reduced labour requirements.

Loblolly pine is among the most critical commercial forest tree species worldwide due to its wide adaptability and suitability for production purposes. To produce full-sib seed in pine orchards, breeders use a pollination bag to isolate female strobili from outside pollen contamination before receptivity. The desired pollen is applied when the female strobilus is at maximum receptivity.

Kraft paper bags used in this process, however, are susceptible to tearing and damaging the flowers. PBS International partnered with NCSU-TIP to develop a new pollination bag to give better economic return during the controlled mass pollination seasons.

The goals were to:

- **compare the survival of strobili covered by the nonwoven prototype pollination bags made by PBS International to the industry standard kraft paper pollination bag with and without a support wire.**
- **assess the efficiency of seed production under different pollination bag types.**

A multi-year study compared a total of 13 prototypes at more than nine seed orchard sites across the southeastern United States. Several materials and designs outperformed the kraft paper, but the CMP.55 bag performed the best overall.

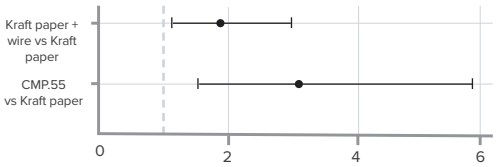
Key findings about the CMP.55 bags from this research:

- Resulted in 3 times greater odds ratio of survival compared to kraft paper without wires.
- Significantly faster to install and remove than kraft bags with wires – reduced labour by 35%.
- Saw 20% more conelet survival at June drop compared to other bags.
- Effectively eliminated bag failure.

As a result of this study, it is clear that PBS CMP.55 pollination bags offer significant benefits over the standard paper bags that are currently used for loblolly pine controlled mass pollinations.

Read the research paper

Odds ratio for cone survival



Odds ratio of strobili survival at cone harvest with 95% confidence limits vs Kraft paper bags.

Labour requirements: PBS vs Kraft Paper + Wire

Bag type	Bagging	Pollination	Bag removal	Total
CMP.55	35.1	16.2	24.3	75.6
Kraft paper + wire	65.8	16.4	34.6	116.8

Estimated time (seconds per bag) for installation, pollination and bag removal.

Expected seed yield

Bag type	Cones per bag	Seed / Cone	Expected seed per bag
Open Pollinated	6.7	114.4	762
CMP.55	6.2	83.2	514
Kraft paper + wire	5.4	79.5	426
Kraft paper	4.2	77.1	320

Source: Heine AJ, Walker TD, McKeand SE, Jackson BJ, Fikret I. (2020) Pollination bag type has a significant impact on cone survival in mass production of controlled pollinated seeds in loblolly pine. Forest Sci. 66(5):589–599. All charts adapted from this paper.

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Seeking answers for pollination control in cannabis and hemp

The global legal marijuana and CBD market is expected to grow at 14% and 21%, respectively, between 2021 & 2028. But for pollination control there are plenty of challenges to overcome in this relatively new market. PBS International is on the case.

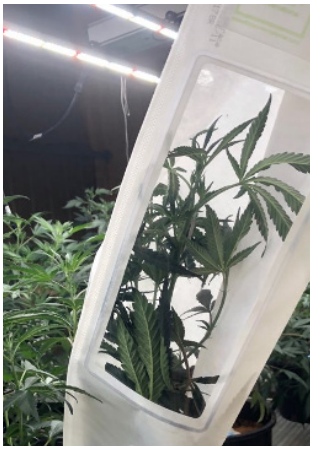
Cannabis sativa pollen is small, light and produced in prodigious quantities. This presents a challenge for those in the hemp and cannabis world who may have very different pollination control needs.

Farmers producing hemp for seed and for CBD can be at odds with each other. Seed production relies on copious fertilisation with little regard for where the pollen originates, whereas CBD producers prefer unfertilised flowers because they produce more phytochemicals. Hemp-seed fields produce a lot of pollen which disperses widely, so neighbouring farmers commonly use temporal and spatial isolation for pollination control to manage these antagonistic challenges.

However, for hemp & cannabis breeders these controls are not enough. To ensure genetic purity, breeders must segregate individual crosses from any unintended wind-borne pollen.

A common solution is to dedicate a glasshouse or growth room to each cross. This is not ideal - it is expensive, limits production capacity and can be inflexible. It can also be overkill if only a small quantity of seed is needed.

Some breeders rely on paper or polythene bags to control crosses but in a crop which is highly sensitive to mold, disease pressure is a major risk.



To improve on current solutions, PBS International has initiated a research study in partnership with PureGene AG, a Swiss company committed to improving cannabis genetics. The project aims to test the efficiency and effectiveness of a range of PBS International prototypes in facilitating crosses in cannabis both indoor and out. Researchers will collect data on seed set, growing environment and plant health.

We're excited to invest in this research to give the cannabis industry much-needed tools for effective pollination control.
Look for study results in the next PBS International Research Update.

Does one nonwoven material suit all species?

Research funded by InnovateUK and executed in collaboration with both academic and commercial partners demonstrates a complex picture of which pollination control bags (PCBs) perform best for both pollination control and seed set.

The collaborators set out to explore the interaction between species, environment & pollination bag type, hoping to shed light on what makes an optimal pollination bag. The species chosen for this study represent a variety of breeding systems, default PCB types and pollen sizes including **Arabidopsis, wheat, Miscanthus, and sugar beet**.

Six novel nonwoven PCB fabrics were developed & tested across species. Nonwoven fabrics consistently outperformed paper and cellophane, as a group, for pollination control and seed set, but the characteristics of the optimal nonwoven material was not consistent across species or environmental settings. The authors propose that this could be due to crop-specific pollination mechanisms and variation in the environmental conditions required for successful crossing and seed production.

Interestingly, coloured PCBs were found to be detrimental to seed yield; **white-coloured bags resulted in better seed production than any other colour tested**. This conclusion reinforces that the full range of wavelengths are required for healthy seed development, which is important as the material development aspect of the study aimed to increase light transmission of PCB materials.

Overall this research indicates that different PCB materials can optimise species performance during crossing, but that it is unlikely that one fabric type will perform equally well for all crops.

PBS International is dedicated to using sound science to deliver state-of-the-art, reliable and cost-effective pollination control materials, which means further research is needed on a crop-by-crop, application-by-application basis.

Key Findings:

- The optimal fabric for pollination control and seed set varies by species
- Nonwoven materials as a group consistently outperform paper & plastic bags
- Coloured bags are detrimental to seed yield

UKRI Innovate UK · Prifysgol Aberystwyth University · NIAB

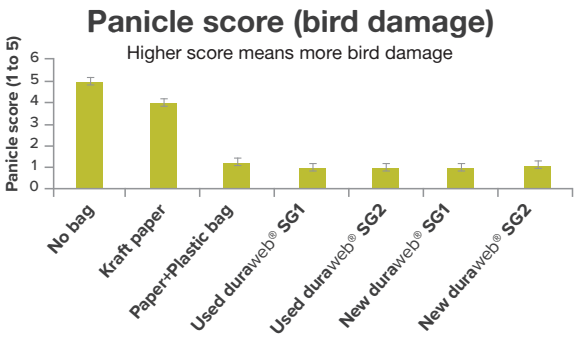
Revisiting sorghum research

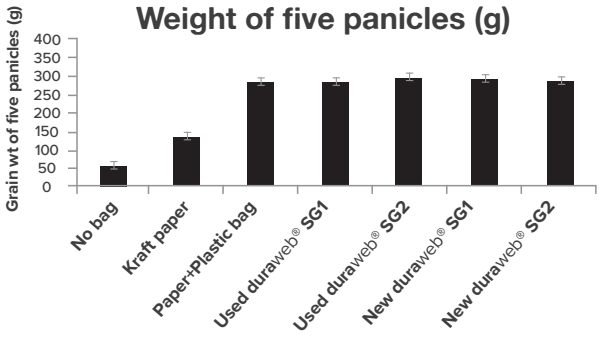
Our last research update highlighted studies that support using nonwoven bags for sorghum pollination control to eliminate bird damage and improve grain yield. Subsequent research:

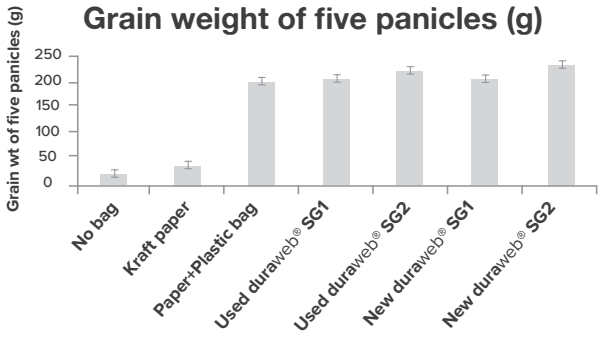
- replicated the findings that nonwoven pollination bags perform well with high levels of bird pressure.
- demonstrated pollination bags made from **dura**web® fabrics can be successfully re-used, but with an increased risk of some diseases.
- assessed the relative occurrence of seed-borne diseases within pollination bags.
- nonwoven PCBs compared favourably against labour intensive use of paper plus additional plastic screening.

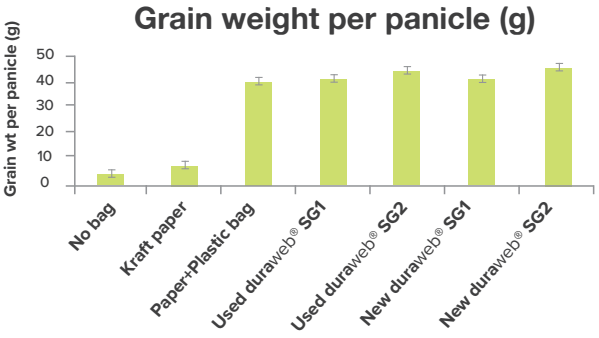
Studies over two years revealed the superiority of nonwoven pollination bags over the traditional kraft paper bags where bird pressure creates problems for sorghum breeding. Nonwoven bags virtually **eliminated bird damage** and resulted in **greater total panicle weight, total grain weight and average seed weight per panicle** than paper bags across three sorghum varieties. The work also provided evidence that **novel pollination bags are reusable** provided they are cleaned, sterilised or chemically treated between seasons.

Read the research paper









Bar diagrams for mean values (±SE) of bag treatments over all varieties for different traits.

References:

Schaffert RE, etal (2016). Comparing pollination control bag types for sorghum seed harvest. J. Plant Breed. Crop Sci. 8(8):126-137.

Schaffert RE, etal (2017). Are nonwoven synthetic pollination bags a better choice for sorghum breeding? J. Plant Breed. Crop Sci. 10(3):58-68.