Sprayable biodegradable mulch

Ending Plastic Waste Symposium 2024

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Systems Program

CSIRO Agriculture and Food

Outline

- Plastic mulch films – benefits and problems
- Changing climate and farm viability
- A ‘new’ sprayable biodegradable mulch – GRDC project
  - Adaptation of an ‘exiting’ technology
  - Application to broadacre
  - Role of crop residues

Plastic mulch films (PMFs)…

PMFs account for ≈45% of all agricultural plastics

- >9.1B people to feed by 2050 (same arable area)
- USA led application of PMFs from the 1950s onwards
- China now has >20M ha covered with PMFs = 25%↑ in yield
  - Asia-Pacific is largest user of PMFs
- Globally, >400 Mt virgin plastic/year at a CAGR of 1.2%
  - PMFs = >2.3 Mt/year at a CAGR >6.5%
- **EU have initiated stricter regulation, e.g., the SUPD in Jul21**

Multiple benefits of plastic mulch films…

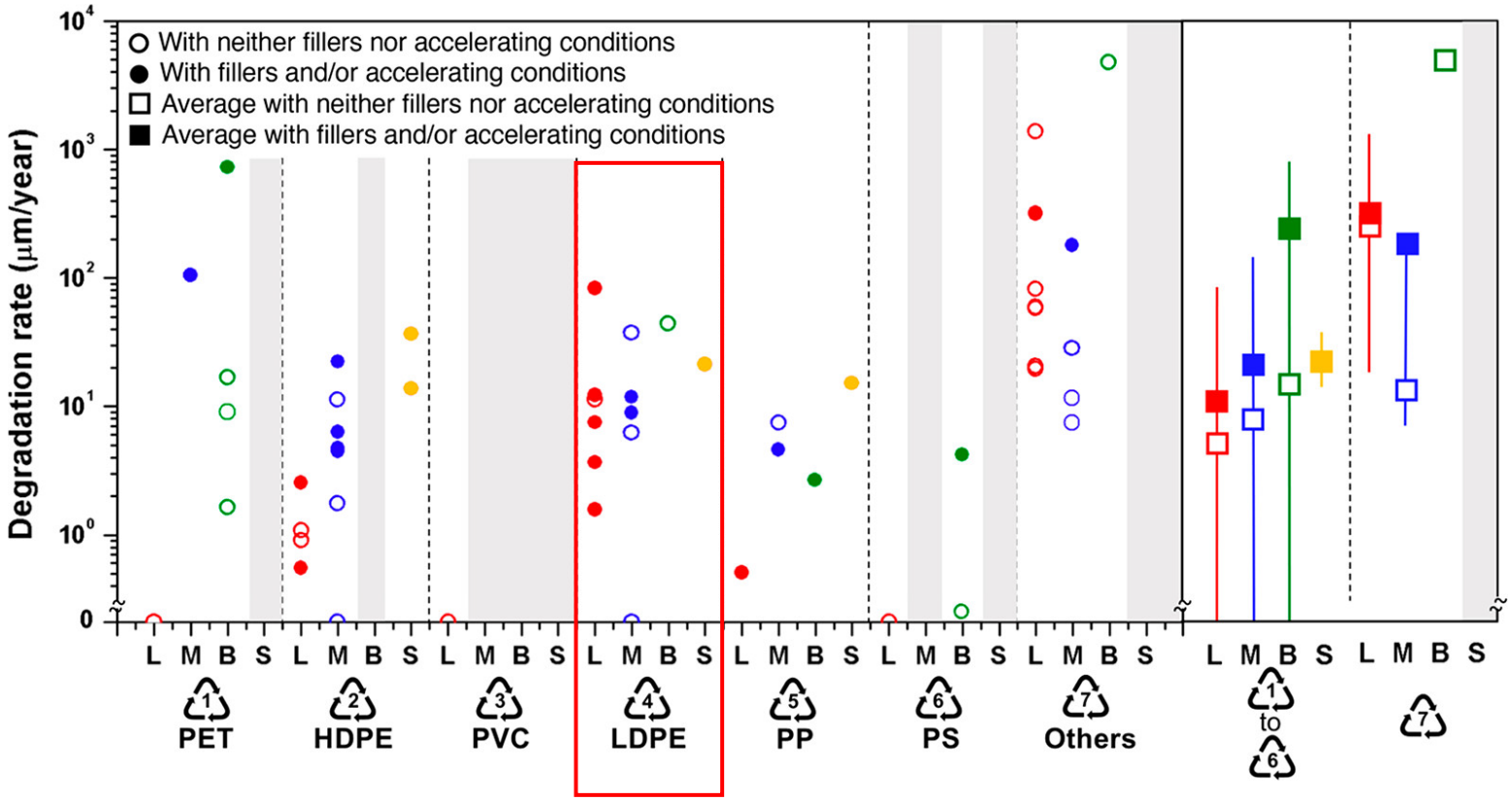
Use of PMFs improves crop productivity

- Reduce soil water evaporation, suppress weeds, increase transpiration
  - Black plastic – increase soil and air temperature
  - White/silver plastic – increase light, decrease soil and air temperature
- Reduce soil erosion
- Reduces staining of fruit/vegetables
- Controls insects and reduces pesticide use

Problems with PMFs

- Most PMFs are not readily biodegradable…
  - High volume of waste generated by plastic mulches
  - Burning plastic mulch has undesirable environmental impacts; release of GHG's, dioxins and other airborne pollutants
  - Plastics are accumulating in and polluting soil and water systems… a growing global problem (especially China)…
- High dollar cost to retrieve and dispose of used plastics…
- Future legislation to phase out their use in agriculture…

Degradation profile of plastics



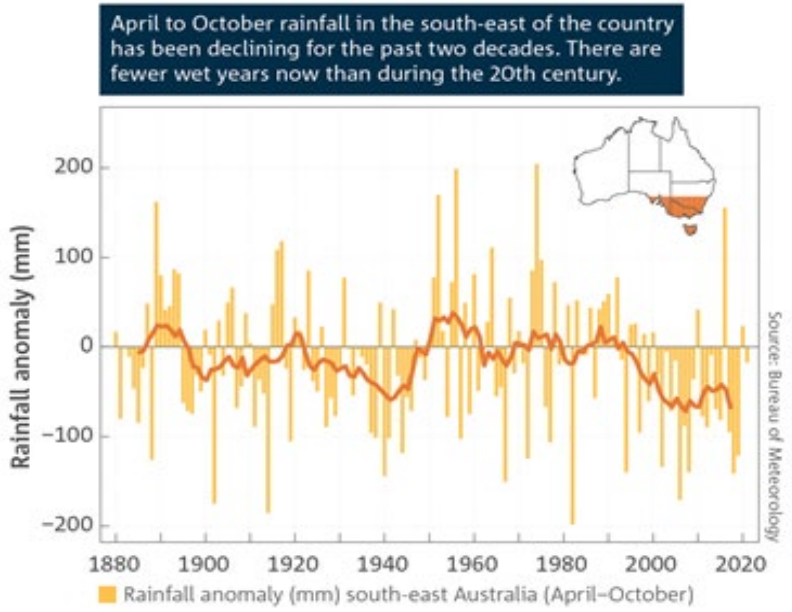
7 – 250 μm

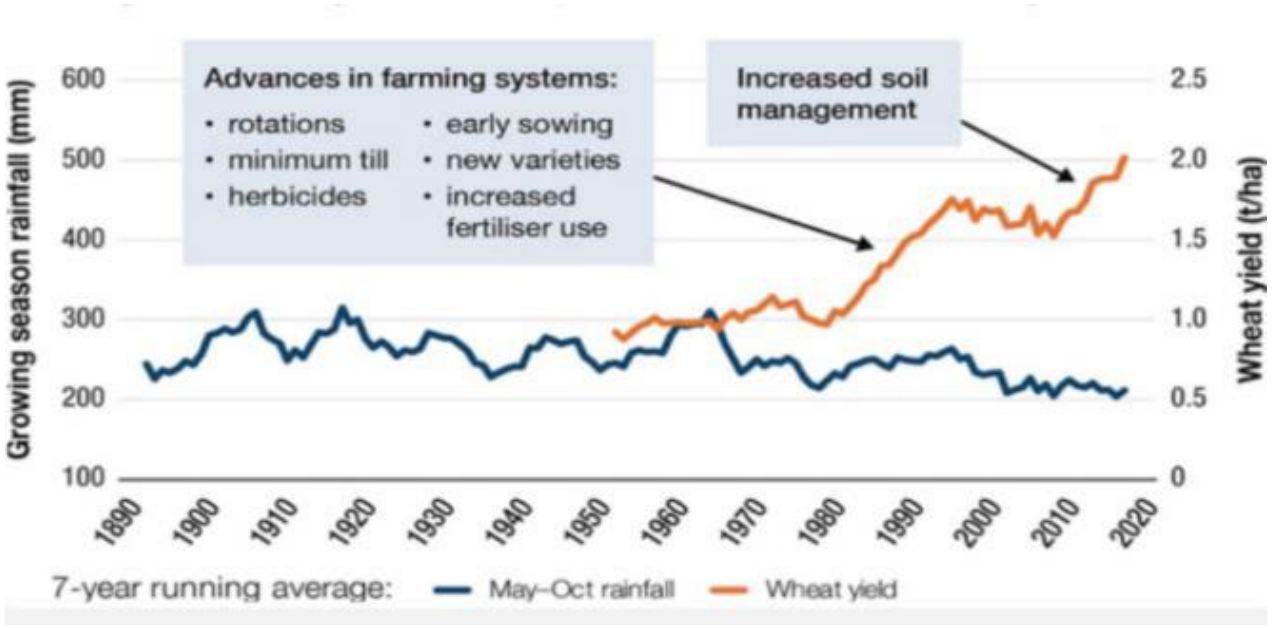
Specific surface degradation rates for various plastics, in μm $year^{-1}$. Vertical columns represent different environmental conditions (L, landfill/compost/soil; M, marine; B, biological; S, sunlight) and plastics types (represented by their resin identification codes). Plastics type 7, "others", corresponds to various nominally biodegradable plastics. The range and average value for plastics types 1–6 are shown on the right as lines and squares, respectively, as well as for biodegradable "others". Data points representing degradation rates that were unmeasurably slow are shown on the *x*-axis. Gray columns represent combinations for which no data were found.

Degradation Rates of Plastics in the Environment, Ali Chamas, Hyunjin Moon, Jiajia Zheng, Yang Qiu, Tarnuma Tabassum, Jun Hee Jang, Mahdi Abu-Omar, Susannah L. Scott, and Sangwon Suh, ACS Sustainable Chemistry & Engineering 2020 8 (9), 3494-3511, DOI: 10.1021/acssuschemeng.9b06635

Farming systems innovation for....

Ongoing gains in productivity, profitability and sustainability in the face of climate challenges, and limited land and water use





By 2027, develop a sprayable biodegradable mulch (SBM) that enhances rainfall capture and/or soil water storage to increase Australian broadacre yield and profit, reduce production risk, and is viable for commercialisation

A CSIRO SBM that is an aqueous emulsion of polyurethane (PU)…

- Water saving (up to 30%)
- Reasonable weed suppression
- Biodegradable
- Mechanical (spray) application
- *Cost parity with plastic*
- No waste, collection or disposal
- Adaptable application

SBM-TranspiratiONal

Broadacre numbers – to PU or not to PU?

Assume mulch on 10M ha of Australian broadacre (two applications)

- Current SBM applied@1.5 kg/m^2 (@20% w/w PU and 60% area coverage) = 3.6M tonnes of PU
- Global PU = 32M tonnes by 2030 & production cost = $3K-6K/ton

Consider crop residues. AV. grain yield ≈2.4 t/ha or crop biomass ≈6 t/ha

- Cellulose-SBM to work as a hybrid composite film or foam
- Soil type and mode of application will be important
- Film needs to provide resistance to WVT, have resilience & be low-cost
- **Exploitation (circular use) of crop residues, and other waste streams, is now a key strategy in many OECD nations**

Biodegradable mulch (from crop residues)

Crop residue

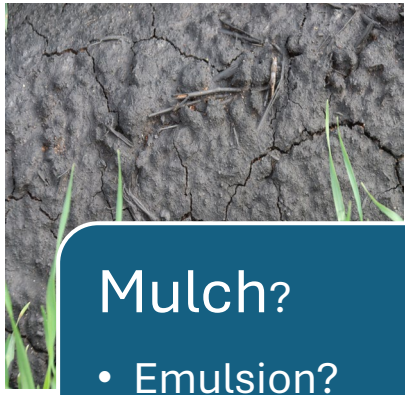
- Residue?
- Chaffed?
- Pulped?

Pulp/chaff

- Refined?
- Activated?
- Pre-polymer?

Plasticizer?

- None?
- Polyurethane?
- Other?



Mulch?

- Emulsion?
- Semi-solid?
- Properties?
- Rate?

Acknowledgements - project team…

- GRDC – funding agency
- CSIRO A&F – project leadership, formulation, characterisation, modelling inc. degradation, application & field trials (Werribee VIC, Waite SA, Black Mountain ACT & Myall Vale NSW)
- Dr Raju Adhikari – inventor of CSIRO's SBM
- CSIRO Manufacturing (Clayton VIC) – formulation & characterisation
- University Queensland (St Lucia QLD) – formulation (cellulose)
- Agriculture Victoria (Horsham & Bundoora VIC) – modelling & field trials
- DPIRD WA (Esperance & Meredin WA) – field trials
- Boron Molecular (Noble Park VIC) – batch processing, initial scale-up

Thank you

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