Spent Mushroom Substrate in a Circular Economy

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Project Background

- "Recycling spent mushroom substrate (SMS) for fertiliser in a circular economy (MU21006)"
- Why strengthen linkages between the mushroom industry and grain growers?
- Can the 'value proposition' of SMS for grain growers be enhanced by value-adding?

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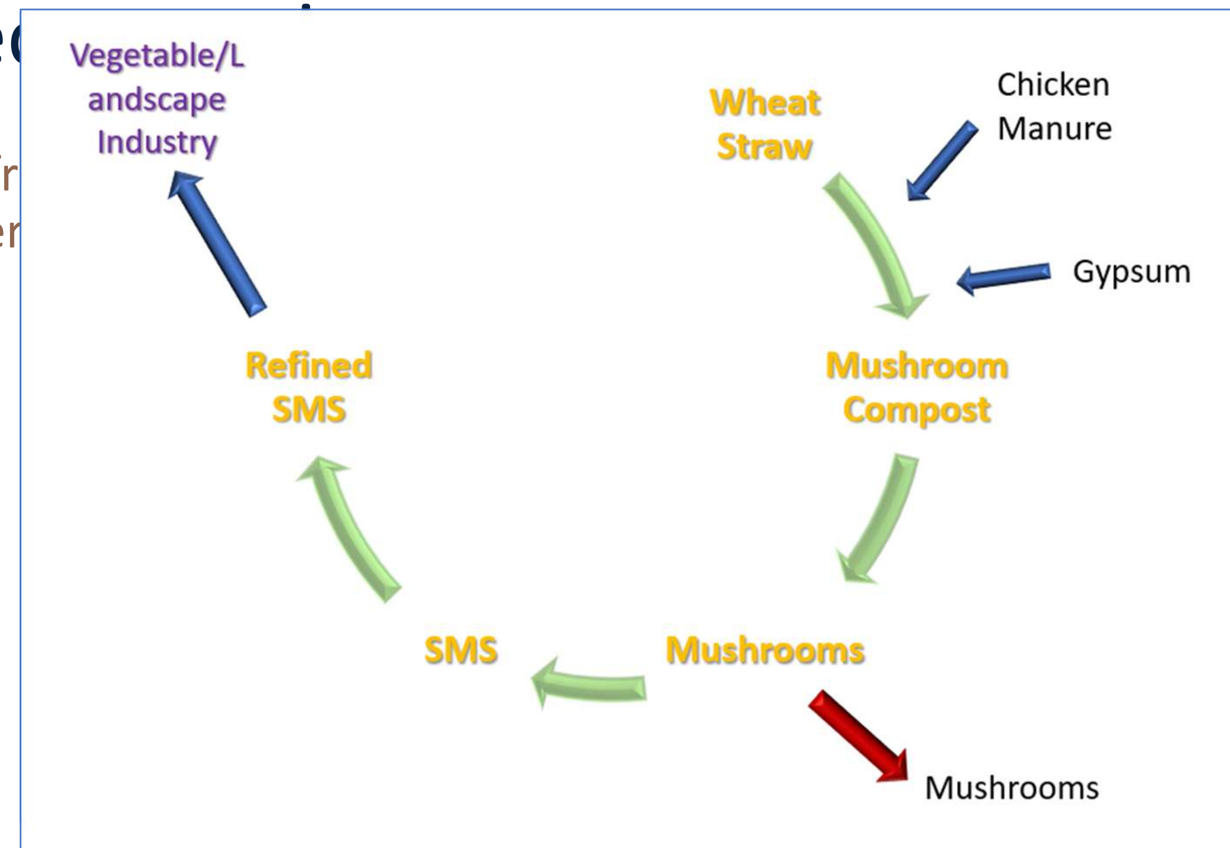
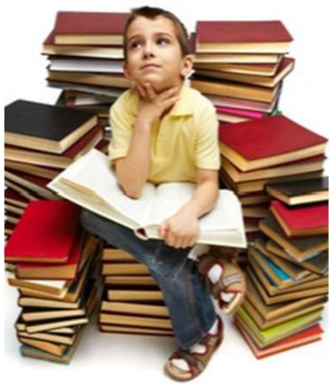
- A move away fr sposing, to models wher



Project methodology

- Desktop review on potential for value-adding to SMS
  - Technical, economics, logistical opportunities and barriers
- Supply chain mapping – straw supply in relation to mushroom producers/composters
- Establishing "value proposition" of SMS to grain growers
  - Physico-chemical characterisation
  - Interviewing grain growers
- Next steps to be determined with assistance from industry
  - Product development/demonstrations?
  - Field trials (grains or vegetables)?



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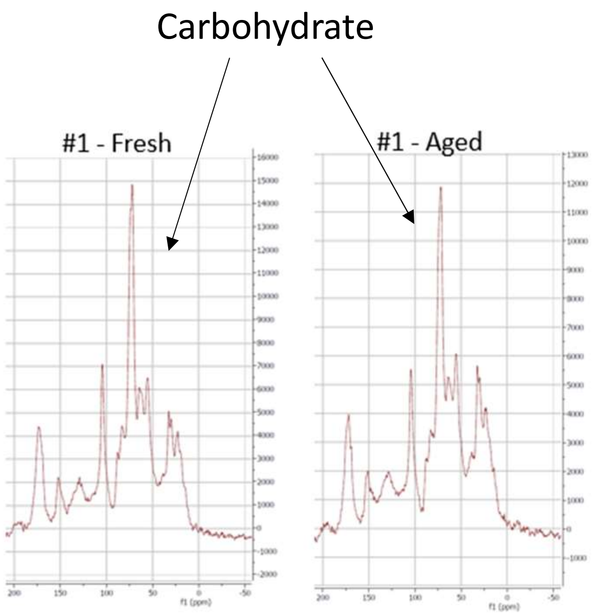
Composition of SMS

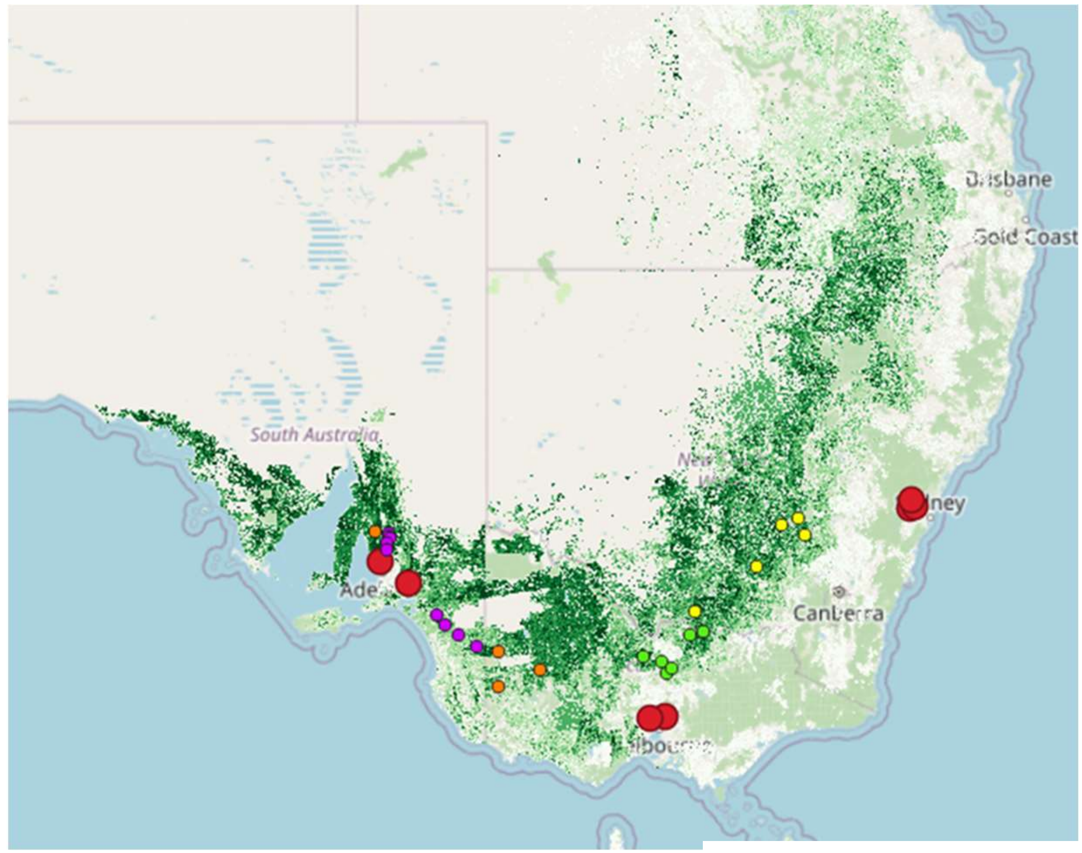
- High moisture content - ~ 50% - 70%
- Carbon is 25 – 35% of total product (DW)
- Similar C composition as greenwaste/decomposed straw
- High carbohydrate content, rapidly decomposed by soil microbes
- Limited, if any, long-term soil C benefit
- Nutrient levels in similar range to other organics
- Slow and unpredictable release of nutrients



Supply chain mapping

- Mushroom farms located in or near capital cities (red dots)
- Green shading indicates wheat production areas (deeper green, higher production areas)
- Coloured dots indicate current locations that straw is being drawn from

Mushroom farms are located significant distances from straw supply



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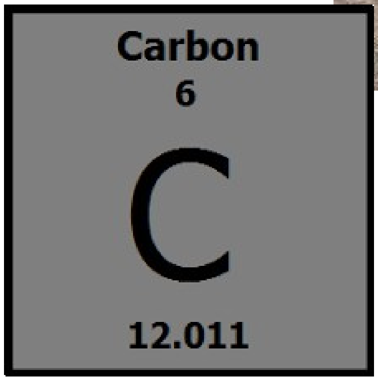
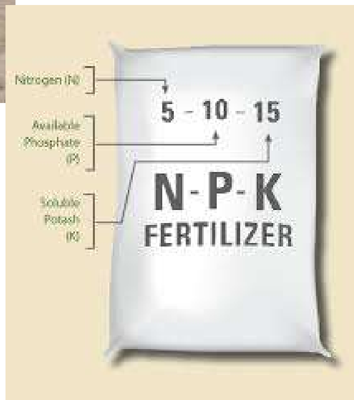
Currently under utilised resources = opportunity?

SMS

- Nutrients
- Carbon

Empty Trucks





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Australian wheat- snapshoot

Winter crop

- Sown March-June
- Harvest Late Oct – Early January

Nutrient Usage – Macronutrients Crop Removal rates (5t/ha yield)

- Nitrogen – 100kg/ha
- Phosphorus – 17.5kg/ha
- Sulfur – 13.75kg/ha

Soil Amendments

- Lime – pH
- Gypsum - Sodicity

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Australian wheat production- logistics

Main SMS application window

- Between harvest and sowing – essentially late summer – early autumn

Storage of SMS – Needs to move year round to align with truck movements

- Degradation of SMS in paddock
- Moisture of SMS
- Paddock access
- Location
- Time to push up

Logistical issues for returning SMS to grain growers

- Current truck configurations
- Distance
- Restrictions of movement of B-Doubles
- Stockpiling
- Year round movement
- Moisture levels of SMS
- Continued decomposition of SMS

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Australian wheat production - logistics

Application

- Specialised equipment – currently lacking
- Cost – approx $45/ha
- High Application Rates
- Ease of Handling

Low nutritional benefit of SMS

- Still requirement to use traditional fertilisers to meet nutrient demand

Quality

- Free from contamination
- Salt

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Australian wheat production - economics

- Cost of stockpiling
- Cost of application
- Yield benefits
- Nutrients supplied
- Time
- Competing uses for straw (straw is not a waste)

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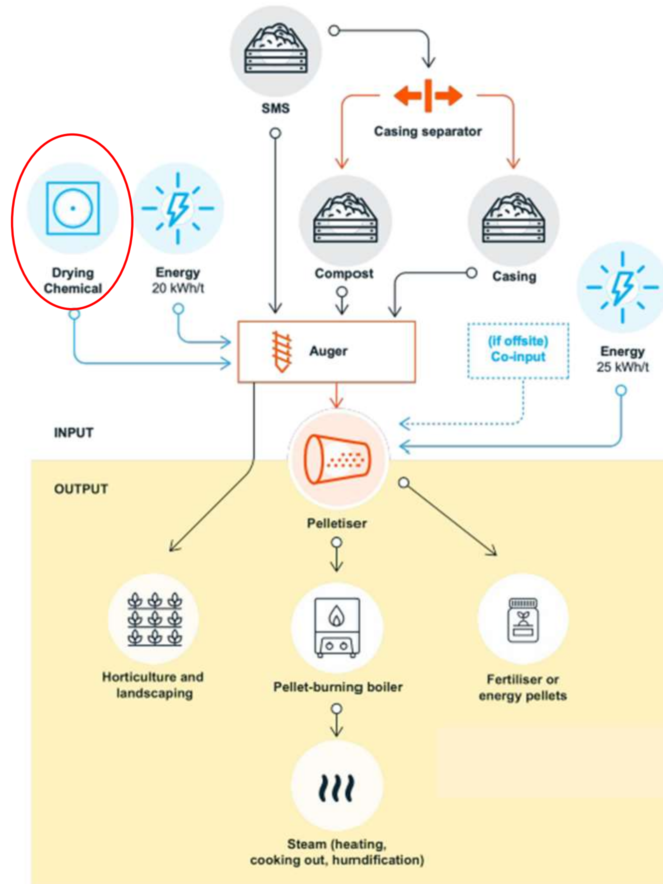
Australian wheat production - organic amendments

- Growing interest in organic amendments
- Most farmers keen to use organic amendments if economics stack up. Often hard to quantify.
- Must be competitive with locally available organic amendments eg feedlot/piggery compost, duck and chicken manure, biosolids, municipal green waste compost.
- Need for consistency in quality and supply
- Benefits and returns must be seen even if only short term
- High analysis products of more interest
- Desire to use often linked with the price of inorganic products

Different approaches to SMS recycling

- Continue with the current system
- Supply higher value industries such as vegetable industry
- Dry and/or pelletize SMS – Who pays?

Potential for value-adding to SMS



*Drying chemicals are flocculating agents with greater application in liquid-phase waste materials.

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SMS value-adding in the international literature

Most common topics:

- Blending with other organic waste streams and re-composting
- Development of products for either fuel or stockfeed
- Other bioenergy approaches such as anaerobic digestion, pyrolysis, ethanol etc
- Biorefining – i.e., extraction of potentially useful bioproducts from SMS
- Re-use of SMS as casing or for the growth of other mushroom species

"Pelletisation is the obvious starting point for development of a biofertilizer"

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Case Study

Recent advances and future directions on the valorization of spent mushroom substrate (SMS): A review

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HIGHLIGHTS

- SMS can be recycled as the substrate for new cultivation cycle of mushroom.
- Utilization of SMS as biofertilizer, bio-control agent and soil amendment.
- SMS as alternative feed for poultry, ruminant, pigs and insects.
- SMS as feedstock for production of 2nd generation biofuel.
- SMS as bioremediation agents for heavy metals, PAHs, pesticides, etc.

GRAPHICAL ABSTRACT

ARTICLE INFO

Keywords:
Circular economy
Animal feed
Renewable energy
Pollution bioremediation
Spent mushroom substrate

ABSTRACT

Commercial mushrooms are cultivated on lignocellulose wastes, such as corncob, saw dust, straw and wood chips. Following the rapidly increasing global mushroom production, the efficient recycling and utilization of the by-product, known as spent mushroom substrate (SMS) has garnered much attention due to the serious pollution issues caused. Embracing the concept of 'circular economy', the SMSs have demonstrated immense potential in wide range of applications, including recycling as the substrate for new cultivation cycle of mushroom, bio-

- Does re-composting SMS for "humification" = value-added biofertilizer?
- "C sequestration" - humification during composting only makes a modest contribution to C stabilisation

SMS value-adding – some technical aspects

Technology

Drying

Grinding

Further stabilisation (e.g., torrefaction, pyrolysis, composting)

Value-add – e.g. nutrients

Pellets / granules

Product development

Identify product specifications (nutrient content vs C content)

Physical attributes: Structural integrity of pellet
'Flowability'
Storage/hygroscopic issues?

Timing of nutrient release – lab/glasshouse

Application rate – is there growth benefit + organics?

Field trials – soil type x crop interaction, seasonal risk

Blending organics + nutrients requires greater rates of application to achieve equivalency of nutrient addition.
+ greater cost of production = greater cost of product per unit nutrient

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Value-adding to organic amendments – in practice

- Few commercial composters value-add to their product
  - 30,000 t out of 1M t per year of municipal compost in Victoria
  - Mainly compost + lime or gypsum
  - Some pelletisation beginning to happen
- Logistics and expense means it doesn’t necessarily add to profit margin

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Next steps – what are the options?

- Within the scope of this project:
  - Product “demonstrations” e.g., pelletisation and presentation to growers?
  - Economic modelling of value-add material using case studies
  - Field trials in grains and/or vegetable production?

- Other work outside the scope of this project:
  - Deep-dive economics on value-adding – cost vs additional value
  - Market research
  - Product development research

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