An introduction to biostimulants and current practices

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Outline

1. Definition of biostimulants
2. Role of microbes in soils and crops
3. Successful biostimulants
4. Issues for Australia
5. Concluding thoughts

What is a biostimulant?

- Generally describes " any substance beneficial to plants, without being nutrients, pesticides or soil improvers"
- First definition Zhang and Schmidt 1997, web journal called 'Ground Maintenance':

  "materials that in minute quantities, promote plant growth"

  humic acids, seaweed extracts, hormone-like activities (Zhang and Schmidt 2000, Crop Science 40:1344-1349)
- Scientific Literature – Defined by Kauffman *et al.* (2007) Crop Science 47:261-267

  "materials other than fertilisers, that promote plant growth when applied in low quantities"
- Available in variety of formulations and generally classified into 3 and later 4 major groups:
  - Humic substances
  - Hormone containing products
  - Amino acid containing products
  - PGPR (Plant growth promoting rhizobacteria)
- Since 2007, increased use and expanding range of substances and modes of action
- "Any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrient content"

  du Jardin (2015) Scientia Horticultura:3-14

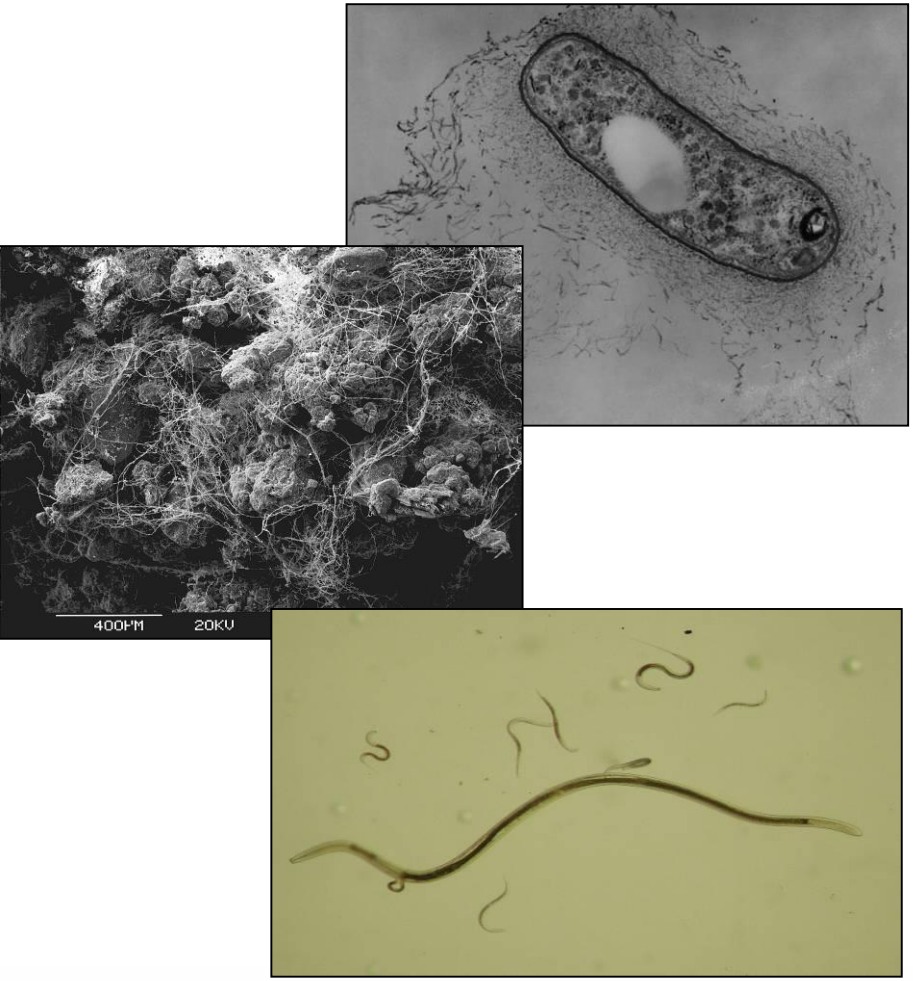
Components of biostimulants

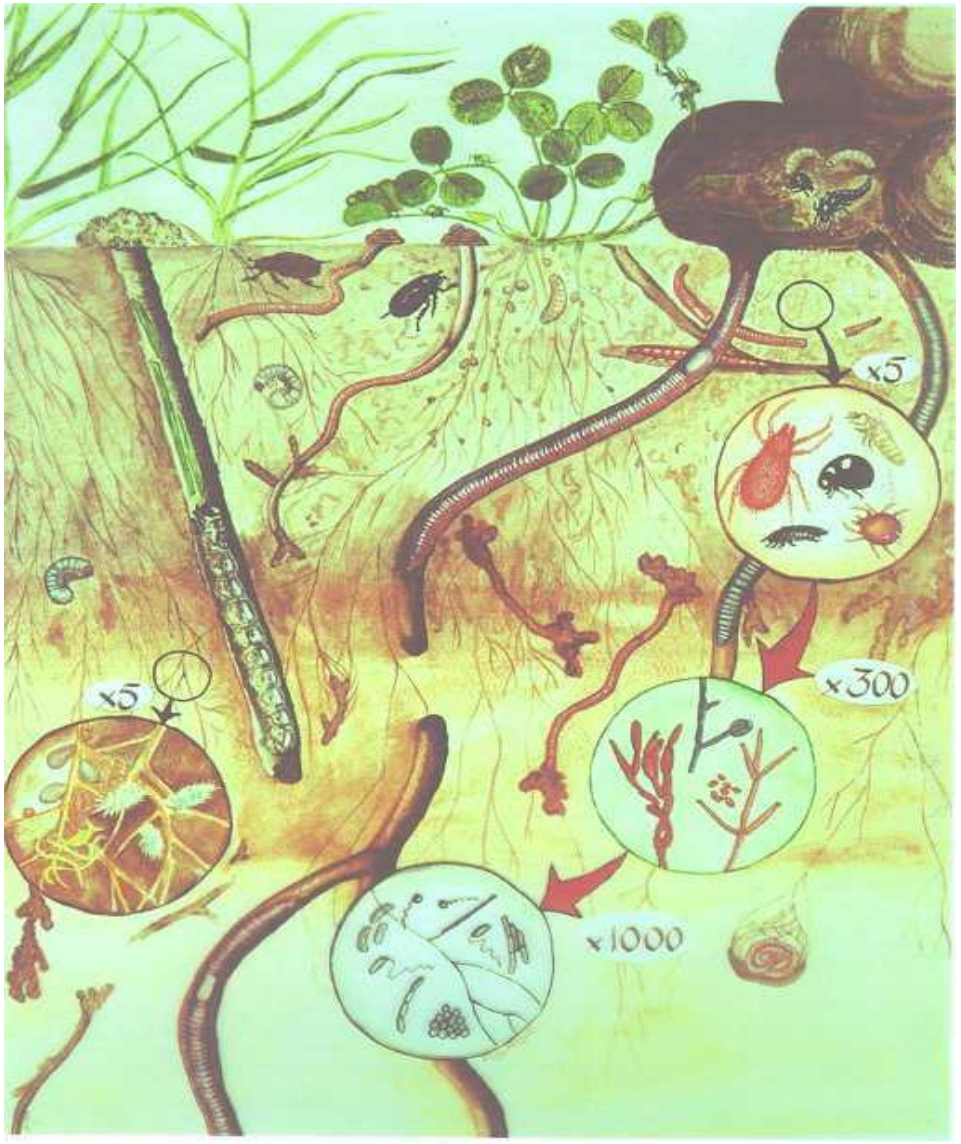
1. Humic and fulvic acids
2. Protein hydrolysates and other N-containing compounds
3. Seaweed extracts and botanicals
4. Chitosan and other biopolymers
5. Inorganic compounds
6. Beneficial fungi
7. Beneficial bacteria

Features of biostimulants:

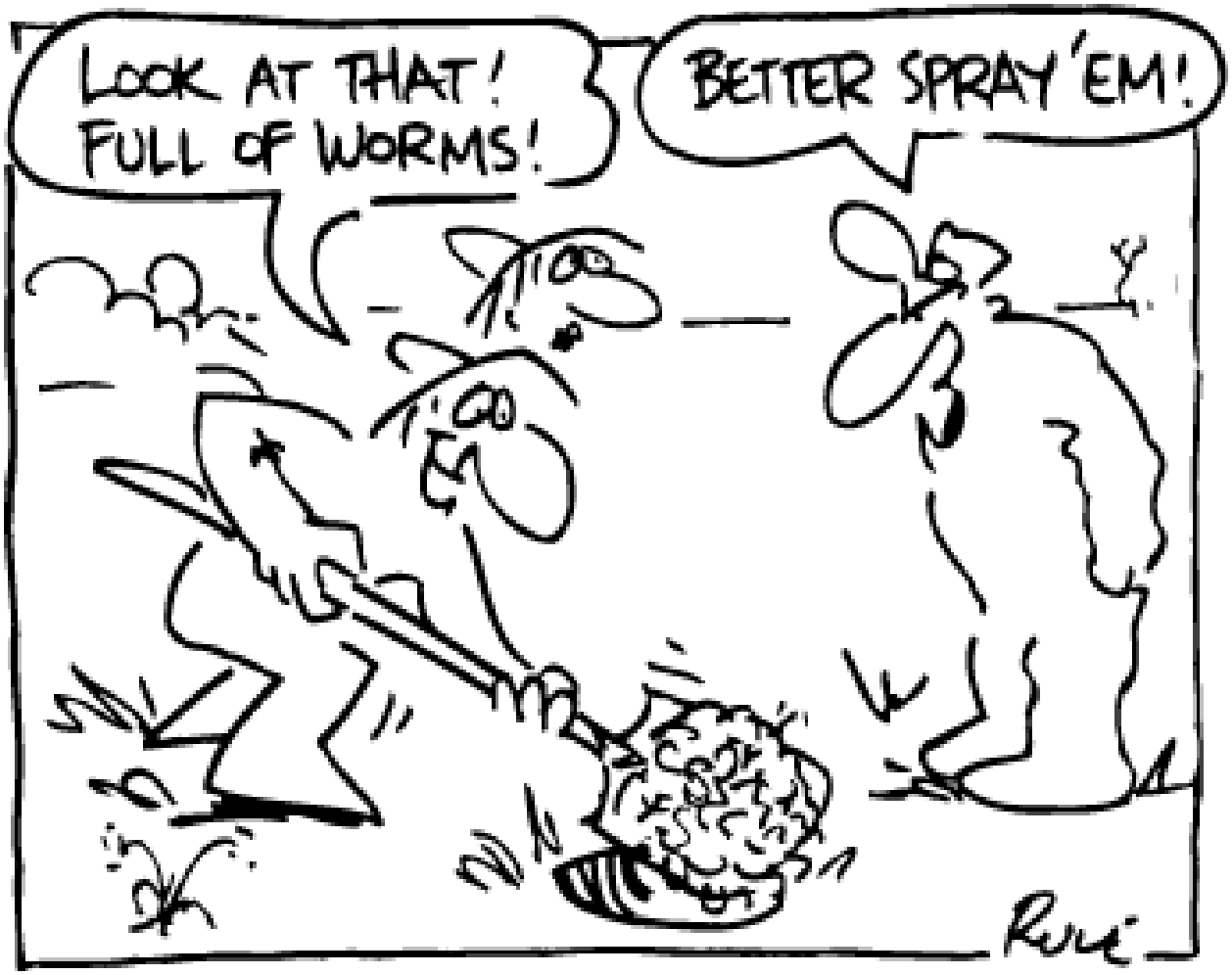
1. Diverse nature : substances (single or groups of compounds, organic, inorganic, synthetic) and microorganisms (single or multiple strains, mixtures of m-o, showing additive or synergistic effects), sometimes combined with fertilisers or crop protection products.
2. Diverse physiological functions: i.e. 'modes of action' or action on plant processes, e.g. protection of photosynthetic machinery, initiation of lateral roots, translates to increased tolerance of abiotic stress or increased N use efficiency, interact with environmental stressors.
3. Effects converge to one or several of the following functions: enhanced nutrition efficiency, abiotic stress tolerance and or crop quality traits that translate to higher crop yield, savings in fertilisers, increased quality and profitability – economic and environmental benefits.
4. Biofertilisers (root growth promoting, N-fixing, PGPRs) and biocontrol agents are subsets

Soil biology is complex and is driven by organic matter inputs

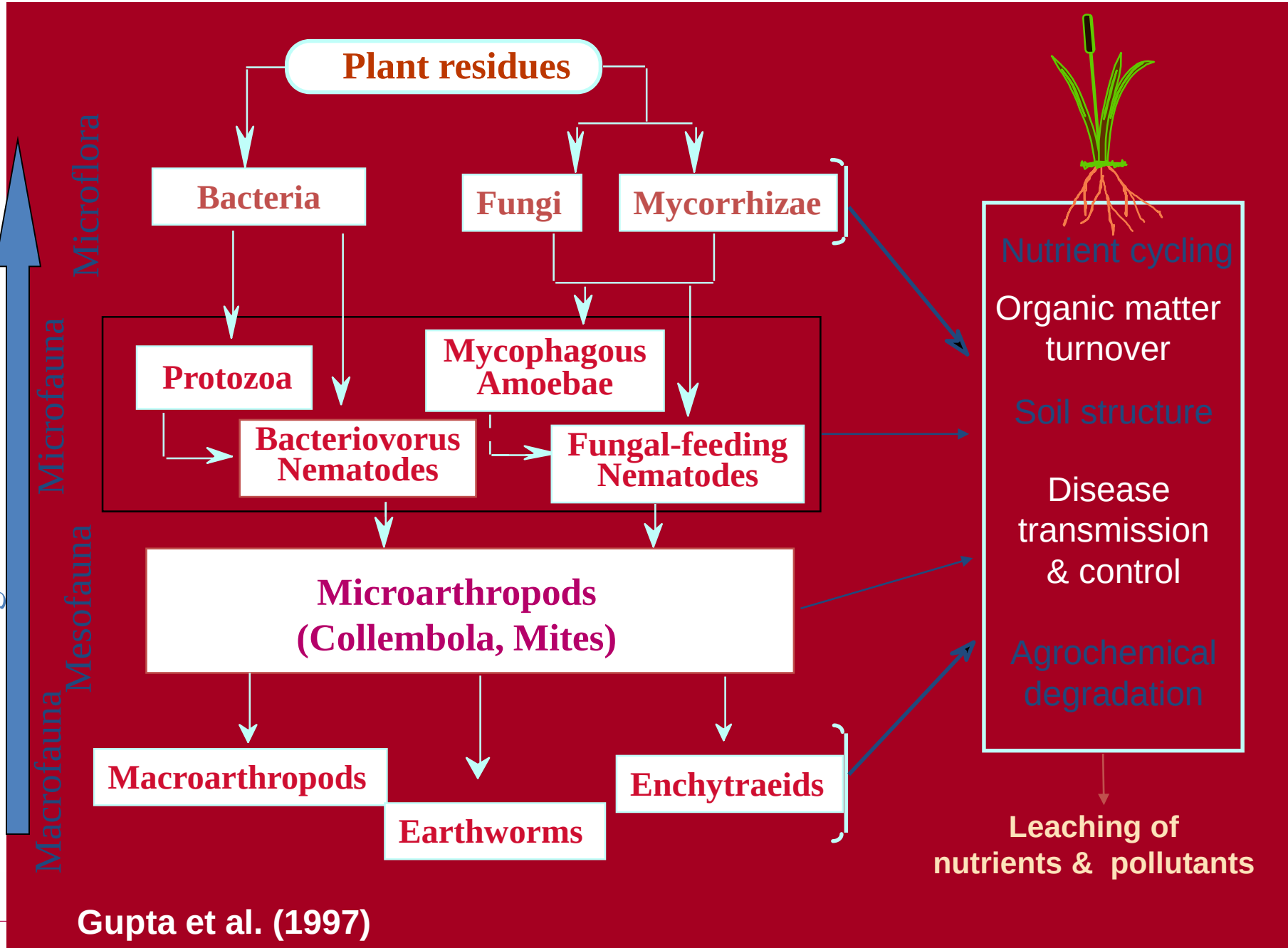




Most biota are beneficial…



Detritus Food-Web



Gupta et al. (1997)

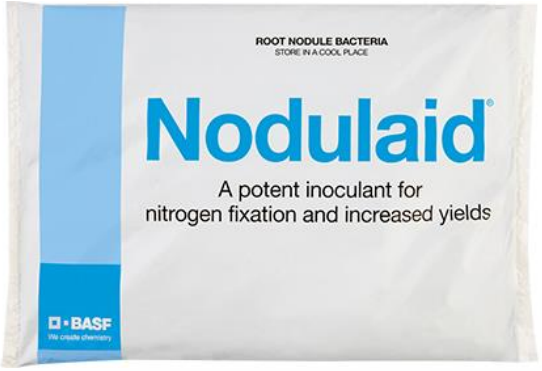
Why is soil biology important?

- Biology is vital for the function of healthy soils

- Biology contributes to fertility, productivity and sustainability of our soils through:
  - better fertiliser use efficiency
  - organic matter turnover and nutrient cycling
  - improved soil structure and increased water storage
  - decreased environmental pollution (gaseous losses, nutrient leaching, pesticide degradation)
  - disease suppression

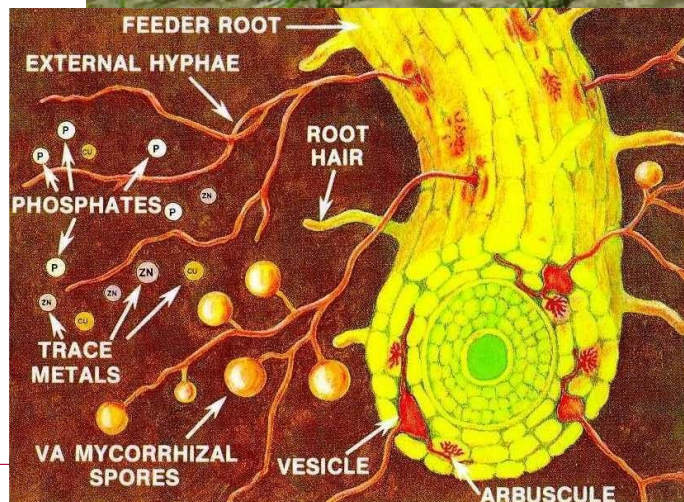
Successful biostimulant - Rhizobia

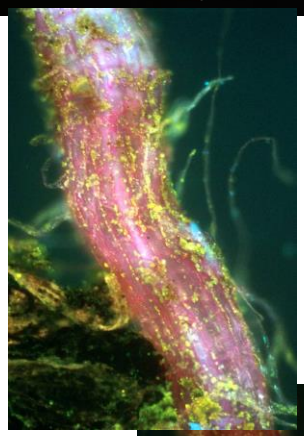
- Inoculation of grain and pasture legumes has been practised in Australia for over 100 years . Average amounts of N fixation can range from 0 to 400+kg/ha annually (depending on species

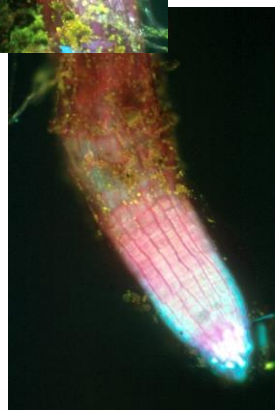


Arbuscular mycorrhizal fungi (AMF)

- AM fungi help nutrient uptake (especially P and Zn) in most crops
- Without AMF, crop production dramatically reduced (as much as 100%) unless large amounts of fertiliser are applied.
- Long fallows to recharge soil moisture reduce AMF populations in soil
- Successful management strategies to maximise benefits from AMF include rotation with host crops, and reducing fallow length and tillage.
- Much more difficult to culture and apply at high rates







Some of the key factors important for an introduced microbe to be effective include:

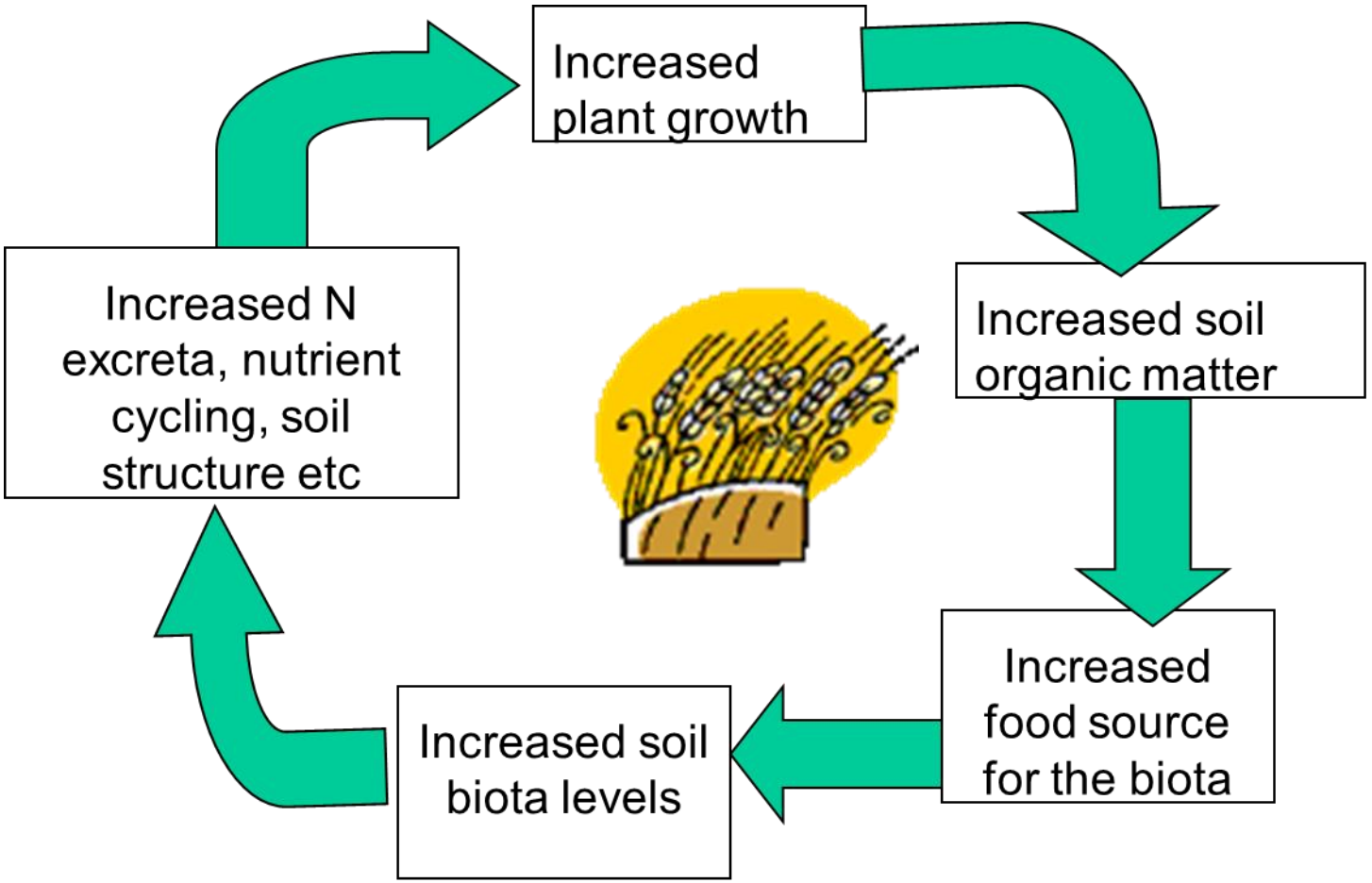
- Availability of energy (carbon) source or a host plant
- Suitable habitat – each functional group of microbes require specific habitat conditions to perform their function e.g. water, oxygen and nutrient concentration etc.
- Protection from predators, competition from general soil microbial community.
- Adequate populations at the time when their activity is needed (seasonal importance of different microbial functions)

Other successes:

- Multiple funded research projects in GRDC and CRDC with some successes
- Commercialisation stage is complex
- Results not always consistent

- Improved NUE through use of biostimulant enhanced anhydrous ammonia

- Particularly useful progress in area of biocontrol agents
  - endophytic actinobacteria (Chris Franco et al, Barnett et al) with activity against cereal diseases



…..SUSTAINABILITY?

Issues for Australia:

- Europe: EBIC indicate steadily growing market for biostimulants (10%+ per year)
  - Driven by general agricultural and environmental policies – increasing awareness of the need to promote sustainable agriculture worldwide combining high productivity and high resource use efficiency – deliver ecosystem services that contribute to the preservation of soils, water and air

- 2015, countries in the EU had largest share in R&D and use of biostimulants
- Global market in 2016 $1.5B growing at 11% to reach $3.79B by 2023
- BUT projections indicate Asia-Pacific will be the fastest growing biostimulant market from 2016 to 2021 (www.futuredirections.org.au) – rising awareness and preference towards biostimulants in India, China and Australia

- Australia not as regulated as Europe and US regarding biostimulants
- Quality of products sold in Australia varies widely particularly when live organisms are involved.
- Labelling often inadequate or generic
- Products not always tested under Australian conditions
- No regulating body (apart from APVMA)

Concluding thoughts:

- Amplifying local beneficial microorganisms instead of inoculating standardized microbial products – due to fact that microbial biostimulants use is limited by the capacity of the inoculant to establish and maintain sufficient activity in the rhizosphere
- General vs specific suppression
- Similar to human health – probiotics (inoculants) vs feeding beneficial bacteria with prebiotics could be even more important – we just need more
- Some good examples of inoculant success
- Inspires new avenues in sustainable crop management – new fertilisers and breeding plants with enhanced capacity to 'manage' their rhizospheric and endospheric microbiota
- Growers need to test for themselves – strip trials
- Some will work some won't, we are in the discovery phase!