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AgroSolutions Division

Endo Fuse™

Technical overview & trial data

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Endo Fuse™

What is EndoFuse and what is Mycorrhizae?

- EndoFuse from Sumitomo is a plant and soil enhancement product that contains Arbuscular Mycorrhizal Fungi (AMF)
- Mycorrhizae are beneficial fungi that naturally exist in soils colonizing the root systems of plants.
- EndoFuse includes 4 high performing endo-mycorrhizae species that have been proven to increase crop productivity and overall plant and soil health.

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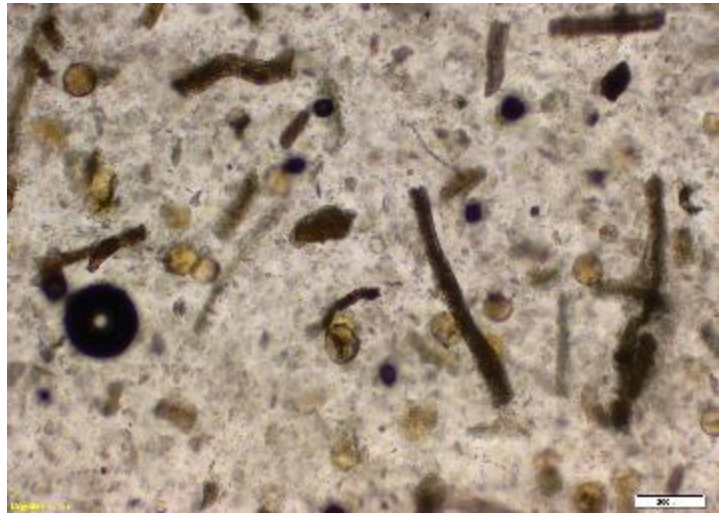
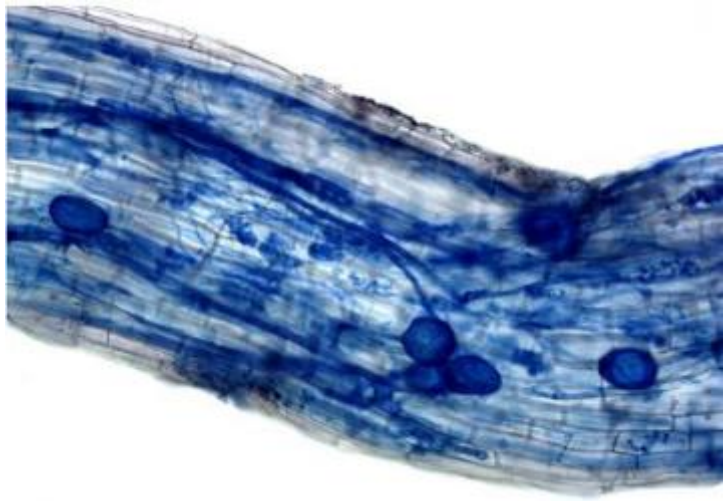
Images of EndoFuse propagules & infected roots



Mixture of 3 types of infective units make up the propagules in EndoFuse,

1) Spores
2) Colonised root fragments
3) Hyphal segments

Root hairs colonized by EndoFuse



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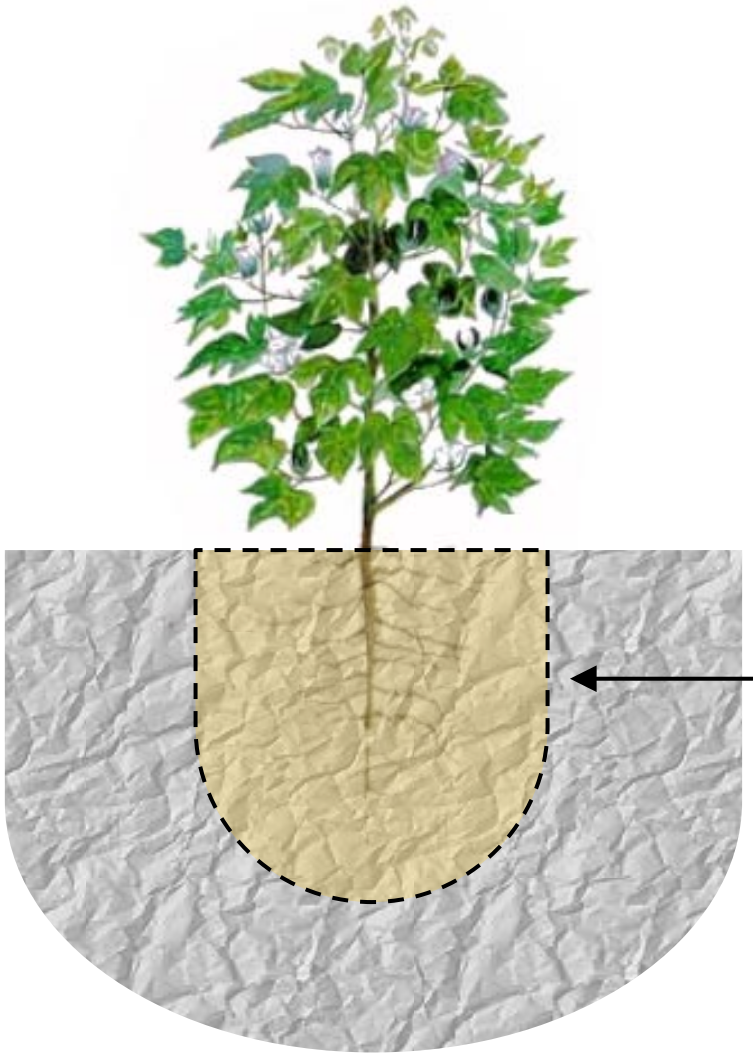
Images by UWA

How Do Mycorrhizae Work?



- Within the soil, plant roots are limited in the area they can absorb nutrients (referred to as the depletion zone).
- Mycorrhizal hyphae grow out well beyond the depletion zone.
- Absorption area increases up to 50x.

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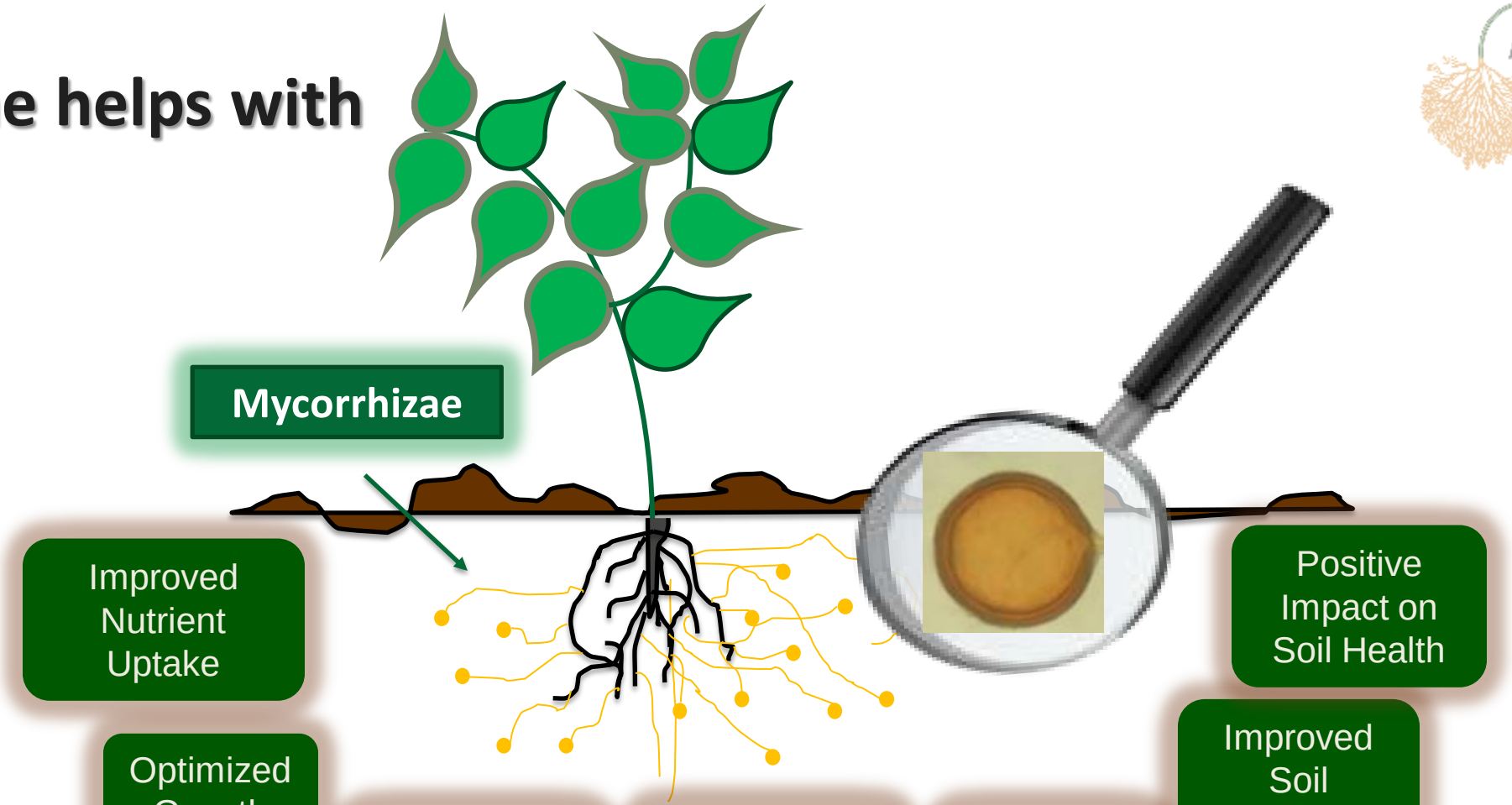
Mycorrhizae helps with



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What impacts Mycorrhizae levels in soils?

- Previous crop or rotations with non-mycorrhizal plants (Brassica's like canola and mustards, lupins etc.)
- Frequent, repeated or extended fallow periods (6 months or longer)
- Continual wetting/drying cycles
- Tillage
- Fumigation (chemical treatments)
- Once depleted, mycorrhizal populations are slow to recolonize naturally as propagules have to migrate from nearby reservoirs (plant hosts).

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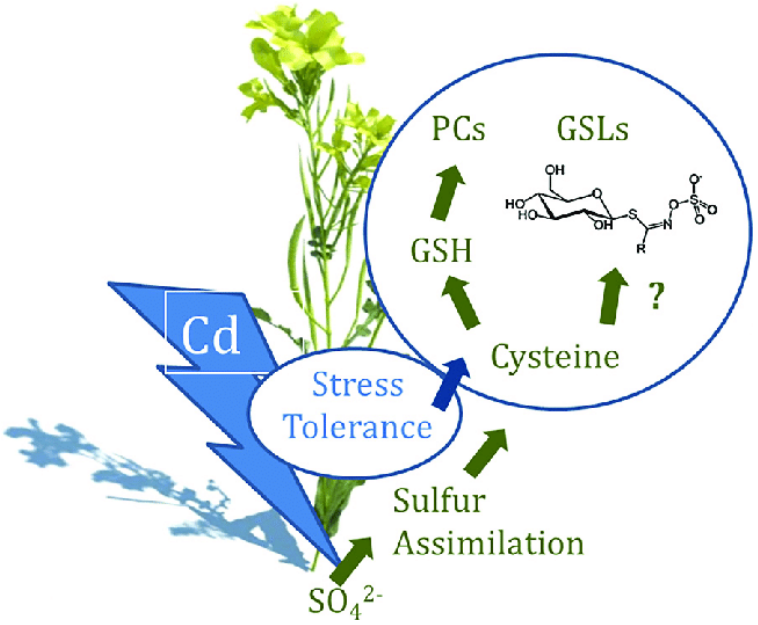
Growing canola bio-fumigates AMF

Canola & other brassica's produce chemicals called glucosinolates (GSL's) which are toxic to AMF and many other soil fungi.

Glucosinolates accumulate in the roots of *Brassica* plants and hydrolyse to release isothiocyanates (ITCs), toxic to soil fungi (Ryan, 2001).

Due to these bio-fumigation effects, having canola, mustard, and other Brassicaceae crops in a crop rotation adversely affects beneficial organisms such as AMF in soil and their establishment on subsequent crops (Spenceley *et al.*, 2003).



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Cultivation destroys the Propagule Bank

Colonization of roots arises from three sources of inoculum:

1. Spores
2. Colonized root fragments
3. Hyphae

Propagules in the soil are often called the ‘propagule bank’

Tillage reduces the propagule bank by:

(i) Breaking up of the hyphal network
(ii) Dilution of the propagule-rich topsoil
(iii) Accelerated root decomposition.

Tillage has one of the biggest impacts on reducing soil mycorrhizal infectivity

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Why 4 Mycorrhizal Species in EndoFuse?

- One mycorrhizae species does not fit all conditions
  - Soil microclimate (e.g., changes in soil moisture, phosphate availability)
  - Plant phenology
- Different species dominate in different ecological conditions (e.g., soil type, cropping system, nutrient content).
- Plant utilises different species by growth needs, environmental conditions, soil conditions and species available.
- Plant can turn on multiple species at once
- Endemic AMF species that have evolved with native plants do not perform with introduced crops like the species they evolved with (mostly from Northern hemisphere countries).

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Mycorrhizal fungi – likes and dis-likes

Highly preferred plant species :

- Solanaceous crops (tomato/capsicum)
- Legume vegetables
- Tuber and root crops (carrot/potato)
- Onion & garlic
- Citrus & Pome
- Hemp
- Melons
- Corn/Sorghum
- Mungbeans
- Cotton
- Pigeon Peas
- Faba Beans
- Chickpeas
- Lab Lab
- Linseed

Known to benefit from Mycorrhiza:

1. Rice
2. Wheat
3. Barley
4. Banana
5. Sugarcane

Plants that DO NOT form a bond with AMF

1. Carnation
2. Spinach
3. Canola & Mustard
4. Cabbage
5. Canola
6. Lupins

TABLE 1 Arbuscular mycorrhizal dependency of various crop species.

Mycorrhizal dependency	Winter crops	Summer crops
Very high	Linseed Faba beans	Cotton Maize Pigeon peas Lablab
High	Chickpeas	Sunflowers Soybeans Navy beans Mungbeans Sorghum
Low	Field peas Oats Wheat Triticale	
Very low	Barley	
Independent	Canola Lupins	

SOURCE: JOHN THOMPSON

GRDC source

Over 80% of the world plant species form a bond with Mycorrhizae

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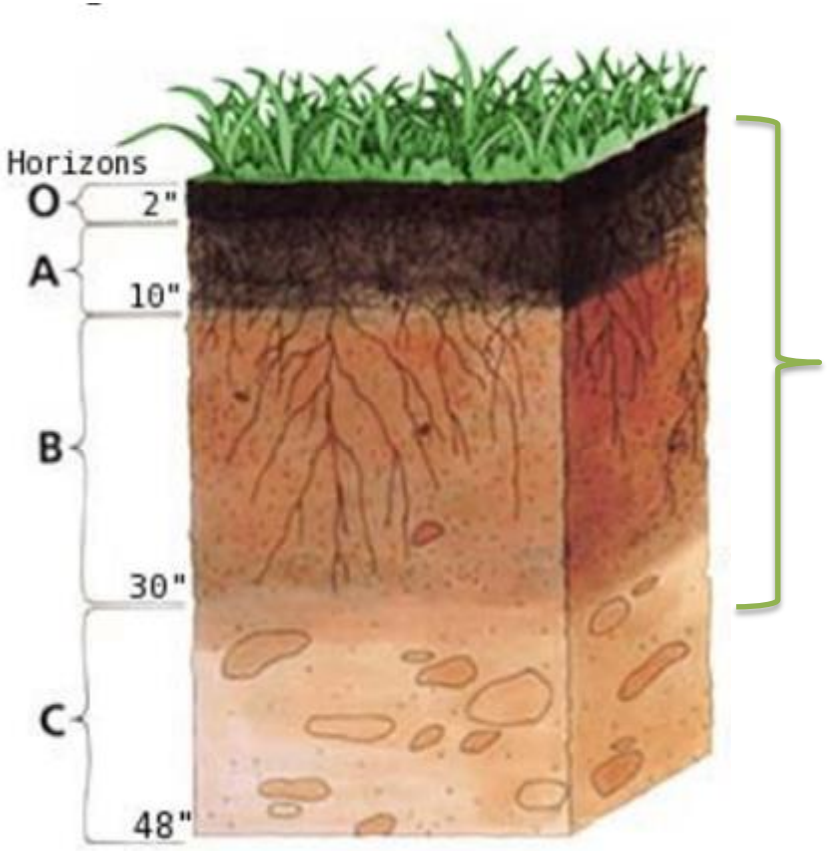
Improving soil structure



Mycorrhizae improve soil structure by secreting Glomalin to form soil aggregates & pores, which are fundamental to Soil Health and optimum plant production

Glomalin improve the soil structure across all soil horizons where roots and AMF have colonized.

Glomalin is a carbon rich secretion which can increase soil carbon levels over time.

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Can I test for Mycorrhizae in my soil?

- Yes
- Various methods exist
  - Many non specific tests indicate overall microbial life
  - Some very specific like DNA methods (predicta B)

- Commercial tests are available and are not too expensive

NORTHERN REGION
PREDICTA B
DNA Soilborne disease tests

crown ANALYTICAL SERVICES


PRICE LIST
OCTOBER 2017
microbiology laboratories australia
TEST PRICING
Getting you the best deal is important to us. Here's a few tips to help you save money:
Packages are a great deal, with substantial savings - up to $550!
Combine a sampling kit with a package for maximum savings - up to $600!
Order and pay up front online for a 5% discount
Get a 5% discount when you order $2500 or more in tests
Get up to $15 credit per test when you complete the optional info on the order form
Avoid unnecessary fees - type all required information into PDF order form and pay on time
OUR ONLINE DUCT SELECTOR
online product selector
HOW TO ORDER
1 Select your test package or individual tests
2 Select your report option (page 9)


AgVita Analytical Pty Ltd
AGVITA ANALYTICAL
NU-test
nutrient uptake
Plant Sap Analy
PLANT RESPONSE
Plant Tissue (digestion)

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What is the recommendation for how to apply?

Seed treatment or in-furrow

EndoFuse can easily be applied to seed using equipment such as a well calibrated auger injection system.

EndoFuse mixes readily with water, liquid fertilisers and insecticides and can be easily applied as an in-furrow spray/injection during the sowing operation.

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Directions for use

APPLICATION INSTRUCTIONS FOR CROP CATEGORIES

Sorghum, Cotton, Mungbeans, Soybeans, Wheat, Barley, Oats, Corn, Chickpeas, Faba beans, Lentils, Rice, Sugarcane, Pigeon Peas, Lablab, Sunflowers, Linseed, Field Peas, Triticale, Navy beans, Peanuts, Hemp, Poppies, Pyrethrum, Grass Pastures, Lucerne, and Clover Pastures	In-furrow or seed treatment	10-15 mL/ha	Apply in-furrow with seed (or cane billets) with the goal for the solution to come in contact with the seed (or cane billets) and roots when germination occurs. OR Apply as a seed treatment at a sufficient rate per kg of seed to give 10-15mL of product per hectare when seeding rate is accounted for. If applying as a seed treatment, mix with water at a sufficient dilution to adequately cover all the seeds. 10-15mL of EndoFuse mixed with a minimum of 100 mL and a maximum of 1 Litre of water per hectare of seed equivalent s recommended. Refer to COMPATIBILITY WITH OTHER AGRICULTURAL PRODUCTS section when mixing with other products. Maintain continuous agitation in mix tank during mixing and application to assure a uniform suspension.

Use the higher rate where growing more intensive crops with higher plant stands such as irrigated crops

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Packs

- 500mL pack (35-50 ha per pack)

8 x 500mL (4L) Shipper

500mL Pack

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When should EndoFuse be used?

- When growing a highly mycorrhizae dependent crop
- When trying to optimize yield and quality.
- When field has been devoid of vegetation for any length of time, 6 months or more.
- When soil moisture is not expected to be abundant or crop is non - irrigated.
- When soil constraints are present such as sodicity or salinity.
- When soil structure is in decline and needs improving.
- When a non-mycorrhizal crop like canola has been grown previously
- When soil carbon is low and increased carbon levels is desired.
- When soil cultivation has been used

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EndoFuse trial data

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Barley trial Garoke, Vic, 2020 – Darren Walter

- Endofuse went out on barley at 12.5ml/ha, 1 hr before sowing barley on the 11th of may.
- The barley was previously treated with 150ml/100kg Systiva and 120ml/100kg of gaucho. As well as 400ml/100kg of BSN superstrike.
- Previous years crop was Vetch
- Latrobe barley was sown at 50kg/ha with MAPz at 70kg/ha
- **8.5% yield increase**

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Barley trial Garoke, Vic, 2020

- **+ 8.5% yield** observed through growers yield monitor
- **Untreated 6.078 t/Ha**
- **EndoFuse 6.597 t/Ha**
- **ROI** of **6 ½** : **1** or $120
  (+519kg/ha x $275/t)

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University of Western Australia – Mycorrhizae inoculation trial

- Controlled environment Pot trial in glass house.
- Inoculant tested on Sub Clover and Wheat
- Sandy soil was collected (at 0–10 cm) from the Shenton Park Field Station at The University of Western Australia (31°94′69″S, 115°79′53″E).
- Soil analysis showed the following soil chemical properties: 4.8 pH ($CaCl_2$), 2 mg kg^{-1} nitrate N, 3 mg kg^{-1} bicarbonate-extractable P, and 20 mg kg^{-1} K.
- Unsterilised soil was used as very low mycorrhiza found in this soil.

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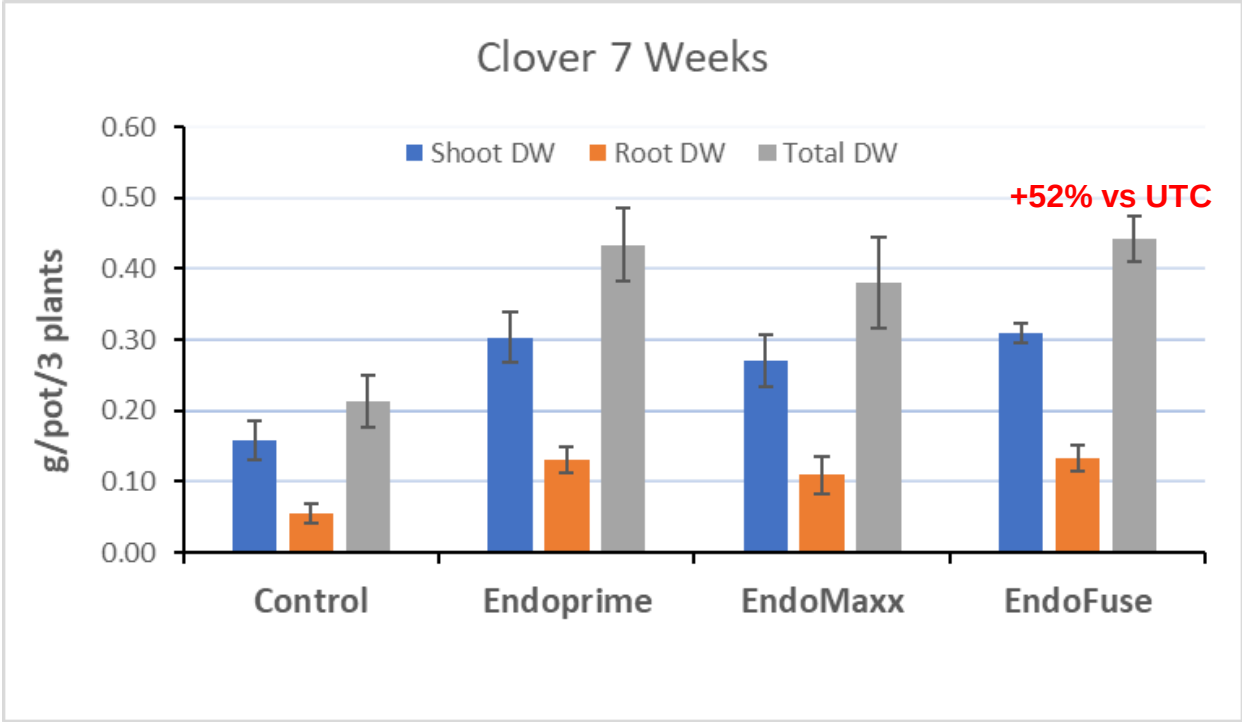
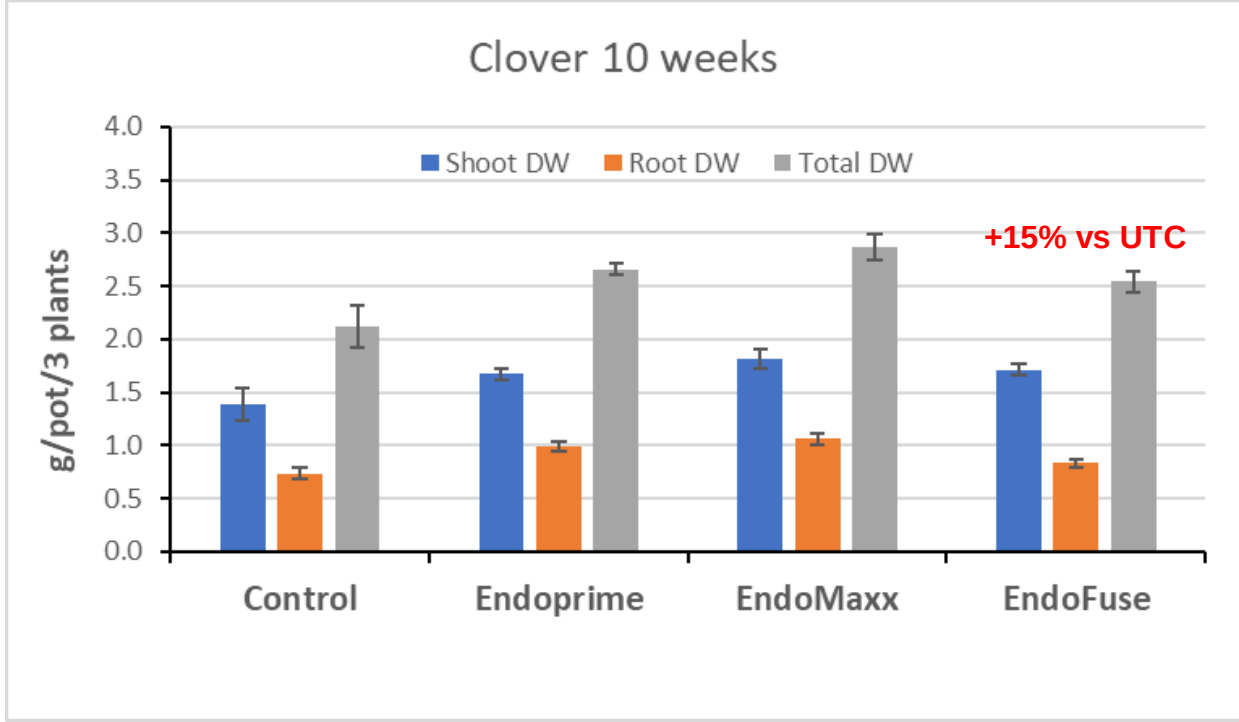
Mycorrhizae inoculation trial – Clover biomass assessments



All inoculum increased clover biomass



All inoculum increased clover biomass

Dr Zakaria Solaiman
Research Assistant Professor
UWA School of Agriculture and Environment

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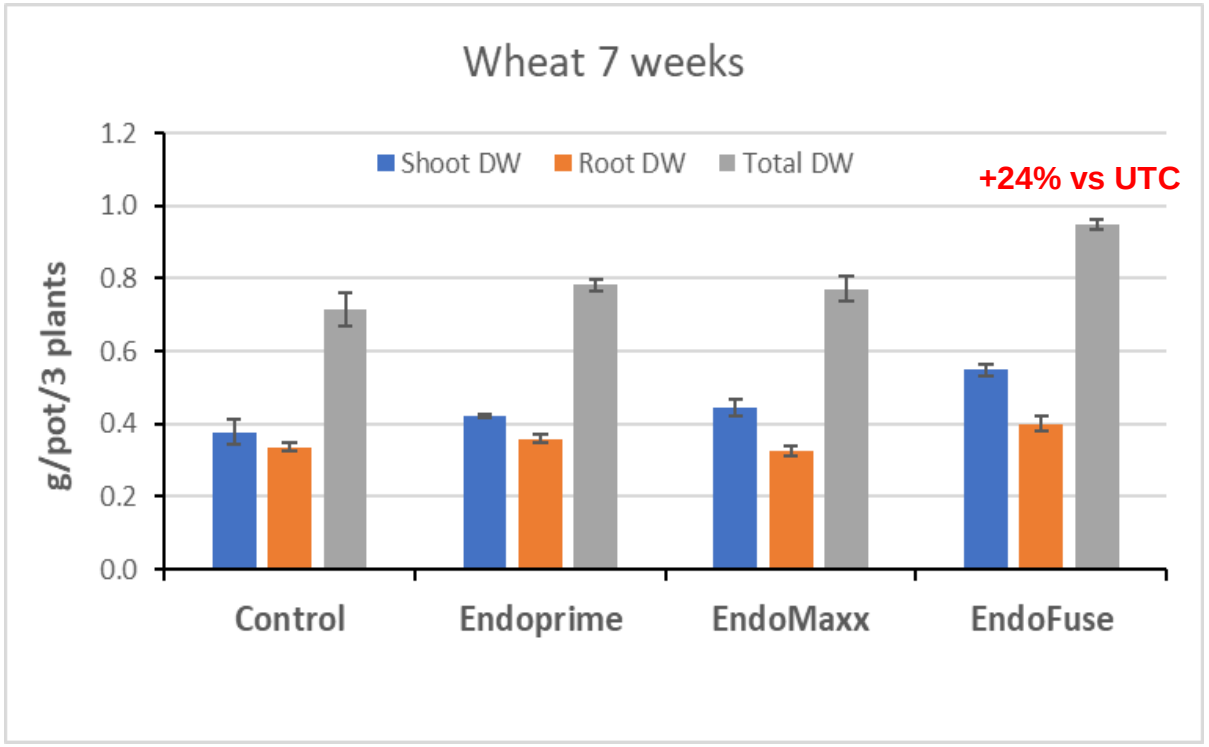
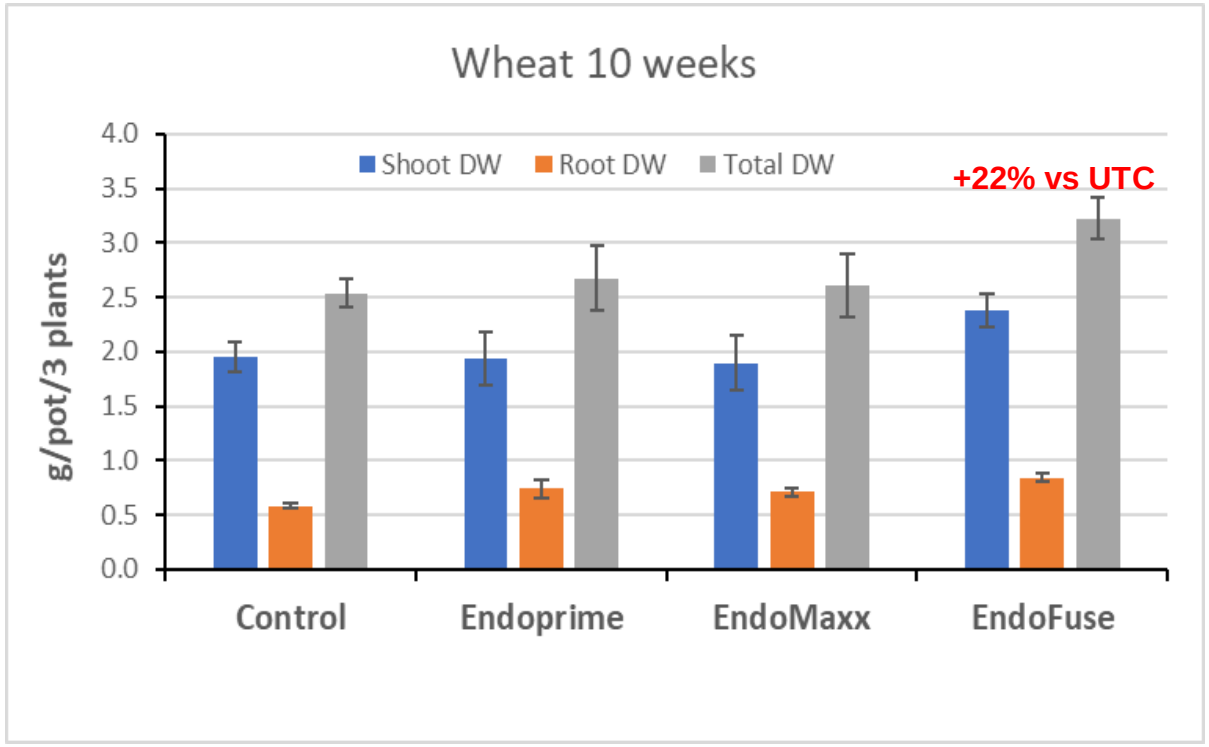
Mycorrhizae inoculation trial – Wheat biomass assessments



All inoculum increased but EndoFuse did significantly



EndoFuse increased significantly

Dr Zakaria Solaiman
Research Assistant Professor
UWA School of Agriculture and Environment

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University of Southern Queensland - Exploring interactions of AMF and rhizobia in mungbean

- Inoculation with both AMF and rhizobia resulted in a synergistic effect (Figure 1) which significantly ($P<0.001$) increased nodule numbers, dry biomass, seed weight, plant uptake of nitrogen, phosphorus, potassium and zinc in mung bean

- Establishing adequate levels of AMF in the soil, a soil analysis of AMF by PREDICTA®B prior to planting mung bean, and inoculation with the correct isolate of rhizobia, may lead to increased nodulation thereby increasing yield productivity of mung bean.

Elaine Gough, Kirsty Owen, Rebecca Zwart, Alla Marchuk and John Thompson, Centre for Crop Health, USQ

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University of Southern Queensland - Exploring interactions of AMF, rhizobia and root-lesion nematode in mung bean -

The addition of AMF and rhizobia to mung bean cv. Jade-AU increased plant biomass and seed yield four-fold 12 weeks after inoculation

Elaine Gough, Kirsty Owen, Rebecca Zwart, Alla Marchuk and John Thompson, Centre for Crop Health, USQ

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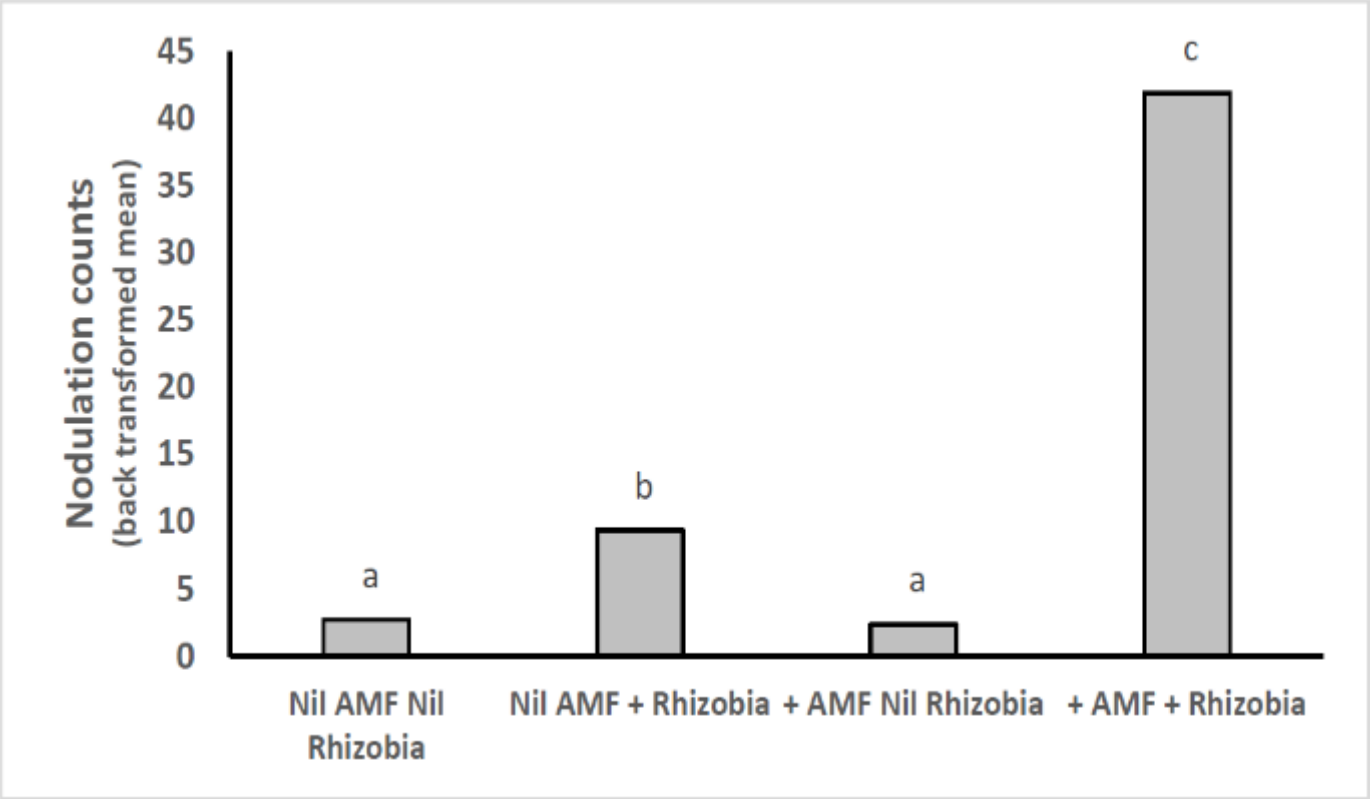
University of Southern Queensland - Exploring interactions of AMF and rhizobia in mung bean



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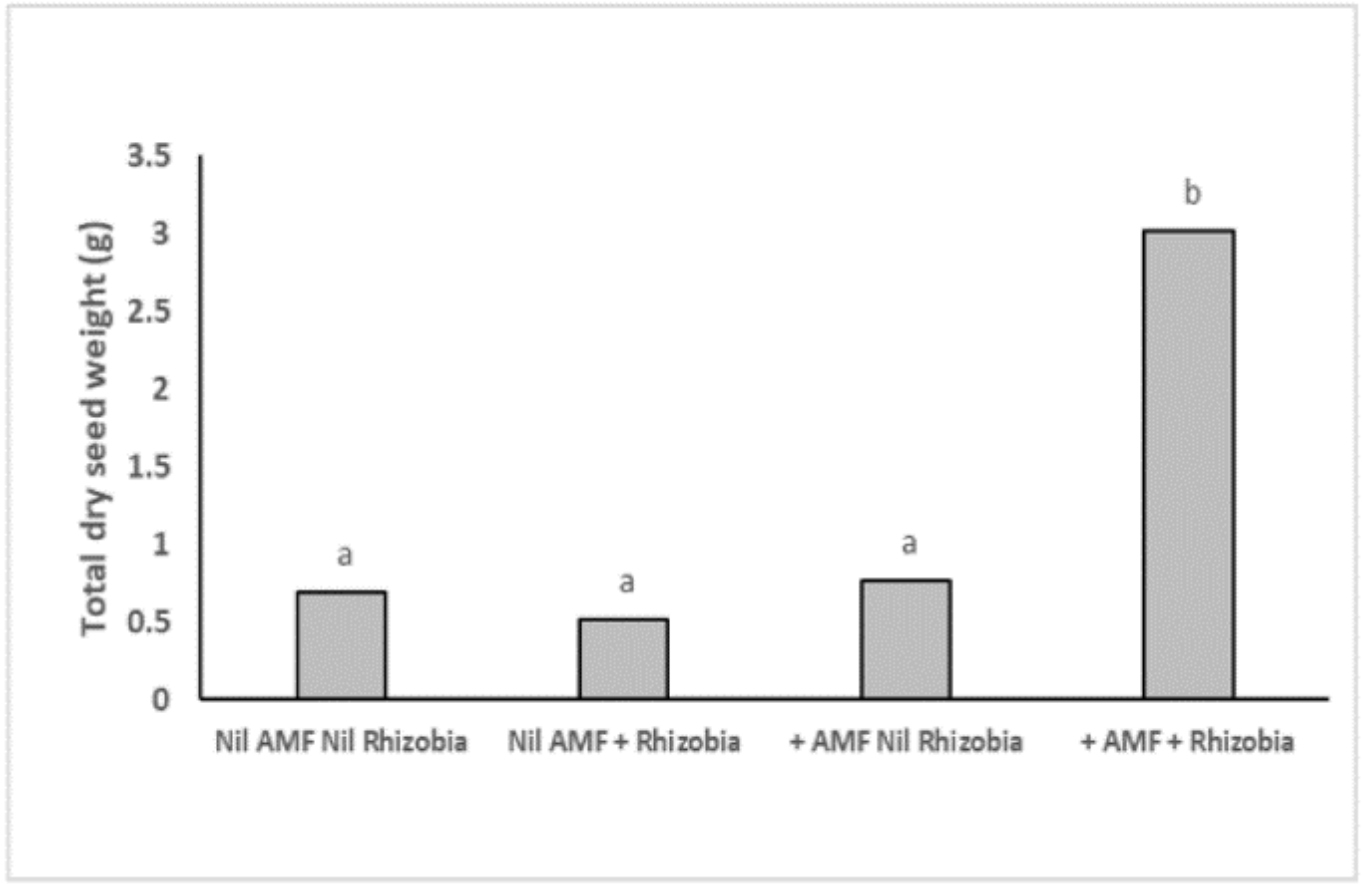

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EndoFuse trial in Barley, Wee Waa, 2020

- EndoFuse applied at sowing 10mL/ha
- Applied in-furrow
- Sown 14th May into cotton trash
- Irrigated crop (lateral move)
- Cotton crop harvested March 2020
- Zero fertiliser applied given relatively high carry over following cotton crop
- Colwell P of 7
- Single 50mm irrigation mid-season
- **5% yield increase** recorded through growers yield monitor

Photo taken 15th July – 8 WAT

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EndoFuse trial in Barley, Wee Waa, 2020

Yield Results

EndoFuse	Untreated
Bay 3: 5380kg Bay 5: 5430kg	Bay 2: 5140kg Bay 4: 5340kg
Average yield 4.504t/ha	Average yield 4.366t/ha
Barley Price at $200/t	Barley price at $200/t
=$900.8/ha	=$873.2/ha
Minus cost of product $22.86/ha = $877.94/ha	

At tillering it showed a significant increase in root biomass and plant biomass above the soil.
A major improvement that was observed throughout the season was how much more even the treated sites were. In the untreated sites there were holes in the paddock which were typical of a long fallow disorder; this did not happen in the treated areas.

With a tougher finish a more significant difference in yield may have resulted.

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Mycorrhizae: EndoFuse on **barley**

- Trial: Garoke, Vic (near Horsham)
- Seed treated and crop sown 4 June 2019
- 50kg seed / Ha, Variety La Trobe
- EndoFuse 10mL/Ha
- Product mixed in 700mL water and sprayed onto seed
- 0.9Ha strips sown per treatment
- Very sandy loam
- Fallow pasture previous season

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Trial: Garoke, Vic, 2019

	Trial harvest area (Ha)	Barley Yield (kg/Ha)	Diff to UTC (%)
UTC	0.42	4,836	
EndoFuse 10mL/Ha	0.38	5,130	**+6.1**

-Seed weight
-No. seeds per head
-yield

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Mycorrhizae: EndoFuse on **faba bean**

- Trial: Garoke, Vic (near Horsham)
- Seed treated and crop sown 14 May 2019
- 110kg seed/Ha, Variety Samira
- EndoFuse 10mL/Ha
- Product mixed in 1L water and sprayed onto seed
- 0.9Ha strips sown per treatment
- Sandy loam
- Wheat previous crop

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Mycorrhizae: EndoFuse on **faba bean**

	Seedling emergence (seedlings/10m row)	Faba bean mass at harvest (g/100 beans)	Bean mass Diff to UTC (%)
UTC	35.8 a	73.04 a	
EndoFuse 10mL/Ha	35.2 a	74.99 a (P=0.12)	**+2.7**

	Trial harvest area (Ha)	Yield (kg/Ha)	Diff to UTC (%)
UTC	0.86	4,024 a	
EndoFuse 10mL/Ha	0.86	4,348 b	**+8.1**

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Effect of EndoPrime on Wheat at Ogilvie, WA – 2018

- EndoPrime applied at 100g/ha at sowing
- 80 km North West of Geraldton
- Little visual difference through 1st half of the season
- Visible difference at the end due to a sharper finish.
- It is important to note that both controls as well as one other biological product had Flexi-N at seeding, EndoPrime didn't.
- EndoPrime did not have an issue maintaining protein despite having no UAN at seeding
- 55kg MAP across all treatments at planting
- 200mm growing season rainfall. Fell evenly except for a dry finish
- Applied as a liquid in furrow
- Grey non-wetting sands
- UAN at sowing rate was 40L / ha
- 250g Copper Chelate across all treatments at sowing
- All biological treatments were on Wyalkatchum

Treatment	Yield (t/ha)	Protein (%)	Hectoliter Weight (g)	Screenings (%)	Grade
NIL - Cobra	3.42	10.3	79.2	5	APW1
NIL - Wyalkatchem	3.45	10.1	81.2	3.88	APW1
Product X	3.68	10.1	80.28	4.6	APW1
EndoPrime	4.1	10.1	81.94	4.32	APW1
Product Y	3.7	9.9	80.74	7.3	AGP1
Product Y + Flexi N	3.41	10.2	84.18	5.08	AGP1

EndoPrime is a WP formulation similar to EndoFuse although 10 x less concentrated

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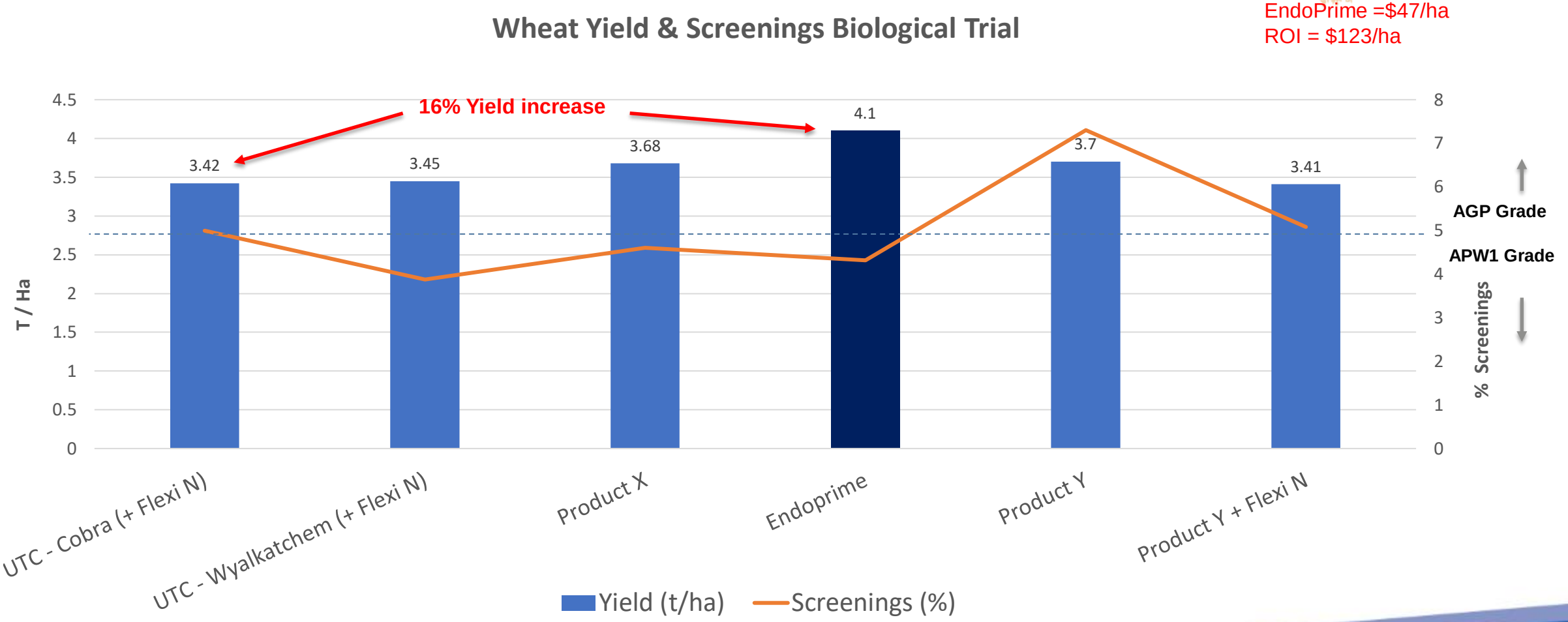
Effect of EndoPrime on Wheat at Ogilvie, WA – 2018

16% = 680KG = $170 (@$250/T)
EndoPrime =$47/ha
ROI = $123/ha



EndoPrime achieved screening below 5% and APW1 Grade vs AGP1 for treatments above 5%

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Long Fallow Sorghum EndoPrime Trial, Mullaley N-NSW, 2019

- Previous crop: Long Fallow (2 years)
  - Chickpeas 2016 on one section
  - Durum wheat 2016 on another section
- Very low AMF situation
- Sowing date: 14th Nov 2018
- Soil: Self mulching heavy black soil
- Treatment: EndoPrime at 100g/ha (as seed treatment)
  - Difficult to apply this Vol. on seed.
- Rain grown (< 50% of ave. in crop rainfall)
- Moisture stressed

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Long Fallow Sorghum EndoPrime Trial, Mullaley N-NSW

EndoPrime 100 g/ha

UTC

Photos: 15th Jan - 9 WAT

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Long Fallow Sorghum EndoPrime Trial, Mullaley N-NSW

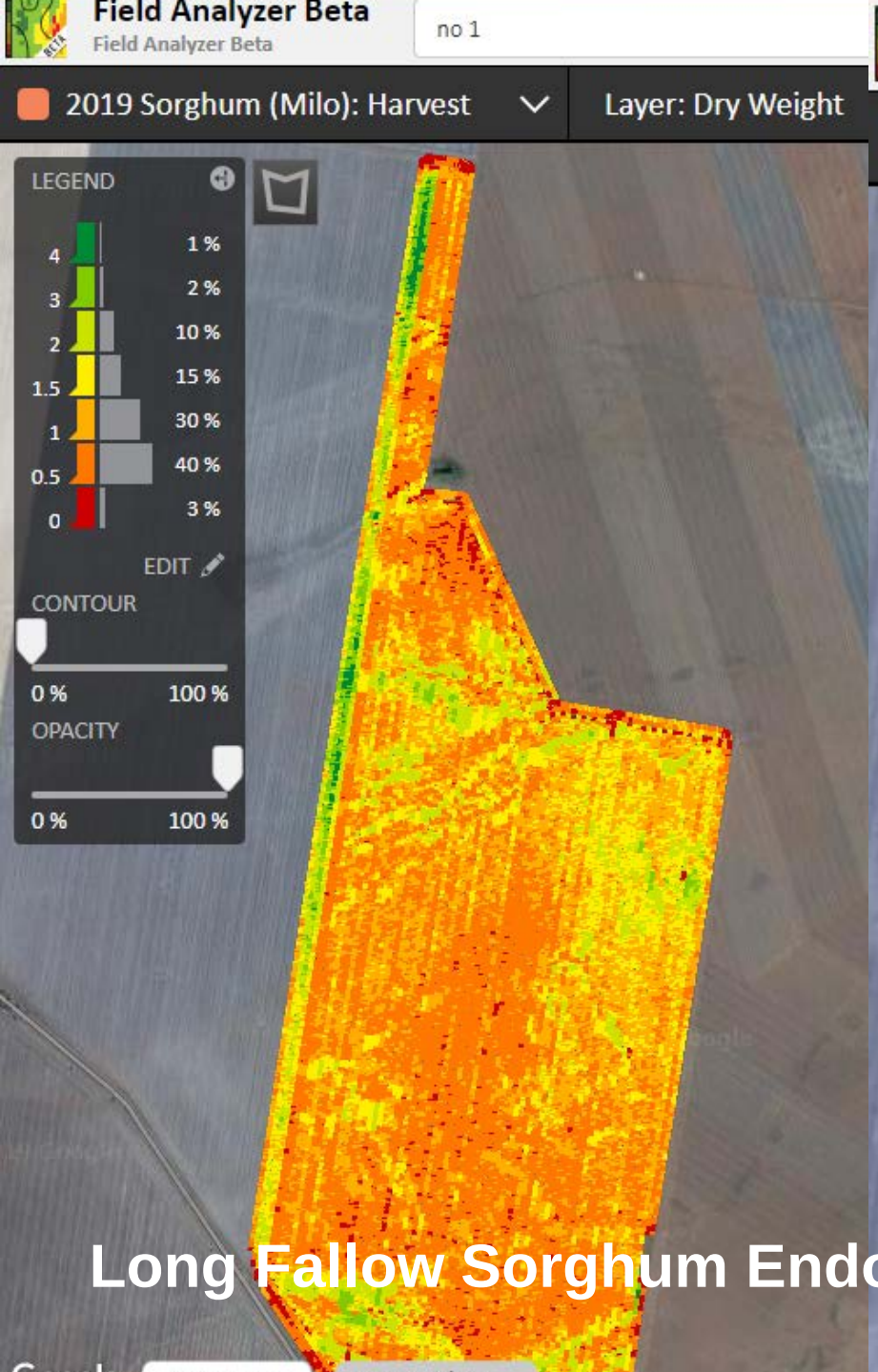
UTC

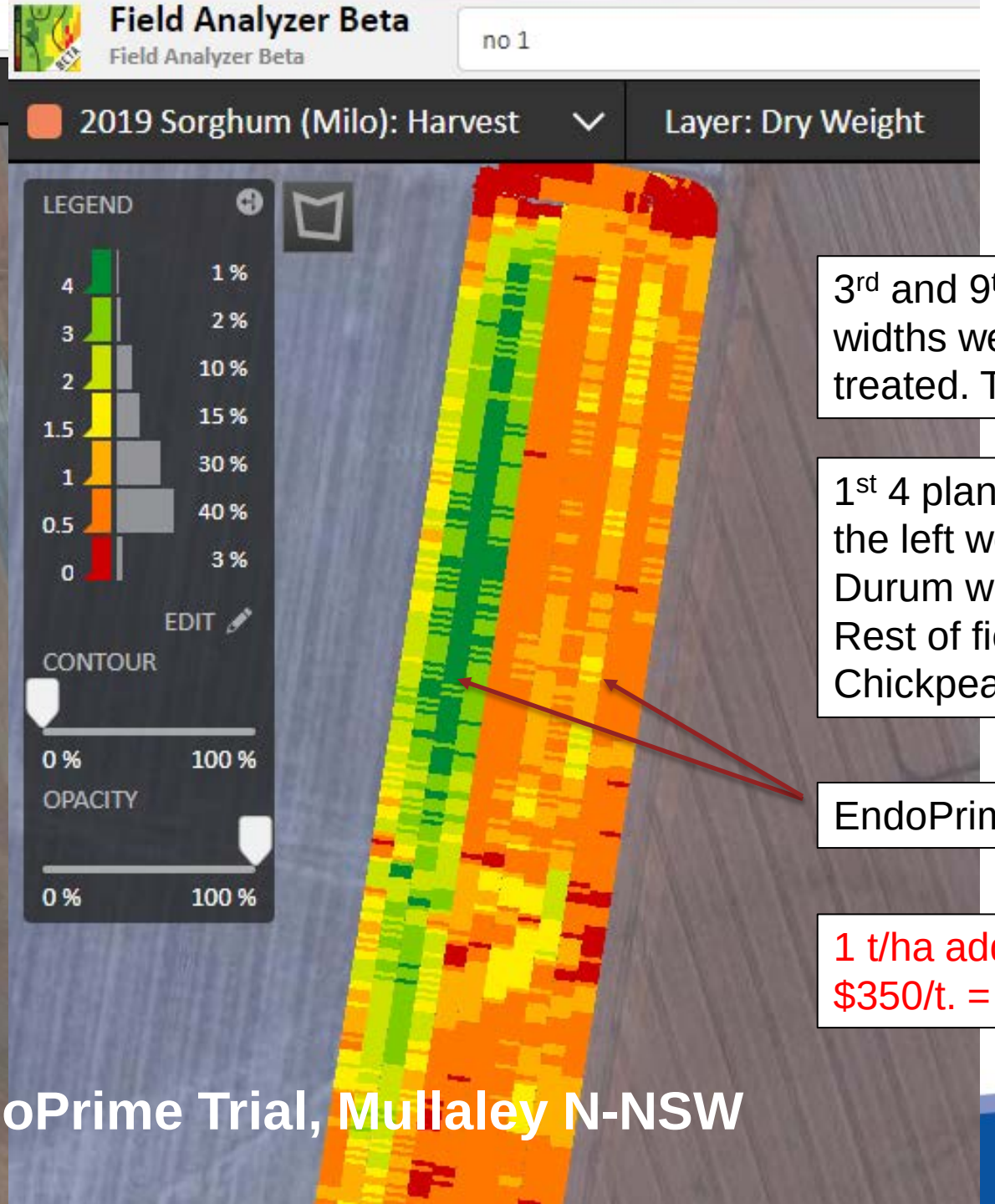
EndoPrime 100 g/ha

EndoPrime 100 g/ha

UTC

Photos: 15th Jan - 9 WAT





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3rd and 9th planter widths were EndoPrime treated. The rest UTC

1st 4 planter widths from the left were 2016 Durum wheat stubble. Rest of field was 2016 Chickpea stubble

EndoPrime 100g/ha

1 t/ha additional yield at $350/t. = ROI of $303/ha

Long Fallow Sorghum EndoPrime Trial, Mullaley N-NSW

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Sorghum Performance after Canola

Richard Daniel – Northern Grower Alliance

Northern Grower Alliance
"Grower needs first"

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The concern raised

- “Sorghum following canola often appears less thrifty”
- Possible reasons ?
- Less soil water than after cereals
- Soil nutrition differences
- Residual herbicide carryover
- **Reduced arbuscular mycorrhizae (AMF or VAM)**

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What we tested ?

	Results	Conclusion
Soil water	Both trials ~ 270mm PAW	No difference
Comprehensive eg P, K, S, Zn	Colwell P 22-24 mg/kg at 0-15cm Colwell P 5-6 mg/kg at 15-60cm Zn at ~1mg/kg then 0.2-0.3	No difference apparent
Nitrogen	Both trials ~130kg N/ha	No difference
Residual herbicides	Tested for wide range including imazapyr and imazamox	No detection
Pythium	Low levels in both	No difference
AM	**Manual - Durum 3-4x canola PreDicta B – Durum 3-5x canola**	**Significant differences**

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What was done ?

- Paddock sown to canola in 2014 but with marginal moisture
- Sections sprayed out and re-sown with durum
- Duplicate sorghum trials sown late Nov 2015, in canola vs durum stubble
  - 2 hybrids: MR Buster and G33
  - 4 rates of Granulock Z Extra: 0, 20, 24 or 80kg/ha
  - N rates balanced with urea

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Crop Impact on AMF Levels

Spring Ridge:

- Strips of wheat v canola v fallow in 2016
- AMF: 180 v 13 v 16 (kilocopies DNA/g)

Macalister 2015:

- 13 mth fallow after durum AMF 11 (kilocopies DNA/g)

Commercial sorghum, Dec 2015

Ex Canola 2014
Low AMF
(13 kilocopies DNA/g)

Ex Durum 2014
Medium AMF
(36 kilocopies DNA/g)

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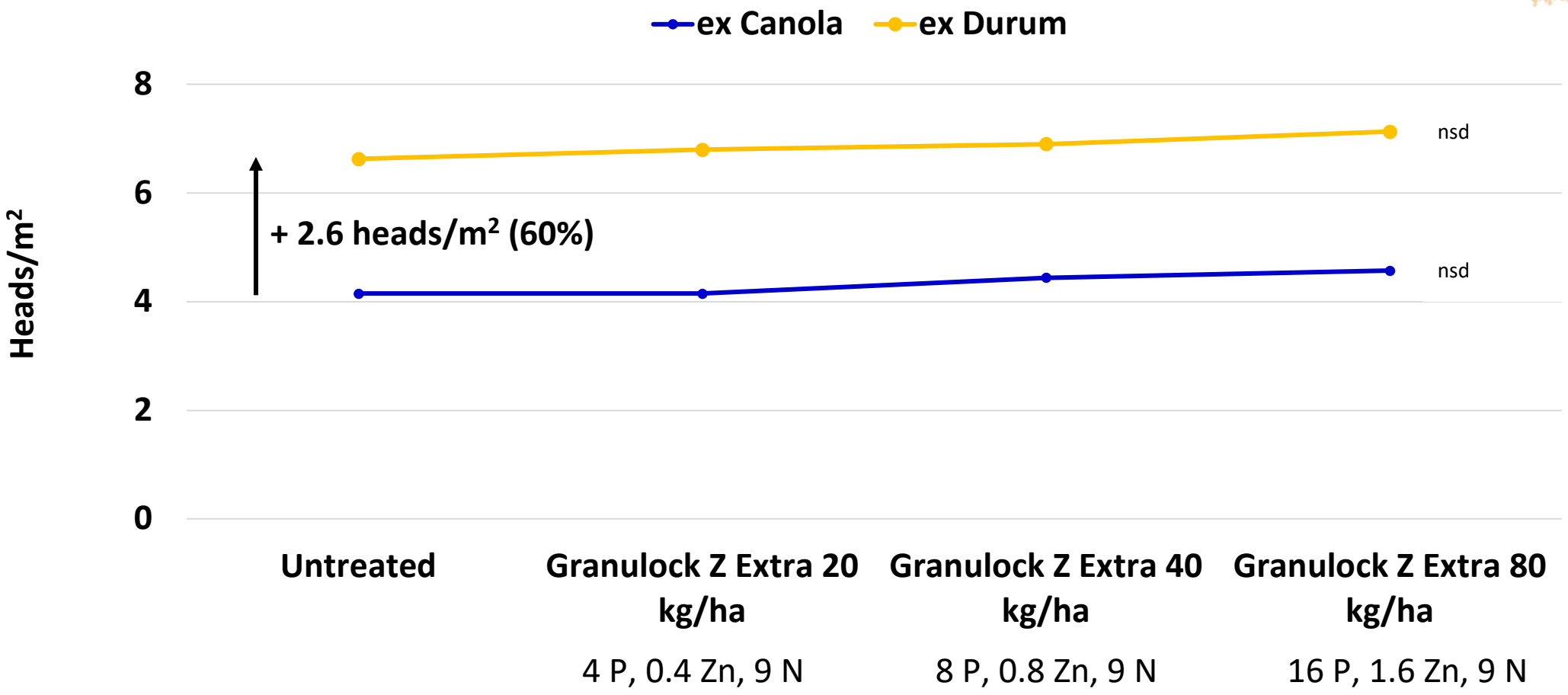
Head counts (74 DAP)



NB Emergence counts similar ~40,000/ha

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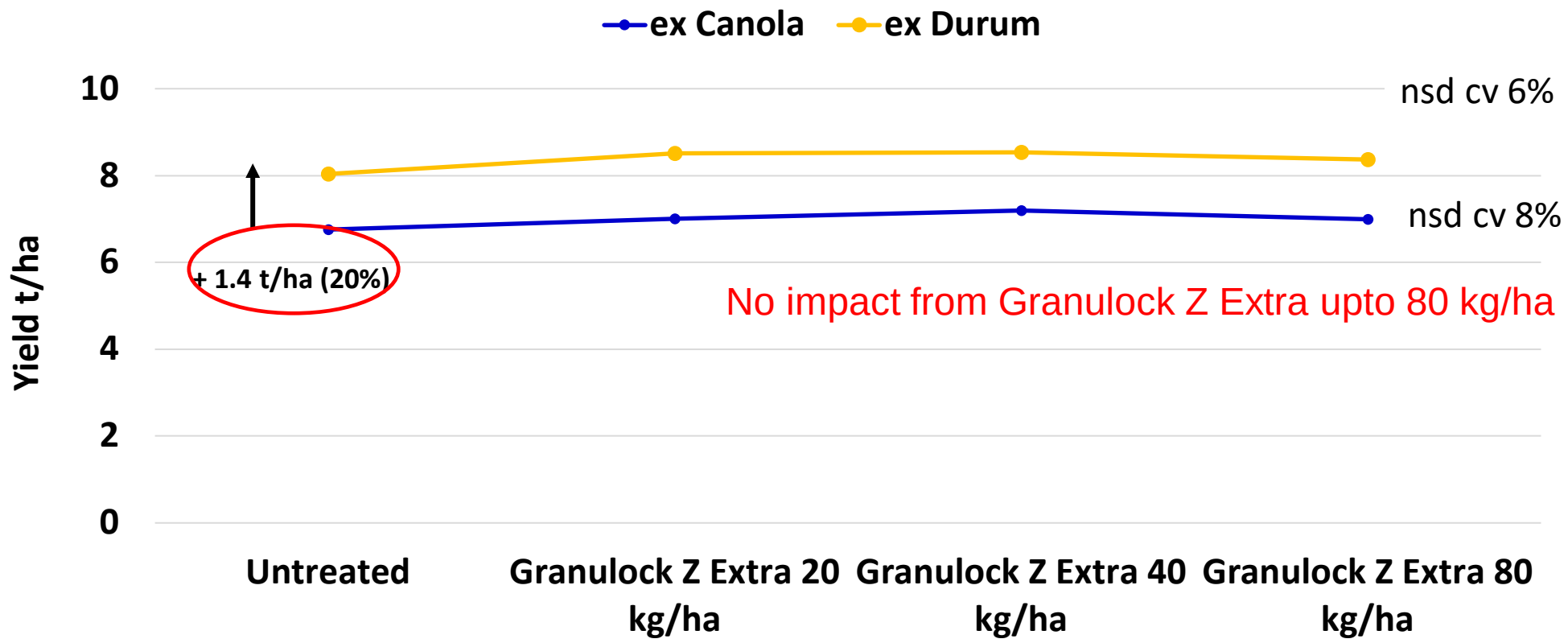
Sorghum Yield



Spring Ridge, NSW - 2015

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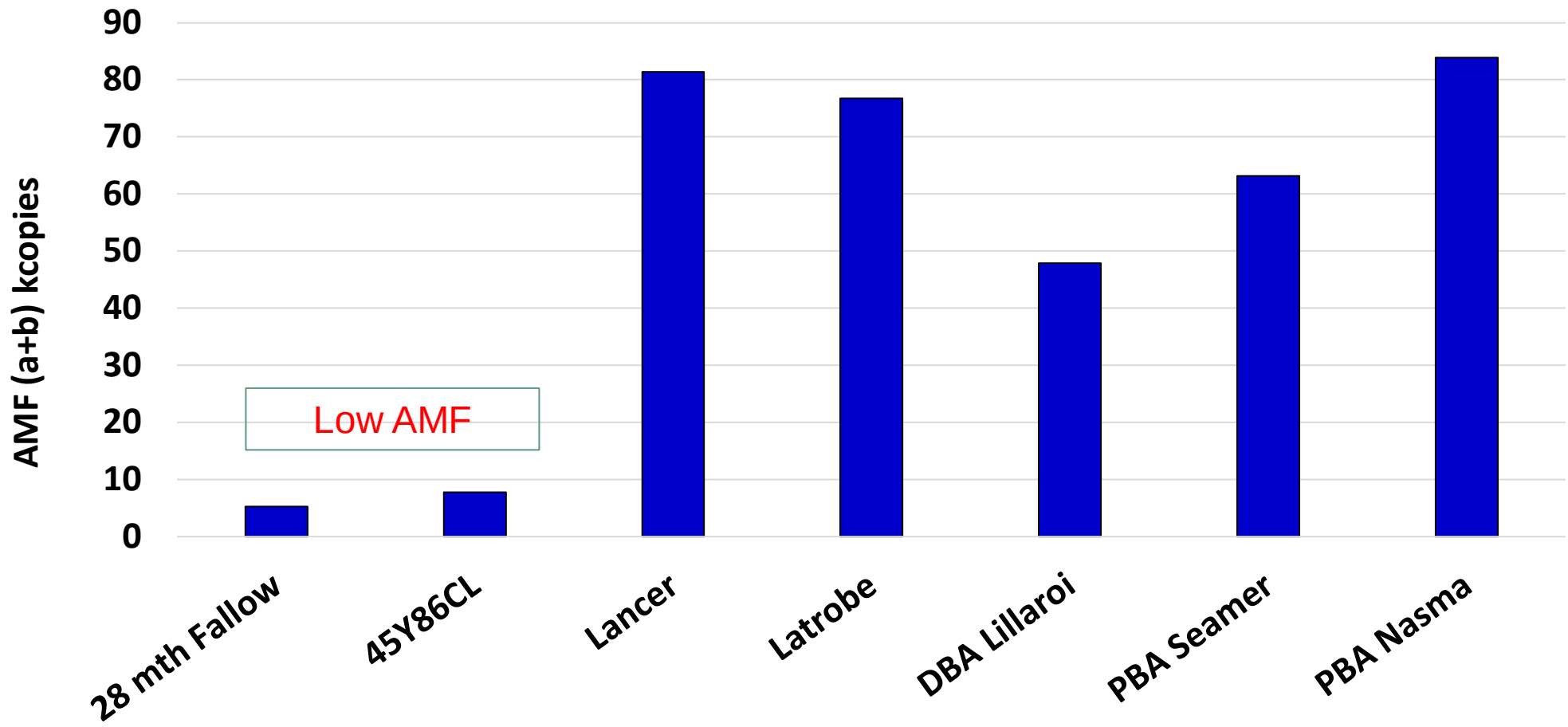
AMF levels following previous crops and fallow - Macalister Qld



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EndoPrime Sugarcane Trial Ingham Qld – 2020/21

- Trial Laid Down – 22/08/2019
- Trial Harvested – 14/09/2020
- Bins and Mill Results - 09/2020
- Rainfall received for past 12 months – 981mm
- Variety Q208 & Q253

Application	
Method:	Billet Planter
Nozzles	D4 Air Induction
Pressure	30PSI
Water rate	200l/Ha

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EndoPrime Sugarcane Trial Ingham Qld – 2020/21

15.10.2019

07.11.2019

Post Harvest 14/09/2020

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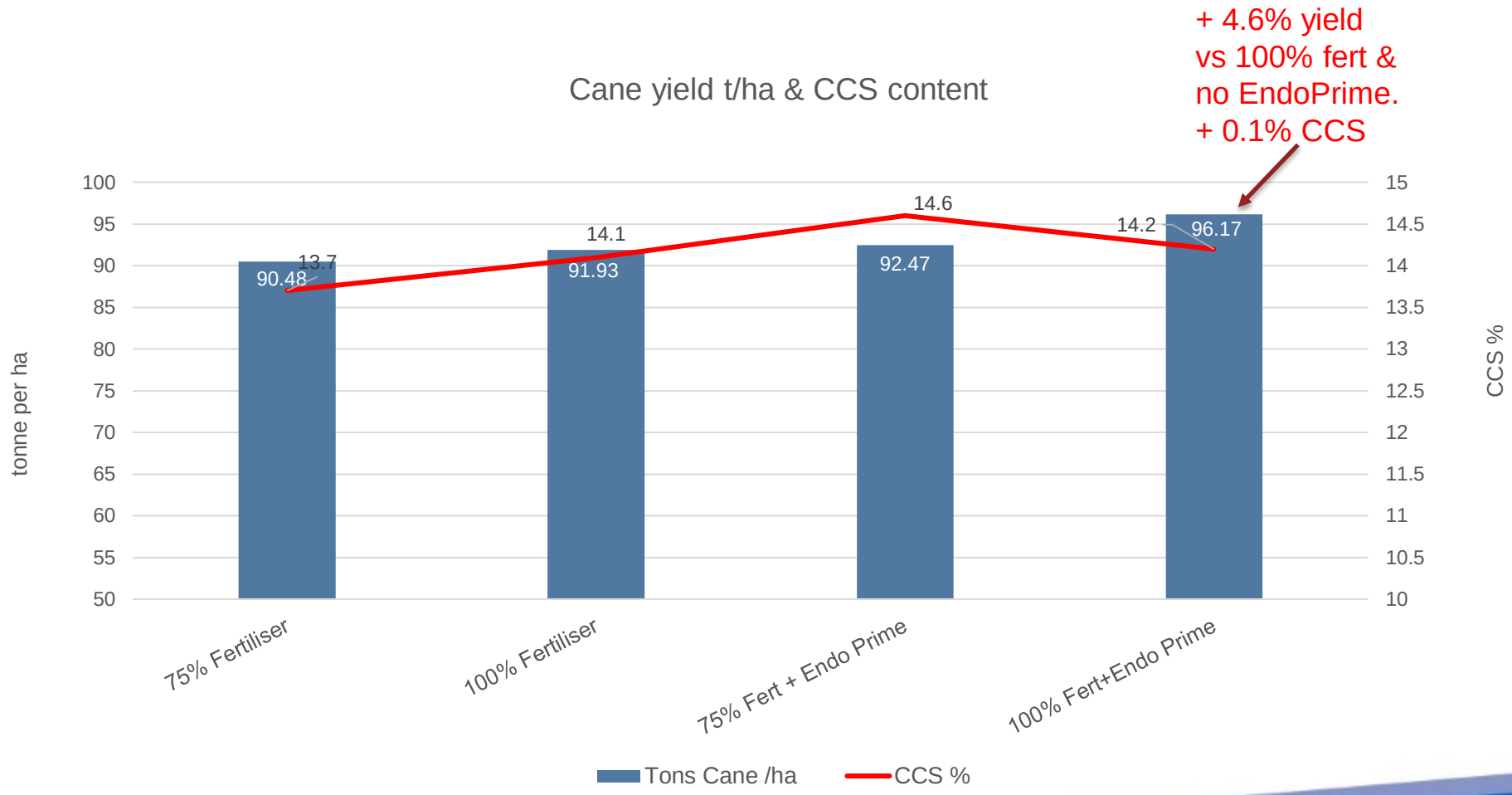
EndoPrime Sugarcane Trial Ingham Qld – 2020/21



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Mycorrhiza on sugarcane

V17-002

Large plot trial – sandy grey loam.

Propiconazole applied at planting with 13N, 10P, 5K, 0.35 Zn- kg/ha by liquid. Followed by 69N, 6P, 54K and 12S kg/ha granules

EndoFuse at 5 and 10mL/ha applied after 3 months growth by coulter soil injector down the middle of the stool with imidacloprid insecticide

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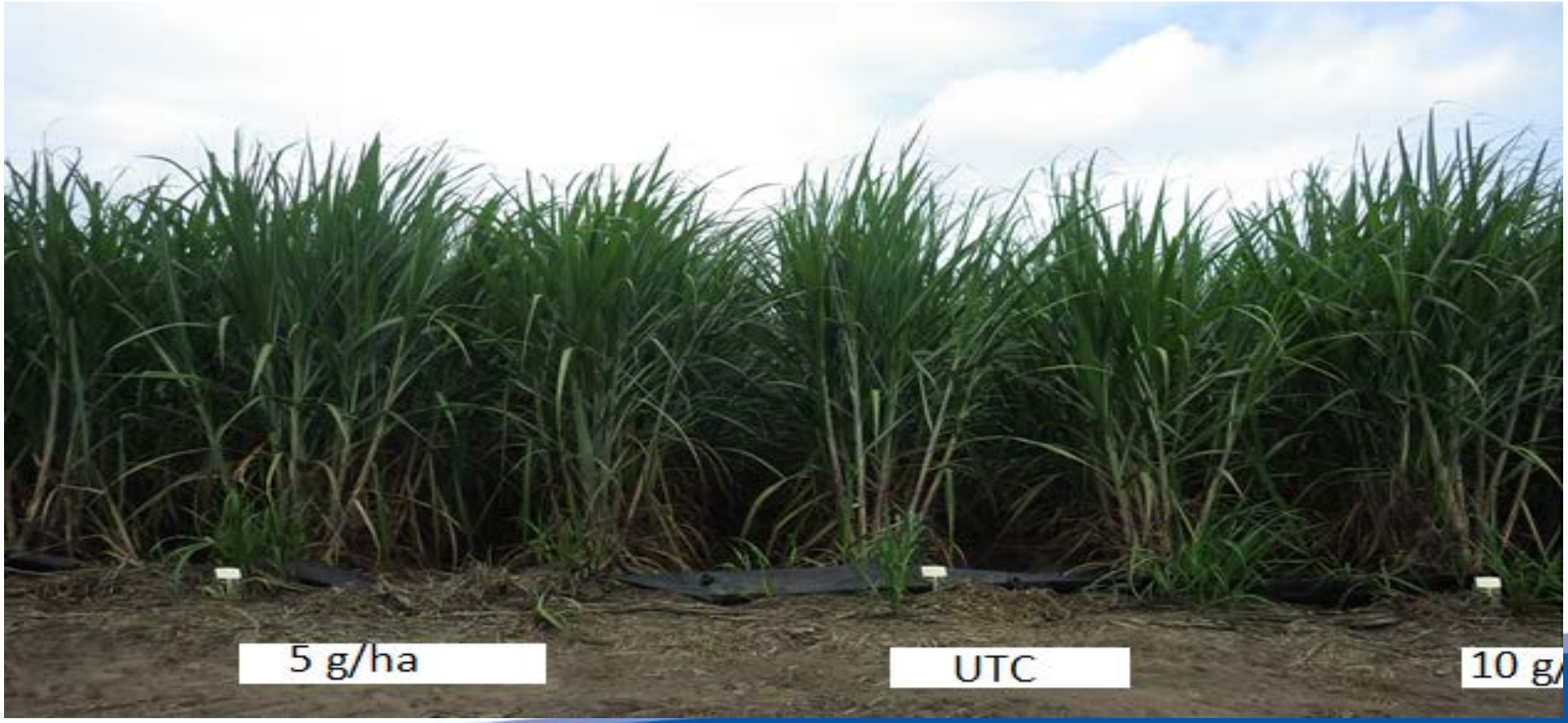
Mycorrhiza on sugarcane

V17-002

Large plot trial – sandy grey loam.
Some visual differences in growth



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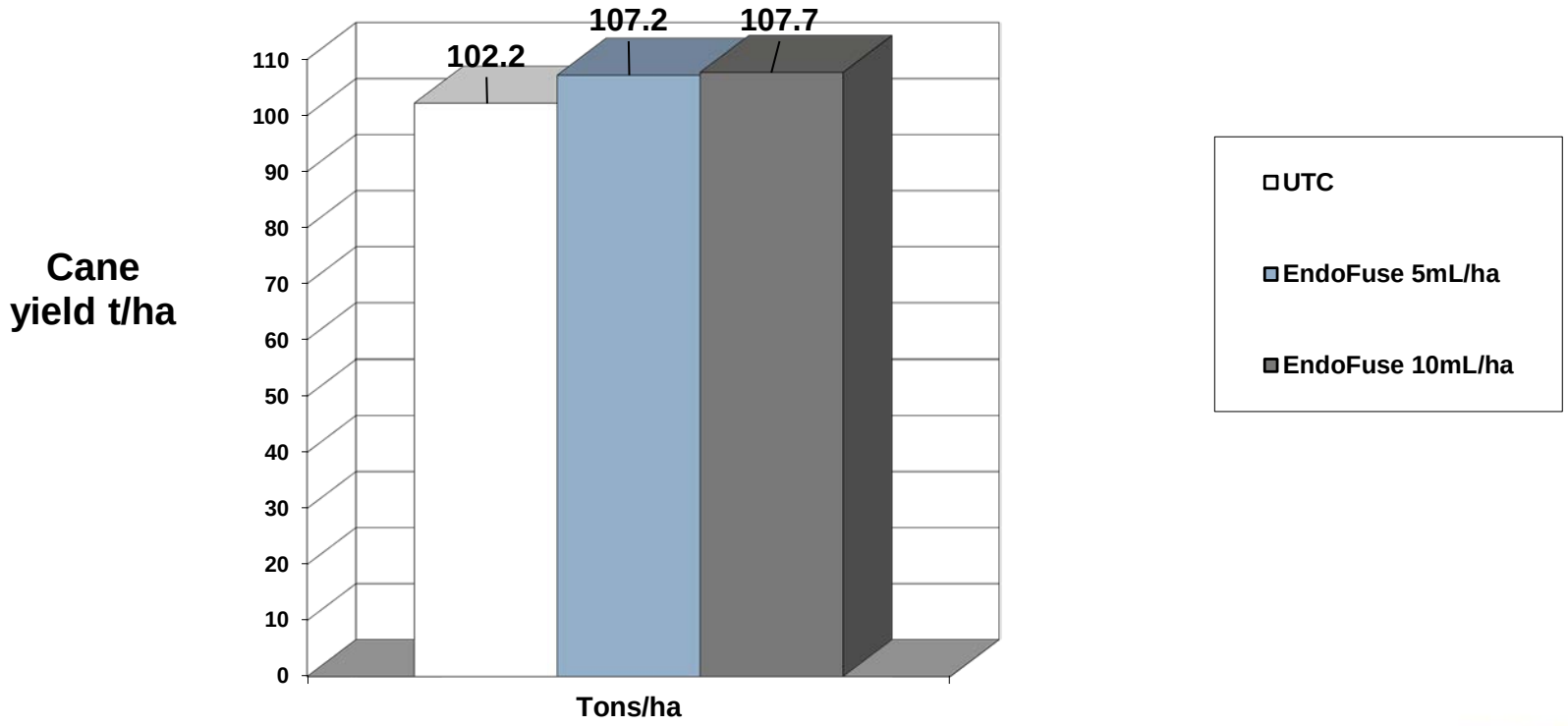
Mycorrhiza on sugarcane

V17-002



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More resilience, more productivity, powered by biology