Enhancing Biochars to Meet Soil Labour and Financial Constraints Building Viable Markets

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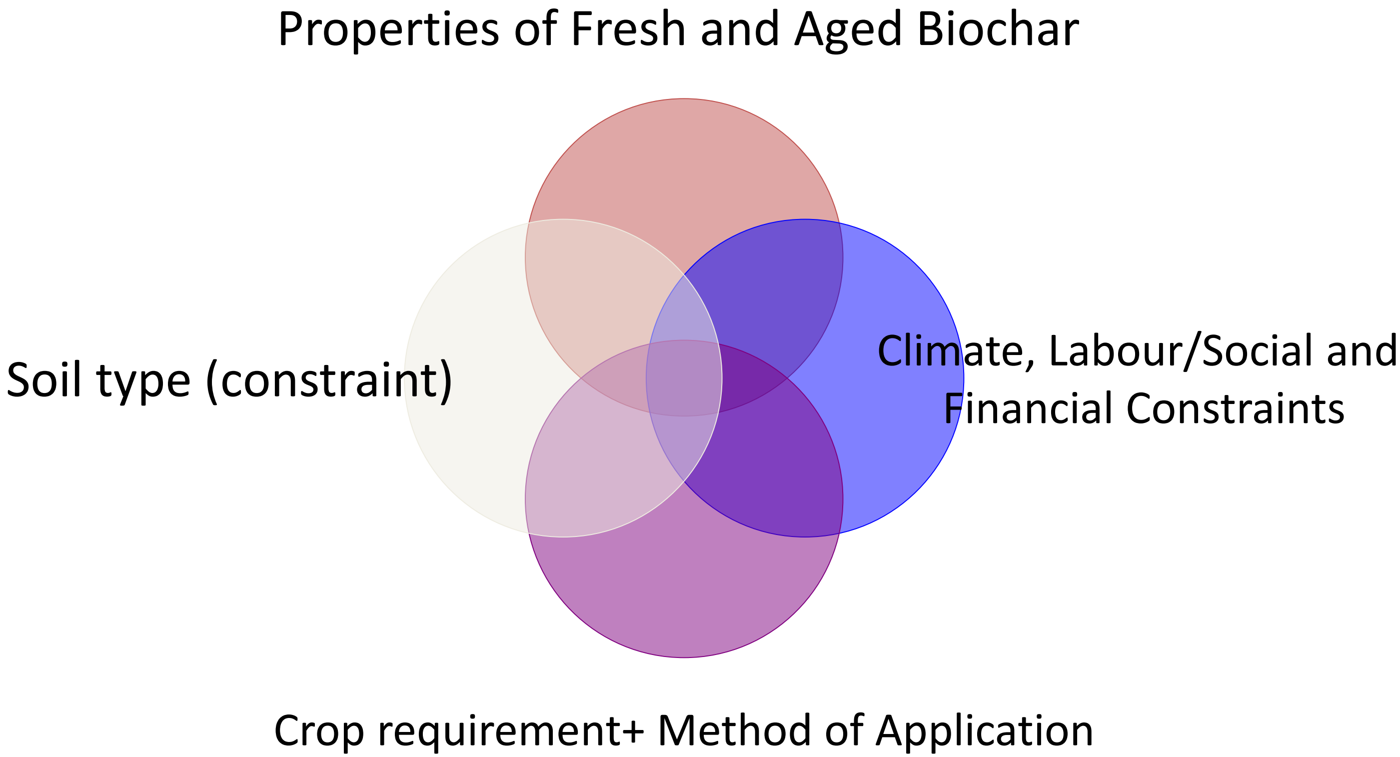
Enhancing Biochars to Meet Constraints
A Decision Matrix



Why Do We Need To Enhance Specific Biochars

1. To ensure farmers get a greater return on their investment than existing practices without increasing labour requirements.
2. To improve the soils physical, biological and chemical properties at application rates that are viable
3. To increase the availability of macro and micro-nutrients when the plant requires them
4. To reduce plant diseases and make them more resistant to a range of environmental stresses

Why Do We Need To Enhance Specific Biochars

1. Reduce nutrient run off and bioavailability of heavy metals
2. To increase ease of handling and reduce any OHS risks
3. Increase biochars ability to reduce greenhouse gas emissions and form stable carbon pools
4. For use as an animal breeding or feed supplement followed by use in gardens of fields
5. To improve the effectiveness in anaerobic or aerobic composting or digestion

How Do We Enhance Biochars

1. Use a range of biomass feedstocks to make a composite biochar with a range of properties
2. Pretreat biomass and post-treat biochars with minerals, organic matter or chemicals to either improve the surface properties and/or add nutrients.
3. Produce composite chemical/biochar fertilisers or compost/biochar soil amendments in granulated or pelleted form.
4. Add liquids that have either a high nutrient or microbial content (worm juice, compost tea, seaweed extract) or have a role in signalling
5. Make liquid biochar that can be sprayed onto plants or in root zone

Case Study 1; EB with Mixed Feedstock, Minerals and Acid Activation

- Potato farmers wish to decrease their input of fertilisers, increase yields and also decrease loss through disease
- A new biochar with high mineral content was developed to enhance the efficiency of NPK fertiliser for growing seed potatoes
- Standard Fertilisation 7N;14P;14K at 778kg/ha
- Replaced fertiliser with 5%, 10%,20% and 40% enhanced biochar

Biochar Energy Systems (BES) Pty Ltd
Low Cost Open Source Transportable Trough Pyrolyser

The Unit is operating on a farm where chicken litter is mixed with the biochar and pyrolysed

Method of Making the Biochar

Material	% Dry Weight
Wheat Straw	60%
Poultry Litter	25%
Bentonite/Iron Bearing Kaolinite	5%
Basalt dust	4%
Wheat Straw Ash	6%

1. Make ash by taking the biochar from the pyrolyser at 350C, wet and add finely ground basalt and micro nutrients
2. mix and make into a fine slurry
3. then add clay
4. and then coat straw and chicken litter and allow to dry slowly
5. pyrolyse at 425°C-450°C
6. adjust pH to 7.5 with 50% solution of Phosphoric acid
7. Mix NPK and biochar and allow to stand in bag for 2 weeks

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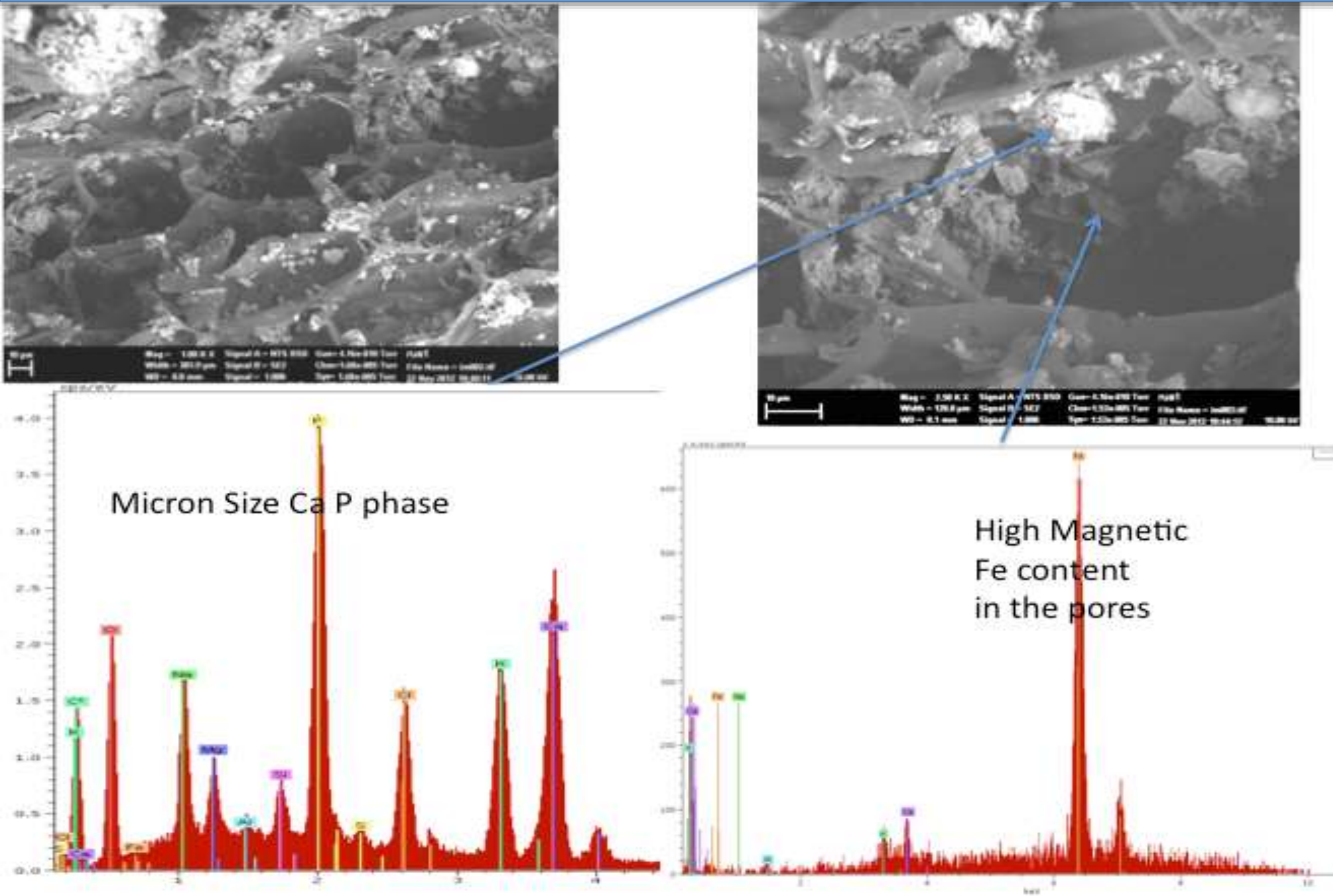
Porous Structure and High Nutrient Content of Biochar

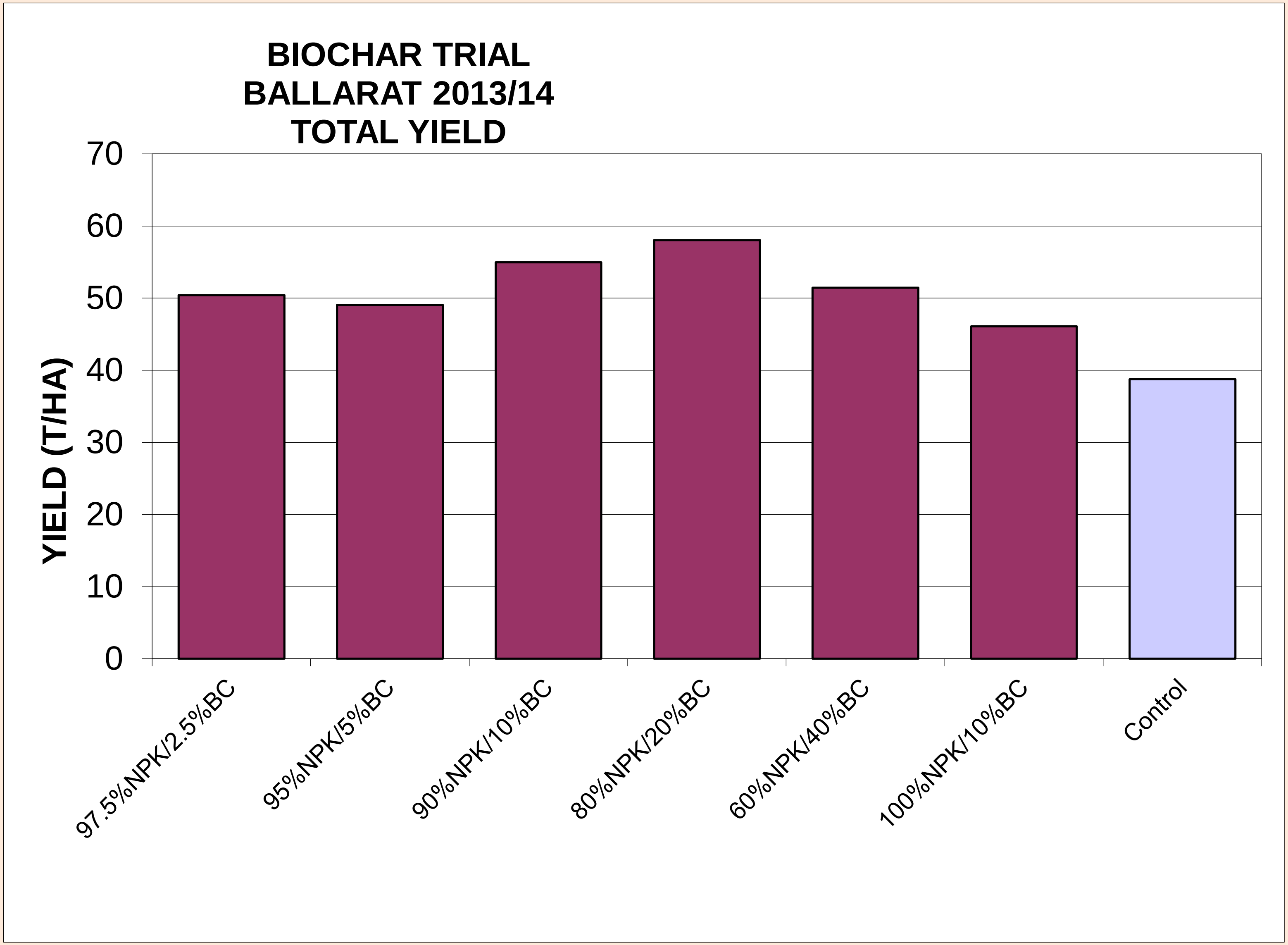


Composition of Surface Using XPS; High Concentration of O and N Functional Groups and Available Minerals

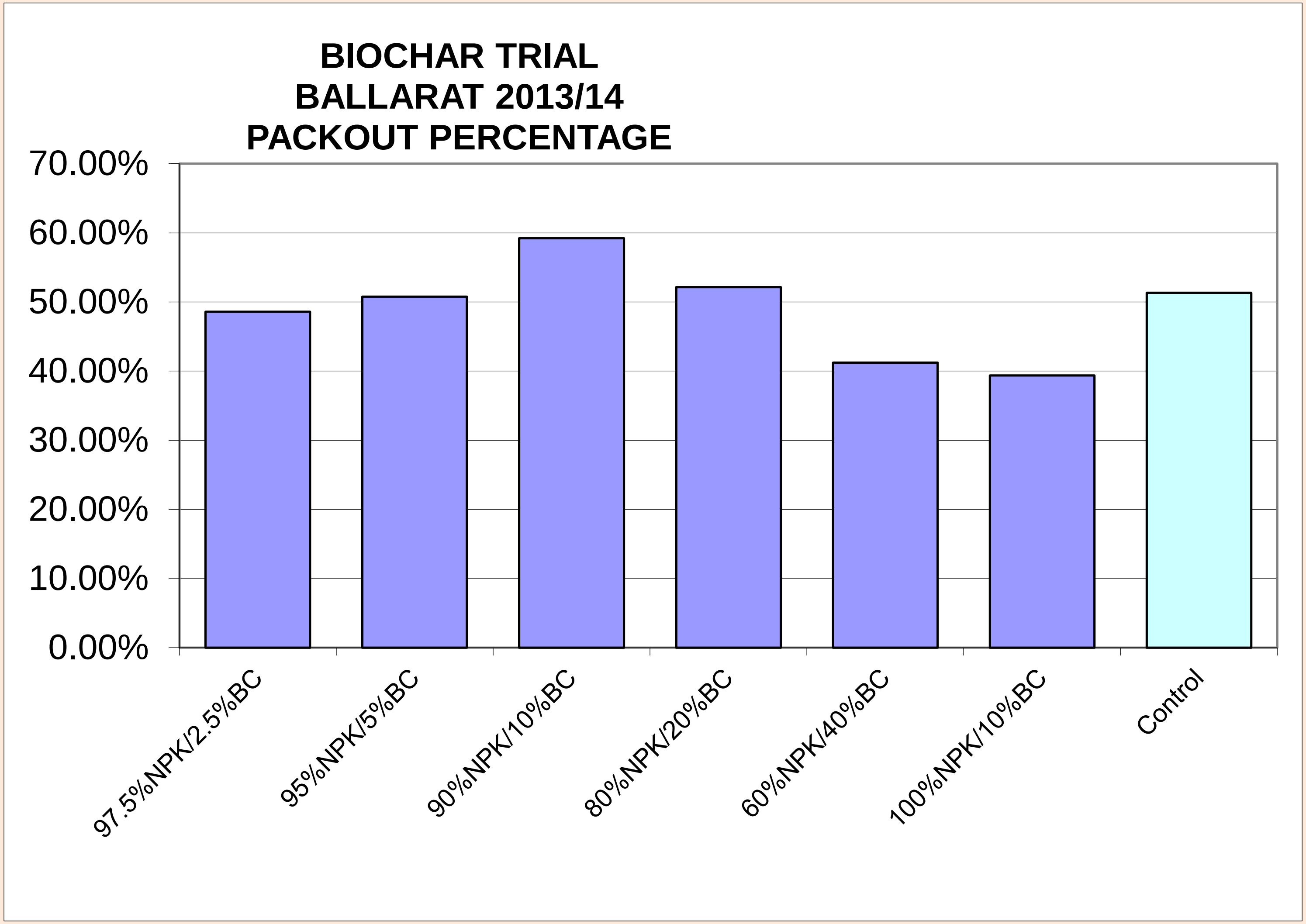
region scans

Name		At. %
C1s A	C=C	51.96
C1s B	C-C/C-H	18.25
C1s C	C-O	6.99
C1s D	C=O	2.61
C1s E	O=C-O	2.24
	O=C-N- C	
C1s F	C*(=O)NH2	3.81
K2p3 A		0.87
N1s A	N-C_COOH	0.36
N1s B	NH4/NH2 groups	0.25
O1s		12.67

Results of Trials with Enhanced Biochar; 20 tonne/ha Improvement



Improvement in Saleable Seed Potatoes of 10% with Yield Improvement of



Results of Trials; Economics

- Farmer is only paid for the potato seedlings that are in the correct size range 120-150mm. The amount is given in the previous graph
- The amount earnt per hecatare if 10% of biochar and 90% NPK is used is $23,100
- The amount earnt per hecatare if 100% NPK is used is $14,000
- By replacing approximately 80kg of NPK with an enhanced biochar the profit could be as high as $9100/hectare

Case Study 2; Stimulating Growth of Cabbage through Biochar Extract Foliar Spray

Methods of extraction:

10 gram of each sample was added to 200ml distilled water at 100℃ for 3 hours ,

Shake for 24 hours at 180r/min on shaking table,

Filtered to separate the liquid and solid phases， then use the liquid for determination.

Two Biochars produced at approximately 450-480 ℃

Wheat Straw Biochar (SW) and Maize Straw Biochar (SM)

Pot Trials; Cabbage with 3 replicates

Step 1: Each pot 2kg dry soil, rate of fertilizer application :N/P2O5/K2O=0.2/0.15/0.2g per kilogram soil.
Step 2: Each pot set 20 seeds, then choose 4 after germination.
Step 3:. Extraction proportion is 10g biochar in 200ml hot water. Then diluted 25:1 , 50:1, 100:1, each concentration have 4 replications.
Step 4: A week after germination, begin to spray biochar extraction, each time 200ml a pot, during the first two weeks ,spray once a week, then spray every three days. Total ten times and grow 45 days.

Basic Properties of Foliar Spray

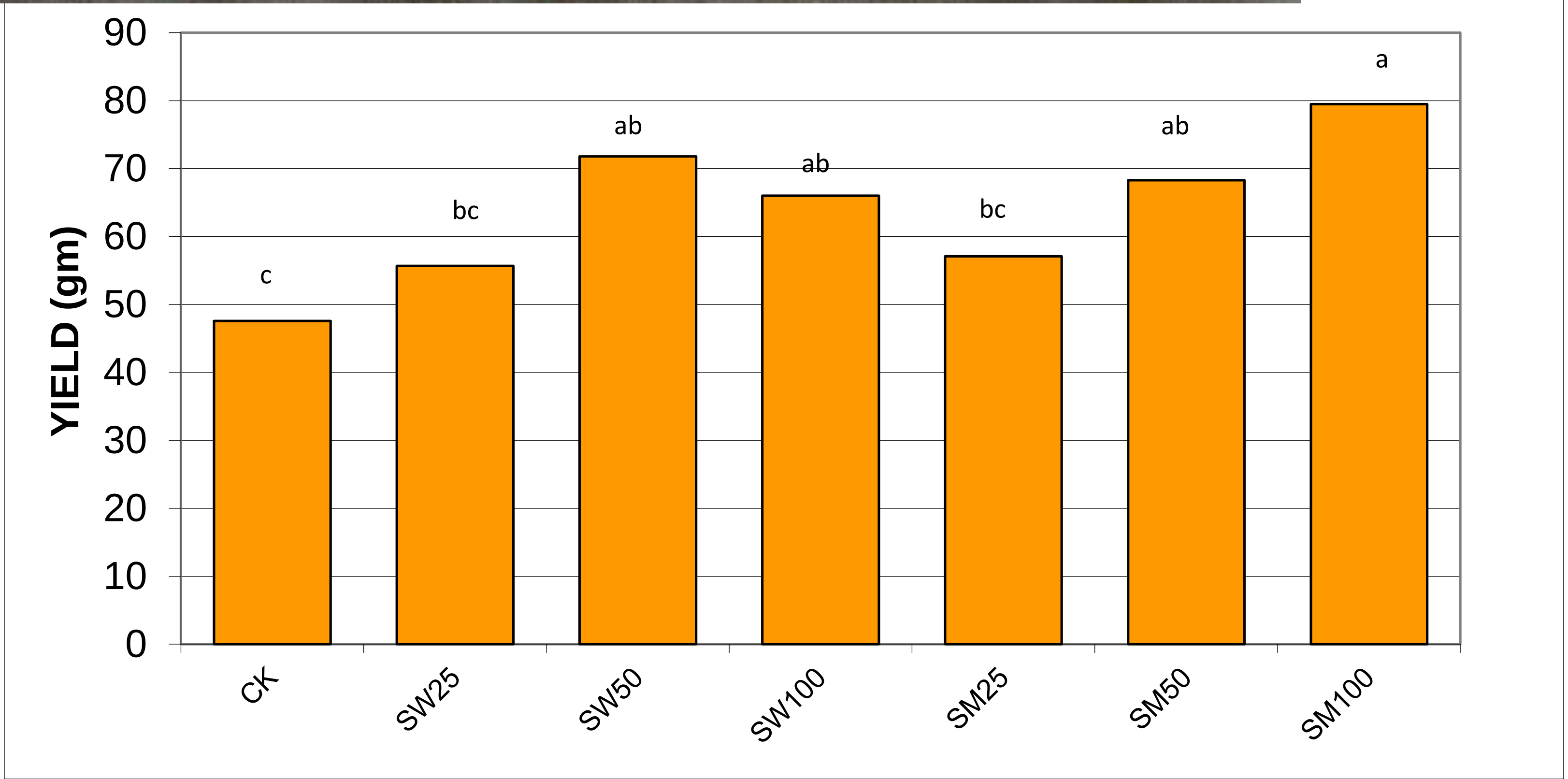
	Wheat Straw	Maize Straw
DOC	570mg/l	303mg/L
pH	9.6	9.5
EC	5.6ms/cm	6.22ms/cm
Total K	1.13g/L	1.28g/L
Total P	.009g/L	.008g/L
Total Ca	7.5g/L	14g/L

Compound By GC-MS	SW	SXM
2-Butenoic acid	Y	Y
Triethyl phosphate	Y	—
Benzoic acid	Y	Y
1-pentene	Y	—
Phenol	Y	Y
Cyclopentene	Y	—
Valeric acid	Y	Y
Phthalic acid	Y	Y
1,2-Benzendicarboxylic acid	Y	—
9,12,15-octadecatrienoic acid	Y	—
2-propenoic acid	—	Y
n-Hexadecanoic acid	Y	Y
Nicotinic acid	—	Y
N-Methynicotinic acid	—	Y
Heptadecanoic acid	Y	Y
Glycerol	Y	—
1-Hexadecanol	—	Y
Behenic alcohol	Y	Y
Urea	—	Y
1-Monolinoleoylglycerol trimethylsily ether	Y	Y

40-60% Enhanced Yield with Application of Foliar Spray

Wheat Straw BC (SW)

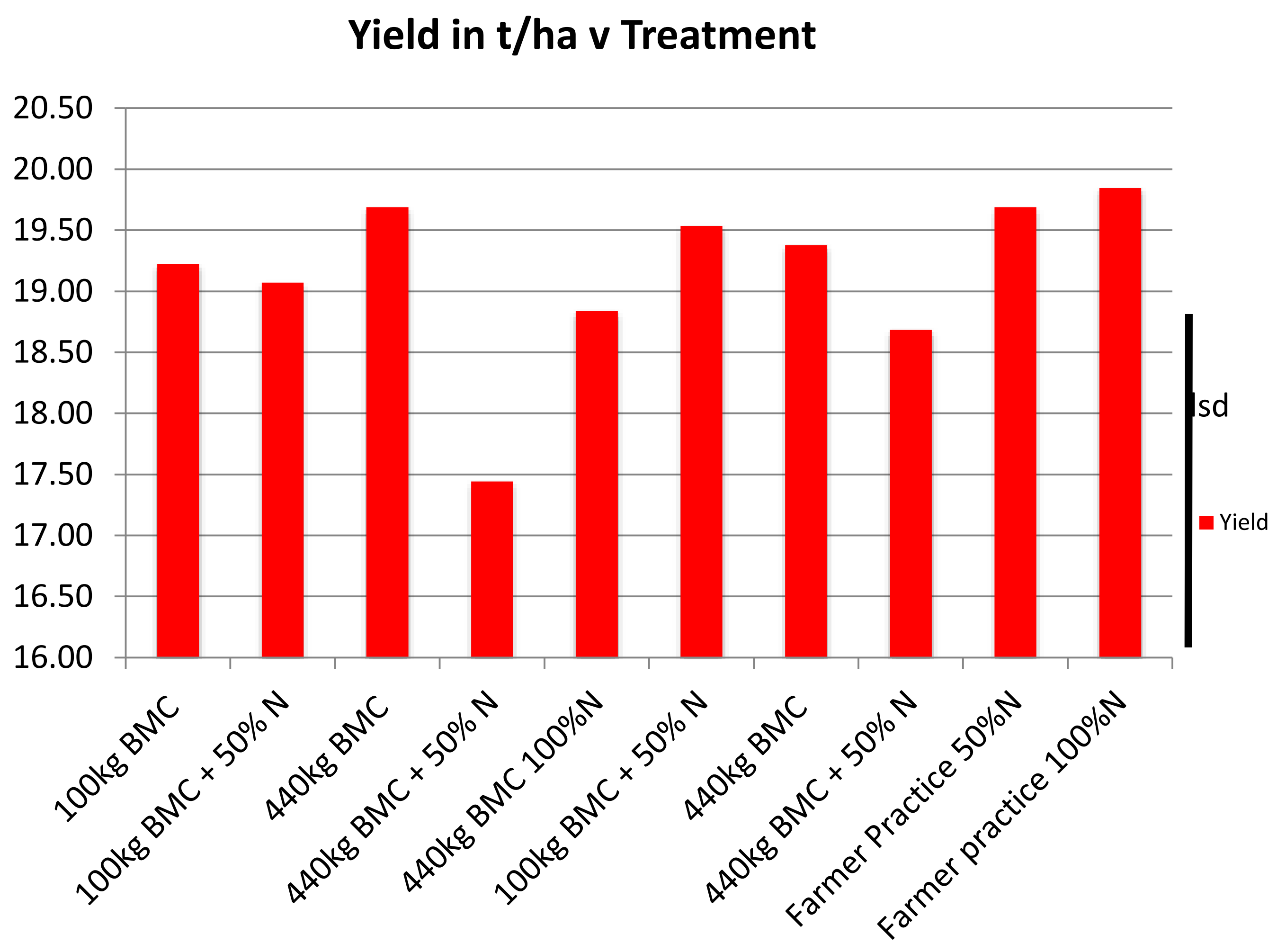
Maize Straw BC (SM)



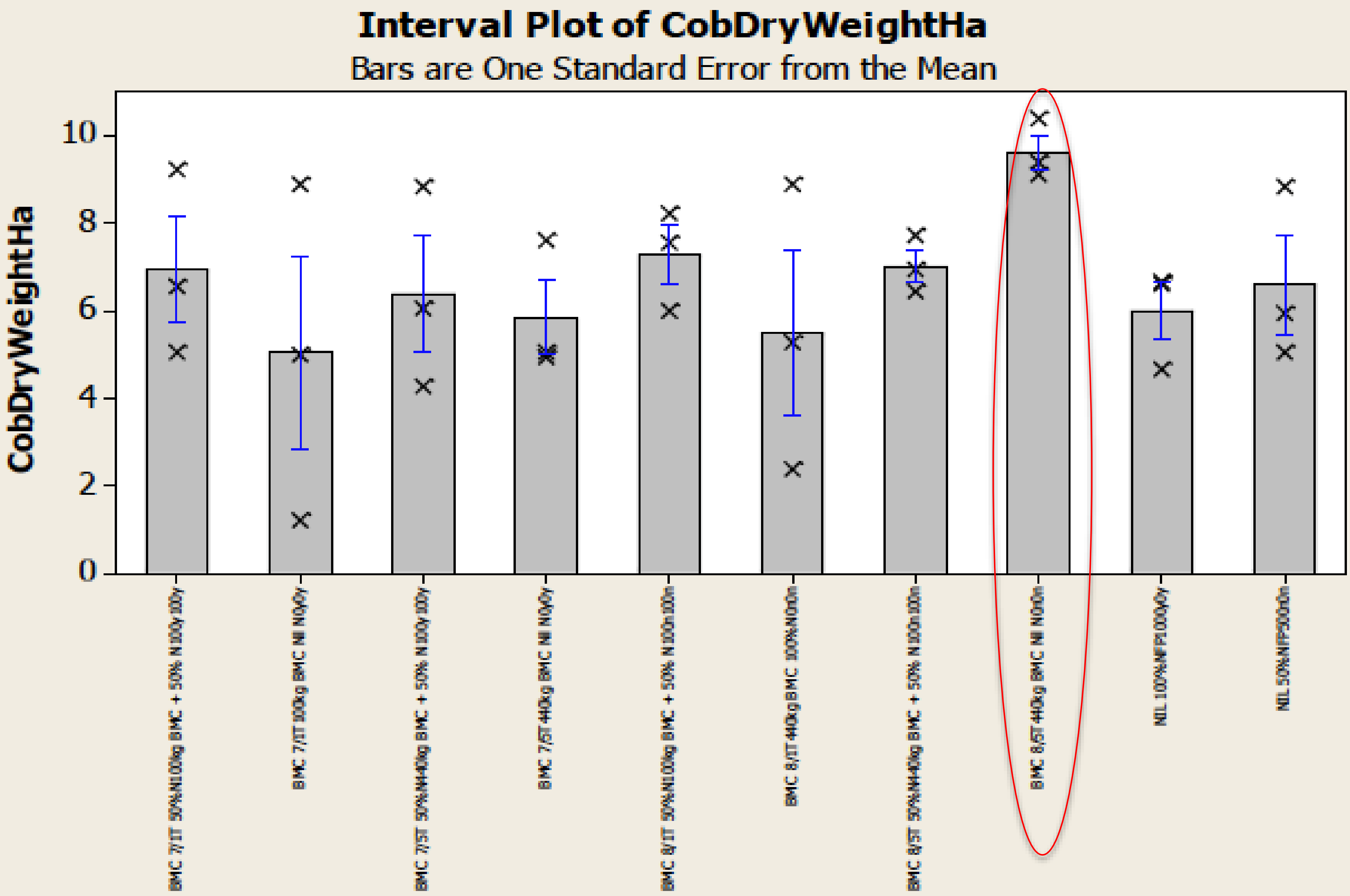
Field Trials with 3 Crop Cycles of Barley then Sweet Corn: by NSW DPI

- Control: Farmer practice of NPK + Urea
- BMC: Initial application 1t/ha and 5t/ha with 0, 50% 100% of farmer practice with addition of Urea, growing Barley
- Then either 100kg/ha or 440kg/ha for the next 3 cycles with 0, 50% 100% of farmer practice with addition of Urea
- Then either no BMC or 2t/ha with 0, 50% 100% of farmer practice with Urea for the last barley crop
- Then no amendment for the last sweet corn trials

2nd Sweet Corn Trial: No Difference between Farmer Practice and BMC



5 Crop cycle with no amendments and Sweet Corn: BMC 440kg/ha + 0kg/ha N significantly greater yield



Some Preliminary Observations and Conclusions on Applying Enhanced Biochars at Low Application Rates

- Pyrolysing a woody material with a biomass that is high in macro and micro nutrients can enhance the properties of both biochars
- EB applied in the rhizosphere at rates less than 150kg/ha can significantly increase the N and P use efficiency of NPK fertilisers.
- EB with high N and P content can provide significant improvements in yields in soils where chemical fertilisers have been applied for a considerable period of time
- However effects of EB may take 2-3 years to be observed
- Production of liquid fertilisers and foliar sprays is a promising avenue for use in intensive agriculture.

Some Hypotheses on Underlying Mechanisms that Lead to the Development of Enhanced Biochars

- Biochars produced from manures and grasses at around 450C that have significant quantities of labile organic molecules that are both redox active and can assist plant resist disease.
- Adding clay that is high in Fe appears to functionalise the surface as well as increasing the percentage of labile organic compounds
- High concentrations of nano-sized mineral phases (especially Fe/O/S, Mn/O, Si/O and Ca/P) on the surface of the biochars can be partly responsible for increase in plant nutrient uptake and resistance to disease
- EB encourage the growth of Non Nodulising nitrogen fixers and P solubilising bacteria

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Are Mineral Enhanced Biochars Natures Bio-Catalysts and Bio-Batteries?