Effect of Artificially Aged Biochar (BMC) on the mycorrhizal colonization, plant growth, nutrient uptake and soil quality improvement

Zakaria Solaiman and Stephen Joseph

What is BMC

Materials

1) Biochar made at low temperatures (approx 450C) from woody waste
2) Clay (preferably a swelling clay that has a high content of smectite)
3) High mineral ash biomass such as bagasse palm waste, manures, bark, clean paper sludge, rice husks, bones, waste from shrimp processing
4) Minerals such as calcium carbonate, rock phosphate, dolomite, crushed granite
5) Ash from biomass burning in furnaces.

Process

1)Mix ingredients with a small amount of boiling water and mix at approximately 80C for 1 hour to ensure that the as much of the nitrogen is adsorbed onto and into the clay. Each different mix will need different amounts of water

2)Place material into the torreffication kiln and heat to approximately 220C. Hold this temperature for 3 to 5 hours. The specific time and final temperature depends on the materials and the results of agronomic trials.

3)Let the kiln cool and remove the BMC and add vinegar

Typical Agronomic Analysis an high mineral content BMC

Analysis of the BMC 2/3

Ash Constituent Analysis

			BMC2	BMC3
Silicon	as	SiO2	51.2	51.4
Aluminium	as	Al2O3	18.2	19
Iron	as	Fe2O3	6.2	5.5
Calcium	as	CaO	11.6	11
Magnesium	as	MgO	1.1	1.2
Sodium	as	Na2O	0.4	0.35
Potassium	as	K2O	2.2	2.3
Titanium	as	TiO2	2.3	2.3
Manganese	as	Mn3O4	0.34	0.36
Phosphorus	as	P2O5	4.4	4.1
Sulfur	as	SO3	0.65	0.69
Strontium	as	SrO	0.04	0.04
Barium	as	BaO	0.07	0.04
Zinc	as	ZnO	0.04	0.04
Vanadium	as	V2O5	0.07	0.09

The ash constituent analysis is almost similar for both samples.

Proximate Analysis		BMC3	BMC2
Ash (at 575°C)	(%)	60.3	57.2
Volatile Matter	(%)	29.4	36
Fixed Carbon	(%)	10.3	6.8
Ultimate Analysis			
Carbon	(%)	21.2	22.7
Hydrogen	(%)	2.04	2.28

Analysis of Clay

Ultimate Analysis

Carbon	(%)	0.87	0.91
Hydrogen	(%)	0.90	0.94
Nitrogen	(%)	0.04	0.04

(ad) = "air dried" basis, (db) = "dry basis"

Ash Constituent Analysis			(%db)
Silicon	as	SiO_2	63.7
Aluminium	as	Al_2O_3	24.7
Iron	as	Fe_2O_3	7.6
Calcium	as	CaO	0.55
Magnesium	as	MgO	1.1
Sodium	as	Na_2O	0.16
Potassium	as	K_2O	2.0
Titanium	as	TiO_2	1.0
Manganese	as	Mn_3O_4	0.07
Phosphorus	as	P_2O_5	0.07
Sulfur	as	SO_3	0.09
Strontium	as	SrO	<0.01
Barium	as	BaO	0.03
Zinc	as	ZnO	0.02
Vanadium	as	V_2O_5	0.04

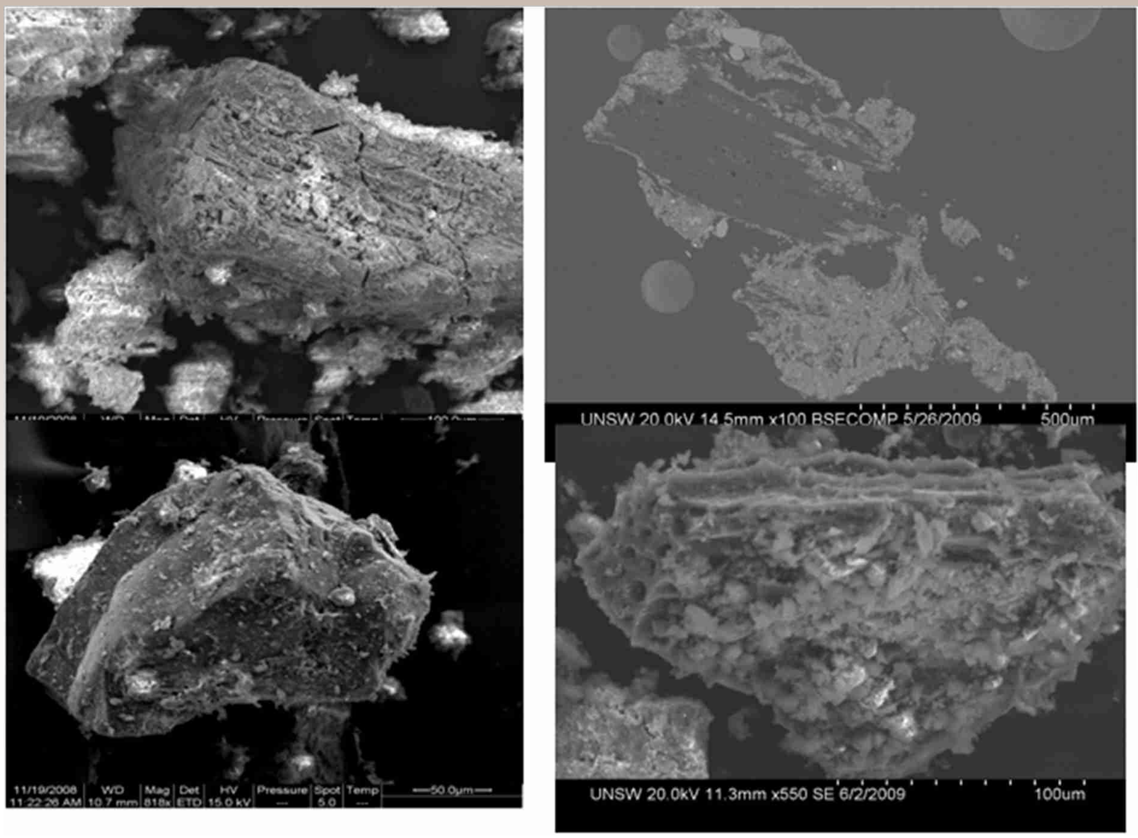
Typical Agronomic Analysis an high mineral content BMC

Some Agronomic Properties

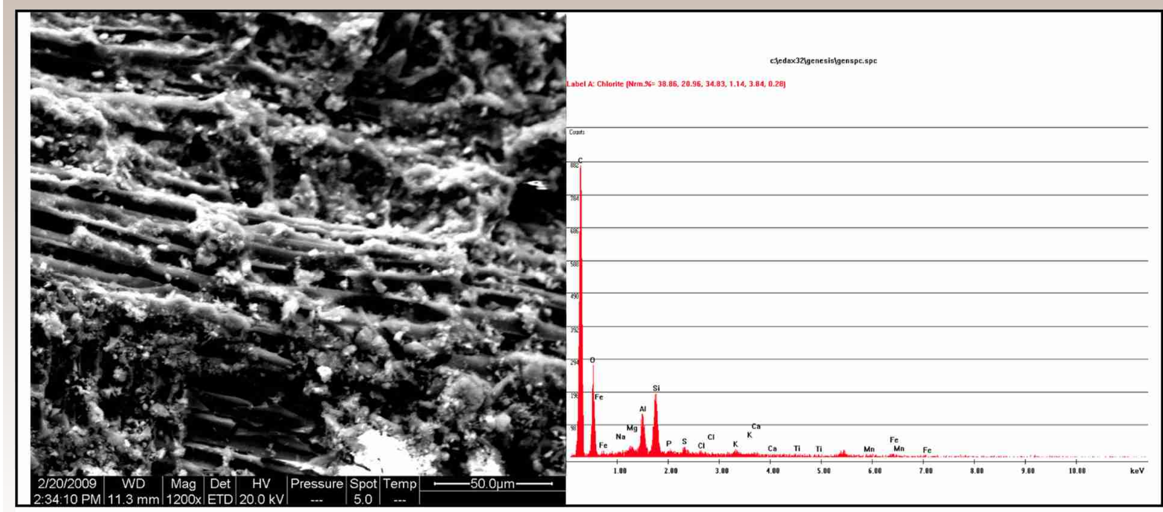
EC	.01-3.6	Ds/m
pH (CaCl2)	5.7-8.0	
Bray (available) P	500-1500	mg/kg
Colwell P	2700	mg/kg
Total Nitrogen	1.0-1.5	%
Total Carbon	20-30	%
KCl extractable Ammonium	17-100	mg/kg
KCl extractable Nitrate	<0.2-.32	mg/kg
Organic Carbon	5-18	%
ANC	7.0-10.0	% CaCO3 equiv.

Typically Exchangeable ranges from 50 to 110 cmol(+)/kg with ash analysis indicating that Ti, Mg, Mn, Fe and K between .3 to 1%. Ca is usually between 2 and 5%.

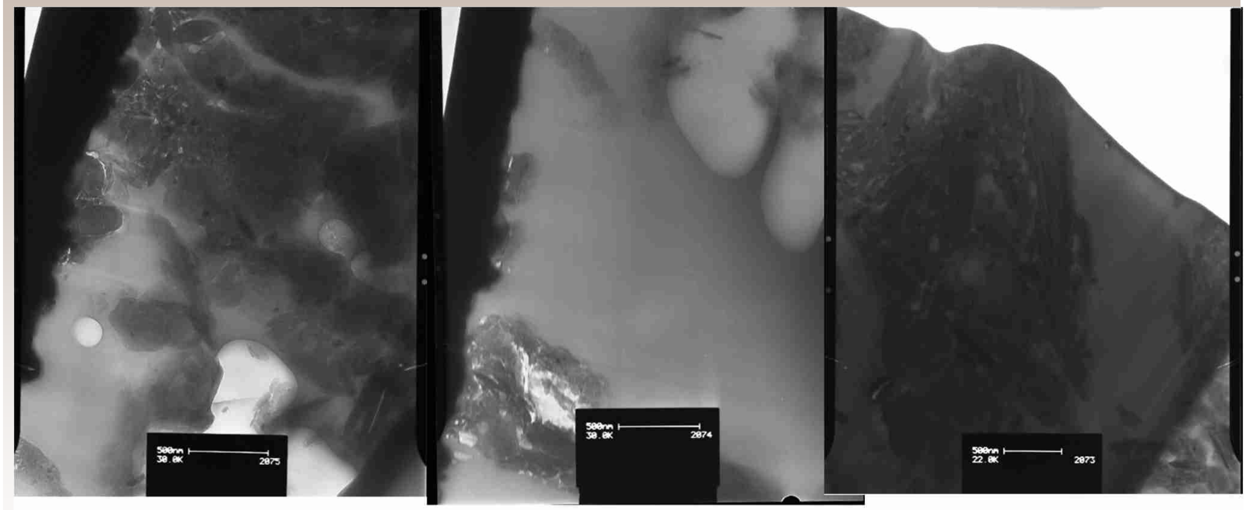
Structure of BMC



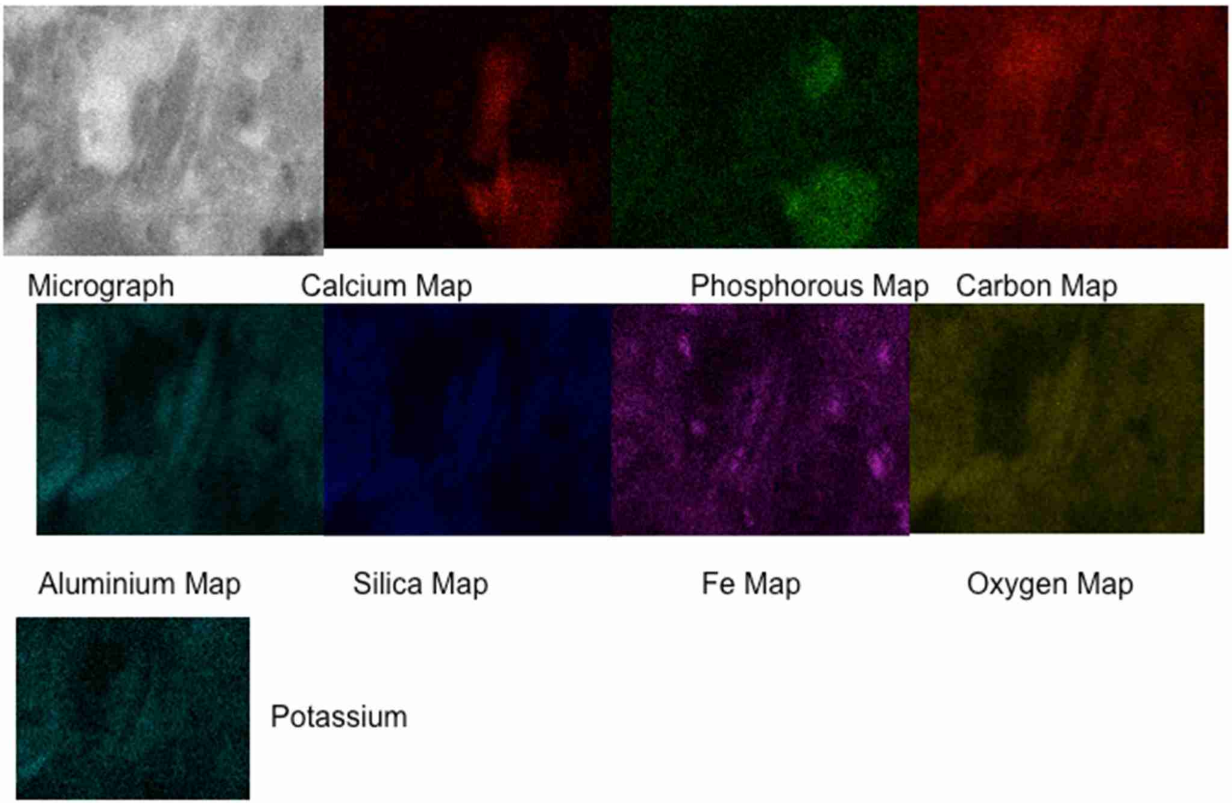
Structure of BMC



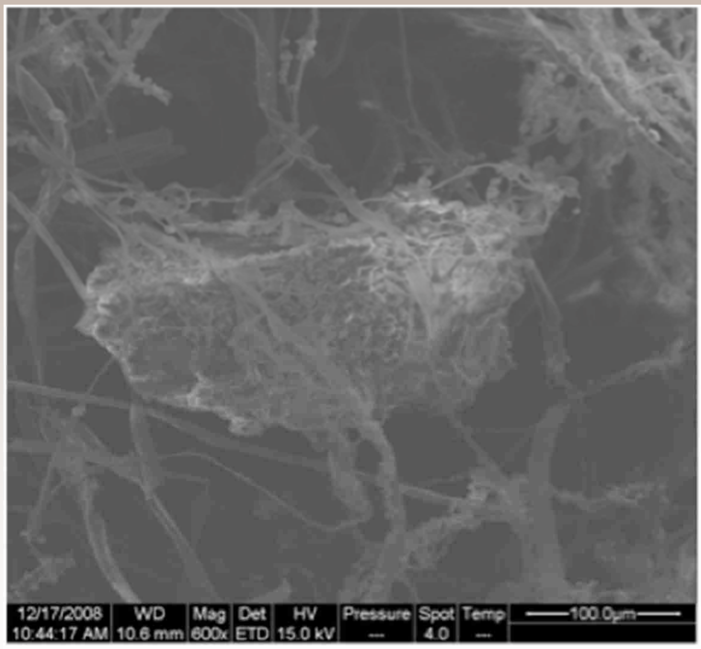
Structure of BMC



Structure of BMC



IMPROVEMENT IN FUNGI GROWTH



BMC Particle Surrounded by AMF ands Linked to Root

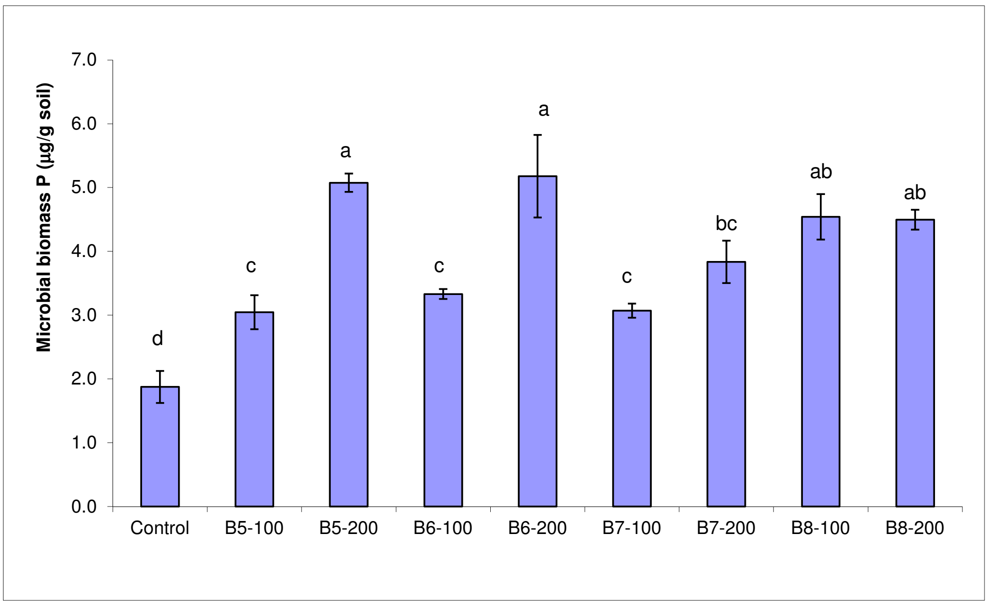
Aims

- Can BMC stimulate microbial activity including mycorrhizal fungi?
- Can BMC increase wheat growth and nutrient (N and P) uptake?
- Can BMC improve soil quality?

Design and method

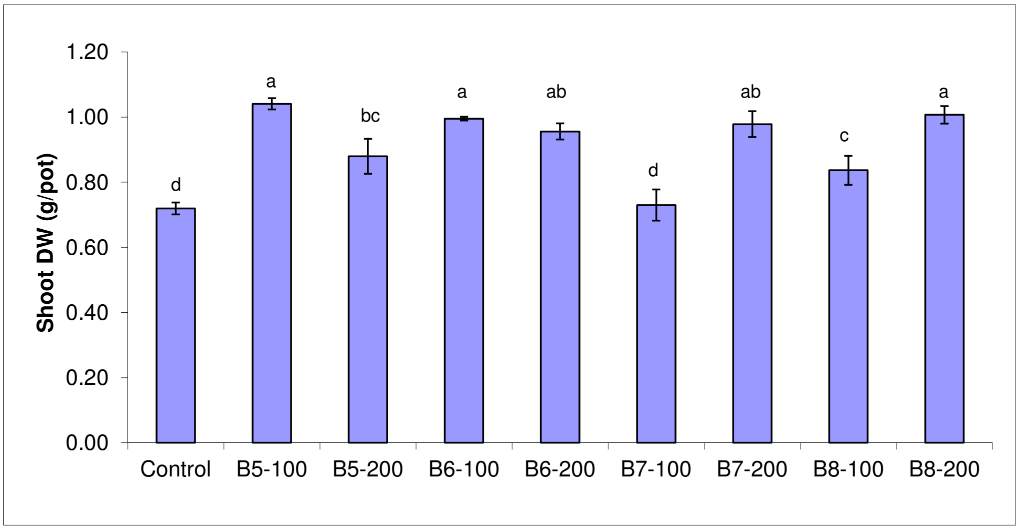
- Wheat plants were grown for 6 weeks under glasshouse conditions in a sandy loam soil amended with BMC.
- There are 9 treatments combining 4 types of BMCs (BMC5, BMC6, BMC7, BMC8), two rates (100 and 200 kg/ha) including a control along with 3 replications.
- Microbial biomass P, % of root colonized by mycorrhizal fungi, shoots and roots dry weight, plant N and P concentration and uptake.

Microbial biomass P



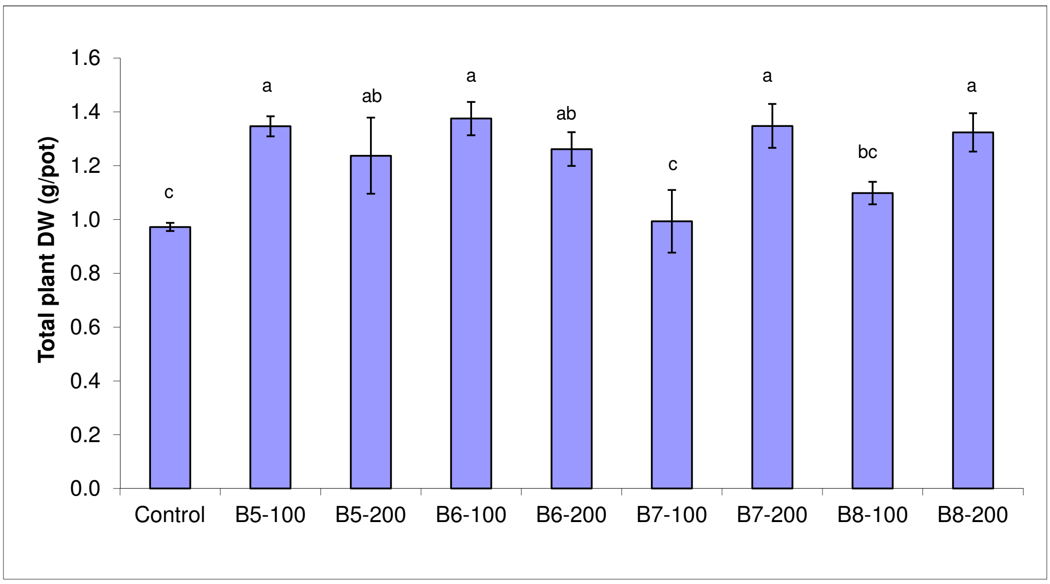
BMC increases microbial biomass P in soil

Shoot biomass



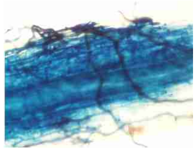
BMC increases shoot biomass

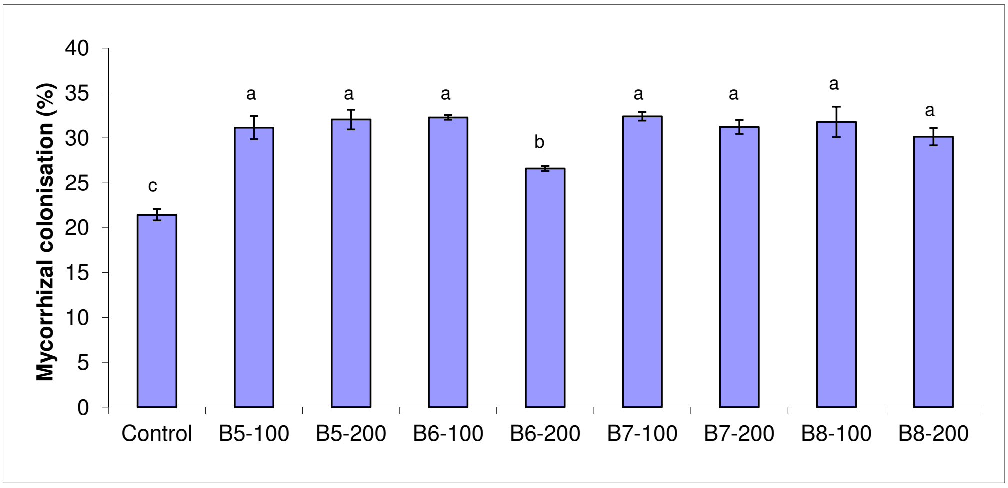
Total biomass



BMC increases total plant biomass

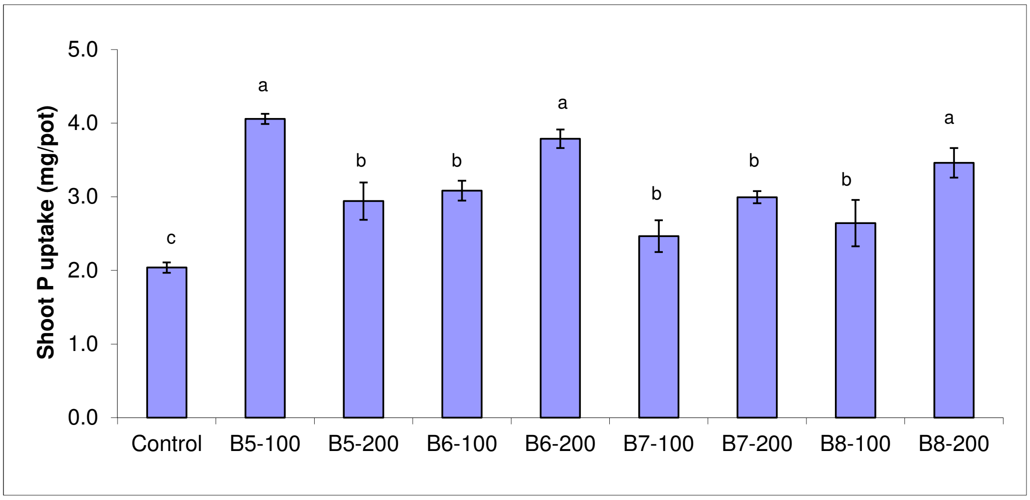
Arbuscular mycorrhizal colonization





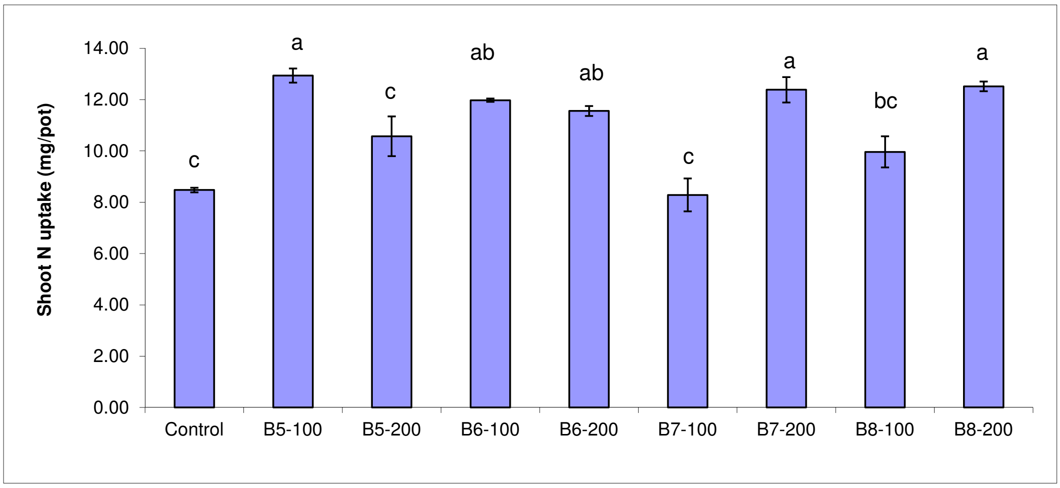
BMC increases AM colonization in wheat roots

Shoot P uptake



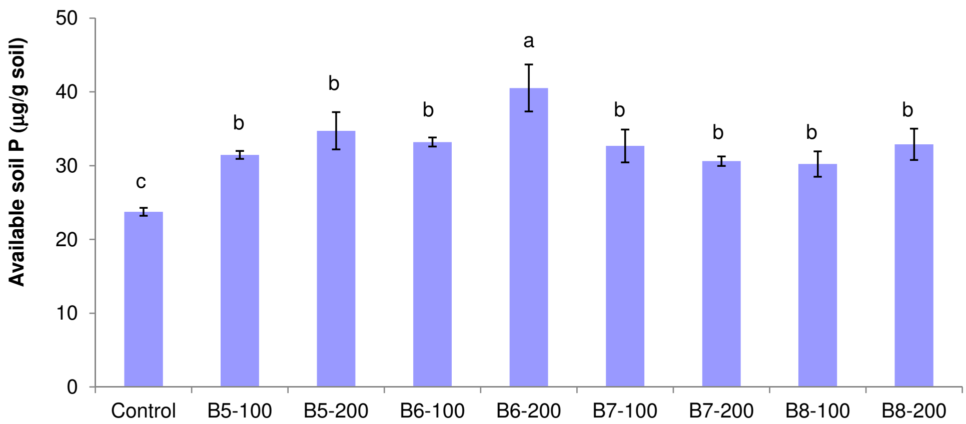
MBC increases shoot P uptake

Shoot N uptake



BMC increases N uptake in some cases

Available soil P



BMC increases available soil P

Conclusions

- BMC is effective in enhancing growth of wheat at low application rates (100kg/ha).
- The increase in biomass appears due to an increase in P and N uptake in the plants which could be partly attributed to increase in AMF colonization.
- Soil fertility also increased.

Acknowledgements

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