

# Screening techniques and results for evaluation of beneficial reuse options for thermally treated soil

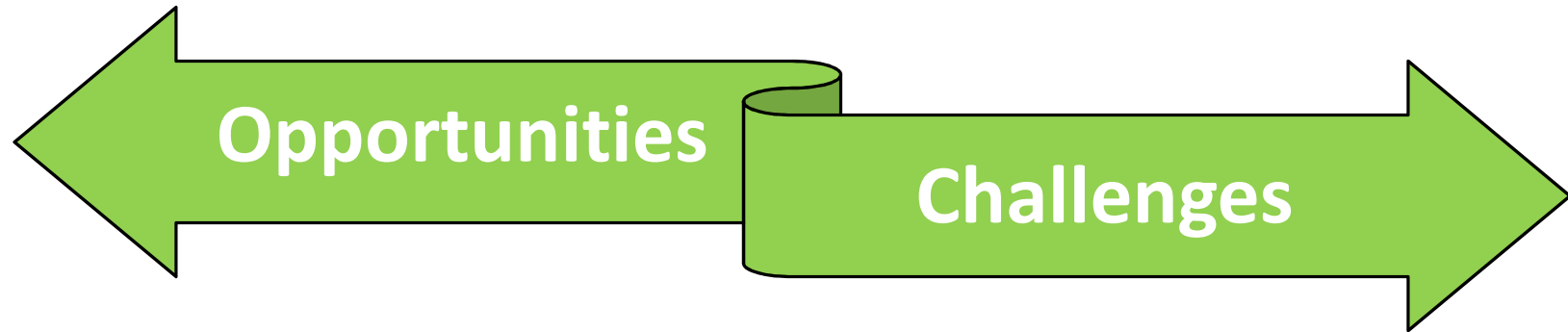
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# Beneficial Reuse

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- Reduce the cost
- Reduce resource consumption
- Improve overall environmental performance
- Enhance community relationships

- Prevent environmental or human health impacts
- Technical
- Regulatory
- **Testing tools and targets**
- Finding a market for reuse

# Thermally Treated Soil Opportunities for Beneficial Reuse

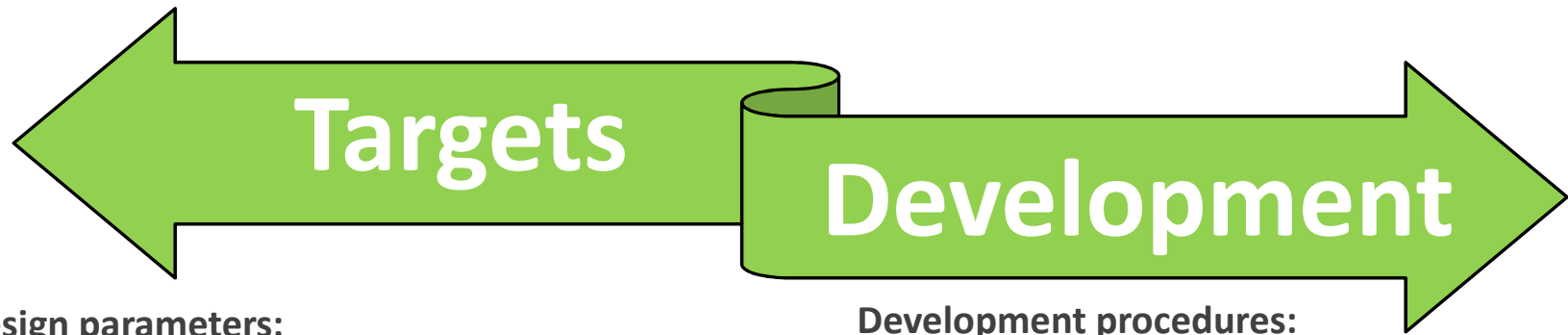
## Thermally Treated Soil

- Use of recovered soil as construction aggregate
- Energy recovery
- **Use of solids as a soil or soil enhancer**
- Use for wetland restoration



# Thermally Treated Soil Screening Technique Development and Targets

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## Design parameters:

1. Maximum discriminatory power
2. Maximum repeatability of results
3. Practicality of implementation
4. Ranking of known test substances as expected
5. Ecological relevance
6. Government acceptance of the protocols

## Development procedures:

1. Identify all of the available tests
2. Experimentally modify the tests
3. Conduct screening tests to identify the strengths and weaknesses
4. Select top contenders and further develop protocols
5. Select a top contender and propose the method
6. Validate the test methodology
7. Implement the test method in the field

# Phase I

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Prepare thermally treated soil

- Collect simulated native soil based on anticipated field conditions
- Place soil into stainless steel pans
- Heat soil to 500 C for 1 hour in large oven
- Leave soil in oven overnight to cool to room temperature
- Remove soil and place into sealed 5 gallon containers

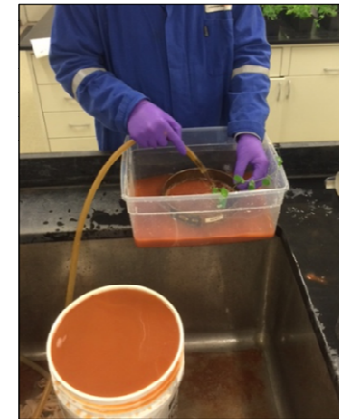
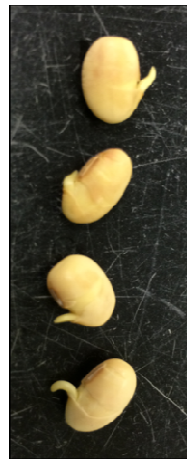


# Phase II

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Screening tests for amendments and testing procedures

- Peas, Soybeans, Alfalfa
- Simulated Native Soil, Treated Soil, Treated Soil Mix
  - 10+ additional amendments
  - Various concentrations



# Phase III

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Repeat procedure for Peas based on Phase II results with 5 replicates of 5 plants



# Phase III

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Biomass evaluation with grass





# Phase II Results



Treated Soil Mix with Rice Hulls



Native Soil



Thermally Treated Soil



Treated Soil Mix with Composted Cow Manure

# Phase II Results

## Plant Growth in mm

Control Soil	Control Sand	Native	Treated	Mix	.1 Manure	1 Manure	.1 Humus	1 Humus	.1H M	1H M	Hulls	Hulls Gyp	SAP	Mech	Chips
ENR-512	ENR-513	ENR-514	ENR-515	ENR-516	ENR-517	ENR-518	ENR-519	ENR-520	ENR-521	ENR-522	ENR-523	ENR-524	ENR-525	ENR-526	ENR-527
405	420	310	455	345	395	491	347	462	440	475	215	230	395	483	378
390	403	312	460	405	375	415	320	457	430	415	255	280	445	350	407
390	385	385	380	370	383	380	330	370	390	365	217	225	390	293	395
315	428	407	405	365	345	418	360	464	445	415	275	275	240	358	375
270	450	417	390	415	265	455	385	378	230	350	215	230	280	310	430
405	390	263	480	440	440	330	365	365	465	390	240	240	340	325	375
350	405		410	365	405	465	363	433	395	445	340	160	310		375
510	345		350	360	375	465	373	405	380	410	257	210	385		400
390	460		320	460	315	365	425	404	410	460	248	250	335		380
455	405		415	345	360	480	355	352	440	320	256	130	345		270
388.0	409.1	349.0	406.5	387.0	365.8	426.4	362.3	409.0	402.5	404.5	251.8	223.0	346.5	353.2	378.5
63.8	31.4	57.1	47.3	38.4	46.4	51.2	27.7	40.5	63.1	46.7	35.3	44.6	57.2	62.1	40.0
0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.1
0.9	0.9	1.0	0.9	0.9	1.0	0.8	1.0	0.9	0.9	0.9	1.4	1.6	1.0	1.0	0.9
100.0	100.0	60.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	60.0	100.0

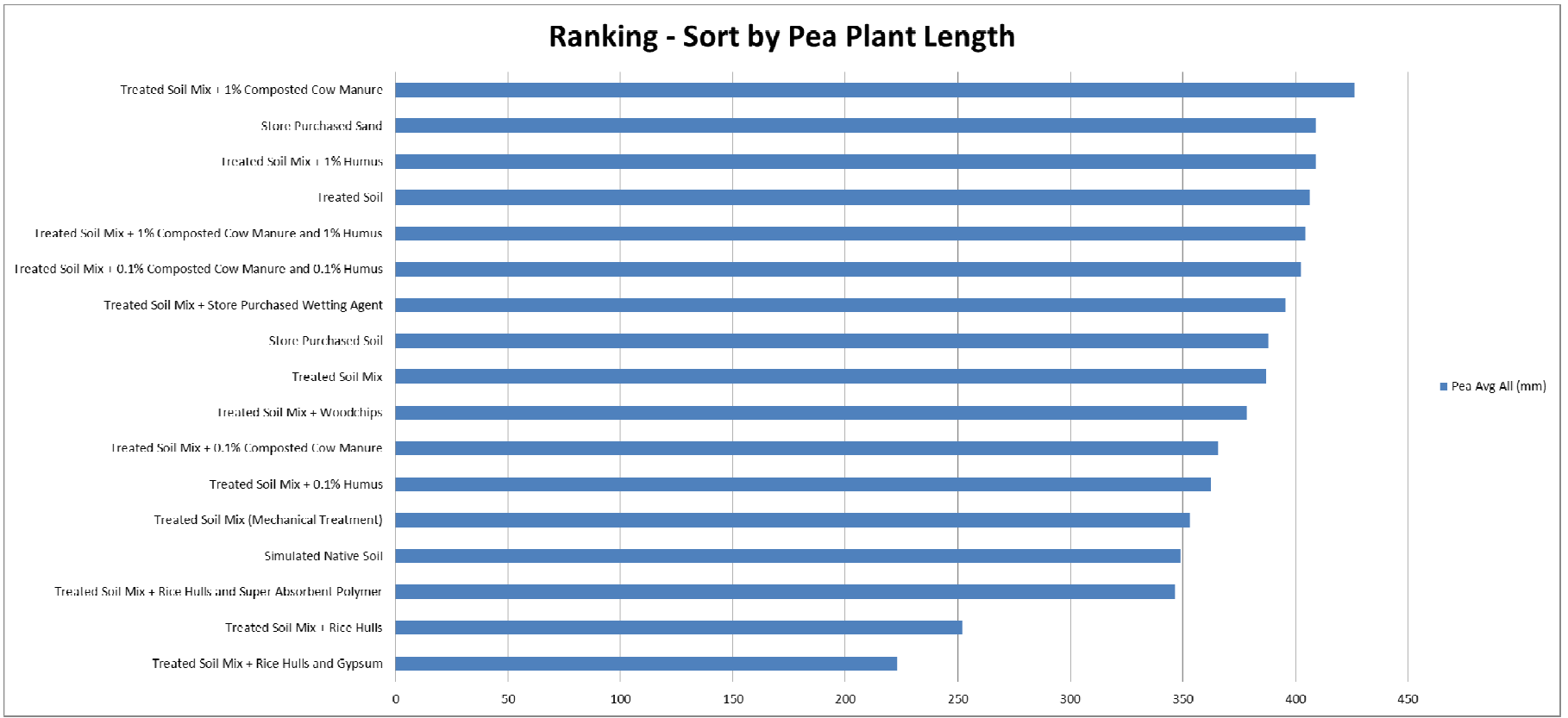
# Phase II Results

## Nitrogen, Phosphorous, Potassium, Bacteria results

Phase II Description	Moisture %	Solids %	Nitrogen mg/kg	Potassium mg/kg	Phosphorus mg/kg	Bacteria
Store Purchased Soil	42.9	57.1	880	1710	243	9
Store Purchased Sand	0.08	99.9	0.778	126	59.1	
Simulated Native Soil	1.7	98.3	112	495	36.3	1
Treated Soil	0.4	99.6	43.8	561	0.513	
Treated Soil Mix	0.7	99.3	46.6	586	42.5	5
Treated Soil Mix + 0.1% Composted Cow Manure	0.8	99.2	62.7	578	31.2	1
Treated Soil Mix + 1% Composted Cow Manure	0.9	99.1	83.9	583	82	3
Treated Soil Mix + 0.1% Humus	0.8	99.2	59.4	532	170	7
Treated Soil Mix + 1% Humus	2.2	97.8	144	581	179	1
Treated Soil Mix + 0.1% Composted Cow Manure and 0.1% Humus	0.8	99.2	91.3	550	54.5	9
Treated Soil Mix + 1% Composted Cow Manure and 1% Humus	2.8	97.2	192	618	114	5
Treated Soil Mix + Rice Hulls	0.9	99.1	380	645	34.7	8
Treated Soil Mix + Rice Hulls and Gypsum	0.9	99.1	405	633	55.5	4
Treated Soil Mix + Rice Hulls and Super Absorbent Polymer	0.9	99.1	68.5	2180	102	1
Treated Soil Mix (Mechanical Treatment)	0.6	99.4	731	565	70.9	1
Treated Soil Mix + Woodchips	1.4	98.6	51.1	583	43	2
Treated Soil Mix + Store Purchased Wetting Agent	0.7	99.3	64.4	557	53.4	5

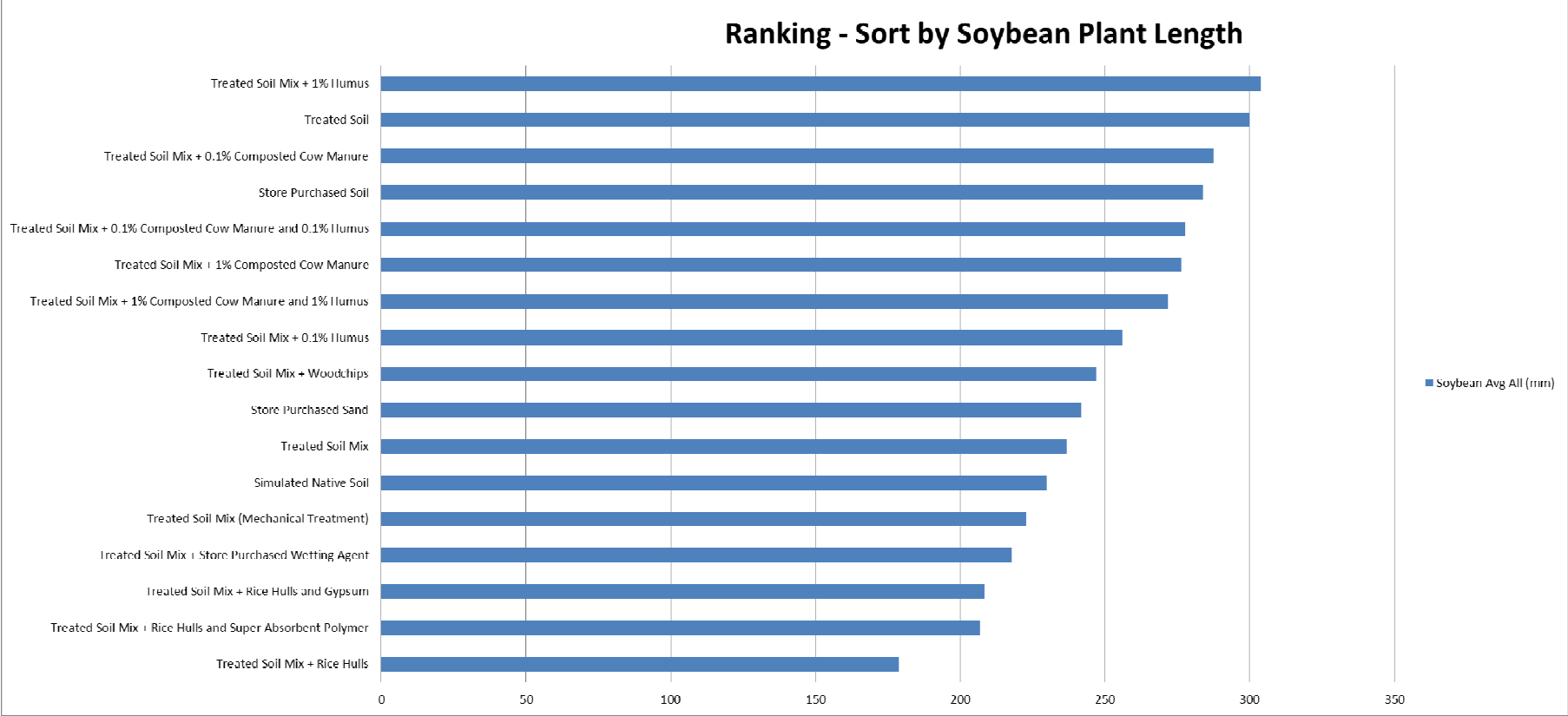
# Phase II Results

## Phase II Test Matrix Results: Peas



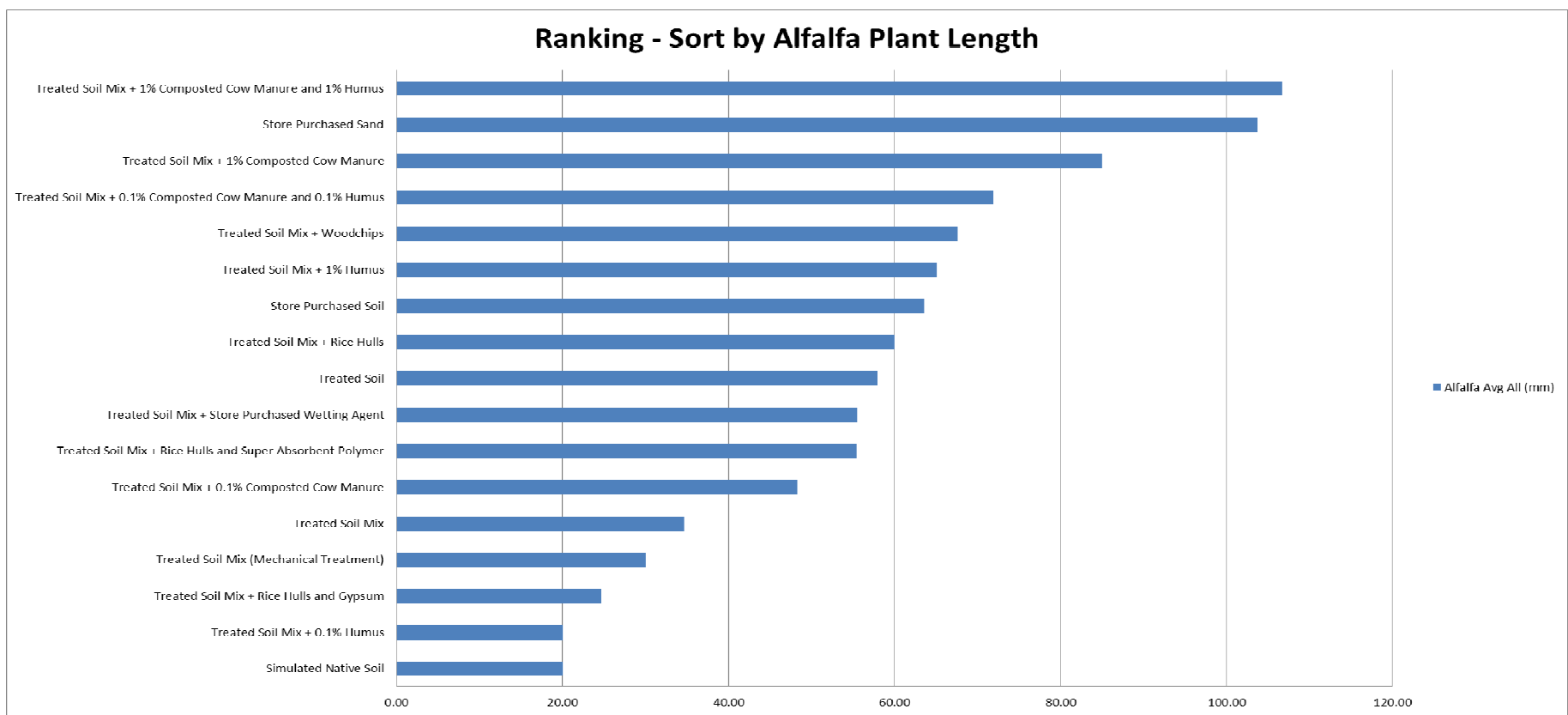
# Phase II Results

## Phase II Test Matrix Results: Soybeans

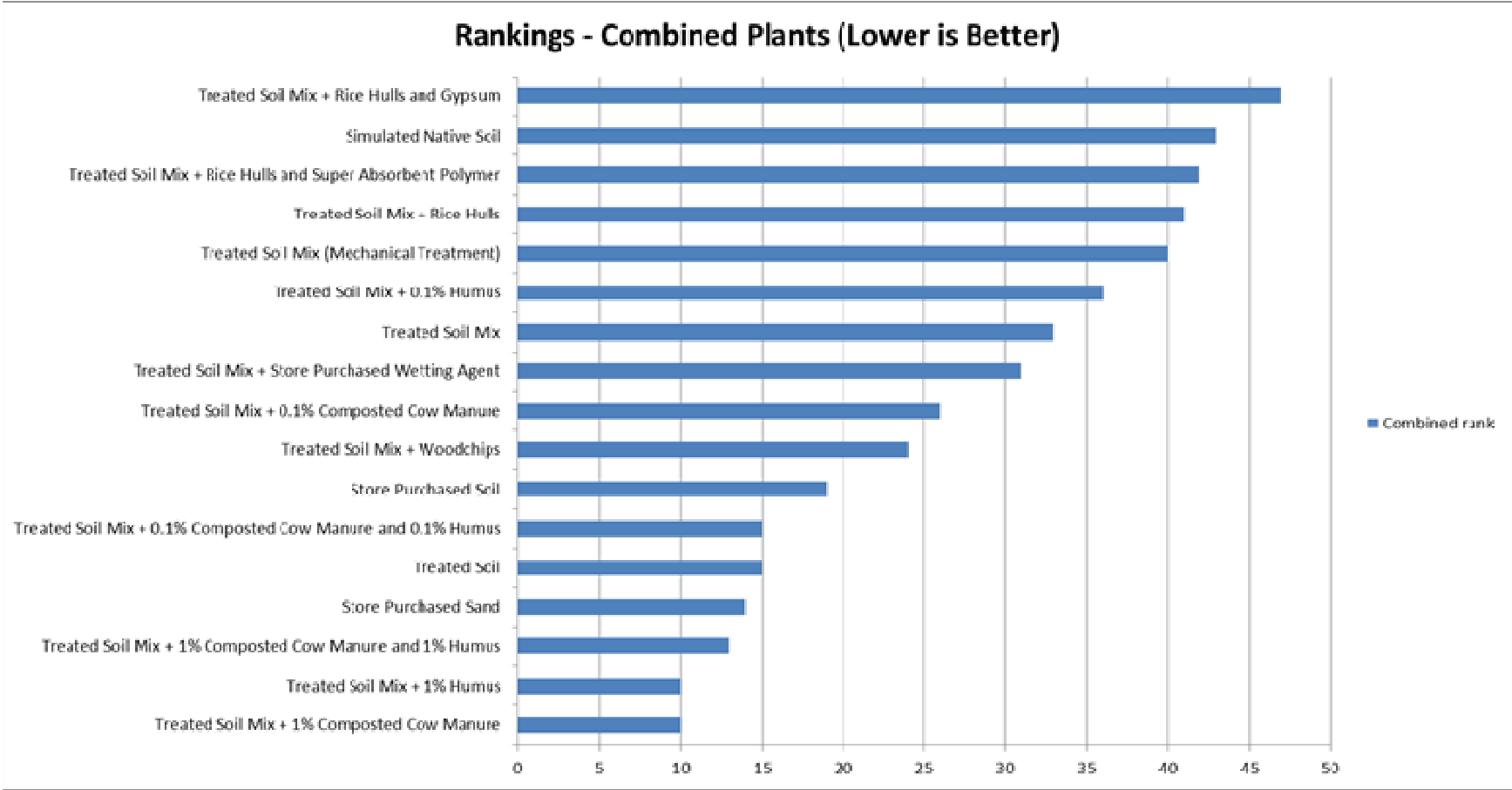


# Phase II Results

## Phase II Test Matrix Results: Alfalfa



# Phase II Results



# Phase III Results

Plant Growth in mm

Replicate	Control Soil	Control Sand	Native	Treated	Mix	Compost	Rice Hulls
	543	544	545	546	547	548	549
1	480	535	500	500	480	510	390
2	460	492	455	480	470	505	370
3	455	470	450	475	460	495	355
4	445	455	445	470	445	480	340
5	445	455	440	465	440	480	330
6	425	450	435	460	420	470	315
7	425	440	430	455	415	470	310
8	415	440	420	445	415	465	300
9	405	440	415	445	395	460	300
10	395	435	415	440	390	460	295
11	395	425	410	435	390	455	285
12	385	425	405	425	385	440	280
13	380	420	405	420	375	440	270
14	375	410	405	400	370	440	265
15	370	410	405	390	360	435	255
16	360	405	400	385	355	430	250
17	355	405	390	375	352	425	240
18	347	400	390	360	350	425	230
19	340	395	385	360	350	415	215
20	335	395	375	355	345	395	210
21	330	385	375	355	330	380	205
22	300	380	355	325	320	360	195
23	260	380	335	325	300	235	180
24	375	417	315	270	65	200	130
25			405		375	440	270
Mean	385.71	427.67	406.40	408.96	374.08	428.40	271.40
Std	52.14	35.97	38.20	57.77	78.14	71.63	61.25
% CV	13.5	8.4	9.4	14.1	20.9	16.7	22.6
DP	1.1	1.0	1	1.0	1.1	0.9	1.5



# Phase III Results

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ed Soil Mix with  
Rice Hulls



Native Soil



Thermally Treated Soil



Treated Soil Mix w  
Composted Cow M

# Phase III Results



ated Soil Mix with  
Rice Hulls



Native Soil



Thermally Treated Soil



Treated Soil Mix with  
Composted Cow M

# Phase III Results

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Treated Soil Mix with  
Rice Hulls



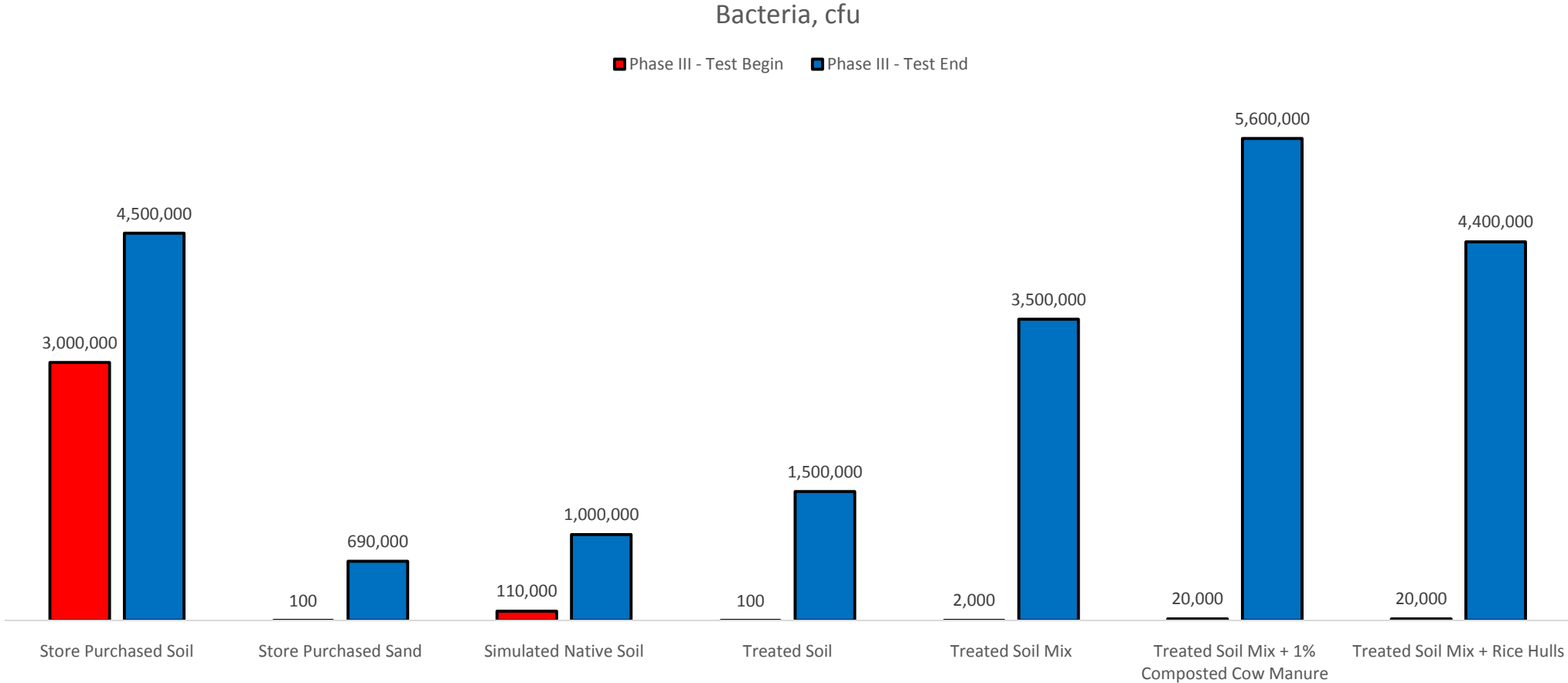
Treated Soil Mix with 1%  
Composted Cow Manure

# Phase III Results

## Nitrogen, Phosphorous, Potassium, Bacteria results

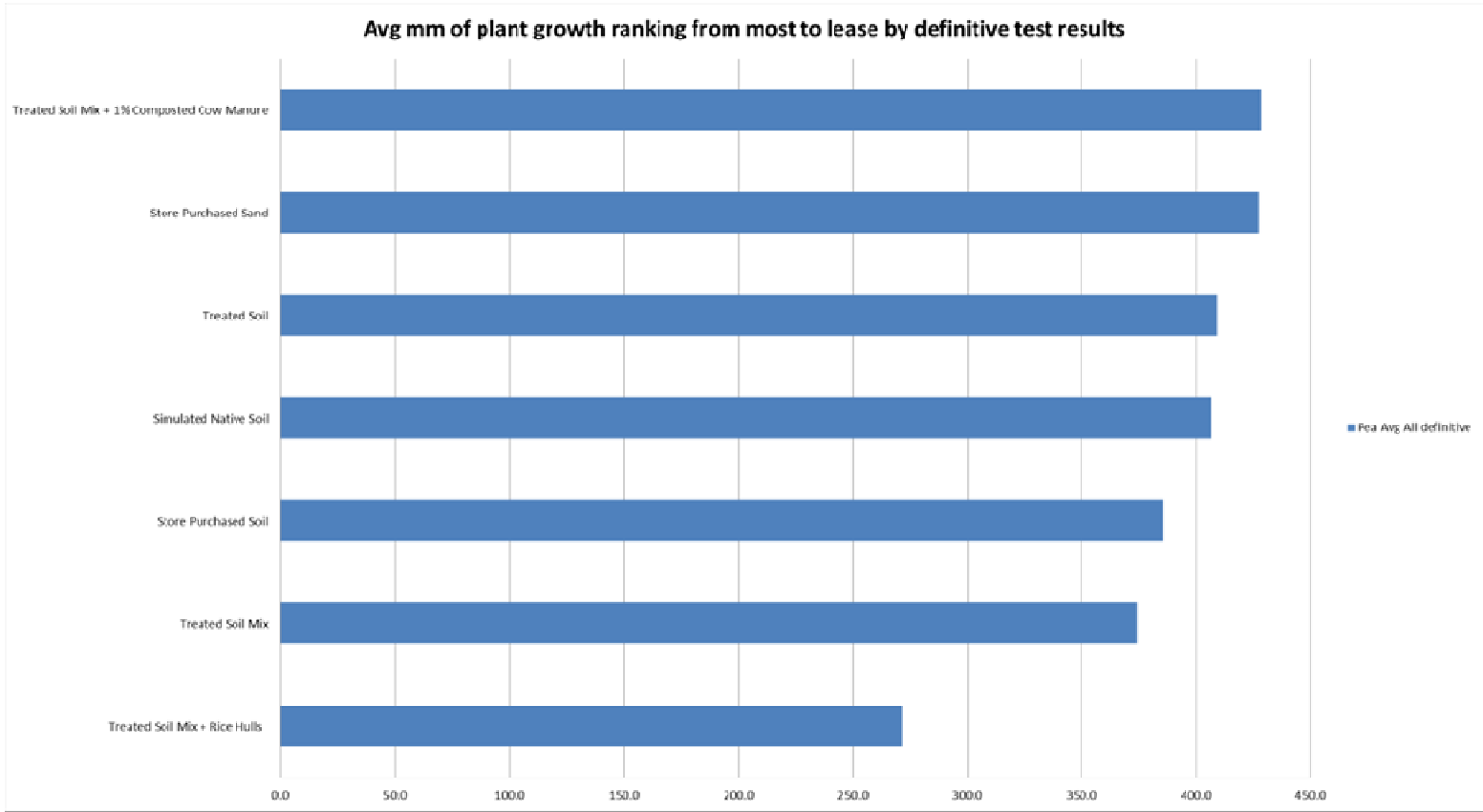
<b>Phase III - Test Begin</b>	Moisture	Solids	Nitrogen	Potassium	Phosphorus
Description	%	%	mg/kg	mg/kg	mg/kg
Store Purchased Soil	43.7	56.3	618	1810	235
Store Purchased Sand	0.07	99.9	1.97	93.3	71.6
Simulated Native Soil	1.4	98.6	123	385	67.5
Treated Soil	0.2	99.8	69.2	551	129
Treated Soil Mix	0.3	99.7	85.2	506	74.7
Treated Soil Mix + 1% Composted Cow Manure	0.6	99.4	116	740	77
Treated Soil Mix + Rice Hulls	0.5	99.5	60.9	531	23.6
<b>Phase III - Test End</b>	Moisture	Solids	Nitrogen	Potassium	Phosphorus
Description	%	%	mg/kg	mg/kg	mg/kg
Store Purchased Soil	47.2	52.8	1520	656	12.6
Store Purchased Sand	0.9	99.1	0.784	91.7	143
Simulated Native Soil	9.4	90.6	98.3	394	166
Treated Soil	3.2	96.8	56.6	516	92
Treated Soil Mix	9	91	79.9	537	117
Treated Soil Mix + 1% Composted Cow Manure	12.8	87.2	133	598	111
Treated Soil Mix + Rice Hulls	7.2	92.8	110	564	146

# Phase III Results for Bacteria

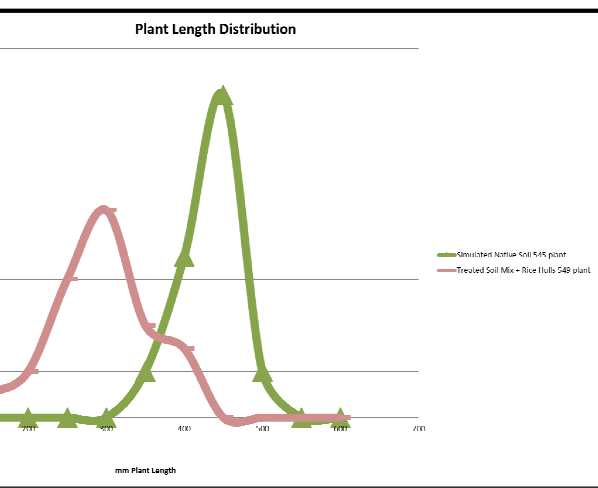


# Phase III Results

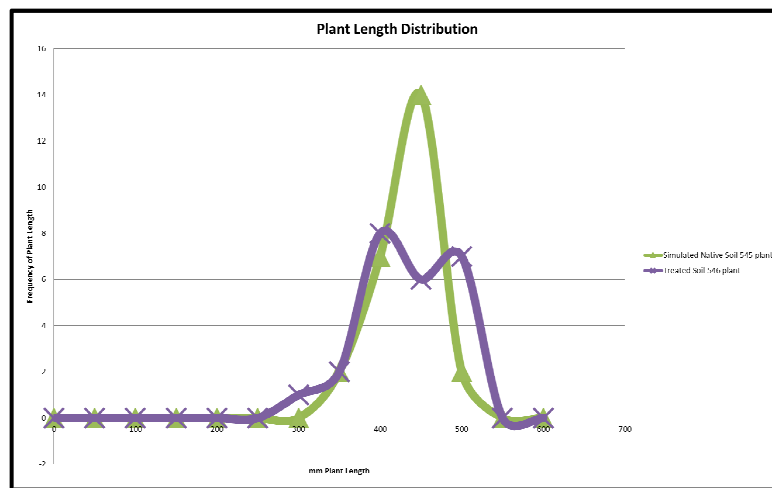
## Phase III Test Matrix Results: Peas



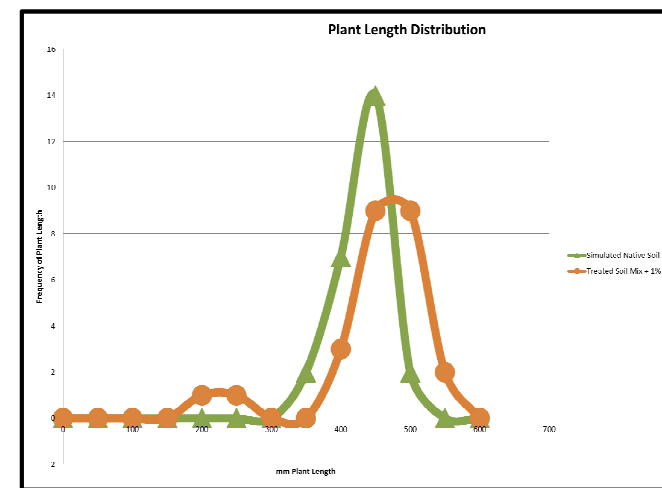
# Phase III Results



Native Soil vs  
Thermally Treated Soil Mix  
with Rice Hulls  
Discriminatory Power = 1.5



Native Soil vs  
Thermally Treated Soil  
Discriminatory power = 1.0



Native Soil vs  
Thermally Treated Soil Mix with  
Composted Cow Manure  
Discriminatory power = .9

# Phase III Results

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Soil Mix with  
Rice Hulls



Native Soil



Thermally Treated Soil

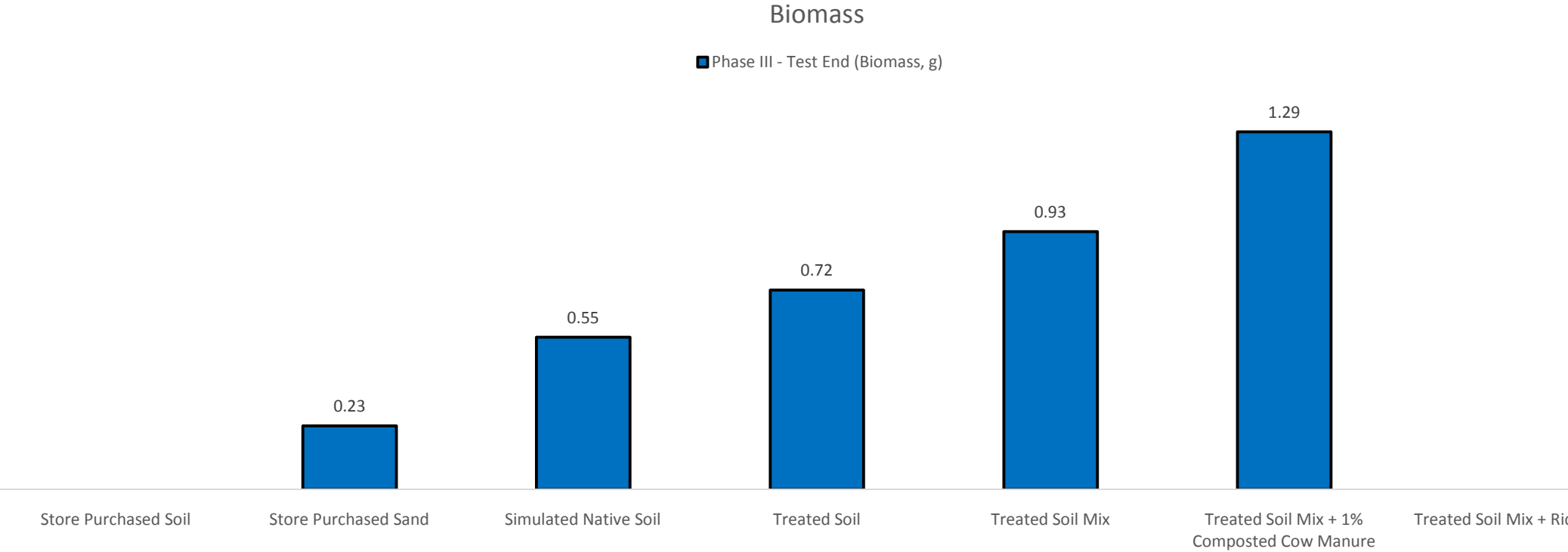


Treated Soil Mix w/  
Composted Cow M

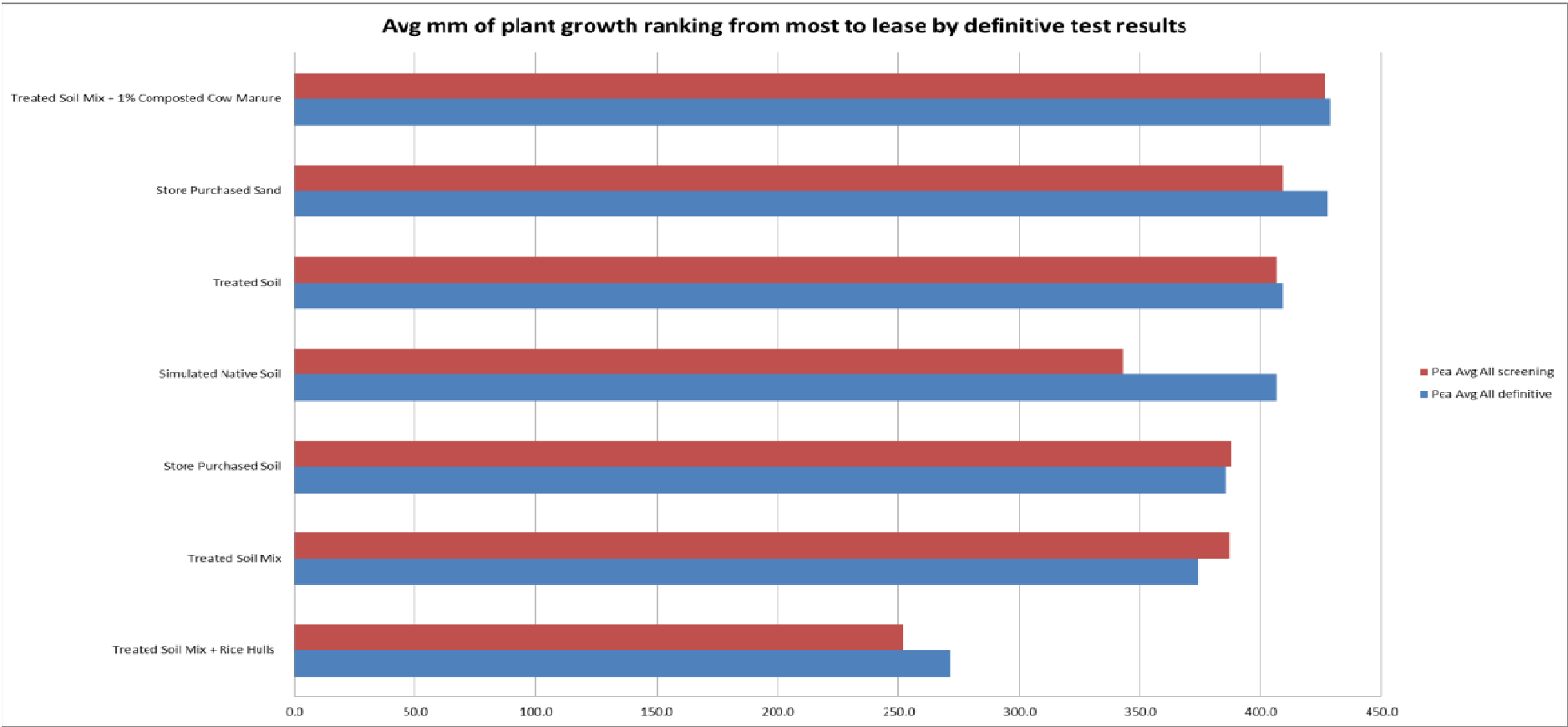


# Phase III Results

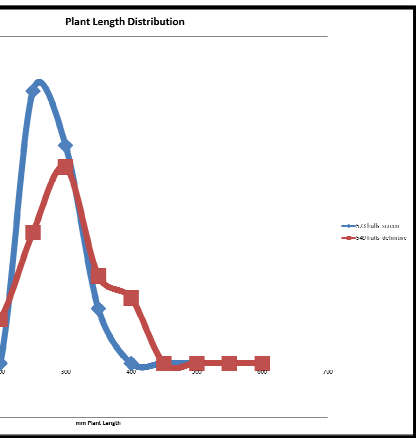
Biomass evaluation with grass



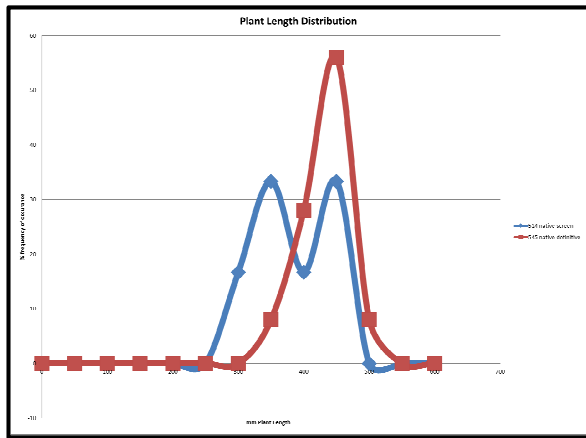
# Review of Phase II and Phase III Results for Peas



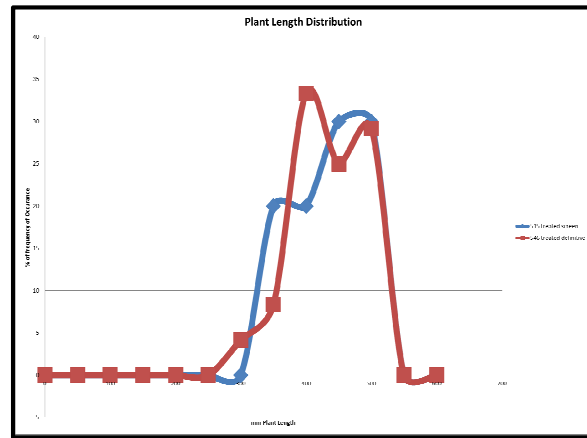
# Comparison of Phase II and Phase III Repeatability



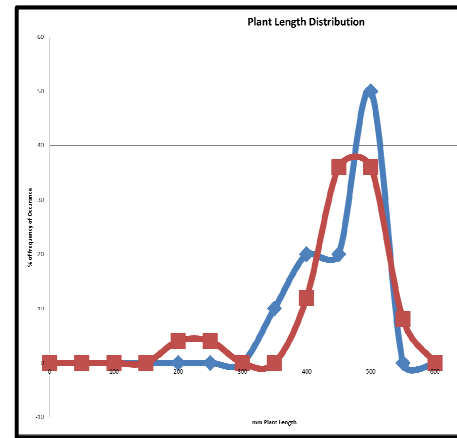
ed Soil Mix with Rice Hulls  
(Mean values 252, 271 mm)



Native Soil  
(Mean values 349, 406 mm)

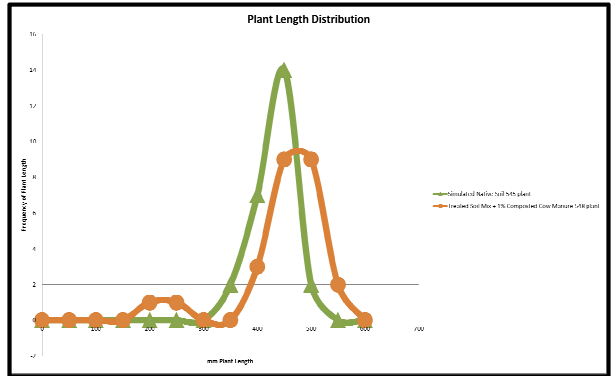
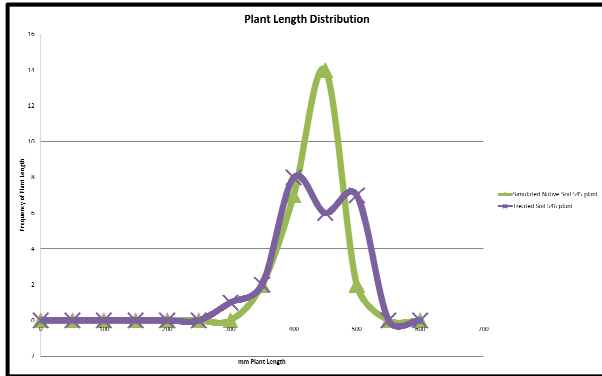
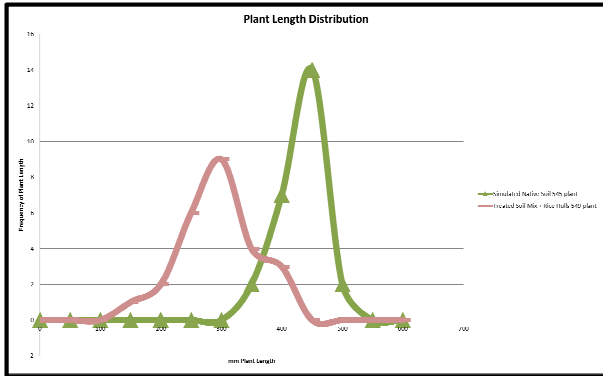


Thermally Treated Soil  
(Mean values 407, 409 mm)



Treated Soil Mix with Composted Cow Manure  
(Mean values 426, 426 mm)

# Comparison of Phase II and Phase III Discriminatory Power



Phase III Histograms

	Native Soil vs Thermally Treated Soil Mix with Rice Hulls	Native Soil vs Thermally Treated Soil	Native Soil vs Thermally Treated Soil Mix with 1% Composted Cow Manure
Phase II Peas	1.4X	0.9X	0.8X
Phase III Peas	1.5X	1.0X	0.9X

# Design Parameter Review

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Design target	Results From This study
. Maximum discriminatory power	+
. Maximum repeatability	+
. Practicality of implementation	+
. Ranking of known test substances as expected	+
. Ecological relevance	+
. Government acceptance of the protocols	+

# Conclusions

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Use of the modified EPA protocol and Peas, as a Screening tool demonstrates some repeatability and discriminatory power.

Additional development of the modified EPA test as a screening tool is recommended.

The results from Phase III indicate no significant difference in the performance of native soil and thermally treated soil.