

# Quality requirements for wood ash as K component in recycled NPK fertilizers

Trond Knapp Haraldsen<sup>1</sup> Eva Brod<sup>2</sup> Tore Krogstad<sup>2</sup>

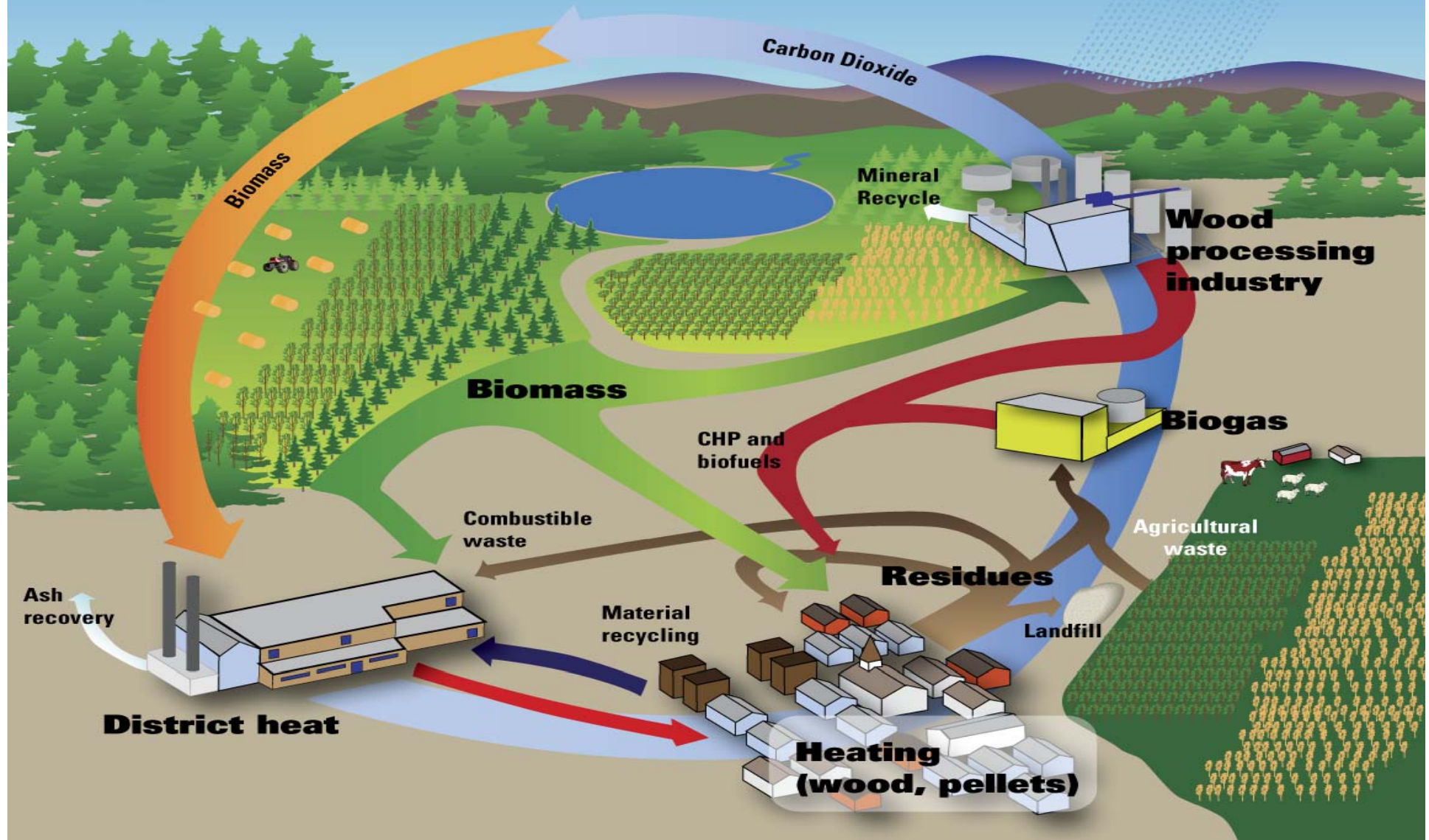
<sup>1</sup>Bioforsk Soil and Environment, Ås

<sup>2</sup>University of Life Sciences, Ås

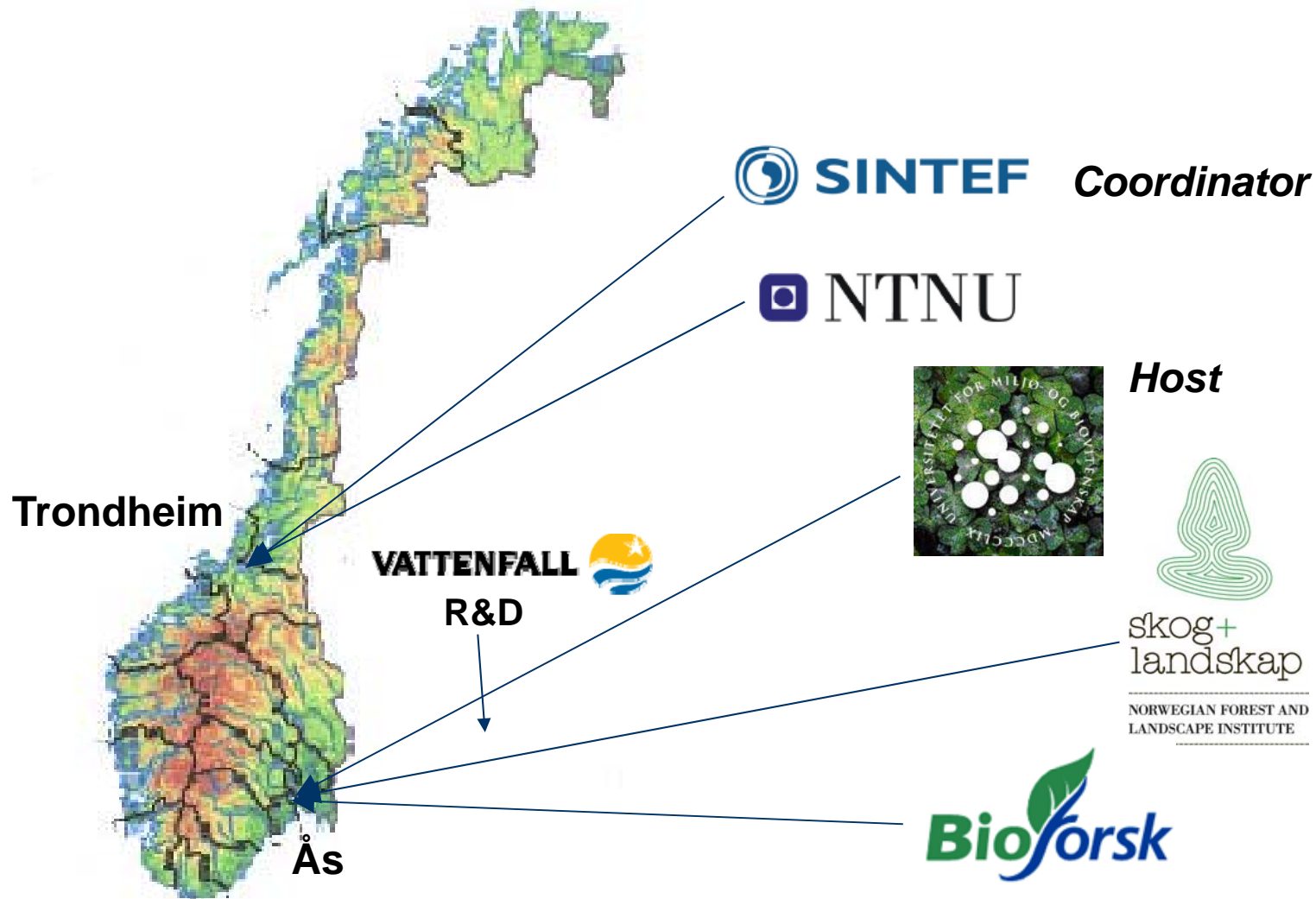
ASH 2012

Stockholm, Sweden, 26 January 2012

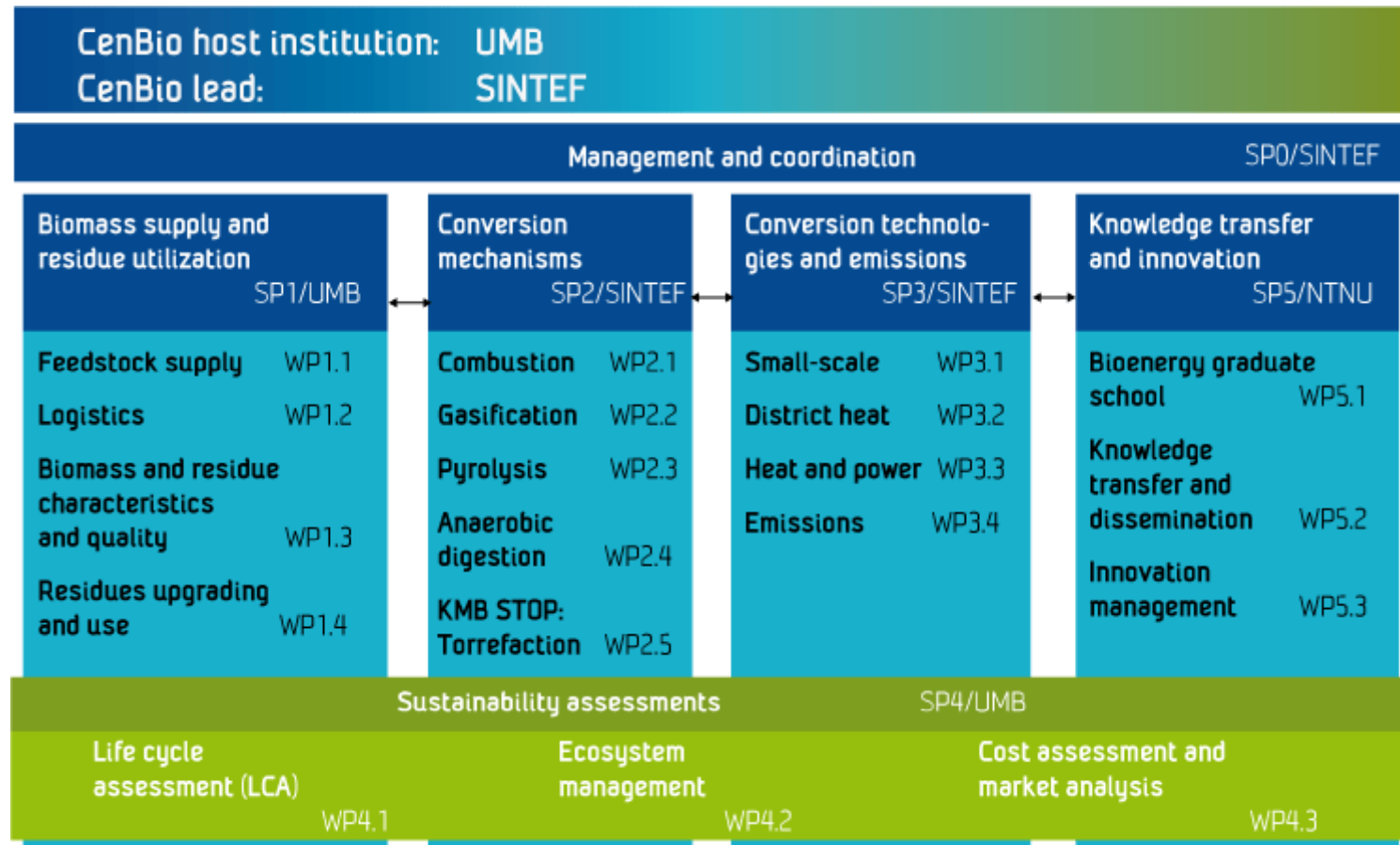
# CenBio



# R&D partners in CenBio



# Organization in subprogrammes and workpackages in CenBio



# Research in WP 1.4 "Residues upgrading and use"

- ▶ Development of waste based organic or organic-mineral NPK fertilizers, particularly made of bioenergy residues
- ▶ Scientific based input for development of national regulations on waste based fertilizers and soil amendments

## Characteristics of Norwegian bioenergy plants

- ▶ Grate furnace design is most common, only a few large fluidized bed plants exist
- ▶ Wood material is the main material combusted
- ▶ Ash has mainly been landfilled, partly on landfill areas owned by industry
- ▶ Ash is mainly collected as blended ash (bottom ash + fly ash in the same container)
- ▶ The regulations for use of ash in agriculture and urban greening is the same as for organic waste products
- ▶ Application of ash in forested areas is not permitted

# Variation in chemical properties of bottom wood ash

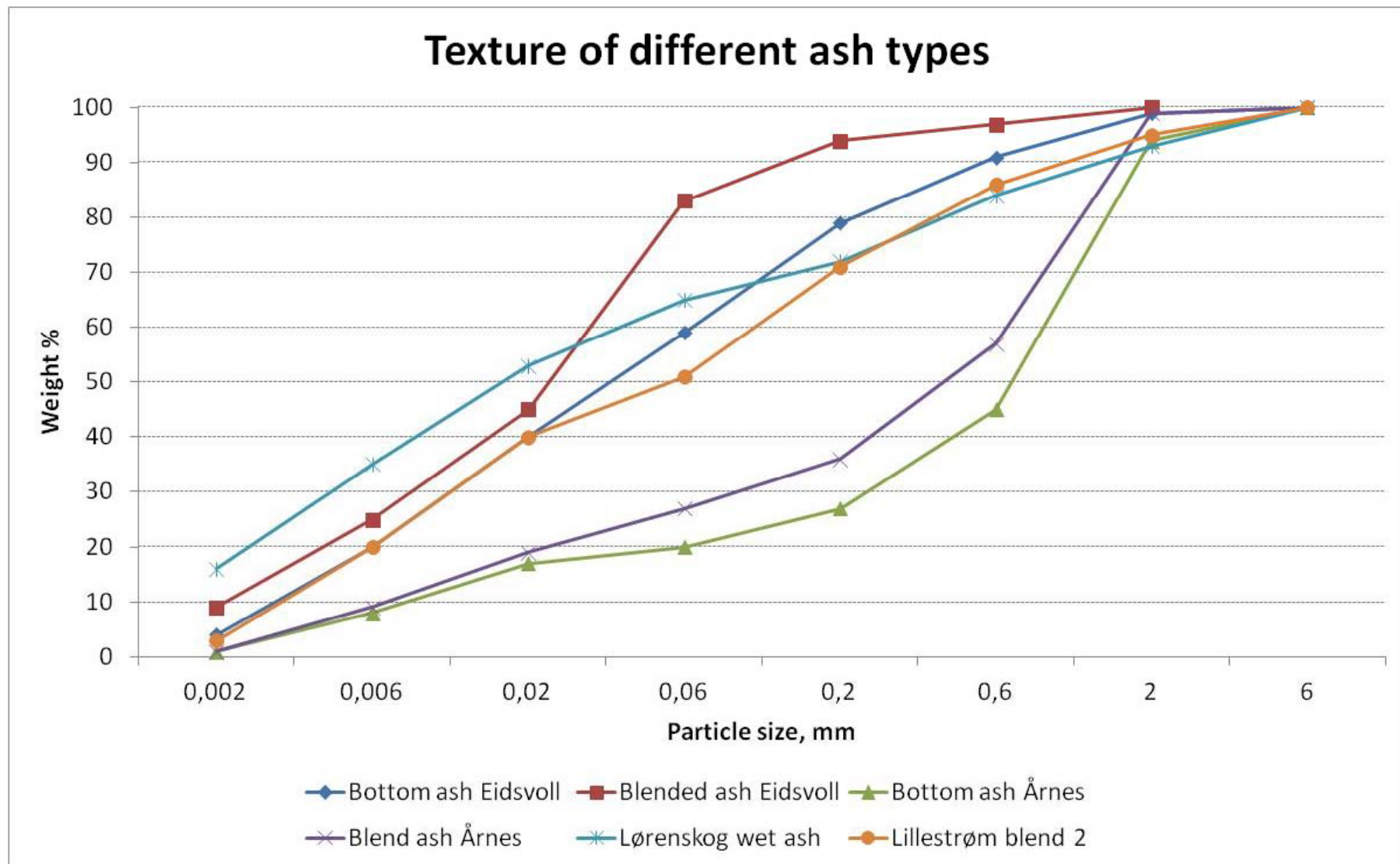
	TOC	Total extraction by 7 M HNO <sub>3</sub> , g/100g				
	g/100 g DM	P	K	Ca	Mg	S
Bottom wood ash, B (spruce)	0.7	1.4	4.3	36.1	2.5	0.19
Bottom wood ash, R1	1.1	1.3	3.2	32.4	3.9	0.29
Bottom wood ash, R2	0.7	1.3	7.2	28.2	4.3	0.21
Bottom wood ash, K (pine)	6.6	0.7	4.3	15.0	1.7	0.06
Bottom ash, cereal waste	1.3	4.9	9.0	-	3.0	-

## Total extraction by 7 M HNO<sub>3</sub>, mg/kg dry matter

	Zn	Pb	Ni	Cu	Cd	Cr	Mn
Bottom wood ash, B (spruce)	69.5	10.7	25.9	79.5	<0.4	17.9	30400
Bottom wood ash, R1	106	5.5	26.4	116	0.8	29.5	36100
Bottom wood ash, R2	107	7.1	30.9	120	2.1	47.2	39300
Bottom wood ash, K (pine)	279	34	26	34	0.26	47	10000
Bottom ash, cereal waste	190	15	36	93	<0.5	61	2800

# Chemical properties of different wood ashes

Unit	Årnes		Lillestrøm		Lørenskog		Eidsvoll		
	Stem wood + cereal waste		Stem wood + GROT		Wet ash blended		Stem wood		
	Bottom	Blend	Blend1	Blend2	Stem wood	Stem wood+ GROT	Bottom	Blend	
P	g/100 g DM	<b>1.6</b>	<b>2.2</b>	0,82	1,4	1,1	1,2	0,37	0,87
K	g/100 g DM	<b>6.9</b>	<b>10.0</b>	6,5	7,2	7,4	4,1	4,0	7,1
Ca	g/100 g DM	<b>14.0</b>	<b>12.0</b>	15	31,0	21,0	23	14.0	25.0
Mg	g/100 g DM	<b>1.7</b>	<b>1.9</b>	1,2	3,3	1,6	2,6	1.8	3.1
Cd	mg/100 g DM	<b>0.015</b>	<b>0.27</b>	0,43	0,99	2,2	<b>18</b>	2,9	<b>27</b>
Zn	mg/100 g DM	<b>54</b>	<b>490</b>	110	160	130	<b>1200</b>	200	<b>1900</b>
Ni	mg/100 g DM	<b>13</b>	<b>32</b>	32	<b>140</b>	28	23	18	23
Cr	mg/100 g DM	<b>21</b>	<b>21</b>	180	<b>1300</b>	23	35	120	180
Cu	mg/100 g DM	<b>43</b>	<b>77</b>	120	110	120	81	49	90

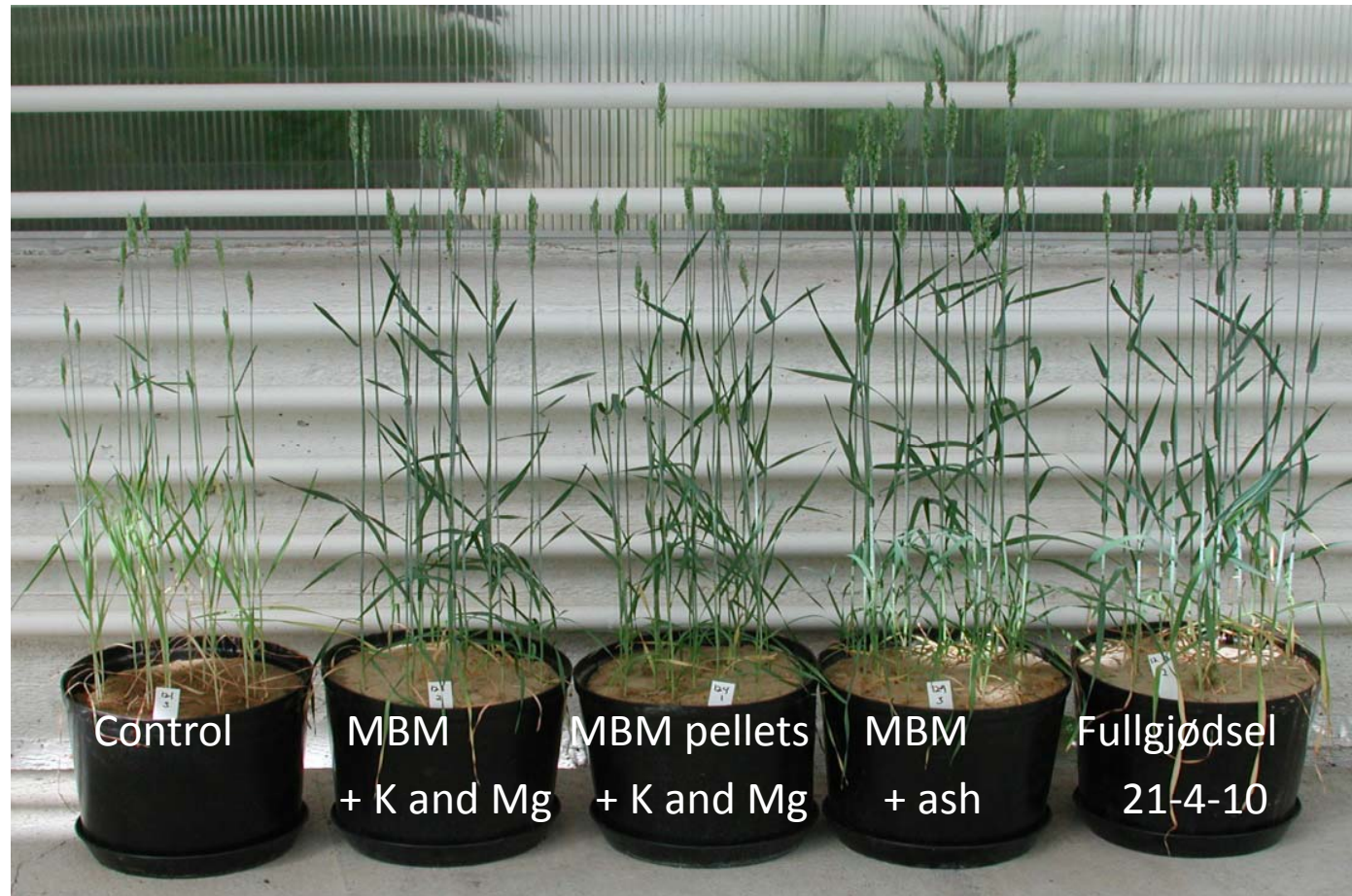


# Some potential raw materials for organic NPK fertilizer



- ▶ Bottom wood ash (BWA): Ca, K, Mg, P and trace elements
- ▶ Meat and bone meal (MBM): N, P, Ca and minor amount of S, Mg and K
- ▶ In agriculture materials with high solubility of plant nutrients is needed

# Initial experiments with spring wheat

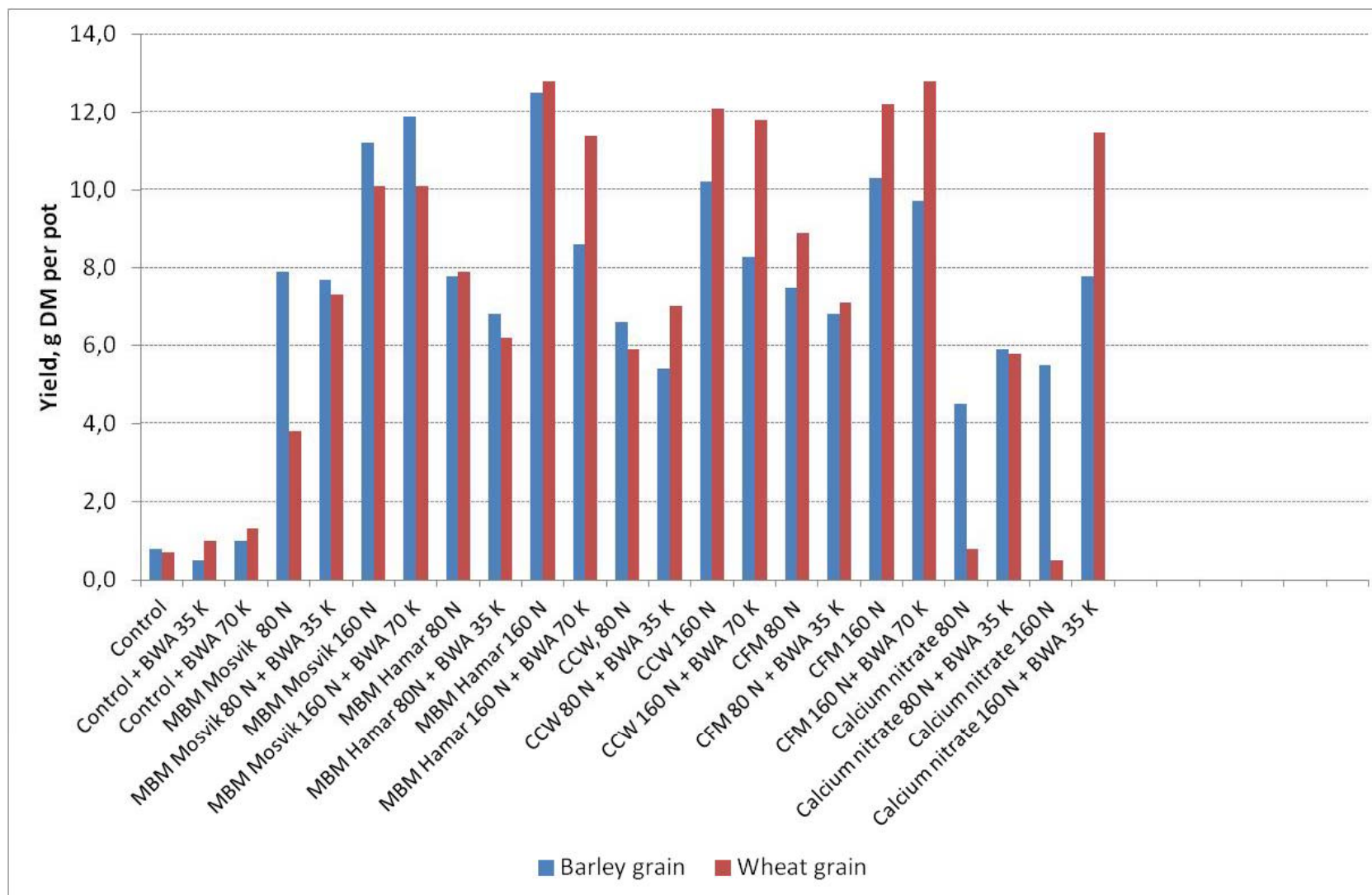


Haraldsen et al. 2011. Mixtures of bottom wood ash and meat and bone meal as NPK fertilizer

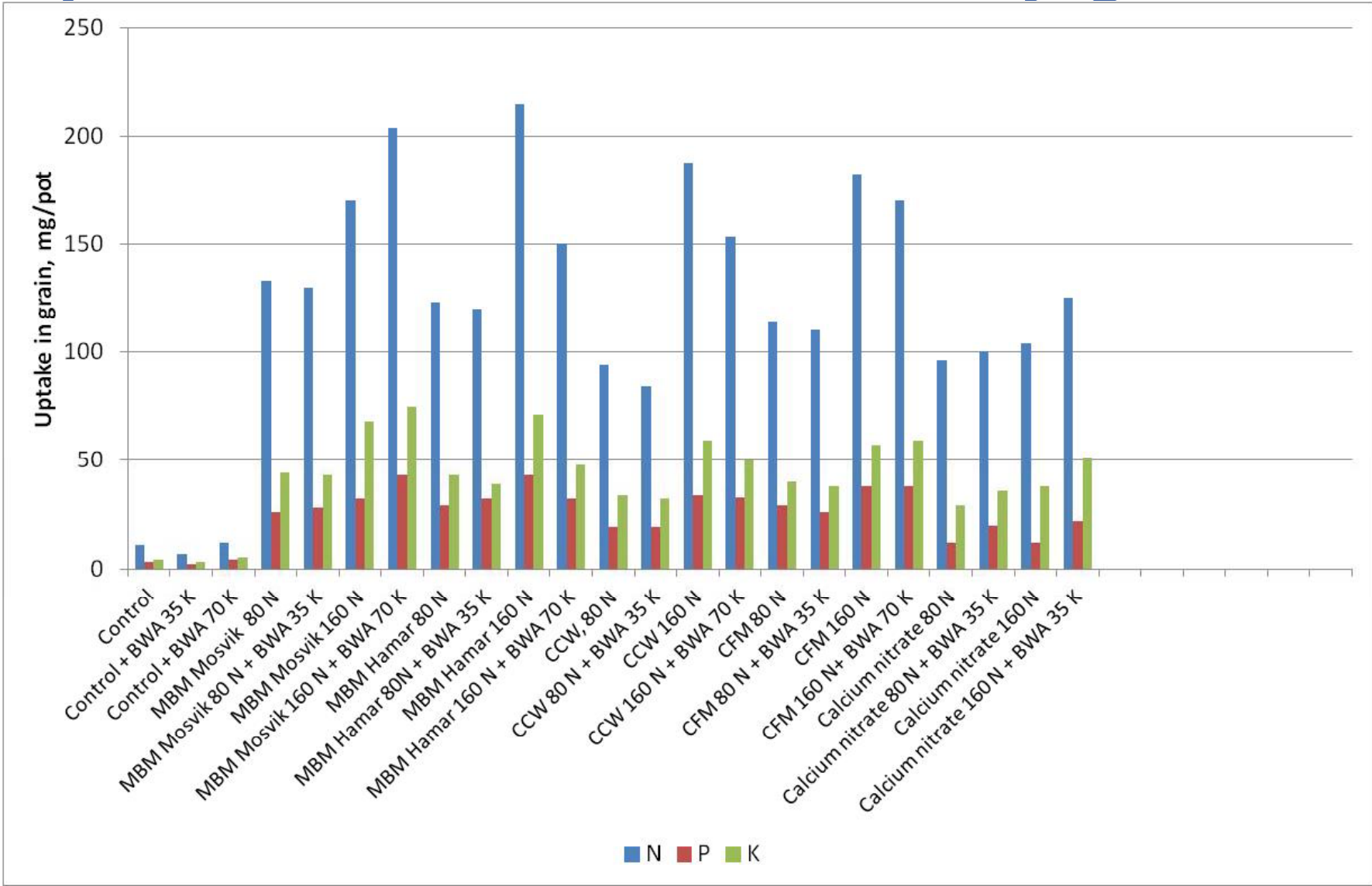
# Objectives of the investigation

- ▶ **Study the efficiency of organic NPK fertilizers combining N-rich organic wastes and bottom wood ash for use in agricultural plant production**
- ▶ Materials studied: meat and bone meal (MBM), composted catering waste (CCW), composted fish manure (CFM), and calcium nitrate, composted industrial sludge (Dynea), with or without addition of bottom wood ash (BWA)
- ▶ Fertilization levels: 80 and 160 kg N ha<sup>-1</sup>, 35 and 70 kg K ha<sup>-1</sup> in BWA to cereals, 150 and 300 kg N ha<sup>-1</sup>, 120 and 240 kg K ha<sup>-1</sup> to rye grass, unfertilized control
- ▶ Crops: spring barley (1<sup>st</sup> year), spring wheat (2<sup>nd</sup> year)
- ▶ Soil: sand, low in phosphorus and potassium to cereals, sandy loam, low in phosphorus and potassium to rye grass

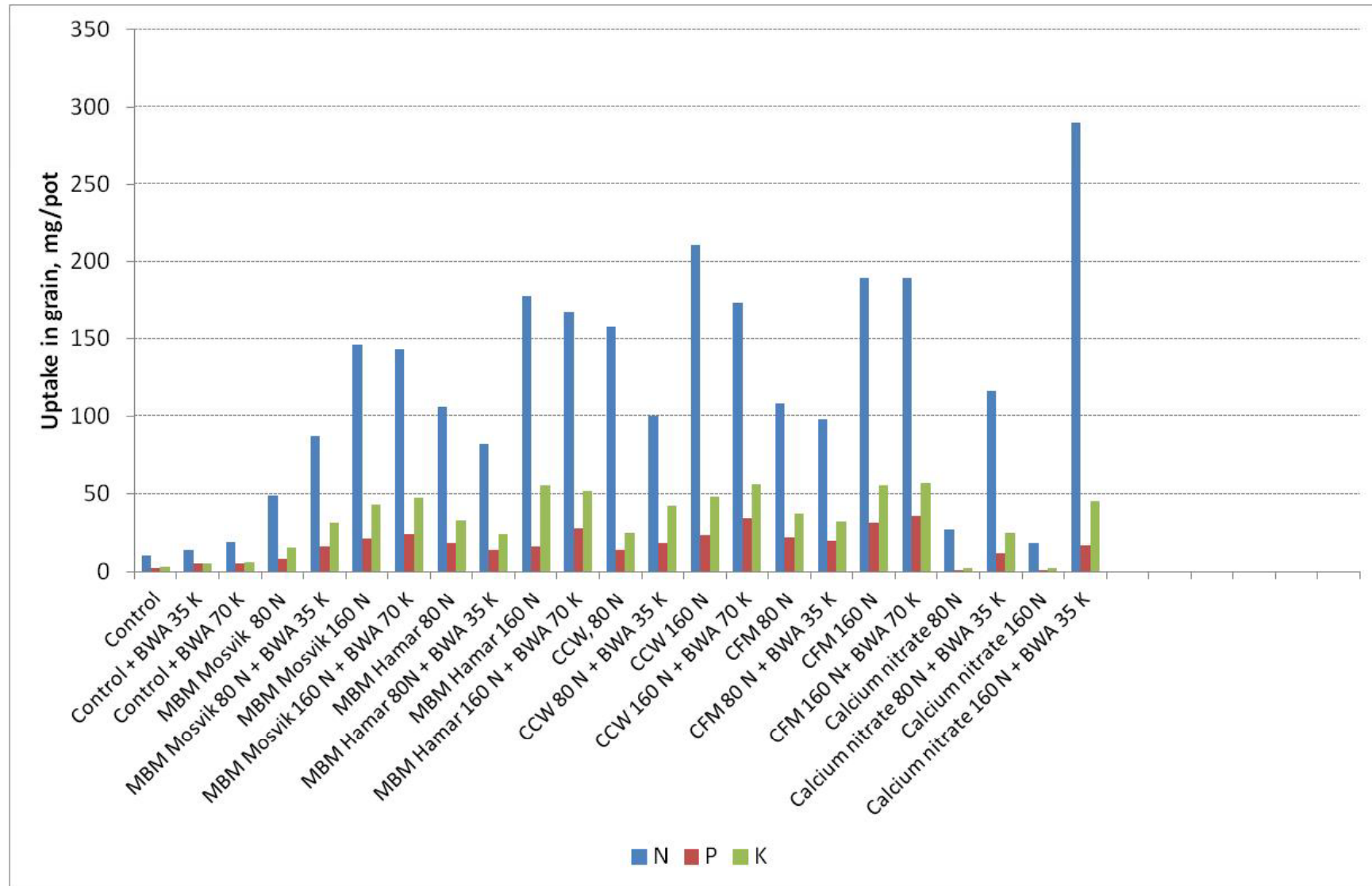
# Yield of barley and wheat in pot experiments



# Uptake of N, P and K in barley grain



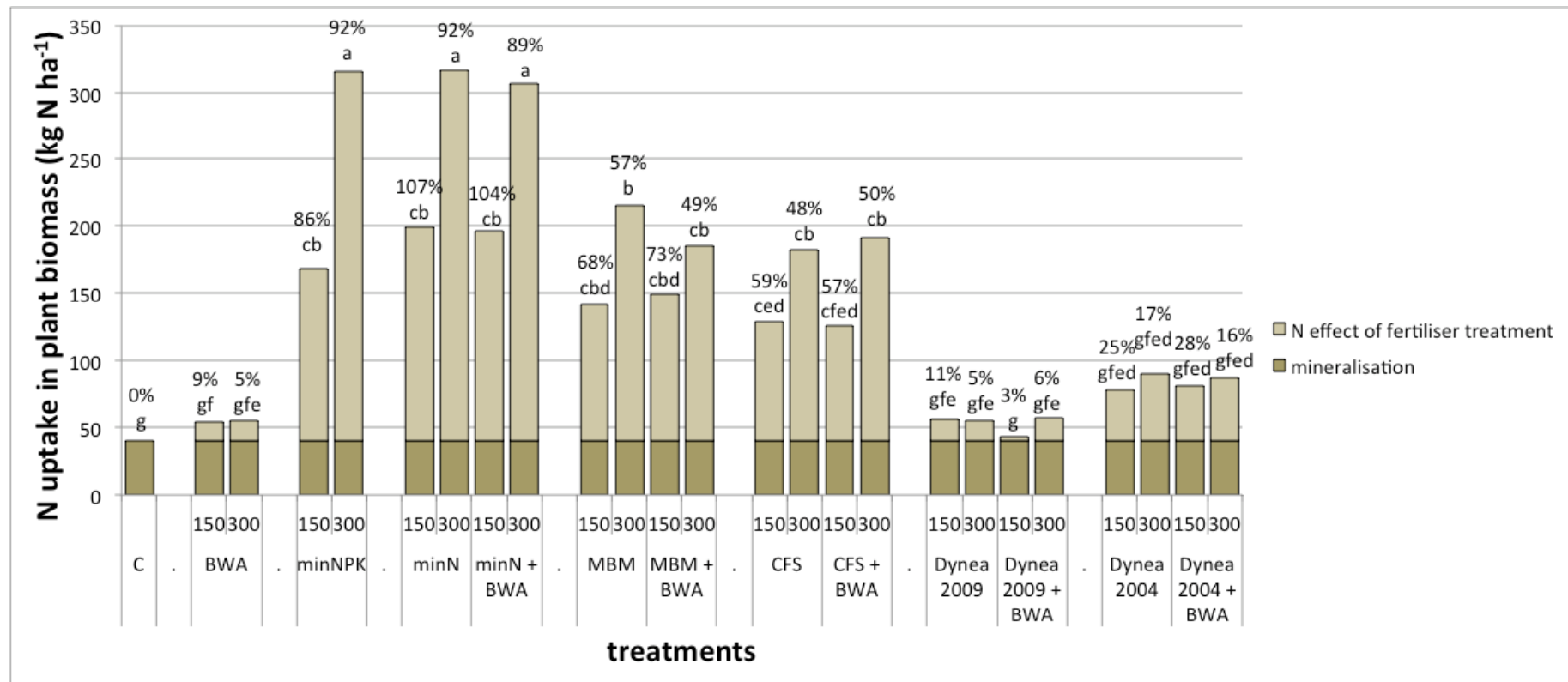
# Uptake of N, P and K in wheat grain



# Chemical analyses of soil after harvest of wheat in sandy soil

Treatment	pH	P-AL	K-AL	Mg-AL	Ca-AL
Control	7.20	1.6	4.6	2.0	21.9
Control + BWA	7.51	1.8	4.3	2.8	30.3
Calcium nitrate	7.28	1.5	1.8	1.5	28.7
Calcium nitrate + BWA	7.70	1.6	2.5	2.1	35.7
MBM Mosvik	7.10	2.7	1.8	1.7	28.0
MBM Mosvik + BWA	7.47	6.4	3.5	2.8	43.0
MBM Hamar	7.00	4.0	1.0	1.8	28.3
MBM Hamar + BWA	7.68	5.9	4.3	2.7	40.3
CCW	7.05	1.3	2.3	2.0	24.3
CCW + BWA	7.55	2.0	5.3	2.6	30.7
CFM	7.08	2.7	1.7	1.9	28.0
CFM + BWA	7.39	3.6	2.7	3.0	36.0

# N uptake in rye grass on sandy loam

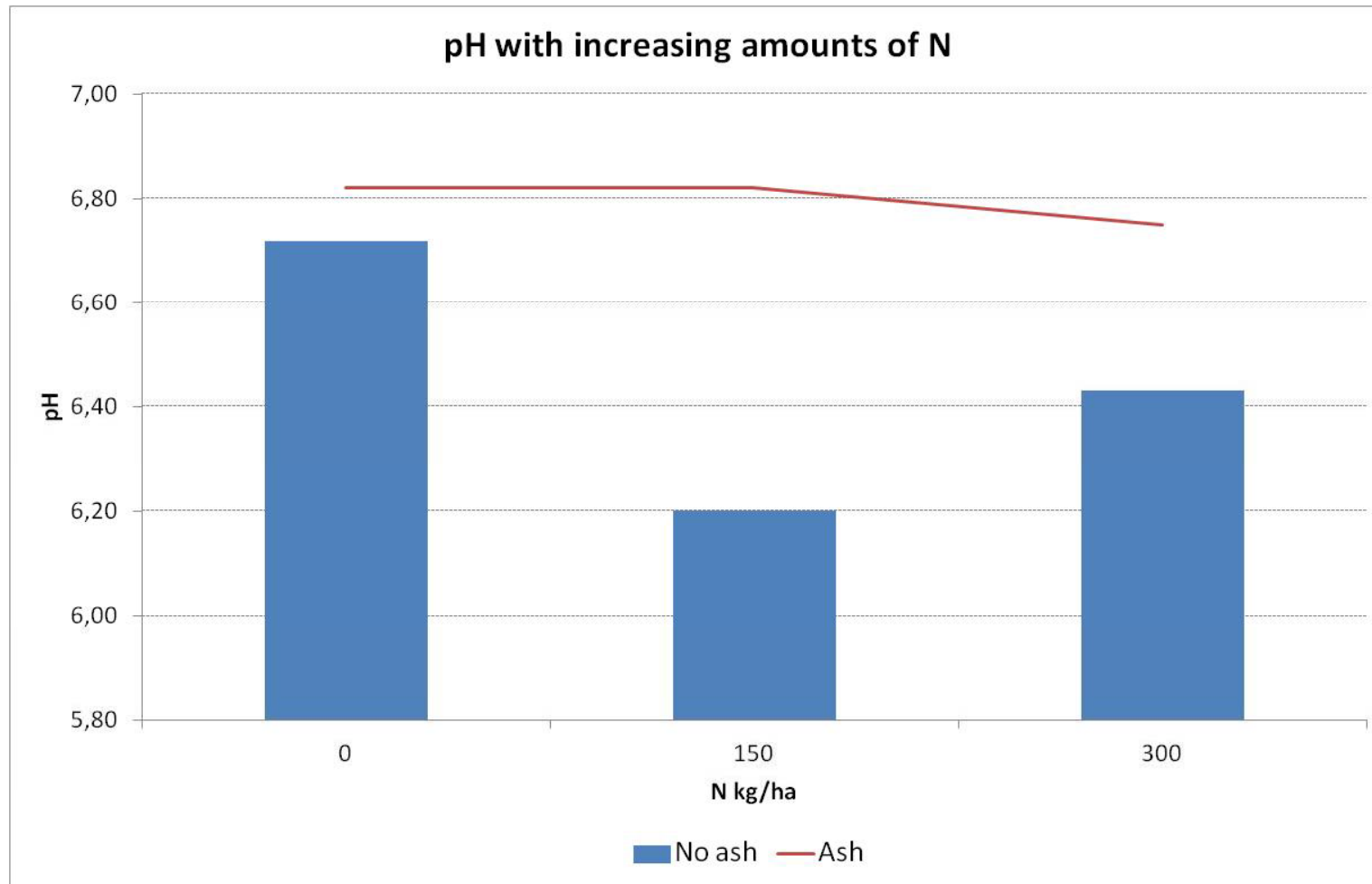


Brod (2011)

# Chemical analyses of soil after harvest of ryegrass in sandy loam soil

Treatment	pH	P-AL	K-AL	Mg-AL	Ca-AL
		mg/100 g			
Control	6.72	2.5	3.5	12.5	247
Control + BWA	6.82	4.8	7.8	15.5	268
Calcium nitrate	6.70	2.6	4.0	12.7	264
Calcium nitrate + BWA	6.93	4.1	5.5	14.8	283
MBM Mosvik	6.56	9.2	3.7	13.1	264
MBM Mosvik + BWA	6.77	12.3	6.3	15.8	287
CFM	6.48	5.1	3.7	12.9	257
CFM + BWA	6.75	7.9	7.0	16.4	284
Dynea 2009	6.57	2.8	3.6	12.8	244
Dynea 2009 + BWA	6.69	4.2	6.4	14.7	258
Dynea 2004	6.52	2.6	3.5	12.3	247
Dynea 2004 + BWA	6.75	4.8	6.5	15.4	267

# Effects on pH in soil after harvest of rye grass



# Conclusions

- ▶ There are large variations in bottom wood ash (BWA) quality between different bioenergy plants.
- ▶ Collection of BWA separately may give ash that can be applied as liming material or fertilizer on agricultural or urban greening areas
- ▶ Bottom wood ash (BWA) had no effect on plant growth applied alone, but gave significant increase in soil pH.
- ▶ Combination of calcium nitrate and BWA showed that BWA released significant amounts of P that was taken up in the grain
- ▶ BWA used as fertilizer should have high concentration of K (>6 g/100 g DM) and a low Ca/K ratio. BWA for liming should have a high concentration of Ca (20 g/100 g DM or higher)
- ▶ Application of organic NP fertilizers with limited amounts of K caused no effect of BWA supply on plant growth, but application of BWA had positive effects on K-AL levels in soil after harvest
- ▶ Potentially available amounts of BWA with sufficient low concentrations of heavy metals for application in agriculture or urban greening have not been quantified in Norway