Integrating Cover Crops Into Annual Cropping Systems To Increase Total Biofuel Production And Environmental Sustainability

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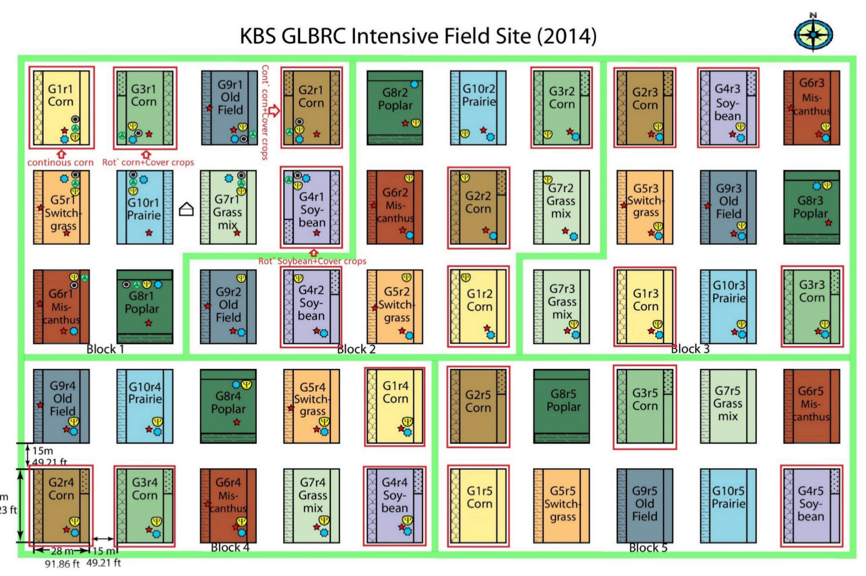
GREAT LAKES BIOENERGY RESEARCH CENTER

Abstract

Integrating cover crops into existing annual crop systems is a plausible way to increase available cellulosic bioethanol feedstock; improve the environmental performance of annual cropping systems; and address food versus fuel concerns. An Austrian pea plus winter cereal rye cover crop mix was integrated into continuous corn and corn plus soybean cropping systems at Arlington, Wisconsin and Hickory Corners, Michigan in 2013 and 2014. The experimental design was a randomized complete block with five replications at each location. The objective of the study was to evaluate the yield and quality of biomass feedstock produced from the cover crop plus annual rotational crop systems. Biomass quality analysis included total sugars, lignin and estimated ethanol yield. Long term analysis will include a determination of the global warming potential, energy balance, and economic performance of each respective system.

Field Design and Picture



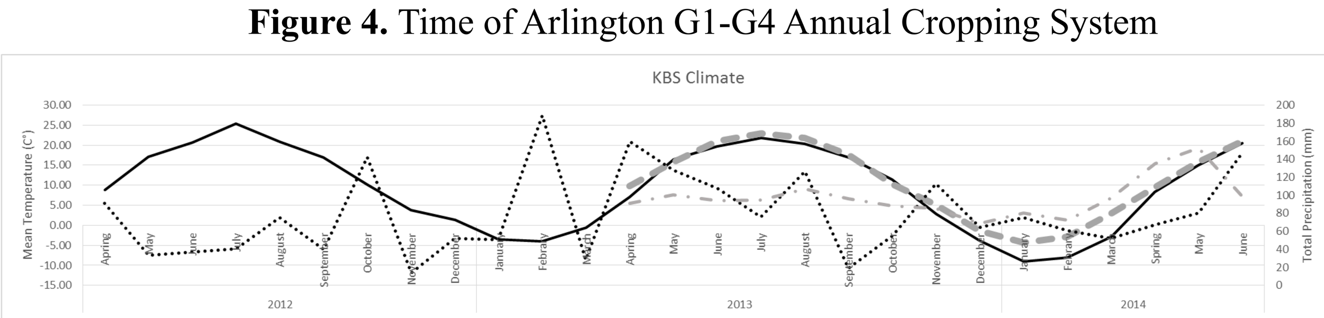
G1: Continuous Corn (full season)
G2: Continuous Corn (short season) + Cover crops
G3: Soybean & Corn + Cover crops (2013 soybean)
G4: Corn & Soybean + Cover crops [2013 corn(full season)]

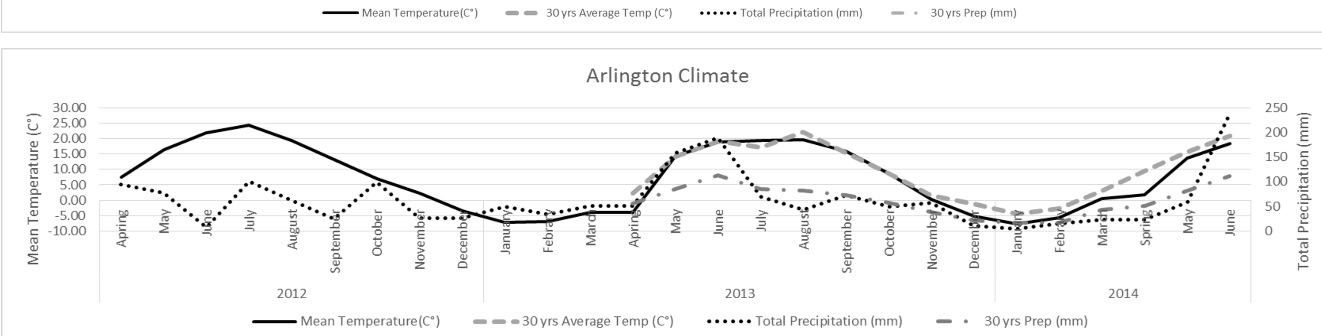
Figure 1. RCBD with 10 treatments and 5 Blocks at KBS, this study focused on G1-G4 annual cropping systems

Timeline of Field Activities and Climatological Summary of two locations

Figure 3. Timeline of KBS G1-G4 Annual Cropping Systems

Figure 4. Time of Arlington G1-G4 Annual Cropping System





KBS		Mean Temperature(C°)			Total Precipitation (mm)		
Crop	Month	2012/2013	2013/2014	30 years	2012/2013	2013/2014	30 years
Soybean/Corn	Apring	8.81	6.98	9.78	91.19	159.51	91.40
	May	17.05	16.44	15.85	33.53	127.76	100.79
	June	20.71	19.70	20.98	37.34	107.95	93.75
	July	25.36	21.75	22.93	40.39	75.95	94.60
	August	20.79	20.38	21.85	75.18	126.49	106.79
	September	16.86	16.90	17.66	39.62	19.30	96.36
	October	10.10	11.41	10.32	141.99	55.12	87.97
	November	3.87	2.82	5.02	13.72	113.03	85.43
Cover crops	October	10.10	11.41	10.32	141.99	55.12	87.97
	November	3.87	2.82	5.02	13.72	113.03	85.43
	December	1.31	-3.78	-1.33	52.07	64.26	68.41
	January	-3.47	-9.00	-4.38	50.55	75.44	80.25
	Febrary	-4.01	-8.03	-2.81	188.47	60.45	72.52
	March	-0.56	-2.94	2.96	28.70	52.07	96.59
	Spring	6.98	8.40	9.54	159.51	67.31	134.92
	May	16.44	14.93	15.73	127.76	80.52	152.33
	June	19.70	20.51	20.93	107.95	146.81	98.94

Table 1. Monthly mean precipitation and temperature with 30-yr means at KBS

Arlington		Mean Temperature(C°)			Total Precipitation (mm)		
Crop	Month	2012/2013	2013/2014	30 years	2012/2013	2013/2014	30 years
Soybean/Corn	Apring	7.45	-3.91	2.25	93.96	51.04	54.85
	May	16.33	14.34	14.07	76.94	158.25	85.41
	June	21.85	18.80	19.14	7.37	188.70	113.41
	July	24.48	19.53	17.25	101.36	69.07	85.64
	August	19.45	19.79	22.21	61.73	42.42	81.41
	Septemb	13.27	15.95	15.33	23.87	73.40	72.19
	October	6.96	8.80	8.75	98.81	49.51	56.89
	Novembe	2.30	0.35	1.57	25.90	56.89	39.11
Cover crops	October	6.96	8.75	10.32	98.81	49.51	56.89
	Novembe	2.30	1.57	5.02	25.90	56.89	39.11
	Decembe	-3.49	-5.31	-1.33	26.16	10.67	20.80
	January	-7.31	-7.65	-4.38	49.02	4.32	16.55
	Febrary	-7.01	-5.66	-2.81	33.79	15.24	16.52
	March	-4.07	0.50	2.96	51.04	22.61	43.62
	Spring	-3.91	1.83	9.54	51.04	22.61	50.33
	May	14.34	13.67	15.73	158.25	59.18	81.82
	June	18.80	18.51	20.93	188.70	237.75	111.22

Table 2. Monthly mean precipitation and temperature with 30-yr means at Arlington

Yield Results

Yield Results: Total crop yields, energy yields and cover crop yields are analyzed from 5 different cropping systems. *Means with the same letter(s) are not statistically different (α= 0.05).

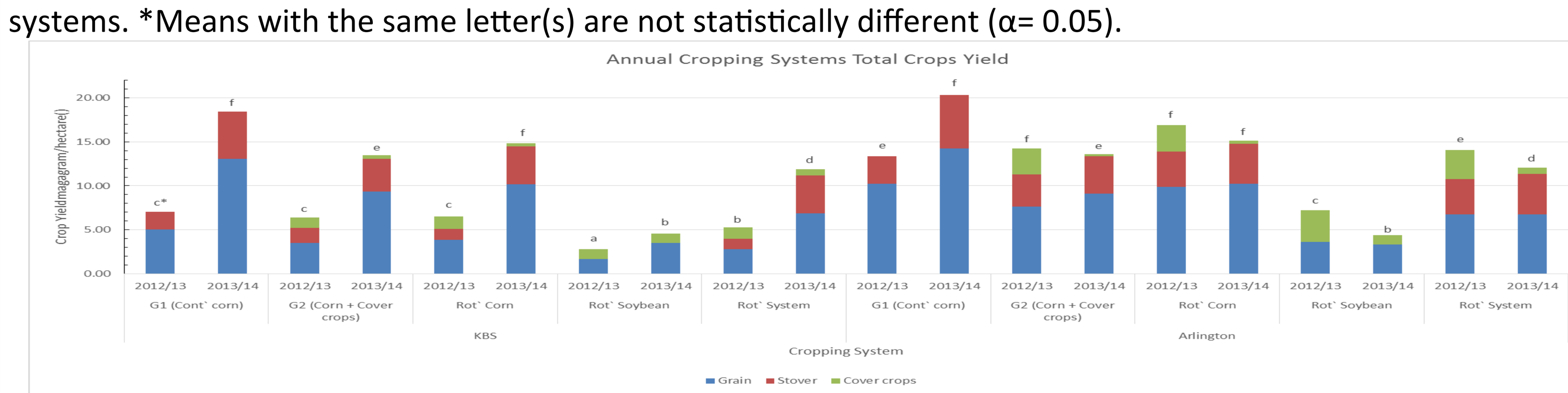


Figure 5. Crops Yield of KBS & Arlington for 2012/13 & 2013/14 Growing Seasons

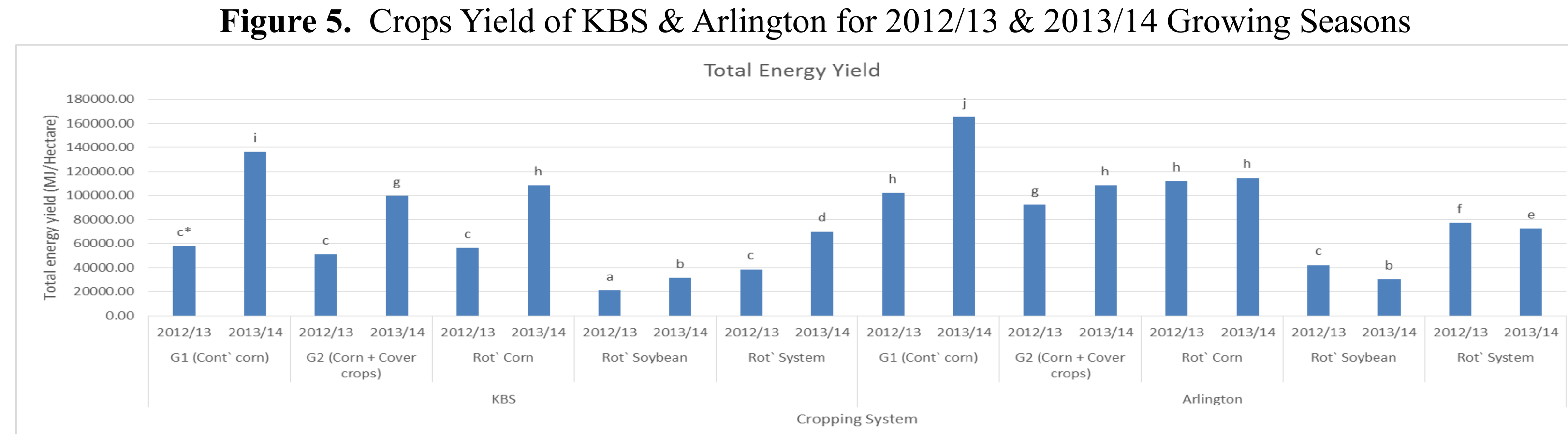


Figure 6. Estimated Total Energy Yield of KBS & Arlington for 2012/13 & 2013/14 Growing Seasons

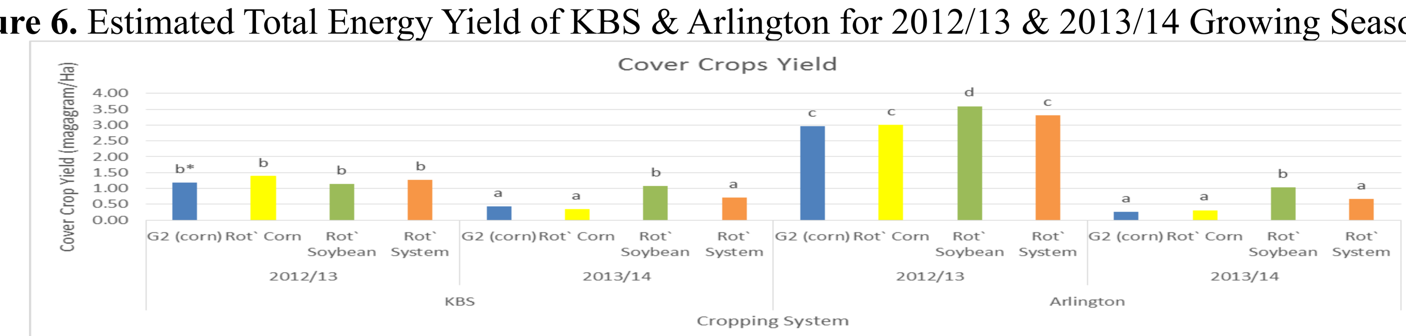


Figure 7. 2012/2013, 2013/2014 Cover Crop Yield

Conclusions: The continuous corn (full season variety) and rotational corn + cover crops cropping system had a significantly higher total yield at both location during the 2013/14 growing season. The continuous corn (full season variety) cropping system had significantly higher energy yields at both locations during the 2013/14 growing season. The cold weather and delayed spring warm up during the 2013/2014 winter annual growing season, reduced cover crop yields relative to the 2012/2013 winter annual growing season. Higher cover crops yields during 2012/13 growing season do not make up the yield lost of grain and corn stover due to 2012 drought. During the 2013/2014 winter annual growing season, cover crops from the soybean system had a significantly higher yield than from the corn systems, due to a slightly earlier fall planting date facilitated by an earlier soybean harvest date relative to corn.

Digestibility Results

Digestibility Results: Cell wall crystalline cellulose (glucose), xylose, and lignin compositions were obtained. Weak-acid enzymatic digestibility of untreated biomass was performed to obtain glucose and xylose hydrolysis yields. *Means with the same letter(s) within the same composition are not statistically different (α= 0.05).

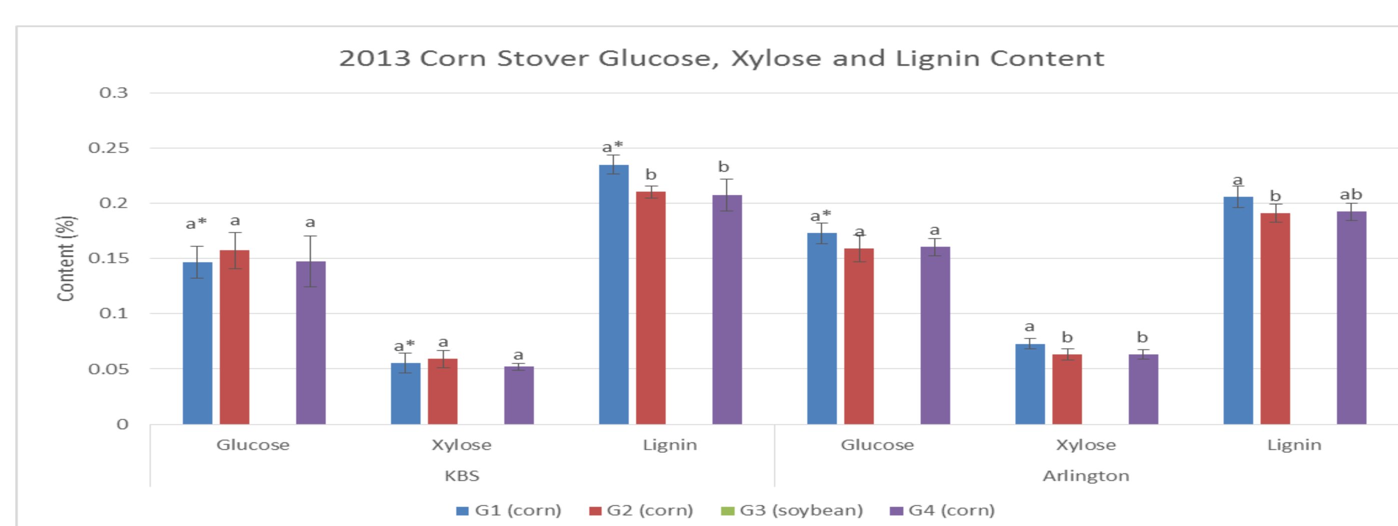


Figure 8. Glucose, Xylose and Lignin Content of Corn Stover

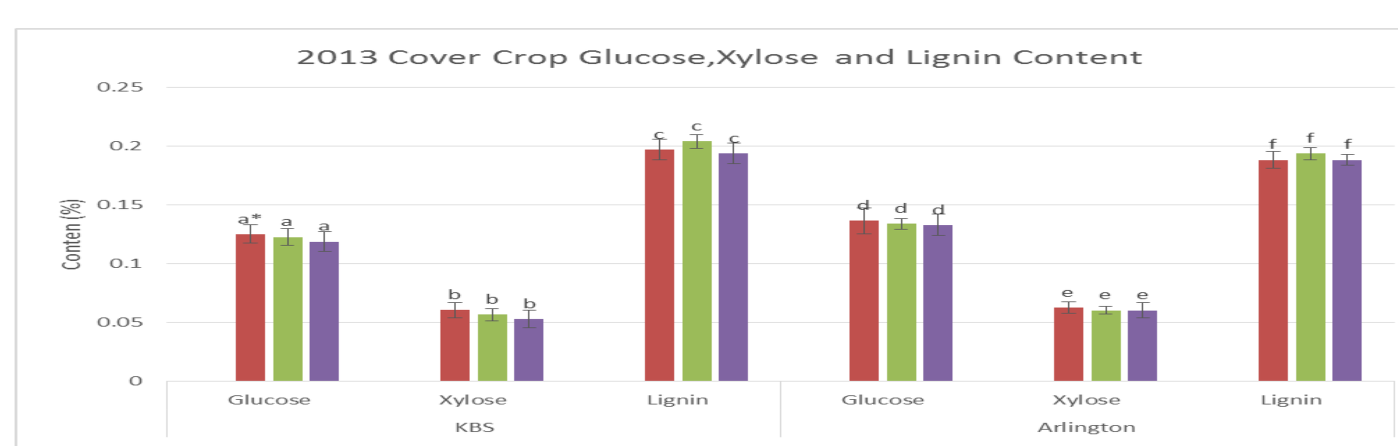


Figure 9. Glucose, Xylose and Lignin Content of Cover crops

Conclusions: The cover crop glucose, xylose and lignin content from the different cropping systems were not significantly different. The lignin content in stover from the full season continuous corn grown w/o cover crops was significantly higher than that from stover from the shorter season corn grown with cover crops. At Arlington (WI), stover xylose content was significantly higher from the full season continuous corn grown w/o cover crops relative to the other corn systems. Glucose content was not significantly different in the stover or cover crops at both locations.

Life Cycle Assessment

Life Cycle Assessment: Life Cycle Assessment (LCA) was performed using GaBi 6 Professional + Extension 2012 database (PE international). This study complies with ISO14000 and ISO 14040. TRACI 2.1 Impact Assessment Method is adopted to evaluate environmental burden of Global Warming Potential, Acidification Potential, Eutrophication Potential and non-renewable energy use.

Goal and Scope:

- **Temporal Scope** - 2012/2013& 2013/2014 growing seasons
- **Geological Scope** - two locations
  Hickory corner, MI (KBS)
  Arlington, Wisconsin
- **System boundary** - cradle to farm gate
- **Functional Unit** -one hectare of arable land per year
- **Reference Flow –** average yield of crops from the system on one hectare of arable land per year

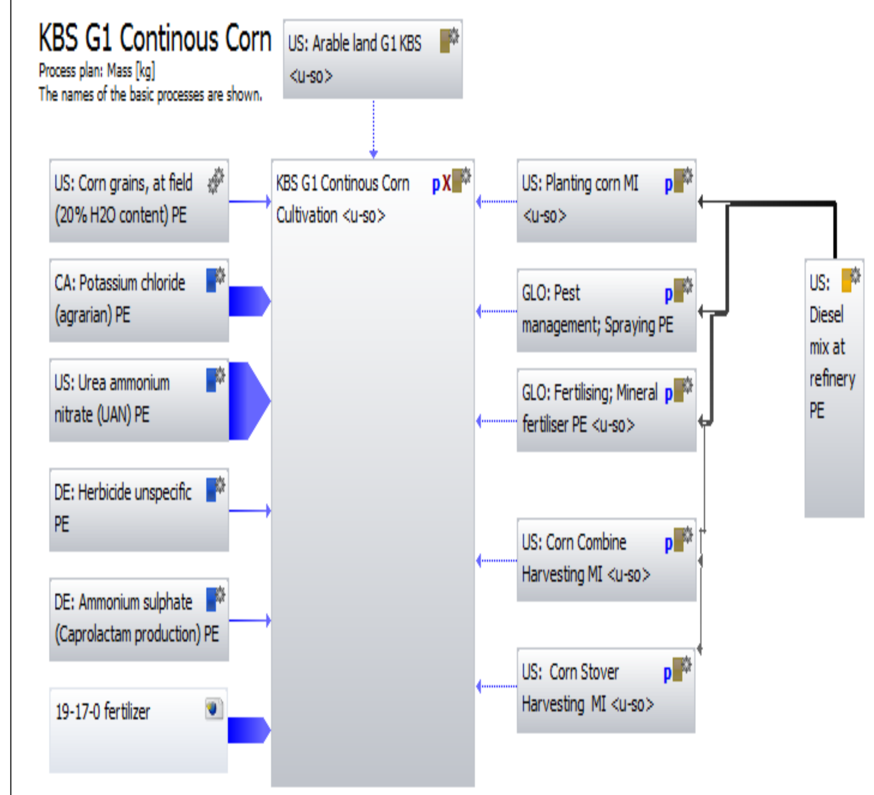


Figure 10. KBS G1 Continuous Corn Cultivation flow diagram

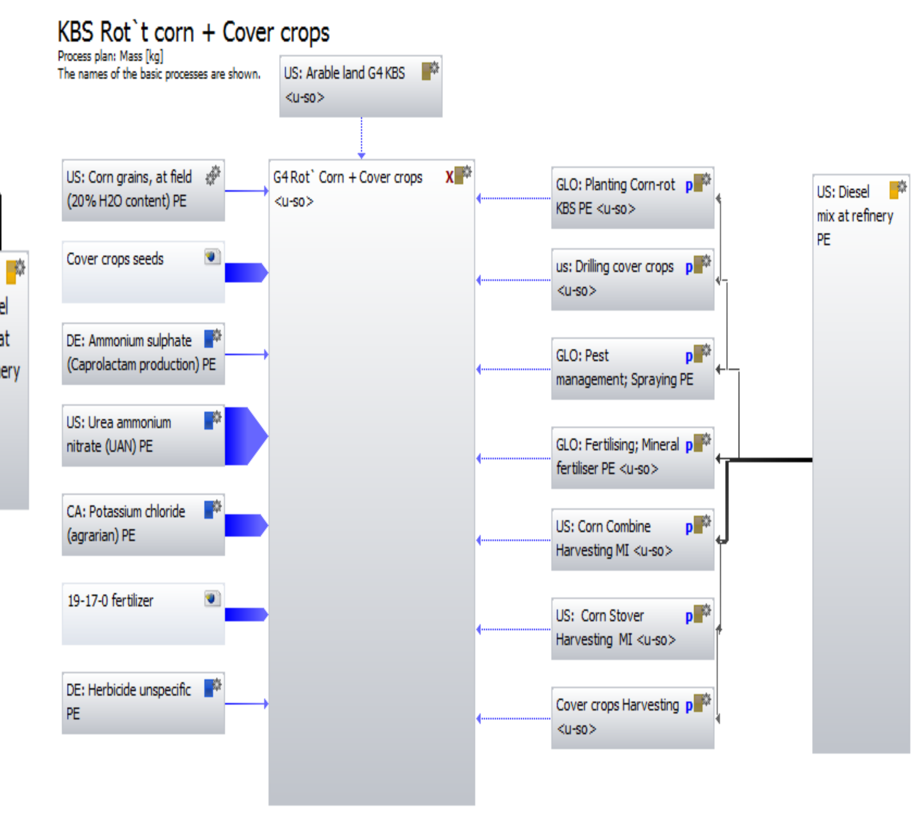


Figure 11. KBS Rotational Corn + Cover crops Cultivation flow diagram

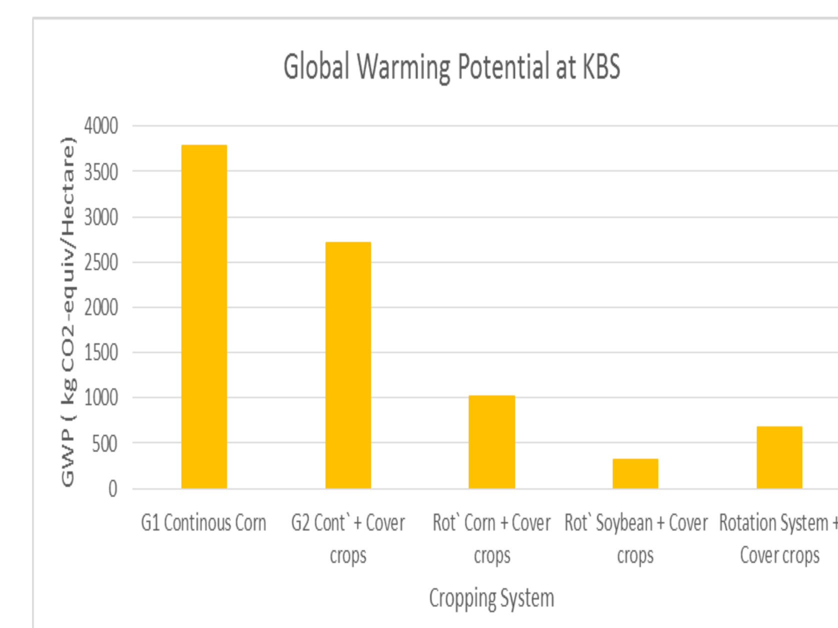


Figure 12. Global Warming Potential of different cropping systems at KBS

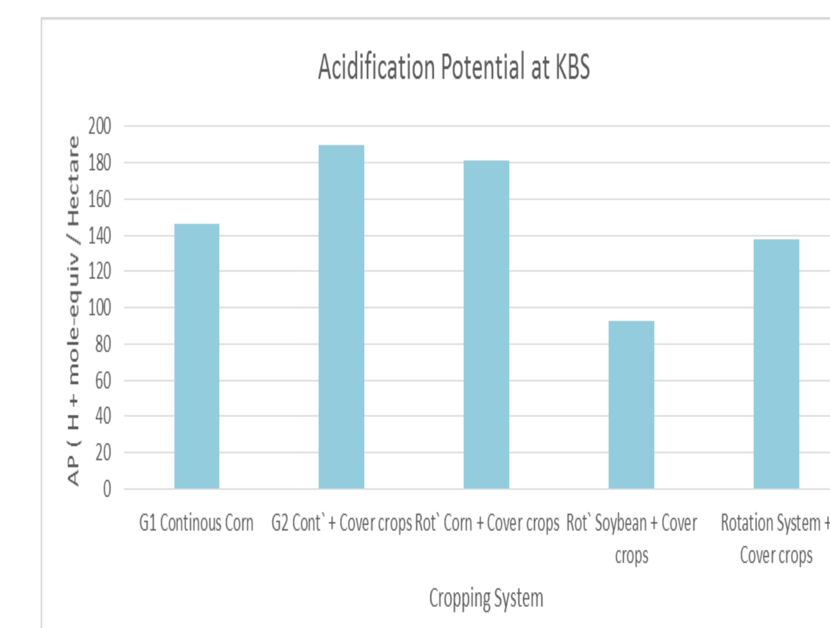


Figure 13. Acidification Potential of different cropping systems at KBS

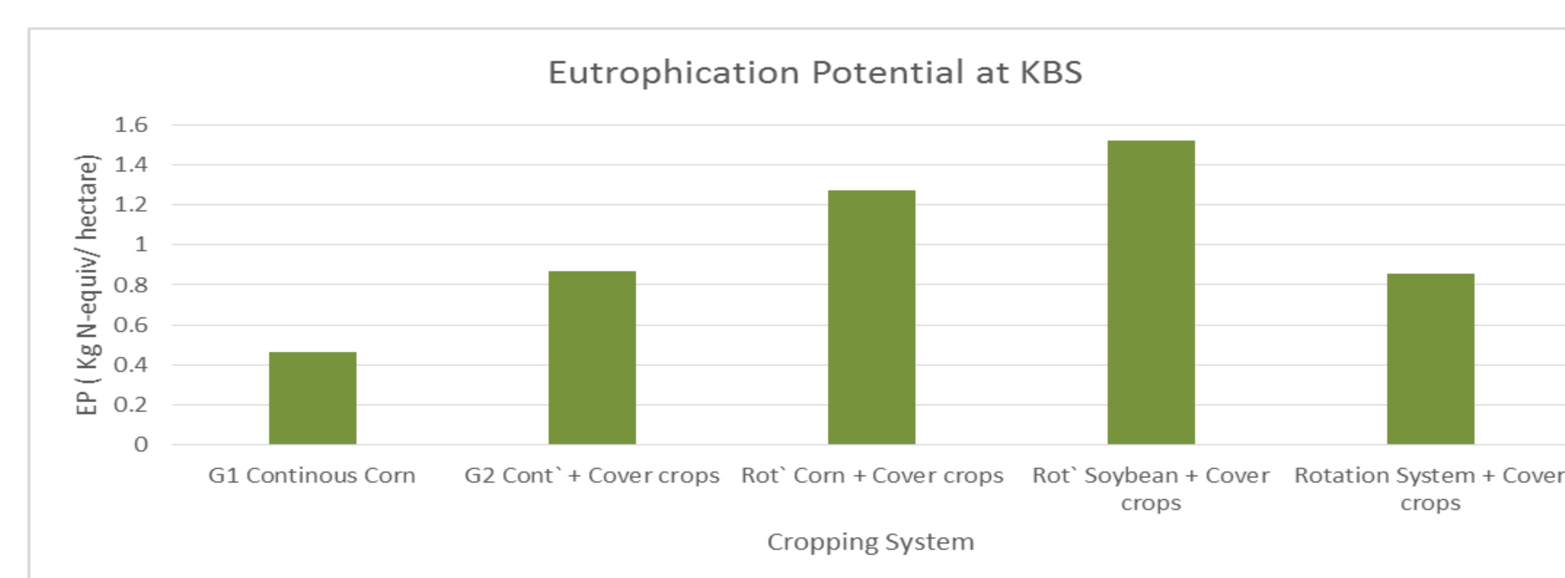


Figure 14. Eutrophication Potential at KBS

Conclusions: Preliminary results of tow years study indicate that the Rotational Soybean + Cover crops system tended to perform more environment friendlier in terms of GWP and AP. Continous corn w/o Cover crops system does better in EP. These are primarily driven by yield and the number of mechanized field activities respectively.

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