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Nutrient Distribution Between the Different Corn Crop Components, Corn Residue, Cob and Grain in the Northern Corn Belt

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Abstract: Over the next several years, producers and the bioethanol industry are challenged to develop a working relationship in which the producers are receiving adequate compensation for their commodities while maintaining the profitability of the industry. There is currently limited information available on the amount of nutrients that will be removed from the soil resources if corn cobs are to become a feedstock for the industry. In the short-term, producers want to know the increase in nutrients removal that would occur if cobs are to be utilized as a feedstock. A limited field study was conducted to evaluate the amount of dry matter and nutrients taken up in the cob compared to the rest of the above ground plant. Random plant samples were collected from 53 different production fields in southeastern South Dakota and Northwestern Lowa. The fields varied in soil type, agronomic management practices and hybrid. Plant samples were separated in to three components: grain, cobs and residual biomass (stalks, leaves and hulks). Once the samples were separated, dry weights were measured and chemical analysis was performed for several nutrients (carbon, nitrogen, phosphorus, potassium, calcium, magnesium, iron and sulfur). On average <7% of the total for each nutrient was stored within the cob. Removal of the cob would remove an additional 6 kg ha^{-1} of nitrogen, 0.34 kg ha^{-1} of phosphorus and 4 kg ha^{-1} of potassium. In the short-term, it appears that additional removal of the cob might have limited impact on the soil environment but additional long-term studies will need to be conducted to support this statement.

Key words: Nutrient distribution, corn residue, biofuels, feedstock, agronomic management, South Dakota

INTRODUCTION

The production of biofuels is one of the most important aspects of the President's plan to reduce the dependence on imported petroleum products. Producers throughout the corn-belt are prepared to increase production of corn grain, corn stover and other crops necessary to supply adequate feedstock for the bioethanol industry. However, the economic and environmental impacts associated with this shift within the production systems need to be evaluated.

Over the past decade, biofuel production has been promoted as a potential avenue to decease the countries dependency on foreign oil and possibly solving the nation's energy crisis. Additionally, this reduction in energy dependency reduces the countries political and economic vulnerabilities reduce greenhouse gas emissions and other pollutants and bring additional economic vale to agricultural products (Demirbas, 2009).

To produce the amount of biofuels necessary to meet these needs, crop residue must play an important role. The billion ton report (Perlack *et al*., 2005) concluded that with the adoption of new technologies and production practices that agriculture and forest land have the potential to supply the necessary feedstocks. Foust *et al*. (2007) concluded that corn stover could be utilized as a major feedstock that it currently available and could meet up to 25% of the feedstock necessary to meet the 30×30 plan by 2030 as it is considered to be a low cost waste product.

The long-term success of the biofuels industry is predicated on the adoption of sustainable cropping practices. Producers are interested in utilizing crop residue as an additional commodity but additional information is needed on the agronomic importance of these residues as well as the environmental impact of providing additional bioethanol feedstock. Additional research is needed to understand how these new production systems will impact our natural resources and what agronomic value is contained within the feedstock utilized (Wilhelm *et al*., 2007).

The biofuels industry is providing an additional outlet for producers to market and sell their crop commodities (grain and residue fractions). Historically, producers have been price takers for their commodities and have been unable to pass along increasing input cost

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onto consumers of products (Costantini and Bracceva, 2004). The prospect of utilizing crop residue as a feedstock for ethanol production brings an additional value to their current production system, potentially increasing the economic sustainability of the farming operation. The research objective was to evaluate the agronomic value of corn cobs relative to the remaining above ground biomass of the corn plant (grain, stalks, leaves, etc.).

MATERIALS AND METHODS

We identified 53 producer fields with varying soil types, corn hybrid and crop management practices for use in this analysis. Whole plant corn samples were collected from 32 production fields near Scotland, South Dakota and 21 production fields near Emmetsburg, Lowa area. Basic agronomic information was collected on each field; the information collected included planting date, seeding rate, crop hybrid, fertilizer management, tillage systems, cropping history and any available soil testing information. Individual sampling sites within each field were determined based differences in hybrid (which were planted to meet corn Bt refuge requirements), soil type and landscape position. Approximately 4-5 sampling site within each field was identified prior to sampling, totaling to 241 sample sites. At physiological maturity, a total of 10 random above ground whole plant were collected at each of the 241 sampling site. These samples were collected, bundled, labeled and transported to the laboratory for further chemical and physical analyses.

Plant samples were dried in a 60°C forced-air oven and total dry matter production was determined. Samples where than separated into three different components; biomass (stalks, leaves and husks), grain and cobs, all samples were weighed separately to obtain individual dry weights.

Plant nutrient concentrations were determined on each plant component at each sampling site. All plant components were ground to pass a 2 mm sieve. Dried and ground samples were wet digested with concentrated nitric acid for chemical analyses on an Inductively Coupled Plasma atomic emission spectrometer (ICP) to determine phosphorus, potassium, calcium, magnesium, sulfur, manganese, zinc, boron, molybdenum, iron and sodium levels.

Samples were also analyzed for carbon and nitrogen concentration using a LECO TruSpec total combustion system. Statistical analysis of data was performed using the Proc GLM procedures in SAS (Littell *et al*., 1996) utilizing $\alpha = 0.05$. Analysis was performed by location and hybrid to determine if there were statistical differences between components and/or within components across location or hybrid. Monthly precipitation totals collected in close proximity to sampling locations are shown in Fig. 1 (South Dakota State University Climatology and Iowa State University Climatology). Throughout the growing season, average air and soil temperatures were near normal for the region while there were differences in monthly rainfall amounts (Fig. 1). With no measurable rainfall within the month of July for the South Dakota sites and extremely high precipitation in August for the Iowa sites.

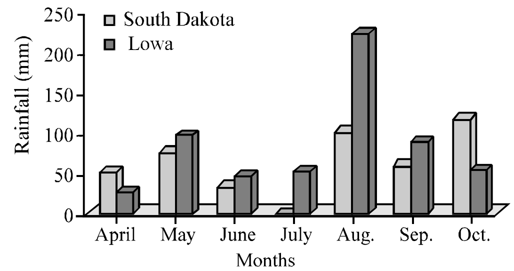

Fig. 1: Monthly precipitation values for South Dakota and Iowa

RESULTS AND DISCUSSION

Samples were collected from 53 different sites. Across all locations there were 48 different corn hybrids, representing a number of different manufacturers, maturity groups and agronomic practices. Statistical analysis was performed on only the nutrients that were present in sufficient concentration; zinc, boron (cob), molybdenum and sodium each were not present in high enough concentrations to be analyzed with standard methodology. Statistical analysis for dry weights and nutrient content for sampling location and hybrid for each component is shown in Table 1.

For the grain fraction, nitrogen, phosphorus and iron were the only nutrients which were present at significantly different levels among locations. Differences in grain nitrogen and phosphorus was due to difference in fertilizer management practices where fields that received higher nitrogen and phosphorus fertility had higher nutrient content in grain at harvest. Different hybrids grown in the same field did not have significantly different nitrogen and phosphorus content. Differences in iron content were identified across locations however, this were likely due to difference in soil iron content due to variation in soil parent material and soil types across locations. Results for the cob fractions were similar to those for grain. There was a significant difference in cob

Table 1: Analysis of variance for dry weight and nutrient uptake for each of the components

	Grain		Cob		Biomass	
Samples	Location	Hybrid	Location	Hybrid	Location	Hybrid
Dry weight	0.1920	0.6238	0.0482*	0.1145	0.2162	0.9525
Carbon	0.1914	0.6369	0.0625	0.1357	0.2213	0.9690
Nitrogen	0.0053*	0.3201	0.0109*	0.0198*	0.1873	0.8754
Phosphorus	0.0404*	0.2716	0.0033*	0.3900	0.0032*	0.3844
Potassium	0.1820	0.3199	0.1259	0.0797	0.1078	0.2059
Calcium	0.6702	0.5378	0.4925	0.9741	0.1407	0.4162
Magnesium	0.1123	0.1100	0.0011*	0.0027*	0.0101*	0.6866
Iron	0.0022*	0.5447	0.0440*	0.4641	0.1295	0.4550
Sulfur	0.2978	0.2272	0.1131	0.2060	0.3449	0.3370
Boron	0.0548	0.5702	0.0354*	0.1108	--	--

*Significant at the $\alpha = 0.05$

nitrogen, phosphorus and iron across different locations as well as significant differences in dry weight, magnesium and boron content. These differences in nutrient content could possible be due to difference in fertilizer management practices as well as inherent soil nutrient levels with the South Dakota fields having relatively higher average cob dry weights (1322/1280), nitrogen (6.25/5.72), phosphorus (0.42/0.25), magnesium (0.27/0.25), iron (0.04/0.03) and boron (0.13/0.12) (South Dakota/Iowa). The remaining biomass fractions showed differences across locations only for phosphorus and magnesium levels. Significant difference among hybrids was observed only within the cob fraction and only for nitrogen and magnesium.

Among the different plant fractions, analysis revealed significant differences among all three fractions for all measured variables including dry weight and all nutrients (Fig. 2-10). Total average above ground plant dry matter accumulation was 20,771 kg ha^{-1}, partitioned as follows: 49% as grain (182 bu/ac avg. yield), 45% as stalks, leaves and husks and only 6% of the total weight within the cob portion of the plant (Fig. 2). Total carbon was partitioned much the same as dry matter. Total carbon stored within the plant was 9, 358 kg ha^{-1} with 49, 44 and 7% as grain, biomass and cob, respectively. Therefore, under traditional management practices nearly 50% of the carbon is removed from the system as grain yield (Fig. 3). Removal of cobs would only take an additional 7% of the plant accumulated carbon away from the soil resource.

For the 3 macro-plant nutrients, total plant accumulation was 209, 18 and 73 kg ha^{-1} for nitrogen, phosphorus and potassium, respectively (Fig. 4-6). Of the 209 kg ha^{-1} of nitrogen within the plant, 132 kg ha^{-1} are removed when the grain is harvested, 71 kg ha^{-1} will remain in the biomass and 6 kg ha^{-1} will be removed with the cob. The cob fraction represents around 3% of the total nitrogen stored within the plant. On average, there was 18 kg ha^{-1} of phosphorus taken up by the plant with 72% stored in the grain, 26% stored in biomass and 2% in the cob (Fig. 5). In contrast, potassium is partitioned with

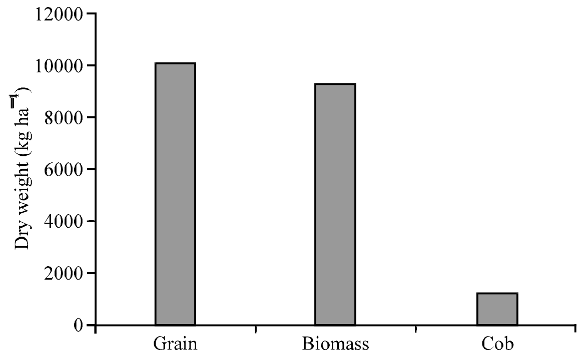

Fig. 2: Dry matter accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

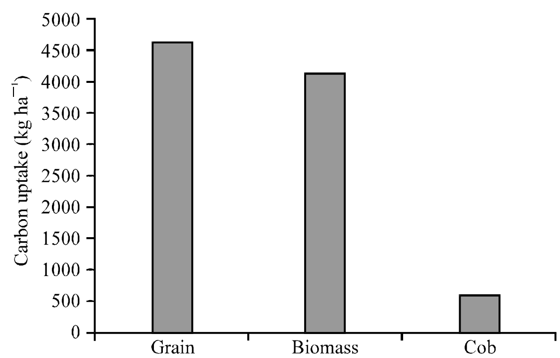

Fig. 3: Carbon accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

the greatest fraction stored in the biomass. Of the 73 kg ha^{-1} of potassium stored within the plant, an average of 72% is stored within the biomass, 23% in the grain and 5% in the cobs (Fig. 6). Of the micro-nutrients measured, only calcium, magnesium, iron and sulfur were present in sufficient enough concentrations. Calcium,

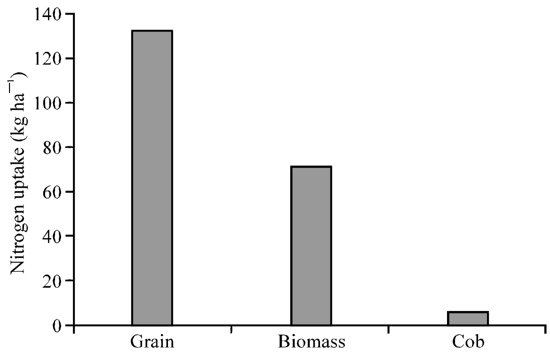

Fig. 4: Nitrogen accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

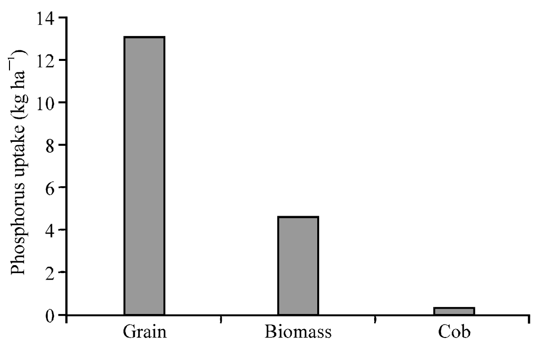

Fig. 5: Phosphorus accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

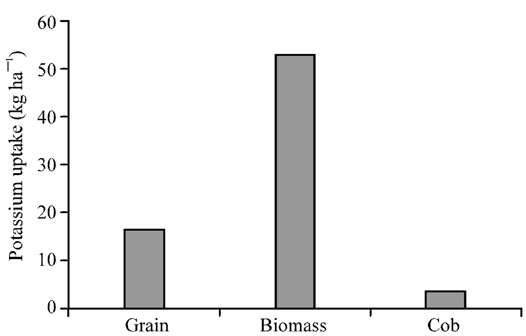

Fig. 6: Potassium accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

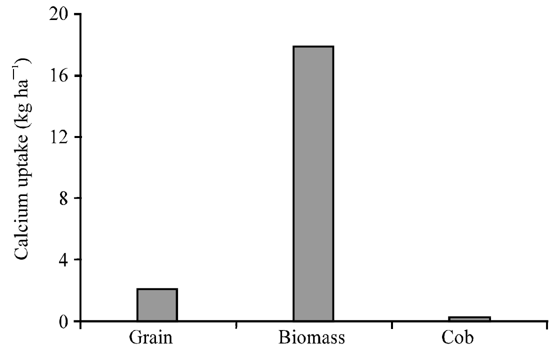

Fig. 7: Calcium accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

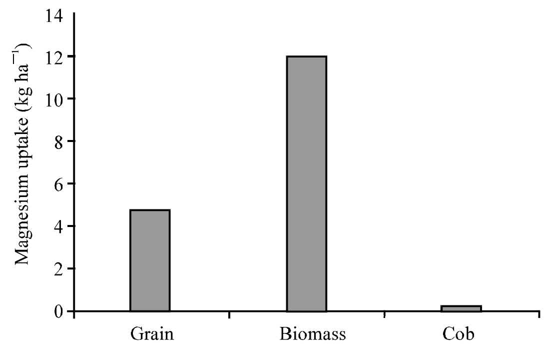

Fig. 8: Magnesium accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

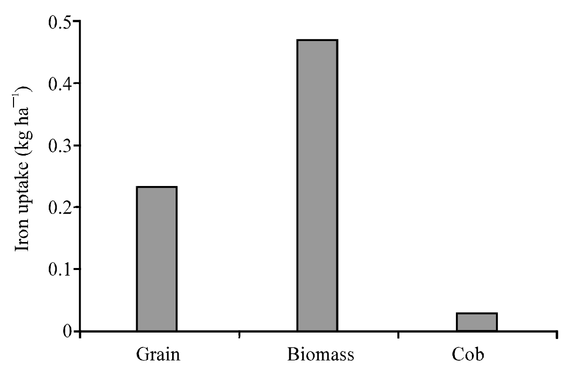

Fig. 9: Iron accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

magnesium and iron had 20, 17 and 0.73 kg ha^{-1} uptake, respectively with an average higher percentage in the biomass (88, 70 and 64%, respectively) compared to the grain (10, 28 and 31%, respectively) and cob (2, 2 and 5%, respectively) (Fig. 7-9). Sulfur uptake was an average of

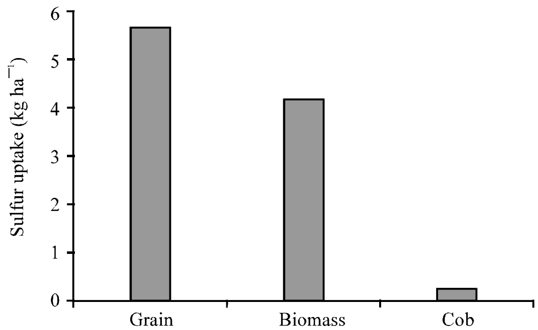

Fig. 10: Sulfur accumulation at physiological maturity over all sampling sites by plant component, grain, biomass (stalks, leaves and husks) and cobs, South Dakota and Iowa 2007

10 kg ha^{-1} with 55% within the grain, 42% within the biomass and 3% stored within the cob (Fig. 10). Differences between location and hybrid were low for the different plant components with differences in location due to differences in fertilizer management practices for nitrogen and phosphorus. Accumulation of plant nutrients within the cob is relatively low compared to the other plant components for all measured nutrients. Of the measured components, carbon had the greatest relative concentration (7%) stored within the cob. On average, there were approximately 2-3% of the measured nutrients stored in the cob for nitrogen, phosphorus, calcium, magnesium and sulfur. Removal of this residue stream from the soil system would remove on average, a limited amount of plant nutrient in cluding: 6 kg ha^{-1} of nitrogen, 0.34 kg ha^{-1} of phosphorus, 4 kg ha^{-1} of potassium, 0.38 kg ha^{-1} of calcium, 0.26 kg ha^{-1} of magnesium, 0.03 kg ha^{-1} of iron and 0.28 kg ha^{-1} of sulfur. If cobs are to be utilized as a feedstock for ethanol production, it would require a limited amount of additional nutrients to be added back to the system to compensate. It is important to note that this study is only accounting for the short-term difference and that to evaluate the impact of removal of cobs in the long-term, additional years of research are necessary.

REFERENCES

Costantini, V. and F. Bracceva, 2004. Social costs of energy disruptions. Center for European Policy Studies. http://www.ceps.eu/book/social-costs-energy-disruptions.

Demirbas, A., 2009. Political, economic and environmental impacts of biofuels: A review. Applied Energy, 86: S108-S117.

Foust, T.D., R. Wooley, J. Sheehan, R. Wallace and K. Ibsen *et al*., 2007. A national laboratory market and technology assessment of the 30x30 scenario. NREL/TP-510–40942. http://catalogue.nla.gov.au/Record/4591527.

Littell, R.C., G.A. Miliken, W.W. Stroup and R.D. Wolfinger, 1996. SAS System for Mixed Models. SAS Institute Inc., Cary, North Caroline.

Perlack, R.D., L.L. Wright, A. Turhollow, R.L. Graham, B. Stokes and D.C. Erbach, 2005. Biomass as a feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply. USDA, Washington, DC. http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA436753.

Wilhelm, W.W., J.M.F. Johnson, D.L. Karlen and D.T. Lightle, 2007. Corn stover to sustain soil organic carbon further constrains biomass supply. Agron. J., 99: 1665-1667.