Cropping Systems Research for Biomass Energy Production

A final report prepared for the Chariton Valley Resource Conservation and Development, Inc.

By

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April 1, 2002

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Rationale

Energy derived from biomass crops is gaining momentum as an alternative to fossil fuels. Originally proposed as a renewable source of energy during the oil crisis of the 1970's, biomass lost favor with the return of low-priced oil and coal. However, there is a renewed interest in biomass spurred by major advances in conversion technologies and concern over the environmental costs associated with fossil fuels. The 1992 National Energy Policy Act provides a $0.15kWh tax credit to stimulate the development of "closed-loop" power systems, which includes energy derived from biomass. Development of a biomass industry offers many opportunities and advantages for Iowa.

Production of perennial biomass crops on marginal land is sustainable. Perennial grasses used for biomass have lower input requirements and much less soil erosion potential than row crops which are currently grown on marginal land. Iowa has had over 2 million acres enrolled in the Conservation Reserve Program much of which will be released in the near future. Most people would agree that these lands should remain in permanent vegetation, but without an alternative market for the forage produced on this land much of it will likely be returned to row-crop production. Biomass energy could provide an alternative market, and thus economic incentive, for perennial crops grown on marginal land. The need for a "third crop" in Iowa has long been recognized and biomass has great potential for fulfilling this role.

Production of biomass crops is environmentally sound. Biomass is a clean and renewable source of energy. The Department of Energy (DOE) and the Electrical Power Research Institute (EPRI) have concluded that dedicated energy crops are a viable alternative to fossil fuels and could provide a significant proportion of the nation's energy. Production of biomass crops could easily be linked to the disposal of organic wastes, which contain high concentrations of nitrogen and other potential surface and ground water pollutants. Organic wastes derived from municipal waste and livestock production facilities could be safely applied to biomass crops, which are outside of the food chain.

Biomass crops will enhance economic development in rural communities. Because biomass crops are bulky and expensive to transport, biomass energy conversion facilities will have to be decentralized. The biomass industry will likely develop in areas suitable for production of biomass crops; i.e., rural areas. This will bring new jobs to rural communities and contribute to their economic development.

As with any new crop, there are many questions related to biomass cropping systems, which need to be addressed through research. While much research has been done on managing switchgrass either as a biomass or as a forage crop, little work has been done on developing systems in which switchgrass is managed for both purposes in a complementary manner. This work may become extremely important. The economics of switchgrass production as a fuel energy source are and will likely remain marginal. Therefore, it is important to find ways to enhance the value of the switchgrass crop beyond its value as a biofuel. Using the switchgrass crop for both forage and biomass production may increase the return per land unit and lessen the risk to the total enterprise.

Overall Objective

The overall objective of the proposed research is to develop management systems for producing switchgrass as both a biomass and forage.

Specific Objectives

1) Determine the effect of timing of spring grazing on subsequent production of switchgrass biomass for fuel.
2) Determine the effect of timing of haying on subsequent production of switchgrass biomass for fuel.
3) Determine the effects of spring interseeding legumes into switchgrass on yield and quality of first cutting hay and subsequent yield and burn characteristics of biomass.
4) Determine the effects of fall interseeding legumes into switchgrass on yield and quality of first cutting hay and subsequent yield and burn characteristics of biomass.
5) Evaluate establishment technologies for switchgrass using corn or forage sorghum as companion crops.

Objective 1
The effect of timing of spring grazing of switchgrass on subsequent biomass production

Introduction

In addition to being a valuable biofuel source, switchgrass has proven itself as a tremendous source of high-yielding, high-quality forage. Managed correctly, switchgrass provides an ample early and mid-summer supply of forage for grazing when cool-season grasses have gone dormant due to temperature and moisture conditions outside of their optimum growth parameters. Under proper management conditions switchgrass recovers quickly from grazing and has the ability to produce large amounts of regrowth for subsequent grazing or mechanical harvests. To capitalize on this, it would be possible to utilize switchgrass for two purposes in the same growing season. It could be harvested early by grazing and allowed to regrow, stockpiling this accumulation of biomass for later harvest as biofuel. This would allow the grass producer greater flexibility in managing an enterprise. He could utilize switchgrass as a forage in a comprehensive rotational cool- and warm-season grass system or concentrate on its accumulation as biofuel or a combination of both.

Information exists on the amount of switchgrass herbage available for grazing under several grazing systems and also in amounts available for haying. However, information is lacking on a hybrid of these systems as well as the realistic yield potential of switchgrass within the Chariton Valley Biomass Project area of production. Consequently, this study looked at the effect that early grazing, when switchgrass was at the vegetative growth period (V2-V3) or slightly later at the vegetative to early elongation period (V2-E2), had on subsequent regrowth available for post-frost biofuel harvest.

Materials and Methods

Two locations of existing switchgrass stands were identified early in 1999 to serve as sites for this research. One was located on the Eddy Farm near Centerville, Iowa in Appanoose County and the second on the Sellers Farm near Corydon, Iowa in Wayne County. Due to difficulties with the placement and retention of cattle as grazing treatments on the Eddy Farm site in 1999, this location and its data were dropped from the research. A new site was selected on the Sellers farm in 2000 so that the previous year's treatments would not affect the second year's data.

The experimental design was a randomized complete block with four replications. Treatments included: 1) a control with no grazing, 2) grazing at the vegetative growth period (V2-V3), and 3) grazing at the vegetative to early elongation period (V2-E2). Plots were 125 feet by 30 feet areas fenced with temporary electric fence. Twenty-five cow-calf pairs were placed in the treatment areas for one-half day periods at appropriate grass development stages in June of each year to meet treatment requirements. No animal performance data or potential forage availability/quality data was taken at this time. Regrowth was allowed to accumulate until after a killing frost and was then harvested for subsequent biomass accumulation. Strips 3 feet wide by 30 feet long were cut by a walk-behind sickle bar mower, gathered and weighed to determine out-of-field yield. Samples of the switchgrass were taken from the harvested portion to determine the percentage moisture of the harvested grass and to analyze appropriate quality traits in the laboratory. Harvests occurred on 20 October 1999 and 4 November 2000.

Laboratory quality analyses utilized the following procedures: Percentage ash was determined by igniting 1.5 grams of sample material in a muffle furnace over night at 600 degrees C. ADL (lignin) was determined using 72% sulfuric acid and ashing. NDF and ADF were determined using an ANKOM Fiber Analyzer. Percentage IVDMD was measured by following the NC-64 Marten and Barnes direct acidification system based on the Tilley and Terry *in vitro* method. Crude protein was derived from percentage nitrogen determined by combustion using a LECO CHN-2000.

Results and Discussion

Yield

The two research years differed in rainfall amount totals and timings of occurrence. These issues greatly affected yields of biomass for the year (Table 1.1). However, changing locations of this study probably had an even greater effect. The 1999 location was near a ridge top and had a very thick stand with great vigor. The 2000 site was on low-lying land that had a greater amount of cool-season grass competition and an overall less vigorous stand. Control yields of nearly 3.5 T/A on the 1999 site were indicative of the productivity thick, vigorous, switchgrass stands could have on productive ridge top soils in this region. Conversely, the lower control yields in 2000 showed the great range of yield potential this grass could exhibit based on its environment and strength of stand.

Table 1.1 Average Total Post-Frost Biomass (lb./A).

Time of Grazing	1999	2000
Control (no grazing)	6945	3755
Grazing V2-V3	4568	2044
Grazing V2-E2	4504	2205

The timing of grazing had little effect on the total amount of regrowth harvested after frost. Regrowth from the earlier grazing yielded nearly the same as that from the later grazing treatment in each year. As a percentage, regrowth from grazing treatments (regardless of time of grazing) yielded approximately 55% to 65% of the no grazing control treatment yields.

Quality

Because the focus of this study was to look at post-frost biomass yield and quality following summer grazing, no sampling of forage took place at the time cattle were placed on plot areas as treatments (Objective 2 contains mid summer quality information).

The results for post-frost quality trait analyses (Table 1.3) revealed what would normally be expected from this type of warm-season grass stockpiling system. As forage, quality was quite low. Digestibility ranged from only 25.5% for the ungrazed control to about 27.5% for grazing treatments and protein ranges from only 3.4% for the control to about 4.8% for the grazing treatments. Both ADF and NDF levels followed similar narrow difference trends. Little difference was found between treatments when considering lignin concentration. The range was only 5.4% from grazed to 6% for the control.

As biofuel, a major factor that could be viewed as limiting in the combustion process was relatively low regardless of treatment. Ash contents of most forage species can range from about 5.0% to approximately 11.0%. Ash concentrations in this study ranged from only 5.4% for the control to about 6.0% for grazing treatments.

Table 1.3 Quality Data for 2000 Harvest.

Time of Grazing	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
Control	5.40	5.96	43.75	76.11	3.40	25.49
Grazing V2-V3	6.01	5.38	41.14	74.62	4.90	27.27
Grazing V2-E2	5.94	5.49	41.52	74.59	4.70	27.47

The control treatment differences in percentage concentration were likely due, in part, to the differences in leaf to stem ratios as responses to the treatments. Ash content is typically higher in leaf tissue than stem tissue. The control, which had no defoliation, progressed, unmolested, through a maturation process that included vegetative, stem elongation, and ultimately reproductive stages. This results in a mature plant with a high proportion of stem compared to leaf.

The lignin concentration is also higher in more mature cells as they are cemented together. If the natural process of maturation is disturbed, such as by grazing, the plant must produce more leaves to intercept more light in order to proceed with the maturation process. As a result, the plant will not be able to grow as tall (less stem) before day length triggers the plant to become reproductive and complete its maturation process for the year. In addition, defoliation also induces the plant to tiller, which increases the leaf to stem ratio

Demineralization may also lead to differences in some concentrations. As the plant matures and reaches a point of cessation, it loses its need and ability to keep some minerals and elemental components tied up inside certain tissues. Some of these leach out with water and those that are structurally tied up are gradually released by microbial degradation.

Conclusions

Under a carefully managed grazing system, a livestock producer may be able to harvest a second cash crop of switchgrass for biofuel if this grass was not needed in the livestock production enterprise. It appears that if grazed properly, a fairly predictable 55 to 65% of the potential ungrazed biomass would be available for post frost harvest. However, the yield of the regrowth following initial grazing would have to be such that it would be economically feasible to pay for the harvesting and still provide a return on investment greater than using the switchgrass as forage rather than biofuel.

Switchgrass that is allowed to stockpile from mid summer to post frost has poor forage quality traits. Digestibility is only 27% or lower and crude protein is less than 5%. However, as a perennially available renewable source of biofuel, it contains large amounts of combustible energy and minimal amounts of ash (approximately 6% or less).

Great variability exists in the soil type, fertility, slope and other yield determining characteristics of the southern Iowa landscape. Add to these factors sporadic and unpredictable weather patterns that seem to bounce around the extremes, and it is nearly impossible to set realistic yield potentials of any crop, including one of Iowa's most dynamic and adapted native species. However, there are relationships that can be found and this experiment has helped identify that. Under the right circumstances, switchgrass yields may reach the 3.5 to 4 T/A level on well-managed farms. Because this is the high extreme, caution should be used in making yield predictions. More likely encountered landscapes include slopes of less productive soils with less natural or modified fertility.

Objective 2
The effects of timing of haying of switchgrass on subsequent biomass production

Introduction

In addition to being a valuable biofuel source, switchgrass has proven itself as a tremendous source of high-yielding, high-quality forage. Managed correctly, switchgrass can provide an ample early and mid-summer supply of forage for hay or silage when not needed for grazing. Under proper management conditions switchgrass can recover quickly from mechanical harvest and has the ability to produce large amounts of regrowth for subsequent grazing or mechanical harvests. To capitalize on this, it would be possible to utilize switchgrass for two purposes in the same growing season. It could be harvested early by mechanical means then allowed to regrow and be stockpiled for later harvest as biofuel. This could allow the grass producer greater flexibility in managing an enterprise. He could utilize switchgrass as a forage in a comprehensive grazing or mechanical harvest system or concentrate on its accumulation as biofuel or a combination of both.

A fair amount of information exists on the amount of switchgrass herbage available for mechanical harvest to be stored as a feedstuff. However, information is lacking on taking an initial hay or haylage harvest and stockpiling the regrowth for a post frost biofuel harvest. In addition, more yield potential data is needed within the Chariton Valley Biomass Project area of production. Consequently, this study looked at the effect that haying, when switchgrass was at the vegetative growth period (V3-V4) or later at the boot stage (R0), had on subsequent regrowth available for post-frost biofuel harvest.

Materials and Methods

Two locations of existing switchgrass stands were identified early in 1999 to serve as sites for this research (adjacent to Objective 1 studies). One was located on the Eddy Farm near Centerville, Iowa in Appanoose County and the second on the Sellers Farm near Corydon, Iowa in Wayne County. Due to the plot area on the Eddy Farm site being defoliated by the landowner for hay production, this location and its data were dropped from the research. A new site was selected on the Sellers farm in 2000 so that the previous year's treatments would not affect the second year's data.

The experimental design was a randomized complete block with four replications. Plot treatments included: 1) a control with no haying, 2) haying at the vegetative growth period (V3-V4), and 3) haying at the boot stage (R0). Plots were 30 feet by 30 feet areas with alleys between replications. Strips 3 feet wide by 25 feet long were cut by a walk-behind sickle bar mower, gathered and weighed to determine out-of-field yield. Samples of the switchgrass were taken from the harvested portion to determine the percentage moisture of the harvested grass and to analyze appropriate quality traits in the laboratory. Harvests took place on 29 June 1999 and 8 June 2000 for the vegetative stage harvests.

Boot stage harvests occurred on 27 July 1999 and 11 July 2000. Regrowth was allowed to accumulate until after a killing frost and was then harvested by the same procedure for subsequent biomass accumulation. These harvests took place on 20 October 1999 and 4 November 2000.

Laboratory quality analyses utilized the following procedures: Percentage ash was determined by igniting 1.5 grams of sample material in a muffle furnace over night at 600 degrees C. ADL (lignin) was determined using 72% sulfuric acid and ashing. NDF and ADF were determined using an ANKOM Fiber Analyzer. Percentage IVDMD was measured by following the NC-64 Marten and Barnes direct acidification system based on the Tilley and Terry *in vitro* method. Crude protein was derived from percentage nitrogen determined by combustion using a LECO CHN-2000.

Results and Discussion

Yield

As with Objective 1, weather (temperature and rainfall) probably had some effect on the differences in yield between years but moreover it was likely the change in location of the study that had an even greater effect. Since the two studies were adjacent in both years, the reasons discussed for yield differences in Objective 1 Results and Discussion apply here as well. The 1999 location was near a ridge top and had a very thick stand with great vigor. The 2000 site was on low-lying land that had a greater amount of cool-season grass competition and an overall less vigorous stand.

Similar total biomass yields were produced when switchgrass was either not hayed (control treatment) or hayed at V3-V4 before being harvested again after frost. Production of switchgrass when hayed once at R0 and then again post-frost produced significantly higher yields than the other two treatments both years.

The first cut at the V3-V4 stage made up 64% of the total harvested material in 1999 and 45% in 2000. In either year only about 1600 lb/A of biomass remained to be harvested after frost. The post-frost available biomass regrowth was even lower for the boot stage harvest treatments. Only 924 lb/A remained to be harvested in 1999 and 1310 lb in 2000. This translates into 83% of total biomass being removed at first cut in 1999 and 70% in 2000.

Table 2.1 Yield by Harvest and Total for Year (lb/A).

		1999			2000	
Treatment	1st Cut	2nd Cut	Total	1st Cut	2nd Cut	Total
Control	-	4771	4771	-	2643	2643
Hay @ V^n	3001	1685	4686	1323	1593	2916
Hay @ R^0	4405	924	5329	3050	1310	4360

Quality

The results from mid summer and post-frost quality trait analyses (Table 2.2) show the large differences that existed in plant composition between maturity stages and seasons. During the early season (mid summer) the digestibility (IVDMD) fell from 58.72% (vegetative stage) on 8 June 2000 to 48.76% (boot stage) on 11 July 2000 and crude protein (CP) fell from nearly 7% to slightly over 4% during that same time. The lignin concentration also rose during this period from 2.89% to 4.16% as the plants matured. Associated ADF and NDF values also changed markedly in this short period of maturity advancement.

Ash concentrations, which tend to decline as the plant matures, followed a similar trend as levels did in Objective 1. Plots that were harvested post-frost, and that were harvested earlier as hay in mid summer, had higher IVDMD, CP, and ash content than the control plots. Values for ADF, NDF and lignin were lower.

Ash content of most forage species ranged from about 5.0% to approximately 11.0%. Ash concentrations ranged from only 4.8% to about 5.6% for plots harvested as haying treatments in the early season portion of this study. After frost levels were as low as 4.8% for control plots and ranged from 5.8% to 6.0% for the two haying treatments.

Table 2.2 Quality Data for 2000 Harvest.

	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
Early Season						
Hay @ V^n	5.59	2.89	33.33	64.17	6.92	58.72
Hay @ R^0	4.77	4.16	38.00	69.14	4.11	48.76
Post Frost						
Control	4.82	6.29	45.30	77.30	2.69	25.55
Hay @ V^n	6.02	5.63	40.91	72.45	4.90	28.87
Hay @ R^0	5.78	5.36	39.88	73.53	5.90	28.20

Conclusions

Under a carefully managed mechanical harvesting system, a producer may be able to harvest a second cash crop of switchgrass for biofuel if this grass was not needed as a feedstuff in a livestock production enterprise. It appears that if harvested in the vegetative stage, enough biomass would be available for post frost harvest. However, the yield of the regrowth following initial harvest would have to be such that it would be economically feasible to pay for the harvesting and still provide a return on investment greater than using the switchgrass as forage rather than biofuel.

Quality data from this experiment would also suggest that an assessment would have to be made on not only the timing of haying for yield, but for quality as well. The large drop in forage quality between the vegetative and early reproductive stages must be considered. Nutritional requirements of the consuming livestock must be assessed and taken into consideration when deciding when to harvest. Total season yield may be higher by delaying initial harvest until the boot stage, but quality may be so low that it doesn't meet animal requirements and it could drastically affect regrowth yield in some years as suggested by 1999 data.

Objective 3
The effects of spring interseeding legumes into existing stands of switchgrass on subsequent hay and biomass production

Introduction

Switchgrass has proven itself as a tremendous source of high-yielding, high-quality forage in addition to being a potential valuable biofuel source. Managed correctly, switchgrass can provide an ample early and mid-summer supply of forage for haying or grazing. Under proper management conditions switchgrass can recover quickly from mechanical or grazing defoliation and has the ability to produce large amounts of regrowth for subsequent grazing or mechanical harvests. To capitalize on this, it would be possible to utilize switchgrass for two purposes in the same growing season. It could be harvested early by grazing or mechanical means and allowed to regrow, stockpiling this accumulation of biomass for later harvest as biofuel.

Adding a legume component to the switchgrass may be beneficial to its use as either a forage or biofuel. Legumes add nitrogen to the soil for use by switchgrass thus increasing its total yield and quality without applying chemical fertilizers. The legumes themselves can also add to the total biomass available for harvest. The presence of a legume would also increase the quantity of the available forage and the quality by increasing the protein content. This study looked at the effect of spring interseeding legumes into existing stands of switchgrass to determine their effect on early summer yield and quality of switchgrass harvested for hay and subsequent regrowth available for post-frost biofuel harvest.

Materials and Methods

Two locations of existing switchgrass stands were identified early in 1999 to serve as sites for this research. One was located on the Osenbaugh Farm near Lucas, Iowa in Lucas County and the second on the Lodge Land near Moravia, Iowa in Appanoose County.

The experiment utilized a split plot design with four replications. Plot treatments included: 1) a control with no legumes, 2) red clover seeded at 8 lb/A PLS, 3) birdsfoot trefoil seeded at 5 lb/A PLS, 4) sweetclover seeded at 12 lb/A PLS, and 5) alfalfa seeded at 12 lb/A PLS. Plots, measuring 50 feet by 50 feet with 25-foot alleys were seeded on 4 May 1999 using a Tye no till drill. Plots were allowed to grow during establishment year without data collection harvests. Material was removed from the plot areas after frost.

In 2000 and 2001, early summer and post frost harvests were performed. Strips 3 feet wide by 50 feet long were cut by a walk-behind sickle bar mower, gathered and weighed to determine out-of-field yield. Samples of the switchgrass were taken from the harvested portion to determine the percentage moisture of the harvested grass and to analyze appropriate quality traits in the laboratory. After the early summer harvests, the remaining switchgrass within the split plot was defoliated at the harvest height and removed from the plot to allow regrowth for the post-frost harvest. Summer harvests took place on 8 June 2000 and 21 June 2001. Post-frost harvests took place on 28 October 2000 and 8 November 2001.

Plots located on the Lodge Land were mistakenly combined for seed in 2000 prior to the post-frost biomass yield harvest thus making post-frost harvests impossible.

Laboratory quality analyses utilized the following procedures: Percentage ash was determined by igniting 1.5 grams of sample material in a muffle furnace over night at 600 degrees C. ADL (lignin) was determined using 72% sulfuric acid and ashing. NDF and ADF were determined using an ANKOM Fiber Analyzer. Percentage IVDMD was measured by following the NC-64 Marten and Barnes direct acidification system based on the Tilley and Terry *in vitro* method. Crude protein was derived from percentage nitrogen determined by combustion using a LECO CHN-2000.

Results and Discussion

Yield

In 2000, the one-cut systems produced more biomass than the two-cut system for each switchgrass-legume binary combination and switchgrass as a monoculture (Table 3.1). This contradicts what was found in Objectives 1 and 2. The regrowth of switchgrass and legume biomass was larger than the initial harvest, which also disagreed with findings from Objectives 1 and 2. The biomass accumulation after first harvest in a two-cut system was greater for a switchgrass-legume combination than for switchgrass alone. This was a result of the legume component supplying a boost from added nitrogen and its own biomass.

Yields in 2001 (Table 3.2) were in stark contrast to those in 2000. The 1-cut system was no longer the clear leader in yield at the Osenbaugh Farm and was noticeably lower in yield at the Lodge Land. Only 3 of the 5 legume treatments (control, alfalfa, and sweetclover) yielded more under the 1-cut system than the 2-cut system. Two-cut system yields for all legume treatments were much greater than 1-cut systems at the Lodge Land. A majority of the 2-cut system yield came from the post-frost harvest on the Osenbaugh Farm while it was the June harvest that accounted for the majority of yield for the same system on the Lodge Land. Overall, yields were much lower in 2001 than 2000.

When considering legume treatments, plots containing birdsfoot trefoil and red clover produced the most biomass in the two-cut systems for both locations and both years. Red clover and sweetclover containing plots produced the most biomass in the one-cut system during 2000 at the Osenbaugh Farm. Plots with alfalfa and birdsfoot trefoil were the largest producers of biomass in 2001 at both locations for the 1-cut system.

Table 3.1 Average Harvest Yields (lb/A) for 2000.

		Osenbaugh Farm		
	Two-Cut System	Two-Cut System	Two-Cut System	One-Cut System
	June Harvest	October Harvest	Total	Total
Alfalfa	2399	3083	5482	7187
Birdsfoot Trefoil	2874	3036	5910	6821
Red Clover	2665	3295	5960	7431
Sweetclover	2522	2842	5364	7671
Control	2664	2799	5463	6985
		Lodge Land		
Alfalfa	1838	-	-	-
Birdsfoot Trefoil	2099	-	-	-
Red Clover	3083	-	-	-
Sweetclover	2660	-	-	-
Control	2170	-	-	-

Table 3.2 Average Harvest Yields (lb/A) for 2001.

		Osenbaugh Farm		
	Two-Cut System	Two-Cut System	Two-Cut System	One-Cut System
	June Harvest	October Harvest	Total	Total
Alfalfa	926	2009	2935	3729
Birdsfoot Trefoil	893	2657	3550	3493
Red Clover	1128	2364	3492	2962
Sweetclover	850	1851	2701	3173
Control	820	1991	2811	3091
		Lodge Land		
Alfalfa	2462	1910	4372	3759
Birdsfoot Trefoil	4056	1678	5733	3944
Red Clover	4010	1800	5810	3590
Sweetclover	2535	1704	4239	3462
Control	2654	1563	4217	3012

Quality

As with the previous objectives, the results from mid-summer and post-frost quality trait analyses (Tables 3.3, 3.4 and 3.5) show the large differences in plant composition between maturity stages and seasons.

Data from the Osenbaugh Farm in 2000 (Table 3.3) show the high quality of forage available for haying or grazing switchgrass and legumes in June. Digestibilities (IVDMD) in the 60% range would provide excellent grazing or feed material. Little difference exists between treatments for any of the quality traits. IVDMD and crude protein (CP) values were slightly lower for the control treatment due to the lack of a legume component. ADF and NDF levels varied little, but NDF was slightly lower for the birdsfoot trefoil (62.84%) and alfalfa (63.16%) treatments than for others.

Quality of the regrowth harvested after frost is much lower than the original growth. IVDMD levels fell to about 30% for all treatments and CP fell to levels between 2.9% and 3.9% with birdsfoot trefoil showing the highest level (3.9%). Ash levels remained fairly constant between harvest times for the 2-cut system with levels ranging from 6.0 to 6.5%. Lignin levels did rise from 2.4-2.7% at the time of first harvest to 4.8-5.4% after frost.

The 1-cut harvest system ash levels were lower than either of the 2-cut system harvests. Levels ranged from only 4.4% to 4.8%. Lignin concentrations were higher for the single cut system than for any 2-cut system harvest. Concentrations ranged from about 5.6% for sweetclover to 6.2% for the birdsfoot trefoil treatments. ADF and NDF levels were fairly constant within the harvest as were CP levels.

Table 3.3 Quality Data for 2000 Harvest (Osenbaugh Farm).

	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
2-Cut System						
Early Season						
Alfalfa	6.46	2.67	32.47	63.16	8.43	60.72
Birdsfoot Trefoil	6.18	2.73	32.40	62.84	8.91	60.19
Red Clover	6.03	2.42	32.46	64.32	8.23	60.11
Sweetclover	6.22	2.55	32.70	64.22	8.85	60.99
Control	6.23	2.69	33.24	64.76	8.02	58.95
Post Frost						
Alfalfa	6.25	5.14	41.00	72.65	3.10	29.58
Birdsfoot Trefoil	6.45	5.41	40.71	72.26	3.92	30.19
Red Clover	6.31	4.59	40.70	73.37	2.92	30.55
Sweetclover	6.24	4.84	41.58	74.14	2.74	29.46
Control	6.02	4.91	40.38	71.96	2.89	30.30
1-Cut System						
Post Frost						
Alfalfa	4.61	6.04	46.11	78.80	1.68	25.79
Birdsfoot Trefoil	4.67	6.21	45.60	77.61	1.79	26.83
Red Clover	4.45	5.97	45.90	78.62	1.69	26.00
Sweetclover	4.79	5.58	44.26	77.03	1.96	26.85
Control	4.76	5.76	44.45	77.10	1.62	26.12

Harvests made in 2001 (Tables 3.4 and 3.5) were similar in some aspects and noticeably different in others when comparing quality data from each location. Digestibility ranged from 50.75% to 57.35% for the first cut of the 2-cut system at the Osenbaugh Farm while at the Lodge Land values ranged only from 45.98% to 53.08%. Crude protein was higher for plots containing alfalfa and birdsfoot trefoil at the Osenbaugh Farm for this same harvest while alfalfa and red clover containing plots had higher levels at the Lodge Land. Ash levels for the initial harvest were around 6% or lower for all treatments at either location. ADF, NDF and lignin varied little within or between locations.

Digestibility and crude protein percentages were slightly higher from Lodge Land plots for the post-frost harvest of the 2-cut system. Ash, ADF, NDF and lignin levels were all similar within and between locations.

All quality factors were similar within and between locations for the 1-cut system.

Table 3.4 Quality Data for 2001 Harvest (Osenbaugh Farm).

	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
2-Cut System						
Early Season						
Alfalfa	5.75	3.40	32.11	62.18	9.54	54.60
Birdsfoot Trefoil	5.95	3.51	30.80	59.71	11.20	57.35
Red Clover	4.98	2.93	32.13	64.94	8.16	55.21
Sweetclover	5.06	3.20	32.48	64.35	8.37	53.30
Control	6.05	3.56	33.17	63.61	8.09	50.75
Post Frost						
Alfalfa	5.82	4.92	41.73	74.03	3.45	27.52
Birdsfoot Trefoil	5.47	5.17	42.00	75.54	3.91	26.41
Red Clover	5.35	4.95	42.27	75.71	3.45	25.84
Sweetclover	5.71	5.14	42.73	75.11	3.53	26.82
Control	5.25	4.97	41.51	74.70	3.35	24.94
1-Cut System						
Post Frost						
Alfalfa	4.62	5.61	43.04	75.99	2.91	22.71
Birdsfoot Trefoil	4.15	6.13	44.59	77.47	2.84	22.50
Red Clover	4.47	5.72	43.64	76.92	2.69	21.83
Sweetclover	4.12	5.98	44.89	78.00	2.90	21.71
Control	4.11	5.90	44.36	77.83	2.45	21.19

Table 3.5 Quality Data for 2001 Harvest (Lodge Land).

	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
2-Cut System						
Early Season						
Alfalfa	5.40	4.08	34.16	60.81	7.35	48.51
Birdsfoot Trefoil	5.56	4.67	34.49	61.57	6.62	49.40
Red Clover	5.95	4.24	33.61	59.00	9.33	53.08
Sweetclover	5.57	3.73	33.24	60.76	6.83	49.74
Control	5.28	3.80	35.62	65.83	6.15	45.98
Post Frost						
Alfalfa	5.52	4.54	40.02	73.09	4.26	29.14
Birdsfoot Trefoil	5.53	4.98	40.11	72.85	4.18	28.05
Red Clover	5.34	5.30	39.59	70.26	4.43	29.17
Sweetclover	5.25	4.88	40.91	73.00	3.81	29.01
Control	5.27	4.74	40.31	73.16	3.81	27.29
1-Cut System						
Post Frost						
Alfalfa	3.88	6.62	44.77	74.91	2.65	22.89
Birdsfoot Trefoil	3.92	7.49	47.04	75.14	2.93	22.66
Red Clover	4.18	7.09	44.73	73.58	3.27	25.15
Sweetclover	4.22	6.08	44.04	75.12	2.47	22.48
Control	4.04	6.52	43.99	73.91	2.85	23.09

Conclusions

Great variability exists in yield from year to year in each legume treatment and cutting system. Variability also exists between locations suggesting that it may not only be difficult to arrive at a single figure to represent average yield but misleading as well. Yield is dependent upon a great deal of variabilities such as soils, fertility, slope, strength of stand and most certainly the weather. What may work well one year for managing switchgrass may not work the next. An important conclusion from this research is that there is a great range of yields into which switchgrass may fall.

Little quality difference exists between treatments that are harvested at any one time within any cutting system. Quality and anti quality traits were all similar.

Objective 4
The effects of fall interseeding legumes into existing stands of switchgrass on subsequent hay and biomass production

Introduction

Switchgrass has proven itself as a tremendous source of high-yielding, high-quality forage in addition to being a potential valuable biofuel source. Managed correctly, switchgrass can provide an ample early and mid-summer supply of forage for haying or grazing. Under proper management conditions switchgrass can recover quickly from mechanical or grazing defoliation and has the ability to produce large amounts of regrowth for subsequent grazing or mechanical harvests. To capitalize on this, it would be possible to utilize switchgrass for two purposes in the same growing season. It could be harvested early by grazing or mechanical means and allowed to regrow, stockpiling this accumulation of biomass for later harvest as biofuel.

Adding a legume component to the switchgrass may be beneficial to its use as either a forage or biofuel. Legumes add nitrogen to the soil for use by switchgrass thus increasing its total yield and quality without applying chemical fertilizers. The legumes themselves can also add to the total biomass available for harvest. The presence of a legume would also increase the quantity of the available forage and the quality by increasing the protein content. Difficulties may arise in the establishment of legumes in existing stands of switchgrass because the seedling legumes may be out competed for light and moisture by the switchgrass. Conversely, following successful establishment, legumes may out compete switchgrass early in the growing season thus gaining such a large advantage in leaf area that they may shade and smother the warm-season grass. Choosing legumes with short life spans and using fall establishment may reduce these difficulties of switchgrass management. Consequently this study looked at the effect of fall interseeding a winter annual and two biennial legumes into existing stands of switchgrass to determine their effect on the following year's early summer yield and quality of switchgrass harvested for hay and subsequent regrowth available for post-frost biofuel harvest.

Materials and Methods

Two locations of existing switchgrass stands were identified early in 1999 to serve as sites for this research. One was located on the Dent Farm near Humeston, Iowa in Wayne County and the second on the Lodge Land near Moravia, Iowa in Appanoose County.

The experiment utilized a split plot design with four replications. Plot treatments included: 1) a control with no legumes, 2) crimson clover seeded at 8 lb/A PLS, 3) hairy vetch seeded at 25 lb/A PLS, and 4) sweetclover seeded at 12 lb/A PLS. Plots, measuring 40 feet by 40 feet with 25-foot alleys were seeded on 18 November 1999 using a Tye no till drill.

Early summer and post frost harvests were performed on 8 June and 28 October 2000, respectively. Strips 3 feet wide by 40 feet long were cut by a walk-behind sickle bar mower, gathered and weighed to determine out-of-field yield. Samples of the switchgrass were taken from the harvested portion to determine the percentage moisture of the harvested grass and to analyze appropriate quality traits in the laboratory. After the early summer harvest, the remaining switchgrass within the split plot was defoliated at the harvest height and removed from the plot to allow regrowth for the post-frost harvest.

Plots located on the Lodge Land were mistakenly combined for seed in 2000 prior to the post-frost biomass yield harvest thus making harvest impossible.

Laboratory quality analyses utilized the following procedures: Percentage ash was determined by igniting 1.5 grams of sample material in a muffle furnace over night at 600 degrees C. ADL (lignin) was determined using 72% sulfuric acid and ashing. NDF and ADF were determined using an ANKOM Fiber Analyzer. Percentage IVDMD was measured by following the NC-64 Marten and Barnes direct acidification system based on the Tilley and Terry *in vitro* method. Crude protein was derived from percentage nitrogen determined by combustion using a LECO CHN-2000.

Results and Discussion

Yield

Weather factors following drilling caused subsequent spring stands to be low in legume content. Adequate moisture and above normal temperatures in November and December caused what was supposed to be a fall dormant planting to germinate and begin growth. When subfreezing temperatures did occur, a high level of mortality was realized because the legumes had not reached a stage of growth that could survive winter and continue development in the spring.

The two-cut systems produced more biomass than one-cut systems for each switchgrass-legume combination and switchgrass grown alone (Table 4.1). This result contrasts with the data from Objective 3 in 2000. However, as with Objectives 1 and 2, location of the experiment made a large difference on yield. The June harvest yields (2-cut system) on the Lodge Land were over 2 times greater than those on the Dent Farm. Once again soil fertility, landscape position thickness of stand and overall vigor likely resulted in the large differences. The regrowth of switchgrass and legumes was larger than the initial harvest yield.

All treatments produced similar yields in each respective harvest system. However, sweetclover produced slightly higher yields in both systems.

Table 4.1 Average Harvest Yield (lb/A) for 2000.

		Dent Farm		
	Two-Cut System	Two-Cut System	Two-Cut System	One-Cut System
	June Harvest	October Harvest	Total	Total
Control	1216	1842	3059	2163
Crimson Clover	1234	1667	2902	2267
Hairy Vetch	1357	1793	3150	2212
Sweetclover	1180	2153	3333	2315
		Lodge Land		
Control	3345	-	-	-
Crimson Clover	3281	-	-	-
Hairy Vetch	2997	-	-	-
Sweetclover	2830	-	-	-

Table 4.2 Quality Data for 2000 Harvest (Dent Farm).

	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
2-Cut System						
Early Season						
Control	8.42	3.16	25.02	43.26	8.05	63.42
Crimson Clover	8.11	3.22	26.40	46.17	7.90	62.40
Hairy Vetch	8.26	3.33	25.70	44.14	7.92	62.59
Sweetclover	8.23	3.29	26.32	46.25	8.16	63.19
Post Frost						
Control	7.41	4.30	38.20	70.32	3.53	30.64
Crimson Clover	8.09	4.20	37.78	69.70	3.54	29.12
Hairy Vetch	8.00	4.32	36.53	67.64	3.73	30.80
Sweetclover	7.51	4.54	38.08	69.20	3.30	29.58
1-Cut System						
Post Frost						
Control	7.25	4.76	41.11	72.02	2.00	29.39
Crimson Clover	7.86	4.55	39.82	70.91	2.38	28.73
Hairy Vetch	7.74	4.76	39.32	69.23	2.43	30.21
Sweetclover	6.85	4.90	41.06	72.21	2.47	29.54

Quality

No large quality difference existed between any legume treatment within any harvest (Table 4.2). Ash content (8+%) was greater for this objective than for any other but it is the only study to occur on this particular farm. Digestibility of early season harvested plots was fairly high for all legume treatments at around 63%. Protein levels were somewhat lower than one might expect but visually legumes made up little of the total mass harvested, thus measured protein is likely just that contained in the grass itself.

Conclusions

Great variability exists in yield from location to location and from year to year. The timing of the initial harvest of a 2-cut system may greatly affect the amount of material available for a post-frost harvest. Weather factors such as temperature and rainfall will likely have a great influence on regrowth as well. Winter and biennial legumes can be seeded in late summer or early fall as well as during the fall dormant period. A risk occurs for successful establishment with any planting time, though.

Because legumes made up such a small proportion of the biomass harvested in this study, one would expect results more like those in Objective 3 with one or more legumes making a significant contribution to nitrogen fixation and biomass itself.

Objective 5
The effects of using corn or sorghum-sudangrass as a cover crop for the establishment of switchgrass for biomass production

Introduction

Switchgrass has the potential to provide abundant forage for grazing, haying or biofuel by accumulating large amounts of growth during the hot summer months when most cool-season forages phase into a period of low production. However, establishment of switchgrass is typically more difficult than establishment of cool-season grasses. Weed competition in young stands can inhibit warm-season grass seedling vigor and establishment, and warm-season grass yields may be low or undetectable during the establishment year without any form of weed control.

Atrazine has been widely and successfully used for weed control during establishment of several warm-season grasses including switchgrass. However, weed control is now more difficult to attain because changes in permanent labeling have led to only temporary Special Local Need applications (provided under Section 24C of FIFRA) of Atrazine on warm-season grasses. These temporary relaxations of labeling laws cannot always be counted on to exist when one wishes to establish switchgrass.

Establishment year stands of switchgrass, even if Atrazine is used for weed control, often do not yield a substantial amount of forage or biomass. In addition, if the grass was seeded into a clean-tilled seedbed, often there is insufficient cover to prevent erosion.

There is a solution that does address the Atrazine weed control, low establishment-year yield and erosion potential problem. That solution is to use an annual warm-season row crop as a cover crop. Species such as corn or sorghum or sorghum-sudangrass hybrids are labeled for Atrazine use, provide a crop of grain, silage, stover or biomass and reduce erosion potential. An added bonus is late season weed control provided by the tall canopy of the cover crop that prevents weed emergence because of shading.

Farmers following recommendations of the Natural Resource Conservation Service have used the concept of corn as a cover crop for numerous years with considerable success. This is also the method used by Iowa State University's Forage Management and Utilization Project to establish stands of warm-season grass for small- and large-scale studies. However, little work has been done using sorghum species as a cover. In addition, yield potentials of the cover crop and expected population densities of the new switchgrass stands are unknown in the Chariton Valley Biomass District using this method. Consequently, this study looked at using corn or sorghum-sudangrass as a cover crop with Atrazine as a means to control weeds and compared it with establishment without using a cover crop.

Materials and Methods

Two locations of newly frost-seeded switchgrass were identified early in 2000 to serve as sites for this research. One was located on the Lodge Land near Moravia, Iowa in Appanoose County and the second on the Sellers Farm near Corydon, Iowa in Wayne County. A new location on the Sellers Farm and a second located northwest of Corydon, also in Wayne County were chosen in 2001.

The experimental design was a randomized complete block with four replications. Treatments included: 1) a control which consisted of a clear seeding without herbicide, 2) a clear seeding with Atrazine, 3) a seeding with corn as a companion and Atrazine as herbicide, and 4) sorghum-sudangrass as a companion with Atrazine as herbicide.

Plots were 50 feet by 50 feet with 25-foot alleyways between blocks. Switchgrass had been frost seeded in late winter. Corn was planted at approximately 20,000 seeds per acre population and sorghum-sudangrass at 12 lb per acre in 30-inch row spacings on 25 April 2000 and 27 April 2001. Bicep II Magnum (Atrazine and Dual mix) was applied at the rate of 2 quarts per acre on 8 May 2000 and 23 May 2001.

Results and Discussion

All plots both years were abandoned and no data were collected. Little, if any, switchgrass could be found in any plot either year. Problems with planter coulters and press wheels in 2000 did not allow uniform, proper placement of companion crops in some plots and this was confounded by below normal precipitation which caused germinated seeds to desiccate in the planter groove resulting in sporadic growth of the companion crop. Planter problems were overcome in 2001 with uniform stands of both companion crops being established. However, not enough switchgrass was present to be a successful stand and no measurements were taken.

Conclusions

The failure to gain a suitable stand of switchgrass is probably a function of two independent establishment variables. The first involves placement of the seed. Numerous sources of testing indicate the preferred method of seeding warm-season grasses should be with a grain drill and that the seed should be placed between ¼ and ½ of in inch below the soil surface. Surface seeding does not allow proper seed-soil contact. Even “frost seeding” does not allow proper placement of the seed in the soil to meet the moisture and fertility requirements for proper germination and early growth of small-seeded switchgrass. Dragging with a harrow or cultipacking with a roller after surface-applying seed would probably help deliver some of the seed to the desired depth but it may also scrape seed from some areas and bury it in others. Seeding rates of five pounds per acre, when using a drill, have proven very successful. With fluctuating seed costs that at times climb to amounts in excess of $10 per pound, planting seed in amounts in excess of what is actually needed for successful establishment may make the economics of this enterprise prohibitive. The amount of money saved by accurately drilling lesser amounts of seed would more than offset the costs incurred by seeding more seed with the less expensive and less accurate broadcasting method.

The second factor is the use of Dual herbicide. Dual is a germination inhibitor that works very well at inhibiting the germination of switchgrass. Even with a safening agent, research has shown the use of Dual drastically reduces the germination and establishment of switchgrass. In fact, Cassida *et. al* found that Dual was toxic to switchgrass with 3 out of 4 Dual rates significantly decreasing switchgrass seeding densities compared to check or atrazine-treated plots. Percentage stand scores made one year after establishment show that plots treated with one-half pound of Dual per acre had only 10.2% of a stand and plots treated with 1 pound per acre had a 6.8% stand. Atrazine only plots when treated with either 1 or 2 pounds of chemical per acre resulted in stand scores of 26.2% and 55.0% respectively. Results of this test suggest Dual should not be used by itself or in combination with any other chemical when establishing switchgrass. It may, however, be very effective as a weed inhibitor in years following switchgrass establishment.

Cassida, K. A., W. R. Ocumpaugh, and W. J. Grichar. Using Herbicides For Improving Establishment Of Switchgrass. Pages 196-200. Procedings/Reports Volume 9 American Forage and Grassland Council. 37th North American Alfalfa Improvement Conference. Madison, Wisconsin. July 16-19, 2000.

Executive Summary

Quality and anti quality factors do not appear to be limiting in any of the studies conducted. As expected switchgrass is quite dynamic in that it can be used as either a forage, a fuel source or both. As a feedstuff, quality is quite high in early summer when switchgrass can be used for grazing or haying. Switchgrass ash content is relatively low regardless of time of harvest and should not pose any expected byproduct problem at combustion.

Ideally, a switchgrass producer would like to have a predictable yield on which to base management and economic decisions. However, results of these objectives for researching cropping systems for biomass production have shown that large variations exist in switchgrass biomass yield from location to location and from year to year. Although the research established a range of yields in which switchgrass is expected to yield, this range is wide and may not be narrow enough to make borderline economic decisions.

Developing systems for site-specific management of switchgrass could help alleviate the problems imposed by large variation in yield. Because yield varies from one soil type to another and from one slope to another as well as by other soil and environmental factors, a system that can consider all these factors in deriving a potential yield would be very important. Once a database of yield based on physical parameters is developed, a much tighter range of yield potential can be realized. A narrower yield range can lead to much better management by the producer and within the Chariton Valley Biomass Project, could lead to a much better system for estimating the number of acres needed to contract to reach biofuel requirements for co-firing. Expanding this system to include cool-season grasses may be beneficial as well if combustion characteristics of these species are acceptable.

Acknowledgement

This paper was prepared with the support of a grant from the Iowa Department of Natural Resources and an award, no. DE-FC36-96GO10148, from the U.S. Department of Energy's Biomass Power for Rural Development Program. However, any opinions, findings, conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the view of the U.S. Department of Energy or the Iowa Department of Natural Resources.

Appendix A
Glossary

Acid Detergent Fiber (ADF): The residue remaining after boiling a forage sample in acid detergent solution. ADF contains cellulose, lignin and silica, but not hemicellulose. Often used to calculate digestibility.

Ash (Total Ash): A measure of the total mineral content; the residue remaining after burning a sample. Values above 10% for grasses or 14% for legumes usually indicate soil contamination of forage.

Crude Protein (CP): This value is 6.25 times the nitrogen content of the forage.

***In Vitro* dry matter digestibility (IVDMD):** Digestibility determined by incubation of a ground forage sample with rumen fluid in a beaker or test tube for 24 to 48 hours, followed by addition of acid and pepsin and further incubation for 24 hours.

Lignin: Indigestible plant component, giving the plant cell wall its strength and water impermeability. Lignin also reduces digestibility.

Neutral Detergent Fiber (NDF): Residue left after boiling a sample in neutral detergent solution. The NDF in forages represents the indigestible and slowly digestible components in plant cell walls (cellulose, hemicellulose, lignin, and ash).

Appendix B
Calendar of Field Activity

1999

April 8—Moore, Brummer, Hartmann and Hintz met with Chariton Valley RC&D personnel Braster and Sellers in Chariton.

April 9—Moore, Hartmann and Hintz established design parameters of proposed cropping systems research activities.

April 10—Hintz designed experiments for Objectives 1 and 2 of Cropping Systems Research.

April 15—Hintz designed experiments for Objectives 3 and 4 of Cropping Systems Research.

April 27—Hintz created field maps with experiment information for all objectives.

May 4—Moore and Hintz seeded legumes for Objective 3 at the Lodge Land and Osenbaugh Farm.

May 31—Moore, Hartmann, Vogel and Hintz toured Objective 3 locations to evaluate success of interseeding.

June 29—Hartmann, Vogel, Dea and Hintz harvested and defoliated Objective 2 plots on the Eddy and Sellers Farms.

July 15—Hintz prepared quarterly progress report.

July 27—Hartmann, Vogel, Dea, J. Carpenter and Hintz harvested and defoliated Objective 2 plots on the Eddy and Sellers Farm.

August 9—Hartmann, Vogel and Hintz toured Objective 3 locations to evaluate and photograph legumes in switchgrass.

September 24—Hintz mowed alleys and borders of Objectives 1 and 2 experiments.

October 20—Guretzky and Hintz performed post-frost harvest of Objectives 1 and 2 on the Sellers Farm.

October 21—Hintz defoliated Objective 1 and 2 plots on the Sellers Farm.

November 9—Hintz processed yield data from Objectives 1 and 2.

November 10—Moore and Hintz met with Braster and Sellers in Centerville to discuss progress of objectives, weather delays and new experiments.

November 11—Hintz staked out Objective 4 plots on the Dent Farm and Lodge Land.
November 18—Hintz drilled winter annuals and biennial legumes for Objective 4 experiments on the Dent Farm and Lodge Land.

2000

January 11—Hintz compiled data and photographs for cropping systems research.

January 26—Moore and Hintz attended Chariton Valley Biomass Project meeting in Des Moines.

February 10—Hintz reviewed and updated new research plans for 2000.

February 17—Hintz prepared "to do" list for activities needed from the Chariton Valley RC&D personnel.

March 6-7—Moore and Hintz prepared "next generation" research proposal for site-specific data collection and evaluation.

March 15—Hartmann and Hintz staked out plots with Sellers for Objectives 1, 2 and 5 on the Sellers Farm and the Lodge Land.

April 25—Hintz planted corn and sorghum-sudangrass plots for Objective 5 on the Sellers Farm and Lodge Land.

May 8—Hintz sprayed herbicide on Objective 5 plots on the Sellers Farm and Lodge Land.

May 16—Hintz mowed borders and alleys of Objectives 1, 2, 3 and 4.

May 26—Moore, Barker, A. Carpenter and Hintz toured Chariton Valley District to survey progress of objectives. Met with Braster for lunch to discuss progress.

June 8—A. Carpenter, J. Carpenter, Bartels, Osterhaus and Hintz harvested plots of Objectives 1, 2, 3, and 4 on the Sellers Farm, Osenbaugh Farm, Dent Farm and Lodge Land.

June 13—Hartmann, A. Carpenter, J. Carpenter, Osterhaus, Bartels and Hintz defoliated plot areas of Objectives 3 and 4 on the Osenbaugh Farm, Dent Farm and Lodge Land.

June 14—Hartmann, A. Carpenter, J. Carpenter, Osterhaus, Bartels and Hintz defoliated plot areas of Objectives 1, 2 and 4 on the Sellers Farm and Lodge Land.

July 11—J. Carpenter, Osterhaus, Bartels and Hintz harvested hay plots for Objective 2 on the Sellers Farm and mowed alleys and borders of Objectives 1, 2, 3 and 4 on the Sellers Farm and Lodge Land.

August 1—Hintz mowed alleys and borders around Objective 3 plots on the Osenbaugh Farm and Lodge Land. Hintz attended evening field day with Practical Farmers of Iowa on Sellers Farm to discuss biomass research.

September 8—Moore and Hintz toured Cropping Systems Research objectives and met with Braster and Sellers in Centerville for lunch to discuss progress.

September 29—Hintz mowed alleys and border of Objectives 1, 2, 3, and 4 at all locations.

October 3—Guretzky and Hintz removed fencing around Objective 1 plots with Sellers on the Sellers Farm to facilitate post-frost harvest.

October 28—A. Carpenter, Braden, Osterhaus and Hintz harvested Objectives 3 and 4 plots on the Osenbaugh Farm, Dent Farm and Lodge Land.

November 4—Hintz harvested post-frost plots of Objectives 1 and 2 on the Sellers Farm.

November 10—Hintz met with Braster and Sellers about potential sites for "next generation" research.

November 15—Hintz and Sellers visited potential location for future research.

2001

April 4—A. Carpenter and Hintz met with Sellers in Millerton to discuss "next generation" research sites.

April 25—Hintz staked out plots for Objective 5 and pulled stakes and flags from Objective 4 locations.

April 27—Hintz planted corn and sorghum-sudangrass in Objective 5 plots.

May 23—Hintz sprayed herbicide on Objective 5 plots.

June 20—White, A. Carpenter and Hintz mowed alleys and borders of Objective 3 plots on the Osenbaugh Farm and Lodge Land.

June 21—Bartels, J. Carpenter, Osterhaus and Hintz harvested and defoliated Objective 3 plots on the Osenbaugh Farm and Lodge Land.

July 20—Fales, Moore and Hintz toured Chariton Valley District and met with Braster in Centerville to discuss activities.

August 6—Bartels, Osterhaus and Hintz mowed alleys and borders of Objective 3 plots on the Osenbaugh Farm and Lodge Land.
September 25—Hintz mowed alleys and borders of Objective 3 plots on the Osenbaugh Farm and Lodge Land.

November 8—A. Carpenter, Guretzky, Braden, Osterhaus and Patrick harvested Objective 3 plots on the Osenbaugh Farm and Lodge Land.

November 29—Moore and Hintz met with Chariton Valley RC&D personnel Braster, Glenn and Sellers in Ames to discuss "next generation" research.

Barker=Dr. David Barker, Visiting Scientist (New Zealand)
Bartels=Julie (Bartels) Wheelock, Iowa State University, Graduate Research Assistant
Braster=Marty Braster, Chariton Valley RC&D, Biomass Project Coordinator
Braden=Indi Braden, Iowa State University, Graduate Research Assistant
A. Carpenter=Alison (Carpenter) Tarr, Iowa State University, Graduate Research Asst.
J. Carpenter=Jenny Carpenter, Iowa State University, Undergraduate Assistant
Dea=Jeremy Dea, Iowa State University, Undergraduate Assistant
Fales=Dr. Steve Fales, Iowa State University, Professor and DEO, Dept. of Agronomy
Guretzky=John Guretzky, Iowa State University, Graduate Research Assistant
Hartmann=Wendy Hartmann, Iowa State University, Graduate Research Assistant
Hintz=Roger Hintz, Iowa State University, Assistant Scientist
Moore=Dr. Ken Moore, Iowa State University, Professor of Agronomy
Osterhaus=Amy Osterhaus, Iowa State University, Undergraduate Assistant
Patrick=Trish Patrick, Iowa State University, Research Associate
Sellers=John Sellers, Chariton Valley RC&D, Biomass Field Activities Manager
Vogel=Eric Vogel, Iowa State University, Graduate Research Assistant
White=Dr. Todd White, Iowa State University, Post-Doctoral Scientist

Appendix C
Field Plot Maps

Objective 1: An existing stand of switchgrass will be used to determine the effect of timing of spring grazing on subsequent biomass production. Grazing treatments will include a control (no grazing), grazing during the vegetative growth period (V2-V3), and grazing during the vegetative and early elongation periods (V2-E2). Stocking rates will be adjusted by put-and-take to remove daily growth during the grazing period. After grazing, biomass will be allowed to accumulate until a killing frost occurs at which time it will be harvested and the yield determined.

Objective 2: An existing stand of switchgrass will be used to determine the effect of timing of haying on subsequent biomass production. Haying treatments will include a control (no hay), harvesting during the late vegetative growth period (V3-V4), and harvesting at boot stage (R0). Regrowth will be allowed to accumulate until a killing frost occurs at which time it will be harvested for biomass and yield determined.

Site: Eddy Farm

Objective 1 Treatments
1. Control (no grazing)
2. Grazing during V2-V3
3. Grazing during V2-E2

Plot Size: 30' x 125'
Exp. Size: 360' x 125'
Design: RCBD

Control (no grazing)	**Plot 101**
Grazing at V2-V3	**Plot 102**
Grazing at V2-E2	**Plot 103**
Control (no grazing)	**Plot 201**
Grazing at V2-V3	**Plot 202**
Grazing at V2-E2	**Plot 203**
Control (no grazing)	**Plot 301**
Grazing at V2-V3	**Plot 302**
Grazing at V2-E2	**Plot 303**
Control (no grazing)	**Plot 401**
Grazing at V2-E2	**Plot 402**
Grazing at V2-V3	**Plot 403**

Objective 2
Treatments:
1. Control (no hay)
2. Haying at V3-V4
3. Haying at R0

Plot Size: 30' x 30'
Exp. Size: 90' x 120'
Design: RCBD

Plot 401 R0	**Plot 301 V3-V4**	**Plot 201 V3-V4**	**Plot 101 V3-V4**
Plot 402 Control	**Plot 302 Control**	**Plot 202 Control**	**Plot 102 R0**
Plot 403 V3-V4	**Plot 303 R0**	**Plot 203 R0**	**Plot 103 Control**

Objective 1: An existing stand of switchgrass will be used to determine the effect of timing of spring grazing on subsequent biomass production. Grazing treatments will include a control (no grazing), grazing during the vegetative growth period (V2-V3), and grazing during the vegetative and early elongation periods (V2-E2). Stocking rates will be adjusted by put-and-take to remove daily growth during the grazing period. After grazing, biomass will be allowed to accumulate until a killing frost occurs at which time it will be harvested and the yield determined.

Objective 2: An existing stand of switchgrass will be used to determine the effect of timing of haying on subsequent biomass production. Haying treatments will include a control (no hay), harvesting during the late vegetative growth period (V3-V4), and harvesting at boot stage (R0). Regrowth will be allowed to accumulate until a killing frost occurs at which time it will be harvested for biomass and yield determined.

Site: Sellers Farm

Objective 1 Treatments
1. Control (no grazing)
2. Grazing during V2-V3
3. Grazing during V2-E2

Plot Size: 30' x 125'
Exp. Size: 360' x 125'
Design: RCBD

Grazing at V2-V3	**Plot 101**
Grazing at V2-E2	**Plot 102**
Control (no grazing)	**Plot 103**
Grazing at V2-E2	**Plot 201**
Grazing at V2-V3	**Plot 202**
Control (no grazing)	**Plot 203**
Grazing at V2-V3	**Plot 301**
Grazing at V2-E2	**Plot 302**
Control (no grazing)	**Plot 303**
Control (no grazing)	**Plot 401**
Grazing at V2-V3	**Plot 402**
Grazing at V2-E2	**Plot 403**

Objective 2
Treatments:
1. Control (no hay)
2. Haying at V3-V4
3. Haying at R0

Plot Size: 30' x 30'
Exp. Size: 90' x 120'
Design: RCBD

Plot 401 **Control**	**Plot 301** **R0**	**Plot 201** **Control**	**Plot 101** **V3-V4**
Plot 402 **V3-V4**	**Plot 302** **V3-V4**	**Plot 202** **V3-V4**	**Plot 102** **Control**
Plot 403 **R0**	**Plot 303** **Control**	**Plot 203** **R0**	**Plot 103** **R0**

Objective 1: An existing stand of switchgrass will be used to determine the effect of timing of spring grazing on subsequent biomass production. Grazing treatments will include a control (no grazing), grazing during the vegetative growth period (V2-V3), and grazing during the vegetative and early elongation periods (V2-E2). Stocking rates will be adjusted by put-and-take to remove daily growth during the grazing period. After grazing, biomass will be allowed to accumulate until a killing frost occurs at which time it will be harvested and the yield determined.

Objective 2: An existing stand of switchgrass will be used to determine the effect of timing of haying on subsequent biomass production. Haying treatments will include a control (no hay), harvesting during the late vegetative growth period (V3-V4), and harvesting at boot stage (R0). Regrowth will be allowed to accumulate until a killing frost occurs at which time it will be harvested for biomass and yield determined.

Site: Sellers Farm

Objective 1 Treatments
1. Control (no grazing)
2. Grazing during V2-V3
3. Grazing during V2-E2

Plot Size: 30' x 125'
Exp. Size: 360' x 125'
Design: RCBD

Grazing at V2-V3	**Plot 101**
Grazing at V2-E2	**Plot 102**
Control (no grazing)	**Plot 103**
Control (no grazing)	**Plot 201**
Grazing at V2-V3	**Plot 202**
Grazing at V2-E2	**Plot 203**
Grazing at V2-V3	**Plot 301**
Grazing at V2-E2	**Plot 302**
Control (no grazing)	**Plot 303**
Grazing at V2-V3	**Plot 401**
Control (no grazing)	**Plot 402**
Grazing at V2-E2	**Plot 403**

Objective 2

Plot 401 **V3-V4**	**Plot 301** **R0**	**Plot 201** **R0**	**Plot 101** **V3-V4**
Plot 402 **R0**	**Plot 302** **V3-V4**	**Plot 202** **V3-V4**	**Plot 102** **R0**
Plot 403 **V3-V4**	**Plot 303** **V3-V4**	**Plot 203** **V3-V4**	**Plot 103** **V3-V4**

Treatments:
1. Control (no hay)
2. Haying at V3-V4
3. Haying at R0

Plot Size: 30' x 30'
Exp. Size: 90' x 120'
Design: RCBD

Objective 3: Four legumes (red clover, birdsfoot trefoil, sweetclover and alfalfa) will be interseeded into an existing stand of switchgrass using a no-till drill in early spring. The stand will be clipped twice early in the season of the establishing year and subsequent biomass production will be harvested following a killing frost. The following year, hay will be made when the switchgrass crop begins to elongate. Yield and quality of first-cutting hay will be determined. Any impacts on nitrogen fertilizer requirements for switchgrass biomass production will also be evaluated.

Site: Lodge Land

Treatments:
1. Control (no legumes)
2. Red Clover @ 8 lb/A
3. BFT @ 5 lb/A
4. Sweetclover @ 12 lb/A
5. Alfalfa @ 12 lb/A

Plot Size: 50' x 50'
Alley Size: 25'
Exp. Size: 250' x 275'
Design: RCBD

North

101 Red Clover	102 Alfalfa	103 Control	104 Sweet-clover	105 BFT

201 Alfalfa	202 Red Clover	203 BFT	204 Sweet-clover	205 Control

301 Red Clover	302 Control	303 Sweet-clover	304 Alfalfa	305 BFT

401 Alfalfa	402 BFT	403 Control	404 Sweet-clover	405 Red Clover

Objective 3: Four legumes (red clover, birdsfoot trefoil, sweetclover and alfalfa) will be interseeded into an existing stand of switchgrass using a no-till drill in early spring. The stand will be clipped twice early in the season of the establishing year and subsequent biomass production will be harvested following a killing frost. The following year, hay will be made when the switchgrass crop begins to elongate. Yield and quality of first-cutting hay will be determined. Any impacts on nitrogen fertilizer requirements for switchgrass biomass production will also be evaluated.

Site: Osenbaugh Farm

Treatments:
1. Control (no legumes)
2. Red Clover @ 8 lb/A
3. BFT @ 5 lb/A
4. Sweetclover @ 12 lb/A
5. Alfalfa @ 12 lb/A

Plot Size: 50' x 50'
Alley Size: 25'
Exp. Size: 250' x 275'
Design: RCBD

North

101 Control	102 Sweet-clover	103 BFT	104 Alfalfa	105 Red Clover

201 BFT	202 Alfalfa	203 Control	204 Sweet-clover	205 Red Clover

301 Control	302 Sweet-clover	303 Alfalfa	304 BFT	305 Red Clover

401 Red Clover	402 Alfalfa	403 Control	404 Sweet-clover	405 BFT

Objective 4: Three legumes (crimson clover, hairy vetch and sweetclover) will be interseeded into an existing stand of switchgrass using a no-till drill in early fall. The stand will be harvested for yield and quality the following year in June and again after frost. Any impacts on nitrogen fertilizer requirements for switchgrass biomass production will be evaluated.

Site: Dent Farm

Treatments:

1. Control (no legumes)
2. Crimson Clover (8 lb/A)
3. Hairy Vetch (25 lb/A)
4. Sweetclover (12 lb/A)

Plot Size: 40' x 40'
Alley Size: 25'
Exp. Size: 160' x 235'
Design: RCBD

North

101 Control	102 Hairy Vetch	103 Crimson Clover	104 Sweet-clover

201 Hairy Vetch	202 Sweet-clover	203 Crimson Clover	204 Control

301 Control	302 Crimson Clover	303 Hairy Vetch	304 Sweet-clover

401 Hairy Vetch	402 Crimson Clover	403 Control	404 Sweet-clover

Objective 4: Three legumes (crimson clover, hairy vetch and sweetclover) will be interseeded into an existing stand of switchgrass using a no-till drill in early fall. The stand will be harvested for yield and quality the following year in June and again after frost. Any impacts on nitrogen fertilizer requirements for switchgrass biomass production will be evaluated.

Site: Lodge Land

Treatments:

1. Control (no legumes)
2. Crimson Clover (8 lb/A)
3. Hairy Vetch (25 lb/A)
4. Sweetclover (12 lb/A)

Plot Size: 40' x 40'
Alley Size: 25'
Exp. Size: 160' x 235'
Design: RCBD

North

101 Control	102 Hairy Vetch	103 Crimson Clover	104 Sweet-clover

201 Sweet-clover	202 Control	203 Crimson Clover	204 Hairy Vetch

301 Crimson Clover	302 Hairy Vetch	303 Sweet-clover	304 Control

401 Control	402 Crimson Clover	403 Sweet-clover	404 Hairy Vetch

Objective 5: New stands of switchgrass will be established using the following techniques: 1) clear seeded with atrazine, 2) clear seeded without herbicide, 3) seeded with corn as a companion crop, and 4) seeded with forage sorghum as a companion crop. Stand counts will be made for switchgrass at 4, 8, and 16 weeks post planting. Biomass and silage yields will be determined for both corn and sorghum companion crops.

Site: Cambria

Treatments:

1. Control (clear seeded w/o herbicide)
2. Clear seeded with atrazine
3. Corn as companion w/ atrazine (24,000 pop.)
4. Sorghum-sudangrass as companion w/ atrazine (20 lb/A)

Plot Size: 40' x 50'
Alley Size: 25'
Exp. Size: 160' x 275'
Design: RCBD

North

101 Atrazine Only	102 Corn	103 Sorghum-sudan	104 Control

201 Corn	202 Sorghum-sudan	203 Control	204 Atrazine

301 Atrazine	302 Control	303 Corn	304 Sorghum-sudan

401 Sorghum-sudan	402 Corn	403 Atrazine	404 Control

Objective 5: New stands of switchgrass will be established using the following techniques: 1) clear seeded with atrazine, 2) clear seeded without herbicide, 3) seeded with corn as a companion crop, and 4) seeded with forage sorghum as a companion crop. Stand counts will be made for switchgrass at 4, 8, and 16 weeks post planting. Biomass and silage yields will be determined for both corn and sorghum companion crops.

Site: Sellers Farm

Treatments:

1. Control (clear seeded w/o herbicide)
2. Clear seeded with atrazine
3. Corn as companion w/ atrazine (24,000 pop.)
4. Sorghum-sudangrass as companion w/ atrazine (20 lb/A)

Plot Size: 40' x 50'
Alley Size: 25'
Exp. Size: 160' x 275'
Design: RCBD

North

101 Sorghum-sudan	102 Control	103 Corn	104 Atrazine

201 Control	202 Atrazine	203 Sorghum-sudan	204 Corn

301 Corn	302 Control	303 Atrazine	304 Sorghum-sudan

401 Control	402 Sorghum-sudan	403 Atrazine	404 Corn

Appendix D
Field and Laboratory Data

Chariton Valley RC&D Switchgrass Research
Objective 1: Effect of timing of grazing
on subsequent biomass production
Harvest date for biomass determination 10-20-99
Sellers Farm

Treatment 1 = Control (no grazing)
Treatment 2 = Grazing V2-V3
Treatment 3 = Grazing V2-E2

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
103	1	6121.26	---	---	---	---	---	---
203	1	6554.89	---	---	---	---	---	---
303	1	6764.00	---	---	---	---	---	---
401	1	8341.21	---	---	---	---	---	---
101	2	4029.93	---	---	---	---	---	---
202	2	4749.91	---	---	---	---	---	---
301	2	4836.01	---	---	---	---	---	---
402	2	4655.26	---	---	---	---	---	---
102	3	4364.57	---	---	---	---	---	---
201	3	4645.07	---	---	---	---	---	---
302	3	4496.73	---	---	---	---	---	---
403	3	4511.90	---	---	---	---	---	---

Year 2
Harvest Date: 11-4-00

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
103	1	4202.17	5.86	5.42	42.59	76.70	3.09	25.01
201	1	3998.63	6.03	5.21	42.37	75.94	3.52	24.56
303	1	3418.83	5.00	5.79	43.55	76.01	2.83	25.58
402	1	3401.67	4.71	7.43	46.50	75.78	3.40	26.80
101	2	1914.03	5.56	5.29	42.18	75.99	4.71	27.18
202	2	2693.13	6.75	5.17	39.74	72.85	5.20	27.90
301	2	1865.48	5.43	5.39	41.35	74.46	4.08	27.41
401	2	1702.13	6.30	5.67	41.29	75.19	4.55	26.60
102	3	1865.30	6.30	5.21	41.15	73.79	4.42	28.18
203	3	1836.86	5.73	5.38	40.79	74.43	4.77	28.11
302	3	2652.10	5.91	5.66	41.88	75.00	4.50	26.93
403	3	2466.20	5.84	5.72	42.24	75.12	4.10	26.66

Chariton Valley RC&D Switchgrass Biomass Research
Objective 2: Effect of timing of haying on subsequent biomass production
Harvest dates for biomass determination 6-29-99, 7-27-99 and 10-20-99.
Sellers Farm Treatment 1 = Control (no graze)
Treatment 2 = Haying at V3-V4
Treatment 3 = Haying at R0

Harvest 6-29-99

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
102	1	0.00	---	---	---	---	---	---
201	1	0.00	---	---	---	---	---	---
303	1	0.00	---	---	---	---	---	---
401	1	0.00	---	---	---	---	---	---
101	2	2926.76	---	---	---	---	---	---
202	2	2947.99	---	---	---	---	---	---
302	2	2878.98	---	---	---	---	---	---
402	2	3250.02	---	---	---	---	---	---
103	3	0.00	---	---	---	---	---	---
203	3	0.00	---	---	---	---	---	---
301	3	0.00	---	---	---	---	---	---
403	3	0.00	---	---	---	---	---	---

Harvest 7-27-99

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
102	1	0.00	---	---	---	---	---	---
201	1	0.00	---	---	---	---	---	---
303	1	0.00	---	---	---	---	---	---
401	1	0.00	---	---	---	---	---	---
101	2	0.00	---	---	---	---	---	---
202	2	0.00	---	---	---	---	---	---
302	2	0.00	---	---	---	---	---	---
402	2	0.00	---	---	---	---	---	---
103	3	2961.81	---	---	---	---	---	---
203	3	5179.42	---	---	---	---	---	---
301	3	4415.59	---	---	---	---	---	---
403	3	5063.02	---	---	---	---	---	---

Harvest 10-20-99

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
102	1	3140.23	---	---	---	---	---	---
201	1	5027.24	---	---	---	---	---	---
303	1	5518.08	---	---	---	---	---	---
401	1	5399.22	---	---	---	---	---	---
101	2	2325.58	---	---	---	---	---	---
202	2	1232.72	---	---	---	---	---	---
302	2	1516.14	---	---	---	---	---	---
402	2	1667.61	---	---	---	---	---	---
103	3	720.08	---	---	---	---	---	---
203	3	939.88	---	---	---	---	---	---
301	3	1003.23	---	---	---	---	---	---
403	3	1032.91	---	---	---	---	---	---

Switchgrass Biomass Research 2000
Harvest dates for biomass determination 6-8-00, 7-11-00 and 11-4-00.
Sellers Farm

Harvest 6-8-2000

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
101	1	---	---	---	---	---	---	---
203	1	---	---	---	---	---	---	---
303	1	---	---	---	---	---	---	---
401	1	---	---	---	---	---	---	---
103	2	1289.04	5.50	2.71	32.91	64.61	6.13	57.56
202	2	1440.62	5.28	2.95	34.23	66.56	5.70	57.69
302	2	1638.94	5.57	2.83	33.28	64.09	6.82	57.99
403	2	924.26	5.99	3.04	32.90	61.42	7.55	61.63
102	3	---	---	---	---	---	---	---
201	3	---	---	---	---	---	---	---
301	3	---	---	---	---	---	---	---
402	3	---	---	---	---	---	---	---

Harvest 7-11-2000

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
101	1	---	---	---	---	---	---	---
203	1	---	---	---	---	---	---	---
303	1	---	---	---	---	---	---	---
401	1	---	---	---	---	---	---	---
103	2	---	---	---	---	---	---	---
202	2	---	---	---	---	---	---	---
302	2	---	---	---	---	---	---	---
403	2	---	---	---	---	---	---	---
102	3	3017.00	4.93	4.04	38.82	69.88	3.72	46.90
201	3	2794.25	4.49	4.39	38.67	69.89	3.70	48.32
301	3	3517.00	4.83	3.87	37.51	69.48	4.03	49.66
402	3	2870.38	4.85	4.33	37.02	67.31	4.18	50.17

Harvest 11-4-2000

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
101	1	2199.30	6.65	5.25	42.35	74.16	4.18	30.73
203	1	3042.60	4.08	6.52	46.85	80.07	1.83	23.67
303	1	2604.11	4.20	7.20	46.79	77.20	2.17	23.52
401	1	2725.57	4.35	6.17	45.21	77.75	2.06	24.28
103	2	1555.13	6.33	4.94	40.77	74.13	3.67	28.67
202	2	1560.15	6.30	5.27	40.51	73.05	3.78	26.02
302	2	1408.56	5.69	5.27	39.43	71.44	6.08	30.18
403	2	1849.21	5.75	7.03	42.92	71.18	5.09	30.61
102	3	1026.73	5.73	5.12	38.74	72.89	6.14	29.61
201	3	1161.38	5.87	5.57	40.31	74.11	6.02	29.39
301	3	1908.71	5.91	5.44	41.35	74.44	4.04	24.76
402	3	1144.55	5.62	5.31	39.13	72.66	6.20	29.02

Chariton Valley Resource Conservation and Development
Switchgrass Biomass Research 2000
Objective 3: Spring Seeded Legumes in Existing Switchgrass

Farm: Osenbaugh
Date: 6-8-2000

Harvest 1 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	2659.28	7.10	2.73	32.55	64.29	7.51	59.75
202	A	1485.62	6.78	2.48	32.16	63.12	7.83	61.10
303	A	2782.74	6.16	2.57	32.97	64.47	7.41	59.75
402	A	2668.67	5.80	2.91	32.21	60.75	8.99	62.27
103	BFT	2640.43	6.59	2.68	32.69	63.92	8.12	58.25
201	BFT	2524.80	6.30	3.13	30.87	58.36	9.26	63.91
304	BFT	2704.05	6.03	2.34	32.42	64.69	8.17	60.11
405	BFT	3626.56	5.81	2.76	33.64	64.40	8.06	58.49
101	C	2499.66	6.05	3.20	34.01	65.67	6.24	55.78
203	C	2597.46	6.48	2.51	33.14	65.13	7.35	59.21
301	C	2733.80	6.31	2.30	31.65	63.73	8.50	61.60
403	C	2827.03	6.06	2.74	34.16	64.50	8.09	59.19
105	RC	2642.85	5.97	2.49	32.25	64.38	7.19	58.41
205	RC	2349.89	6.39	2.44	32.48	64.16	7.18	59.79
305	RC	2855.29	5.83	2.44	33.22	65.20	8.14	60.30
401	RC	2813.35	5.95	2.31	31.89	63.54	8.46	61.95
102	SC	2323.98	6.12	2.88	32.54	64.26	7.59	61.26
204	SC	1798.67	7.10	2.61	33.02	63.54	9.01	59.52
302	SC	2688.10	6.13	2.22	32.83	65.33	8.32	61.66
404	SC	3277.49	5.54	2.49	32.42	63.76	8.43	61.54

Farm: Osenbaugh
Date: 10-28-2000
Harvest 2 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	3027.18	6.73	4.89	40.24	72.68	4.24	29.17
202	A	4087.85	6.28	5.62	41.23	70.18	3.95	31.33
303	A	2653.94	6.36	4.55	41.12	74.19	3.57	28.50
402	A	2564.75	5.61	5.49	41.43	73.57	4.63	29.34
103	BFT	3230.17	6.79	6.11	41.87	72.76	4.95	31.04
201	BFT	3071.50	5.90	6.12	41.48	72.08	5.30	30.48
304	BFT	2507.57	6.80	4.55	39.45	71.38	4.43	30.16
405	BFT	3334.59	6.31	4.84	40.03	72.84	5.01	29.08
101	C	3021.76	6.44	4.60	39.15	71.80	3.34	30.87
203	C	2560.62	6.28	4.83	40.12	70.57	3.64	31.82
301	C	3063.23	5.86	5.42	41.67	72.78	4.24	29.08
403	C	2549.02	5.51	4.81	40.58	72.71	3.94	29.43
105	RC	2997.80	6.44	4.64	40.85	74.10	3.91	29.79
205	RC	3433.91	6.76	4.46	40.35	72.00	3.47	30.61
305	RC	3330.79	6.54	4.49	40.34	73.43	4.34	30.77
401	RC	3419.02	5.49	4.78	41.24	73.94	3.85	31.03
102	SC	2404.00	6.67	4.68	39.97	73.97	3.53	30.06
204	SC	2994.84	6.92	4.53	41.44	72.87	3.74	31.44
302	SC	3400.02	6.50	4.62	40.13	72.69	4.17	27.88
404	SC	2569.17	4.86	5.54	44.80	77.05	3.05	28.47

Farm: Osenbaugh
Date: 10-28-2000
1-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	7064.42	4.56	5.69	45.81	79.55	2.56	25.95
202	A	7219.91	4.40	5.33	44.43	77.64	2.41	25.53
303	A	8048.84	5.12	6.46	47.64	80.24	2.57	23.79
402	A	6414.88	4.36	6.69	46.58	77.75	3.37	27.89
103	BFT	5876.47	4.14	6.92	46.46	77.27	2.68	26.18
201	BFT	4927.51	4.80	6.04	44.55	77.15	3.11	26.92
304	BFT	7525.23	5.58	5.90	45.41	77.61	3.03	26.54
405	BFT	8953.89	4.19	5.96	46.01	78.40	2.41	27.70
101	C	5598.91	4.34	5.21	43.69	77.19	2.24	28.49
203	C	7534.94	4.80	5.48	43.04	75.34	2.51	26.85
301	C	7964.52	4.84	6.09	45.86	78.53	2.71	24.90
403	C	6843.60	5.06	6.24	45.23	77.34	2.93	24.26
105	RC	7179.80	4.66	5.54	45.67	78.41	2.42	24.95
205	RC	5821.55	4.32	6.16	46.28	78.92	2.43	25.05
305	RC	8795.91	4.77	5.82	44.60	77.67	3.30	26.90
401	RC	7928.17	4.03	6.37	47.05	79.49	2.70	27.09
102	SC	7896.57	5.02	5.80	44.33	76.60	2.87	26.11
204	SC	7630.87	4.41	5.85	45.68	78.38	2.43	24.17
302	SC	7337.61	5.13	5.70	44.99	78.02	2.70	26.33
404	SC	7817.81	4.59	4.96	42.05	75.14	3.48	30.80

Farm: Lodge Land

Date: 6-8-2000

Harvest 1 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
102	A	1753.25	5.10	2.89	31.73	62.89	6.10	58.85
201	A	1770.89	5.57	2.68	31.38	61.77	6.73	59.46
304	A	1764.84	6.00	2.98	30.98	59.32	7.62	60.59
401	A	2062.11	5.60	2.65	31.75	62.76	6.08	57.34
105	BFT	1901.01	5.93	3.53	30.72	57.56	8.84	61.32
203	BFT	2084.80	5.54	2.84	30.69	61.14	7.19	58.86
305	BFT	2091.59	6.44	2.78	29.12	57.46	7.96	62.37
402	BFT	2319.30	6.49	2.70	29.79	58.43	6.81	59.82
103	C	1970.04	5.24	2.87	32.68	63.67	6.18	59.09
205	C	1851.12	6.08	2.89	30.83	61.98	6.31	56.74
302	C	2597.02	6.42	2.69	30.99	60.20	7.54	60.71
403	C	2262.88	6.64	2.63	30.46	59.11	7.17	60.24
101	RC	2411.21	5.71	3.03	29.99	56.14	9.53	63.37
202	RC	2328.41	6.17	3.26	28.62	51.01	10.80	64.77
301	RC	3785.80	6.90	3.78	28.70	47.80	12.17	64.68
405	RC	3808.00	7.54	4.20	28.01	42.13	15.14	67.16
104	SC	1680.41	5.64	3.37	31.69	57.72	8.41	61.50
204	SC	2527.55	6.01	4.13	31.49	54.49	10.33	62.13
303	SC	3107.50	6.19	4.38	30.71	52.94	11.19	63.46
404	SC	3322.93	6.13	7.01	34.29	47.03	14.79	61.55

Chariton Valley Resource Conservation and Development
Switchgrass Biomass Research 2001
Farm: Osenbaugh
Date: 6-21-2001

Harvest 1 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	1080.40	5.06	2.98	33.13	66.11	6.17	52.61
202	A	325.42	7.97	4.42	32.12	55.77	9.60	52.72
303	A	1089.09	4.96	2.94	31.84	64.87	11.41	55.97
402	A	1207.85	5.00	3.25	31.36	61.98	10.99	57.11
103	BFT	1554.36	5.80	4.02	29.46	53.30	12.26	61.54
201	BFT	390.24	8.35	3.87	29.13	55.97	12.31	57.32
304	BFT	855.92	4.98	3.01	32.31	65.17	10.29	55.59
405	BFT	772.40	4.65	3.15	32.28	64.41	9.95	54.96
101	C	792.64	5.37	3.29	33.20	64.49	6.52	50.08
203	C	402.98	8.47	3.19	32.04	61.12	6.57	51.89
301	C	1275.22	5.22	3.89	33.51	62.98	9.57	51.35
403	C	807.85	5.15	3.87	33.91	65.85	9.68	49.69
105	RC	980.08	4.75	2.65	31.64	64.84	6.66	56.57
205	RC	1424.55	5.01	3.30	34.34	66.79	5.80	49.86
305	RC	1221.62	5.29	3.07	32.23	65.67	10.58	55.49
401	RC	886.98	4.87	2.70	30.32	62.48	9.61	58.92
102	SC	621.47	5.33	3.04	31.31	61.08	6.80	55.02
204	SC	1012.97	5.23	3.07	32.68	65.74	6.56	51.32
302	SC	864.02	5.23	3.54	33.13	65.32	9.76	53.08
404	SC	901.78	4.45	3.14	32.80	65.27	10.37	53.76

Farm: Osenbaugh
Date: 11-8-01
Harvest 2 of 2-Cut system

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	1297.69	5.25	5.16	43.31	75.40	2.75	26.51
202	A	967.77	6.08	4.96	40.88	72.23	3.12	31.11
303	A	2578.84	6.74	4.53	39.55	72.12	4.24	26.75
402	A	3192.35	5.20	5.02	43.20	76.36	3.70	25.71
103	BFT	2406.74	5.94	5.63	41.36	72.33	4.68	31.50
201	BFT	1638.62	5.50	4.59	40.70	75.60	2.96	25.29
304	BFT	3172.44	5.07	5.29	43.87	78.66	3.71	23.90
405	BFT	3410.74	5.39	5.18	42.08	75.56	4.29	24.95
101	C	1272.71	5.71	4.48	38.42	71.41	2.91	26.11
203	C	1599.09	5.71	4.33	40.10	73.80	2.94	26.09
301	C	2522.37	4.79	5.89	44.70	77.49	3.60	22.94
403	C	2569.95	4.78	5.17	42.84	76.12	3.94	24.60
105	RC	2236.79	5.48	4.76	41.94	75.84	3.29	25.00
205	RC	1354.15	5.70	4.40	39.86	72.34	3.11	28.50
305	RC	3666.86	4.87	5.73	45.61	78.98	4.05	24.32
401	RC	2198.22	5.38	4.89	41.66	75.67	3.35	25.55
102	SC	967.88	5.97	4.48	39.55	71.66	3.22	27.25
204	SC	1629.14	7.45	4.87	43.48	73.37	3.21	31.05
302	SC	1701.88	4.86	5.69	43.43	75.96	4.68	24.87
404	SC	3104.42	4.54	5.50	44.48	79.46	3.01	24.11

Farm: Osenbaugh
Date: 11-8-01
Harvest 1 of 1-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	2741.17	5.28	5.02	41.71	73.91	2.32	25.97
202	A	2665.87	4.72	4.94	41.38	74.87	2.00	23.97
303	A	5137.85	4.80	5.94	43.23	76.23	3.95	21.73
402	A	4370.98	3.68	6.54	45.86	78.94	3.39	19.17
103	BFT	3110.86	3.44	7.18	48.73	80.60	1.75	21.86
201	BFT	3446.08	4.71	5.87	41.99	73.82	3.36	26.50
304	BFT	3694.33	4.96	5.27	41.45	75.38	3.52	21.40
405	BFT	3719.73	3.47	6.19	46.18	80.07	2.75	20.24
101	C	2637.83	3.49	6.20	45.82	80.23	1.43	19.76
203	C	2588.25	4.74	5.16	42.33	76.57	2.43	23.05
301	C	3843.01	3.47	6.87	47.76	79.73	2.11	18.41
403	C	3294.14	4.75	5.39	41.53	74.77	3.84	23.55
105	RC	2209.91	5.17	5.00	42.21	75.56	2.74	22.92
205	RC	3561.51	3.94	5.95	44.30	76.95	1.84	21.28
305	RC	2819.50	3.93	6.56	46.01	78.98	3.11	21.71
401	RC	3256.23	4.86	5.37	42.02	76.20	3.09	21.41
102	SC	2018.08	4.53	5.56	44.16	78.12	2.21	21.94
204	SC	2662.74	4.29	6.75	45.82	77.98	2.31	22.00
302	SC	5064.50	3.72	6.23	46.24	79.62	3.80	20.76
404	SC	2946.22	3.92	5.39	43.35	76.29	3.28	22.15

Farm: Lodge Land
Date: 6-21-2001
Harvest 1 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
102	A	1394.10	4.61	3.11	33.87	65.89	6.28	48.78
201	A	2151.09	5.87	4.31	34.44	60.58	6.70	46.03
304	A	3903.32	6.26	4.88	32.92	52.60	9.40	53.07
401	A	2407.38	4.86	4.02	35.41	64.19	7.00	46.16
105	BFT	5527.19	5.97	4.07	33.93	62.74	7.83	51.08
203	BFT	3868.50	4.78	4.48	35.62	63.72	6.84	49.03
305	BFT	4030.90	5.84	6.38	34.53	56.90	5.93	48.91
402	BFT	2797.56	5.63	3.73	33.86	62.93	5.87	48.58
103	C	1994.80	4.87	3.42	34.41	67.56	6.46	44.79
205	C	2082.60	5.20	3.72	35.82	66.35	5.50	44.17
302	C	4043.27	5.50	3.77	35.41	64.51	6.14	47.52
403	C	2495.33	5.54	4.31	36.82	64.92	6.50	47.44
101	RC	2619.53	4.91	3.86	34.49	63.11	8.05	48.97
202	RC	3720.36	5.61	3.52	32.33	59.45	10.08	56.45
301	RC	4517.88	6.59	4.58	33.26	56.71	9.92	54.05
405	RC	5182.83	6.67	5.01	34.35	56.73	9.29	52.85
104	SC	1648.66	4.60	3.34	34.28	65.36	5.52	49.60
204	SC	2307.21	5.62	3.03	30.94	61.34	7.48	52.97
303	SC	4193.00	5.68	4.11	35.04	61.91	6.48	45.88
404	SC	1992.11	6.39	4.43	32.69	54.43	7.86	50.52

Farm: Lodge Land
Date: 11-08-01
Harvest 2 of 2-Cut system

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	1591.92	5.79	4.08	40.52	74.35	3.47	31.09
202	A	2083.62	5.55	4.29	38.82	72.52	5.28	27.53
303	A	2142.96	5.22	4.59	39.88	72.81	4.29	27.74
402	A	1821.68	5.54	5.19	40.86	72.66	4.00	30.22
103	BFT	1503.25	6.27	3.81	36.76	70.35	3.84	29.99
201	BFT	1392.11	5.58	5.28	39.72	71.03	5.29	30.01
304	BFT	2005.29	5.31	5.19	39.94	72.61	4.57	25.66
405	BFT	1809.35	4.95	5.65	44.03	77.40	3.01	26.55
101	C	1000.27	5.41	3.84	36.79	71.42	4.90	30.56
203	C	1569.47	5.44	4.79	39.47	71.50	3.88	26.77
301	C	2152.38	5.09	4.99	42.87	76.29	3.46	25.75
403	C	1528.88	5.13	5.34	42.10	73.44	3.01	26.08
105	RC	2161.12	5.27	5.42	39.29	69.07	4.12	28.13
205	RC	1532.42	5.36	4.86	41.00	73.64	3.66	27.64
305	RC	2035.02	5.04	6.86	40.76	68.57	5.73	31.87
401	RC	1470.86	5.70	4.05	37.29	69.74	4.20	29.03
102	SC	1970.57	5.50	4.17	39.02	72.05	3.88	29.69
204	SC	1789.49	4.85	4.99	41.92	74.46	3.31	29.35
302	SC	1384.89	5.47	4.90	40.62	72.75	3.97	29.95
404	SC	1669.11	5.19	5.46	42.06	72.72	4.08	27.05

Farm: Lodge Land
Date: 11-8-01
Harvest 1 of 1-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
104	A	2906.90	4.25	6.95	44.37	74.00	3.14	22.97
202	A	4374.42	3.42	6.13	45.26	76.58	2.38	22.37
303	A	4763.94	3.84	6.61	45.24	75.22	2.78	22.54
402	A	2988.91	3.99	6.79	44.23	73.84	2.32	23.68
103	BFT	2592.23	3.92	7.00	45.45	75.31	2.95	23.41
201	BFT	4339.75	3.72	8.67	49.70	74.28	3.07	22.86
304	BFT	2448.93	4.18	6.99	44.99	73.21	2.95	24.29
405	BFT	6393.41	3.88	7.30	48.03	77.76	2.74	20.09
101	C	3135.58	4.08	6.17	42.34	73.24	3.60	23.56
203	C	3345.88	4.44	6.32	42.84	73.40	2.70	23.34
301	C	2286.09	3.77	7.47	46.09	73.58	3.02	24.03
403	C	3279.88	3.87	6.12	44.68	75.41	2.10	21.42
105	RC	3479.45	4.33	6.84	43.51	73.64	3.06	24.58
205	RC	2880.29	4.53	6.19	42.04	72.22	2.55	24.70
305	RC	4203.54	3.98	8.49	47.68	72.69	4.80	29.48
401	RC	3798.22	3.88	6.83	45.68	75.76	2.67	21.82
102	SC	3162.46	4.39	5.54	41.76	74.07	2.75	23.23
204	SC	3543.50	4.21	6.67	46.20	77.74	2.43	20.98
302	SC	2386.33	4.21	5.47	42.24	72.82	2.32	23.78
404	SC	4756.83	4.08	6.66	45.97	75.84	2.38	21.93

Chariton Valley Resource Conservation and Development
Switchgrass Biomass Research 2000
Objective 4: Fall Seeded Legumes in Existing Switchgrass

Farm: Dent
Date: 6-8-2000
Harvest 1 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
101	C	951.76	7.90	2.78	24.28	43.09	7.51	62.55
204	C	1040.57	9.04	3.76	24.08	38.06	8.55	65.24
301	C	1197.66	8.25	3.66	25.44	43.46	8.24	62.93
403	C	1674.80	8.50	2.44	26.27	48.45	7.89	62.94
103	Crim	1046.96	8.07	3.32	24.68	42.30	7.82	62.39
203	Crim	1078.79	8.21	3.35	24.34	42.13	8.48	64.62
302	Crim	1250.72	7.96	3.11	26.83	45.86	8.05	61.17
402	Crim	1560.99	8.20	3.11	29.74	54.38	7.24	61.44
102	HV	1179.75	8.35	3.63	24.09	39.90	7.94	62.75
201	HV	1499.50	7.92	3.21	26.29	47.36	8.21	64.07
303	HV	1186.08	8.07	3.55	26.20	43.69	7.84	61.49
401	HV	1560.90	8.71	2.92	26.20	45.60	7.70	62.04
104	SC	1008.08	8.20	3.16	25.57	43.99	7.95	62.85
202	SC	982.52	8.52	3.47	24.78	42.51	8.32	62.79
304	SC	1072.30	8.26	3.79	26.24	45.98	8.61	63.84
404	SC	1658.21	7.95	2.74	28.68	52.53	7.75	63.29

Farm: Dent
Date: 10-28-2000
Harvest 2 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
101	C	1373.48	8.18	3.74	37.56	69.77	4.35	30.58
204	C	1430.11	7.61	4.75	36.86	66.80	4.98	32.90
301	C	2141.70	6.92	4.35	39.44	73.30	4.44	29.57
403	C	2424.32	6.92	4.36	38.96	71.42	4.03	29.51
103	Crim	1213.93	8.45	3.83	36.73	69.16	4.42	29.13
203	Crim	1644.15	7.90	4.45	39.42	71.25	4.29	28.36
302	Crim	1638.87	7.80	4.78	38.22	68.66	4.91	31.12
402	Crim	2172.16	8.20	3.75	36.76	69.74	4.53	27.85
102	HV	1379.10	7.91	4.30	36.31	66.52	4.48	31.33
201	HV	2405.48	7.99	4.55	37.74	69.56	4.74	27.38
303	HV	1324.33	8.12	4.33	35.39	65.92	4.91	32.44
401	HV	2063.16	7.96	4.09	36.69	68.58	5.19	32.07
104	SC	1458.93	8.04	4.27	36.50	66.27	4.67	31.98
202	SC	2646.67	7.59	4.87	40.26	71.08	3.29	28.64
304	SC	2192.69	7.42	4.27	37.32	70.03	4.66	28.51
404	SC	2312.21	6.97	4.76	38.26	69.41	4.87	29.17

Farm: Dent

Date: 10-28-2000

1-Cut System - Totals

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
101	C	2425.89	7.67	4.44	41.01	72.60	2.69	28.97
204	C	1980.72	6.84	5.33	40.90	70.73	2.57	28.55
301	C	1691.70	7.25	4.78	41.63	72.22	3.21	29.49
403	C	2553.06	7.23	4.47	40.89	72.51	3.11	30.53
103	Crim	2088.46	8.77	4.45	39.06	69.09	3.53	29.22
203	Crim	2105.40	7.84	4.10	38.22	69.80	3.14	28.75
302	Crim	2541.80	7.15	4.65	41.00	73.43	2.78	27.95
402	Crim	2330.67	7.70	5.01	41.00	71.32	3.84	29.01
102	HV	1914.04	7.91	4.76	39.52	69.97	3.26	29.40
201	HV	2239.38	7.39	4.55	40.27	71.51	3.06	31.17
303	HV	2228.64	7.90	4.46	37.90	68.56	3.68	29.73
401	HV	2466.73	7.74	5.29	39.61	66.87	3.23	30.55
104	SC	1492.38	7.09	4.76	40.67	71.75	3.27	30.23
202	SC	1505.80	7.18	4.20	39.33	71.83	4.29	29.55
304	SC	2933.94	6.53	4.72	41.31	73.56	2.74	28.90
404	SC	3327.25	6.59	5.92	42.92	71.71	3.41	29.48

Farm: Lodge Land

Date: 6-8-2000

Harvest 1 of 2-Cut System

Plot #	Trt	lb/A	Ash (%)	Lignin (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)
101	C	1874.29	5.73	2.76	31.74	61.95	6.77	60.08
202	C	4749.53	5.71	2.56	33.89	64.30	6.84	61.82
304	C	3411.65	6.32	2.80	31.96	60.91	6.75	59.19
401	C	---	---	---	---	---	---	---
103	Crim	2998.85	5.48	2.46	32.45	64.29	6.16	59.65
203	Crim	4107.25	5.78	2.63	34.31	65.60	7.04	59.78
301	Crim	2738.20	5.78	2.55	31.42	60.11	6.45	60.95
402	Crim	---	---	---	---	---	---	---
102	HV	3106.34	5.83	2.59	32.01	62.06	7.08	61.66
204	HV	3238.28	6.04	2.45	31.25	60.65	6.80	60.46
302	HV	2645.05	5.75	2.43	31.90	63.53	5.94	60.65
404	HV	---	---	---	---	---	---	---
104	SC	2595.90	5.76	2.29	30.90	62.29	6.67	60.84
201	SC	2837.32	6.87	2.63	32.17	61.46	7.49	62.85
303	SC	3056.93	5.96	2.59	31.39	61.90	6.55	61.36
403	SC	---	---	---	---	---	---	---