NW CROPS & SOILS PROGRAM

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Double Crop System

To Maximize Annual Forage Yield & Quality

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2009 VERMONT DOUBLE CROP SYSTEM TRIAL

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In 2009, the University of Vermont Extension began a two year research project in collaboration with the University of Maine, examining the potential benefits to an environmentally sustainable winter grain, short-season corn double crop production system. Many farmers in both Vermont and Maine have expressed the need for information on alternative forage systems that maximize yield and quality per acre with minimal external inputs. These include systems that minimize weed competition.

TESTING PROCEDURE

The experiment was conducted at Borderview Farm in Alburgh, Vermont. The experimental plot design was randomized split block with four replications. The main plots were three winter grains: barley (var. 'Thoroughbred'), triticale (var 'Trical336'), and wheat (var 'Richland'). The split plot was harvest time of grain in either the boot or soft dough stage followed by organic short season corn (78-80 RM). The plots that were not planted with a winter grain were seeded with a long season organic corn (87 RM) (Table 1). Plot size was 10' x 25'.

WEATHER DATA

Seasonal precipitation and temperature recorded at weather stations in close proximity to the 2009 sites are shown in Table 3. This growing season brought cooler temperatures and higher than normal rainfall patterns across the region. The cooler temperatures and increased precipitation encouraged fungal pathogens and increased weed populations. A severe thunderstorm on June 26 produced quarter sized hail that damaged corn plants.

Table 2. 2009 Temperature, precipitation, and GDD summary

	April	May	June	July	August	September	October
Average Temperature	44.9	53.9	62.8	65.9	67.7	57.7	44.1
Departure from Normal	+1.4	-2.7	-3.0	-5.2	-1.3	-2.7	-4.7
Precipitation	2.89	6.32	5.19	8.07	3.59	4.01	5.18
Departure from Normal	+0.38	+3.39	+1.98	+4.66	-0.26	+0.55	+0.79
Growing Degree Days (32˚)	406	680.5	923.5	1052.5	1107	771	395.5
Departure from Normal	+61.0	-82.1	-90.5	-158.1	-40.0	-81.0	-125.3
Growing Degree Days (50˚)	111.5	209.0	398.0	494.5	557	286	40.5
Departure from Normal	+71.0	-51.4	-76.0	-158.1	-32.0	-26.0	-61.8

Based on National Weather Service data from cooperative observer stations in close proximity to field trials. Historical averages are for 30 years of data (1971-2000)

CULTURAL PRACTICES

The seedbed was prepared by conventional tillage methods. The grain plots were planted on September 19, 2008 with a John Deere 750 grain drill. Prior to boot or soft dough grain harvest, two 24" hoop subsamples were taken from each plot before mowing with a Jeri sickle bar mower. In each of the subsamples weed biomass was measured. The forage harvested from the plot was weighed and a subsamples taken for forage analysis. The forage samples were sent to Cumberland Valley Forage Laboratory in Maryland for forage quality analysis. After the grains were harvested, composted poultry manure was applied to supply 120lbs of N to the acre. The composted manure and plant debris were incorporated with a disc harrow. All corn plots were seeded with a John Deere 1750 corn planter. Weeds were controlled with tine weeding and cultivation. Weed samples were taken using the 24 inch hoop at harvest; weeds were identified, weighed and dried. The corn was hand harvested with machetes. Row sections were harvested and weighed with a small platform scale. A 10 plant subsample was chopped with Troy-Built chipper shredder. After mixing, a subsample of chopped corn was taken and analyzed for forage quality by the Cumberland Valley Forage Laboratory in Maryland. Pertinent trial information is summarized in Tables 3 & 4.

Table 3. General plot management of the IPM trial.

Trial Information	Small Grains	Corn
Location	Alburgh Borderview Farm	Alburgh Borderview Farm
Soil type	Silt loam	Silt loam
Previous Crop	Soybeans	Soybeans
Plot Size (ft.)	10 x 20	10 x 20
Seeding Rate	150 lbs/acre	34,000 seeds/acre
Replicates	4	4
Tillage operation	Fall chisel plow	Spring disk
Tine weeding	-	2x.
Row cultivation	-	1x

Image 1. Spreading chicken manure

Table 4. Double crop planting and harvest dates.

Variety	Harvest	Planting Date	Harvest Date
Richland Wheat	Boot	19-Sep-08	1-Jun-09
Thoroughbred Barley	Boot	19-Sep-08	25-May-09
336 Triticale	Boot	19-Sep-08	25-May-09
Short Season Corn	Boot	2-Jun-09	2-Oct-09
Richland Wheat	Soft Dough	19-Sep-08	2-Jul-09
Thoroughbred Barley	Soft Dough	19-Sep-08	24-Jun-09
336 Triticale	Soft Dough	19-Sep-08	6-Jul-09
Short Season Corn	Soft Dough	6-Jul-09	21-Oct-09
Long Season Corn	Control	20-May-09	2-Oct-09

SILAGE QUALITY

Silage quality was analyzed using Near-Infrared Reflectance (NIR) Spectroscopy at the Cumberland Valley Forage Laboratory in Maryland. Plot samples were dried, ground and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), 30 hour digestible NDF (dNDF), Net Energy Lactation (NEL) and Nonstructural Carbohydrates (NSC). Mixtures of true proteins, composed of amino acids, and nonprotein nitrogen make up the CP content of forages. The CP content of forages is determined by measuring the amount of N and multiplying by 6.25. The bulky characteristics of forage come from fiber. Forage feeding values are negatively associated with fiber since the less digestible portions of plants are contained in the fiber fraction. The detergent fiber analysis system separates forages into two parts: cell contents, which include sugars, starches, proteins, nonprotein nitrogen, fats and other highly digestible compounds; and the less digestible components found in the fiber fraction. The total fiber content of forage is contained in the neutral detergent fiber (NDF). Chemically, this fraction includes cellulose, hemicellulose, and lignin. Because of these chemical components and their association with the bulkiness of feeds, NDF is closely related to feed intake and rumen fill in cows. Recently, forage testing laboratories have begun to evaluate forages for NDF digestibility. Evaluation of forages and other feedstuffs for NDF digestibility is being conducted to aid prediction of feed energy content and animal performance. Research has demonstrated that lactating dairy cows will eat more dry matter and produce more milk when fed forages with optimum NDF digestibility. Forages with increased NDF digestibility will result in higher energy values, and perhaps more importantly, increased forage intakes. Forage NDF digestibility can range from 20 – 80% and is the best indicator for NEL. The NSC or non-fiber carbohydrates (NFC) include starch, sugars and pectin.

LEAST SIGNIFICANT DIFFERENCE (LSD)

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSD's) at the 10% level of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. Grain varieties that were not significantly lower in performance than the highest variety in a particular column are indicated with an asterisk. In the example below variety A is significantly different from variety C but not from variety B. The difference between A and B is equal to 1.5 which is less than the LSD value of 2.0. This means that these treatments did not differ in yield. The difference between A and C is equal to 3.0 which is greater than the LSD value of 2.0. This means that the yields of these treatments were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid.

Treatment	Yield
A	6.0
B	7.5*
C	9.0
LSD	**2.0**

CEREAL GRAIN RESULTS

The adverse winter conditions of 2008, resulted in 50% stand losses in the winter barley plots. Both the wheat and triticale had an average 90% survival rate. The barley and triticale reached the Boot stage on May 25th, while the wheat took an additional week to reach this stage. In the barley plots, the soft dough stage was attained two weeks before the other two grains. The influence of grain species on forage yield and quality was reported in table 5. Triticale had the highest overall average yield of 6595 DM lbs ac^{-1}, while barley had the lowest DM yield 4995 lbs ac^{-1}. This could be attributed to the barley's lower winter survival rate increasing weed pressure and impacting yield. Overall, barley had the highest weed biomass. Forage fiber concentrations and digestibility w as significantly higher in the barley forage then both the wheat and triticale. Wheat had significantly higher CP concentrations. Cereal grains harvested in the soft dough stage yielded significantly higher then the boot stage grains. The soft dough grain also was considerably drier at harvest and theoretically could be mowed and chopped simultaneously. The boot stage forage had higher CP, and lower fiber concentrations. However the soft dough stage produced forage with twice the amount of NSC than boot stage forage.

The soft dough forage had begun to produce grain and hence would have a higher starch content. Ultimatley, a farmer would need to determine farm feed goals to decide what type of forage harvests. The highest yielding was the soft dough 7501 lbs a^{-1} while the boot stage harvest yielded 4502 DM lb ac^{-1} (Table 6). There was a significant difference between cereal grains for all analyses except for the NSC. Overall the triticale and wheat yielded higher than the barley (Tables 7 &8).

Table 5. Overall barley, wheat, and triticale harvest analyses

					Forage Quality Characteristics						
Cereal	DM	DM Yield	Weeds	Weed Biomass	CP	ADF	NDF	dNDF	TDN	NEL	NSC
	%	lbs/acre	%	lbs/acre	%	%	%	%	%	Mcal	%
Barley	26.8	4995	**10.6**	**519***	10.0	**30.4***	**52.8***		**64.8***	**0.67***	19.6
Triticale	30.4	**6595***	2.20	121	10.2	34.0	55.5		62.4	0.64	19.4
Wheat	**32.6***	6415*	1.70	90.0	**11.0***	33.7	54.4		62.0	0.64	**20.0**
Mean	30.0	6002	4.8	243	10.4	32.7	54.2		63.0	0.65	19.7
LSD (0.10)	1.89	711	NS	181	0.49	0.85	0.95		0.65	0.01	NS

* Grain that did not perform significantly lower than the top performing treatment in a particular column is indicated with an asterisk.
NS - None of the varieties were significantly different from one another.

Table 6. Overall boot and soft dough harvest analyses

					Forage Quality Characteristics						
Harvest	DM	DM Yield	Weeds	Weed Biomass	CP	ADF	NDF	dNDF	TDN	NEL	NSC
	%	lbs/acre	%	lbs/acre	%	%	%	%	%	Mcal	%
Boot	20.3	4502	**6.9**	**279**	**12.2**	**33.6**	**55.5**		**63.2**	0.65	14.2
Soft Dough	**39.6**	**7501**	2.8	208	8.6	31.8	53		62.8	0.65	**25.1**
Mean	30	6002	4.8	243	10.4	32.7	54.2		63	0.65	19.7
LSD (0.10)	*	*	*	NS	*	*	*		NS	NS	*

*****Significantly different, NS-No significant difference

Table 7. Boot harvest grain analyses

						Forage Quality Characteristics						
Cereal	Harvest	DM	DM Yield	Weeds	Weed Biomass	CP	ADF	NDF	dNDF	TDN	NEL	NSC
		%	lbs/acre	%	lbs/acre	%	%	%	%	%	Mcal	%
Barley	Boot	21.8	2843	**12.9**	416	11.4	31.4	53.8		**65.3**	**0.68**	*15.9*
Triticale	Boot	19	5107	4.4	242	12.2	34.1	56.1		63.1	0.65	13.6
Wheat	Boot	20.2	5557	3.4	179	**13**	**35.2**	**56.4**		61.3	0.63	13.3
Mean												
LSD (0.10)												

Table 8. Soft dough harvest grain analyses

						Forage Quality Characteristics						
Cereal	Harvest	DM	DM Yield	Weeds	Weed Biomass	CP	ADF	NDF	dNDF	TDN	NEL	NSC
		%	lbs/acre	%	lbs/acre	%	%	%	%	%	Mcal	%
Barley	Soft Dough	31.9	7146	8.4	**623**	8.7	29.4	51.8		64.2	0.66	23.4
Triticale	Soft Dough	41.9	**8083**	0	0	8.3	33.9	54.8		61.7	0.63	25.2
Wheat	Soft Dough	**45**	7272	0	0	8.9	32.1	52.5		62.6	0.65	**26.8**
Mean												

LSD (0.10)	

* Grain that did not perform significantly lower than the top performing treatment in a particular column is indicated with an asterisk.
NS - None of the varieties were significantly different from one another.

CORN RESULTS

Corn emergence was lower than expected. The cool wet weather this growing season most likely contributed to poor emergence in the untreated organic corn seed. The lower corn populations allowed for reduced canopy closure and resulted in increased weed populations. In addition, wet conditions limited mechanical weed control. The primary weeds found; Common lambsquarters, Redroot pigweed, Large crabgrass, Barnyard grass, and Hairy galinsoga. Our data, suggests that later planted corn does grow faster and reaches canopy closure at a faster rate (Table 9).

Image 3. Corn emergence in boot harvested grain plots

Image 4. Weed pressure in the corn plots.

Table 9. Corn planting information

Treatment	Grain	Planting Date	Date Canopy Closure	Days to Closure
Full Season Corn	None	5/20/2009	7/17/2009	58
Corn following Boot stage harvest:	Barley	6/2/2009	7/17/2009	58
	Wheat	6/2/2009	7/17/2009	58
	Tritcale	6/2/2009	7/17/2009	58
Corn following Soft Dough stage harvest:	Barley	6/24/2009	8/13/2009	51
	Wheat	7/6/2009	8/27/2009	52
	Tritcale	7/6/2009	8/27/2009	52

Corn harvested from the barley plots had the highest average yield of with 19.7 tons ac^{-1} at 35% DM, while corn harvested from the triticale plots had the lowest yield, 17.9 tons ac^{-1} at 35% DM. These yields were significantly different. The amounts of crude protein in the corn harvested from the different grain crops were significantly different. Corn sampled from the former wheat plots had a 9.92% CP while corn sampled from the triticale plots had a CP of 9.53% (Table 10). Corn harvested from the boot stage or soft dough stage plots were significantly different in all measurements except for %CP (Table 11). Corn harvested from the boot stage plots yielded higher at 19.9 ton ac^{-1} at 35% DM in contrast to corn harvested from the soft dough stage plots which yielded 18.2 ton ac^{-1}. The nutrition analysis indicates that the corn harvested from the boot stage plots is more digestible than the corn harvested from the soft dough plots. The later harvest date of the soft dough corn plots and earlier killing frost this season may have been a contributing factor. Corn harvest analysis of each of the grains; barley, wheat, and triticale, after boot or soft dough harvest indicate significant differences

in the majority of the measurements and analyses, except for the %CP and the 30 hour dNDF (Table 12 &13). The highest yielding, at 21.6 tons ac^{-1} at 35% DM, was corn harvested from plots seeded after the boot stage wheat. The lowest yielding was corn harvested from plots seeded after soft dough triticale, 17 tons ac^{-1} at 35% DM (Figure 1). We observed Loose smut, *Ustilago zaea*, contaminated cobs in a few of the plots during harvest.

Table 10. Corn harvest analyses following grain

Cereal	DM	Yield @ 35% DM	Weeds	Weed Biomass	Forage Quality Characteristics						
					CP	ADF	NDF	dNDF	TDN	NEL	NSC
	%	t/a	%	kg/ha	%	%	%	%	%	Mcal	%
Barley	**37.7***	**19.7***	2.69	473	9.88*	24.8	41.9		**71.8***	**0.75***	33.5
Triticale	35.0	17.9	**3.49***	**642**	9.53	**26.8***	**43.9***		70.9	0.74	30.3
Wheat	32.9	19.5*	2.92*	579	**9.92***	26.2*	43.5*		70.8	0.73	30.5
Mean	35.2	19.1	3.03	565	9.77	25.9	43.1		71.2	0.74	31.4
LSD (0.10)	1.56	1.39	0.60	NS	0.34	1.29	1.35		0.62	0.01	NS

* Corn that did not perform significantly lower than the top performing hybrid in a particular column is indicated with an asterisk.
NS - None of the varieties were significantly different from one another.

Figure 1. Corn harvest yields

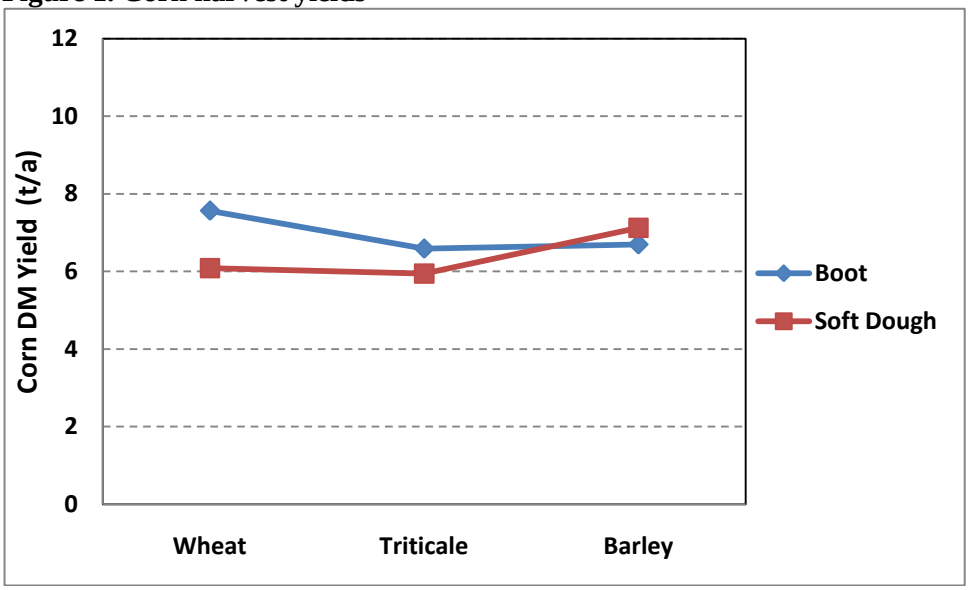


Table 11. Corn harvest analyses following boot or soft dough

Corn Following	DM	Yield @ 35% DM	Weeds	Weed Biomass	Forage Quality Characteristics						
					CP	ADF	NDF	dNDF	TDN	NEL	NSC
	%	t/a	%	kg/ha	%	%	%	%	%	Mcal	%
Boot stage	**37.0**	**19.9**	**3.84**	**697**	**9.85**	23.8	40.2		**72.2**	**0.75**	**34.9**
Soft Dough stage	33.4	18.2	2.23	432	9.70	**28.1**	**46.0**		70.1	0.72	27.9
Mean	35.2	19.1	3.03	565	9.77	25.9	43.1		71.2	0.74	31.4
LSD (0.10)	*	*	*	*	NS	*	*		*	*	*

* Significantly different, NS-No significant difference

Table 12. Corn harvest analyses following boot stage grains

Cereal	Harvest	DM	Yield @ 35% DM	Weeds	Weed Biomass	Forage Quality Characteristics						
						CP	ADF	NDF	dNDF	TDN	NEL	NSC
		%	t/a	%	kg/ha	%	%	%	%	%	Mcal	%
Barley	Boot	36.2	19.1	3.8	611	**10.1**	23.8	40.7		72.2	**0.75**	**35.5**
Triticale	Boot	39.2	18.8	**4.6**	**824**	9.66	23.9	40.2		72.1	**0.75**	34.3
Wheat	Boot	35.6	**21.6**	3.2	656	9.78	23.7	39.7		**72.4**	**0.75**	34.9
Mean												
LSD (0.10)												

Table 13. Corn harvest analyses following soft dough stage grains

Cereal	Harvest	DM	Yield @ 35% DM	Weeds	Weed Biomass	Forage Quality Characteristics						
						CP	ADF	NDF	dNDF	TDN	NEL	NSC
		%	t/a	%	kg/ha	%	%	%	%	%	Mcal	%
Barley	Soft Dough	**39.3**	20.4	1.6	335	9.64	25.8	43.2		71.4	0.74	31.4
Triticale	Soft Dough	30.8	17	2.4	459	9.39	**29.8**	**47.6**		69.6	0.72	26.4
Wheat	Soft Dough	30.3	17.4	2.7	503	**10.1**	28.7	47.4		69.2	0.71	26.1
Mean												
LSD (0.10)												

* Significantly different, NS-No significant difference

Double Cropping Forage System

Our goal was to evaluate cereal grains used as forage system that double crops. The corn combined with the both wheat harvests (boot and soft dough) yielded the highest with 20065 DM lbs ac^{-1}, and corn combined with both barley harvests yielded the lowest at 18816 DM lbs ac^{-1} (Table 14 & Figure 2). The amount of crude protein in the combined corn and wheat harvests was 2027 lbs ac^{-1} compared to the corn and barley harvest CP at 1840 lbs ac^{-1}. Both the yields and crude protein were significant. Harvested short season corn combined with the Soft Dough grains yielded the highest at 20273 DM lbs ac^{-1}, while the corn and boot harvested grains yielded lower at 18402 DM lbs ac^{-1}. The combined corn to grain growth stage harvest was significantly different (Table15). The dry matter yield in lbs ac^{-1}, combining the corn and grain yields from the boot or soft dough growth stage was not significantly different. Not surprisingly the corn and barley boot plots had the highest percentage of weeds, at 6.4% compared to the corn and wheat soft dough plots with 2.4%, these values were significantly different. The amount of CP lbs ac^{-1} was significantly different, corn and wheat harvested from the Boot stage plots yielded 2182 lbs ac^{-1}, while the corn and barley harvested from the boot plots yielded 1681 lbs ac^{-1} (Table 16 &17).

Table 14. Double cropping system harvest yields

Cereal	Total DM yield	Weeds	Forage Quality Characteristics	
			CP	NSC
	lbs/acre	%	lbs/acre	lbs/acre
Barley	18816*	**5.5**	1840	**5712***
Triticale	19130*	4.2	1842	5208*
Wheat	**20065***	3.4	**2027***	5609*

Mean	19337	4.3	1903	5510
LSD (0.10)	1320	NS	121	572

* Corn and grain that did not perform significantly lower than the top performing hybrid in a particular column is indicated with an asterisk.
NS - None of the varieties were significantly different from one another.

Table 15. Combined corn with boot or soft dough grain yields

			Forage Quality Characteristics	
Harvest	Total DM yield	Weeds	CP	NSC
	lbs/acre	%	lbs/acre	lbs/acre
Boot	18402	**5.5**	**1924**	5506
Soft Dough	**20273**	3.2	1882	**5513**
Mean	19337	4.3	1903	5510
LSD (0.10)	*	*	NS	NS

* Significantly different, NS-No significant difference

Table 16. Combined corn and boot harvest yields

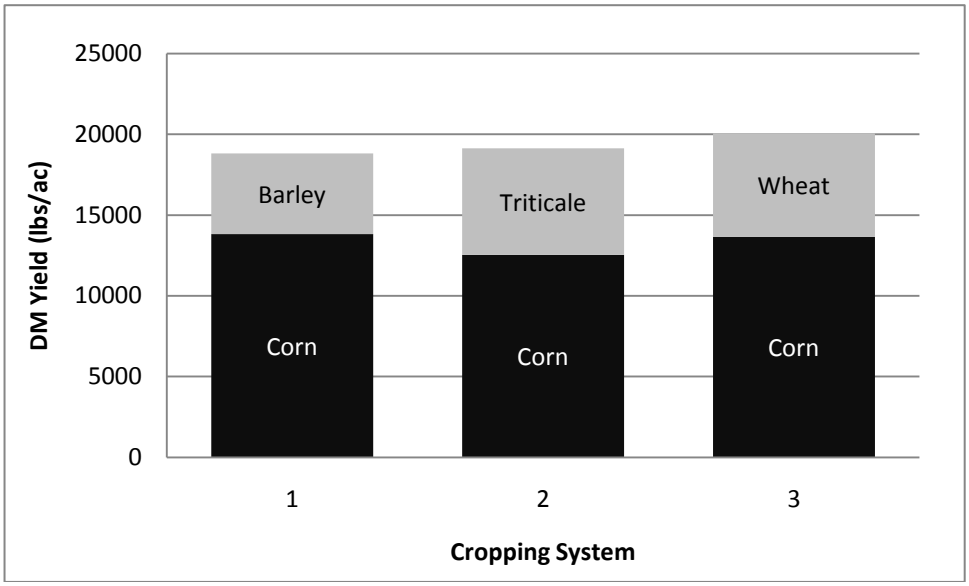
				Forage Quality Characteristics	
Cereal	Harvest	Total DM yield	Weeds	CP	NSC
		lbs/acre	%	lbs/acre	lbs/acre
Barley	Boot	16236	**6.4**	1681	5209
Triticale	Boot	18283	5.9	1908	5241
Wheat	Boot	20687	4.1	**2182**	6069
Mean		19337	4.3	1903	5510
LSD (0.10)		NS	*	*	NS

Table 17. Combined corn and soft dough harvest yields

				Forage Quality Characteristics	
Cereal	Harvest	Total DM yield	Weeds	CP	NSC
		lbs/acre	%	lbs/acre	lbs/acre
Barley	Soft Dough	**21396**	4.6	1998	**6215**
Triticale	Soft Dough	19977	2.4	1776	5175
Wheat	Soft Dough	19444	2.7	1872	5149
Mean		19337	4.3	1903	5510
LSD (0.10)		NS	*	*	NS

* Significantly different, NS-No significant difference

Figure 2. Double cropping harvest yields



DISCUSSION

The cropping system did not greatly impact weed dynamics as much as expected in the short season corn plots compared to the full season corn. The cool, wet growing season likely played a major role in this. Even with the environmental conditions being what they were this summer, the double cropping system resulted in ten dry matter tons ac^{-1} of forage harvested from the wheat followed by short season corn. Winter triticale and wheat both produced excellent quality forage. Winter barley, though it had the lowest yields still produced high quality forage and the corn yields from these plots were the highest, therefore, we will continue to evaluate it next season.

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