**Reducing Fuel and Fertilizer Costs for Corn Silage in the Northeast with Cover Crops and No-Till**

1. **Corn Silage Maturity Trial:**

Corn silage hybrids were evaluated for silage yield performance at the University of Massachusetts Crops Research and Education Center Farm, in South Deerfield, Massachusetts in 2011. Hybrids were grouped in three groups based on relative maturity (RM) provided by the seed companies; Group I, early maturity group (88-94 days), group II mid maturity group (95-100 days), and group III, full season group (101-114 days). In Massachusetts we are encouraging farmers to use shorter season corn hybrids along with earlier planting so when combined can provide the opportunity for early planting of cover crops which maximizes N recovery after corn and fall manure application. Our multi-year research studies have shown that well-established cover crops, planted by September 1 (achieving 1100 GDDs) can accumulate more than 100 lb N per acre.

All hybrids were planted on May 10th. A cone type distributor mounted on a double disc opening corn planter was used in a conventionally prepared seed bed. Plots were planted at the rate of 33,000 seeds per acre in 30 inch rows.

Ten feet of the central rows was harvested by hand at 50% milk line for evaluation of silage yield. Groups I and II hybrids were harvested on September 1st. Group III was harvested on September 9th. Harvested hybrids were evaluated for silage and ear yield, percentage ears, and moisture content. Silage yield was adjusted to 70% moisture and earcorn yield to 25% moisture.

Climate data for the evaluation site is presented in Table 1-1. Overall, the 2011 the corn crop experienced an extremely wet growing season. High rainfall and cloudy conditions during grain growth stages in August reduced yield in all maturity groups especially in short-season and mid maturity corn hybrids. In average corn silage yield were about 30% lower than 2010.

Summary of mean comparison of silage and grain yield, ear %, and grain moisture content for three maturity group hybrids is shown in Table 1-2. Silage and grain yields, as well as ear percentage for all hybrids tested in 2011 are presented in Table 1-3.

**Table 1-1:** Climate data for 2011 in South Deerfield, MA.

 GDD1 Rainfall (inches)

 2011 Norm Deviation 2011 Norm Deviation

May (10-31) 258 185 73 4.06 3.79 0.27

Jun 448 483 - 35 6.58 3.75 2.83

Jul 695 645 50 1.66 3.91 - 2.25

Aug 599 595 4 8.21 4.10 4.11

**Total 2000 1908 92 20.51 15.55 4.96**

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1 Growing Degree Days was calculated as: GDD = Σ(Tmax +Tmin)/2 – 50

**Table 1-2:** Mean comparisons of silage and earcorn yield, and
percent ear, for three maturity group hybrids planted on
May 10th, 2011 and harvested at 50% milk line.
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Maturity Silage1  Earcorn2 Pctear

 T/ac T/ac %

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Group I 24.4 b†  5.6 b 57.9 a

Group II 23.4 b 5.2 b 53.1 c

Group III 28.7 a 6.2 a 54.5 b

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1Silage @70%moisture 2Earcorn @ 25% moisture
† Means with the same letter within each column are not significantly
 different at *P ≤ 0.05*.

**Table 1- 3:** Mean silage and earcorn yields, with earcorn weight as a percent of total
weight at harvest, for each hybrid of the three maturity groups planted on May 10th, 2011.

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**Brand** **Hybrid**  **Maturity Silage**1 **Earcorn**2 **Pct ears**

 **group T/ac T/ac %
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

DEKALB DKC38-89 I 25.4 5.7 57.7

DEKALB DKC40-22 I 22.8 5.4 58.0

TA Seeds TA370-11 I 25.3 5.7 56.5
DEKALB DKC42-72 I 24.5 5.8 59.1

**Mean 24.4 5.6 57.9**

DEKALB DKC46-61 II 24.6 5.2 52.9

Pioneer P98907HR II 24.1 5.0 52.9

DEKALB DKC49-94 II 25.0 5.3 53.6

**Mean 24.6 5.2 53.1**

DEKALB DKC52-59 III 27.1 6.6 60.3
DEKALB DKC53-45 III 26.9 6.3 58.3

Pioneer P0115AM1 III 26.8 6.2 57.8
Pioneer P0216HR III 29.9 6.8 56.7

DEKALB DKC62-54 III 26.6 6.4 55.7

Pioneer P0210HR III 27.9 6.1 54.8

TA Seeds TA545-20 III 28.5 6.2 54.7
TA Seeds TA657-13VP III 31.8 7.0 54.3
Pioneer P0448XR III 30.0 6.5 54.3
DEKALB DKC63-84 III 27.3 5.9 54.0
Pioneer P0125HR III 27.8 5.7 51.8
Pioneer P1498HR III 29.9 6.2 51.2

Pioneer P1018AM1 III 27.1 5.4 50.0
Pioneer P0891AM1 III 30.6 6.0 49.2

**Mean 28.7 6.2 54.5**

**Overall Mean 27.3 5.9 54.9**

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1Silage @70%moisture 2Earcorn @ 25% moisture

Although the results of 2011 study showed that full-season maturity corn hybrids out-yielded shorter-season hybrids, partly due to the exceptional wet condition, our multi-year results indicates that full season-hybrids yielded only about 4% more than shorter-season maturing hybrids (Table 1-4).

**Table 1-4:** Average yields of shorter and full-season
 maturing corn hybrids.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
Year Shorter-season Full-season
 Hybrids Hybrids
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2002 26.0\* (10)¶ 26.6 (19)

2003 30.4 (18) 29.4 (7)

2004 21.8 (11) 22.8 (14)

2005 29.1 (6) 27.9 (12)

2006 30.0 (7) 32.0 (13)
2007 29.6 (14) 30.2 (7)

2008 35.0 (7) 36.4 (10)

2009 23.5 (15) 29.4 (10)

2010 28.6 (10) 30.3 (10)

2011 24.5 (7) 28.7 (14)

**Avg.± 27.6 (105) 28.9 (116)**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\*Ton/acre, ¶Number of hybrids in trial,

±Weighted Average

1. **Grain Corn; Hybrid Yield Evaluation**

Massachusetts has over 1,000 growers producing greenhouse crops in over 17 million square feet of protected growing space (2007 Census of Agriculture). This includes over 16,500,000 sq ft. in bedding plants, flowers and floral greens, foliage plants and potted flowering plants and over 1,200,000 sq ft in vegetable crops. Temperature needs of the crops vary, but often require a night temperature of at least 60 degrees F. Most of Massachusetts’ greenhouses are heated with either fuel oil or liquid propane. A 20,000 sq. ft. greenhouse, heated all winter with a night temperature of 60 degrees F, uses an estimated 3200 gallons of fuel oil or the equivalent. While there are no firm figures on the total fossil fuel used for greenhouse heat in the state, we know that we have the equivalent of at least 800 greenhouses that are 20,000 sq. ft. in size. If only one third of these greenhouses are heated all winter, and two thirds of these greenhouses begin heating in late winter (using one-third the heat energy), our total use of fossil fuels for greenhouse heat is equivalent to more than 1.5 million gallons of fuel oil.

This project focuses on shelled corn, a renewable heat source that can be grown and used in Massachusetts more cheaply than fossil fuels, using available and proven technology. Corn was chosen for this project because, unlike other potential biomass fuel sources, it is an annually renewable fuel source, burns cleanly, requires minimal processing, helps to preserve agricultural land and businesses, and can be produced in quantity locally. At current prices, corn compares very favorably with the standard fossil fuels that are used for greenhouse heat. Changing to energy sources that can be produced locally, travel a short distance from producer to user, and that have a high ratio of energy output to fossil fuel input is key to a viable future for farming in Massachusetts. To that extent, we have partnered with numerous growers across the state that is currently using corn furnaces and boilers as their source of heat for greenhouses. Information is collected on their experience with the corn furnace technology and is shared with a wider circle of interested growers through field days, on-farm meetings, newsletter articles, and the umassvegetable.org website.

The emphasis of this project is on making the best possible use of our land for food and fuel production and not to detract from our ability to grow food crops. We're envisioning a system where fuel crops become a valuable rotational crop in vegetable farms and an alternative revenue stream for dairy farmers, during this time of shrinking demand for silage; not a system in which the production of fuel shifts acreage away from food production.

Corn silage hybrids were evaluated for grain yield performance at the University of Massachusetts Crops Animal Research and Education Farm, in South Deerfield, Massachusetts in 2010 and 2011. Hybrids were placed in three groups based on relative maturity (RM) provided by the seed companies; Group I, shorter season maturity group (85-94 days), group II mid maturity group (95-100 days), and group III, full season group (101-115 days). In 2010 the corn crop experienced hot and dry condition especially in August, which coincides with grain filling stage. The late dry condition had a less negative impact on shorter-season hybrids compared to full-season hybrids. As a result, the shorter-season maturity hybrids, in general, performed better compared to full-season maturity groups. In 2011 corn plants experienced a very wet condition, especially in the month of August which coincides with tasselling, silking, and pollination. While the average grain yield of the three maturity groups was not significantly different, shorter season hybrids had two percent less moisture at harvest. The result of grain yield, grain moisture at harvest, and cob/ear ratio of all hybrids tested in 2010 and 2011 are presented in the tables 2-1, 2-2, and 2-3.

**Table 2-1**: Grain yield, grain moisture at harvest, and cob/ear ratio for three
maturity group hybrids planted on May 6th, 2010 and harvested at
about 20% grain moisture.

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**Brand** **Hybrid**  **Maturity grain grain cob/ear**

 **group Bu/ac\* moisture% %**

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TA Seeds TA290-11 (CB/LL) I 208 18 13

Dairyland ST-9789 (RR) I 208 19 9

Agrisure (NK) N20R-GT I 152 18 13

**Mean 189.3 18.3 11.7**

TA Seeds TA501-161 II 183 21 11

Dairyland ST-3195Q (RR) II 172 20 10

DEKALB DKC 46-07 II 206 20 9
DEKALB DKC 46-6 II 193 21 10

DEKALB DKC 49-94 II 181 21 12

DEKALB DKC 45-52 II 181 19 11

DEKALB DKC 48-37 II 183 20 11

**Mean 185.6 20.3 10.6**

TA Seeds TA788-13 (YGVT3) III 164 23 13

Dairyland ST- 9703Q III 182 20 11

DEKALB DKC 52-59 (VT3) III 162 18 13

DEKALB DKC 54-16 (VT3) III 192 19 10

DEKALB DKC 57-50 (VT3) III 174 24 13

DEKALB DKC 59-64 III 185 21 11

DEKALB DKC 61-69 III 199 21 11

DEKALB DKC 63-42 III 187 23 11

DEKALB DKC 63-84 III 183 21 11

DEKALB DKC 50-35 III 195 17 10

**Mean 182.3 20.7 11.4**

**Overall Mean 185.7 19.8 11.2**

CV (%) 15.2 7.9 8.6

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\*Grain yield was adjusted to 15.5% moisture, 56 lb grain corn in a bushel.

**Table 2-2:** Mean grain yields for three grain corn maturity
group in 2011.

|  |  |  |
| --- | --- | --- |
| Maturity Group | Grain yield (bushel/acre)\*@ 15.5 % moisture | % Moisture at Harvest |
| Shorter-season | 195.7 A | 18.7 C |
| Mid-season | 198.9 A | 19.9 B |
| Full-season | 197.1 A | 20.9 A |

\*56 lb of grain corn in a bushel

**Table 2-3:** Mean grain yields, with harvest moisture percentages as
measured by a Dickey-John moisture meter, separating the three
maturity groups planted on May 10th, 2011.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Brand | Hybrid | Maturity group | Grain\* Bushel/ac | % moisture at Harvest |
| DEKALB | DKC42-72 | I |  238.9  | 18.3 |
| DEKALB | DKC38-89 | I | 184.3  | 19.0 |
| TA Seeds | TA370-11 | I | 182.9  | 19.3 |
| DEKALB | DKC40-22 | I | 176.4 | 18.3 |
| **Mean** |  |  | **195.7** | **18.7** |
| **LSD (0.05)** |  |  | **43.2** | **2.15** |
| DEKALB | DKC46-61 | II | 211.8 | 20.2 |
| Pioneer | P98907HR | II | 198.2 | 20.3 |
| DEKALB | DKC49-94 | II | 186.4 | 19.1 |
| **Mean** |  |  | **198.9** | **19.9** |
| **LSD (0.05)** |  |  | **47.8** | **2.05** |
| TA Seeds | TA545-20 | III | 229.6 | 20.8 |
| Pioneer | P0891AM1 | III | 222.1 | 20.6 |
| DEKALB | DKC52-59 | III | 217.1 | 19.6 |
| Pioneer | P1498HR | III | 215.4 | 22.4 |
| Pioneer | P1018AM1 | III | 212.5 | 21.4 |
| DEKALB | DKC62-54 | III | 209.3 | 22.0 |
| TA Seeds | TA657-13VP | III | 204.3 | 21.8 |
| DEKALB | DKC63-84 | III | 196.4 | 22.0 |
| Pioneer | P0448XR | III | 188.6 | 21.4 |
| Pioneer | P0125HR | III | 183.6 | 20.8 |
| Pioneer | P0115AM1 | III | 179.3 | 19.4 |
| Pioneer | P0216HR | III | 175.4 | 20.2 |
| DEKALB | DKC53-45 | III | 164.3 | 20.4 |
| Pioneer | P0210HR | III | 160.4  | 20.4  |
| **Mean** |  |  | **197.1** | **20.9** |
| **LSD (0.05)** |  |  | **60.4** | **1.44** |

\*Grain @15.5%moisture, 56 lb of grain corn in a bushel.

1. Strategies to Allow Cover Cropping Following Corn Harvest

Cover crops can serve several purposes. The presence of plant material on a field in the autumn can reduce soil losses by eliminating dust if conditions are dry and can eliminate erosion if conditions are wet and the field is not level. Cover crop plants also take nutrients from the soil. This nutrient uptake has two benefits. First, nutrients, nitrate in particular, taken up by the cover crop are made available to future crops as the cover crop breaks down in the soil. Secondly, nitrate leaching is reduced, thus reducing groundwater contamination and excessive biomass growth in ponds and other water bodies into which the nitrate may make its way. On dairy farms, in particular, nitrogen leaching is an autumn/winter problem, because it is generally necessary to spread manure on fields in autumn in order to empty manure storages to leave space for winter-produced manure.

Many farmers would like to grow cover crops after removing the main crops from their fields. One of the difficulties in doing this relates to timing. In order for a cover crop to be effective, it must have time to become established. This means that the primary crop must be removed from the field early enough for a cover crop to be planted and become established.

In the spring of 2010 a study was initiated on a commercial farm in West Millbury, MA to study the feasibility of combining effective cover cropping with growing silage corn.

The first part of the project was the planting of an early maturing hybrid field corn, in addition to the mid-late season hybrid which the farmer would normally have chosen. There is a common belief that the shorter season corn hybrids do not yield as well as the mid- and full-season hybrids. However, results of corn silage hybrid evaluation have shown many shorter-season corn hybrids yield similar to full-season maturity corn hybrids (Table 1-4). Both hybrids were planted in early May, 2010, in a well-manured ten acre field and harvested August 17. Figure 1 shows yield of the two hybrids to be comparable; the shorter-season hybrid in fact outyielded the mid-season hybrid in both silage and ear yield (Table 3-1).

The early harvest of both maturity group corn hybrids allowed early planting of the winter rye cover crop on September 1, 2010. Manure applied to the entire field at the rate of 20 ton per acre following corn silage harvest. The area of the field planted to rye was disked before planting. Corn stubble was left on the rest of the field which was left unplanted for comparison with cover cropped area.

During the fall of 2010 soil from both the cover cropped and bare areas was sampled biweekly to document nitrate concentrations at both the surface 6 inches and the 6-12 inch soil layer beneath. At the same time as soil sampling, cover crop tissue was harvested from one ft square plots in order to assess biomass and nitrogen accumulation. Figure 3-2 shows that nitrate concentration in the soil dropped rapidly as the autumn progressed. Statistical analysis indicated that the nitrate concentration remained higher in the bare soil compared with the cover cropped soil. Figure 3-3 shows biomass increase of cover crop over time, as well as nitrogen accumulation in the plants. In particular, by April 15, 2011, when the soil had begun to warm up, nitrate concentration was higher in the bare soil, just as the rye had begun a growth spurt (Figure 3-3). This suggests that the newly available nitrate from soil denitrification was immediately being taken up by the rye as soon as they released through soil organic matter mineralization.



Figure 3-1. Effect of hybrid choice on yield of silage and ear of two maturity group corn hybrids in 2010.



Figure 3-2 Effect of cover crop on soil nitrate at 0-6 inches and 6-12 inches.

In late April, 2011, the rye was disked, and the entire field received manure at the rate of 20 ton per acre. Same corn hybrid was planted on May 2nd. Pre-sidedress soil nitrate tests (PSNT) taken of 15μg NO3-N.g-1 soil in late June and 8μg NO3-N.g-1 soil in early July 2011 indicated that the crop might benefit from additional nitrogen fertilizer. In general, when soil PSNT is under 25μg NO3-N.g-1 soil, sidedressing with nitrogen fertilizer is recommended. However, when soils have a relatively high organic matter content (consistent with a history of manuring or cover cropping), this may be unnecessary. Both the previously cover cropped and the non-cover cropped soils had low PSNT values ranging from 8 to 20μg NO3-N.g-1 soil, but no additional fertilizer was used. Thus the yield data shown in Figure 3-4 reflect effect of manure applied nitrogen and any influence of one year’s cover crop. Silage yields from both cover cropped and non-cover cropped areas were around 25 tons per acre. Ear yield was close to 6 tons per acre. Ear yield from the cover cropped area was slightly higher. Because the small increase was consistent, it was statistically significant at odds of 1:20, though for practical purposes the yields were the same.

One year of cover croppping saved up to 40 pounds of nitrogen per acre (Figure 3-3). Some amount of nitrogen (considerably less than 40 pounds per acre) will be required for breakdown of the rye cover crop into mineral forms which can be taken up by plants. Over years of cover cropping, the minerals released from previous years’ cover crops will greatly exceed the nitrogen required to break down the cover crop. Thus, increased available nitrogen for the corn silage crop may not be seen for several years after a cover crop is initiated into a cropping system. Cover cropping, however, will benefit the farm even in the very short term by controlling erosion caused by wind or water as soon as the roots are substantial enough to hold the soil in place.



Figure 3-3 Cover crop biomass and nitrogen increase over the season of growth.



Figure 3- 4. Effect of 2010 cover cropping on 2011 corn silage and ear yield.

It is important to note that in order for a cover crop to be effective, it must be planted early enough to produce significant biomass before cold temperatures halt growth. Thus, it is important to plant corn early enough, and to plant a hybrid which matures quickly enough to allow for timely harvest. In most of Massachusetts, cover crop should be planted by the first week in September.

**4- Cultivation with Manure Application Affects Ammonia Volatilization and Corn Silage Yield**

**Rationale:** Nitrogen management of farm fields is becoming increasingly important as the price of nitrogen fertilizer rises and as the negative effects of agricultural volatiles such as ammonia become better recognized. Manure is an important contributor to both nitrogen for crop growth and to ammonia volatilization. The time of manure application and the method of manure incorporation into the soil (or lack of manure incorporation into the soil) will influence both ammonia volatilization and the amount of nitrogen available for uptake by crops. Preliminary research assesses a method of determining ammonia volatilization. This volatilization measure can be useful in assessing differences among tillage methods as they relate to losses of crop-available nitrogen. The ultimate goal of the research is to develop manure application recommendations which will reduce need for purchased nitrogen fertilizer, as well as reduce air pollution.

**Description of the Project:**  In the spring of 2010, a field at the University of Massachusetts Amherst Crops and Animal Research and Education Center (CAREC)in South Deerfield, MA, approximately 100 ft x 200 ft was selected for the experiment. The field did not have a history of manure application.Stubble had been left from corn grown during the previous season. The field was subdivided into three 200 ft long strips, each approximately 30 ft wide.One strip was conventionally disked, one strip was cultivated vertically with an Aerway®to a depth of about 8 inches, and the third strip was left bare. At approximately 8:00 AM on May 27, 2010, liquid manure was spread uniformly at a rate of about 6,000 gallons per acre. Immediately upon the manure truck’s departure, the third strip of the plot was disked. At the same time, 12 ammonia collection units, four for each treatment, were set up in the field to measure ammonia volatilization. A depiction of the unit is shown in Figure 4-1. Each unit remained at its location for one hour, at which time the jar collecting the ammonia was removed for N analysis. Each apparatus was moved to a new location within the plot hourly. This continued for the first 8 hours. After 8 hours, units were placed on the plots in one-hour incrementsfour times for the next three days.The experiment was repeated in 2011 with changes as follows: The plot used in 2011 was more uniform than the one used in 2010. It was on slightly higher ground located approximately 1000 ft northwest of the plot used in 2010. The disk→manure treatment of 2010 was replaced by a No-till→manure treatment for assessment of ammonia volatilization in 2011. (The disk→manure treatment was repeated, however, and corn yields from this method are included in harvest assessments.).In both years corn was planted on the entire plot in early June, several days after manure application. In order to more fully assess the effects of the specified treatments, no additional fertilizer was used on the plots.


Figure 4-1. A depiction of the apparatus used to collect ammonia samples.

Ten foot linear sections of each plot were harvested on September 3, 2010 and September 13, 2011 for yield analysis. To assess silage quality and total yield, ears and stovers were separated. Because corn plants store excess nitrate at the base of the stalk, 8 inch stalk samples were taken from the base to determine the nitrate status of the plants.



Figure 4-2. Effect of preplant soil treatment on ammonia volatilization. Treatments are as follow: A)Manure→disk, B) Aerway→manure, C) Disk→manure, D) No-till→manure

**Results:** Analysis of manure used in 2010 showed 19.1 lb N per 1000 gallons, of which 10.4 lbs was in the form of ammonia. This translates into 62.4 lbs ammonia N per acre. Figure 4-2 shows ammonia loss over the first 8 hours following manure application. It was very clear that the immediate disking-in of the manure reduced loss of nitrogen through volatilization of ammonia. Volatility is increased by many factors including high temperature and wind. The day of application (both in 2010 and 2011) was hot with temperatures in the ammonia collection chamber ranging from 67oF at the time of manure application in 2010 to over 100oF by the 7th and 8th hours of ammonia collection. Afternoon temperatures also reached the low 90’s on days 2 and 3 following the manure application. For all treatments, except Aerway→manure in 2011, the greatest single hour loss of ammonia was during the first hour following manure application.Ammonia loss continued beyond 3 days, but the rate always dropped to less than 0.5 lb N per acre per day. Measured ammonia nitrogen loss was up to about 5 lbs N per acre in the three days following manure application when no post-manure cultivation was used. This was reduced to less than 1 lb per acre if the field was disked immediately. Pre-application cultivating with the Aerway was better than conventional disking or no-till, but was not nearly as effective in preventing N loss as was immediate post-application disking.

Table 4-1 shows yields of corn grown on the three plot sections for the two years. All plots produced acceptable silage yields in 2010 and low yields in 2011. The central area (Aerway section) of the 2010 field had substantial weed pressure which likely led to a reduction in silage yield. Because corn stalks accumulate excess nitrate taken up by the plant, a harvest time corn stalk nitrate test (CSNT) can be a useful tool in assessing whether appropriate nitrogen fertilizer had been applied for the growing season. A result of less than700 indicates that more nitrogen might have increased yield, while a result of over 2000 indicates an excess of nitrogen. The very low CSNT value the 2010 Aerway plot produced may be related to the weed problem.

Table 4-1. Yield characteristics of silage corn as influenced by manure incorporation method.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatment | PSNTz | SilageyTon/ acre | EarcornxTon/ acre | Percent Earby dry weight | CSNTw |
| Manure→Disk→Plant2010 | - |  28.1 Av | 5.9 A | 52.7 A | 1655 A |
| Aerway→Manure→Plant2010 | - | 22.0 B | 4.1 B | 45.9 B | 79 B |
| Disk→Manure→Plant2010 | - | 27.5 A | 5.6 A | 51.2 A | 321 AB |
| Manure→Disk→Plant2011 | 13 A | 21.7 A | 5.2 A | 59.5 A | 2318 A |
| Aerway→Manure→Plant2011 | 6 B | 20.8 A | 4.9 A | 59.1 A | 799 A |
| Disk→Manure→Plant2011 | 6 B | 13.6 B | 3.2 B | 56.8 A | 193 A |
| No-till→Manure→Plant2011 | 4 B | 16.6 AB | 4.0 AB | 58.9 A | 1446 A |

zPSNT: Preside-dress Soil Nitrate Test taken early July ( μg nitrate-N per gram soil).
ySilage yield adjusted to 70 percent moisture
xEarcorn yield adjusted to 25 percent moisture
w CSNT corn stalk nitrate-N concentration at harvest ( μg nitrate-N per gram stalk tissue)
v Values followed by a different letter within a column x year are significantly different from one another at odds of 1:20.

Overall, silage yield and quality were best on the Manure→Disk→Plant treatment. In both years, silage yield and earcorn produced under this treatment were unexcelled. Immediate disking after manure application significantly reduced ammonia loss to the atmosphere and saved nitrogen for uptake by the corn crop.