

Mid-Atlantic Grain and Forage Journal

***A Compilation of
Research and Extension Projects on Corn, Soybean,
Small Grain and Forage Production***



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PREFACE

This is the ninth edition of the *Mid-Atlantic Grain and Forage Journal*, formerly named the *New Jersey Grain and Forage Journal*. The current name reflects the fact that submissions to this journal come from researchers and Extension educators from the Mid-Atlantic region. Articles from New Jersey, Virginia and Maryland are included in this edition.

A goal of this publication is to provide summaries of research, demonstration and outreach activities to farmers and producers, industry personnel, researchers and educators. Other goals are to assist in information sharing across state borders and to increase collaborative efforts in research and extension activities.

I would like to acknowledge and thank Rutgers Cooperative Research and Extension for their on-going support of this project, as well as the following people who served as reviewers for this edition: Richard Taylor, University of Delaware; Greg Roth, Penn State University; and Greg Binford, University of Delaware. Lastly, thank you to the Rutgers-Cook College/NJAES Resource Center for their assistance in publishing this web-based journal.

I hope that these results will be of interest and use to you. Your suggestions are always welcome, as it is our desire to meet your most important needs.

Sincerely,



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Mid-Atlantic Grain and Forage Journal

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Assessment of Equine Industry Hay Selection Criteria in New Jersey and Eastern Pennsylvania

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Research Criteria

The hay market in New Jersey and Pennsylvania continues to increase due to a strong demand for hay for the equine industry. Knowledge of equine hay needs can be a wonderful marketing tool for farmers. Feed manufacturers utilize their expertise on horse nutrition as a marketing strategy, and employ knowledgeable sales representatives to help promote their products. Their knowledge elicits a bond of trust between the horse owner and dealer. Since hay does not have a label or come with sales representatives, horse owners frequently do feel confident in selecting hay. In helping to educate customers about hay quality and production, the farmer can promote the value of feeding quality forage and become a very credible source of information for the horse owner.

In order to successfully produce and market hay to the equine industry, farmers need to know what selection criteria is important to horse owners. A customer profile that includes information on the average farm size and stocking rates, and typical hay purchasing and feeding practices would be beneficial to farmers in planning production and marketing strategies. To properly price hay, producers also need to be aware of local and regional variations in hay price.

Literature Summary

The equine industry in New Jersey and Pennsylvania is an important component of agriculture, and supports thousands of jobs, generates millions of dollars in horse-related expenditures, provides a variety of recreational opportunities, and maintains thousands of acres of open space. According to recent surveys, 49,000 horses exist in New Jersey with a value of \$882 million and 215,693 horses are located in Pennsylvania with a value of \$1.3 billion. In 2001, over \$746 million was spent by horse owners and the racing industry in Pennsylvania. In 1996, New Jersey horse owners spent over \$474 million on their horses. A significant proportion of these expenditures was made for hay and bedding.

Hay is an important component of the equine diet. Research conducted at Purdue University substantiates the fact that horses need long stem forage as part of their diet. Horses need to consume 1.5% to 3.5 % of their body weight each day. According to National Research Council standards, good pasture or hay can supply nearly 100% of an inactive pleasure horse's nutritional needs.

Study Description

To determine what hay selection criteria is most important to consumers, and to document trends and changes in attitudes about hay quality, a survey on hay buying practices was mailed to horse owners in 1999 and 2004. In addition to documenting important selection criteria, the survey was designed to develop a profile of the typical hay consumer in New Jersey and eastern Pennsylvania, and included questions on farm size, stocking rates and pasture availability. In order to help farmers identify county and regional differences in hay prices and to document changes in hay value from 1999 to 2004, the survey also collected data on hay prices on a county basis.

In 1999, the survey was mailed to 730 horse owners in New Jersey and eastern Pennsylvania with over 130 horse owners returning the survey. In 2004, approximately 950 surveys were mailed to horse owners. The survey was also available on line at the Rutgers Cooperative Research and Extension Equine Science Center web site. Over 196 surveys were returned in 2004.

Applied Questions

What are the size, animal density and hay purchasing and feeding practice of the average horse operation in New Jersey and Pennsylvania?

Over 80% of the horse farms in New Jersey and eastern Pennsylvania are small and contain less than 20 horses. Most of the farms are less than ten acres in size and have less than one acre per horse available for grazing. Almost 95% of the horse owners feed hay all year long. Most horse owners buy hay from local farmers. Nearly half of the farm owners can only store hay for six months or less, and an increasing amount of horse owners prefer hay to be delivered. Nearly 43% of horse owners are feeding forage substitutes to their horses.

What hay selection criteria is important to horse owners and farm managers?

The hay of choice for most horse owners is first and second cuttings of timothy. Second cutting orchardgrass, and first and second cuttings of mixed alfalfa/grass hay are also desirable. The most frequently purchased bale size is 40 pound. Horse owners are not interested in feeding hay processed in large round or square bales. Horse owners preferred to purchase hay that had not been treated with preservatives, insecticides or herbicides. Lack of mold is the most important selection criteria to horse owners. Other important criteria are the type of hay, lack of weeds and the reputation of the supplier. The cutting of hay and color of hay was only fairly important to consumers. Both the availability of delivery and price of hay were only fairly important in the 1999 survey but were reported as being very important in 2004.

What local and regional differences in price exist in New Jersey and eastern Pennsylvania?

The 1999 and 2004 surveys documented a significant price increase that occurred over the five year period. The average price of hay increased from \$147.63 per ton to \$171.86 per ton and bale price (converted to 40 pound bales) averaged \$2.93 in 1999 and \$3.43 in 2004. Regional differences were also apparent in the hay prices. County hay prices ranged from a low of \$2.82 for a 40 pound bale in rural Warren County to an average price of \$4.29 in Monmouth County, New Jersey. Monmouth County ranks #1 in the number and value of horses in the state.

Recommendations

In order to maximize market opportunities, hay producers need to develop and foster good customer relations with the horse owners, and take into consideration the following key strategies:

- Produce the type of hay most preferred by the horse industry. Timothy still ranks first within the equine community, with alfalfa/grass mixes and second cuttings of orchardgrass also being popular.
- Keep bale size small, approximately 40 pounds.
- Do not sell customers moldy hay. Mold is very detrimental to equine health, and a major concern to 96-97% of the horse owners surveyed.
- Attempt to eliminate weeds in hay, especially toxic weeds.

- Since many horse owners are unsure about the use of herbicides and insecticides in hay, take time to educate horse owners about crop protectant materials when necessary.
- Hay producers should not underestimate the value of their hay, and should analyze the hay market in the area they are willing to serve. Remember that the hay price, although very important to the end user, is not the most important selection criteria.
- Most horse owners cannot store more than a six month supply of hay, therefore the ability to store hay for your customers is important. The ability to deliver hay is important to many equine operations.
- Regional differences in hay prices exist, especially in areas of New Jersey that contain large numbers of horses and very few crop farms. These regions provide very good markets for farmers that can deliver hay.
- Over 60% of the horse owners prefer to purchase hay directly from local farmers. This provides a ready market for local hay producers.
- Although large (greater than 800 pound bales) are convenient to producers, they are not marketable to the average horse owners. Over 80% will not purchase large bales.
- Although heat drying hay may greatly enhance quality, the price of drying hay needs to be considered. Horse owners report that they are not interested in heat dried hay if it costs more than \$.50 extra per bale.
- Since 47% of horse owners reported that they feed forage substitutes, a market may exist for locally produced hay cubes or other forage products.
- Do not ever sell good customers questionable hay. Poor quality hay can be dangerous to horses and equally detrimental to good customer relations
- Find and cultivate good customers, and educate them about your hay program. Producers' reputation goes a long way in keeping satisfied and repeat customers.

Assessment of Equine Industry Hay Selection Criteria in New Jersey and Eastern Pennsylvania

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Introduction

The Hay Market in New Jersey and Eastern Pennsylvania

The hay market in New Jersey and Pennsylvania continues to increase due to a strong demand for hay for the equine industry. The equine industry in New Jersey and Pennsylvania is an important component of agriculture in both states. The industry supports thousands of jobs, generates millions of dollars in horse-related expenditures, provides a variety of recreational opportunities, and maintains thousands of acres of open space. The 1996 New Jersey Equine Industry Profile revealed there are over 49,000 horses valued at over \$682 million in New Jersey. A similar study conducted in Pennsylvania, in 2002, indicates that 215,693 horses are located in Pennsylvania with a net value of \$1.3 billion.

Horse owners spend a great deal of money on their horses. In 2001, over \$746 million in horse-related expenditures was made by horse owners and the race horse industry in Pennsylvania. In 1996, New Jersey horse owners and farm managers spent over \$474 million on their horses. A significant proportion of these expenditures were made for hay and bedding in both states. The 2001 equine industry survey revealed Pennsylvania horse owners spend over \$41 million on hay for their horses each year. According to the 1996 survey conducted in New Jersey, horse owners in New Jersey spend an average of \$41 million for hay and bedding combined. The strength of the equine industry and prospect for future growth indicates that a strong market for hay production will continue.

Equine Forage Needs

Hay is an extremely important component of the equine diet.

- Horses are grazing animals. They have 100 feet of intestine designed to continuously digest fiber. Colic, which manifests itself as pain associated with a variety of digestive disorders, is the #1 killer of horses and a major concern to horse owners.
- Research conducted at Purdue University substantiates the fact that horses need long stem forage as part of their diet. Feeding a complete feed that consists of less than one inch particle size, without providing access to pasture or hay, can contribute to digestive problems.
- Horses need to consume 1.5 to 3.5 % of their body weight each day (a 1000 pound horse needs to consume 15 to 30 pounds of feed on a dry matter basis). Good hay or pasture can supply nearly 100% of an inactive pleasure horse's nutritional needs.
- Horses crave fiber in their diets. If they don't receive enough hay and pasture they will find other sources of fiber – board fences, trees, barns etc.
- Some horses may colic and founder on high carbohydrate, low-fiber diets. Rapidly growing grasses in spring and fall can be too high in carbohydrate and low in effective fiber. Feeding hay at these times, even if the pasture is good, may reduce digestive problems.

- A pleasure horse requires only 8 to 10% protein in the diet. Lactating mares, rapidly growing foals, and horses in heavy training may require protein levels up to 14.5%. Grain rations are sold based on percent protein. Horse owners focus on, and understand protein levels (Table 1).

Table 1. Nutrient Concentrations in Total Diets for Horses and Ponies (dry matter basis)

	Digestible Energy ^a		Diet Proportions		Crude Protein (%)	Lysine (%)	Calcium (%)	Phosphorus (%)	Magnesium (%)	Potassium (%)	Vitamin A	
			Conc. (%)	Hay (%)							(IU/kg)	(IU/kg)
	(Mcal/kg)	(Mcal/kg)										
<i>Mature horses</i>												
Maintenance	2.00	0.90	0	100	8.0	0.28	0.24	0.17	0.09	0.30	1830	830
Stallions	2.40	1.10	30	70	9.6	0.34	0.29	0.21	0.11	0.36	2640	1200
<i>Pregnant mares</i>												
9 months	2.25	1.00	20	80	10.0	0.35	0.43	0.32	0.10	0.35	3710	1680
10 months	2.25	1.00	20	80	10.0	0.35	0.43	0.32	0.10	0.36	3650	1660
11 months	2.40	1.10	30	70	10.6	0.37	0.45	0.34	0.11	0.38	3650	1370
<i>Lactating mares</i>												
Foaling to 3 mo	2.60	1.20	50	50	13.2	0.46	0.52	0.34	0.10	0.42	2750	1250
3 mo to weaning	2.45	1.15	35	65	11.0	0.37	0.36	0.22	0.09	0.33	3020	1370
<i>Working horses</i>												
Light work	2.45	1.15	35	65	9.8	0.35	0.30	0.22	0.11	0.37	2690	1220
Moderate work	2.65	1.20	50	50	10.4	0.37	0.31	0.23	0.12	0.39	2420	1100
Intense work	2.85	1.30	65	35	11.4	0.40	0.35	0.25	0.13	0.43	1950	890
<i>Growing horses</i>												
Weanling, 4 mo	2.90	1.40	70	30	14.5	0.60	0.68	0.38	0.08	0.30	1580	720
Weanling, 6 mo												
Moderate growth	2.90	1.40	70	30	14.5	0.61	0.56	0.31	0.08	0.30	1870	850
Rapid growth	2.90	1.40	70	30	14.5	0.61	0.61	0.34	0.08	0.30	1630	740
<i>Yearling, 12 mo</i>												
Moderate growth	2.80	1.30	60	40	12.6	0.53	0.43	0.24	0.08	0.30	2160	980
Rapid growth	2.80	1.30	60	40	12.6	0.53	0.45	0.25	0.08	0.30	1920	870
<i>Long yearling, 18 mo</i>												
Not in training	2.50	1.15	45	55	11.3	0.48	0.34	0.19	0.08	0.30	2270	1030
In training	2.65	1.20	50	50	12.0	0.50	0.36	0.20	0.09	0.30	1800	820
<i>Two year old, 24 mo</i>												
Not in training	2.45	1.15	35	65	10.4	0.42	0.31	0.17	0.09	0.30	2640	1200
In training	2.65	1.20	50	50	11.3	0.45	0.34	0.20	0.10	0.32	2040	930

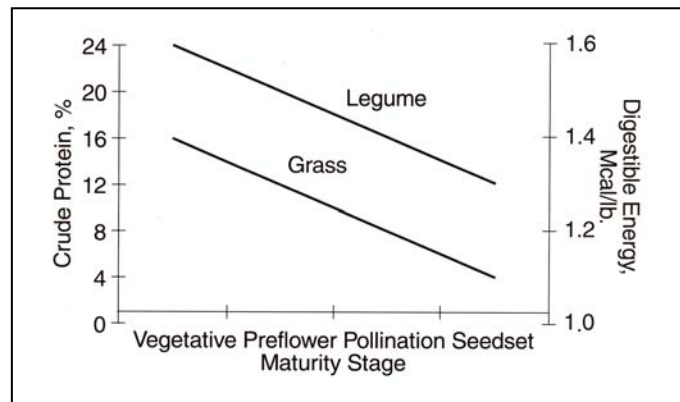
Nutrient Requirements of Horses, 1989

- Most species of hay are suitable for horses. First cutting grass hay (timothy, orchardgrass, or brome grass), provides adequate nutrition for most pleasure horses. Orchardgrass matures earlier than timothy and brome grass and quickly loses quality and palatability when cut late. When possible, hay

should be harvested at the late boot/early head stage to balance quality and yield. Timothy hay should be cut in the early head stage, orchardgrass in the boot to early head stage, and brome grass in the early to medium head. After these stages, the grasses start to increase levels of lignin and cellulose, which horses cannot digest. Protein levels and energy content of the hay drops and the quality of the hay rapidly deteriorates as the forage matures.

- Horses that have difficulty maintaining their weight, growing horses, older horses, and horses in heavy training may need a second cutting grass hay that is higher in protein and subsequently higher in energy. This type of hay is more readily digestible and therefore a better economic value.

Figure 1. Maturity Effects on the Crude Protein and Digestible Energy of Legume and Grass Hays



Source: *Horse Industry Handbook*

- Alfalfa/grass mixed hay is ideal horse hay. If the hay is cut later than desired, the alfalfa component helps to maintain quality.
- Pure alfalfa can be much higher in protein than a horse typically needs. In addition the calcium to phosphorous ratio in a horse's diet should be about 2:1. Alfalfa may exceed a calcium/phosphorous ratio of 6:1. Extra phosphorous may be needed as a supplement in the diets of growing foals receiving alfalfa hay.
- Hay containing weeds and mold is not acceptable for horses! Toxic weeds retain their toxic properties when dry in hay.

Challenges in Producing and Marketing Hay to the Equine Industry

Most farmers agree that horse owners can be an extremely "interesting" and challenging group of consumers. Individual horses, in both Pennsylvania and New Jersey, can have an extremely high economic value. In almost all cases whether the horses are Olympic caliber or backyard pets, there is often a strong emotional bond between the owner and the animal. Many owners are fastidious about the care that they provide.

Horse owners can be very opinionated about the type of hay that they feed their horses. In some instances, the type of hay preferred is based on solid evidence that a certain type of hay best fits overall farm management practices. In many cases, a desire for only one type and cutting of hay stems from a lack of knowledge about hay species, production, and quality. Many horse owners do not have agricultural backgrounds and do not understand how hay is produced. Some horse owners may not really know what kind of hay will best meet their horse's nutritional needs.

Knowledge of equine hay needs can be a wonderful marketing tool for farmers. Feed manufacturers utilize their expertise on horse nutrition as a marketing strategy. These companies employ knowledgeable sales representatives to help promote their products. Their knowledge elicits a bond of trust between the dealer and the horse owner. Farmers can use their knowledge about equine hay needs in much the same way. Horse owners frequently do not feel comfortable buying hay. Hay doesn't have a label or come with a sales representative. Farmers should use their knowledge to promote the value of feeding quality hay as part of the farm's nutritional program. By helping to educate customers about hay production and quality, farmers gain credibility in much the same way as the feed representatives. In order to successfully produce and market hay to the equine industry, farmers need to know what selection criteria is important to horse owners. To properly price their hay, producers also need to be aware of local and regional variations in hay prices. The objectives of this study were:

1. To determine what hay selection criteria is most important to consumers.
2. To document trends and changes in attitudes about hay quality.
3. To develop a profile of the typical hay consumer in New Jersey and eastern Pennsylvania.

Materials and Methods

A survey on hay buying practices was mailed to horse owners in 1999 and 2004 to document important hay selection criteria. The survey also included questions on farm size, stocking rates, and pasture availability to help develop a profile of the typical hay consumer in the region. In order to help farmers identify county and regional differences in hay price and to document changes in hay value from 1999 to 2004, the survey also collected data on hay prices on a county basis.

In 1999, the survey was mailed to 730 horse owners in New Jersey and eastern Pennsylvania with over 130 horse owners returning the survey. In 2004, approximately 950 surveys were mailed to horse owners. The survey was also available on line at the Rutgers Cooperative Research and Extension Equine Science Center web site. Over 196 surveys were returned in 2004.

Results and Discussion

Customer Profile

Although a large number of horse farms exist in New Jersey and eastern Pennsylvania, the majority of horse farms are fairly small. Approximately 40% of the horse owners that responded to the survey had less than six horses on their farms. Another 40% of the farms were 6-20 horse operations. Less than 10% of the horse owners that responded to the survey manage more than 50 horses (Table 2).

Table 2. Number of horses on the farm

	1999	2004
1-5	38%	37%
6-10	19%	27%
11-20	20%	15%
21-50	14%	15%
Over 50	9%	7%

The amount of hay purchased by each farm also mirrors the small nature of the equine operations, with 50% of the respondents in 1999, and 60% of the respondents in 2004, revealing that they used less than 1,000 bales each year (Tables 3 and 4).

Tables 3 and 4. Volume of hay used per year, expressed as tons (Table 3) or bales (Table 4).

Tons	1999	2004
Less than 1	0	0
1-4.9	18%	0
5-9.9	6%	15%
10-19.9	12%	15%
20-49.9	15%	18%
50-100	24%	26%
Over 100	26%	26%

Bales	1999	2004
1-99	0	5%
100-499	24%	27%
500-999	26%	28%
1,000-1,999	24%	17%
2,000-4,999	20%	16%
5,000-9,999	8%	4%
10,000-15,000	2%	1%
Over 15,000	0	2%

The majority of the survey respondents reported that they relied on nutrition from pasture forages as part of their nutrition program (69% in 1999; 51% in 2004). However, most of the horse owners managed farms that were less than ten acres in size (52% in 1999; 58% in 2004). In 2004, 60% of the horse owners reported that they had one acre or less of pasture available per horse, indicating that pastures alone could not meet the horses' nutritional needs. The vast majority of survey respondents (95% in 1999; 91% in 2004) reported that they feed hay all year (Tables 5, 6, 7 and 8).

Table 5. Reliance on nutrition from pasture forages as part of the feeding program

	1999	2004
Yes	69%	51%
No	29%	23%
Partially	2%	25%
Number of responses	130	190

Table 6. Acres of pasture or turn-out

	1999	2004
<1 acre	2%	2%
1-4.9 acres	30%	26%
5-9.9 acres	22%	30%
10-19.9 acres	26%	23%
20-49.9 acres	16%	13%
50-100 acres	5%	3%
>100 acres	3%	3%
Number of responses	127	189

Table 7. Current stocking rate

	2004
<1/2 acre per horse	26%
1 acre per horse	34%
1-1-1/2 acre per horse	16%

2 acres per horse	10%
3 acres per horse	6%
4 acres per horse	4%
>4 acres per horse	3%
Number of responses	182

Table 8. Percent of horse owners that feed hay year round.

	1999	2004
Yes	95%	91%
No	7%	9%
Number of responses	100	188

Hay storage is a concern for most farm managers with 48% reporting that they only had enough room to store hay for six months or less (Table 9).

Table 9. Hay storage

	2004
Two weeks	2%
One to three months	26%
Three to six months	20%
Six months to one year	32%
More than one year	21%

The majority of horse owners purchase hay from local farmers (62% in 1999; 61% in 2004). The number of horse owners producing their own hay declined from 18% in 1999 to 11% in 2004, which is a trend that is likely to continue. The number of horse owners purchasing hay from out-of-state suppliers increased from 11% in 1999 to 14% in 2004. This is a trend that is also likely to continue as the number of traditional crop farms decrease in New Jersey and eastern Pennsylvania (Table 10).

Table 10. Source of hay

	1999	2004
Produce it on your own farm	18%	11%
Buy directly from local farmers	62%	61%
Buy from local hay distributors or feed stores	7%	10%
Buy from out-of-state suppliers	11%	14%
Purchase at auction	5%	2%

Forage Selection Criteria

A large part of the survey was designed to identify those hay characteristics that are important to horse owners and to document opinions on a variety of hay production practices.

Type of Hay: In both 1999 and 2004, horse owners were given a list of types of hay and were asked to check all that they preferred to use in their feeding program. In both survey years, timothy was the hay of choice with nearly 40% of the horse owners in 1999 and 38% in 2004 stating that first cutting timothy was a preferred type of hay. Second cutting timothy was a preferred hay type for 39% of the respondents in 1999 and 37% in 2004. Alfalfa/grass mixed hay also was highly regarded by horse owners, with 28% listing first cutting mixed hay as a preferred hay type in 1999 and 21% in 2004. Over 38% of the horse owners in 1999 and 29% in 2004 listed second cutting alfalfa/grass mixed hay as important to their farm operation. Second cutting orchardgrass also ranked fairly high, with 23% and 24% of the respondents identifying it as a preferred hay type in 1999 and 2004, respectively. In general, first cutting alfalfa, brome, and reed canarygrass were not highly preferred. Since brome is an excellent hay for horses, but rarely produced locally, it is possible that horse owners are not familiar with this species of hay. It is also remarkable that 27% of horse owners listed first cutting clover as a preferred species in 1999 and only 1% preferred this hay in 2004 (Table 11).

Table 11. Type of hay preferred in equine programs

	1999	2004
Timothy, first cutting	40%	38%
Timothy, second cutting or later	39%	37%
Orchardgrass, first cutting	17%	19%
Orchardgrass, second cutting or later	23%	24%
Brome, first cutting	3%	4%
Brome, second cutting or later	0	6%
Alfalfa, first cutting	7%	6%
Alfalfa, second cutting or later	19%	19%
Clover, first cutting	27%	1%
Clover, second cutting or later	0	2%
Alfalfa/grass mix, first cutting	28%	21%
Alfalfa/grass mix, second cutting or later	38%	29%
Clover/grass mix, first cutting	1%	9%
Clover/grass mix, second cutting or later	0	12%
Reed canarygrass, first cutting	0	0
Reed canarygrass, second cutting or later	0	0
Other - Timothy/orchardgrass mix	0	1%

Size of Bales: The weight of hay bales varies greatly from one supplier to the next. Reported bale weights ranged from 30 to 60 pounds in 1999 and 25 to 80 pounds in 2004. In both 1999 and 2004, horse owners reported that they most frequently purchased hay in 40 pound bales (Table 12).

Table 12. Size bales usually purchased

Bale Size	1999	2004
25 lb	0	2%
30 lb	9%	8%
35 lb	8%	2%
40 lb	42%	35%
45 lb	9%	7%
50 lb	20%	25%

55 lb	8%	6%
60 lb	5%	7%
65 lb	0	1%
70 lb	0	4%
75 lb	0	2%
80 lb	0	2%

Large Bales: In 2004, consumers were asked if they would consider feeding large (over 800 pound) round or square bales to their horses. The horse owners overwhelmingly supported feeding small bales with over 80% reporting that this was the only size that they would purchase (Table 13).

Table 13. Percentage of horse owners willing to use large (over 800 pound) round or square bales

	2004
Feed large bales now	5%
Would consider feeding large bales	15%
Will only feed small square bales	80%
Number of responses	193

Forage Substitutes: Due to the increasing availability of forage substitutes on the market, horse owners were asked if they incorporated any forage substitutes into their nutritional program. Surprisingly, 47% reported that they currently supplement with hay cubes, dengie, beet pulp, or other forage equivalents (Table 14).

Table 14. Forage substitutes

	2004
Hay cubes	23%
Dengie	13%
Other responses (alfalfa cubes, beet pulp, chaff, complete feed, grass, hay stretcher, hay pellets)	7%

Hay Cooperatives: Due to the difficult hay making conditions frequently experienced in the Northeast, hay suppliers often are unable to completely provide their customers with “horse-quality” hay from their farm. Horse owners are often forced to look for other sources of hay to meet their needs. When asked if they would be interested in purchasing hay from a cooperative composed of several local farmers rather than relying on one farmer to supply their needs, horse owners overwhelmingly were in favor of a cooperative with 77% supporting the idea in 1999, and 84% in 2004 (Table 15).

Table 15. Would you be interested in buying hay from a cooperative composed of several local farmers?

	1999	2004
Yes	77%	84%
No	13%	16%
Not sure	1%	0%
Number of responses	146	177

Crop Protectant Materials: Hay preservatives, herbicides and insecticides are valuable tools that can be used to enhance hay quality. Hay preservatives and drying agents can be used to help prevent mold growth in hay. Herbicides can be used in hayfields to help reduce weeds and toxic plants, and insecticides can be used to reduce insects that feed on hay and reduce hay quality.

When horse owners were asked if they would consider purchasing hay treated with preservatives, insecticides or herbicides, the results consistently showed that horse owners prefer to buy hay that has not been treated with crop protectant materials. The number of horse owners that reported that they were willing to buy hay treated with preservatives or drying agents ranged from 30% in 1999 to 21% in 2004. In 1999 and 2004, only 25% and 28% of the horse owners reported that they would buy hay treated with herbicides and insecticides.

A significant change in attitude was detected in 2004, however, when a much greater percentage of horse owners reported that they were “unsure” whether they would buy hay treated with crop protectant materials. In 1999, 58% to 63% of the survey respondents reported that they would not buy treated hay; only 12% to 13% were unsure about the purchase of treated hay. In 2004, 36% to 37% of the horse owners reported that they would not buy hay treated with preservatives, herbicides, or insecticides and 44% to 43% stated that they are not sure (Tables 16 and 17).

Table 16. Percentage of horse owners that would purchase hay that was cured with hay preservatives and drying agents

	1999	2004
Yes	30%	21%
No	58%	36%
Not sure	12%	43%

Table 17. Percentage of horse owners that would purchase hay that was treated with herbicides and insecticides

	1999	2004
Yes	25%	28%
No	63%	37%
Not sure	13%	34%

Partially Heat-Dried Hay: To minimize the loss in hay quality caused by the frequent rainy conditions and high humidity experienced in spring and fall, many farmers have constructed on-farm dryers to partially heat dry their hay. Heat drying generally enhances hay quality and nutrition, maintains color, and reduces the chance of mold. Surprisingly, when asked if they would be interested in purchasing heat-dried hay, 47% of the survey respondents reported that they were not interested. Of those that were interested in heat dried hay, 62% would not pay more than \$.50 extra per bale (Table 18).

Table 18. Value of partially heat-dried hay to the equine industry

	1999	2004
I am not interested in purchasing heat dried hay	-	47%
\$.25 extra per bale	-	37%
\$.50 extra per bale	-	25%
\$1.00 extra per bale	-	2%
\$2.00 extra per bale	-	0%

Ranking of Selection Criteria: In order to determine what factors are important to horse owners when purchasing hay, horse owners were provided with a list of selection criteria and were asked to rank each factor as: 1) very important; 2) fairly important; 3) slightly important; or 4) not important. Selection criteria included: type of hay, cutting of hay, maturity of hay, color of hay, absence of weeds, absence of mold, price, delivery availability, and reputation of supplier.

In both 1999 and 2004, the single most important selection criteria for horse owners was absence of mold, with 96% and 97% indicating that this factor was very important in 1999 and 2004, respectively.

The type of hay was also listed as being very important to most horse owners, with 54% of the horse owners giving this factor a #1 ranking in 1999 and 64% ranking it as #1 in 2004. Forty-six percent of horse owners in 1999 ranked lack of weeds as being an important selection criterion, and 60% gave this factor a #1 ranking in 2004. The reputation of the supplier is also important to horse owners, with 57% of the respondents ranking this criterion #1. The color of hay and cutting of hay was only ranked as fairly important to horse owners.

Two selection criteria showed significant changes in the responses obtained in 1999 and 2004. In 1999, the price of hay was only fairly important to horse owners. Only 25% listed price as being very important in 1999. In 2004, 49% of the horse owners listed price as very important. In 1999, only 33% of the horse owners listed delivery as being very important. This figure increased to 51% in 2004 (Tables 19, 20, 21, 22, 23, 24, 25, 26 and 27).

Table 19. Type of hay

	1999	2004
1. Very important	54%	64%
2. Fairly important	40%	31%
3. Slightly important	4%	5%
4. Not important	2%	1%
Number of responses	113	187

Table 20. Cutting of hay

	1999	2004
1. Very important	-	30%
2. Fairly important	-	46%
3. Slightly important	-	20%
4. Not important	-	4%
Number of responses	0*	186

*Not asked in 1999.

Table 21. Maturity of hay

	1999	2004
1. Very important	-	48%
2. Fairly important	-	40%
3. Slightly important	-	10%
4. Not important	-	2%
Number of responses	0*	184

*Not asked in 1999.

Table 22. Color of hay

	1999	2004
1. Very important	26%	39%
2. Fairly important	52%	44%
3. Slightly important	17%	14%
4. Not important	5%	3%
Number of responses	109	185

Table 23. Absence of weeds

	1999	2004
1. Very important	46%	60%
2. Fairly important	40%	32%
3. Slightly important	13%	7%
4. Not important	1%	2%
Number of responses	117	188

Table 24. Absence of mold

	1999	2004
1. Very important	96%	97%
2. Fairly important	3%	2%
3. Slightly important	0%	0%
4. Not important	1%	2%
Number of responses	111	192

Table 25. Price

	1999	2004
1. Very important	25%	49%
2. Fairly important	52%	39%
3. Slightly important	17%	9%
4. Not important	5%	2%
Number of responses	111	188

Table 26. Delivery available

	1999	2004
1. Very important	33%	51%
2. Fairly important	20%	24%
3. Slightly important	21%	15%
4. Not important	26%	10%
Number of responses	109	185

Table 27. Reputation of supplier

	1999	2004
1. Very important	-	57%
2. Fairly important	-	31%
3. Slightly important	-	8%
4. Not important	-	4%
Number of responses	0*	185

*Not asked in 1999.

Hay Costs

An additional goal of the survey was to document changes in average hay prices from 1999 to 2004. Average hay prices were also computed on a county basis to determine local differences in value and help identify prime hay market areas. In order to compare hay prices, horse owners were asked to supply ton prices or the cost of hay and bale weights. Prices were then converted to bale prices, based on a 40 pound bale.

Table 28 lists all of the prices reported by horse owners in the 1999 and 2004 surveys. Of significant note is the increase in price that occurred in 2004 at the high levels of the hay market. In 2004, over eleven respondents reported purchasing hay at prices greater than \$5.00 per 40 pound bale.

Table 28. How much do you typically pay for hay?

Price Per ton	Price per 40 lb bale	1999	2004
\$45	\$0.90	1	-
\$50	\$1.00	1	-
\$65	\$1.30	2	-
\$80	\$1.60	6	3
\$95	\$1.90	-	1
\$100	\$2.00	4	7
\$105	\$2.10	-	1
\$110	\$2.20	8	4
\$115	\$2.30	5	1
\$120	\$2.40	6	8
\$125	\$2.50	12	2
\$130	\$2.60	2	2
\$135	\$2.70	11	4
\$140	\$2.80	2	7
\$145	\$2.90	2	7
\$150	\$3.00	23	13
\$155	\$3.10	11	4
\$160	\$3.20	7	8
\$165	\$3.30	5	3
\$170	\$3.40	-	7
\$175	\$3.50	-	13

Price per ton	Price per 40 lb bale	1999	2004
\$180	\$3.60	1	8
\$185	\$3.70	1	3
\$190	\$3.80	4	2
\$195	\$3.90	-	3
\$200	\$4.00	1	16
\$210	\$4.20	-	1
\$215	\$4.30	-	2
\$220	\$4.40	-	6
\$225	\$4.50	9	4
\$230	\$4.60	-	1
\$235	\$4.70	2	-
\$240	\$4.80	-	1
\$245	\$4.90	-	1
\$250	\$5.00	3	2
\$255	\$5.10	-	2
\$260	\$5.20	-	2
\$265	\$5.30	-	2
\$275	\$5.50	1	2
\$290	\$5.80	-	2
\$300	\$6.00	1	-
\$375	\$7.50	-	1

Table 29 lists the average median price and price range per bale of hay and per ton in 1999 and 2004. Price increases over the five year period were significant, with the average price per ton increasing from \$147.63 to \$171.86, and bale price (based on 40 pound bales) increasing from \$2.95 to \$3.43. Hay prices

at the lower end and upper end increased with price ranges from \$45 to \$300 per ton being reported in 1999 and \$80 to \$375 per ton being reported in 2004.

Table 29. Hay purchase price

	1999	2004
Average price per ton	\$147.63	\$171.86
Average price per bale*	\$2.95	\$3.43
Median price per ton	\$150.00	\$170.00
Median price per bale*	\$3.00	\$3.40
Price range per ton	\$45-\$300	\$80-\$375
Price range per bale*	\$.90-\$6.00	\$1.30-\$7.50

Survey results revealed that, as expected, county and regional differences occurred in hay prices. County hay prices in New Jersey ranged from a low of \$2.82 per bale in rural Warren County to a high of \$4.29 in Monmouth County. Monmouth County ranks #1 in the number of horses in New Jersey, with 11,500 horses, and also ranks first in the average value of the horses at \$18,829. Eastern Pennsylvania hay prices fluctuated from a low of \$2.35 per 40 pound bale in rural Schuylkill County to a high average of \$3.72 in Bucks County (Table 30).

Table 30. Hay prices by county

County	Average Hay Price (per 40 lb bale)	Price Range (per 40 lb bale)	No. of Responses	No. of Horses	County Rank	Average Value of Horses	County Rank
NEW JERSEY							
Bergen	\$4.70	\$4.00-\$5.30	3	1,500	12	\$18,069	6
Burlington	\$3.64	\$3.10-\$5.00	6	5,500	3	\$12,249	3
Gloucester	\$2.63	\$2.00-\$3.25	2	2,200	7	\$11,083	10
Hunterdon	\$3.29	\$2.08-\$4.00	18	6,500	2	\$12,304	2
Mercer	\$3.60	\$2.40-\$5.11	7	1,900	8	\$13,056	9
Monmouth	\$4.29	\$2.70-\$7.50	33	11,500	1	\$18,829	1
Morris	\$3.80	\$2.40-\$5.20	13	2,400	5	\$10,405	8
Somerset	\$3.10	\$2.00-\$4.00	6	1,900	8	\$13,389	7
Sussex	\$3.05	\$2.40-\$4.40	5	4,500	4	\$10,215	4
Warren	\$2.82	\$1.88-\$3.42	9	1,700	10	\$11,782	12
PENNSYLVANIA							
Bucks	\$3.72	\$3.30-\$4.40	4	5,795	6	-	-
Chester	\$2.80	\$2.60-\$3.00	2	15,504	2	-	-
Lehigh	\$3.33	\$2.30-\$5.00	4	1,994	29	-	-
Monroe	\$2.85	\$1.86-\$4.50	13	1,576	38	-	-
Northampton	\$2.88	\$1.60-\$3.85	7	1,023	51	-	-
Schuylkill	\$2.35	\$1.60-\$3.25	3	1,077	50	-	-

Conclusions

The equine industry in New Jersey and Pennsylvania continues to exhibit growth, in both the number of horses and horse farms. Simultaneously, traditional crop farms are being lost to development, which increases the potential for local farmers to increase and improve hay production to meet the forage needs of the equine industry. To maximize market opportunities, hay producers need to develop and foster good customer relations with the horse owners, and take into consideration the following key strategies:

- Produce the type of hay most preferred by the horse industry. Timothy still ranks first within the equine community, with alfalfa/grass mixes and second cuttings of orchardgrass also being popular.

- Keep bale size small, approximately 40 pounds.
- Do not sell customers moldy hay. Mold is very detrimental to equine health, and a major concern for 96 to 97% of the horse owners surveyed.
- Attempt to eliminate weeds in hay, especially toxic weeds.
- Since many horse owners are unsure about the use of herbicides and insecticides in hay, take time to educate horse owners about crop protectant materials when necessary.
- Hay producers should not underestimate the value of their hay, and should analyze the hay market in the area they are willing to serve. Hay price, although very important to the end user, is not the most important selection criteria.
- Most horse owners cannot store more than a six month supply of hay, therefore the ability to store hay for your customers is important. The ability to deliver hay is important to many equine operations.
- Regional differences in hay prices exist, especially in areas of New Jersey that contain large numbers of horses and very few crop farms. These regions provide very good markets for farmers that can deliver hay.
- Over 60% of the horse owners prefer to purchase hay directly from local farmers. This provides a ready market for local hay producers.
- Although large (greater than 800 pound bales) are convenient to producers, they are not marketable to the average horse owners. Over 80% will not purchase large bales.
- Although heat drying hay may greatly enhance quality, the price of drying hay needs to be considered. Horse owners report that they are not interested in heat dried hay if it costs more than \$0.50 extra per bale. Educate consumers about the benefits of heat dried hay to increase knowledge and marketability.
- Since 47% of horse owners reported that they feed forage substitutes, a market may exist for locally produced hay cubes or other forage products.
- Never sell good customers questionable hay. Poor quality hay can be dangerous to horses and equally detrimental to good customer relations
- Find and cultivate good customers, and educate them about your hay program. Producers' reputation goes a long way in keeping satisfied and repeat customers.

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Evaluation of Double Crop Corn Production

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- Research Question** Mid-Atlantic farmers experience a better than average corn market that is supported primarily by the large poultry and dairy industries in the region. If construction of proposed fuel ethanol plants utilizing corn as the feedstock occurs, there could be an increase in the demand for corn regionally. A fuel ethanol plant utilizing barley as its feedstock would increase the acreage available for either the traditional double crop of soybean or possibly create an opportunity for double crop production of corn. Additionally, the recent introduction of Asian soybean rust in the United States may adversely affect the production of double crop soybean in the Mid-Atlantic region increasing the likelihood that farmers will look to other crops for double crop production. For these reasons, information regarding the agronomic performance of corn produced as a double crop is necessary.
- Literature Summary** Research conducted in Virginia indicated that double crop production of corn following barley had potential. This research indicated that corn hybrids with relative maturity between 91 to 105 days would be suitable. Given that the majority of the states comprising the Mid-Atlantic are north of where this research was conducted, it is important to determine the corn relative maturity range that would be most suitable for Mid-Atlantic production.
- Study Description** Eight corn hybrids representing four corn relative maturity groups (87, 93, 101, and 110 day) were grown after barley at two locations in Maryland during 2003 and 2004. Each relative maturity group had two hybrids that were near-isolines for expression or non-expression of the Bt genetic event. Variables measured during the study included corn yield corrected to 15% moisture content, harvest moisture content, European corn borer infestation (2003 only), and lodging.
- Applied Questions** *What kind of yield can be expected with double crop corn?*
- At three of the four locations, corn yields exceeding 100 bu per acre were observed. Best performance occurred when hybrids were planted during mid-June (2004) with two hybrids exceeding 140 bu per acre. With late-planted double crop corn (~ July 1) and unfavorable growing conditions (excessively wet weather like occurred during 2003), poor performance can result and yields can be very poor (50 to 75 bu per acre).
- What relative maturity range is most suitable?*
- This is closely linked to the average number of growing degree units that can be accumulated during the growing season. For Maryland Eastern Shore, hybrids with a relative maturity ranging from 95 to 102 days will likely yield well and have a harvest moisture content that either will not require excessive drying costs for safe storage or incur high moisture discounts when it is sold. Hybrids with maturity in this range would probably be harvested early enough to allow planting of winter wheat. For environments that have weather conditions similar to the Central Maryland region, hybrids with relative maturity ranging from 90-95 day would probably be a better choice.

Should a Bt hybrid be used for double crop production?

Bt hybrids are ideally suited for later planted corn that, by nature of late planting, is highly susceptible to European corn borer infestation. In this study, the Bt hybrids generally produced 20 to 30% greater yields than their near-isoline maturity group mates. Selection of Bt hybrids should be done with careful consideration to disease resistance, particularly stalk rot resistance.

Recommendations

Double crop production of corn appears to have agronomic potential when the growing season precipitation level is suitable and if soil moisture holding capacity is suitable. Bt hybrids will generally perform significantly better than non-Bt hybrids for this system. Consideration must be given to the selection of hybrids with a suitable relative maturity. Hybrids ranging from 90 to 102 days probably are best suited for areas with growing conditions similar to Maryland. Any decision to produce double crop corn should also include a careful economic analysis.

Evaluation of Double Crop Corn Production

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Introduction

Corn is a grain crop of major importance in the mid-Atlantic region. The region has a better than average demand for corn supported by the large poultry broiler industry on the Delmarva and by a sizable dairy industry scattered across the region. Demand for feed corn by the poultry industry alone has been estimated to exceed Maryland's average annual production by 50%. Recent developments have raised speculation that the region's demand for feed grains may grow even more.

Three separate entities have been actively researching the feasibility of fuel ethanol production. Penn-Mar Ethanol, consisting of interested members from Pennsylvania and Maryland, recently announced a land purchase in Franklin County, PA for the purpose of constructing a 50 million gallon per year corn ethanol plant. Garden State Ethanol, a New Jersey based organization, has been studying the feasibility of a 40 million gallon per year ethanol plant that would also use corn and possibly some grain sorghum. If these two plants are built, the demand for corn in the region will increase by approximately 30 million bushel annually. The Maryland Grain Producers' Utilization Board (MGPUB) is evaluating the construction of an ethanol plant that would not use corn but rather barley as its primary feedstock. The Maryland group chose barley for two primary reasons. First, there already exists a better than average corn market supported by the poultry industry that is concentrated in the Delmarva area. Second, barley has been considered a more suitable crop to precede double crop soybeans because of the relatively early date that barley can be harvested. Since barley is harvested throughout much of the Delmarva by mid-June and because there is a better than average corn market in the region, interest in the potential for corn as a double crop has increased.

The recent identification of Asian soybean rust in the United States has also fueled interest in double crop corn. Since soybean rust spores will not over-winter in the region, the disease will have to be introduced to the region each year via air currents and weather events carrying them from the south. It is expected that rust spores will not likely arrive until mid- to late-summer. If this is the correct scenario for Asian rust, predictions are that the later planted double crop soybean crop will be damaged more by the disease than full season soybean. If Asian soybean rust proves to be an annual pest problem for the mid-Atlantic region, the costs associated with managing this disease in double crop soybean that is often marginally profitable may influence farmers to choose another double crop option like double crop corn.

Double crop corn following either a small grain (Behl et al., 1998) or first cutting alfalfa (Roth et al., 1997) is commonly grown for silage production purposes across the mid-Atlantic region. Little information is available about the practice of double crop corn for grain production. Virginia Polytechnic Institute and State University (Virginia Tech) conducted a study during 1997 evaluating a number of corn hybrids ranging in relative maturity from 75 to 115 days. Corn hybrids with relative maturity less than 90 days produced 50% less yield than the hybrids ranging from 100 to 115 days (Behl et al., 1998). It was concluded that double crop corn planted in early to mid June following a barley crop could be successful and that hybrid relative maturity ranging from 91 to 105 days could yield similar to hybrids with relative maturity ranging from 106 to 115 days and attain suitable harvest moisture content a few days earlier allowing for fall planting of a small grain. During a four-year period (1998 to 2001) of a cropping systems study conducted by Virginia Tech, double crop corn (103-day relative maturity hybrid) grown on loamy sand and sandy loam soils averaged 111 bu per acre or only 22% less than full season corn planted on average 6-8 weeks earlier (Alley et al., 2003). The range of yield (16 to 197 bu per acre) for the double crop corn reflected the precipitation received during those years and the soil moisture holding capacity for the study site soils. Since the research reported by VPI occurred in the southern fringe of the mid-

Atlantic, it is unknown if the same agronomic performance of corn grown as a double crop in the central mid-Atlantic could be expected. With funding support supplied by the Maryland Grain Producers' Utilization Board, this project was conducted during 2003 and 2004 to evaluate the performance of corn hybrids of suitable relative maturity in a double crop (after barley) production system in Maryland.

Materials and Methods

This study was established during autumn of 2002 and 2003 with the planting of barley plots at two locations, Wye Research and Education Center (Wye) near Queenstown, MD and Central Maryland Research and Education Center-Beltsville Facility (Beltsville), Beltsville, MD.

The study utilized a split-split plot arrangement of treatments within a randomized, complete block experimental design with three replications at each location. The whole plots were fall planted barley varieties (three and two for 2003 and 2004, respectively). Split plots were the four corn hybrid maturity group pairs (Table 1) and the split-split plots consisted of the Bt and non-Bt isoline hybrids that represented the Bt and non-Bt events (Table 1) for each maturity group. Hybrids were not selected per their prior double crop performance but rather they were selected because they were near isoline hybrids representing each of the relative maturity groups.

Table 1. Corn relative maturity (CRM) and Bt event for corn hybrids used in the double crop corn study at two locations in Maryland during 2003-2004.

Maturity Group	Bt Hybrid	Non-Bt Near Isoline Hybrid
87 day CRM	Pioneer brand 39F06	Pioneer brand 3905
93 day CRM	Pioneer brand 38P06	Pioneer brand 38P05
101 day CRM	Pioneer brand 36N71	Pioneer brand 36N70
110 day CRM	Pioneer brand 33V08	Pioneer brand 3394

2003 and 2004 Barley Crop Years

Three barley varieties were planted during fall 2002. They were Nomini and Starling that represented commonly grown winter feed barley produced in this region, and a hull-less breeding line from the Virginia Tech program. Planting dates were 25 October (Beltsville) and an extremely late 27 December at Wye. All varieties were planted at a seeding rate of 2.5 bu per acre. The cooler, wetter than normal fall, winter and spring delayed the development and maturity of barley during 2003. Barley plots were harvested 26 June (Beltsville) and 27 June (Wye). Yield measurements for the barley were collected for the Beltsville location but not at Wye because this location experienced extremely wet conditions that delayed planting until very late and resulted in very poor stand establishment. It was determined during early spring 2003 that the stand would not be suitable for yield measurements but that it would be adequate for planting double crop corn into the standing, mature barley.

Only two barley varieties were planted during fall 2003 at the same seeding rate used the previous year. The varieties were Nomini and Doyce, the first hull-less barley variety release from Virginia Tech. The Wye location was planted on 21 October; however, the CMREC location was not planted until 16 November resulting in a relatively weak stand establishment at that location for both varieties. Much better growing conditions prevailed for barley throughout the spring of 2004 allowing the crop to grow and mature at a faster than normal pace. Harvest at both locations was completed on 14 June.

Corn Production 2003-2004

Corn was planted on 30 June, and 1 July 2003 at Beltsville and Wye, respectively. Corn was planted earlier in 2004, 14 June at Wye and 22 June at Beltsville at 26,000 seeds per acre. Nitrogen fertility consisted of 100 lb per acre available N and was applied at planting both years. Corn was harvested on 5 November 2003 for Beltsville. The majority of plots at Wye were harvested on 6 November; however, some of the later maturity group plots did not get harvested until two weeks later negating the value of the harvest moisture content data for this location. Harvest dates for 2004 were 2 and 8 November at Wye

and Beltsville, respectively. Just prior to harvest, lodging score (2003 and 2004) and European corn borer (2003 only) damage ratings were assessed.

Results and Discussion

Results Barley Performance 2003-2004

Significant differences were observed among the three barley varieties tested during 2003. The relative yield for the hull-less barley line (Table 2) was similar to those reported in other evaluations of hull-less barley conducted by Virginia Tech and University of Maryland which showed approximately 20% less than hulled barley varieties. During 2004, no yield differences were observed between 'Nomini' and 'Doyce' at either location with very good yields observed at Wye (Table 2). This was a significant observation since hull-less barley lines generally produce 15 to 20% less than elite hulled barley varieties. The late planting date for barley at Beltsville resulted in yields that were approximately 50% of those attained at Wye.

Table 2. Yield for barley varieties used in the 2003-2004 double crop corn study conducted at Wye and Beltsville locations in Maryland.

Variety	2003-Beltsville bu/ac	2004-Wye bu/ac	2004-Beltsville bu/ac
Nomini	68 a ¹	86 a	41 a
Hull-less Line	52 b	N/A	N/A
Starling	62 a	N/A	N/A
Doyce (hull-less variety)	N/A	85 a	44 a

¹Barley yields within a column followed by the same letter are not significantly different at p=0.05.

Corn Yield-2003

Yield was significantly affected by location, corn relative maturity (CRM) and Bt event. Figure 1 displays the yields by location for the Bt event by CRM response. The two locations differed significantly for yield with best performance occurring at Beltsville on a sandy loam soil that was able to drain well following the frequent and sometimes excessive rain events that occurred during 2003. The Wye site had a silt loam soil that did not drain as well. In addition, the Wye had an excessively heavy rainfall event immediately following planting that effected stand establishment. Bt hybrids produced significantly higher yields than their non-Bt isolines (Figure 1) for each of the relative maturity groups at each location. At both locations and for both the Bt and non-Bt hybrids, the longer relative maturity hybrids (101 and 110 day) produced the best yields (Figure 1). A good indication that double crop corn production following barley can be successful in this region was observed with the yields attained for the 101 and 110-day Bt hybrids grown at Beltsville (109 and 110 bu per acre, respectively). The performance of the Bt hybrids supported area agronomist recommendations to consider using them when corn is planted late in the season.

Corn Yield-2004

Overall, the yield for double crop corn during 2004 was significantly better than in 2003. This was likely due to the nearly two week earlier planting dates at both locations and the suitable growing conditions that prevailed throughout the summer of 2004. At Wye, the Bt hybrids for each of the maturity groups produced significantly more corn than their corresponding near isolines (Figure 2). In addition, the two Bt hybrids with longer relative maturity (101 and 110 days) produced better yield compared to the 87 and 93-day Bt hybrids. At Beltsville, only the 87-day Bt hybrid produced significantly more corn than its non-Bt near isolate. The 93 and 101-day Bt hybrids produced comparable to their non-Bt near isolines. The 110-day Bt hybrid performed poorly at Beltsville achieving a yield that was nearly 60% less than its non-Bt near isolate. This poor yield performance for Pioneer brand 33V08, the 110-day Bt hybrid, was probably due to its susceptibility to organisms causing stalk rot as evidenced by the 80% lodged plants when this hybrid was harvested at Beltsville. No clear maturity group advantage was identified at Beltsville as hybrids representing both Bt and non-Bt events within each of the four maturity groups produced the same (see asterisked bars) (Figure 2).

Figure 1. Yield by location and Bt event for eight hybrids representing four different corn relative maturity groups that were grown following barley in Maryland during 2003. CRM group bars that have the same letter are not significantly different at $p=0.05$. Bars for hybrids that have an asterisk (*) indicate top-yielding hybrids that did not yield differently at the location.

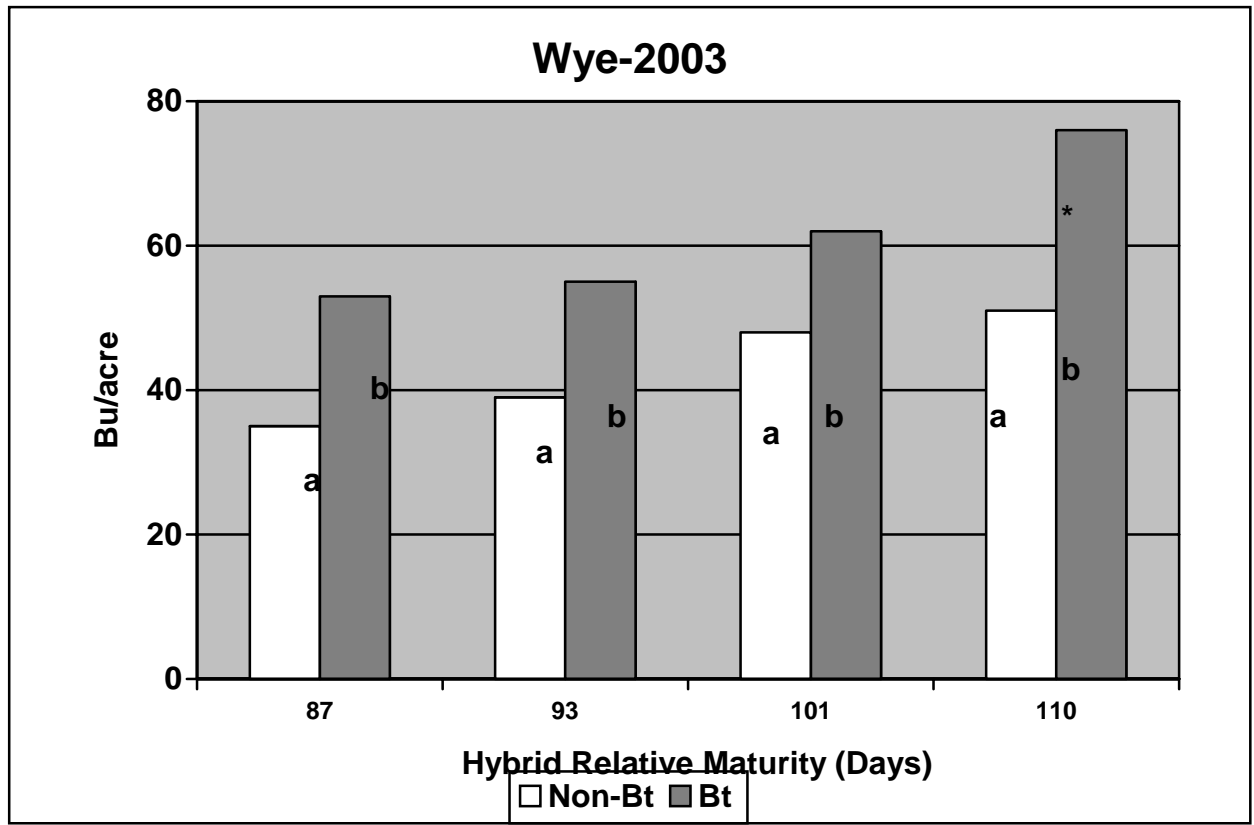
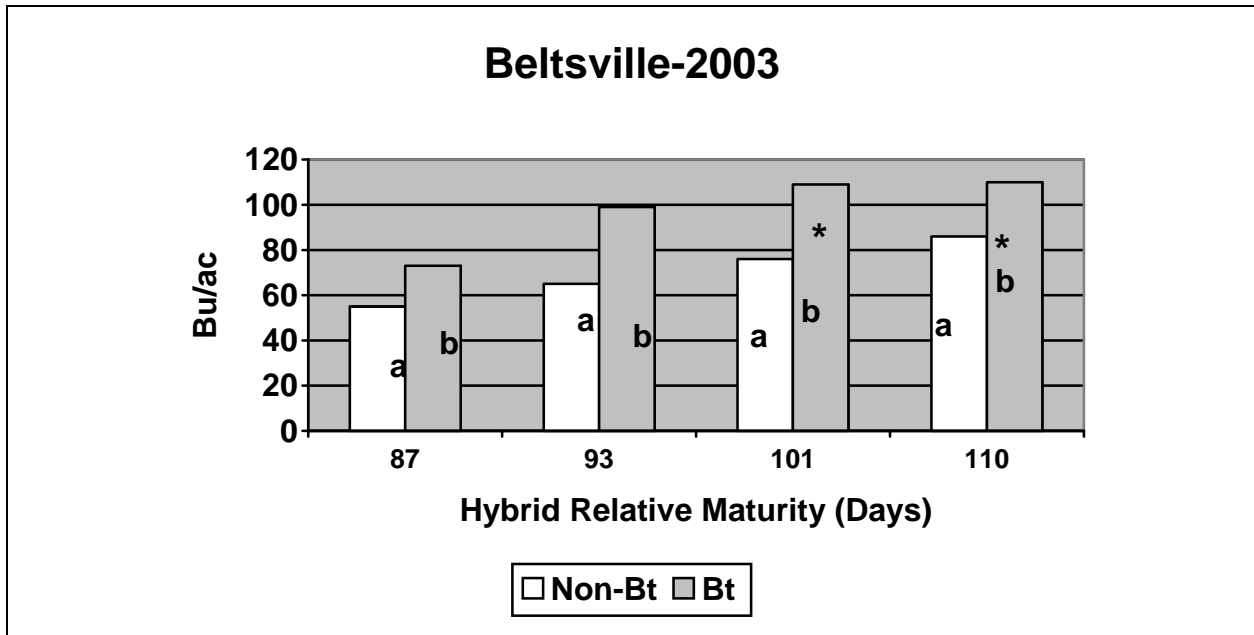
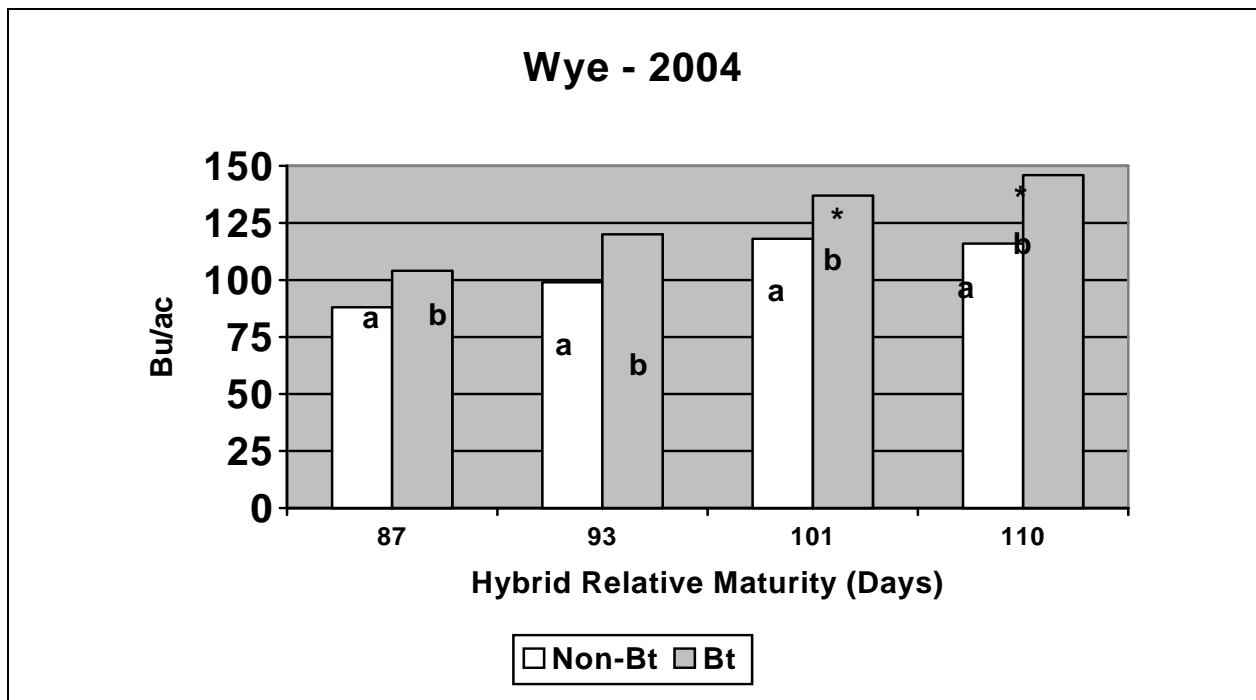
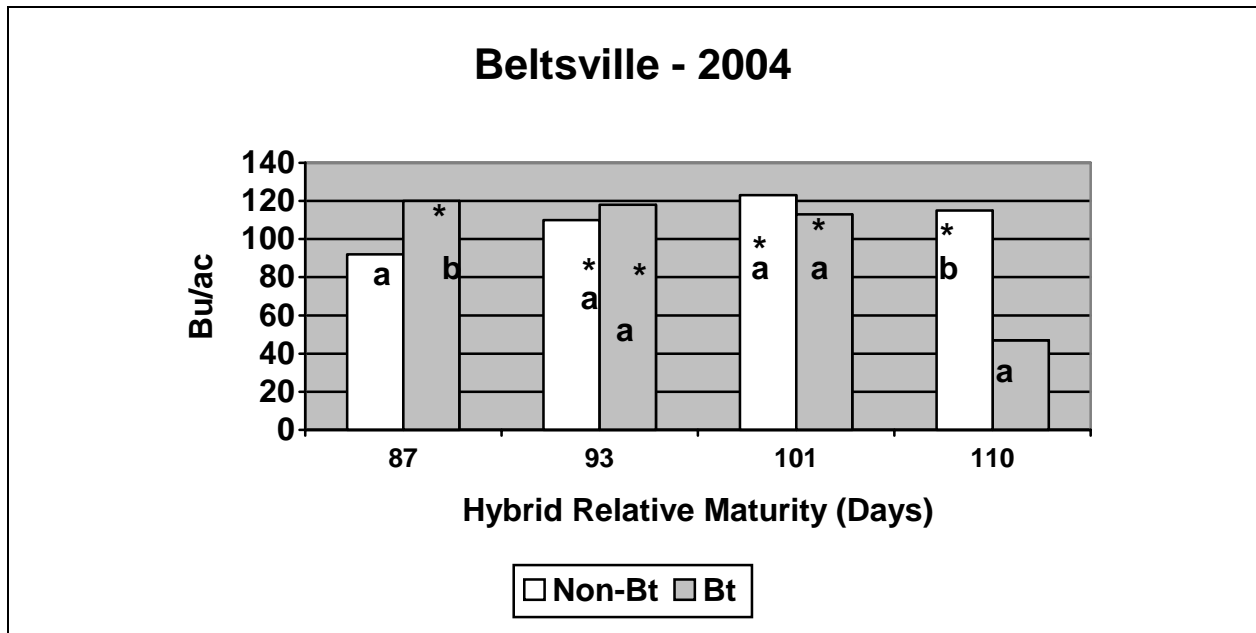


Figure 2. Yield by location and Bt event for eight hybrids representing four different corn relative maturity groups that were grown following barley in Maryland during 2004. CRM group bars that have the same letter within a location are not significantly different at $p=0.05$. Bars that have an asterisk (*) indicate top-performing hybrids that had yield that was not significantly different at the location.



Harvest Moisture Content

A major consideration regarding the production of double crop corn for grain production is harvest moisture content. It is possible that the later maturing hybrids will produce best but they may have higher harvest moisture contents at harvest. Excessive harvest moisture content can result in higher drying costs and reduced profitability. During 2003, the trend at Beltsville was for Bt hybrids to be approximately 1% wetter at harvest compared to their non-Bt near isolines though there were only two instances when the differences were statistically significant (Table 3). This difference in harvest moisture content for the Bt and non-Bt near isolate hybrids was comparable to what Dillehay et al. (2004) reported. A more critical aspect was the harvest moisture contents across maturity groups. The two best producing Bt hybrids during 2003 were in the 110 and 101-day relative maturity groups. However, the 93-day hybrid had harvest moisture content less than 14% (compared to over 25% and 19% for the 110 and 101 day Bt hybrids, respectively) and it produced only 10 bu acre⁻¹ less than those two hybrids at Beltsville. This would have allowed the 93-day hybrid to be either safely stored without drying or sold directly from the field with no moisture content discount. At Beltsville during 2004, the trend was again for the Bt hybrids to have approximately 1% greater moisture content at harvest compared to their non-Bt isolines (Table 3). As relative maturity decreased, the moisture content decreased with both 93 and 87-day hybrids having harvest moisture contents less than 15%. The 93-day Bt hybrid yielded the same as the 101-day Bt hybrid, but its harvest moisture content was 3.5% less than the 101-day Bt hybrid. At Wye during 2004, harvest moisture content for the Bt hybrids for maturity groups 87, 93 and 101 days was less than 15% and was not significantly different from their non-Bt isolines (Table 3). The 110-day Bt hybrid had harvest moisture that was greater than the other three maturity group Bt hybrids as well as its non-Bt isolate.

Table 3. Harvest moisture content by location, hybrid relative maturity, and Bt event during 2003 and 2004. Means followed by the same letter for Bt and Non-Bt hybrids within a relative maturity group within the same year are not significantly different.

Relative Maturity (days)	Location	Bt 2003	Non-Bt 2003	Bt 2004	Non-Bt 2004
		-----% Harvest Moisture-----			
110	Beltsville	25.6 a	24.6 a	23.0 b	17.4 a
101	Beltsville	19.7 a	18.7 a	17.9 a	16.9 a
93	Beltsville	13.8 a	12.9 a	14.4 a	13.4 a
87	Beltsville	16.2 b	14.0 a	14.7 a	14.0 a
110	Wye	N/A	N/A	16.3 b	14.3 a
101	Wye	N/A	N/A	14.0 a	13.6 a
93	Wye	N/A	N/A	12.8 a	12.7 a
87	Wye	N/A	N/A	12.8 a	13.0 a

Harvest Moisture Content and Profitability

One way to better define the influence that the choice of hybrid relative maturity group may have upon double crop production is to evaluate the hybrids for their profitability potential after drying costs are deducted. To accomplish this simple economic analysis was conducted using 2003 (\$2.75/bu) and 2004 (\$2.25/bu) corn prices (MASS) and assessing a cost of \$0.04 per moisture point per bushel for drying corn to a 15.5% moisture content. For example, the 101-day Bt hybrid grown at Beltsville during 2003 produced 109 bu/acre and had harvest moisture content of 19.7%. This hybrid had 4.2% moisture removed by drying at a cost of \$0.168/bu or \$18.31/acre (\$0.168 X 109 bu). At \$2.75 per bushel selling price, this hybrid grossed \$299.75 per acre. Less the drying costs this hybrid would have netted \$281.44 to cover all other costs incurred with production. A hybrid that had harvest moisture content less than 15.5% had no drying costs. This economic evaluation for each hybrid averaged over the three locations where harvest moisture content was collected (none for Wye in 2003) is shown in Table 4. Two important factors related to hybrid choice for double crop production can be seen in this table. First, the value of selecting a Bt hybrid for later planting can be seen by comparing the net return between the two hybrids representing each relative maturity group. Except for the Bt hybrid representing the 110-day maturity group, there is a clear economic advantage with the Bt hybrids representing each maturity group. Second, net return for the Bt hybrids representing the 93- and 101-day maturity groups were substantially better than the net returns for the other hybrids evaluated indicating that hybrids within this range of relative maturity are likely to be the best choice for profitable double crop production in this region.

Table 4. Economic impact of drying costs upon double crop corn profitability.

Hybrid	CRM	Bt Event	Drying Costs (per acre)	Gross Return	Net Return
Pioneer 39F06	87	Bt	\$0.68	\$234.91	\$234.23
Pioneer 3905	87	Non-Bt	\$0.00	\$185.42	\$185.42
Pioneer 38P06	93	Bt	\$0.00	\$269.25	\$269.25
Pioneer 38P05	93	Non-Bt	\$0.00	\$216.33	\$216.33
Pioneer36N71	101	Bt	\$9.72	\$287.42	\$277.70
Pioneer 36N70	101	Non-Bt	\$5.54	\$250.42	\$244.88
Pioneer 33V08	110	Bt	\$21.07	\$245.58	\$224.51
Pioneer 3394	110	Non-Bt	\$13.35	\$252.08	\$238.73

Corn Lodging – 2003 and 2004

Considerable European corn borer infestation was observed in the non-Bt hybrids at Beltsville (the only location where ECB infestation was measured) during 2003 (Figure 4). The amount of lodging damage (Figures 5 and 6) measured during 2003 was certainly exacerbated by Hurricane Isabella on 18 September. The causes of the 2003 lodging are attributed to three factors. First, there was lodging that was the result of the European corn borer damage measured by burrowed tunnels anywhere along the corn stalk. For assessment purposes, this cause of lodging was only counted when the tunneling caused stalk breakage below the ear increasing the potential for ears dropping to the ground prior to harvest. As expected with this type of lodging, there was less lodging for the Bt hybrids than for the non-Bt hybrids (Figure 6) across all four maturity groups. Another contributing factor to overall lodging was the considerable amount of stalk rot that occurred during 2003. In this case, the corn stalks generally broke approximately 1 foot or less from the soil surface and would frequently lean against plants in an adjacent row. A third type of lodging was the result of wind from Hurricane Isabella uprooting the root-ball of a plant. As with the stalk rot lodging, the plants that had this type of lodging would frequently be found leaning against an adjacent row. However, occasionally, this last lodging type resulted in numerous corn plants either completely flat or leaning against each other because of the domino response that occurred.

The response of corn hybrids to lodging damage differed somewhat at the two locations. The number of lodged corn plants at Beltsville declined as the relative maturity of the corn hybrids increased (Figure 5). At Wye, a lodging response to relative maturity was not present as reflected by the level of lodging being a few percentage points above or below 40% for each of the four maturity groups (Figure 5). There also was significantly less lodging for the Bt hybrids representing the two longer day relative maturity groups compared to the two shorter maturity groups (Figure 6). This indicated that even though ECB damage was not the only contributing factor to lodging, the Bt hybrids in general expressed better overall stalk quality and this was particularly apparent in the two later maturing hybrids.

European corn borer tunnel damage was not assessed during 2004 so the lodging response that was measured was cumulative for both insect and disease causes. In general, the amount of lodging during 2004 (Figure 7) was less for the Bt hybrids than it was for the non-Bt isolines for each maturity group except for the 110- day Bt hybrid at Beltsville. This hybrid is highly susceptible to fungi causing stalk rot. Lodging response during 2004 again confirmed that for later planted corn, a Bt hybrid is the better option. When selecting hybrids, attention should also be given to the stalk rot susceptibility of the hybrid.

Conclusions

Double crop corn for grain production following barley can be successfully incorporated as a cropping system option for the region provided it is planted timely (10 June to 25 June). Corn hybrids expressing the Bt trait and with relative maturity ratings between 100 to 110 days should have adequate time to attain the necessary growing degree units required to reach maturity and will likely produce the best yields. However, Bt hybrids with relative maturity between 90 and 100 days are more likely to attain harvest moisture contents that will minimize drying costs and probably allow the timely planting of either winter wheat or a winter small grain cover crop. Planting double crop corn as soon as possible after barley harvest is recommended. Double crop corn following wheat harvested prior to July 1 might also be a

Figure 4. Percentage of plants damaged by European corn borer for Bt and their non-Bt hybrid isolines that were grown as a double crop following barley at Beltsville (Hayden) during 2003.

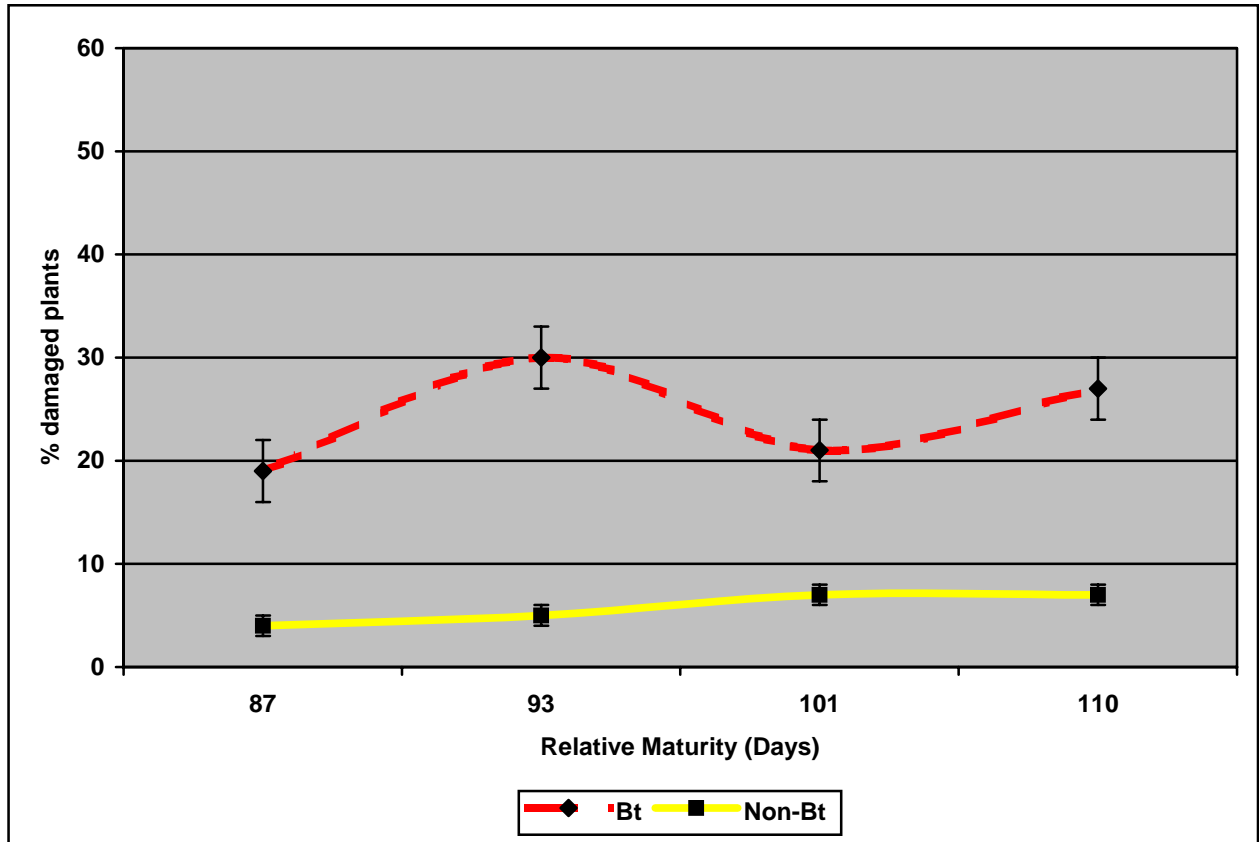


Figure 5. Percentage of lodged corn plants averaged over the two Bt events at each location for each of the four relative maturity groups during 2003.

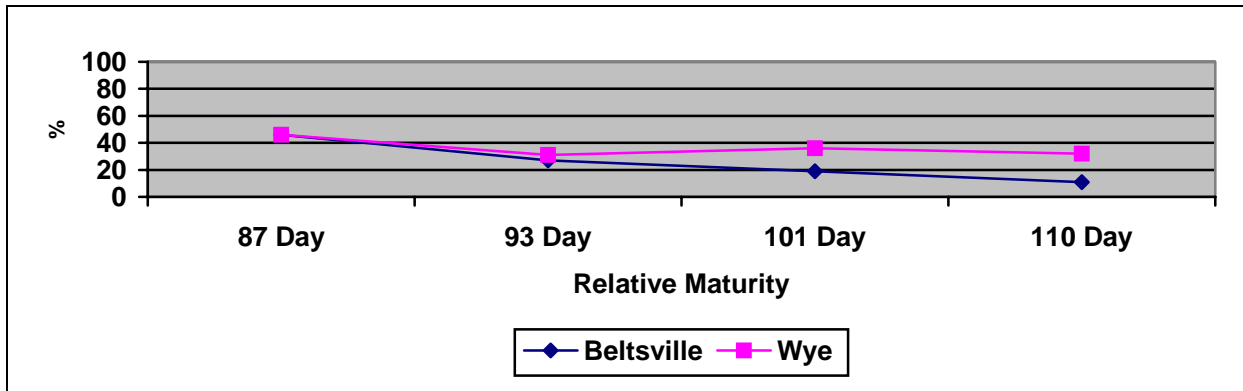


Figure 6. Percentage of lodged corn plants for Bt and non-Bt hybrids that represented four relative maturity groups grown in a double crop study following barley in 2003.

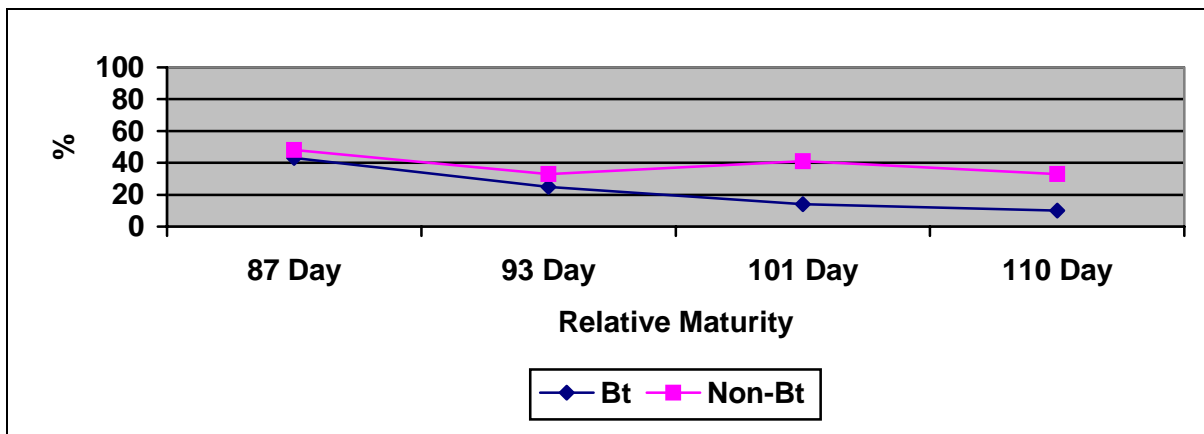
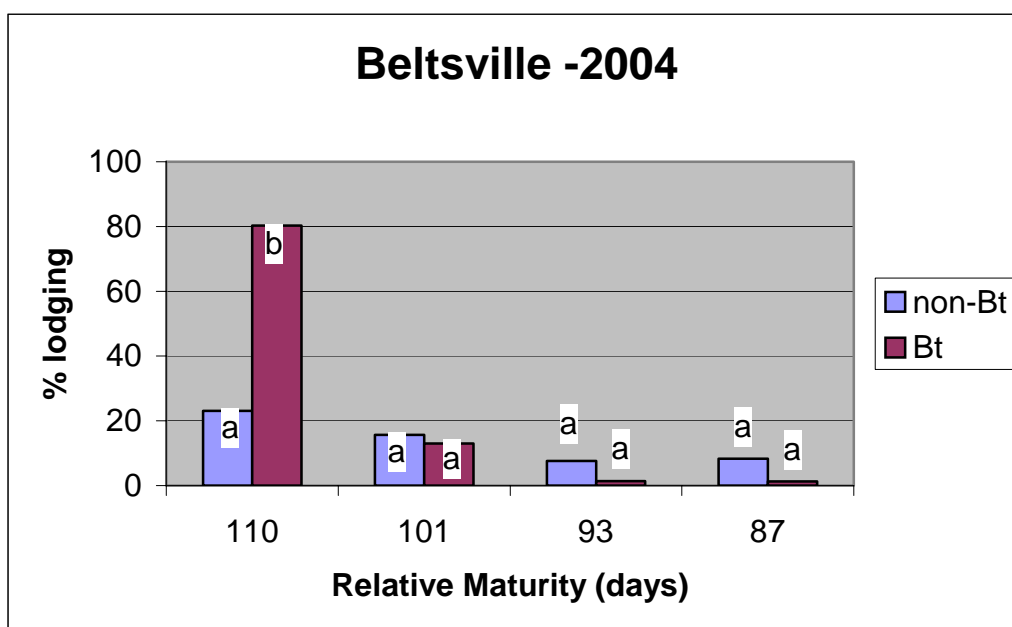
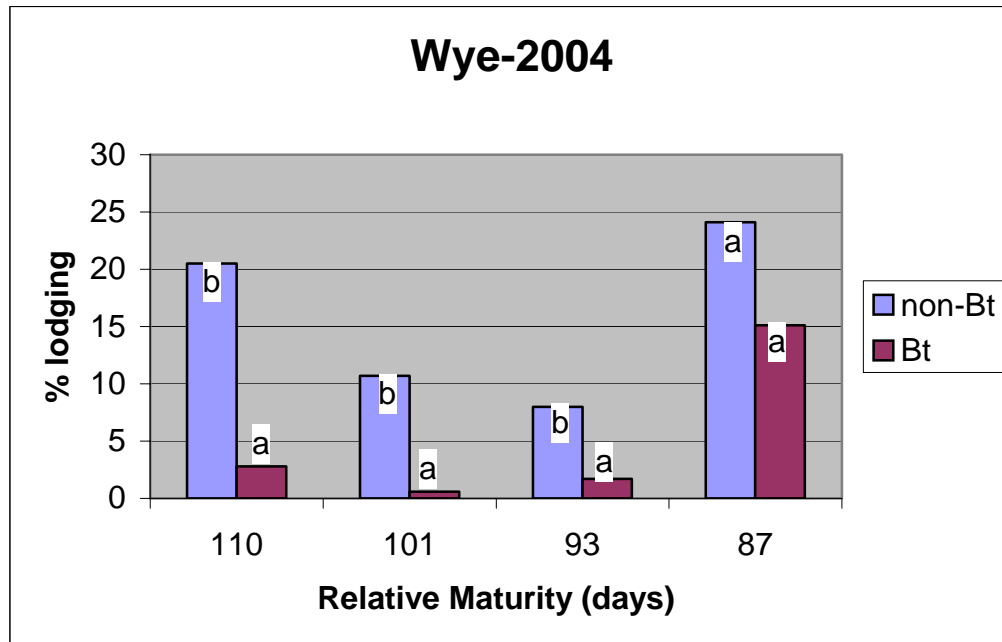


Figure 7. Lodging response for double crop corn at the two locations during 2004 for Bt and non-Bt near isoline hybrids representing four hybrid relative maturity groups. Bars with the same letter within a relative maturity group and location are not different at $p=0.05$.





viable option based upon the performance observed at one location in this study when a late planting date of July 1 produced good (100 bu per acre or greater) corn yields during 2003. In addition, this research supported the findings of others for corn planted late; the Bt technology generally can provide considerable plant health benefits though the choice of hybrid should include evaluation of stalk rot resistance. This research evaluated only a few of the many corn hybrids available to farmers that have both relative maturity and Bt event characteristics that are considered suitable for double crop production. Additional testing of other hybrids under double crop conditions is currently underway in Maryland to provide a broader database for farmers to use for selection purposes. Farmers who consider double crop corn need to calculate the costs incurred with producing corn in this type cropping system prior to making the double crop corn decision.

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Monitoring Plant and Soil Nitrogen Status in a High Yield Corn Environment

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Research Question The pre-sidedress soil nitrate test (PSNT) and the end of season corn stalk N test (CSNT) have been effectively employed in recent decades for improving the N management in field corn. Because there is little known about how well these soil and plant tests perform when corn is grown in a high yield environment, this study was conducted to examine the use and interpretation of PSNT and CSNT testing under the potentially high yielding conditions of narrow row spacing, high plant population, early planting, irrigation, and high soil fertility levels.

Literature Summary The PSNT is used for the purpose of predicting crop need for sidedress N application based on soil test nitrate-N concentrations in the surface 12 inches of soil when corn plants are about 6 to 12 inches tall. The CSNT is used at crop maturity by collecting basal corn stalk tissue for the purpose of determining the post-mortem crop N status. The results of the PSNT provide useful information to corn producers during the growing season while the CSNT provides information for improving N management in future growing seasons. These well established soil and plant testing technologies were developed for use with corn grown at normal yield levels using conventional production practices. They have not been evaluated for narrow row corn production under intensive management.

Study Description Field experiments were conducted in 2003 and 2004 on a sandy loam soil near Adelphia, NJ on land previously cropped to forage legumes. The corn experiments were intensively managed using irrigation, high soil fertility, 15 inch row spacing, and a plant population of 43,560 plants per acre. In addition to 50 lbs/acre of starter N applied with the planter as MAP, sidedress N rates (0, 87.5, 175, and 350 lbs/acre) were split equally between applications when plants were 10 inches and 30 inches tall. The center row of each control plot was soil sampled to the 12 inch depth when the plants were 6 to 12 inches tall. The soil samples were analyzed for ammonium-N and nitrate-N. Stalk samples were collected after grain harvest by cutting the stalk at 6 and 14 inches aboveground from 10 randomly selected plants within the two center rows of each plot. All leaf tissue was removed from the 8 inch stalk samples. The samples were dried at 70 C and ground to pass a 1-mm screen and sent to Brookside Lab for analysis for nitrate-N. Grain yield was determined by harvesting from an area 36 square feet from the center of each plot.

Applied Questions *How well did the PSNT soil test perform with corn grown in narrow rows under intensive management?*

In 2003, the PSNT averaged 18 ppm nitrate-N at the appropriate growth stage for soil sampling. This PSNT soil test level was below the critical level of 25 ppm when sidedress N would be recommended by Rutgers Cooperative Research and Extension. Corn grain yields increased linearly from 229 bu/acre for the zero sidedress treatment to 249 bu/acre for the 350 lbs/acre sidedress treatment. The crop response to sidedress N confirms that a recommendation, based on the PSNT, to apply sidedress N was a correct recommendation. Without sidedressing, however, a relative yield of 92% (control plot yield as a percentage of maximum yield) indicates that the yield response was modest and that this

soil, with a PSNT of only 18 ppm, supplied nearly enough N to achieve a respectable yield level. This is of interest because PSNT critical levels as low as 17 ppm in some regions of the USA have been identified as separating N-deficient from N-sufficient sites but this was based on research conducted at lower yield levels. In 2004, PSNT averaged 28 ppm nitrate-N, but ranged from 16 to 44 ppm among control plots. Grain yields ranged from 239 to 263 bu/acre and suggested a quadratic response to sidedress N. The variability in soil N supply among control plots may explain why a 91% relative yield was not accompanied by a statistically significant yield response.

How well did the CSNT perform with corn grown in a high yield environment?

Concentrations of nitrate in the corn stalks as measured by the CSNT increased with increasing N rate in both years. The previously established CSNT standard of 2000 ppm nitrate-N that is considered adequate for typical corn production practices appear to be appropriate for high yield corn production.

Recommendations

Overall results suggest that the PSNT can be used effectively with corn grown in narrow rows and under high yield management but additional field trials should be conducted to refine PSNT interpretations and recommendations. While the PSNT appears to be helpful for predicting corn responses to sidedress N in high yield environments, the PSNT test may not accurately determine the most economical application rates of sidedress N to apply. In summary, the results of this two-year study suggest that the presidedress soil nitrate test and the end of season corn stalk N test are useful tools when employed with corn grown in narrow row high yield environments. The standards for interpretation of these tests do not appear to differ substantially from that associated with corn grown under typical production practices.

Monitoring Plant and Soil Nitrogen Status in a High Yield Corn Environment

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Introduction

The pre-sidedress soil nitrate test (PSNT) and the end of season corn stalk N test (CSNT) have been effectively employed in recent decades for improving the N management in field corn. The PSNT is used for the purpose of predicting crop need for sidedress N application based on soil test nitrate-N concentrations in the surface 12 inches of soil when corn plants are about 6 to 12 inches tall (Magdoff, 1992; Heckman, 2002). The CSNT is used at crop maturity by collecting basal corn stalk tissue for the purpose of determining the post-mortem crop N status (Binford et al., 1990; Binford et al., 1992). The results of the PSNT provide useful information to corn producers during the growing season while the CSNT provides information for improving N management in future growing seasons. These well established soil and plant testing technologies were developed for use with corn grown at normal yield levels using conventional production practices. Because little was known about how well these tests would perform when corn is grown in a high yield environment, this two year study was conducted to examine the use and interpretation of PSNT and CSNT testing under the potentially high yielding conditions of narrow row spacing, high plant population, early planting, irrigation, and exceptional soil fertility levels. Four levels of sidedress N application were examined.

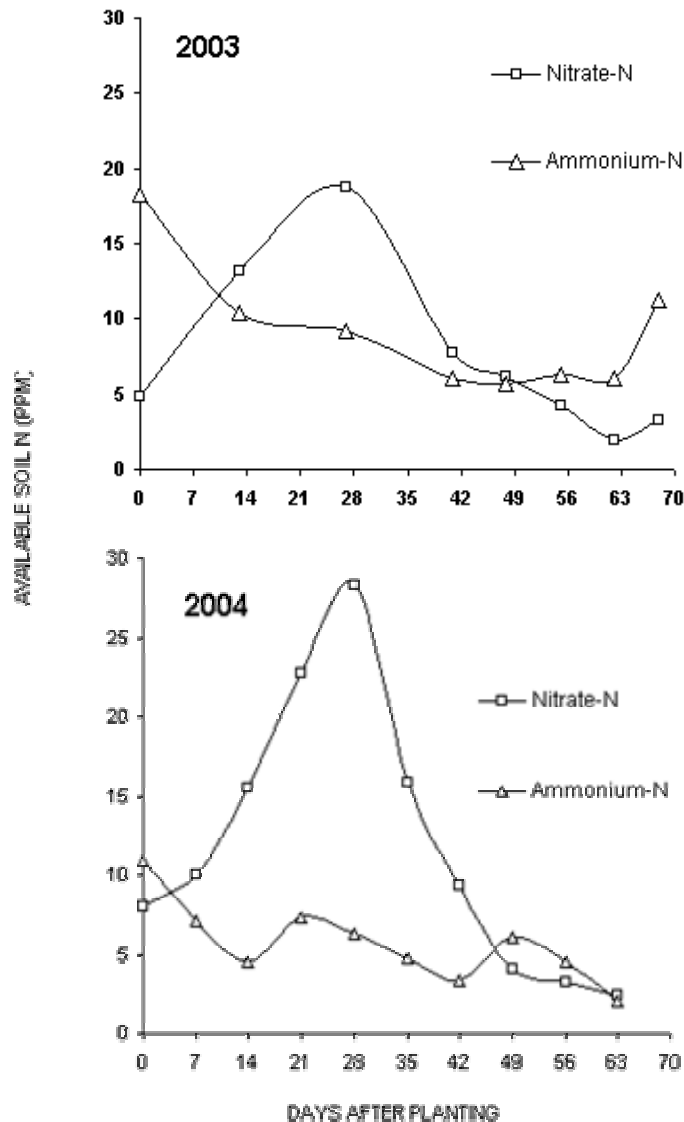
Materials and Methods

Field experiments were conducted in 2003 and 2004 at the Rutgers Plant Science Research Station near Adelphia, NJ on land previously cover cropped with a mixed stand of alfalfa and white clover for two or more years. The soil series at the experimental site was a Freehold sandy loam with an organic matter content of 2.3%. Maximum corn yield research methods were used similar to those developed by Dr. Roy Flannery during the 1980s (Heckman, 1995; Flannery, 1982). The experiment attempted to achieve a minimum stress field environment by use of irrigation and effective control of insects, diseases and weeds. A plant (Pioneer Hybrid 33B51-BT) population of 43,560 plants per acre was established using a near equidistant 15 by 9.6 inch spacing pattern. Planting dates were April 25, 2003 and April 30, 2004. Applications of N, P, and K fertilizer were made at planting and N and K were also sidedressed during the growing season. Nitrogen was banded 2 inches beside and 2 inches below the seed at the rate of 50 lbs/acre to all plots. Sidedress N rates (0, 87.5, 175, and 350 lbs/acre) were split equally between applications when corn was 10 inches and 30 inches tall. The total P application for the season was 100 lbs/acre (229 lbs P_2O_5 /acre). The total K application for the season was 400 lbs/acre (480 lbs K_2O /acre) applied half as preplant and half as sidedress. Boron was broadcast to all plots at 1.5 lbs. B/acre at planting and also sidedressed at 1.5 lbs. B/acre when corn was one foot tall. The N rate treatments were replicated four times in a completely randomized experimental design. Fertilizer materials included monoammonium phosphate, ammonium sulfate, potassium chloride, and borax. The center row of each control plot was soil sampled to the 12 inch depth repeatedly every 14 days from day of planting to approximately time of crop anthesis (Fig. 1). The soil sample that corresponded to the 6 to 12 inch plant growth stage was considered the PSNT sample. The soil samples were analyzed for ammonium-N and nitrate-N at the University of Delaware Soil Testing Laboratory. Stalk samples were collected after grain harvest by cutting the stalk at 6 and 14 inches aboveground from 10 randomly selected plants within the two center rows of each plot. All leaf tissue was removed from the 8 inch stalk samples. The samples were dried at 70 C and ground to pass a 1-mm screen and sent to Brookside Lab in New Knoxville, OH for analysis for nitrate-N. Grain yield was determined by harvesting 36 plants per plot from an area 36 square feet from the center of each plot.

Results and Discussion

The weekly sampling and analysis of the surface 12 inches of soil for concentrations of ammonium-N and nitrate-N from the time of planting to approximately silking, show that these mineral forms of N can change concentration rapidly in the soil under a developing corn crop (Fig. 1). At time of planting ammonium-N concentrations were higher than nitrate-N concentrations. During mineralization of N from soil organic matter, mineral N first accumulates as ammonium-N before it is converted over, or nitrified, to nitrate-N. When soils are plowed and as soil temperature rises in the spring there is typically a flush of mineral N released and nitrified as was illustrated in this data set. At about 4 weeks after planting the accumulation of nitrate-N peaked. This peak occurred in late May or early June when the corn plants were about 6 to 12 inches tall. This growth stage corresponded, as expected, with the recommended stage for PSNT soil sampling. Following this peak, nitrate-N concentrations decreased rapidly as the increasing crop demand for N caused depletion of soil mineral N. Although not measured in this study, presumably mineralization of N from soil organic matter continued but the rate of crop N uptake exceeded

Figure. 1 Concentrations of ammonium-N and nitrate-N in the surface 12 inches of soil from control plots from time of planting to anthesis.



soil mineral N release. This data set provides a good illustration of why the focus of the PSNT is on nitrate-N concentrations at the corn plant growth stage of 6 to 12 inches tall (Magdoff, 1991). The data also underscores the critical nature of soil sampling at the proper growth stage for the PSNT.

In 2003, the PSNT averaged 18 ppm nitrate-N at the appropriate growth stage for soil sampling. This PSNT soil test level is below 25 ppm where sidedress N would be recommended by Rutgers Cooperative Research and Extension (Heckman et al., 1996). Corn grain yields increased linearly from 229 bu/acre for the zero sidedress treatment to 249 bu/acre for the 350 lbs/acre sidedress treatment (Table 1). The crop response to sidedress N confirms that a recommendation, based on the PSNT, to apply sidedress N was a correct recommendation. Without sidedressing, however, a relative yield of 92% (control plot yield as a percentage of maximum yield) indicates that the yield response was modest and that this soil, with a PSNT of only 18 ppm, supplied nearly enough N to achieve a respectable yield level. This is of interest because PSNT critical levels as low as 17 ppm have been identified as separating N-deficient from N-sufficient sites but this was based on research conducted at lower yield levels (Sims et al., 1995).

Table 1. Corn grain yield and end of season stalk nitrate concentration in relation to N application rate.

N Application Banded Sidedress lbs/A	Grain bu/A			Stalk Nitrate-N ppm	
	2003	2004		2003	2004
50 0	229	239		1949	66
50 87.5	239	263		6898	3661
50 175	245	260		8757	5551
50 350	249	253		9490	8316
			P>F		
Treatment	0.0024	0.27		0.0001	0.0027
Linear	0.0003	0.34		0.0001	0.0003
Quadratic	0.2657	0.107		0.0001	0.70
Check vs. Other	0.0007	0.082		0.0001	0.001

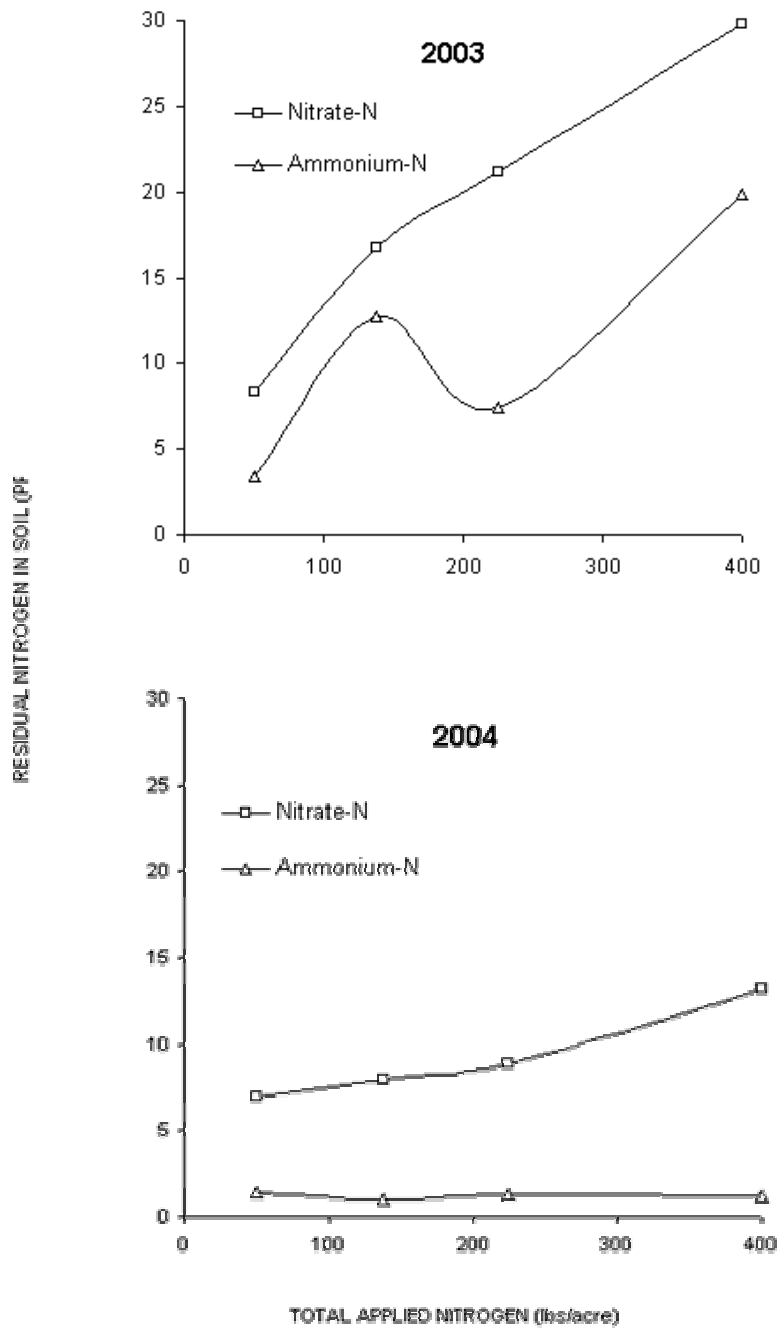
In 2004, PSNT averaged 28 ppm nitrate-N, but ranged from 16 to 44 ppm among control plots, when sampled at the appropriate growth stage. Grain yields ranged from 239 to 263 bu/acre and suggested a quadratic response to sidedress N (Table 1). The variability in soil N supply among control plots may explain why a 91% relative yield was not accompanied by a statistically significant yield response. A grain yield of 239 bu/acre, from the zero sidedress N plots, reflects that a PSNT level of 28 ppm is capable of an impressive yield level.

In both years the PSNT correctly predicted whether or not corn grown in a high yield environment would respond to the application of sidedress N. While the PSNT is useful for making such predictions regarding sidedress N, the PSNT is of limited value for determining the economically optimum sidedress N rate to apply.

From soil sampling at time of grain harvest in 2003 it was apparent that residual levels of mineral N in soil increased with increasing N rates (Fig 2). In 2004, there was no relationship between sidedress N rate and the level of residual N in the soil after harvest. Heavy rainfall received during the 2004 growing season probably caused a major loss of mineral N from the soil.

Concentrations of nitrate in the corn stalks as measured by the CSNT increased with increasing N rate in both years (Table 1). Based on research in Iowa (Binford et al., 1990; Binford et al., 1992), CSNT levels greater than 2000 ppm nitrate-N are considered adequate. By this standard the corn growing with zero sidedress N, had an inadequate supply of N. Grain yield levels in the range of 229 to 239 bu/acre may be impressive for an N application of only 50 lbs/acre, but relative yields near 91% would suggest that the previously established CSNT standard and interpretation correctly indicated that the soil N supply limited corn yield potential.

Figure 2. Concentrations of residual ammonium-N and nitrate-N in surface 12 inches of soil immediately after corn harvest in 2003 and 2004.



Conclusion

In summary, the results of this two year study suggest that the presidedress soil nitrate test and the end of season corn stalk N test are useful tools when employed with corn grown in narrow row high yield environments. The standards for interpretation of these tests do not appear to differ substantially from that associated with corn grown under typical production practices.

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Remote Sensing Estimates of Corn Silage Yield and Nutritive Value

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- Research Question** Can real-time, pre-harvest information on corn silage yield and nutritive value benefit producers by allowing them to more accurately determine necessary harvested acres and allocate silage of differing quality into different storage areas?
- Literature Summary** The amount of light reflected from the plant canopy in the red and near infrared (NIR) bands has been shown to be highly correlated with plant biomass and nitrogen (N) status for many crops, including corn. These values are often used to calculate the normalized difference vegetative index (NDVI), which allows comparison of values across sites and environments. These measurements have been used to estimate N fertilizer needs, but little evidence exists on using this technology to evaluate forage quality and quantity in a real-time basis.
- Study Description** Optical sensor readings used to calculate NDVI were collected using a Greenseeker® sensor manufactured by NTech Industries, Inc. Ukiah, Ca, from hybrid corn silage yield evaluation trials at three locations in Virginia during the 2004 growing season. In total, 42, 55, and 37 hybrids were evaluated at the northern Piedmont, Shenandoah Valley, and southern Piedmont locations, respectively. In all cases, a randomized, complete block design with four replications was used. Plot size was 2 rows (5 feet) by 35 feet. Sensor readings were taken once at each location and growth stage of the corn varied from V8 to V12, depending on site. Plots were harvested at 65% moisture with small farm-scale silage chopping equipment and weighed in the field using electronic scales on mix wagons. A subsample was taken for moisture determination and laboratory analysis. Analysis was performed by Cumberland Valley Analytical Labs, Inc. Crude protein, ADF, and NDF were determined via NIRS analysis.
- Applied Questions**
- Did NDVI values differ by hybrid?*
- No. If NDVI had varied by hybrid, then separate correlations would have been necessary to relate specific hybrids to yield and quality factors. Since values did not differ between hybrids, it appears that NDVI can be used across all hybrids as an indirect measure.
- Was NDVI a good predictor of dry matter yield?*
- No. The relationship between NDVI and final yield was weak for this first year of data (Figure 1). In fact, the correlation coefficient was 0.01 which indicates that there was no linear increase in yield with a corresponding increase in NDVI. One did not predict the other.
- Was NDVI a good predictor of crude protein?*
- Again, the answer is no. The relationship between NDVI and crude protein was extremely weak (Figure 2).

Figure 1. Normalized difference vegetative index (NDVI) versus Yield, 2004.

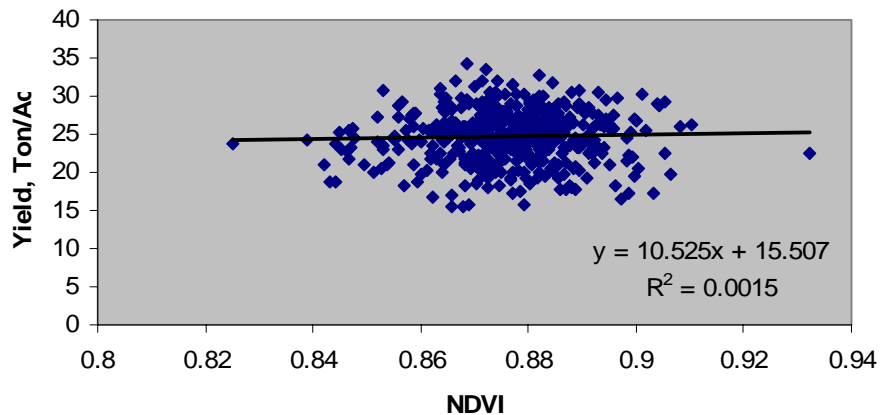
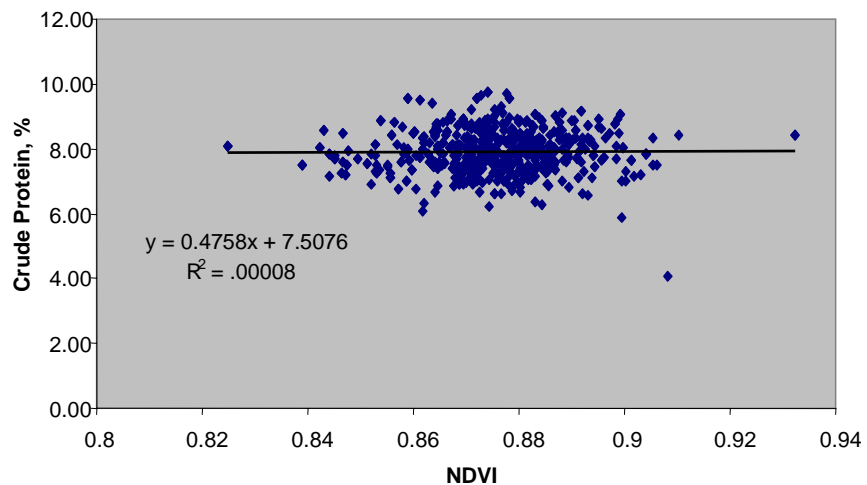


Figure 2. NDVI versus crude protein, 2004.



What about TDN?

The relationship between NDVI and TDN, which is a calculated measure of energy, was higher than that observed for yield or crude protein but was not statistically significant.

What happened? It seems like this should work.

As stated in the study description, NDVI is a ratio of reflected light in the red and NIR ranges. One problem with this index is that as the amount of plant matter in view of the sensor increases, everything is green. With canopy closure the amount of red light reflected is decreased to low levels. This can occur to such a degree that the index is 'saturated' and is not responsive to changes that occur. This has been demonstrated by other researchers working in both wheat and corn where NDVI values greater than 0.80 were found to be non-responsive to change in plant status. Another potential problem is the length of time between sensing and harvest of the crop. Other factors including environment after sensing could have affected final yield and quality results. However, researchers in NE and OK have found NDVI readings from V9 corn to be a good predictor of corn grain yield.

Recommendations

More research is needed before any conclusions are drawn. Initial results indicating that measurements across hybrids are appropriate are encouraging because of the widespread application. The fact that NDVI was not highly correlated with dry matter yield and/or nutritive characteristics is discouraging but the lack of results may be due to the advanced stage of growth at time of sensing in 2004. This work will be continued in 2005 and protocols will be modified so that sensor readings will be taken earlier in the season, when corn leaf area is less. We will also evaluate the use of other wavelengths, specifically those in the green bands, for predictive performance.

Soybean Aphid in New Jersey

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- Situation Statement** The soybean aphid (*Aphis glycines*) is the newest insect pest of soybeans in New Jersey. The soybean aphid is native to Asia. It was first discovered in the mid-western United States during the 2000 growing season. The first reports of soybean aphid in New Jersey were during the 2003 growing season in northern and central portions of the state. The soybean aphid has since spread throughout the state during the 2004 growing season. Researchers do not know how, when, or where this exotic species entered the US. Many growers and their advisors in the state will be making aphid management decisions for the first time. Because of limited experience with soybean aphid in the US, information about management and thresholds continue to evolve.
- Casual Agent or Factor** Soybean aphids are small (~ 1/16 inch), greenish-yellow insects with distinct black cornicles, or “tail-pipes” on their abdomens. The soybean aphid has a complex life cycle that requires two different host plants. The aphid over winters as eggs on buckthorn plants (*Rhamnus* spp.). Nymphs hatch in the spring and after a few generations, winged females search for soybean plants. Visit the North Central Soybean Research Plant Health Initiative website (www.planthealth.info/aphids_basics) for identification information and photos of soybean aphid and buckthorn plants.
- Importance and Impact** Aphids suck fluids (sap) from the soybean plant. Plant damage occurs from large numbers of aphids removing a significant amount of water and nutrients as they feed on leaves and stems. Studies conducted in Michigan, Minnesota and Wisconsin have shown the most important effect of aphid damage on yield was the reduction in the number of soybean pods. Yield may be affected most when soybean plants that are flowering or setting pods are attacked by soybean aphid. The soybean aphid is also capable of spreading viruses that infect soybeans such as alfalfa mosaic, soybean mosaic, tobacco ring spot (bud blight) and soybean dwarf virus. Currently, it is not definitively known when the soybean aphid will begin its migration from buckthorn to soybean in New Jersey. Experience in Pennsylvania has shown the arrival timing of soybean aphids to be very close to what has been observed in the Midwest over the last few years. During late June to early July, crop consultants and producers need to start scouting to determine the aphid pressure in fields.
- Recommendations** The soybean aphid is very new to North America and experience managing this insect is limited. As a result treatment thresholds continue to evolve. The current economic threshold used is 250 aphids per plant if the aphid population is increasing. Research has shown this threshold to work well when plants are in the late vegetative or early reproduction stages (R1 – R4). This threshold has been designed to include a seven day lead time before the aphid population would be expected to exceed 1,000 aphids per plant, the population expected to cause economic damage. This lead time also allows growers to acquire spray materials and schedule custom applications. Recent studies have shown no benefit to spraying after the plants have reached the R4 (full pod) growth stage. Soybean aphids have numerous natural enemies, however, the lady bird beetle appears to be the most common. It has been reported that lady bird beetles can eat 180 aphids per day. These predators may keep low or

moderate aphid populations under control. Comparing population trends of natural enemies with that of the soybean aphid can help in determining control needs. The importance of predators for aphid control was clearly demonstrated during the 2004 growing season at the Rutgers Snyder Research and Extension farm. During early July soybean aphids were encountered on soybean fields at the research farm at populations of 250 aphids per plant. The presence of adult and larval lady bird beetles was noted at the time. During a second visit 4 days later to the same fields aphid populations were near non-existent and a large population of lady bird beetles was present. The natural control of the soybean aphids by lady bird beetles eliminated the need for an insecticide application. This shows the importance of scouting when making spray decisions. Spraying too early may be unwarranted and negatively impact the population of beneficial insects.

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