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RESPONSE OF SELECTED PLANT CHARACTERISTICS OF A *NORMAL* AND A *SHRUNKEN-2* SWEET CORN CULTIVAR TO FERTILIZER NITROGEN

A Thesis

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Degree

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ABSTRACT

In 1986 and 1987, 'Silver Queen' and 'How Sweet It Is' sweet corn cultivars were grown using three rates of nitrogen fertilization at the Plateau Experiment Station, Crossville, Tennessee. The nitrogen rates were 100, 135, or 200 kg•ha^{-1} in 1986 and 67, 135, or 200 in 1987. Yield in dozens, yield in weight, ear weight, plant height, stalk diameter, ear height, plant stand, ear number per plant, tissue nitrogen concentration, ear length, ear diameter, and percent grain, plus pH and °Brix of kernel extract and firmness of kernel pericarp tissue were measured during both years.

More rainfall was received early in the 1987 season than in 1986, with more uniform distribution throughout the year. Growing degree day accumulation differed little between the two years with 23 more days in 1986 than in 1987. Overall, climatic conditions appeared to have little effect on the results between years.

In 1986, 'How Sweet It Is' out-yielded 'Silver Queen' in ear number, total weight, individual ear weight, and ear number per plant, and had larger diameter ears. 'Silver Queen' grew taller and larger in stalk diameter, set ears higher, had longer ears, plus had a higher pH and °Brix of kernel extract and firmness of kernel pericarp tissue than did 'How Sweet It Is'.

In 1987, 'Silver Queen' yielded more in ear number, total weight, individual ear weight, grew taller, set ears higher, had a higher plant density and had a higher pH and °Brix reading for kernel

extract than did 'How Sweet It Is'. 'How Sweet It Is' had a higher ear leaf nitrogen concentration than 'Silver Queen'.

The cultivar differences between years appears to be related to the quality of the 'Silver Queen' seed used in 1986. The overall vigor of the plants was much lower and not typical of the cultivar in 1986, while in 1987 the seeds germinated more consistently and the plants had a vigorous appearance throughout the growing season.

Nitrogen fertilization had little effect on any of the characteristics measured. Perhaps the organic matter plowed into the soil each spring provided enough nitrogen, from mineralization throughout the growing season, to mask the effects of added nitrogen.

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CHAPTER I

INTRODUCTION

Recently, there has been an increased interest in the production of vegetable crops, such as sweet corn (Zea mays var. rugosa L.). Extension personnel have reported that 1500 acres of sweet corn were grown in Tennessee in 1987 and this acreage is expected to increase. This increase is a result of some farmers need for an alternate crop that will produce a reasonable return per acre.

Economics plays an integral part in the level of fertilizer usage. Today's farmers are more cognizant of the need to place more emphasis on the return per unit of fertilizer input than simply striving for maximum yield.

The possibility of excess nitrate accumulation in the soil profile needs to be considered as nitrogen useage increases. Often, large amounts of nitrate remain in the soil unneeded by the plants to produce a crop. Should nitrates be allowed to accumulate, a potential for ground water contamination will exist and the problems associated with nitrate pollution will escalate.

Increased interest has been shown in the use of the new 'super sweet' (shrunken-2) cultivars that have a sweeter flavor than the normal cultivars. Also, the shrunken-2 cultivars are able to retain their quality for a longer time than the normal cultivars but the shrunken-2 cultivars are not without their disadvantages. Much concern exists because of a lack of vigor inherent in the small seeds of the shrunken-2 cultivars which often translates to poor germination and lower yields than the normal cultivars. Because of the increased interest in the newer sweet corn cultivars and because there has been little recent research conducted with the nitrogen requirements of sweet corn in Tennessee, an experiment was established with the following objectives. They are:

1. To determine if differences in yield, quality and selected plant characteristics between a normal and a shrunken-2 cultivar exist.
2. To determine the effects of fertilizer nitrogen on yield, quality, and selected plant characteristics of hybrid sweet corn cultivars.

CHAPTER II

LITERATURE REVIEW

As early as 400 B.C. historians reported that use of manure or green manure crops increased the productivity of the soil. Zenophon (430-355 B.C.) recorded green manure crops enriched the soil nearly as much as manure, while Cato (234-149 B.C.) wrote a handbook describing the use of animal manure and legumes to improve soil productivity (6).

These early findings were then lost to the world throughout the dark ages, and little research was conducted on determining plant nutrient needs until 1731 when Jethro Tull found that nitrate salts were essential for plant growth. In the remainder of the 18th and the 19th centuries, investigators like Home, Liebig, Lawes, and Gilbert demonstrated that nitrogen was an essential element for plant growth (6).

From these findings, early researchers such as Justus von Liebig found that the initial amount of added nitrogen produced a rather large growth response, which caused many producers to believe that ever larger amounts of added nitrogen should be equally as beneficial. Subsequent research has proved that incremental increases of nitrogen cause yield to rise to a level where the next increment of nitrogen has little effect on yield. At this point yield response disappears and may actually decline if excess nitrogen is added. Evidence of this trend was shown by Mack (11). In 1966, he found that yields of 'Jubilee' sweet corn increased as the nitrogen rate increased as high as 224 $kg \cdot ha^{-1}$, but decreased when the nitrogen rate reached 448 $kg \cdot ha^{-1}$. Ear weight and ear number per plant were unaffected by nitrogen rate. Data reported in 1968, showed ear number per plant at the 392 $kg \cdot ha^{-1}$ rate was higher than at the 168 $kg \cdot ha^{-1}$ rate of nitrogen, but no difference was reported between the rates for yield or ear weight (11).

Similar experiments have confirmed Mack's findings that sweet corn yields increased up to 224 $kg \cdot ha^{-1}$ of nitrogen. Rudert and Locascio reported higher sweet corn yields as nitrogen, applied in the ammonium sulfate form, increased from 56 to 224 $kg \cdot ha^{-1}$ in 1976. In 1977, nitrogen applied both as ammonium sulfate and calcium nitrate forms caused elevated yields. Nitrogen concentrations in plant tissue eleven weeks after fertilization were found to increase as the sulfate form of applied nitrogen increased to 224 $kg \cdot ha^{-1}$ for both years, while differences in the rate of calcium nitrate were found only during the 1977 growing season (23). In 1976 and 1978, Tabor and Cox reported increases in both the yield and ear leaf nitrogen concentrations of sweet corn as the nitrogen rate increased from 56 to 224 $kg \cdot ha^{-1}$ (28).

In a wheat, turnip, and sweet corn sequential cropping study, Sammaneechai found sweet corn yields increased up to only the 135 $kg \cdot ha^{-1}$ rate, while nitrogen uptake continued to increase up to an application of 180 $kg \cdot ha^{-1}$. Residual nitrogen was found to elevate yield and nitrogen uptake of sweet corn with the greatest response resulting from applications of nitrogen to both wheat and turnips.

Nitrogen mineralization was found to be an important factor in the nitrogen uptake of crops as the total nitrogen uptake for all three crops was greater than the total nitrogen applied (24).

Soil organic matter decomposition at a rate of one to two percent per year results in a nitrogen mineralization rate of 22-44 $kg \cdot ha^{-1} \cdot year^{-1}$ (10). Soil organic matter decomposition rate is greatest in warm, well-aerated, moist soils (6).

Smith at Pennsylvania State University showed an increase in the yield of the sweet corn cultivar 'Deep Gold' with nitrogen rates up to 112 $kg \cdot ha^{-1}$, but no yield difference was found with the 'Northern Bell' cultivar beyond the 56 $kg \cdot ha^{-1}$ rate. When the cultivar data was combined, plant height, yield in weight, and tissue nitrogen concentration was found to increase as nitrogen rate rose to 112 $kg \cdot ha^{-1}$. Ear length and ear weight were unaffected by nitrogen applications above 56 $kg \cdot ha^{-1}$ (25).

In contrast to previous experiments, there has been research showing that nitrogen fertilization rate has little or no effect upon sweet corn yields. In the southern Alberta province of Canada, Freyman found no difference in the yield and ear length of sweet corn when nitrogen rates increased from 50-100 $kg \cdot ha^{-1}$ (6). Moss and Mack found yield, plant height, ear length, and ear weight of sweet corn increased when nitrogen fertilizer was applied, but no differences in any of these characteristics were noted above 56 $kg \cdot ha^{-1}$. However, stalk diameter was found to increase as nitrogen rate increased to 112 $kg \cdot ha^{-1}$ (14).

At the Plateau Experiment Station, Mullins and Coffey, working with tomatoes, found no yield response as nitrogen rate increased from 75-135 kg•ha^{-1} (17). Work at this location with Bush Blue Lake snap beans gave somewhat erratic results. In 1972, in evaluating the nitrogen requirements of this crop, a yield increase to nitrogen occurred only from the first incremental rate (17 kg•ha^{-1}). No response to nitrogen fertilization was obtained in this experiment in 1973, however (3). Mullins et al. also reported that the highest yields of snap beans were obtained at N rates ranging from 22-45 kg•ha^{-1} (16). Later research from the Plateau Experiment Station again showed no differences between the 17 and 67 kg•ha^{-1} rates of nitrogen (18).

In a corn, wheat, and red clover rotation cropping system, Parks and Odom did not find any yield response to nitrogen above 67 kg•ha^{-1}, indicating that the corn used some nitrogen that was fixed by the red clover (20). Other corn yields at this location have been reported to increase from nitrogen rates up to 135 kg•ha^{-1} for selected crosses, however when the yields of selected inbred lines were evaluated, no nitrogen response was obtained above 67kg•ha^{-1} (1).

In the State of Tennessee, the recommended nitrogen rate for sweet corn is 100 kg•ha^{-1} applied at planting and 35 kg•ha^{-1} applied as sidedressed for a total of 135 kg•ha^{-1} (29). The neighboring state of North Carolina recommends 34-56 kg•ha^{-1} applied at planting and an additional 90-112 kg•ha^{-1} added as sidedressed nitrogen (19). Indiana researchers recommend 135 kg•ha^{-1} broadcast and tilled into the soil with an additional 12 $kg{\cdot}ha^{-1}$ of nitrogen banded in the row at planting (22).

Nitrogen fertilization also influenced the plant in ways other than through yield characteristics. Tesha and Eck found that increasing nitrogen rate on sweet corn seedlings partially compensated for a decrease in dry-matter accumulation resulting from water stress. The plants receiving an eight millimolar nitrogen solution showed similar dry matter production across both moderate and high levels of water stress, indicating that this low rate may be adaquate in helping plants survive (30).

Another factor affecting the yield of sweet corn is the lack of germination. Compared to field corn, the germination of sweet corn seed of most genotypes is low, but this characteristic is especially striking in the shrunken-2 hybrids such as 'How Sweet It Is' and 'Crisp and Sweet'. Gunzman, Wolf, and Martin showed a significant linear decrease in the yield of U.S. Fancy ears (a marketable grade) as the germination percentages of the seed decreased (9).

Water stress has been linked to a decrease in the seed quality and size of sweet corn seed. Chotena et al. showed that water stress at silking decreased both yield components and seed quality characteristics. Also, seed size was influenced by all water deficits occuring after tasseling (2). El-Forgany and Makus reported a significant decrease in both seed yield and seed vigor when water stress occurred at silking (7).

Lack of germination has been thought to be linked to the amount of leakage of ATP and other seed components. Damage to the pericarp and the breakdown in the integrity of membranes may be responsible for this leakage. Wann found that protein leakage was greater in the _shrunken-2_ genotypes than in the _sugary_ genotypes suggesting that the seed pericarps and membranes of the _shrunken-2_ genotypes may be more susceptible to damage during harvest and drying than the _sugary_ genotypes (33). This was also reported by other researchers who found that during imbibition, mature seeds of _shrunken-2_ genotypes had a higher rate of leakage than did seeds of _sugary_ genotypes (27).

Other seed characteristics include a lower total polysaccharide content in the _shrunken-2_ genotype as compared to most other genotypes. Styer and Cantliffe found that dry seeds of a _shrunken-2_ cultivar contained less total carbohydrates than a _sugary_ cultivar (27). Styer et al. reported 50% less total polysaccharides in the _shrunken-2_ genotype than was found in the _sugary_ and _normal_ genotypes, while germination, germination rate, radicle length, fresh weight, and dry weight of the _shrunken-2_ genotype were found to be lower than the other genotypes (26). Michaels and Andrews showed that kernel polysaccharide content of early and medium harvests was affected by temperature, while late harvest was unaffected. The sucrose content of the kernal was high while the reducing sugar content was found to be low during warm seasons. The opposite was true during cool seasons. Total sugar in the kernel of the _shrunken-2_ genotype was found to be higher than that found in the _sugary_ genotype (13).

Collins et al. showed the sugar content was higher in 'Silver Queen' with a °Brix reading of 19.1 as compared to 'Summer Sweet

8601' (same genotype as 'How Sweet It Is') at 11.5 (4). According to J.R. Mount (15) 'Silver Queen' and 'How Sweet It Is' grown at the Plateau Experiment Station were found to contain 22.3 and 15.2 °Brix at harvest, respectively. However, 'How Sweet It Is' was found to have three times more sucrose than 'Silver Queen', which may result in the sweeter flavor of the 'super sweet' cultivars. The higher °Brix reading for 'Silver Queen' may be explained by the content of soluble starch and the enzymatic breakdown of non-soluble starch which are not present in the *shrunken-2* cultivar.

CHAPTER III

MATERIALS AND METHODS

The experiment was established on a Lonewood silt loam (Typic Halpudult) in 1986 and repeated on the same site in 1987, near the Plateau 4-H camp located four miles west of Crossville, Tennessee. The Lonewood series is a deep well-drained soil, loamy in texture, and well distributed on the Cumberland Plateau (32).

In both years, 'Silver Queen', a normal sugary cultivar and 'How Sweet It Is', a shrunken-2 cultivar of sweet corn were grown at three levels of nitrogen. The nitrogen rates used in 1986 were 100, 135, and 200 kg•ha^{-1}. Nitrogen rates of 67, 135, and 200 kg•ha^{-1} were applied to the plots in 1987. In both years, 67 kg•ha^{-1} of nitrogen as ammonium nitrate was banded near the row at seeding. Additional applications were applied as a sidedressing 30 days after emergence when the 'Siver Queen' plants were approximately 45 cm in height and the 'How Sweet It Is' plants were about 35 cm. In 1986, the plots received a sidedressing of 33, 68, and 133 kg•ha^{-1} of nitrogen on the 100, 135 and 200 kg•ha^{-1} plots, respectively. In 1987, the rates were changed to 0, 68, 133 kg•ha^{-1} sidedressed on the 67, 135 and 200 kg•ha^{-1} plots, respectively.

A randomized complete block experiment was employed with a split-plot factorial arrangement of treatments. The two cultivars of sweet corn were the main plots and the three rates of nitrogen were the subplots. The original design included an irrigation variable, but because of a lack of an irrigation response in 1986 and not needing supplemental water in 1987, the irrigation variable was dropped thus increasing the number of replications from four to eight. The analysis of variance table for this experiment is given in the Appendix (Table A-1). It was used to analyze each years results separately because of the different nitrogen rates employed each year. A separate analysis of variance was used in determining year and cultivar effect, and any interactions that might have occurred.

The combined 1986 and 1987 data were analyzed using the analysis of variance table in the Appendix (Table A-2). It was used for all interactions, including those of year times cultivar, year times nitrogen, cultivar times nitrogen, and year times cultivar times nitrogen.

The Student-Newman-Keuls test was used for separating the cultivar means if the analysis of variance showed a significant Fisher F at the .05 level of probability. Significant nitrogen effects at the .05 level of probability were analyzed using the Linear, Quadratic, and Cubic method of regression.

Main plot size was 20.7 meters long and 5.8 meters wide and subplots were 6.1 meters long and 5.8 meters wide with an alley 1.2 meters long between each bordering main and subplot. The 5.8 meters width allowed for six 96 cm rows of which the four center rows were harvested.

In 1986, all plots were planted on May 5 with a two-row International 185 plate type planter. The planter was set on 96 cm

The initial rate of nitrogen and all of the phosphorus and potassium were banded near the row at planting at the rate of 67 $kg \cdot ha^{-1}$ of nitrogen, 30 $kg \cdot ha^{-1}$ of phosphorus and 56 $kg \cdot ha^{-1}$ of potassium.

On May 6, butylate was applied pre-emergence at a rate of 2.24 kg $ai \cdot ha^{-1}$ for weed control.

Due to poor germination all plots were sprayed with paraquat on June 2 and replanted June 3. Plants that germinated from the first planting date, after spraying were removed by hand.

Nitrogen fertilization was completed on July 15 with the addition of ammonium nitrate as a sidedressing. The sidedressed nitrogen rates were 33, 68, and 133 $kg \cdot ha^{-1}$ to bring the total nitrogen rates to 100, 135, and 200 $kg \cdot ha^{-1}$.

Insect control began at silking. Fenvalerate, permethrin, or methomyl were applied every three to five days as recommended. Spraying was continued until harvest.

In 1986, a once-over harvest was conducted for each cultivar. 'How Sweet It Is' was harvested on August 19 and 'Silver Queen' was harvested on August 20.

In 1987, all plots were planted June 9. The seeding rate for 'Silver Queen' was the same used in 1986, 15 cm, but 'How Sweet It Is' was seeded at a rate to allow 10 cm between seeds due to poor germination experienced in 1986.

The initial rate of nitrogen and all of the phosphorus and potassium were banded near the row at planting at the rate of 67

$kg \cdot ha^{-1}$ of nitrogen, 30 $kg \cdot ha^{-1}$ of phosphorus, and 56 $kg \cdot ha^{-1}$ of potassium.

Pendimethalin was applied as a pre-emergence herbicide at a rate of 1.12 kg $ai \cdot ha^{-1}$ on June 10.

Stand counts were taken on July 16 and all 'Silver Queen' plots were thinned to 1 plant every 30 cm. 'How Sweet It Is' plots were not thinned due to poor germination. Sidedressed nitrogen treatments were also applied on this date. Banded sidedressed rates of 0, 68, and 133 $kg \cdot ha^{-1}$ were applied to bring the total nitrogen rates up to 67, 135, and 200 $kg \cdot ha^{-1}$.

Fenvalerate and permethrin were used for insect control starting at silking according to the label. Spray treatments were continued until harvest.

Two harvests were conducted in 1987 due to erratic germination and non-uniform ripening of either cultivar. The first harvest of 'How Sweet It Is' was August 21 and the second August 26. "Silver Queen' was harvested on August 24 and 26.

In both years prior to harvest, ear leaf samples were taken at silking to determine ear-leaf nitrogen content. The samples were dried soon after collection in a forced air oven at 65 °C and ground in a Wiley mill with a 10-mesh screen. After wet-digestion samples were analyzed according to Thomas et al. (31). Nitrogen concentation of the digestate was analyzed by a Technicon continuous flow analyzer.

At harvest, the number of marketable ears were counted and weighed to determine yield. Individual ear weight was calculated by dividing the number of ears into the total weight of the ears. Percent stand was calculated by dividing the total number of plants for each 4 row plot by 80 and multiplying by 100. Ear number per plant was calculated by dividing the total number of plants for each 4 row plot into the total number of marketable ears for that 4 row plot.

A sample of 2 dozen ears was taken from each plot for ear characteristic evaluation and laboratory analysis. An average ear length and ear diameter was determined from an ear subsample. Six representative ears were then taken from each two dozen ear sample and weighed. Each ear was then shucked and weighed again. The grain was then removed with a knife and weighed to determine the percent grain.

The grain was used for laboratory analysis. A subsample was taken to determine pericarp firmness on a Food Technology Corporation Texture Press. Pericarp firmness was measured to estimate palatability. The extract collected from this procedure was then used to determine °Brix and pH. °Brix was determined on a Bausch and Lomb hand held refractometer. The extract pH was determined on a Fisher Accument* 800 pH meter.

Plant characteristics were evaluated from measurements taken at harvest. These measurements included plant height, stalk diameter, and ear height.

CHAPTER IV

RESULTS AND DISCUSSION

Climatological data collected at the Plateau Experiment Station, Crossville, Tennessee, in 1986 and 1987 showed few differences in the growing conditions. There was some additional rainfall early in the 1987 season as compared to 1986, but moisture conditions were not yield limiting in either year. Harvest was completed in 77 days in 1986 and 78 days in 1987, a difference of only 23 growing degree days (Table 1). Growing degree day accumulation has been found to differ considerably with varying physical and environmental conditions. Phillips suggested that soil type, slope, drainage, depth of planting, plant stand, seed vigor, and drought all influenced the accumulation of degree hours (21). Production guidelines for the Continental Can Company have considered the effects of drought, light intensity, length of day, humidity, and rainfall when predicting the time between planting and harvest (5). Magoon and Culpepper suggested that rainfall influenced the time period from planting to maturity (12). Precipitation was 161 mm and 180 mm for 1986 and 1987, respectively, with a more even distribution in 1987 than in 1986 (Table 1).

In 1986, 'How Sweet It Is' had significantly higher ear numbers total yield in weight, and individual ear weights than 'Silver Queen', but in 1987, the reverse was true. 'Silver Queen' outyielded 'How Sweet It Is' in all three components (Table 2). Due to a highly

Table 1. Growing degree days (GDD) and precipitation at Plateau Experiment Station during the 1986 and 1987 growing seasons.

Time	GDD[x]		Precipitation mm	
Week	1986	1987	1986	1987
1	119	121	36	18
2	109	123	3	32
3	127	102	0	10
4	132	128	5	51
5	122	135	41	32
6	146	113	33	0
7	159	150	2	0
8	167	146	0	20
9	124	147	14	6
10	133	126	18	10
11	131	133	9	1
12	---	22	--	0
Total	1469	1446	161	180

[x] Base temperature of 55° F (12.8° C).

Table 2. Effect of cultivar and nitrogen level on yield and ear weight of hybrid sweet corn in 1986 and 1987.

Treatment	Yield						Ear Weight		
	Dozen•ha^{-1}			kg•ha^{-1}			grams		
	1986	1987	mean	1986	1987	mean	1986	1987	mean
Cultivar									
Silver Queen	2331b*	4100a	3216	7322b	14144a	10734	261b	287a	274
How Sweet It Is	3161a	2855b	3008	10696a	7553b	9125	280a	221b	251
N Level kg•ha^{-1}									
67	----	3444a	----	----	10682a	----	---	253a	---
101	2819a	----	----	9157a	----	----	269a	---	---
135	2594a	3532a	----	8572a	11052a	----	273a	255a	---
202	2826a	3457a	----	9298a	10812a	----	271a	254a	---

* Means in a column within main and subplot treatments followed by the same letter are not significantly different at the .05 level of probability.

significant year by cultivar interaction, the means of the yield components across years were not separated. Interaction means are shown in Table 3. The interaction that occurred between cultivar and year resulted from the higher yield of 'Silver Queen' over 'How Sweet It Is' in 1987, a reversal of that found in 1986. This yield increase exhibited by 'Silver Queen' in 1987 may be due, in part, to a slight increase and better distribution of rainfall that year (Table 1). Unfortunately, this does not explain the lower yields of 'How Sweet It Is' in 1987. Variability in plant stand between 1986 and 1987 may partially explain the yield differences. In 1987, there was a 25 percent increase in the plant stand of 'Silver Queen' and an eight percent decrease in the stand of 'How Sweet It Is' (p. 24). This stand reduction with 'How Sweet It Is' occurred despite a nearly 300 percent overplanting of the desired population.

There was a definite lack of vigor in the 1986 'Silver Queen' seedlings that was not noted in 1987. Seed company representatives have reported that seed from the 1986 lot may have been damaged by frost. This damage may explain some of the differences in vigor between the 1986 and 1987 'Silver Queen' seedling growth and subsequent yields.

Nitrogen fertilization rate had no effect on ear numbers, total weight, or individual ear weight in 1986 or 1987 (Table 2). These results agree with research reported by Smith where 'Northern Bell' sweet corn did not respond to nitrogen rates above 56 $kg \cdot ha^{-1}$ (25), and with the findings of Moss and Mack who found no yield differences of sweet corn among nitrogen rates of 56, 112, or 224 $kg \cdot ha^{-1}$ (14).

Table 3. Interaction effects between years, cultivars, and among nitrogen levels on the yield and ear weight of hybrid sweet corn in 1986 and 1987.

Interaction	Yield		Ear Weight
	dozen•ha^{-1}	kg•ha^{-1}	grams
Year x Cult	**	**	**
Year x Nit	NS	NS	NS
Cult x Nit	NS	NS	NS
Year x Cult x Nit	NS	NS	NS

(**) Indicates significance at the .01 level of probability.

Ashburn, investigating the response of inbred corn varieties to nitrogen, also found no yield increase to nitrogen rates above 67 $kg \cdot ha^{-1}$ at the Plateau Experiment Station (1). In a wheat, red clover,and corn rotation, Parks and Odom (20) also found no yield response of corn to nitrogen rates greater than 67 $kg \cdot ha^{-1}$.

During both years of this sweet corn study, the plants were grown on newly turned soil consisting of fescue and red clover cover plowed in the spring. The decomposition of the organic matter originating from the sod may have supplied sufficient nitrogen throughout the growing season to minimize the effects of fertilizer nitrogen. These results agree with those reported by Sammaneechai who worked in a wheat, turnip, and sweet corn sequential cropping study. He found residual nitrogen from the previous cropping year that became available during the subsequet growing season played a major role in the amount of nitrogen available to plants (24).

At no time during this experiment were plant characteristics such as height, stalk diameter, and ear height affected by added nitrogen (Table 4). Moss and Mack also reported that plant height was unaffected by nitrogen rates greater than 56 $kg \cdot ha^{-1}$, but they did measure significant increases in stalk diameter up to 112 $kg \cdot ha^{-1}$ (14). However, in a similar study, Smith found an increase in plant height up to 112 $kg \cdot ha^{-1}$, but no differences in stalk diameter (25).

A highly significant year by cultivar interaction occurred for both plant height and ear height (Table 5). This interaction resulted from shorter stalks of 'How Sweet It Is' in 1987 compared to 1986, which may have been a result of less seedling vigor in 1987

Table 4. Effect of cultivar and nitrogen level on plant height, plant diameter, and ear height of hybrid sweet corn in 1986 and 1987.

Treatment	Plant Height m 1986	1987	mean	Plant Diameter cm 1986	1987	mean	Ear Height m 1986	1987	mean
Cultivar									
Silver Queen	2.2a[x]	2.1a	2.1	2.6a	2.4a	2.5a	0.9a	0.8a	0.8
How Sweet It Is	1.9b	1.5b	1.7	2.3b	2.7a	2.5a	0.6b	0.4b	0.5
N Level $kg \cdot ha^{-1}$									
67	---	1.8a	---	---	3.2a	---	---	0.6a	---
101	2.1a	---	---	2.4a	---	---	0.7a	---	---
135	2.0a	1.8a	---	2.4a	2.2a	---	0.7a	0.6a	---
202	2.0a	1.8a	---	2.4a	2.3a	---	0.7a	0.6a	---

[x] Means in a column within main and subplot treatments followed by the same letter are not significantly different at the .05 level of probability.

Table 5. Interaction effects between years, cultivars,and among nitrogen levels on plant height, plant diameter, and ear height of hybrid sweet corn in 1986 and 1987.

Interaction	Plant Height m	Plant Diameter cm	Ear Height m
Year x Cult	**	NS	**
Year x Nit	NS	NS	*
Cult x Nit	NS	NS	NS
Year x Cult x Nit	NS	NS	NS

(*) Indicates significance at the .05 level of probability.
(**) Indicates significance at the .01 level of probability.

(Table 4). There appeared to be an overall lack of plant vigor in the 1987 'How Sweet It Is' seedlings as compared to those in 1986. In addition, a significant year by nitrogen interaction occurred as a result of an overall shorter stalk of both cultivars in 1987 (Table 5).

'Silver Queen' was taller and set ears higher than 'How Sweet It Is' both years. Stalks of 'Silver Queen' were larger in diameter than stalks of 'How Sweet It Is' in 1986, but there was no difference between the cultivars in 1987. The mean diameter across years for each cultivar was the same at 2.5 cm (Table 4).

In 1986, there was no difference between the number of plants per hectare for both cultivars. In 1987 'Silver Queen' had a 100 percent stand (34,000 plants•ha^{-1}) while 'How Sweet It Is' had only a 66 percent stand although almost 100,000 seeds per hectare were planted (Table 6). The stand differences between year and cultivars resulted in a highly significant year by cultivar interaction (Table 7). Nitrogen fertilization rate had no effect on plant stand for either year (Table 6). The persistent difficulties in obtaining an optimum stand for 'How Sweet It Is' may be due in part to the leakage of seed components during imbibition as described by Wann (33) and Styer and Cantliffe (27).

The number of ears per plant was also unaffected by added nitrogen for both years (Table 6), but a significant year by nitrogen interaction occurred (Table 7). This interaction appeared to be a result of plot variation in 1986 that did not occur in 1987. There was a significant year by cultivar interaction for ear number per

Table 6. Effect of cultivar and nitrogen level on plant stand, ears per plant, and N concentration of hybrid sweet corn in 1986 and 1987.

Treatment	Plant Stand %			Ears per Plant			N Concentration %		
	1986	1987	mean	1986	1987	mean	1986	1987	mean
Cultivar									
Silver Queen	75a[z]	100a	88	1.1b	1.5a	1.3	2.6a	2.3b	2.4b
How Sweet It Is	74a	66b	70	1.5a	1.5a	1.5	2.7a	2.4a	2.5a
N Level $kg \cdot ha^{-1}$									
67	--	84a	--	---	1.5a	---	---	2.3a	---
101	74a	--	--	1.4a	---	---	2.6a	---	---
135	73a	84a	--	1.3a	1.5a	---	2.6a	2.4a	---
202	77a	82a	--	1.3a	1.5a	---	2.6a	2.3a	---

[z] Means in a column within main and subplot treatments followed by the same letter are not significantly different at the .05 level of probability.

Table 7. Interaction effects between years, cultivars, and among nitrogen levels on plant stand, ears per plant, and tissue N concentrations of hybrid sweet corn in 1986 and 1987.

Interactions	Plant Stand %	Ears per Plant	N Concentration %
Year x Cult	**	*	NS
Year x Nit	NS	*	NS
Cult x Nit	NS	NS	NS
Year x Cult x Nit	NS	NS	NS

(*) Indicates significance at the .05 level of probability.
(**) Indicates significance at the .01 level of probability.

plant (Table 7). This interaction was a result of an increase from 1.1 ears per plant for 'Silver Queen' in 1986 to 1.5 ears per plant in 1987, while the number of ears per plant of 'How Sweet It Is' remained at 1.5 for both years (Table 6). This increase in ear numbers per plant from 1986 to 1987 for 'Silver Queen' is another indication that there could have been a lack of vigor in the 1986 seed. Time of harvest had no effect on the maturity of second ears for either cultivar either year. 'How Sweet It Is' produced more ears per plant in 1986 than did 'Silver Queen', but they both produced 1.5 ears per plant in 1987 (Table 6).

Tissue nitrogen concentration was the same for both cultivars in 1986, but in 1987 'How Sweet It Is' had a higher ear leaf nitrogen content than did 'Silver Queen' (Table 6). When averaged across both years, 'How Sweet It Is' had a small but significantly higher nitrogen concentration than 'Silver Queen', 2.5 percent and 2.4 percent, respectively (Table 7). There were no differences in nitrogen contents among nitrogen fertilization rates for either year of the experiment (Table 6). These nitrogen results differ from those of Rudert and Locascio, who reported that nitrogen tissue concentration progressively increased as nitrogen rate increased to 224 $kg \cdot ha^{-1}$ (23). Tabor and Cox also found an increase in the ear leaf nitrogen concentration as the nitrogen rate increased to 224 $kg \cdot ha^{-1}$ (28), while Smith showed an increase to only 112 $kg \cdot ha^{-1}$ (25).

Ear length was not affected by nitrogen fertilization rate in either year. Ears of 'Silver Queen' were longer than those of 'How

Sweet It Is' in 1986, but there were no differences between the ear lengths of the cultivars in 1987 (Table 8). This difference in ear length between years explains the occurrence for the year by cultivar interaction for this characteristic (Table 9). These results agree with those of Smith (25) and Moss and Mack (14). Results from their studies showed nitrogen rates greater than 56 kg•ha^{-1} had no effect on ear length.

'How Sweet It Is' had a larger ear diameter than 'Silver Queen' in 1986. Both cultivars had ear diameters of 4.5 cm in 1987 (Table 8). This difference in ear diameter explains the highly significant year by cultivar interaction (Table 9). Nitrogen fertilization rate had no effect on ear diameter in either year (Table 8).

Percent grain was not affected by nitrogen fertilization nor were any cultivar effects noted in either year (Table 8).

The kernel extract pH was higher for 'Silver Queen' than 'How Sweet It Is' in both years (Table 10). The only significant interaction is a year by nitrogen effect (Table 11). This interaction resulted from a nitrogen rate response to 67 kg•ha^{-1} in 1987 and a lack of a response in 1986 (Table 10). In 1987, the 67 kg•ha^{-1} rate of nitrogen fertilization had an extract pH of 7.0, whereas the extracts from the plants grown at the 135 and 200 kg•ha^{-1} rates of nitrogen had a pH of 6.9 (Table 10). The pH differences of the kernel extract as influenced by nitrogen rate was evaluated by Linear, Cubic, and Quadratic analysis and found to be linear in nature.

Table 8. Effect of cultivar and nitrogen level on ear length, ear diameter, and percent grain of hybrid sweet corn in 1986 and 1987.

Treatment	Ear Length cm			Ear Diameter cm			Percent Grain %		
	1986	1987	mean	1986	1987	mean	1986	1987	mean
Cultivar									
Silver Queen	20a[x]	20a	20	4.4b	4.5a	4.4	51a	69a	60a
How Sweet It Is	19b	19a	19	5.1a	4.5a	4.8	51a	65a	58a
N Level $kg \cdot ha^{-1}$									
67	--	19a	--	---	4.5a	---	--	66a	--
101	20a	--	--	4.7a	---	---	52a	--	--
135	19a	19a	--	4.7a	4.5a	---	50a	69a	--
202	19a	20a	--	4.7a	4.5a	---	50a	66a	--

[x] Means in a column within main and subplot treatments followed by the same letter are not significantly different at the .05 level of probability.

Table 9. Interaction effects between years, cultivars, and among nitrogen levels on ear length, ear diameter, and percent grain of hybrid sweet corn in 1986 and 1987.

Interactions	Ear Length cm	Ear Diameter cm	Percent Grain %
Year x Cult	*	**	NS
Year x Nit	NS	NS	NS
Cult x Nit	NS	NS	NS
Year x Cult x Nit	NS	NS	NS

(*) Indicates significance at the .05 level of probability.
(**) Indicates significance at the .01 level of probability.

Table 10. Effect of cultivar and nitrogen level on pH, brix, and firmness of hybrid sweet corn extract in 1986 and 1987.

Treatment	pH			Brix %			Firmness Mpa		
	1986	1987	mean	1986	1987	mean	1986	1987	mean
Cultivar									
Silver Queen	7.0a[x]	7.0a	7.0a	16a	23a	20	4.0a	3.7a	3.9a
How Sweet It Is	6.9b	6.9b	6.9b	14b	15b	15	3.8b	3.5a	3.7a
N Level $kg \cdot ha^{-1}$									
67	---	7.0a	---	--	19a	--	---	3.7a	---
101	6.9a	---	---	15a	--	--	3.8a	---	---
135	7.0a	6.9b	---	16a	20a	--	4.0a	3.7a	---
202	7.0a	6.9b	---	15a	19a	--	4.0a	3.6a	---

[x] Means in a column within main and subplot treatments followed by the same letter are not significantly different at the .05 level of probability.

Table 11. Interaction effects between years, cultivars, and among nitrogen levels on pH, brix, and firmness of hybrid sweet corn extract in 1986 and 1987.

Interactions	pH	Brix %	Firmness MPa
Year x Cult	NS	**	NS
Year x Nit	*	NS	NS
Cult x Nit	NS	NS	*
Year x Cult x Nit	NS	NS	NS

(*) Indicates significance at the .05 level of probability.
(**) Indicates significance at the .01 level of probability.

'Silver Queen' had a higher °Brix reading than 'How Sweet It Is' for both years of the study. 'Silver Queen' had a °Brix reading of 23 in 1987 as compared to 16 in 1986 (Table 10). This substantial difference in °Brix reading between years for 'Silver Queen' resulted in a year by cultivar highly significant interaction (Table 11). The °Brix data agrees with that of Collins et al. using similar cultivars (4). They reported 'Silver Queen' to have a significantly higher °Brix reading than 'How Sweet It Is'. Nitrogen fertilization rate had no effect on °Brix for either year (Table 10).

In 1986, pericarp firmness was significantly lower for 'How Sweet It Is' than 'Silver Queen' (Table 10). There were no differences in nitrogen fertilization rates for either year (Table 10). However, a significant cultivar by nitrogen interaction did occur (Table 11). This interaction resulted from an increase in firmness as nitrogen rate increased in 1986 and a decrease in firmness as nitrogen rate increased in 1987.

CHAPTER V

SUMMARY AND CONCLUSIONS

In 1986 and 1987, 'Silver Queen' and 'How Sweet It Is' sweet corn cultivars were grown at three nitrogen rates on a Lonewood silt loam at the Plateau Experiment Station. Nitrogen rates selected for 1986 were 100, 135, and 200 kg•ha^{-1}. The 100 kg•ha^{-1} rate was reduced to 67 kg•ha^{-1} in 1987 because the 100 kg•ha^{-1} rate was found to give an adequate nitrogen supply to the crop. Fifteen yield, plant, and quality characteristics were measured. These characteristics included yield in dozens, yield in weight, ear weight, plant height, stalk diameter, ear height, plant stand, ears per plant, tissue nitrogen concentration, ear length, ear diameter, percent grain, plus the pH and °Brix of the kernel extract and firmness of pericarp tissue.

In 1986, 'How Sweet It Is' out-performed 'Silver Queen' in ear number, total weight, ear weight, ear number, and ear diameter. 'Silver Queen' grew taller, was larger in stalk diameter, set ears higher, had longer ears, plus had a higher pH and °Brix of kernel extract and a higher firmness of the kernel pericarp than 'How Sweet It Is'.

In 1987, the opposite results were obtained with some characteristics. 'Silver Queen' yielded more in ear number, total weight, ear weight, grew taller, set ears higher, and had a better stand establishment, plus had a higher pH and °Brix reading for the kernel extract than 'Silver Queen'. 'How Sweet It Is' had a higher ear leaf nitrogen concentration than 'Silver Queen'.

In 1986, no difference in stand establishment between the cultivars existed, but in 1987 the 'Silver Queen' stand was nearly ideal, but the 'How Sweet It Is' stand was even lower than that attained in 1986 because of poor germination and seedling vigor.

Year by cultivar interactions occurred in yield in dozens, yield in weight, ear weight, plant height, ear height, plant stand, ear number per plant, ear length, ear diameter, and percent brix. Year by nitrogen interactions occurred in ear height, ear number per plant, and pH. A cultivar by nitrogen interaction occurred for firmness.

A difference in the vigor of the seed lots and plants had a great influence on the results between years. The 'Silver Queen' seed planted in 1986 germinated poorly, showed a lack of vigor throughout the growing season, and did not yield comparable with the 'Silver Queen' plants in 1987. The assumption of frost damage to the 1986 seed as suggested by seed suppliers appears to be the most feasible explanation for the tremendous differences in 'Silver Queen' production and quality between the two years. 'How Sweet It Is' plants were less vigorous in 1987 than in 1986. This also added to the variability of the results. Results of this study indicated that the production potential of the <u>shrunken-2</u> cultivar, 'How Sweet It Is' was inferior to that of the <u>normal</u> sugary cultivar, 'Silver Queen'.

The absence of a nitrogen response at this location may be explained by assuming the soil contained sufficient nitrogen as a result of the decomposition of the fescue-red clover sod. Sixty-seven kg•ha^{-1} of added nitrogen was apparently adequate to satisfy the nitrogen requirement of the sweet corn cultivars used in this study. The only factor affected by fertilizer nitrogen was that of kernel extract pH and one might question its importance with a difference of 0.1 of a pH unit.

Since no nitrogen response was measured either at the 100 kg•ha^{-1} rate in 1986 or the 67 kg•ha^{-1} rate in 1987 with either cultivar for almost every plant characteristic evaluated in this study, one might consider that the recommended nitrogen rate for sweet corn of 135 kg•ha^{-1} is excessive. On the other hand, continuing to add nitrogen to a crop without positive yield responses, did not result in any detrimental effects to other plant characteristics. One should realize, however, that this investigation was performed in somewhat localized conditions that may not apply to all areas of the state.

Additional research is needed to determine the cause of these high yields with such small amounts of added nitrogen. A feasible experiment should probably contain similar nitrogen fertilization rates used in this study in conjunction with a zero rate. Cultivar differences should be evaluated again, hopefully with seed of consistant quality.

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APPENDIX

Table A-1. ANOVA table used in analysis of yearly data.

Source of Variation	Degrees of Freedom	Test
Replication	7	<---
Cultivar	1	<---
Replication x Cultivar	7	---
Nitrogen	2	<---
Nitrogen x Cultivar	2	<---
Replication x Nitrogen (Cultivar)	28	---

Table A-2. ANOVA table used in analysis of data for both years.

Source of Variation	Degrees of Freedom	Test
Year	1	<---
Replication (Year)	14	---
Cultivar	1	<---
Cultivar x Year	1	<---
Cultivar x Replication (Year)	14	---
Nitrogen	2	<---
Nitrogen x Year	2	<---
Nitrogen x Cultivar	2	<---
Nitrogen x Year x Cultivar	2	<---
Nitrogen (Cultivar) x Replication (Year)	56	---

VITA

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