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I am submitting herewith a thesis written by Jenny Dale Clement entitled "Potassium and Cultivar Effects on Carbohydrate Partitioning in Upland Cotton." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant Sciences.

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POTASSIUM AND CULTIVAR EFFECTS ON CARBOHYDRATE PARTITIONING IN UPLAND COTTON

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Jenny Dale Clement
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DEDICATION

I would like to dedicate this thesis to my family, Nana, and soon to be husband, Mike Bailey. Thank you for your support, love and patience as I have continued my education. God has truly blessed me.

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ABSTRACT

The indeterminate growth habit of upland cotton (*Gossypium hirsutum* L.) reduces the efficiency of yield formation when grown as an annual for its lint. Altering the determinacy may provide greater carbohydrate partitioning to reproductive structures, allowing higher yields. Another factor that may influence partitioning is potassium (K) nutrition. Potassium is essential for physiological and biochemical processes including translocation. It is necessary for ATP production, which is crucial for phloem loading and unloading. A three-year experiment was conducted at the West Tennessee Research and Education Center to evaluate carbohydrate partitioning in Paymaster 1218BG/RR (PM1218), a relatively determinate cultivar, and Deltapine 555BG/RR (DP555), a more indeterminate variety. The two cultivars were grown in the field under two levels of potassium fertilization, 60 and 120 lbs K_2O/acre/year, representing adequate and excessive K fertility, respectively. Plots containing cultivars and K treatments were arranged in randomized complete blocks with six replications per year. Plant samples were harvested at early bloom and after cutout, to evaluate partitioning during boll filling. Eight stem samples per plot were collected immediately below the cotyledonary node, freeze dried and ground for carbohydrate analysis by enzymatic methods. The two sampling dates were treated as subplots in the statistical analysis. Plots were mechanically harvested and samples of seedcotton were ginned to determine lint yields. Results showed that K had significant effects on monosaccharide concentrations of both cultivars and on lint yields of PM1218. Lint yields of PM1218 were lower than DP555 with 60 lb K_2O/ac/yr, but were equivalent at 120 lb K_2O/ac/yr. Total soluble sugar

concentrations were higher in DP555 than in PM1218 at early bloom but declined to equivalent concentrations after cutout. Starch analysis revealed both a cultivar and harvest sample date interaction. In all years, PM1218 had more starch than DP555 at early bloom. Accumulation or depletion of starch reserves during boll filling differed by year, along with lint yields. Relating these results to shoot biomass data, also collected at both harvest dates for another study, confirms that the determinate variety PM1218 allotted more photoassimilates for reproductive growth during this time than DP555, despite similar lint yields. Previous research has found decreased vegetative growth during reproductive development in more determinate cultivars. Lower lint yields in PM1218 at 60 lbs K_2O/ac/yr could be due to soil nutrient uptake efficiency and may explain the need for additional potassium in the more determinate cultivar. The two cultivars differed in carbohydrate concentrations at early bloom but by cutout were similar. Further investigation into the components of carbohydrate sink strength, such as seed constituents and root growth, may help in determining the carbohydrate partitioning trends of cultivars. Additional research is needed to establish potassium fertilization for optimum reproductive partitioning in determinate cultivars.

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List of Abbreviations

ATP- Adenosine triose phosphate

BG/RR- Bollgard (*Bt*)/Roundup Ready (glyphosate resistant)

DAP- Days after planting

DF- Degrees of freedom

DP555- Deltapine 555 BG/RR

LSD- Least Significant difference

NADH- Nicotinamide adenine dinucleotide

PM1218- Paymaster 1218 BG/RR

SAS- Statistical analysis system

TNC- Total Nonstructural Carbohydrates

TSS- Total Soluble Sugars

CHAPTER I:

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a complex crop to grow due to its indeterminate growth habit and its production as an annual. This growth habit allows vegetative growth to continue during the reproductive phase of its lifecycle (Mauney, 1986). An annual plant typically has specific growth stages; growth, reproduction, maturation, senescence and eventually death in a relatively short period of time. Cotton, however, is a woody perennial; its vegetative parts grow continuously while the fruit matures for harvesting as an annual. The technical term for cotton's fruit is a boll; the main economic product of a boll is lint, a fibrous mass composed of nearly pure cellulose. The perennial characteristics of cotton are not advantageous when grown as an annual.

Cotton is a thermophilic plant, seen by its tropical origins (Brubaker et al., 1999). Temperature, measured in heat units, determines the growth rate of cotton. The heat units required from plant to harvest are approximately 2,600 degree-days at a base of 60°F (Oosterhuis, 1990). There are only seventeen states in the U.S. that have adequate climates to support cotton production, collectively known as the cotton belt. Tennessee is located on the northern edge of the cotton belt, limiting its yield and production potential due to cooler climates and shorter growing seasons. To provide a more efficient plant for these conditions, a better understanding of carbohydrate physiology is needed.

Photoassimilates are products of photosynthesis formed in the leaves of plants. The disaccharide sucrose, composed of glucose and fructose, is the form of carbohydrate

transported to vegetative and reproductive sinks (Salisbury and Ross, 1992). The ability to partition more photoassimilates to reproductive sinks could potentially increase boll size and number allowing higher amounts of lint. Increasing lint production would mean increasing the amount of available cellulose. Cellulose is a polymer of glucose, therefore increasing glucose concentrations to bolls is theoretically a way to improve lint production. However, glucose is also stored as starch in the plant. Starch is the primary reserve carbohydrate needed when photoassimilates are limited. Remobilizing more starch to reproductive growth during boll filling and partitioning more glucose in favor of cellulose production is of primary interest.

Breeding efforts through the years have produced more determinate cotton cultivars that limit excessive vegetative growth during reproductive development. Theoretically this could cause indeterminate and more determinate cultivars to differ in their partitioning strategies. It would suggest better utilization of storage reserves in the more determinate plant, due to less vegetative growth generating less photoassimilate when compared to an indeterminate cultivar. Gwathmey (2005) found more vegetative growth in the indeterminate and more reproductive growth in the determinate cultivar when comparing their biomass partitioning.

Another area to consider for increasing lint formation is mineral nutrition. Potassium is an essential nutrient for plant production. It is particularly vital for the fruiting phase of cotton. From flowering through early boll filling it is required in large amounts. Bennett et al. (1965) found a direct correlation between boll size and the amount of applied potassium. Potassium is indirectly involved in partitioning by

supplying ample ATP for phloem loading and unloading. It is also a catalyst for many enzymes (Salisbury and Ross, 1992) and is involved with the distribution of photoassimilates. Perhaps increasing potassium fertilization could alter the amount of carbohydrate partitioning to various sinks and increase remobilization of starch reserves during boll filling. Utilizing proper management tools will aid in maximizing a crop's potential.

Objectives

The objectives of this research are:

1. To characterize the storage and remobilization of nonstructural carbohydrates in two contemporary cotton cultivars with contrasting growth habits. The main hypotheses are that: A.) stored starch reserves are depleted during boll filling; B.) starch reserves are depleted more in the determinate cultivar than the indeterminate cultivar; and C.) there is more sucrose transport in the more indeterminate cultivar.

2. To determine if additional potassium fertility promotes the remobilization or transport of nonstructural carbohydrates in contrasting cultivars. The main hypothesis is that additional potassium promotes translocation of stored carbohydrates to support lint yield formation during boll filling.

CHAPTER II:

LITERATURE REVIEW

The family Malvaceae hosts approximately 40 wild and cultivated species of cotton (Brubaker et al., 1999). Originating in tropical latitudes, this fibrous plant is a perennial, which partitions photoassimilates more in favor of parent plant survival than to reproduction. Domestication of the upland cotton species *(Gossypium hirsutum* L.) allowed it to be grown commercially as an annual crop harvested for its lint. As a commercial crop, producers need to maximize its reproductive potential. To achieve this, cotton's growth habit and perennialistic nature need improvement. Perhaps understanding cotton's physiology will aid in maximizing yields.

Photoassimilates are partitioned either to support current metabolic processes, to produce growth of new plant tissue, or to fortify storage reserves for future use. Starch, the primary storage carbohydrate, is an alternative energy source for the developing plant. Its synthesis is labile, allowing the uptake and release of glucose. It is frequently stored in roots and stems, which are vegetative sinks (Salisbury and Ross, 1992). De Souza and Vieira da Silva (1987) found higher concentrations of starch in roots of perennial type cotton than in more annual cotton. They attributed the higher starch to the extensive rooting system in perennials that make it more resistant to drought. This in turn reduced the amount of reproductive fruit the first year of their study. However, perennials in the following years have adequate starch supplies that are remobilized to readily support reproduction (Kramer and Kozlowski, 1979). In cotton, it is hypothesized that starch

reserves are depleted during reproductive growth allowing the free glucose to be converted into cellulose.

Cellulose, a structural carbohydrate, is the major component of cell walls, including the fiber cells that produce cotton's lint (DeLanghe, 1986). Its synthesis is a strong, irreversible carbon sink in cotton. Cotton fiber development begins with an increased growth of the ovary at anthesis, the day of flowering. Select outer ovule epidermal cells protrude through the epidermal surface, creating fiber initials. This initiation phase occurs for three days, followed by cell elongation. Consisting of a thin cuticulum, a thin primary wall and an enormous vacuole, the cells begin elongation at a rapid pace lasting approximately 10 days. At this point the secondary wall biosynthesis initiates by depositing nearly pure cellulose on the inner surface of the primary wall, shrinking the vacuole. Approximately 50 to 60 days after flowering, depending on the growing season, fiber development reaches maturity by drying out, a process induced by the opening of the boll (Basra, 1999, Mauney et al., 1986). Because fiber cells are specialized epidermal cells on the surface of cotton seed, it is possible to classify lint as part of the reproductive sink.

Increases in lint yields are directly related to greater partitioning of assimilate to reproductive growth over vegetative growth or storage (Wells and Meredith, 1984). Yields are based on number of bolls that assimilate supply can support, but Kerby and Buxton (1981) proved that cotton plants produce more fruiting forms than available assimilates can support. A greater pool of photoassimilates could support more bolls, thus higher yields (Kerby and Buxton, 1981; Constable and Rawson, 1980). The location of

source and sinks influence transport patterns and photoassimilate partitioning (Dixon, 1992). Ashley (1972) found that the main source of new photosynthate for developing fruit was the subtending leaf, but that the main concentration of photoassimilates came from the main-stem leaves. However, in early stages of growth, roots and lower stem had the highest total available carbohydrates, indicating areas where carbohydrates are actively stored (Saleem and Buxton, 1976). During peak boll filling, stem carbohydrates were depleted but later restored when boll filling ceased. This indicates that there may be an extra source of carbohydrate for filling bolls, in the roots and lower stems.

Improving crop yields has been the object of breeders for decades and advanced cultivars have resulted in cotton (Wells, 2002). Overcoming perennial and indeterminate characteristics has to some extent been achieved. Altering carbohydrate partitioning to reproductive over vegetative structures has improved cotton yields. Modern cultivars partition a greater proportion of dry matter into reproductive organs, and do so earlier than obsolete cultivars (Wells and Meredith, 1984). Pace et al. (1999) and Gwathmey (2005) have confirmed that more determinate cultivars have greater reproductive partitioning.

Though partitioning is directly related to the genetic background of cotton, nutritional requirements should be considered. Potassium is an essential element needed in both physiological and biochemical processes, especially translocation (Huber, 1985). Photoassimilates are transported through the phloem to various sinks. Energy in the form of ATP is necessary for this movement to occur. Potassium helps balance the ionic charge in ATP production. If K is inadequate, less ATP is available, and the transport

system breaks down. Photoassimilates begin to build up in the leaves, and photosynthetic rates are reduced. Also, potassium promotes the loading of phloem sieve cells, by increasing water uptake, enabling an elevated flow rate. Exactly how potassium does this is still unclear (Mengel, 1985). Mengel (1996) found that tissue K concentration influenced the distribution of labeled photosynthate. Phloem loading and unloading requires a substantial amount of ATP, which is indirectly supported by potassium. Work by Ashley and Goodson (1972) showed a decline in translocation when potassium was limited. In cotton, potassium is important in boll filling by promoting sink metabolism, acting as an osmoregulatory solute for turgor pressure needed in fiber elongation (Dhindsa, 1975).

Extensive work has shown a detrimental effect on cotton when potassium is deficient (Pettigrew, 1999; Cassman et al., 1989). A typical symptom is small bolls. Leaf area is decreased, lowering the photosynthetic capacity and therefore reducing lint yields and fiber quality (Pettigrew, 1999). Cassman et al. (1989) determined that there was not a significant yield difference between two Acala cultivars when potassium was not limited. However, when potassium levels were inadequate, the more determinate cultivar was able to utilize the mineral for reproductive growth more efficiently than the indeterminate cultivar. The result was 29 and 35% higher yields in 1986 and 1987.

Tennessee soil fertility recommendations (Savoy and Joines, 2001) show that applying 60 lbs K_2O/acre is adequate for economic yield formation in cotton; when Mehlich I test levels of soil potassium are high (Hanlon, 2001). Higher amounts have not

shown any economic return, although foliar tissue testing may indicate greater uptake when excess fertilizer K is applied (Kerby and Adams, 1985).

CHAPTER III:

MATERIALS AND METHODS

Field Study

A three-year field experiment was conducted on a Memphis-Loring silt loam with long term K fertility plots at the West Tennessee Education and Research Center, Jackson TN in 2003, 2004 and 2005. This was done to evaluate carbohydrate partitioning in Paymaster1218BG/RR, (PM1218) a relatively determinate cultivar, and Deltapine 555BG/RR, (DP555) a more indeterminate cultivar under two levels of potassium fertilization (60 and 120 lb K_2O/ac/yr) (Gwathmey, 2005). Characteristics of the two cultivars were described by Albers et al. (1999) and Legé and Leske (2003) when commercially released.

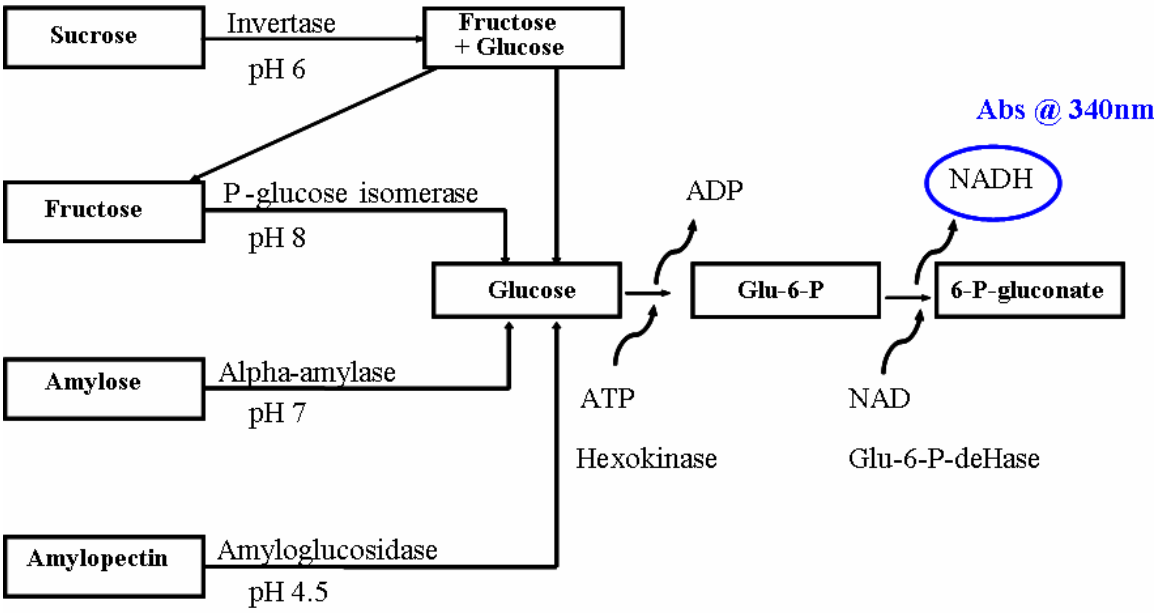
Four hundred square foot plots containing cultivars and K treatments were arranged in a randomized complete block design with six replications per year. In the winter prior to each season, soil samples were collected from all plots to determine residual (carryover) K fertility. Between March and April each year, specified quantities of potassium chloride were applied by hand to the plots. Planting occurred on April 30th in 2003, and on May 5th in 2004 and 2005. Cultivars were planted in 38-inch rows in 4-row plots with a no-till planter. The inner 2 rows were used for data collection and sampling, and were thinned for uniformity shortly after emergence. Agricultural Extension Service guidelines for Bollgard (*Bt*)/Roundup Ready (glyphosate resistant) cotton were used to manage the crop. A mepiquat plant growth regulator was applied at

three separate times each year. In 2003, 33oz/ac of PixPlus was applied between 55 and 87 days after planting (DAP). In 2004, 38oz/ac of Mepex® was used between 37 and 69 DAP and in 2005, 26 oz/ac of Mepex® was applied during 54 and 78 DAP.

Plant sampling occurred on two separate dates; early bloom, when boll set begins; and cutout, which is the cessation of flowering. This was performed so that carbohydrate analysis would demonstrate the amount of partitioning during boll filling. The two sampling dates were treated as subplots in the experimental design. Plants were sampled around solar noon on 89 and 118 DAP in 2003, at 69 and 112 DAP in 2004, and 74 and 109 DAP in 2005. Eight consecutive plants from a row were cut at the soil level and a 2-cm sample of stem tissue below the cotyledonary node was cut and immediately placed on dried ice. The samples were then freeze dried and ground through a 20-mesh screen with a Wiley mill. The ground tissue was then stored with desiccant until carbohydrate analysis could be performed. The remaining plant was dissected and dried at 60°C for biomass partitioning analysis.

Carbohydrate Analysis

Glucose, fructose, sucrose and starch concentrations were determined colorimetrically by methods developed by Hendrix (1993). Each carbohydrate was enzymatically converted to glucose (Figure 1). Glucose was then converted to 6-phosphogluconate; this two-part reaction releases one NADH molecule per glucose converted. The NADH absorbance was read using a microplate reader (Multiskan MCC/340, Thermo Labsystems, Helsinki, Finland) at a wavelength of



Adapted from D.L. Hendrix.(1993).

Figure 1. A diagram of enzymes needed to convert carbohydrates to glucose, and for colorimetric assay of glucose.

340 nanometers and unknown glucose concentrations were calculated with a standard curve ranging from 0.05 to 0.8 mg/ml.

To begin analysis, one hundred milligrams of ground stem tissue from each plant was subjected to a series of three hot ethanolic washes to extract the soluble sugars for thirty minutes. After each wash, the tubes were centrifuged to separate the soluble and insoluble fractions. The ethanolic extract was then decanted. The combined extract was brought to a volume of 10 ml, and a 1.5 ml aliquot was purified with twenty mg of activated charcoal, and centrifuged. Twenty microliters of the aliquot was placed in a separate well of a microplate and dried overnight to evaporate the remaining ethanol.

Subsamples were made by placing aliquots of the same sample in two separate wells, providing two absorbance readings. The sugars were resolubilized with 20 microliters of water for twenty minutes. Glucose assay reagents (Sigma glucose kit GAHK-20) were brought to volume with water as noted in the instructions with the kit (Sigma Aldrich, 1997). The glucose kit contained the enzymes hexokinase and glucose-6-phosphate dehydrogenase. One hundred microliters of this preparation was then added to each well and allowed to sit for fifteen minutes. Absorbance at 340 nanometers was then read by a microplate reader. Ten microliters of phosphoglucose isomerase (Sigma P-9544) preparation was then added to each well, converting fructose to glucose and the absorbance was read again. This enzyme was prepared by adding 1.0 milliliter of a 0.2M Hepes buffer, pH 7.6, to 1000 units of the enzyme. The absorbance was read at 340nm. An increase in absorbance was noted due to the conversion of fructose to glucose. The difference between the two readings indicated fructose concentration. The last enzyme added was invertase (Sigma I-4504). Eighty-three enzyme units were needed per well to convert sucrose into glucose and fructose. This invertase solution was prepared by adding 50 milligrams of powdered enzyme to a 5 milliliter 0.1 M citrate buffer (pH 6.0). The increase in absorbance was attributed to sucrose. In each case, absorbances were compared to a standard curve to determine sugar concentrations.

Starch analysis was performed on the pellet remaining after soluble sugar extraction. It was treated with one milliliter of 0.1M KOH and each tube was placed in a hot water bath for an hour to gelatinize the starch. Once cooled, pH was lowered between 6.6 and 7.5 with acetic acid. Three hundred and sixty units of the prepared enzyme, α-

amylase (Sigma A3-3403) was added and placed in an 80°C bath for thirty minutes. This enzyme is responsible for breaking the straight α-1,4 glucose bonds present in starch. The α-amylase was prepared by diluting ten fold in 1M Tris acetate buffer (pH 7.2). The enzyme was dialyzed against water to rid any glucose that might have been present. The test tubes were allowed to cool and the pH was lowered to 5 by adding 0.1M acetic acid. One hundred and twenty two units of prepared enzyme, amyloglucosidase (Sigma A-3042) was then added and placed in a 55°C bath for one hour. Amyloglucosidase was prepared by diluting fifty fold with sodium acetate buffer (pH 4.5) and dialyzing against the same buffer overnight. This enzyme breaks starch's branching α-1,6 glucose linkages. To stop all reactions, the samples were immediately placed in boiling water for four minutes. Aliquots were taken, centrifuged and placed in wells for analysis. One hundred microliters of glucose assay reagent was added and absorbance read at 340nm.

Statistical Analysis

Data were analyzed using the Mixed Procedure in SAS 9.0 and means were separated using pairwise LSD comparisons at p=0.05. Years, treatments, and sampling dates were fixed effects with replications being random effects. The year effects were tested with reps within years; sampling dates were treated as subplots nested within the whole plots of cultivar and potassium rates.

CHAPTER IV:

RESULTS AND DISCUSSION

Analyses of Variance

Results of analysis of variance of fixed effects on monosaccharide concentrations are presented in Table 1. Effects on sucrose and total soluble sugars are presented in Table 2, and effects on starch and total nonstructural concentrations are shown in Table 3. Cultivars had significant effects on all nonstructural carbohydrates whereas potassium (K) fertilization had significant effects only on the monosaccharides. The sampling date had significant effects on all carbohydrates except glucose (Table 1, 2, 3). The year*cultivar*date interaction was significant only in the soluble sugars (Table 1, 2).

Table 1. Analysis of variance of fixed effects on monosaccharide concentrations in cotton stem tissue. Significant (p<.05) effects are highlighted in bold.

			Glucose		Fructose	
Effect	Num DF	Den DF	F Value	PR>F	F Value	PR>F
Year	2	15	5.25	**0.0187**	141.33	**<.0001**
Cultivar	1	45	39.12	**<.0001**	1.38	0.2459
Year*Cultivar	2	45	0.73	0.4863	0.79	0.4614
K	1	45	18.43	**<.0001**	4.51	**0.0392**
Year*K	2	45	0.88	0.4202	4.63	**0.0149**
Cultivar*K	1	45	0.31	0.5805	0.17	0.6856
Year*Cultivar*K	2	45	2.87	0.0668	1.40	0.2582
Date	1	60	2.85	0.0966	26.70	**<.0001**
Year*Date	2	60	30.39	**<.0001**	8.19	**0.0007**
Cultivar*Date	1	60	0.54	0.4664	0.57	0.4531
Year*Cultivar*Date	2	60	8.57	**0.0005**	4.64	**0.0134**
K*Date	1	60	1.45	0.2328	0.23	0.6300
Year*K*Date	2	60	1.14	0.3255	0.82	0.4435
Cultivar*K*Date	1	60	2.33	0.1323	3.08	0.0846
Year*Cultivar*K*Date	2	60	0.02	0.9815	0.05	0.9533

Table 2. Analysis of variance of fixed effects on sucrose and total soluble sugar concentrations in cotton stem tissue. Significant (p<.05) effects are highlighted in bold.

Effect	Num DF	Den DF	Sucrose F Value	Sucrose PR>F	Total Soluble Sugars F Value	Total Soluble Sugars PR>F
Year	2	15	2.06	0.1626	6.15	**0.0112**
Cultivar	1	45	9.99	**0.0028**	9.57	**0.0034**
Year*Cultivar	2	45	4.57	**0.0156**	2.94	0.0632
K	1	45	0.69	0.4094	0.04	0.8339
Year*K	2	45	1.00	0.3751	0.8	0.4552
Cultivar*K	1	45	0.64	0.4285	0.38	0.5428
Year*Cultivar*K	2	45	2.01	0.1457	2.43	0.0994
Date	1	60	57.06	**<.0001**	27.9	**<.0001**
Year*Date	2	60	38.37	**<.0001**	33.89	**<.0001**
Cultivar*Date	1	60	0.99	0.3232	0.61	0.4372
Year*Cultivar*Date	2	60	4.08	**0.0218**	5.5	**0.0064**
K*Date	1	60	0.84	0.3627	0.91	0.3427
Year*K*Date	2	60	0.30	0.7420	0.24	0.7845
Cultivar*K*Date	1	60	3.27	0.0740	3.36	0.0716
Year*Cultivar*K*Date	2	60	0.21	0.8088	0.13	0.8823

Table 3. Analysis of variance of fixed effects on starch and total nonstructural carbohydrate concentrations in cotton stem tissue. Significant (p<.05) effects are highlighted in bold.

Effect	Num DF	Den DF	Starch F Value	Starch PR>F	Total Nonstructural Carbohydrates F Value	Total Nonstructural Carbohydrates PR>F
Year	2	15	37.87	**<.0001**	24.55	**<.0001**
Cultivar	1	45	47.04	**<.0001**	27.21	**<.0001**
Year*Cultivar	2	45	3.36	**0.0438**	2.75	0.0749
K	1	45	0.93	0.3396	0.97	0.3308
Year*K	2	45	0.36	0.7015	0.05	0.956
Cultivar*K	1	45	0.02	0.8781	0	0.9458
Year*Cultivar*K	2	45	0.28	0.7599	0.11	0.8925
Date	1	60	102.41	**<.0001**	52.16	**<.0001**
Year*Date	2	60	187.15	**<.0001**	185.61	**<.0001**
Cultivar*Date	1	60	38.71	**<.0001**	30.38	**<.0001**
Year*Cultivar*Date	2	60	0.67	0.5170	0.54	0.5856
K*Date	1	60	2.17	0.1456	3.84	0.0546
Year*K*Date	2	60	0.52	0.5971	0.23	0.7981
Cultivar*K*Date	1	60	0.01	0.9330	0.71	0.4014
Year*Cultivar*K*Date	2	60	0.19	0.8282	0.11	0.8921

Potassium Effects

The soil test potassium noted in the following table (Table 4) is an indicator for the amount of potassium fertilization needed according to the Mehlich I test (Hanlon, 2001). When soil potassium concentrations are high (161 to 320 lb K/ac), application of 60 lbs K_2O/acre is recommended as adequate for cotton production, but anything exceeding 60 lbs/acre is considered excessive (Savoy and Joines, 2001). For soil test K levels above 320 lb K/ac, no potassium fertilization is recommended (Savoy and Joines, 2001). Study plots receiving 60 lb K_2O/ac/yr had adequate K fertility, but plots receiving 120 lb K_2O/ac/yr had excessive K fertility (Table 4). Across years, potassium treatments showed a decrease in monosaccharide concentration for 120 lbs/ac/yr when compared to 60 lbs/ac/yr (Table 4). This could be an indication that more cellulose synthesis occurred in stem tissue with excessive K fertility.

Table 4. Glucose and fructose concentrations in cotton stem tissue at two potassium fertilization rates, averaged across cultivars.

Year	Soil Test K	K Tmt.	Glucose		Fructose	
	lb K/ac	lb K_2O/ac/yr	mg/g dry wgt		mg/g dry wgt	
	200	60	4.94	a	4.44	a
	335	120	4.21	b	4.06	b
2003	206	60	5.29		4.58	b
2003	301	120	4.49		3.47	c
2004	219	60	5.17		2.55	d
2004	396	120	4.21		2.28	d
2005	177	60	4.36		6.20	a
2005	307	120	3.94		6.43	a

Within groups, means followed by the same letter do not differ at p=0.05.
Absence of letters indicates P(F) >0.05.

The significant year*K interaction in Table 1 was due to the potassium rates significantly influencing fructose concentrations only in 2003.

There was no significant response to K in sucrose, total soluble carbohydrates, or starch concentrations (Tables 2 and 3). This is consistent with the findings of Pettigrew (1999) that potassium fertilizer treatments have more effect on monosaccharide concentrations. The interaction effects of K and sampling date on total nonstructural carbohydrates approached statistical significance (p=0.0546) (Table 3). This interaction was due to a decrease in carbohydrate concentration in response to additional K at early bloom, but no difference in concentration at cutout (data not shown).

Cultivar Effects

Across years and sampling dates, glucose concentrations were higher in main stems of DP555 than PM1218, but cultivars did not differ significantly in fructose (Table 5). In PM1218, there was a significant increase in glucose during boll filling only in 2005. In DP555, glucose concentrations decreased between early bloom and cutout in 2003 and increased between dates in 2005. Fructose concentrations increased significantly between sample dates in both cultivars only in 2003. This indicates that the indeterminate cultivar required more free glucose during early boll filling; perhaps these stem carbohydrates are needed to maintain a balance between new reproductive and continued vegetative growth. A further look at sucrose and starch concentrations may provide insight as to what was occurring in the cultivars.

Table 5. Monosaccharide concentrations in stem tissue of two cultivars sampled at early bloom and cutout, averaged across potassium treatments.

Year	Cultivar	Sampling Date*	Glucose		Fructose	
			mg/g dry wgt		mg/g dry wgt	
		EB	4.43		3.78	b
		CO	4.72		4.72	a
	PM 1218		4.04	b	4.35	
	DP555		5.10	a	4.14	
2003	PM 1218	EB	4.38	cd	2.98	ef
2003	PM 1218	CO	4.08	cd	5.60	bc
2003	DP555	EB	6.24	a	3.18	ef
2003	DP555	CO	4.84	bcd	4.34	d
2004	PM 1218	EB	4.29	cd	2.23	f
2004	PM 1218	CO	4.02	de	2.61	ef
2004	DP555	EB	5.53	ab	2.49	ef
2004	DP555	CO	4.92	bc	2.32	ef
2005	PM 1218	EB	3.22	ef	6.25	abc
2005	PM 1218	CO	4.27	cd	6.47	ab
2005	DP555	EB	2.93	f	5.56	c
2005	DP555	CO	6.17	a	6.97	c

*Early bloom (EB) and Cutout (CO)

Within groups, means followed by the same letter do not differ at p=0.05. Absence of letters indicates P(F) >0.05.

The indeterminate cultivar, DP555, had higher concentrations of the main soluble sugar, sucrose, than the more determinate cultivar (Table 6). Sucrose and total soluble sugar (TSS) concentrations changed significantly with time, with higher concentrations at early bloom and a decline by cutout. Sucrose and total soluble sugars declined in concentration in both cultivars between early bloom and cutout in 2003 and 2004. DP555 had higher concentrations at early bloom but by cutout the concentrations of both cultivars were equivalent. However in 2005, DP555 had an increase in sucrose and TSS concentrations while there was no significant change in PM1218.

Starch concentrations were higher in PM1218 than in DP555 at early bloom, but by cutout, both cultivars had equivalent concentrations (Table 6). In 2003, starch reserves were depleted between early bloom and cutout but in the following years starch accumulated. The starch concentrations are consistent with observations by Wells (2002) who also found year and cultivar effects. An explanation for the depletion of starch in 2003 may be due to variations in sampling date and possibly the environmental conditions that favored lint yield formation.

As the indeterminate cultivar had higher TSS at early bloom, the more determinate had higher starch concentrations. Since the determinate plant has less vegetative growth during boll filling, it could account for an excess of photoassimilates that are readily converted to starch. Halevy (1976) found that more determinate cultivars have a decreased root-to-shoot ratio when compared to indeterminate cultivars. The amount of starch present in the lower stem of the PM1218 may be directly related

Table 6. Sucrose, total soluble sugar (TSS) and starch concentrations in stem tissue of two cultivars sampled at early bloom and cutout, averaged across potassium levels.

Year	Cultivar	Sampling Date *	Sucrose		TSS		Starch	
			mg/g dry wgt		mg/g dry wgt		mg/g dry wgt	
	PM 1218		32.3	b	40.9	b	76.3	a
	DP555		35.5	a	44.8	a	58.7	b
		EB	37.7	a	46.2	a	54.5	b
		CO	30.1	b	39.5	b	80.4	a
2003	PM 1218	EB	35.2	bc	42.6	cd	116.5	a
2003	PM 1218	CO	29.6	de	39.3	d	56.8	cd
2003	DP555	EB	43.9	a	53.6	a	73.2	b
2003	DP555	CO	30.3	cde	39.5	d	46.2	de
2004	PM 1218	EB	37.1	bc	44.5	bcd	63.7	bc
2004	PM 1218	CO	21.7	f	28.4	e	114.4	a
2004	DP555	EB	45.1	a	53.2	a	30.6	f
2004	DP555	CO	25.7	ef	32.7	e	119.9	a
2005	PM 1218	EB	34.6	bcd	44.1	cd	33.6	ef
2005	PM 1218	CO	35.7	b	46.5	bc	72.6	b
2005	DP555	EB	30.6	cde	30.1	d	9.4	g
2005	DP555	CO	37.6	b	50.7	ab	72.7	b

* Early bloom (EB) and Cutout (CO)

Within groups, means followed by the same letter do not differ at p=0.05.

to its rooting system. Where PM1218 may store starch in the lower stem due to its decreased rooting system, DP555's sucrose levels may be an indication of movement to the roots for starch storage or continued root growth.

The indeterminate cultivar, DP555, could have a higher root-to-shoot ratio due to its more perennial characteristics which would require more carbohydrate partitioning to vegetative growth. PM1218, the more determinate cultivar, has higher seed oil content, shown by the National Cotton Variety Test 2003. This could potentially increase the sink strength of the reproductive fruit, resulting in greater photoassimilate demand than in DP555. Variations in sampling date along with environmental conditions from year to year may be responsible for the differences in starch accumulation and depletion in different years.

Lint Yield

Potassium and cultivars had significant effects on lint yields, and there was a significant K-by-cultivar interaction. The total lint yield showed a significant response to additional potassium only in the more determinate cultivar (Table 7). The more determinate cultivar, PM1218, had lower yields with 60 lbs/acre/year potassium fertilizer regimen, but DP555 did not. Perhaps a higher potassium fertilizer rate is needed in the more determinate cultivar to increase lint production. This is consistent with findings of Cassman et al. (1989) that a more determinate cultivar had a greater lint yield response to additional potassium. The indeterminate cultivar seems to produce higher yields with limited K fertility when compared with the more determinate cultivar. Cassman et al.

Table 7. Total lint yields of two cultivars with two potassium fertilization treatments averaged across three years.

Cultivar	Soil Test K	K	Total Lint Yield	
	lb K/ac	lb K_2O/ac/yr	lb/ac	
PM1218	194	60	1496	b
PM1218	335	120	1648	a
DP555	206	60	1669	a
DP555	333	120	1676	a

Means followed by the same letter do not differ at p=0.05.

(1989) also noted that the determinate cultivar had a higher uptake of potassium during boll development. Perhaps the indeterminate cultivar has a more extensive rooting system, allowing it to extract potassium more readily from the soil, in contrast to the determinate cultivar which may have had an insufficient rooting system to meet the needs for reproductive growth under lower potassium levels.

The relationship between lint yield and the accumulation or depletion of starch reserves was examined by linear regression (Fig. 2). The significant linear regression (Figure 2) indicates that as lint yields increased, starch reserves were not depleted as hypothesized, but rather accumulated. Within each year, there was no significant correlation of lint yield to change in stem starch between early bloom and cutout. The results suggest that stem starch reserves tended to increase in years with higher lint yields, and to decrease in a year (2003) with lower lint yields.

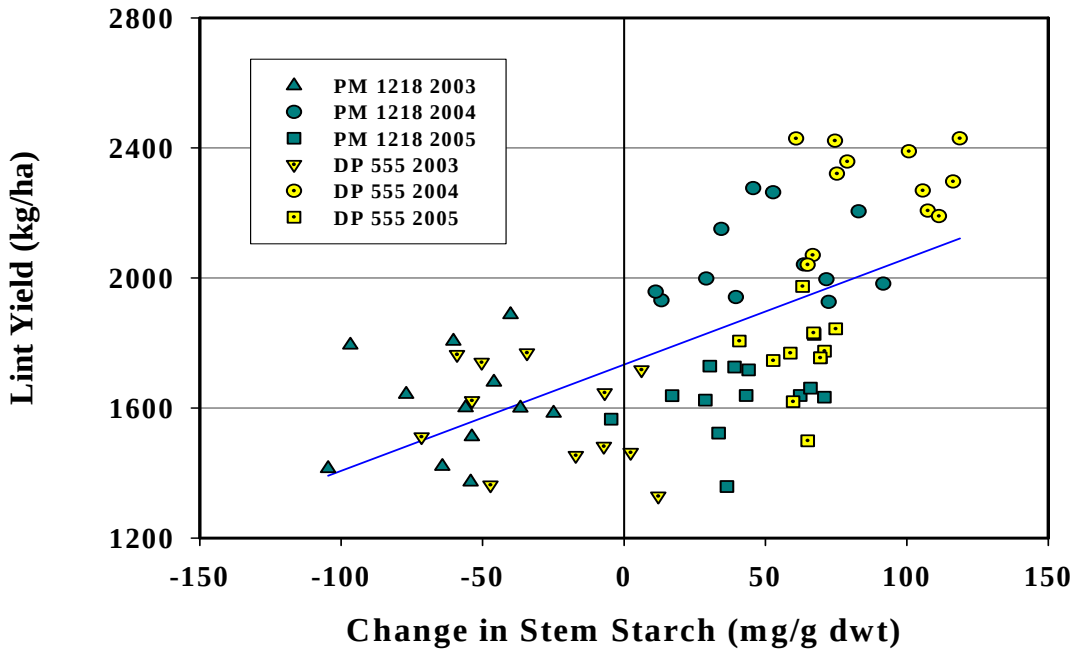


Figure 2. Change in stem starch from early bloom to cutout relative to lint yield formation in two cultivars 2003-2005.

CHAPTER V:

CONCLUSIONS

In conclusion, the cultivars had different concentrations of soluble sugars and storage carbohydrates in stem tissue at early bloom, but were statistically the same by cutout. Therefore the carbohydrate partitioning in indeterminate and determinate cultivars differed more in the early stages of reproductive development than later in boll filling. The starch reserves were not depleted as hypothesized, but rather accumulated between early bloom and cutout in two of three years. Evidently these stored photoassimilates were not remobilized to support reproductive growth during this period. The amount of sucrose transport was higher in the indeterminate cultivar at early bloom. The direction of transport is not determined in this study, but is assumed to move from source to sink.

Indeterminate cultivars tend to continue vegetative growth during reproductive development; this allows for higher above ground biomass as described by Gwathmey (2005) and a more extensive rooting system (Halevy, 1976) when compared to more determinate cultivars. The leaf area associated with more vegetative biomass increases the relative amount of photoassimilates, so as bolls develop there is an adequate supply of carbohydrates for reproductive development, hence less demand for remobilization of lower stem/root starch. The high amounts of sucrose at early bloom may be due to its transportation to the roots where it may support root growth or be stored as starch.

On the other hand, more determinate cultivars tend to decrease in vegetative growth during reproductive onset. This decrease affects not only the shoot which limits photoassimilate supplies, but possibly the root system, limiting soil nutrient uptake.

Though bred to improve lint yields, perhaps the determinate plant can not support the new reproductive demands under the same potassium management conditions as indeterminate plants.

Additional potassium fertilization had an effect only on the monosaccharides but it was sufficient to increase the lint yields in the determinate cultivar. If the findings of Gwathmey (2005) on differences in vegetative biomass extend to the root system, then the yield response to potassium may relate to differences in uptake at the root level. However, cultivar differences in potassium response were not seen in the transport or storage carbohydrates. The hypothesis of greater remobilization and transport of carbohydrates with additional potassium fertility is not supported by these results.

Future work on potassium fertility is necessary to determine if additional potassium plays a role in maximizing lint yields in the more determinate cultivars. Further research needs to be conducted on the components of carbohydrate sink strength, such as seed constituents and root to shoot ratios. Determining cotton's use of soluble sugar and labile starch reserves would provide a better understanding of its vegetative and reproductive requirements. This would help in identifying particular carbohydrate partitioning strategies in cultivars with contrasting growth habits.

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APPENDICES

Appendix A: Field Study Plot Assignments

Table 8. 2003 N&K Study: Variety response to K.

Cul. No.	Cultivar	lbs/acre K2O	Rep. I.	Rep. II.	Rep. III.	Rep. IV.	Rep. V.	Rep. VI.
1	PM 1218	60	102	211	301	412	509	603
1	PM 1218	120	206	109	306	407	505	605
2	DP 555	60	205	108	404	311	512	606
2	DP 555	120	303	111	405	208	501	602

Table 9. 2004 N&K Study: Variety response to K.

Cul. No.	Cultivar	lbs/acre K2O	Rep. I.	Rep. II.	Rep. III.	Rep. IV.	Rep. V.	Rep. VI.
1	PM 1218	60	108	205	311	404	512	606
1	PM 1218	120	111	208	303	405	501	602
2	DP 555	60	102	211	301	412	509	603
2	DP 555	120	109	206	306	407	505	605

Table 10. 2005 N&K Study: Variety response to K.

Cul. No.	Cultivar	lbs/acre K2O	Rep. I.	Rep. II.	Rep. III.	Rep. IV.	Rep. V.	Rep. VI.
1	PM 1218	60	102	211	301	412	509	603
1	PM 1218	120	109	206	306	407	505	605
2	DP 555	60	108	205	311	404	512	606
2	DP 555	120	111	208	303	405	501	602

Appendix B: Weather Data

Table 11. Summary of weather conditions by week of the 2003 growing season at Jackson TN.

WTES	TEMPERATURE (F)				PRECIPITATION (in.)				GDD BASE 60F	
Week Ending	HIGH	LOW	AVG	DFN	Current Week	Rainy Days	Cumul. Since 1-Apr	Departure From Normal	Since April 1 Total	Since April 1 DFN
5/4/2003	86	53	70	6	0.33	1	13.37	-5.73	153	50
5/11/2003	86	58	74	9	6.8	6	20.17	-0.21	252	103
5/18/2003	84	52	68	1	2.13	2	22.3	0.66	309	103
5/25/2003	78	54	67	-3	0.85	2	23.15	0.28	360	85
6/1/2003	82	51	66	-6	0.09	1	23.24	-0.76	405	49
6/8/2003	80	53	66	-7	1.3	2	24.54	-0.48	451	1
6/15/2003	89	56	75	0	0.96	3	25.5	-0.46	556	1
6/22/2003	84	55	73	-4	3.55	5	29.05	2.18	651	-18
6/29/2003	91	58	75	-3	0.22	1	29.27	1.47	760	-31
7/6/2003	92	66	79	1	0.56	2	29.83	1.05	891	-29
7/13/2003	92	69	81	3	0.08	1	29.91	0.1	1037	-16
7/20/2003	94	68	81	3	0.51	2	30.42	-0.37	1184	-2
7/27/2003	92	59	77	-3	0.48	2	30.9	-0.8	1302	-20
8/3/2003	95	68	79	-1	2.63	5	33.53	1.04	1436	-19
8/10/2003	88	67	77	-2	0.83	2	34.36	1.22	1557	-31
8/17/2003	91	65	78	0	1.17	2	35.53	1.79	1684	-30
8/24/2003	94	68	82	5	0.24	2	35.77	1.4	1837	2
8/31/2003	93	67	81	6	0.1	1	35.87	0.79	1987	40
9/7/2003	90	60	75	0	1.82	4	37.69	1.76	2095	47
9/14/2003	89	55	73	0	0.63	1	38.32	1.45	2190	52
9/21/2003	89	49	67	-4	0.02	1	38.34	0.49	2242	28
9/28/2003	87	47	68	-1	1.35	3	39.69	0.94	2301	24
10/5/2003	77	36	56	-10	0.07	1	39.76	0.21	2306	-18
10/12/2003	80	53	66	5	0.6	4	40.36	0.11	2352	-6
10/19/2003	76	40	60	0	1.02	4	41.38	0.43	2366	-15
10/26/2003	84	46	64	8	2.79	1	44.17	2.5	2399	4

GDD = Growing Degree-Days (base 60 F). DFN = Departure from normal.

Source: Tennessee Agricultural Statistics Service, Nashville TN.

Table 12. Summary of weather conditions by week of the 2004 growing season at Jackson TN.

WTES Week Ending	TEMPERATURE (F)				PRECIPITATION (in.)				Cumul. Degree-Base 60F Since April 1	
	HIGH	LOW	AVG	DFN	Current Week	Rainy Days	Cumul. Since 1-Apr	Departure From Normal	Total	DFN
5/2/2004	78	44	63	-2	1.27	3	16.95	-1.96	117	21
5/9/2004	86	39	65	-2	0.2	1	19.37	-1.19	179	12
5/16/2004	87	58	71	3	2.87	4	22.24	0.42	255	26
5/23/2004	88	64	76	7	0.08	3	22.32	-0.71	371	68
5/30/2004	88	62	77	5	2.41	3	24.73	0.43	509	106
6/6/2004	88	53	72	-4	3.15	2	25.58	0.41	575	85
6/13/2004	92	64	79	5	0.07	2	25.07	-0.75	712	174
6/20/2004	91	66	79	4	0.9	4	25.97	-0.76	848	197
6/27/2004	86	63	74	-4	1.08	5	27.05	-0.6	949	177
7/4/2004	86	68	77	-2	0.72	4	27.77	-0.86	1067	167
7/11/2004	92	67	80	2	1.24	2	29.01	-0.65	1208	175
7/18/2004	95	68	80	2	0.44	1	29.45	-1.19	1353	187
7/25/2004	93	62	78	-1	2.1	2	31.55	-0.02	1482	180
8/1/2004	88	57	74	-6	0.59	3	32.14	-0.24	1580	145
8/8/2004	92	57	75	-4	0.5	1	32.64	-0.4	1691	123
8/15/2004	90	48	70	-9	0.05	1	32.69	-0.96	1762	67
8/22/2004	93	52	74	-5	2.2	3	34.89	0.62	1859	42
8/29/2004	89	65	79	3	2.14	3	37.03	2.07	1993	62
9/5/2004	88	59	74	-1	0.04	1	37.07	1.28	2094	61
9/12/2004	91	58	73	0	0	0	37.07	0.35	2189	64
9/19/2004	87	53	74	3	0.68	3	37.75	0.05	2285	82
9/26/2004	84	51	70	2	0.01	1	37.76	-0.86	2355	87
10/3/2004	84	42	64	-2	0.01	1	37.77	-1.66	2390	73
10/10/2004	84	42	65	2	0	0	37.77	-2.37	2424	71
10/17/2004	75	40	58	-2	3.01	5	40.78	-0.06	2444	66
10/24/2004	81	48	65	9	2.41	5	43.19	1.64	2484	92

DFN = departure from normal

Source: Tennessee Agricultural Statistics Service, Nashvill

Table 13. Summary of weather conditions by week of the 2005 growing season at Jackson TN.

WTREC Jackson TN	High Temp	Low Temp	Avg. Temp	Temp DFN†	Precip. Week	Rainy Days	Cumul. Precip.	Cumul DFN†	GDD Base 60°F Since April 1	
Week ending	°F	°F	°F	°F	in.	d.	in.	in.	Total	DFN†
1-May-05	70	36	54	-10	2.05	5	20.97	2.41	94	7
8-May-05	80	38	57	-9	0	0	20.97	1.14	103	-25
15-May-05	91	54	73	7	0.36	3	21.33	0.23	196	16
22-May-05	87	44	68	-1	0	0	21.33	-1.03	259	15
29-May-05	86	50	70	-1	0	0	21.33	-2.2	330	10
5-Jun-05	90	57	71	-2	3.13	2	24.46	-0.14	409	1
12-Jun-05	92	64	78	5	2.79	3	27.25	1.68	536	27
19-Jun-05	91	59	74	-3	0.86	1	28.11	1.63	636	17
26-Jun-05	93	62	77	1	0.04	1	28.15	0.76	759	22
3-Jul-05	95	67	80	3	0.27	3	28.42	0.06	899	36
10-Jul-05	93	66	79	1	1.66	3	30.08	0.71	1034	38
17-Jul-05	88	67	77	-3	2.88	5	32.96	2.59	1156	27
24-Jul-05	95	72	83	5	0.08	1	33.04	1.72	1319	55
31-Jul-05	96	66	80	2	0.66	1	33.7	1.53	1464	66
7-Aug-05	94	67	81	2	0.16	1	33.86	0.99	1611	80
14-Aug-05	97	68	82	5	0.65	1	34.51	1.01	1768	108
21-Aug-05	98	71	85	8	0.98	3	35.49	1.39	1943	159
28-Aug-05	95	69	81	5	2.94	3	38.43	3.67	2092	192
4-Sep-05	89	56	75	-2	2.54	2	40.97	5.42	2198	192
11-Sep-05	89	59	75	2	0	0	40.97	4.52	2303	202
18-Sep-05	90	59	75	4	1.99	1	42.96	5.53	2412	229
25-Sep-05	93	63	80	11	0	0	42.96	4.59	2550	298
2-Oct-05	87	45	68	2	1.98	3	44.94	5.72	2613	307
9-Oct-05	88	46	68	5	0.01	1	44.95	5	2682	337
16-Oct-05	83	42	61	1	0.07	1	45.02	4.37	2703	331
24-Oct-05	90	41	65	7	0	0	45.02	3.67	2747	358
30-Oct-05	64	30	46	-11	0.02	1	45.04	2.91	2747	347

†DFN = departure from normal. GDD = Growing degree-days (base 60 F).

Source: Tennessee Agricultural Statistics Service

Appendix C: Hendrix Protocol

Hendrix CH_2O Extraction and Analysis Protocol Outline and Supply List

Revised 5/12/05

I. Soluble Sugar Extraction	Materials
1. Scratch-mark clean poly tubes at 6.0 mL level, label these tubes to correspond to tissue samples. Label clean cylinders to match poly tube labels.	- (13 x 100 mm) polypropylene tubes. - Pipetter set on 6.0 mL. - Extra-fine Sharpie pen. - Rack(s) for tubes.
2. Weigh 100 mg (dry wt.) of each sub-sample of plant tissue into labeled poly tubes for extraction. Batch size = 48	- Labeling tape. - Analytical balance precise to 0.1 mg. - Spatula. - Weigh funnel (match tube size).
3. Add ~2 mL 80% ethanol to each tube. Set tubes in 70 ^{o}C waterbath for 30 min., with slow oscillation.	- Prepared 80% v/v aqueous ethanol in dispenser-top bottle.
4. Remove tubes from waterbath. Centrifuge at low speed to separate solid from liquid. Decant ethanolic extract by pipette into corresponding graduated cylinders.	- Heated waterbath w/thermometer. - Timer. - Low-speed centrifuge - Disposable 6-in. transfer pipettes
5. Repeat Step I-4. Vortex tubes lightly to resuspend solids.	- Prepared 80% v/v aqueous ethanol - Vortex shaker.
6. Repeat Steps I-5, I-6 (2nd extract), and I-7 also Repeat Steps I-5 and I-6 (3rd extract).	- 80% v/v aqueous ethanol in squeeze bottle. - Parafilm
7. Bring contents of cylinder to 10-ml volume with ethanol. Mix by gentle inversion.	- Refrigerator set between 2 - 8 ^{o}C.
8. Refrigerate ethanolic extracts and residual solid samples.	
[May pause here]	

II. Soluble Sugar Sample Prep.	Materials
1. Label microfuge tubes to match graduated cylinder from sugar extraction (or from starch digestion tubes in step VI-13).	- Microfuge tubes, 1.5 ml,
2. Add ~20 mg finely divided charcoal (Norit SA-3) to each microfuge tube.	- Norit SA-3 - Spatula marked for ~20 mg aliquot
3. Pipette 1.5 ml of extract from graduated cylinder (or from starch digestion tubes) into corresponding microfuge tubes.	- Micropipetter for 1.5 mL. - Disposable micropipette tips, 1.5 mL.
4. Close microfuge tubes tightly and vortex. Centrifuge tubes at 2200 g, 15 min. Set tubes gently into rack in sequence for microplate wells.	- Vortex shaker. - Microcentrifuge w/timer. - Microfuge tube rack.
5. Label microplate wells to match microfuge tubes. Label wells for standards and blanks. Standards = 0.1, 0.25, 0.5, 0.8, 1.0ug/uL each of glucose, fructose, and sucrose. Also need water blanks for zeroing the microplate reader.	- 96-well microplate(s) - Microplate well orienter and well pad - Well plate stand
6. Carefully pipette 20uL of extract solution from each tube into corresponding wells on microplate. Avoid charcoal granules. Aliquot size may need adjustment for different [GLU] in different samples. Record any changes in aliquot size.	- Micropipetter set at 20 uL. - 12x disposable micropipette tips, 20 uL.
7. Close residual extract microfuge tubes and store them in refrigerator (in case needed for re-analysis).	- Refrigerator set between 2 - 8 ^{o}C.
8. Cover microplate(s) very loosely with aluminum foil and dry overnight in forced air oven at 55 ^{o}C. All ethanol must be evaporated before proceeding.	- Aluminum foil - Forced air oven set at 55 ^{o}C.
[May pause here.]	

III. Enzyme Prep for Sugar Analyses

1. Reconsititute Glucose [HK] assay reagent with 20 ml deionized water. Invert vial to mix. May store at 2 - 8 ^{o}C up to 4 weeks. Makes enough for 200 samples or standards at 100 uL each.

2. Prepare glucose standards = 0.1, 0.25, 0.5, 0.8, 1.0 ug/uL from glucose standard solution.

3. Prepare phosphoglucose isomerase solution by adding 1.0 mL of 0.2 M HEPES (pH 7.8) to a vial containing 1000 EU of phosphoglucose isomerase. Makes enough for 100 samples or standards at 10 uL each. Store in refrigerator.

4. Prepare invertase solution by adding 5.0 mL of 0.1 M citrate buffer (pH 6.0) to 50 mg powdered invertase preparation. Makes enough for 214 samples or standards at 23uL each. Refrigerate.

[May pause here]

Materials

- 1x Glucose [HK] assay reagent (Sigma product G2020 in Sigma kit GAHK-20).
- deionized water.
- 20 ml pipette.
- Refrigerator set at 2- 8 ^{o}C.

- Glucose standard (Sigma G-3285), 1 mg/mL
- 10 ml pipette.
- Deionized water.

- Phosphoglucose isomerase (Sigma P-9544)
- HEPES (Sigma H-3375)
- Labeled vial with cap.
- Pipette for 1.0 mL.

- Invertase (Sigma I-4504), 825 EU/mg.
- Sodium citrate buffer (Sigma 82588), pH 6.0
- Labeled vial with cap.
- Pipette for 5.0 mL.

IV. Sugar Analyses

1. Add 20 uL of distilled water to each microplate well containing samples and standards.

2.Add 100uL of reconstituted glucose [HK] reagent to each microplate well containing dried samples, standards, and reagent blank.

3. Gently tap sides of microplate(s) to mix well contents as described by Hendrix.

4. Incubate 15 min. at room temperature (18-35 ^{o}C)

5. Measure absorbances of each well at 340 nm with microplate reader.

6. Calculate [GLU] by the slope of the standard curve. Assume that all sample [GLU] are within range of standards before continuing. If not, change aliquot size in step II.7 and repeat.

7. Add 10 uL of solution containing phosphoglucose isomerase to each well containing samples.

8. Repeat steps IV-2, IV-3, IV- 4, and IV-5 above. Increase in [GLU] is attributed to fructose in sample.

9. Add 23 uL of solution containing invertase to each well containing samples.

10. Repeat steps IV-2, IV-3, IV-4, and IV-5 above. Increase in [GLU] is attributed to sucrose in sample.

[May pause here]

Materials

- Reconstituted [HK] glucose reagent prepared in step III-1 above).
- Pipetter set on 100 uL

- Microplate reader with 340 nm filter.

Slope- y = mx + b
- Phosphoglucose isomerase solution prepared in step III-3 above.
- Pipetter set on 10 uL.

- Microplate reader with 340 nm filter.
- Slope- y = mx + b
- Phosphoglucose isomerase solution prepared in step III-3 above.
- Pipetter set on 10 uL.

- Microplate reader with 340 nm filter.

- Invertase solution prepared in step III-4 above.
- Pipetter set on 10 uL.

- Microplate reader with 340 nm filter.

V. Enzyme prep for starch analysis

1. For each batch (48 samples, dilute 17,280 EU of alpha amylase solution 10x with 1 M Tris-acetate buffer (pH 7.2). (One mL of undiluted enzyme solution contains 21,390 EU.) *Need 360EU/sample

2. Dialyze diluted alpha-amylase solution against distilled water overnight at room temp. Place each 10-mL aliquot in a separate, labelled dialysis tube floating in a 500ml Erlenmeyer flask.

3. For each batch (48 samples), dilute 5,856 EU of amyloglucosidase solution 50x with 50 mM sodium acetate buffer (pH 4.5). (One mL of undiluted enzyme solution contains 11,500 EU.) *Need 122EU/sample

4. Dialyze diluted amyloglucosidase solution against sodium acetate buffer overnight at room temp. Place each 10-mL aliquot in a separate, labeled dialysis tube floating in separate 100ml graduated cylinder. Note: At some point will have to transfer to fresh buffer and dialyze for remainder of time.

5. Next morning, transfer dialyzed alpha-amylase and amyloglucosidase preparations to labeled and covered erhlenmeyer flasks. Store in refrigerator if not used soon.

[May pause here]

Materials

- Alpha-amylase (Sigma A-3403)
- Tris-acetate buffer (Sigma T-9650 is 0.4M, pH 8.3)
- Pipette
- Labeled vial

- Dialysis tubes, floatable, 10 ml capacity, 25 KDa membrane.
- 10 mL pipette
- Large Erlenmeyer flask
- Distilled water

- Amyloglucosidase (Sigma A-3042)
- Sodium acetate buffer (Sigma 36050 is pH 4.65). Need ~ 60 mL/12 samples.

- Dialysis tubes, floatable, 10 ml capacity, 25 KDa membrane.
- 10-mL pipette
- large beaker
- Sodium acetate buffer

- Erlenmeyer flasks
- Parafilm
- Refrigerator

VI. Starch digestion

1. Add 1.0 mL of 0.1 M KOH to each poly tube containing solid residues from step I-11.

2. Place tubes in a beaker of boiling water for 1 hr. Adjust water volume to avoid splashing into tubes.

3. Remove beaker from hotplate to cool. Transfer tubes to rack to cool more.

4. Add 0.2 mL of 1.0 M acetic acid to each tube.

5. Adjust pH to ~7.2 with dilute (0.1 M) acetic acid. Add 0.17 mL (360 EU) of dialyzed alpha-amylase preparation to each tube.

6. Place tubes in water bath at 80 ^{o}C for 30 min., with gentle oscillation.

7. Remove tubes from water and cool in rack. Adjust pH to 5.0 with dilute (0.1 M) acetic acid.

8. Add .52 mL (122 EU) of dialyzed amyloglucosidase preparation to each tube.

9. Place tubes in water bath at 55 ^{o}C for 60 min., with gentle oscillation. Adjust speed and water volume in bath to avoid splashing into tubes.

10. Transfer tubes to boiling water bath for 4 min. to stop digestion.

11. Bring tubes to 6.0 mL volume with distilled water (use the 6.0 mL marks made in step I-1.) Mix contents of tubes by inversion. Refrigerate if not used soon.

12. Go to steps II-1 thru II-9 (skip II-2), III-1 and III-2, and IV-1 thru IV-5.

Materials

- KOH (0.1 M) in dispenser set for 1.0 mL.

- Glass beaker (sized for number of tubes).
- Tap water.
- Hot plate.
- Timer.
- Lined gloves
- Test tube rack(s)

- Acetic acid (1.0 M) in dispenser set for 0.2 mL.

- pH meter
- 0.1 M acetic acid in squeeze bottle

- Dialyzed alpha-amylase from step V-5.
- Pipetter set on 0.2 mL.

- Shaker water bath w/thermometer.
- Timer

- 0.1 M acetic acid in squeeze bottle

- Dialyzed amyloglucosidase from step V-5.
- Pipetter set on 1.0 mL.

- Shaker water bath w/thermometer.
- Timer

- Materials used in step VI-2.

- Squeeze bottle of distilled H_2

Calculations for absorbance @340nm

I. Glucose:

1. Find the net absorbance of your glucose standards
netAbs= grossAbs(glu)- reagent blank
2. Take the net abs and the glucose standards and form a standard curve, using linear regression.
3. Using the slope, generated by the curve, one can now calculate the concentration of diluted glucose in each well. Y=(netAbs*constant)+coefficient
4. Multiply by dilution factor to receive the concentration of undiluted glucose in each well.
5. Lastly, to determine the amount of sugar /100mg dry wgt, multiply by 10.

II. Fructose:

1. Find the net absorbance of fructose.
netAbs= grossAbs(fruc)- reagent blank
2. The net abs is then subtracted from the glucose abs giving a fructose abs.
3. Take the fructose abs and apply Step I. Glucose#3-5. This gives the fructose absorbance.

III. Sucrose:

1. Find the net absorbance of sucrose.
netAbs=grossAbs(suc)-reagent blank
2. Subtract the netAbs(suc) from the netAbs(fru) to get the sucrose abs.
3. Take the sucrose abs and apply Step I. Glucose #3-5 finding the sucrose absorbance.

Appendix D: N&K Study SAS data

N&K Starch
SAS Input

Variety 1= PM1218
2= DP555
K 1= 60lbs K_2O/acre/yr
2= 120lbs K_2O/acre/yr
Date 1= Early Bloom
2= Cutout

```
Starch is in mg/g dry weight
data NKStarch;
input Batch Plot Year Rep   Variety   K      Starch Date;
cards;
16      102     2003    1       1       1       96.41   1
16      108     2003    2       2       1       49.30   1
16      109     2003    2       1       2       84.94   1
16      111     2003    2       2       2       58.60   1
16      205     2003    1       2       1       88.12   1
16      206     2003    1       1       2       113.18  1
16      208     2003    4       2       2       19.26   1
16      211     2003    2       1       1       101.48  1
16      301     2003    3       1       1       88.20   1
16      303     2003    1       2       2       93.84   1
16      306     2003    3       1       2       77.87   1
16      311     2003    4       2       1       34.13   1
16      404     2003    3       2       1       53.73   1
16      405     2003    3       2       2       100.49  1
16      407     2003    4       1       2       139.39  1
16      412     2003    4       1       1       127.58  1
16      501     2003    5       2       2       61.39   1
16      505     2003    5       1       2       82.30   1
16      509     2003    5       1       1       107.91  1
16      512     2003    5       2       1       91.50   1
16      602     2003    6       2       2       40.10   1
16      603     2003    6       1       1       105.38  1
16      605     2003    6       1       2       85.71   1
16      606     2003    6       2       1       81.83   1
16      102     2003    1       1       1       83.18   1
16      108     2003    2       2       1       22.74   1
16      109     2003    2       1       2       88.79   1
16      111     2003    2       2       2       35.16   1
16      205     2003    1       2       1       84.94   1
16      206     2003    1       1       2       119.34  1
16      208     2003    4       2       2       15.96   1
16      211     2003    2       1       1       109.44  1
16      301     2003    3       1       1       94.21   1
16      303     2003    1       2       2       102.12  1
16      306     2003    3       1       2       80.11   1
16      311     2003    4       2       1       51.20   1
16      404     2003    3       2       1       99.44   1
16      405     2003    3       2       2       84.11   1
16      407     2003    4       1       2       108.62  1
16      412     2003    4       1       1       19.59   1
16      501     2003    5       2       2       41.75   1
16      505     2003    5       1       2       74.36   1
16      509     2003    5       1       1       98.75   1
16      512     2003    5       2       1       81.35   1
16      602     2003    6       2       2       41.13   1
16      603     2003    6       1       1       108.62  1
16      605     2003    6       1       2       87.62   1
16      606     2003    6       2       1       42.30   1
17      102     2003    1       1       1       144.76  1
17      108     2003    2       2       1       55.80   1
17      109     2003    2       1       2       126.19  1
```

17	111	2003	2	2	2	71.19	1
17	205	2003	1	2	1	127.12	1
17	206	2003	1	1	2	143.55	1
17	208	2003	4	2	2	51.90	1
17	211	2003	2	1	1	151.52	1
17	301	2003	3	1	1	149.38	1
17	303	2003	1	2	2	129.49	1
17	306	2003	3	1	2	145.53	1
17	311	2003	4	2	1	59.92	1
17	404	2003	3	2	1	140.48	1
17	405	2003	3	2	2	101.19	1
17	407	2003	4	1	2	152.79	1
17	412	2003	4	1	1	168.94	1
17	501	2003	5	2	2	51.57	1
17	505	2003	5	1	2	95.91	1
17	509	2003	5	1	1	156.74	1
17	512	2003	5	2	1	93.33	1
17	602	2003	6	2	2	80.58	1
17	603	2003	6	1	1	135.26	1
17	605	2003	6	1	2	104.60	1
17	606	2003	6	2	1	87.84	1
17	102	2003	1	1	1	164.38	1
17	108	2003	2	2	1	54.98	1
17	109	2003	2	1	2	132.89	1
17	111	2003	2	2	2	44.37	1
17	205	2003	1	2	1	99.92	1
17	206	2003	1	1	2	167.62	1
17	208	2003	4	2	2	57.78	1
17	211	2003	2	1	1	148.99	1
17	301	2003	3	1	1	166.74	1
17	303	2003	1	2	2	135.26	1
17	306	2003	3	1	2	86.24	1
17	311	2003	4	2	1	41.35	1
17	404	2003	3	2	1	138.66	1
17	405	2003	3	2	2	105.36	1
17	407	2003	4	1	2	147.02	1
17	412	2003	4	1	1	148.61	1
17	501	2003	5	2	2	36.18	1
17	505	2003	5	1	2	159.38	1
17	509	2003	5	1	1	107.73	1
17	512	2003	5	2	1	117.51	1
17	602	2003	6	2	2	88.93	1
17	603	2003	6	1	1	110.04	1
17	605	2003	6	1	2	96.52	1
17	606	2003	6	2	1	89.04	1
18	102	2003	1	1	1	125.98	1
18	108	2003	2	2	1	30.04	1
18	109	2003	2	1	2	148.84	1
18	111	2003	2	2	2	26.14	1
18	205	2003	1	2	1	107.58	1
18	206	2003	1	1	2	127.41	1
18	208	2003	4	2	2	45.43	1
18	211	2003	2	1	1	155.77	1
18	301	2003	3	1	1	147.36	1
18	303	2003	1	2	2	131.15	1
18	306	2003	3	1	2	128.68	1
18	311	2003	4	2	1	44.66	1
18	404	2003	3	2	1	112.19	1
18	405	2003	3	2	2	113.95	1
18	407	2003	4	1	2	78.18	1
18	412	2003	4	1	1	99.94	1
18	501	2003	5	2	2	39.71	1
18	505	2003	5	1	2	98.84	1
18	509	2003	5	1	1	89.66	1
18	512	2003	5	2	1	79.55	1
18	602	2003	6	2	2	63.56	1
18	603	2003	6	1	1	119.66	1
18	605	2003	6	1	2	74.83	1
18	606	2003	6	2	1	67.74	1

18	102	2003	1	1	1	108.57	2
18	108	2003	2	2	1	19.38	2
18	109	2003	2	1	2	72.74	2
18	111	2003	2	2	2	47.35	2
18	205	2003	1	2	1	38.62	2
18	206	2003	1	1	2	56.42	2
18	208	2003	4	2	2	53.01	2
18	211	2003	2	1	1	13.28	2
18	301	2003	3	1	1	39.17	2
18	303	2003	1	2	2	76.04	2
18	306	2003	3	1	2	80.32	2
18	311	2003	4	2	1	40.76	2
18	404	2003	3	2	1	74.83	2
18	405	2003	3	2	2	46.42	2
18	407	2003	4	1	2	39.00	2
18	412	2003	4	1	1	66.25	2
18	501	2003	5	2	2	27.96	2
18	505	2003	5	1	2	72.57	2
18	509	2003	5	1	1	19.60	2
18	512	2003	5	2	1	53.07	2
18	602	2003	6	2	2	73.89	2
18	603	2003	6	1	1	76.92	2
18	605	2003	6	1	2	69.28	2
18	606	2003	6	2	1	31.53	2
19	102	2003	1	1	1	94.39	2
19	108	2003	2	2	1	59.22	2
19	109	2003	2	1	2	93.07	2
19	111	2003	2	2	2	64.77	2
19	205	2003	1	2	1	53.07	2
19	206	2003	1	1	2	28.23	2
19	208	2003	4	2	2	44.33	2
19	211	2003	2	1	1	14.77	2
19	301	2003	3	1	1	60.05	2
19	303	2003	1	2	2	42.24	2
19	306	2003	3	1	2	54.39	2
19	311	2003	4	2	1	52.74	2
19	404	2003	3	2	1	47.68	2
19	405	2003	3	2	2	31.75	2
19	407	2003	4	1	2	.	2
19	412	2003	4	1	1	93.12	2
19	501	2003	5	2	2	48.73	2
19	505	2003	5	1	2	70.49	2
19	509	2003	5	1	1	59.06	2
19	512	2003	5	2	1	33.18	2
19	602	2003	6	2	2	57.90	2
19	603	2003	6	1	1	100.76	2
19	605	2003	6	1	2	79.00	2
19	606	2003	6	2	1	68.84	2
19	102	2003	1	1	1	34.66	2
19	108	2003	2	2	1	22.35	2
19	109	2003	2	1	2	67.46	2
19	111	2003	2	2	2	64.44	2
19	205	2003	1	2	1	32.41	2
19	206	2003	1	1	2	26.09	2
19	208	2003	4	2	2	55.43	2
19	211	2003	2	1	1	19.93	2
19	301	2003	3	1	1	65.10	2
19	303	2003	1	2	2	61.75	2
19	306	2003	3	1	2	43.95	2
19	311	2003	4	2	1	89.66	2
19	404	2003	3	2	1	78.89	2
19	405	2003	3	2	2	57.68	2
19	407	2003	4	1	2	133.18	2
19	412	2003	4	1	1	72.90	2
19	501	2003	5	2	2	61.31	2
19	505	2003	5	1	2	84.06	2
19	509	2003	5	1	1	96.15	2
19	512	2003	5	2	1	39.00	2
19	602	2003	6	2	2	46.47	2

19	603	2003	6	1	1	25.87	2
19	605	2003	6	1	2	71.86	2
19	606	2003	6	2	1	41.31	2
20	102	2003	1	1	1	36.35	2
20	108	2003	2	2	1	.	2
20	109	2003	2	1	2	.	2
20	111	2003	2	2	2	55.31	2
20	205	2003	1	2	1	33.11	2
20	206	2003	1	1	2	14.48	2
20	208	2003	4	2	2	27.06	2
20	211	2003	2	1	1	34.04	2
20	301	2003	3	1	1	37.06	2
20	303	2003	1	2	2	30.36	2
20	306	2003	3	1	2	104.82	2
20	311	2003	4	2	1	37.39	2
20	404	2003	3	2	1	48.82	2
20	405	2003	3	2	2	42.17	2
20	407	2003	4	1	2	41.90	2
20	412	2003	4	1	1	32.56	2
20	501	2003	5	2	2	18.11	2
20	505	2003	5	1	2	77.40	2
20	509	2003	5	1	1	61.68	2
20	512	2003	5	2	1	56.68	2
20	602	2003	6	2	2	32.39	2
20	603	2003	6	1	1	66.63	2
20	605	2003	6	1	2	23.99	2
20	606	2003	6	2	1	16.07	2
20	102	2003	1	1	1	19.54	2
20	108	2003	2	2	1	40.86	2
20	109	2003	2	1	2	48.11	2
20	111	2003	2	2	2	15.30	2
20	205	2003	1	2	1	81.79	2
20	206	2003	1	1	2	62.07	2
20	208	2003	4	2	2	71.19	2
20	211	2003	2	1	1	62.12	2
20	301	2003	3	1	1	59.59	2
20	303	2003	1	2	2	23.77	2
20	306	2003	3	1	2	34.37	2
20	311	2003	4	2	1	41.84	2
20	404	2003	3	2	1	42.83	2
20	405	2003	3	2	2	32.06	2
20	407	2003	4	1	2	45.47	2
20	412	2003	4	1	1	28.77	2
20	501	2003	5	2	2	40.42	2
20	505	2003	5	1	2	23.16	2
20	509	2003	5	1	1	55.25	2
20	512	2003	5	2	1	.	2
20	602	2003	6	2	2	18.66	2
20	603	2003	6	1	1	28.88	2
20	605	2003	6	1	2	80.91	2
20	606	2003	6	2	1	.	2
21	102	2004	1	2	1	46.86	1
21	108	2004	1	1	1	68.40	1
21	109	2004	1	2	2	70.49	1
21	111	2004	1	1	2	94.99	1
21	205	2004	2	1	1	65.93	1
21	206	2004	2	2	2	.	1
21	208	2004	2	1	2	28.62	1
21	211	2004	2	2	1	57.24	1
21	301	2004	3	2	1	10.26	1
21	303	2004	3	1	2	90.27	1
21	306	2004	3	2	2	41.80	1
21	311	2004	3	1	1	65.27	1
21	404	2004	4	1	1	83.40	1
21	405	2004	4	1	2	69.99	1
21	407	2004	4	2	2	13.28	1
21	412	2004	4	2	1	43.29	1
21	501	2004	5	1	2	97.80	1
21	505	2004	5	2	2	21.31	1

21	509	2004	5	2	1	53.78	1
21	512	2004	5	1	1	44.50	1
21	602	2004	6	1	2	39.50	1
21	603	2004	6	2	1	.	1
21	605	2004	6	2	2	.	1
21	606	2004	6	1	1	52.63	1
21	102	2004	1	2	1	62.74	1
21	108	2004	1	1	1	79.94	1
21	109	2004	1	2	2	21.14	1
21	111	2004	1	1	2	43.45	1
21	205	2004	2	1	1	66.47	1
21	206	2004	2	2	2	19.66	1
21	208	2004	2	1	2	72.74	1
21	211	2004	2	2	1	51.03	1
21	301	2004	3	2	1	20.43	1
21	303	2004	3	1	2	81.37	1
21	306	2004	3	2	2	22.30	1
21	311	2004	3	1	1	65.82	1
21	404	2004	4	1	1	124.61	1
21	405	2004	4	1	2	56.91	1
21	407	2004	4	2	2	68.78	1
21	412	2004	4	2	1	18.45	1
21	501	2004	5	1	2	44.72	1
21	505	2004	5	2	2	38.29	1
21	509	2004	5	2	1	38.95	1
21	512	2004	5	1	1	47.24	1
21	602	2004	6	1	2	16.53	1
21	603	2004	6	2	1	16.25	1
21	605	2004	6	2	2	20.32	1
21	606	2004	6	1	1	43.12	1
22	102	2004	1	2	1	19.37	1
22	108	2004	1	1	1	78.27	1
22	109	2004	1	2	2	23.11	1
22	111	2004	1	1	2	67.61	1
22	205	2004	2	1	1	73.22	1
22	206	2004	2	2	2	14.48	1
22	208	2004	2	1	2	53.00	1
22	211	2004	2	2	1	51.41	1
22	301	2004	3	2	1	20.14	1
22	303	2004	3	1	2	87.12	1
22	306	2004	3	2	2	40.53	1
22	311	2004	3	1	1	32.72	1
22	404	2004	4	1	1	103.50	1
22	405	2004	4	1	2	69.98	1
22	407	2004	4	2	2	.	1
22	412	2004	4	2	1	24.81	1
22	501	2004	5	1	2	68.05	1
22	505	2004	5	2	2	23.22	1
22	509	2004	5	2	1	29.15	1
22	512	2004	5	1	1	44.65	1
22	602	2004	6	1	2	61.79	1
22	603	2004	6	2	1	11.07	1
22	605	2004	6	2	2	16.73	1
22	606	2004	6	1	1	54.59	1
22	102	2004	1	2	1	30.03	1
22	108	2004	1	1	1	69.26	1
22	109	2004	1	2	2	30.47	1
22	111	2004	1	1	2	69.04	1
22	205	2004	2	1	1	73.11	1
22	206	2004	2	2	2	27.83	1
22	208	2004	2	1	2	50.86	1
22	211	2004	2	2	1	38.05	1
22	301	2004	3	2	1	.	1
22	303	2004	3	1	2	51.13	1
22	306	2004	3	2	2	15.58	1
22	311	2004	3	1	1	34.81	1
22	404	2004	4	1	1	55.03	1
22	405	2004	4	1	2	51.57	1
22	407	2004	4	2	2	43.99	1

22	412	2004	4	2	1	23.82	1
22	501	2004	5	1	2	63.16	1
22	505	2004	5	2	2	20.91	1
22	509	2004	5	2	1	14.97	1
22	512	2004	5	1	1	51.41	1
22	602	2004	6	1	2	26.35	1
22	603	2004	6	2	1	10.74	1
22	605	2004	6	2	2	15.41	1
22	606	2004	6	1	1	54.98	1
23	102	2004	1	2	1	45.10	1
23	108	2004	1	1	1	80.43	1
23	109	2004	1	2	2	49.99	1
23	111	2004	1	1	2	37.85	1
23	205	2004	2	1	1	87.41	1
23	206	2004	2	2	2	.	1
23	208	2004	2	1	2	52.41	1
23	211	2004	2	2	1	51.31	1
23	301	2004	3	2	1	17.24	1
23	303	2004	3	1	2	88.12	1
23	306	2004	3	2	2	25.32	1
23	311	2004	3	1	1	70.05	1
23	404	2004	4	1	1	83.78	1
23	405	2004	4	1	2	31.53	1
23	407	2004	4	2	2	15.81	1
23	412	2004	4	2	1	29.16	1
23	501	2004	5	1	2	88.45	1
23	505	2004	5	2	2	24.99	1
23	509	2004	5	2	1	82.03	1
23	512	2004	5	1	1	72.85	1
23	602	2004	6	1	2	88.67	1
23	603	2004	6	2	1	.	1
23	605	2004	6	2	2	11.36	1
23	606	2004	6	1	1	51.75	1
23	102	2004	1	2	1	97.15	2
23	108	2004	1	1	1	91.39	2
23	109	2004	1	2	2	135.76	2
23	111	2004	1	1	2	129.44	2
23	205	2004	2	1	1	113.29	2
23	206	2004	2	2	2	138.40	2
23	208	2004	2	1	2	132.87	2
23	211	2004	2	2	1	124.71	2
23	301	2004	3	2	1	101.80	2
23	303	2004	3	1	2	62.04	2
23	306	2004	3	2	2	120.79	2
23	311	2004	3	1	1	111.46	2
23	404	2004	4	1	1	84.13	2
23	405	2004	4	1	2	137.71	2
23	407	2004	4	2	2	134.93	2
23	412	2004	4	2	1	115.16	2
23	501	2004	5	1	2	87.62	2
23	505	2004	5	2	2	130.04	2
23	509	2004	5	2	1	87.93	2
23	512	2004	5	1	1	102.86	2
23	602	2004	6	1	2	89.91	2
23	603	2004	6	2	1	110.83	2
23	605	2004	6	2	2	135.10	2
23	606	2004	6	1	1	77.06	2
24	102	2004	1	2	1	122.47	2
24	108	2004	1	1	1	94.94	2
24	109	2004	1	2	2	61.97	2
24	111	2004	1	1	2	132.52	2
24	205	2004	2	1	1	168.79	2
24	206	2004	2	2	2	111.70	2
24	208	2004	2	1	2	155.77	2
24	211	2004	2	2	1	153.24	2
24	301	2004	3	2	1	174.94	2
24	303	2004	3	1	2	177.03	2
24	306	2004	3	2	2	177.14	2
24	311	2004	3	1	1	177.86	2

24	404	2004	4	1	1	59.00	2
24	405	2004	4	1	2	82.74	2
24	407	2004	4	2	2	170.05	2
24	412	2004	4	2	1	87.85	2
24	501	2004	5	1	2	142.52	2
24	505	2004	5	2	2	155.60	2
24	509	2004	5	2	1	119.34	2
24	512	2004	5	1	1	36.36	2
24	602	2004	6	1	2	141.59	2
24	603	2004	6	2	1	98.45	2
24	605	2004	6	2	2	101.59	2
24	606	2004	6	1	1	158.90	2
24	102	2004	1	2	1	76.53	2
24	108	2004	1	1	1	136.53	2
24	109	2004	1	2	2	117.96	2
24	111	2004	1	1	2	146.86	2
24	205	2004	2	1	1	167.31	2
24	206	2004	2	2	2	136.15	2
24	208	2004	2	1	2	159.12	2
24	211	2004	2	2	1	120.05	2
24	301	2004	3	2	1	116.75	2
24	303	2004	3	1	2	164.83	2
24	306	2004	3	2	2	104.39	2
24	311	2004	3	1	1	169.94	2
24	404	2004	4	1	1	161.26	2
24	405	2004	4	1	2	103.02	2
24	407	2004	4	2	2	180.55	2
24	412	2004	4	2	1	123.24	2
24	501	2004	5	1	2	94.66	2
24	505	2004	5	2	2	102.74	2
24	509	2004	5	2	1	129.39	2
24	512	2004	5	1	1	113.73	2
24	602	2004	6	1	2	88.45	2
24	603	2004	6	2	1	133.68	2
24	605	2004	6	2	2	130.93	2
24	606	2004	6	1	1	143.07	2
25	102	2004	1	2	1	162.11	2
25	108	2004	1	1	1	60.02	2
25	109	2004	1	2	2	78.21	2
25	111	2004	1	1	2	64.14	2
25	205	2004	2	1	1	130.30	2
25	206	2004	2	2	2	108.59	2
25	208	2004	2	1	2	129.42	2
25	211	2004	2	2	1	133.98	2
25	301	2004	3	2	1	160.24	2
25	303	2004	3	1	2	103.92	2
25	306	2004	3	2	2	134.58	2
25	311	2004	3	1	1	143.54	2
25	404	2004	4	1	1	72.11	2
25	405	2004	4	1	2	86.23	2
25	407	2004	4	2	2	166.07	2
25	412	2004	4	2	1	91.72	2
25	501	2004	5	1	2	107.11	2
25	505	2004	5	2	2	93.70	2
25	509	2004	5	2	1	98.37	2
25	512	2004	5	1	1	53.48	2
25	602	2004	6	1	2	111.51	2
25	603	2004	6	2	1	96.34	2
25	605	2004	6	2	2	118.65	2
25	606	2004	6	1	1	136.62	2
25	102	2004	1	2	1	79.58	2
25	108	2004	1	1	1	59.63	2
25	109	2004	1	2	2	105.52	2
25	111	2004	1	1	2	103.59	2
25	205	2004	2	1	1	104.47	2
25	206	2004	2	2	2	165.41	2
25	208	2004	2	1	2	95.19	2
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25	303	2004	3	1	2	62.16	2
25	306	2004	3	2	2	112.55	2
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25	404	2004	4	1	1	129.80	2
25	405	2004	4	1	2	98.76	2
25	407	2004	4	2	2	119.58	2
25	412	2004	4	2	1	94.69	2
25	501	2004	5	1	2	128.10	2
25	505	2004	5	2	2	41.50	2
25	509	2004	5	2	1	108.54	2
25	512	2004	5	1	1	99.42	2
25	602	2004	6	1	2	159.15	2
25	603	2004	6	2	1	161.23	2
25	605	2004	6	2	2	122.06	2
25	606	2004	6	1	1	103.48	2
26	102	2005	1	1	1	53.45	1
26	108	2005	1	2	1	11.13	1
26	109	2005	1	1	2	31.33	1
26	111	2005	1	2	2	6.77	1
26	205	2005	2	2	1	12.95	1
26	206	2005	2	1	2	57.43	1
26	208	2005	2	2	2	6.63	1
26	211	2005	2	1	1	33.20	1
26	301	2005	3	1	1	73.42	1
26	303	2005	3	2	2	6.91	1
26	306	2005	3	1	2	31.14	1
26	311	2005	3	2	1	8.59	1
26	404	2005	4	2	1	16.11	1
26	405	2005	4	2	2	21.47	1
26	407	2005	4	1	2	20.46	1
26	412	2005	4	1	1	41.05	1
26	501	2005	5	2	2	7.44	1
26	505	2005	5	1	2	11.22	1
26	509	2005	5	1	1	15.96	1
26	512	2005	5	2	1	10.26	1
26	602	2005	6	2	2	4.90	1
26	603	2005	6	1	1	21.76	1
26	605	2005	6	1	2	17.88	1
26	606	2005	6	2	1	7.44	1
26	102	2005	1	1	1	70.79	1
26	108	2005	1	2	1	21.85	1
26	109	2005	1	1	2	23.62	1
26	111	2005	1	2	2	6.24	1
26	205	2005	2	2	1	14.10	1
26	206	2005	2	1	2	38.42	1
26	208	2005	2	2	2	6.87	1
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26	301	2005	3	1	1	86.68	1
26	303	2005	3	2	2	8.11	1
26	306	2005	3	1	2	77.54	1
26	311	2005	3	2	1	16.97	1
26	404	2005	4	2	1	18.79	1
26	405	2005	4	2	2	15.34	1
26	407	2005	4	1	2	25.11	1
26	412	2005	4	1	1	27.50	1
26	501	2005	5	2	2	5.86	1
26	505	2005	5	1	2	21.37	1
26	509	2005	5	1	1	21.04	1
26	512	2005	5	2	1	9.93	1
26	602	2005	6	2	2	7.30	1
26	603	2005	6	1	1	10.70	1
26	605	2005	6	1	2	18.55	1
26	606	2005	6	2	1	6.00	1
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27	108	2005	1	2	1	12.04	1
27	109	2005	1	1	2	28.79	1
27	111	2005	1	2	2	2.70	1
27	205	2005	2	2	1	19.89	1
27	206	2005	2	1	2	25.35	1

27	208	2005	2	2	2	1.50	1
27	211	2005	2	1	1	15.87	1
27	301	2005	3	1	1	71.93	1
27	303	2005	3	2	2	7.25	1
27	306	2005	3	1	2	40.19	1
27	311	2005	3	2	1	17.21	1
27	404	2005	4	2	1	10.79	1
27	405	2005	4	2	2	9.36	1
27	407	2005	4	1	2	20.03	1
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27	501	2005	5	2	2	1.89	1
27	505	2005	5	1	2	10.89	1
27	509	2005	5	1	1	10.31	1
27	512	2005	5	2	1	3.47	1
27	602	2005	6	2	2	1.45	1
27	603	2005	6	1	1	17.21	1
27	605	2005	6	1	2	23.72	1
27	606	2005	6	2	1	2.56	1
27	102	2005	1	1	1	87.97	1
27	108	2005	1	2	1	15.63	1
27	109	2005	1	1	2	40.00	1
27	111	2005	1	2	2	8.06	1
27	205	2005	2	2	1	14.00	1
27	206	2005	2	1	2	39.95	1
27	208	2005	2	2	2	3.66	1
27	211	2005	2	1	1	19.27	1
27	301	2005	3	1	1	62.07	1
27	303	2005	3	2	2	14.05	1
27	306	2005	3	1	2	47.99	1
27	311	2005	3	2	1	4.52	1
27	404	2005	4	2	1	14.86	1
27	405	2005	4	2	2	28.94	1
27	407	2005	4	1	2	15.20	1
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27	501	2005	5	2	2	3.23	1
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27	602	2005	6	2	2	2.70	1
27	603	2005	6	1	1	6.43	1
27	605	2005	6	1	2	21.71	1
27	606	2005	6	2	1	4.14	1
28	102	2005	1	1	1	43.83	1
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28	111	2005	1	2	2	2.41	1
28	205	2005	2	2	1	19.46	1
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28	405	2005	4	2	2	22.43	1
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28	412	2005	4	1	1	32.29	1
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28	603	2005	6	1	1	8.64	1
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28	111	2005	1	2	2	71.07	2
28	205	2005	2	2	1	95.59	2
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28	211	2005	2	1	1	83.90	2
28	301	2005	3	1	1	45.79	2
28	303	2005	3	2	2	99.23	2
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28	311	2005	3	2	1	58.19	2
28	404	2005	4	2	1	87.54	2
28	405	2005	4	2	2	73.04	2
28	407	2005	4	1	2	105.64	2
28	412	2005	4	1	1	31.95	2
28	501	2005	5	2	2	75.67	2
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28	509	2005	5	1	1	53.26	2
28	512	2005	5	2	1	62.93	2
28	602	2005	6	2	2	49.57	2
28	603	2005	6	1	1	80.41	2
28	605	2005	6	1	2	61.54	2
28	606	2005	6	2	1	61.50	2
29	102	2005	1	1	1	110.86	2
29	108	2005	1	2	1	65.33	2
29	109	2005	1	1	2	73.42	2
29	111	2005	1	2	2	54.70	2
29	205	2005	2	2	1	84.91	2
29	206	2005	2	1	2	98.65	2
29	208	2005	2	2	2	99.08	2
29	211	2005	2	1	1	53.41	2
29	301	2005	3	1	1	69.16	2
29	303	2005	3	2	2	80.07	2
29	306	2005	3	1	2	77.49	2
29	311	2005	3	2	1	58.91	2
29	404	2005	4	2	1	27.84	2
29	405	2005	4	2	2	75.38	2
29	407	2005	4	1	2	77.44	2
29	412	2005	4	1	1	100.66	2
29	501	2005	5	2	2	88.74	2
29	505	2005	5	1	2	58.10	2
29	509	2005	5	1	1	134.32	2
29	512	2005	5	2	1	77.92	2
29	602	2005	6	2	2	67.10	2
29	603	2005	6	1	1	88.36	2
29	605	2005	6	1	2	57.47	2
29	606	2005	6	2	1	38.13	2
29	102	2005	1	1	1	135.33	2
29	108	2005	1	2	1	75.14	2
29	109	2005	1	1	2	67.19	2
29	111	2005	1	2	2	73.71	2
29	205	2005	2	2	1	112.01	2
29	206	2005	2	1	2	26.11	2
29	208	2005	2	2	2	72.22	2
29	211	2005	2	1	1	75.91	2
29	301	2005	3	1	1	79.21	2
29	303	2005	3	2	2	70.79	2
29	306	2005	3	1	2	122.21	2
29	311	2005	3	2	1	97.50	2
29	404	2005	4	2	1	69.21	2
29	405	2005	4	2	2	82.80	2
29	407	2005	4	1	2	71.93	2
29	412	2005	4	1	1	105.64	2
29	501	2005	5	2	2	74.52	2
29	505	2005	5	1	2	107.75	2
29	509	2005	5	1	1	105.79	2
29	512	2005	5	2	1	76.67	2
29	602	2005	6	2	2	38.71	2
29	603	2005	6	1	1	107.13	2
29	605	2005	6	1	2	63.32	2
29	606	2005	6	2	1	102.29	2

```
30      102     2005    1       1       1       85.58   2
30      108     2005    1       2       1       95.92   2
30      109     2005    1       1       2       60.16   2
30      111     2005    1       2       2       73.61   2
30      205     2005    2       2       1       32.58   2
30      206     2005    2       1       2       79.69   2
30      208     2005    2       2       2       33.77   2
30      211     2005    2       1       1       48.09   2
30      301     2005    3       1       1       74.71   2
30      303     2005    3       2       2       65.66   2
30      306     2005    3       1       2       61.45   2
30      311     2005    3       2       1       89.70   2
30      404     2005    4       2       1       68.39   2
30      405     2005    4       2       2       84.77   2
30      407     2005    4       1       2       37.08   2
30      412     2005    4       1       1       88.02   2
30      501     2005    5       2       2       35.88   2
30      505     2005    5       1       2       53.84   2
30      509     2005    5       1       1       40.38   2
30      512     2005    5       2       1       145.53  2
30      602     2005    6       2       2       80.03   2
30      603     2005    6       1       1       51.92   2
30      605     2005    6       1       2       .       2
30      606     2005    6       2       1       104.40  2
30      102     2005    1       1       1       91.57   2
30      108     2005    1       2       1       86.20   2
30      109     2005    1       1       2       78.25   2
30      111     2005    1       2       2       127.67  2
30      205     2005    2       2       1       102.72  2
30      206     2005    2       1       2       52.59   2
30      208     2005    2       2       2       40.72   2
30      211     2005    2       1       1       41.58   2
30      301     2005    3       1       1       78.21   2
30      303     2005    3       2       2       72.80   2
30      306     2005    3       1       2       85.87   2
30      311     2005    3       2       1       87.74   2
30      404     2005    4       2       1       21.18   2
30      405     2005    4       2       2       97.46   2
30      407     2005    4       1       2       11.94   2
30      412     2005    4       1       1       23.38   2
30      501     2005    5       2       2       73.23   2
30      505     2005    5       1       2       99.04   2
30      509     2005    5       1       1       70.50   2
30      512     2005    5       2       1       21.56   2
30      602     2005    6       2       2       47.28   2
30      603     2005    6       1       1       66.48   2
30      605     2005    6       1       2       23.91   2
30      606     2005    6       2       1       15.15   2
;

%include'c:\danda.sas';
%mmaov(NKStarch,starch, Class=Year Rep Variety K Date,fixed=Year |Variety |K  |Date,
   random = Rep(Year) Variety*K*Rep(Year) Variety*Date*K*rep(year), DDFM=CONTAIN  );
```

N&K Starch
SAS Output

```
                                        The Mixed Procedure

                                        Model Information

                        Data Set                     WORK.NKSTARCH
                        Dependent Variable           Starch
                        Covariance Structure         Variance Components
                        Estimation Method            REML
                        Residual Variance Method     Profile
                        Fixed Effects SE Method      Model-Based
                        Degrees of Freedom Method    Containment
```

Class Level Information

Class	Levels	Values
Year	3	2003 2004 2005
Rep	6	1 2 3 4 5 6
Variety	2	1 2
K	2	1 2
Date	2	1 2

Dimensions

Covariance Parameters	4
Columns in X	108
Columns in Z	234
Subjects	1
Max Obs Per Subject	720

Number of Observations

Number of Observations Read	720
Number of Observations Used	707
Number of Observations Not Used	13

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	6460.33354644	
1	3	6413.55050626	0.00008084
2	1	6413.32644312	0.00000136
3	1	6413.32288254	0.00000000

Mixed ANOVA for starch

The Mixed Procedure

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Rep(Year)	23.3007	19.7180	1.18	0.1187
Rep*Variety*K(Year)	0	.	.	.
Rep*Var*K*Date(Year)	126.63	33.1582	3.82	<.0001
Residual	536.70	31.9643	16.79	<.0001

Fit Statistics

-2 Res Log Likelihood	6413.3
AIC (smaller is better)	6419.3
AICC (smaller is better)	6419.4
BIC (smaller is better)	6422.0

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	15	37.87	<.0001
Variety	1	45	47.04	<.0001

Year*Variety	2	45	3.36	0.0438
K	1	45	0.93	0.3396
Year*K	2	45	0.36	0.7015
Variety*K	1	45	0.02	0.8781
Year*Variety*K	2	45	0.28	0.7599
Date	1	60	102.41	<.0001
Year*Date	2	60	187.15	<.0001
Variety*Date	1	60	38.71	<.0001
Year*Variety*Date	2	60	0.67	0.5170
K*Date	1	60	2.17	0.1456
Year*K*Date	2	60	0.52	0.5971
Variety*K*Date	1	60	0.01	0.9330
Year*Variety*K*Date	2	60	0.19	0.8282

---------- Effect=Year Method=LSD(P<.05) Set=1 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
1	2003	_	_	_	73.1835	2.9686	B
2	2004	_	_	_	82.1681	2.9737	A
3	2005	_	_	_	47.0364	2.9612	C

---------- Effect=Variety Method=LSD(P<.05) Set=2 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
4	_	1	_	_	76.2499	2.1351	A
5	_	2	_	_	58.6755	2.1440	B

---------- Effect=Year*Variety Method=LSD(P<.05) Set=3 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
6	2003	1	_	_	86.6387	3.7040	A
7	2003	2	_	_	59.7282	3.7101	C
8	2004	1	_	_	89.0453	3.6922	A
9	2004	2	_	_	75.2910	3.7380	B
10	2005	1	_	_	53.0655	3.6980	C
11	2005	2	_	_	41.0073	3.6922	D

---------- Effect=K Method=LSD(P<.05) Set=4 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
12	_	_	1	_	68.6993	2.1390	A
13	_	_	2	_	66.2261	2.1401	A

---------- Effect=Year*K Method=LSD(P<.05) Set=5 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
14	2003	_	1	_	74.5558	3.7101	A
15	2003	_	2	_	71.8111	3.7040	A

16	2004	_	1	_	82.0154	3.7120	A
17	2004	_	2	_	82.3209	3.7184	A
18	2005	_	1	_	49.5266	3.6922	B
19	2005	_	2	_	44.5463	3.6980	B

---------- Effect=Variety*K Method=LSD(P<.05) Set=6 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
20	_	1	1	_	77.6841	2.7917	A
21	_	1	2	_	74.8157	2.8020	A
22	_	2	1	_	59.7144	2.8138	B
23	_	2	2	_	57.6366	2.8071	B

---------- Effect=Year*Variety*K Method=LSD(P<.05) Set=7 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
24	2003	1	1	_	86.9205	4.8354	AB
25	2003	1	2	_	86.3570	4.8712	AB
26	2003	2	1	_	62.1911	4.8900	CD
27	2003	2	2	_	57.2653	4.8354	D
28	2004	1	1	_	89.3980	4.8354	A
29	2004	1	2	_	88.6927	4.8354	A
30	2004	2	1	_	74.6327	4.8956	BC
31	2004	2	2	_	75.9492	4.9150	BC
32	2005	1	1	_	56.7337	4.8354	D
33	2005	1	2	_	49.3973	4.8531	DE
34	2005	2	1	_	42.3195	4.8354	E
35	2005	2	2	_	39.6952	4.8354	E

---------- Effect=Date Method=LSD(P<.05) Set=8 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
36	_	_	_	1	54.4967	2.1405	B
37	_	_	_	2	80.4287	2.1385	A

---------- Effect=Year*Date Method=LSD(P<.05) Set=9 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
38	2003	_	_	1	94.8783	3.6922	B
39	2003	_	_	2	51.4886	3.7218	D
40	2004	_	_	1	47.1518	3.7380	D
41	2004	_	_	2	117.18	3.6922	A
42	2005	_	_	1	21.4599	3.6922	E
43	2005	_	_	2	72.6129	3.6980	C

---------- Effect=Variety*Date Method=LSD(P<.05) Set=10 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
44	_	1	_	1	71.2557	2.7917	B
45	_	1	_	2	81.2440	2.8020	A
46	_	2	_	1	37.7377	2.8187	C
47	_	2	_	2	79.6133	2.8023	A

---------- Effect=Year*Variety*Date Method=LSD(P<.05) Set=11 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
48	2003	1	_	1	116.49	4.8354	A
49	2003	1	_	2	56.7865	4.8712	CD
50	2003	2	_	1	73.2657	4.8354	B
51	2003	2	_	2	46.1908	4.8900	DE
52	2004	1	_	1	63.7122	4.8354	BC
53	2004	1	_	2	114.38	4.8354	A
54	2004	2	_	1	30.5914	4.9742	F
55	2004	2	_	2	119.99	4.8354	A
56	2005	1	_	1	33.5638	4.8354	EF
57	2005	1	_	2	72.5672	4.8531	B
58	2005	2	_	1	9.3560	4.8354	G
59	2005	2	_	2	72.6587	4.8354	B

---------- Effect=K*Date Method=LSD(P<.05) Set=12 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
60	_	_	1	1	57.6223	2.8034	B
61	_	_	1	2	79.7762	2.8023	A
62	_	_	2	1	51.3710	2.8071	B
63	_	_	2	2	81.0812	2.8020	A

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
64	2003	_	1	1	99.3417	4.8354	B
65	2003	_	1	2	49.7700	4.8900	D
66	2003	_	2	1	90.4150	4.8354	B
67	2003	_	2	2	53.2073	4.8712	D
68	2004	_	1	1	49.4982	4.8956	D
69	2004	_	1	2	114.53	4.8354	A

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
---

(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
70	2004	_	2	1	44.8054	4.9150	D
71	2004	_	2	2	119.84	4.8354	A
72	2005	_	1	1	24.0272	4.8354	E
73	2005	_	1	2	75.0260	4.8354	C
74	2005	_	2	1	18.8927	4.8354	E
75	2005	_	2	2	70.1998	4.8531	C

---------- Effect=Variety*K*Date Method=LSD(P<.05) Set=14 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
76	_	1	1	1	74.6871	3.7806	AB
77	_	1	1	2	80.6810	3.7806	A
78	_	1	2	1	67.8242	3.7806	B
79	_	1	2	2	81.8071	3.8110	A
80	_	2	1	1	40.5576	3.8149	C
81	_	2	1	2	78.8713	3.8117	A
82	_	2	2	1	34.9178	3.8260	C
83	_	2	2	2	80.3553	3.7806	A

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
84	2003	1	1	1	121.07	6.5482	A
85	2003	1	1	2	52.7673	6.5482	CDE
86	2003	1	2	1	111.91	6.5482	A
87	2003	1	2	2	60.8056	6.6535	BCD
88	2003	2	1	1	77.6097	6.5482	B
89	2003	2	1	2	46.7726	6.7082	DEF
90	2003	2	2	1	68.9217	6.5482	BC
91	2003	2	2	2	45.6090	6.5482	DEF
92	2004	1	1	1	65.9717	6.5482	BC
93	2004	1	1	2	112.82	6.5482	A
94	2004	1	2	1	61.4527	6.5482	BCD
95	2004	1	2	2	115.93	6.5482	A
96	2004	2	1	1	33.0248	6.7246	F
97	2004	2	1	2	116.24	6.5482	A
98	2004	2	2	1	28.1581	6.7811	FG
99	2004	2	2	2	123.74	6.5482	A
100	2005	1	1	1	37.0160	6.5482	EF
101	2005	1	1	2	76.4513	6.5482	B

Mean separation for starch

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------

(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
102	2005	1	2	1	30.1117	6.5482	F
103	2005	1	2	2	68.6830	6.6002	BC
104	2005	2	1	1	11.0383	6.5482	GH
105	2005	2	1	2	73.6007	6.5482	B
106	2005	2	2	1	7.6737	6.5482	H
107	2005	2	2	2	71.7167	6.5482	B

Check on normality for starch

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.991007	Pr < W	0.0003
Kolmogorov-Smirnov	D	0.051051	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.405516	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.195717	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-96.1271	40	54.4120	421
-70.5030	474	56.1387	643
-57.8913	404	60.9588	394
-54.0312	370	70.7824	692
-53.9112	466	71.4578	183

Missing Values

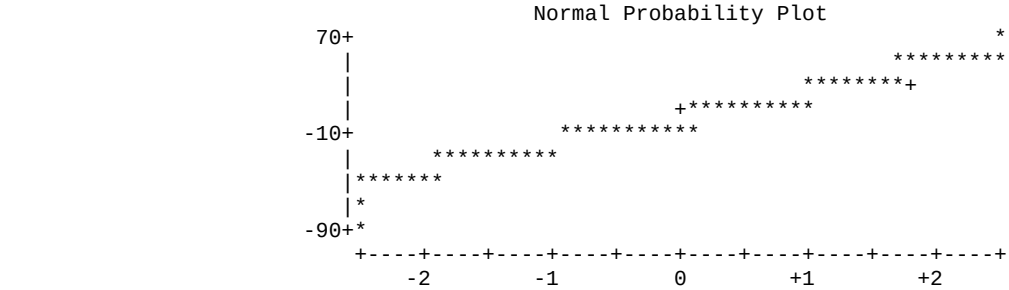
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	13	1.81	100.00

```
                    Histogram                        #             Boxplot
 70+*                                                3                0
   .*****                                           30                0
   .**************                                  80                |
   .*************************************         224             +--+--+
-10+*******************************************   249             *-----*
   .*****************                              102                |
   .***                                              17                0
   .*                                                 1                0
-90+*                                                 1                *
    ----+----+----+----+----+----+----+----+--
    * may represent up to 6 counts
```

Check on normality for starch

The UNIVARIATE Procedure
Variable: Resid (Residual)

Normal Probability Plot



Check equality of stddev for y= starch

Obs	Year	Variety	K	Date	nobs	rawmean_ y	stddev_y	stderr_y	Levene LeveneF_df	P
1	2003	1	1	1	30	121.074	32.6879	5.96796	4.641(23,683)	0.0000
2	2003	1	1	2	30	52.767	27.8113	5.07762		
3	2003	1	2	1	30	111.908	29.1419	5.32056		
4	2003	1	2	2	28	60.671	27.3659	5.17167		.
5	2003	2	1	1	30	77.610	32.1339	5.86683		.
6	2003	2	1	2	27	47.257	18.8039	3.61881		.
7	2003	2	2	1	30	68.922	34.4411	6.28806		
8	2003	2	2	2	30	45.609	17.1540	3.13188		
9	2004	1	1	1	30	65.972	19.9097	3.63499		.
10	2004	1	1	2	30	112.824	39.2288	7.16216		
11	2004	1	2	1	30	61.453	22.1940	4.05205		
12	2004	1	2	2	30	115.933	32.0286	5.84759		.
13	2004	2	1	1	27	33.988	18.6508	3.58935		.
14	2004	2	1	2	30	116.241	26.0386	4.75397		.
15	2004	2	2	1	26	28.350	15.8679	3.11195		.
16	2004	2	2	2	30	123.740	31.9070	5.82539		.
17	2005	1	1	1	30	37.016	25.1439	4.59063		.
18	2005	1	1	2	30	76.451	28.0694	5.12474		.
19	2005	1	2	1	30	30.112	16.3556	2.98612		
20	2005	1	2	2	29	69.048	26.7876	4.97432		
21	2005	2	1	1	30	11.038	5.7563	1.05095		.
22	2005	2	1	2	30	73.601	30.3235	5.53628		
23	2005	2	2	1	30	7.674	6.5857	1.20238		.
24	2005	2	2	2	30	71.717	20.5797	3.75733		

Glucose Standard Curve for N&K Starch

Intercept	-0.01091
NetABS	0.610538

Regression Statistics	
Multiple R	0.997701
R Square	0.995408

N&K Total Nonstructural Carbohydrates-
Combined total of Glucose, Fructose, Sucrose and Starch in mg/g dry weight.
SAS Input

Variety 1= PM1218
2= DP555
K 1= 60lbs K_2O/acre/yr
2= 120lbs K_2O/acre/yr
Date 1= Early Bloom
2= Cutout

```
Data NKSol;
Input plot year Rep Variety K  TotalNonstructural Date ;
Cards;
102     2003    1       1       1       131.77  1
108     2003    2       2       1       129.4   1
109     2003    2       1       2       131.58  1
111     2003    2       2       2       123.08  1
205     2003    1       2       1       132.43  1
206     2003    1       1       2       157.49  1
208     2003    4       2       2       83.02   1
211     2003    2       1       1       164.67  1
301     2003    3       1       1       120.01  1
303     2003    1       2       2       138.69  1
306     2003    3       1       2       116.99  1
311     2003    4       2       1       120.97  1
404     2003    3       2       1       100.57  1
405     2003    3       2       2       165.58  1
407     2003    4       1       2       176.09  1
412     2003    4       1       1       158.33  1
501     2003    5       2       2       117.6   1
505     2003    5       1       2       135.8   1
509     2003    5       1       1       164.42  1
512     2003    5       2       1       127.48  1
602     2003    6       2       2       93.68   1
603     2003    6       1       1       149.59  1
605     2003    6       1       2       147.82  1
606     2003    6       2       1       170.66  1
102     2003    1       1       1       122.1   1
108     2003    2       2       1       78.3    1
109     2003    2       1       2       142.26  1
111     2003    2       2       2       109.2   1
205     2003    1       2       1       138.07  1
206     2003    1       1       2       161.38  1
208     2003    4       2       2       67.77   1
211     2003    2       1       1       137.61  1
301     2003    3       1       1       130.46  1
303     2003    1       2       2       154.01  1
306     2003    3       1       2       118.95  1
311     2003    4       2       1       115.21  1
404     2003    3       2       1       154.02  1
405     2003    3       2       2       140.41  1
407     2003    4       1       2       148.92  1
412     2003    4       1       1       62.07   1
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505	2005	5	1	2	77.14	1
509	2005	5	1	1	66.85	1
512	2005	5	2	1	31.54	1
602	2005	6	2	2	24.42	1
603	2005	6	1	1	44.27	1
605	2005	6	1	2	52.73	1
606	2005	6	2	1	48.05	1
102	2005	1	1	1	105.37	1
108	2005	1	2	1	76.18	1
109	2005	1	1	2	70.79	1
111	2005	1	2	2	22.96	1

205	2005	2	2	1	57.6	1
206	2005	2	1	2	76.12	1
208	2005	2	2	2	46.73	1
211	2005	2	1	1	57.38	1
301	2005	3	1	1	92.11	1
303	2005	3	2	2	38.26	1
306	2005	3	1	2	87.99	1
311	2005	3	2	1	62.47	1
404	2005	4	2	1	53.93	1
405	2005	4	2	2	55.34	1
407	2005	4	1	2	88.99	1
412	2005	4	1	1	70.37	1
501	2005	5	2	2	56.53	1
505	2005	5	1	2	62.23	1
509	2005	5	1	1	41.51	1
512	2005	5	2	1	48.27	1
602	2005	6	2	2	.	1
603	2005	6	1	1	69.89	1
605	2005	6	1	2	63.37	1
606	2005	6	2	1	42.95	1
102	2005	1	1	1	112.74	1
108	2005	1	2	1	57.54	1
109	2005	1	1	2	89.16	1
111	2005	1	2	2	55.01	1
205	2005	2	2	1	29.26	1
206	2005	2	1	2	77.59	1
208	2005	2	2	2	35.85	1
211	2005	2	1	1	71.71	1
301	2005	3	1	1	96.94	1
303	2005	3	2	2	42.13	1
306	2005	3	1	2	95.31	1
311	2005	3	2	1	59.52	1
404	2005	4	2	1	50.56	1
405	2005	4	2	2	67.11	1
407	2005	4	1	2	50.55	1
412	2005	4	1	1	69.7	1
501	2005	5	2	2	42.99	1
505	2005	5	1	2	.	1
509	2005	5	1	1	57.14	1
512	2005	5	2	1	42.73	1
602	2005	6	2	2	35.68	1
603	2005	6	1	1	80.13	1
605	2005	6	1	2	94.61	1
606	2005	6	2	1	65.21	1
102	2005	1	1	1	89.89	1
108	2005	1	2	1	68.61	1
109	2005	1	1	2	.	1
111	2005	1	2	2	24.57	1
205	2005	2	2	1	61.65	1
206	2005	2	1	2	120.66	1
208	2005	2	2	2	49.04	1
211	2005	2	1	1	56.23	1
301	2005	3	1	1	126.29	1
303	2005	3	2	2	34.06	1
306	2005	3	1	2	77.34	1
311	2005	3	2	1	49.8	1
404	2005	4	2	1	35.34	1
405	2005	4	2	2	51.23	1
407	2005	4	1	2	53.29	1
412	2005	4	1	1	73.65	1
501	2005	5	2	2	52.25	1
505	2005	5	1	2	70.38	1
509	2005	5	1	1	47.63	1
512	2005	5	2	1	42.48	1
602	2005	6	2	2	37.51	1
603	2005	6	1	1	45.96	1
605	2005	6	1	2	77.61	1
606	2005	6	2	1	24.52	1
102	2005	1	1	1	128.99	2

108	2005	1	2	1	140.95	2
109	2005	1	1	2	81.94	2
111	2005	1	2	2	128.99	2
205	2005	2	2	1	152.7	2
206	2005	2	1	2	114.62	2
208	2005	2	2	2	121.92	2
211	2005	2	1	1	144.21	2
301	2005	3	1	1	118.35	2
303	2005	3	2	2	184.5	2
306	2005	3	1	2	157.82	2
311	2005	3	2	1	83.58	2
404	2005	4	2	1	128.24	2
405	2005	4	2	2	132.99	2
407	2005	4	1	2	179.88	2
412	2005	4	1	1	68.01	2
501	2005	5	2	2	117.9	2
505	2005	5	1	2	157.31	2
509	2005	5	1	1	90.85	2
512	2005	5	2	1	114.56	2
602	2005	6	2	2	102.37	2
603	2005	6	1	1	122.1	2
605	2005	6	1	2	107.51	2
606	2005	6	2	1	95.79	2
102	2005	1	1	1	160.55	2
108	2005	1	2	1	98.59	2
109	2005	1	1	2	129.25	2
111	2005	1	2	2	95.55	2
205	2005	2	2	1	129.26	2
206	2005	2	1	2	142.15	2
208	2005	2	2	2	133.35	2
211	2005	2	1	1	96.95	2
301	2005	3	1	1	117.61	2
303	2005	3	2	2	146.51	2
306	2005	3	1	2	118.7	2
311	2005	3	2	1	106.98	2
404	2005	4	2	1	100.93	2
405	2005	4	2	2	137.46	2
407	2005	4	1	2	132.25	2
412	2005	4	1	1	145.2	2
501	2005	5	2	2	132.9	2
505	2005	5	1	2	100.8	2
509	2005	5	1	1	164.89	2
512	2005	5	2	1	121.31	2
602	2005	6	2	2	134.98	2
603	2005	6	1	1	139.91	2
605	2005	6	1	2	99.08	2
606	2005	6	2	1	87.64	2
102	2005	1	1	1	170.68	2
108	2005	1	2	1	110.55	2
109	2005	1	1	2	100.34	2
111	2005	1	2	2	117.89	2
205	2005	2	2	1	154.01	2
206	2005	2	1	2	66.81	2
208	2005	2	2	2	92.3	2
211	2005	2	1	1	112.91	2
301	2005	3	1	1	123.53	2
303	2005	3	2	2	123.42	2
306	2005	3	1	2	160.47	2
311	2005	3	2	1	153.44	2
404	2005	4	2	1	141.84	2
405	2005	4	2	2	137.07	2
407	2005	4	1	2	115.44	2
412	2005	4	1	1	138.07	2
501	2005	5	2	2	115.2	2
505	2005	5	1	2	142.12	2
509	2005	5	1	1	125.14	2
512	2005	5	2	1	100.63	2
602	2005	6	2	2	80.96	2
603	2005	6	1	1	149.8	2

```
605     2005    6       1       2       107.26  2
606     2005    6       2       1       145.44  2
102     2005    1       1       1       154.64  2
108     2005    1       2       1       147.79  2
109     2005    1       1       2       111.18  2
111     2005    1       2       2       135.61  2
205     2005    2       2       1       113.54  2
206     2005    2       1       2       142.43  2
208     2005    2       2       2       80.81   2
211     2005    2       1       1       94.17   2
301     2005    3       1       1       166.23  2
303     2005    3       2       2       139.82  2
306     2005    3       1       2       132.81  2
311     2005    3       2       1       132.8   2
404     2005    4       2       1       133.35  2
405     2005    4       2       2       158.35  2
407     2005    4       1       2       83.11   2
412     2005    4       1       1       121.6   2
501     2005    5       2       2       79.71   2
505     2005    5       1       2       118.85  2
509     2005    5       1       1       73.06   2
512     2005    5       2       1       196.9   2
602     2005    6       2       2       126.46  2
603     2005    6       1       1       110.3   2
605     2005    6       1       2       .       2
606     2005    6       2       1       137.27  2
102     2005    1       1       1       130.22  2
108     2005    1       2       1       145     2
109     2005    1       1       2       116.44  2
111     2005    1       2       2       182.34  2
205     2005    2       2       1       152.72  2
206     2005    2       1       2       86.78   2
208     2005    2       2       2       77.12   2
211     2005    2       1       1       68.65   2
301     2005    3       1       1       131.3   2
303     2005    3       2       2       141.71  2
306     2005    3       1       2       138.24  2
311     2005    3       2       1       124.51  2
404     2005    4       2       1       67.5    2
405     2005    4       2       2       154.62  2
407     2005    4       1       2       54.05   2
412     2005    4       1       1       70.58   2
501     2005    5       2       2       128.74  2
505     2005    5       1       2       158.05  2
509     2005    5       1       1       95.08   2
512     2005    5       2       1       85.19   2
602     2005    6       2       2       90.72   2
603     2005    6       1       1       106.7   2
605     2005    6       1       2       60.9    2
606     2005    6       2       1       66.11   2

;
%include'c:\danda.sas';
%mmaov(NKSol,totalnonstructural,Class=Year Rep Variety K Date, fixed=Year |Variety |K
|Date,
   random = Rep(Year) Variety*K*Rep(Year) Variety*Date*K*rep(year),DDFM=CONTAIN);

N&K Total Soluble Sugars
SAS Output                    The Mixed Procedure

                                        Model Information

                        Data Set                     WORK.NKSOL
                        Dependent Variable           TotalNonstructural
                        Covariance Structure         Variance Components
                        Estimation Method            REML
                        Residual Variance Method     Profile
                        Fixed Effects SE Method      Model-Based
                        Degrees of Freedom Method    Containment
```

Class Level Information

Class	Levels	Values
year	3	2003 2004 2005
Rep	6	1 2 3 4 5 6
Variety	2	1 2
K	2	1 2
Date	2	1 2

Dimensions

Covariance Parameters	4
Columns in X	108
Columns in Z	234
Subjects	1
Max Obs Per Subject	720

Number of Observations

Number of Observations Read	720
Number of Observations Used	692
Number of Observations Not Used	28

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	6416.99383457	
1	3	6384.15816765	0.00000313
2	1	6384.14994092	0.00000000

Convergence criteria met.

Mixed ANOVA for totalnonstructural

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Rep(year)	30.1593	22.4841	1.34	0.0899
Rep*Variety*K(year)	0	.	.	.
Rep*Var*K*Date(year)	109.31	34.6815	3.15	0.0008
Residual	650.06	39.2263	16.57	<.0001

Fit Statistics

-2 Res Log Likelihood	6384.1
AIC (smaller is better)	6390.1
AICC (smaller is better)	6390.2
BIC (smaller is better)	6392.8

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
year	2	15	24.55	<.0001

Variety	1	45	27.21	<.0001
year*Variety	2	45	2.75	0.0749
K	1	45	0.97	0.3308
year*K	2	45	0.05	0.9560
Variety*K	1	45	0.00	0.9458
year*Variety*K	2	45	0.11	0.8925
Date	1	60	52.16	<.0001
year*Date	2	60	185.61	<.0001
Variety*Date	1	60	30.38	<.0001
year*Variety*Date	2	60	0.54	0.5856
K*Date	1	60	3.84	0.0546
year*K*Date	2	60	0.23	0.7981
Variety*K*Date	1	60	0.71	0.4014
year*Variety*K*Date	2	60	0.11	0.8921

Mean separation for total nonstructural

---------- Effect=year Method=LSD(P<.05) Set=1 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
1	2003	_	_	_	116.98	3.1793	A
2	2004	_	_	_	121.48	3.2032	A
3	2005	_	_	_	92.2099	3.1724	B

---------- Effect=Variety Method=LSD(P<.05) Set=2 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
4	_	1	_	_	117.03	2.2478	A
5	_	2	_	_	103.41	2.2630	B

---------- Effect=year*Variety Method=LSD(P<.05) Set=3 ----------
---

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
6	2003	1	_	_	127.77	3.8862	A
7	2003	2	_	_	106.18	3.9084	B
8	2004	1	_	_	124.81	3.9009	A
9	2004	2	_	_	118.15	3.9708	A
10	2005	1	_	_	98.5196	3.8927	B
11	2005	2	_	_	85.9002	3.8794	C

---------- Effect=K Method=LSD(P<.05) Set=4 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
12	_	_	1	_	111.50	2.2504	A
13	_	_	2	_	108.94	2.2604	A

---------- Effect=year*K Method=LSD(P<.05) Set=5 ----------

Standard Letter

Obs	year	Variety	K	Date	Estimate	Error	Group
14	2003	_	1	_	117.90	3.8933	A
15	2003	_	2	_	116.05	3.9012	A
16	2004	_	1	_	122.58	3.9270	A
17	2004	_	2	_	120.37	3.9445	A
18	2005	_	1	_	94.0346	3.8728	B
19	2005	_	2	_	90.3852	3.8993	B

Mean separation for totalnonstructural

---------- Effect=Variety*K Method=LSD(P<.05) Set=6 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
20	_	1	1	_	118.23	2.8890	A
21	_	1	2	_	115.84	2.9177	A
22	_	2	1	_	104.78	2.9257	B
23	_	2	2	_	102.04	2.9279	B

---------- Effect=year*Variety*K Method=LSD(P<.05) Set=7 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
24	2003	1	1	_	128.99	4.9970	A
25	2003	1	2	_	126.56	5.0385	A
26	2003	2	1	_	106.80	5.0603	BCD
27	2003	2	2	_	105.55	5.0438	CD
28	2004	1	1	_	124.94	5.0174	A
29	2004	1	2	_	124.68	5.0639	A
30	2004	2	1	_	120.23	5.1439	AB
31	2004	2	2	_	116.07	5.1515	ABC
32	2005	1	1	_	100.75	4.9970	D
33	2005	1	2	_	96.2853	5.0586	DE
34	2005	2	1	_	87.3153	4.9970	E
35	2005	2	2	_	84.4851	5.0174	E

---------- Effect=Date Method=LSD(P<.05) Set=8 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
36	_	_	_	1	100.79	2.2575	B
37	_	_	_	2	119.65	2.2532	A

---------- Effect=year*Date Method=LSD(P<.05) Set=9 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
38	2003	_	_	1	142.96	3.8879	A
39	2003	_	_	2	90.9878	3.9066	C
40	2004	_	_	1	96.3451	3.9492	C
41	2004	_	_	2	146.61	3.9220	A
42	2005	_	_	1	63.0631	3.8927	D
43	2005	_	_	2	121.36	3.8794	B

Mean separation for totalnonstructural

---------- Effect=Variety*Date Method=LSD(P<.05) Set=10 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
44	_	1	_	1	114.80	2.9009	A
45	_	1	_	2	119.27	2.9059	A
46	_	2	_	1	86.7793	2.9359	B
47	_	2	_	2	120.04	2.9175	A

---------- Effect=year*Variety*Date Method=LSD(P<.05) Set=11 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
48	2003	1	_	1	159.05	4.9970	A
49	2003	1	_	2	96.4929	5.0385	EF
50	2003	2	_	1	126.87	5.0438	C
51	2003	2	_	2	85.4827	5.0603	FG
52	2004	1	_	1	107.67	5.0377	DE
53	2004	1	_	2	141.95	5.0438	B
54	2004	2	_	1	85.0225	5.1924	FG
55	2004	2	_	2	151.27	5.1016	AB
56	2005	1	_	1	77.6822	5.0385	G
57	2005	1	_	2	119.36	5.0174	CD
58	2005	2	_	1	48.4439	5.0174	H
59	2005	2	_	2	123.36	4.9970	C

---------- Effect=K*Date Method=LSD(P<.05) Set=12 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
60	_	_	1	1	104.63	2.9093	B
61	_	_	1	2	118.38	2.9052	A
62	_	_	2	1	96.9462	2.9274	C
63	_	_	2	2	120.93	2.9182	A

---------- Effect=year*K*Date Method=LSD(P<.05) Set=13 ----------

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
64	2003	_	1	1	147.29	4.9970	A
65	2003	_	1	2	88.4995	5.0603	C
66	2003	_	2	1	138.63	5.0438	A
67	2003	_	2	2	93.4761	5.0385	C
68	2004	_	1	1	100.37	5.1222	C
69	2004	_	1	2	144.80	5.0385	A

Mean separation for totalnonstructural

---------- Effect=year*K*Date Method=LSD(P<.05) Set=13 ----------
---

(continued)

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
70	2004	_	2	1	92.3250	5.1084	C
71	2004	_	2	2	148.42	5.1069	A
72	2005	_	1	1	66.2458	4.9970	D
73	2005	_	1	2	121.82	4.9970	B
74	2005	_	2	1	59.8803	5.0586	D
75	2005	_	2	2	120.89	5.0174	B

---------- Effect=Variety*K*Date Method=LSD(P<.05) Set=14 ----------
---

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
76	_	1	1	1	117.45	3.8810	A
77	_	1	1	2	119.00	3.8693	A
78	_	1	2	1	112.15	3.9047	A
79	_	1	2	2	119.53	3.9314	A
80	_	2	1	1	91.8165	3.9300	B
81	_	2	1	2	117.75	3.9293	A
82	_	2	2	1	81.7421	3.9599	B
83	_	2	2	2	122.33	3.9057	A

---------- Effect=year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
---

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
84	2003	1	1	1	163.35	6.7018	A
85	2003	1	1	2	94.6333	6.7018	IJKL
86	2003	1	2	1	154.76	6.7018	AB
87	2003	1	2	2	98.3526	6.8249	HIJK
88	2003	2	1	1	131.24	6.7018	CDEF
89	2003	2	1	2	82.3658	6.8892	KLM
90	2003	2	2	1	122.51	6.8404	EFG
91	2003	2	2	2	88.5997	6.7018	JKLM
92	2004	1	1	1	108.85	6.7624	GHI
93	2004	1	1	2	141.04	6.7018	BCDE
94	2004	1	2	1	106.49	6.7624	GHIJ
95	2004	1	2	2	142.86	6.8405	BCD
96	2004	2	1	1	91.8848	7.0126	IJKLM
97	2004	2	1	2	148.57	6.8249	ABC
98	2004	2	2	1	78.1602	6.9720	LM
99	2004	2	2	2	153.98	6.8892	AB
100	2005	1	1	1	80.1650	6.7018	KLM
101	2005	1	1	2	121.34	6.7018	FG

Mean separation for totalnonstructural

---------- Effect=year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
---

(continued)

Obs	year	Variety	K	Date	Estimate	Standard Error	Letter Group
102	2005	1	2	1	75.1994	6.8248	M
103	2005	1	2	2	117.37	6.7624	FGH
104	2005	2	1	1	52.3267	6.7018	N
105	2005	2	1	2	122.30	6.7018	EFG
106	2005	2	2	1	44.5611	6.7624	N
107	2005	2	2	2	124.41	6.7018	DEFG

Check on normality for totalnonstructural

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.996324	Pr < W	0.1086
Kolmogorov-Smirnov	D	0.041533	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.180735	Pr > W-Sq	0.0094
Anderson-Darling	A-Sq	0.92103	Pr > A-Sq	0.0205

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-95.0397	40	63.2001	121
-65.3603	215	63.6695	221
-64.1970	370	64.1132	395
-61.2668	711	64.5632	615
-60.2124	404	75.4302	692

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	28	3.89	100.00

```
                                Histogram                          #
Boxplot
            70+**                                                  6                0
              .*******                                            34                |
              .********************                               97                |
              .***************************************            195             +--+--
+
           -10+************************************************   236             *-----
*
              .******************                                 87                |
              .*******                                            32                |
              .*                                                   4                0
           -90+*                                                   1                0
               ----+----+----+----+----+----+----+----+----+---
               * may represent up to 5 counts
```

```
                    Check on normality for  totalnonstructural

                              The UNIVARIATE Procedure
                            Variable:  Resid  (Residual)

                                   Normal Probability Plot
                 70+                                                  **
                   |                                          ********++
                   |                                   ********
                   |                          +********
                -10+                 **********
                   |          ********
                   |+*********
                   |*
                -90+*
                    +----+----+----+----+----+----+----+----+----+----+
                        -2        -1         0        +1        +2

                 Check equality of stddev for y= totalnonstructural

                                   rawmean_
Levene
 Obs   year   Variety   K   Date   nobs       y      stddev_y  stderr_y     LeveneF_df  P

   1   2003      1      1     1     30     163.349    33.7165    6.15575   3.938(23,668)
0.0000
   2   2003      1      1     2     30      94.633    33.1988    6.06124
   3   2003      1      2     1     30     154.761    27.7839    5.07262                .
   4   2003      1      2     2     28      98.369    30.0125    5.67183                .
   5   2003      2      1     1     30     131.238    27.9901    5.11027                .
   6   2003      2      1     2     27      83.065    28.2934    5.44507                .
   7   2003      2      2     1     28     122.933    32.8159    6.20162                .
   8   2003      2      2     2     30      88.600    17.5564    3.20534                .
   9   2004      1      1     1     29     108.790    20.2570    3.76163                .
  10   2004      1      1     2     30     141.035    42.9570    7.84284                .
  11   2004      1      2     1     29     106.367    20.8421    3.87029                .
  12   2004      1      2     2     28     142.950    33.8014    6.38786                .
  13   2004      2      1     1     26      92.545    20.4113    4.00298                .
  14   2004      2      1     2     28     148.220    26.3322    4.97631                .
  15   2004      2      2     1     26      78.224    19.3414    3.79315                .
  16   2004      2      2     2     27     153.245    36.5183    7.02795                .
  17   2005      1      1     1     30      80.165    26.7318    4.88053                .
  18   2005      1      1     2     30     121.343    29.7613    5.43364                .
. 19   2005      1      2     1     28      75.347    18.2786    3.45434                .
  20   2005      1      2     2     29     117.813    31.5148    5.85215                .
  21   2005      2      1     1     30      52.327    13.0643    2.38520                .
  22   2005      2      1     2     30     122.304    29.5394    5.39314                .
  23   2005      2      2     1     29      44.820    12.7929    2.37559                .
  24   2005      2      2     2     30     124.409    27.9029    5.09436
```

N&K Soluble Sugar-
Glucose, Fructose and Sucrose and the sum of all three
SAS Input

Variety 1= PM1218
2= DP555
K 1= 60lbs K_2O/acre/yr
2= 120lbs K_2O/acre/yr
Date 1= Early Bloom
2= Cutout

- all sugars are in mg/g dry weight

```
Data NKSol;
Input plot Rep Variety K Glu Fruc Suc Total  Date Year;
Cards;

102     1       1       1       5.00    2.24    28.12   35.37   1       2003
108     2       2       1       10.69   4.24    65.17   80.10   1       2003
109     2       1       2       3.84    4.11    38.69   46.65   1       2003
111     2       2       2       7.55    3.81    53.12   64.48   1       2003
205     1       2       1       6.81    0.64    36.86   44.31   1       2003
206     1       1       2       4.30    0.94    39.07   44.31   1       2003
208     4       2       2       7.44    3.20    53.12   63.76   1       2003
211     2       1       1       8.59    5.59    49.01   63.20   1       2003
301     3       1       1       3.25    2.16    26.40   31.81   1       2003
303     1       2       2       4.24    1.85    38.76   44.85   1       2003
306     3       1       2       2.01    1.46    35.65   39.12   1       2003
311     4       2       1       11.54   5.98    69.32   86.83   1       2003
404     3       2       1       6.05    1.20    39.59   46.84   1       2003
405     3       2       2       5.37    2.38    57.34   65.08   1       2003
407     4       1       2       2.85    2.51    31.34   36.70   1       2003
412     4       1       1       1.86    2.42    26.47   30.75   1       2003
501     5       2       2       5.91    3.50    46.80   56.22   1       2003
505     5       1       2       5.96    7.33    40.21   53.50   1       2003
509     5       1       1       5.91    7.46    43.14   56.51   1       2003
512     5       2       1       5.43    6.81    23.74   35.97   1       2003
602     6       2       2       5.68    1.68    46.22   53.58   1       2003
603     6       1       1       4.86    1.07    38.28   44.21   1       2003
605     6       1       2       5.06    1.72    55.33   62.12   1       2003
606     6       2       1       13.68   6.94    68.21   88.83   1       2003
102     1       1       1       6.02    1.46    31.44   38.92   1       2003
108     2       2       1       5.40    2.46    47.70   55.56   1       2003
109     2       1       2       4.98    2.38    46.11   53.46   1       2003
111     2       2       2       8.17    6.15    59.72   74.04   1       2003
205     1       2       1       9.56    3.64    39.93   53.12   1       2003
206     1       1       2       2.74    1.33    37.97   42.04   1       2003
208     4       2       2       4.61    1.64    45.56   51.81   1       2003
211     2       1       1       5.06    5.76    17.35   28.18   1       2003
301     3       1       1       3.82    2.68    29.75   36.24   1       2003
303     1       2       2       5.26    2.24    44.39   51.89   1       2003
306     3       1       2       3.02    2.07    33.75   38.85   1       2003
311     4       2       1       6.19    3.11    54.71   64.02   1       2003
404     3       2       1       6.47    2.38    45.73   54.58   1       2003
405     3       2       2       6.73    1.94    47.63   56.30   1       2003
407     4       1       2       2.80    1.12    36.38   40.29   1       2003
412     4       1       1       3.84    4.68    33.96   42.48   1       2003
501     5       2       2       8.34    1.81    55.95   66.11   1       2003
505     5       1       2       3.73    4.16    38.45   46.34   1       2003
509     5       1       1       5.29    3.42    37.03   45.74   1       2003
512     5       2       1       6.87    4.03    39.66   50.55   1       2003
602     6       2       2       5.51     .      38.79   .       1       2003
603     6       1       1       6.39    6.46    43.77   56.61   1       2003
605     6       1       2       6.22    1.72    49.50   57.44   1       2003
606     6       2       1       8.76    4.42    58.72   71.90   1       2003
102     1       1       1       4.69    0.38    25.26   30.33   1       2003
108     2       2       1       4.89    0.46    35.48   40.83   1       2003
109     2       1       2       3.39    1.25    31.16   35.80   1       2003
111     2       2       2       5.65    1.85    36.03   43.54   1       2003
```

205	1	2	1	3.90	0.81	22.60	27.31	1	2003
206	1	1	2	3.17	1.33	28.47	32.97	1	2003
208	4	2	2	6.95	3.37	51.12	61.45	1	2003
211	2	1	1	5.14	4.46	34.72	44.33	1	2003
301	3	1	1	5.17	4.72	33.75	43.65	1	2003
303	1	2	2	4.52	3.20	36.83	44.55	1	2003
306	3	1	2	3.11	1.46	35.76	40.33	1	2003
311	4	2	1	6.36	2.64	46.05	55.04	1	2003
404	3	2	1	4.27	3.68	31.96	39.90	1	2003
405	3	2	2	4.49	1.94	34.44	40.88	1	2003
407	4	1	2	3.70	2.98	41.80	48.48	1	2003
412	4	1	1	4.81	5.68	33.03	43.51	1	2003
501	5	2	2	4.58	2.77	45.42	52.77	1	2003
505	5	1	2	4.86	5.03	35.24	45.13	1	2003
509	5	1	1	6.22	5.11	39.59	50.92	1	2003
512	5	2	1	6.56	5.85	35.10	47.51	1	2003
602	6	2	2	5.20	3.59	43.56	52.35	1	2003
603	6	1	1	6.22	4.94	44.59	55.75	1	2003
605	6	1	2	6.13	4.42	49.33	59.88	1	2003
606	6	2	1	10.18	6.50	56.65	73.33	1	2003
102	1	1	1	4.35	0.77	23.26	28.38	1	2003
108	2	2	1	4.47	2.68	32.75	39.90	1	2003
109	2	1	2	1.33	0.25	12.45	14.02	1	2003
111	2	2	2	4.49	1.12	32.89	38.50	1	2003
205	1	2	1	2.23	1.94	16.28	20.45	1	2003
206	1	1	2	2.46	0.33	29.13	31.92	1	2003
208	4	2	2	8.17	2.24	55.54	65.96	1	2003
211	2	1	1	6.87	4.11	40.97	51.95	1	2003
301	3	1	1	3.93	3.94	27.85	35.72	1	2003
303	1	2	2	4.13	2.20	34.72	41.05	1	2003
306	3	1	2	4.49	2.77	40.52	47.78	1	2003
311	4	2	1	6.11	4.90	49.84	60.84	1	2003
404	3	2	1	4.18	2.59	31.65	38.42	1	2003
405	3	2	2	6.11	2.90	42.32	51.32	1	2003
407	4	1	2	4.04	1.98	39.69	45.72	1	2003
412	4	1	1	5.99	4.85	31.72	42.56	1	2003
501	5	2	2	3.76	2.11	36.65	42.53	1	2003
505	5	1	2	3.99	2.55	33.44	39.98	1	2003
509	5	1	1	5.88	3.81	32.99	42.68	1	2003
512	5	2	1	6.36	3.72	38.93	49.01	1	2003
602	6	2	2	3.34	.	30.51	.	1	2003
603	6	1	1	7.15	1.25	44.53	52.92	1	2003
605	6	1	2	4.01	2.46	45.87	52.35	1	2003
606	6	2	1	8.43	4.11	49.22	61.76	1	2003
102	1	1	1	7.69	5.20	30.92	43.81	1	2003
108	2	2	1	6.28	2.85	48.70	57.83	1	2003
109	2	1	2	3.84	6.42	39.66	49.92	1	2003
111	2	2	2	4.78	3.03	45.46	53.26	1	2003
205	1	2	1	7.55	5.76	40.11	53.42	1	2003
206	1	1	2	1.64	1.38	34.58	37.60	1	2003
208	4	2	2	7.12	5.03	54.50	66.65	1	2003
211	2	1	1	4.13	3.90	36.86	44.88	1	2003
301	3	1	1	3.96	3.81	29.82	37.58	1	2003
303	1	2	2	6.59	3.85	48.84	59.28	1	2003
306	3	1	2	3.22	1.68	39.21	44.11	1	2003
311	4	2	1	7.21	4.37	53.78	65.36	1	2003
404	3	2	1	6.56	5.72	42.14	54.42	1	2003
405	3	2	2	3.62	2.07	37.10	42.79	1	2003
407	4	1	2	2.06	1.72	30.89	34.67	1	2003
412	4	1	1	3.84	2.77	31.75	38.36	1	2003
501	5	2	2	7.69	3.90	54.06	65.64	1	2003
505	5	1	2	3.17	1.03	25.50	29.69	1	2003
509	5	1	1	5.37	1.51	32.61	39.49	1	2003
512	5	2	1	5.31	2.07	30.61	38.00	1	2003
602	6	2	2	3.53	0.85	29.54	33.93	1	2003
603	6	1	1	3.00	1.03	27.37	31.39	1	2003
605	6	1	2	2.54	1.38	30.51	34.43	1	2003
606	6	2	1	6.33	3.07	43.46	52.86	1	2003
102	1	1	1	6.81	11.41	40.97	59.19	2	2003

108	2	2	1	5.88	3.72	40.76	50.36	2	2003
109	2	1	2	3.79	5.16	34.86	43.80	2	2003
111	2	2	2	3.25	1.46	18.35	23.07	2	2003
205	1	2	1	3.65	3.42	27.85	34.91	2	2003
206	1	1	2	5.96	3.03	44.73	53.72	2	2003
208	4	2	2	3.25	1.33	20.39	24.97	2	2003
211	2	1	1	1.19	3.72	8.55	13.45	2	2003
301	3	1	1	7.75	11.24	59.37	78.36	2	2003
303	1	2	2	5.40	3.37	35.58	44.36	2	2003
306	3	1	2	4.61	4.63	49.53	58.77	2	2003
311	4	2	1	0.90	0.07	6.65	7.62	2	2003
404	3	2	1	5.46	5.03	40.49	50.97	2	2003
405	3	2	2	6.02	4.24	44.49	54.76	2	2003
407	4	1	2	5.80	7.72	45.94	59.46	2	2003
412	4	1	1	3.34	3.20	19.80	26.34	2	2003
501	5	2	2	4.47	4.33	33.65	42.45	2	2003
505	5	1	2	2.29	2.59	25.81	30.69	2	2003
509	5	1	1	2.85	7.20	21.08	31.13	2	2003
512	5	2	1	5.54	6.07	29.33	40.94	2	2003
602	6	2	2	7.92	8.24	53.43	69.59	2	2003
603	6	1	1	5.03	4.24	31.89	41.16	2	2003
605	6	1	2	1.53	2.46	18.42	22.41	2	2003
606	6	2	1	3.22	4.11	25.02	32.35	2	2003
102	1	1	1	7.41	8.63	45.94	61.98	2	2003
108	2	2	1	5.12	1.85	33.34	40.31	2	2003
109	2	1	2	4.61	4.24	29.85	38.70	2	2003
111	2	2	2	3.79	1.81	21.98	27.58	2	2003
205	1	2	1	3.25	2.68	17.28	23.21	2	2003
206	1	1	2	5.06	6.63	33.23	44.93	2	2003
208	4	2	2	4.49	2.46	31.72	38.67	2	2003
211	2	1	1	4.16	7.98	27.61	39.74	2	2003
301	3	1	1	1.95	4.76	21.46	28.17	2	2003
303	1	2	2	6.13	3.81	31.75	41.69	2	2003
306	3	1	2	2.51	1.98	22.01	26.51	2	2003
311	4	2	1	2.66	0.85	19.70	23.21	2	2003
404	3	2	1	2.46	2.59	10.62	15.67	2	2003
405	3	2	2	3.70	3.46	40.93	48.10	2	2003
407	4	1	2	0.68	1.46	7.51	9.65	2	2003
412	4	1	1	2.91	1.77	17.90	22.58	2	2003
501	5	2	2	5.14	3.29	34.51	42.94	2	2003
505	5	1	2	1.41	1.42	12.41	15.25	2	2003
509	5	1	1	2.29	1.38	18.46	22.12	2	2003
512	5	2	1	2.20	0.77	5.82	8.79	2	2003
602	6	2	2	2.12	0.94	25.98	29.04	2	2003
603	6	1	1	1.86	1.68	9.17	12.71	2	2003
605	6	1	2	0.71	0.46	9.41	10.58	2	2003
606	6	2	1	6.56	5.55	32.65	44.75	2	2003
102	1	1	1	4.10	5.81	38.28	48.18	2	2003
108	2	2	1	2.15	1.72	14.24	18.11	2	2003
109	2	1	2	1.24	0.77	10.20	12.21	2	2003
111	2	2	2	3.25	1.59	19.42	24.27	2	2003
205	1	2	1	2.83	2.11	20.04	24.99	2	2003
206	1	1	2	2.32	3.11	23.26	28.69	2	2003
208	4	2	2	3.14	1.20	25.47	29.81	2	2003
211	2	1	1	2.80	2.20	11.79	16.79	2	2003
301	3	1	1	4.55	4.98	46.70	56.23	2	2003
303	1	2	2	7.15	4.72	39.48	51.36	2	2003
306	3	1	2	3.31	3.98	29.44	36.73	2	2003
311	4	2	1	3.99	1.51	23.22	28.71	2	2003
404	3	2	1	4.04	2.24	30.82	37.10	2	2003
405	3	2	2	2.40	1.64	21.94	25.98	2	2003
407	4	1	2	2.97	1.77	22.36	27.09	2	2003
412	4	1	1	2.20	1.25	13.66	17.11	2	2003
501	5	2	2	6.28	3.03	33.41	42.71	2	2003
505	5	1	2	5.65	4.72	26.78	37.15	2	2003
509	5	1	1	5.91	7.33	32.03	45.26	2	2003
512	5	2	1	4.81	2.94	22.36	30.10	2	2003
602	6	2	2	5.29	3.11	38.17	46.57	2	2003
603	6	1	1	3.79	2.64	27.50	33.93	2	2003

605	6	1	2	2.37	1.81	20.18	24.37	2	2003
606	6	2	1	3.96	2.07	30.58	36.60	2	2003
102	1	1	1	4.41	5.07	30.30	39.78	2	2003
108	2	2	1	5.29	2.42	27.47	35.17	2	2003
109	2	1	2	3.14	3.68	27.23	34.04	2	2003
111	2	2	2	2.35	2.55	21.32	26.22	2	2003
205	1	2	1	8.71	6.33	43.56	58.60	2	2003
206	1	1	2	8.54	7.55	46.77	62.85	2	2003
208	4	2	2	9.53	6.68	38.86	55.07	2	2003
211	2	1	1	8.28	10.37	43.87	62.52	2	2003
301	3	1	1	7.92	4.85	48.15	60.92	2	2003
303	1	2	2	8.06	10.07	43.52	61.65	2	2003
306	3	1	2	5.20	7.28	40.38	52.87	2	2003
311	4	2	1	4.30	2.68	30.16	37.14	2	2003
404	3	2	1	8.65	8.20	39.38	56.23	2	2003
405	3	2	2	6.76	8.07	36.62	51.44	2	2003
407	4	1	2	3.34	4.90	23.26	31.49	2	2003
412	4	1	1	2.94	12.15	22.53	37.62	2	2003
501	5	2	2	7.21	3.59	45.70	56.50	2	2003
505	5	1	2	3.73	4.29	27.16	35.18	2	2003
509	5	1	1	4.98	2.38	37.93	45.28	2	2003
512	5	2	1	2.94	8.89	11.90	23.73	2	2003
602	6	2	2	3.82	6.59	30.37	40.77	2	2003
603	6	1	1	2.88	4.24	22.15	29.28	2	2003
605	6	1	2	0.34	0.51	1.78	2.62	2	2003
606	6	2	1	2.71	4.24	15.63	22.58	2	2003
102	1	1	1	4.38	9.33	33.10	46.80	2	2003
108	2	2	1	3.73	3.81	18.84	26.38	2	2003
109	2	1	2	2.57	10.41	16.70	29.68	2	2003
111	2	2	2	4.83	4.20	39.35	48.38	2	2003
205	1	2	1	9.53	12.80	48.50	70.83	2	2003
206	1	1	2	5.17	9.76	41.31	56.25	2	2003
208	4	2	2	6.45	5.98	38.79	51.22	2	2003
211	2	1	1	3.19	18.80	38.00	59.99	2	2003
301	3	1	1	7.52	14.02	47.43	68.97	2	2003
303	1	2	2	5.96	9.24	38.38	53.58	2	2003
306	3	1	2	8.34	8.20	62.07	78.60	2	2003
311	4	2	1	6.93	7.24	41.38	55.55	2	2003
404	3	2	1	7.35	13.58	46.11	67.05	2	2003
405	3	2	2	4.13	5.20	36.93	46.26	2	2003
407	4	1	2	3.70	10.37	29.75	43.82	2	2003
412	4	1	1	6.16	8.67	36.83	51.66	2	2003
501	5	2	2	2.74	4.16	27.71	34.61	2	2003
505	5	1	2	3.76	7.28	32.92	43.97	2	2003
509	5	1	1	7.72	10.41	39.14	57.27	2	2003
512	5	2	1	6.16	8.50	35.00	49.66	2	2003
602	6	2	2	7.46	5.42	43.25	56.13	2	2003
603	6	1	1	6.25	6.02	29.13	41.40	2	2003
605	6	1	2	2.88	6.24	38.03	47.16	2	2003
606	6	2	1	3.17	6.68	17.80	27.64	2	2003
102	1	2	1	11.51	3.03	55.71	70.25	1	2004
108	1	1	1	5.03	0.64	36.10	41.77	1	2004
109	1	2	2	7.35	1.55	43.11	52.01	1	2004
111	1	1	2	7.41	1.07	46.98	55.46	1	2004
205	2	1	1	7.38	1.77	35.86	45.00	1	2004
206	2	2	2	5.77	0.46	30.09	36.32	1	2004
208	2	1	2	7.29	3.11	37.76	48.17	1	2004
211	2	2	1	5.40	1.29	29.57	36.26	1	2004
301	3	2	1	5.63	1.42	45.04	52.09	1	2004
303	3	1	2	3.14	0.98	36.83	40.95	1	2004
306	3	2	2	5.14	1.51	42.73	49.38	1	2004
311	3	1	1	3.50	1.68	32.92	38.11	1	2004
404	4	1	1	3.70	0.98	38.55	43.24	1	2004
405	4	1	2	2.94	0.85	31.27	35.06	1	2004
407	4	2	2	3.34	3.07	45.49	51.90	1	2004
412	4	2	1	6.33	2.16	45.32	53.81	1	2004
501	5	1	2	6.25	2.03	51.71	59.98	1	2004
505	5	2	2	9.81	6.55	60.82	77.18	1	2004
509	5	2	1	8.34	3.94	57.09	69.37	1	2004

512	5	1	1	9.08	2.72	53.09	64.89	1	2004
602	6	1	2	5.57	2.64	46.08	54.28	1	2004
603	6	2	1	4.16	3.20	47.36	54.71	1	2004
605	6	2	2	6.02	1.81	45.46	53.29	1	2004
606	6	1	1	4.24	1.16	36.83	42.22	1	2004
102	1	2	1	4.24	2.03	42.11	48.38	1	2004
108	1	1	1	4.01	2.24	49.15	55.41	1	2004
109	1	2	2	5.91	4.46	54.26	64.63	1	2004
111	1	1	2	6.67	4.29	49.29	60.25	1	2004
205	2	1	1	2.29	3.07	26.67	32.03	1	2004
206	2	2	2	4.24	1.77	50.36	56.37	1	2004
208	2	1	2	3.96	0.55	34.55	39.05	1	2004
211	2	2	1	5.77	1.85	49.98	57.60	1	2004
301	3	2	1	7.92	3.42	59.68	71.02	1	2004
303	3	1	2	4.69	2.11	46.08	52.89	1	2004
306	3	2	2	5.57	3.85	51.67	61.09	1	2004
311	3	1	1	3.11	1.03	37.17	41.31	1	2004
404	4	1	1	3.02	1.07	31.78	35.88	1	2004
405	4	1	2	3.90	1.51	46.46	51.87	1	2004
407	4	2	2	3.93	2.46	49.67	56.06	1	2004
412	4	2	1	5.12	2.51	43.94	51.56	1	2004
501	5	1	2	5.14	2.64	46.29	54.07	1	2004
505	5	2	2	9.56	3.72	57.37	70.65	1	2004
509	5	2	1	7.21	3.59	59.20	70.00	1	2004
512	5	1	1	8.68	2.98	64.93	76.60	1	2004
602	6	1	2	10.55	12.24	68.42	91.20	1	2004
603	6	2	1	10.80	6.94	63.79	81.53	1	2004
605	6	2	2	3.93	1.46	36.27	41.67	1	2004
606	6	1	1	8.96	5.03	51.33	65.32	1	2004
102	1	2	1	4.81	1.64	47.29	53.73	1	2004
108	1	1	1	3.25	1.55	36.14	40.94	1	2004
109	1	2	2	4.35	2.94	48.88	56.17	1	2004
111	1	1	2	2.88	3.24	34.20	40.33	1	2004
205	2	1	1	5.00	1.85	35.44	42.30	1	2004
206	2	2	2	5.63	1.94	52.43	60.00	1	2004
208	2	1	2	2.94	2.24	34.34	39.52	1	2004
211	2	2	1	7.49	4.29	53.64	65.42	1	2004
301	3	2	1	4.58	4.16	38.55	47.29	1	2004
303	3	1	2	1.16	0.59	17.56	19.31	1	2004
306	3	2	2	1.98	0.77	22.43	25.17	1	2004
311	3	1	1	6.95	5.03	56.78	68.76	1	2004
404	4	1	1	5.43	1.20	37.48	44.11	1	2004
405	4	1	2	1.92	0.38	26.99	29.28	1	2004
407	4	2	2	1.61	1.16	27.12	29.89	1	2004
412	4	2	1	4.78	2.72	45.29	52.79	1	2004
501	5	1	2	2.40	3.07	26.26	31.73	1	2004
505	5	2	2	6.59	4.85	39.97	51.41	1	2004
509	5	2	1	5.14	1.85	45.84	52.84	1	2004
512	5	1	1	2.97	5.42	38.38	46.76	1	2004
602	6	1	2	3.76	1.94	38.14	43.84	1	2004
603	6	2	1	7.24	.	42.32	.	1	2004
605	6	2	2	1.98	2.03	22.63	26.64	1	2004
606	6	1	1	3.56	1.85	38.83	44.24	1	2004
102	1	2	1	5.96	2.64	42.49	51.09	1	2004
108	1	1	1	2.20	0.51	30.96	33.67	1	2004
109	1	2	2	3.02	2.51	31.82	37.35	1	2004
111	1	1	2	2.03	0.38	23.98	26.39	1	2004
205	2	1	1	4.47	1.51	37.31	43.28	1	2004
206	2	2	2	5.20	3.07	42.90	51.17	1	2004
208	2	1	2	4.27	2.42	38.52	45.20	1	2004
211	2	2	1	5.88	2.94	46.70	55.52	1	2004
301	3	2	1	6.13	2.24	51.64	60.02	1	2004
303	3	1	2	1.24	1.55	27.33	30.12	1	2004
306	3	2	2	5.82	1.38	46.60	53.80	1	2004
311	3	1	1	1.27	0.42	14.73	16.42	1	2004
404	4	1	1	4.52	3.55	28.40	36.47	1	2004
405	4	1	2	1.21	0.51	15.87	17.59	1	2004
407	4	2	2	4.72	1.20	42.83	48.76	1	2004
412	4	2	1	7.66	4.68	59.41	71.75	1	2004

501	5	1	2	7.29	3.77	61.58	72.64	1	2004
505	5	2	2	4.21	1.72	48.57	54.50	1	2004
509	5	2	1	5.17	2.55	46.84	54.56	1	2004
512	5	1	1	5.20	2.11	31.78	39.10	1	2004
602	6	1	2	4.75	1.77	51.19	57.71	1	2004
603	6	2	1	5.43	2.03	38.93	46.39	1	2004
605	6	2	2	3.73	1.03	30.27	35.02	1	2004
606	6	1	1	5.31	3.33	40.28	48.92	1	2004
102	1	2	1	5.29	2.20	48.84	56.33	1	2004
108	1	1	1	0.65	.	7.30	.	1	2004
109	1	2	2	1.19	0.33	16.32	17.83	1	2004
111	1	1	2	6.64	5.33	45.18	57.15	1	2004
205	2	1	1	3.11	1.59	23.98	28.68	1	2004
206	2	2	2	4.44	0.33	37.27	42.05	1	2004
208	2	1	2	5.91	3.64	39.59	49.13	1	2004
211	2	2	1	6.16	1.42	48.50	56.08	1	2004
301	3	2	1	5.60	3.50	53.16	62.26	1	2004
303	3	1	2	1.27	.	20.56	.	1	2004
306	3	2	2	2.88	1.77	34.55	39.20	1	2004
311	3	1	1	2.23	1.03	26.50	29.76	1	2004
404	4	1	1	4.32	1.59	40.69	46.61	1	2004
405	4	1	2	4.10	2.42	48.77	55.29	1	2004
407	4	2	2	3.82	1.07	41.07	45.96	1	2004
412	4	2	1	7.80	2.55	44.56	54.91	1	2004
501	5	1	2	2.35	0.64	33.17	36.15	1	2004
505	5	2	2	3.87	2.16	42.14	48.17	1	2004
509	5	2	1	7.15	0.51	49.05	56.71	1	2004
512	5	1	1	1.38	1.59	14.00	16.98	1	2004
602	6	1	2	3.59	1.59	29.33	34.52	1	2004
603	6	2	1	6.25	3.59	52.26	62.10	1	2004
605	6	2	2	5.23	2.51	56.89	64.62	1	2004
606	6	1	1	5.14	1.81	40.52	47.48	1	2004
102	1	2	1	1.53	0.90	1.50	3.93	2	2004
108	1	1	1	2.74	0.72	12.17	15.64	2	2004
109	1	2	2	0.08	0.59	11.65	12.33	2	2004
111	1	1	2	0.87	0.29	11.55	12.72	2	2004
205	2	1	1	1.02	1.51	4.20	6.72	2	2004
206	2	2	2	0.93	0.33	9.79	11.05	2	2004
208	2	1	2	2.54	0.81	28.12	31.48	2	2004
211	2	2	1	3.19	1.42	24.98	29.60	2	2004
301	3	2	1	1.78	0.90	11.76	14.44	2	2004
303	3	1	2	1.55	1.90	11.72	15.17	2	2004
306	3	2	2	1.58	1.07	9.79	12.44	2	2004
311	3	1	1	1.58	0.72	6.30	8.61	2	2004
404	4	1	1	3.82	4.16	14.38	22.35	2	2004
405	4	1	2	1.78	2.77	12.03	16.58	2	2004
407	4	2	2	3.70	2.81	33.10	39.61	2	2004
412	4	2	1	5.82	2.24	31.72	39.78	2	2004
501	5	1	2	3.84	2.98	15.52	22.35	2	2004
505	5	2	2	2.09	1.20	27.05	30.35	2	2004
509	5	2	1	4.78	3.24	27.85	35.87	2	2004
512	5	1	1	3.96	4.72	23.74	32.42	2	2004
602	6	1	2	4.89	4.29	26.05	35.23	2	2004
603	6	2	1	5.94	5.46	36.14	47.53	2	2004
605	6	2	2	4.35	1.51	35.79	41.65	2	2004
606	6	1	1	4.61	3.55	16.01	24.16	2	2004
102	1	2	1	8.28	3.59	34.17	46.04	2	2004
108	1	1	1	9.98	9.72	55.92	75.62	2	2004
109	1	2	2	3.42	2.81	24.36	30.59	2	2004
111	1	1	2	2.80	3.03	19.87	25.70	2	2004
205	2	1	1	2.94	4.33	17.80	25.07	2	2004
206	2	2	2	5.80	5.16	23.91	34.86	2	2004
208	2	1	2	3.48	1.03	23.67	28.18	2	2004
211	2	2	1	2.12	0.72	7.86	10.70	2	2004
301	3	2	1	6.53	2.59	27.33	36.45	2	2004
303	3	1	2	2.29	1.12	20.11	23.52	2	2004
306	3	2	2	6.90	2.11	37.65	46.67	2	2004
311	3	1	1	5.43	1.51	26.99	33.92	2	2004
404	4	1	1	4.95	4.94	20.94	30.83	2	2004

405	4	1	2	4.38	2.81	33.10	40.29	2	2004
407	4	2	2	6.64	2.46	35.65	44.76	2	2004
412	4	2	1	3.48	1.72	18.56	23.76	2	2004
501	5	1	2	2.94	1.46	20.15	24.55	2	2004
505	5	2	2	3.99	2.29	17.32	23.59	2	2004
509	5	2	1	9.22	4.63	33.89	47.74	2	2004
512	5	1	1	3.79	2.98	21.39	28.16	2	2004
602	6	1	2	4.44	4.03	26.81	35.28	2	2004
603	6	2	1	9.19	7.24	56.99	73.42	2	2004
605	6	2	2	5.26	1.85	33.61	40.73	2	2004
606	6	1	1	6.78	3.72	35.96	46.47	2	2004
102	1	2	1	11.37	5.50	43.46	60.32	2	2004
108	1	1	1	3.87	2.33	22.08	28.29	2	2004
109	1	2	2	5.26	2.85	24.40	32.51	2	2004
111	1	1	2	3.39	3.11	24.84	31.35	2	2004
205	2	1	1	4.83	6.42	27.02	38.27	2	2004
206	2	2	2	6.08	4.11	24.33	34.52	2	2004
208	2	1	2	4.01	2.38	33.44	39.83	2	2004
211	2	2	1	5.14	1.07	25.19	31.41	2	2004
301	3	2	1	6.50	1.98	31.92	40.41	2	2004
303	3	1	2	2.51	0.90	27.57	30.99	2	2004
306	3	2	2	8.14	4.16	41.49	53.79	2	2004
311	3	1	1	4.30	0.38	25.26	29.93	2	2004
404	4	1	1	3.50	4.16	13.93	21.59	2	2004
405	4	1	2	5.34	3.85	26.09	35.28	2	2004
407	4	2	2	3.19	1.42	29.75	34.36	2	2004
412	4	2	1	7.97	5.50	24.29	37.77	2	2004
501	5	1	2	2.83	1.98	15.90	20.71	2	2004
505	5	2	2	6.36	3.64	24.33	34.32	2	2004
509	5	2	1	8.31	4.55	30.99	43.85	2	2004
512	5	1	1	4.72	4.29	19.39	28.40	2	2004
602	6	1	2	3.56	5.46	19.25	28.27	2	2004
603	6	2	1	5.57	3.03	39.04	47.63	2	2004
605	6	2	2	6.93	1.29	42.59	50.81	2	2004
606	6	1	1	6.47	5.94	27.95	40.36	2	2004
102	1	2	1	1.36	0.90	1.99	4.24	2	2004
108	1	1	1	2.80	1.90	14.11	18.80	2	2004
109	1	2	2	1.72	1.25	3.23	6.20	2	2004
111	1	1	2	2.23	2.03	14.35	18.61	2	2004
205	2	1	1	2.91	1.46	18.39	22.76	2	2004
206	2	2	2	0.93	0.29	1.54	2.76	2	2004
208	2	1	2	0.68	0.25	6.16	7.09	2	2004
211	2	2	1	0.59	0.07	.	.	2	2004
301	3	2	1	3.76	2.51	15.21	21.48	2	2004
303	3	1	2	1.98	1.85	18.63	22.46	2	2004
306	3	2	2	3.79	1.90	22.05	27.73	2	2004
311	3	1	1	2.51	1.03	20.87	24.42	2	2004
404	4	1	1	3.08	1.38	12.34	16.80	2	2004
405	4	1	2	4.07	2.64	27.88	34.59	2	2004
407	4	2	2	2.49	0.81	28.82	32.11	2	2004
412	4	2	1	2.77	0.51	12.48	15.76	2	2004
501	5	1	2	3.53	1.46	18.53	23.52	2	2004
505	5	2	2	1.86	1.12	19.60	22.58	2	2004
509	5	2	1	4.81	2.03	20.87	27.71	2	2004
512	5	1	1	4.24	3.33	16.97	24.54	2	2004
602	6	1	2	4.64	.	15.69	.	2	2004
603	6	2	1	5.85	0.59	38.73	45.17	2	2004
605	6	2	2	5.03	0.72	17.73	23.49	2	2004
606	6	1	1	3.73	1.03	19.08	23.84	2	2004
102	1	2	1	8.09	2.33	24.02	34.43	2	2004
108	1	1	1	4.58	1.94	22.84	29.36	2	2004
109	1	2	2	2.43	0.85	23.88	27.16	2	2004
111	1	1	2	4.32	2.42	25.43	32.17	2	2004
205	2	1	1	6.64	0.07	18.87	25.59	2	2004
206	2	2	2	5.29	.	27.71	.	2	2004
208	2	1	2	13.20	7.37	58.79	79.36	2	2004
211	2	2	1	8.91	2.77	40.76	52.43	2	2004
301	3	2	1	5.88	1.77	26.99	34.63	2	2004
303	3	1	2	2.85	1.90	23.15	27.90	2	2004

306	3	2	2	4.75	2.55	26.64	33.94	2	2004
311	3	1	1	4.86	1.33	25.78	31.97	2	2004
404	4	1	1	5.99	0.38	22.70	29.07	2	2004
405	4	1	2	4.75	1.55	28.23	34.53	2	2004
407	4	2	2	3.96	.	25.19	.	2	2004
412	4	2	1	7.07	2.07	22.95	32.08	2	2004
501	5	1	2	2.63	0.81	14.18	17.61	2	2004
505	5	2	2	9.44	6.46	31.65	47.55	2	2004
509	5	2	1	3.67	0.51	15.35	19.53	2	2004
512	5	1	1	4.07	2.03	14.35	20.45	2	2004
602	6	1	2	6.22	.	25.78	.	2	2004
603	6	2	1	6.95	.	44.49	.	2	2004
605	6	2	2	6.22	.	29.61	.	2	2004
606	6	1	1	8.11	2.29	31.51	41.91	2	2004
102	1	1	1	3.39	5.10	28.66	37.14	1	2005
108	1	2	1	2.38	4.19	30.48	37.05	1	2005
109	1	1	2	3.39	6.17	35.11	44.66	1	2005
111	1	2	2	2.22	4.36	28.89	35.47	1	2005
205	2	2	1	7.64	10.03	42.90	60.58	1	2005
206	2	1	2	3.23	4.93	33.05	41.22	1	2005
208	2	2	2	4.13	5.88	43.16	53.18	1	2005
211	2	1	1	4.88	8.02	49.96	62.86	1	2005
301	3	1	1	4.27	6.54	36.86	47.67	1	2005
303	3	2	2	3.28	5.26	36.95	45.50	1	2005
306	3	1	2	3.42	5.26	33.08	41.76	1	2005
311	3	2	1	1.77	4.07	22.56	28.40	1	2005
404	4	2	1	6.42	9.62	29.57	45.61	1	2005
405	4	2	2	4.40	5.67	42.31	52.39	1	2005
407	4	1	2	4.24	6.37	40.15	50.76	1	2005
412	4	1	1	7.46	9.29	51.14	67.89	1	2005
501	5	2	2	3.89	7.03	36.54	47.47	1	2005
505	5	1	2	1.29	4.36	21.33	26.98	1	2005
509	5	1	1	1.71	4.15	25.79	31.65	1	2005
512	5	2	1	3.20	3.78	29.51	36.49	1	2005
602	6	2	2	4.16	5.14	24.70	34.00	1	2005
603	6	1	1	3.39	4.77	33.55	41.71	1	2005
605	6	1	2	3.39	5.76	32.29	41.44	1	2005
606	6	2	1	5.44	8.10	45.98	59.52	1	2005
102	1	1	1	1.77	3.74	24.47	29.97	1	2005
108	1	2	1	3.55	4.97	30.04	38.56	1	2005
109	1	1	2	4.61	7.52	37.19	49.32	1	2005
111	1	2	2	0.52	3.82	15.27	19.60	1	2005
205	2	2	1	2.99	4.40	28.48	35.87	1	2005
206	2	1	2	0.04	3.58	12.45	16.06	1	2005
208	2	2	2	3.26	5.63	29.74	38.63	1	2005
211	2	1	1	5.44	7.32	42.17	54.92	1	2005
301	3	1	1	6.23	6.37	44.07	56.68	1	2005
303	3	2	2	0.65	4.03	19.60	24.28	1	2005
306	3	1	2	0.86	4.03	24.85	29.74	1	2005
311	3	2	1	1.74	3.99	28.10	33.83	1	2005
404	4	2	1	4.64	8.43	34.43	47.50	1	2005
405	4	2	2	1.69	4.03	24.47	30.18	1	2005
407	4	1	2	3.02	6.66	38.07	47.74	1	2005
412	4	1	1	2.16	5.26	27.60	35.03	1	2005
501	5	2	2	2.99	6.54	41.35	50.87	1	2005
505	5	1	2	4.11	8.76	42.90	55.77	1	2005
509	5	1	1	4.45	7.28	34.08	45.81	1	2005
512	5	2	1	1.82	4.52	15.27	21.61	1	2005
602	6	2	2	0.41	4.11	12.60	17.12	1	2005
603	6	1	1	3.60	6.41	23.56	33.57	1	2005
605	6	1	2	2.57	5.48	26.13	34.17	1	2005
606	6	2	1	3.71	3.82	34.52	42.05	1	2005
102	1	1	1	4.16	5.92	37.86	47.94	1	2005
108	1	2	1	6.13	8.84	49.17	64.14	1	2005
109	1	1	2	2.62	6.00	33.38	42.00	1	2005
111	1	2	2	0.20	3.21	16.85	20.25	1	2005
205	2	2	1	2.94	6.46	28.31	37.70	1	2005
206	2	1	2	3.10	6.29	41.38	50.76	1	2005
208	2	2	2	2.30	7.44	35.49	45.23	1	2005

211	2	1	1	1.61	5.06	34.84	41.50	1	2005
301	3	1	1	0.94	3.12	16.12	20.18	1	2005
303	3	2	2	0.91	3.82	26.28	31.02	1	2005
306	3	1	2	2.27	7.03	38.50	47.81	1	2005
311	3	2	1	3.10	3.86	38.30	45.26	1	2005
404	4	2	1	2.99	5.10	35.05	43.13	1	2005
405	4	2	2	2.64	5.63	37.71	45.99	1	2005
407	4	1	2	4.77	6.25	57.94	68.96	1	2005
412	4	1	1	3.36	6.78	42.78	52.93	1	2005
501	5	2	2	4.51	7.73	42.40	54.64	1	2005
505	5	1	2	3.76	6.99	40.59	51.34	1	2005
509	5	1	1	0.94	4.03	26.23	31.19	1	2005
512	5	2	1	3.20	5.67	35.93	44.80	1	2005
602	6	2	2	.	.	.	.	1	2005
603	6	1	1	3.76	7.28	41.64	52.68	1	2005
605	6	1	2	2.80	6.46	30.39	39.65	1	2005
606	6	2	1	3.07	5.47	31.85	40.39	1	2005
102	1	1	1	1.15	4.52	19.10	24.78	1	2005
108	1	2	1	2.14	6.54	33.23	41.91	1	2005
109	1	1	2	3.26	6.78	39.12	49.16	1	2005
111	1	2	2	2.72	7.98	36.25	46.95	1	2005
205	2	2	1	0.14	5.22	9.90	15.27	1	2005
206	2	1	2	1.05	5.59	31.00	37.64	1	2005
208	2	2	2	1.47	4.11	26.61	32.19	1	2005
211	2	1	1	5.14	6.74	40.56	52.44	1	2005
301	3	1	1	1.53	4.56	28.78	34.86	1	2005
303	3	2	2	4.45	6.46	17.17	28.08	1	2005
306	3	1	2	2.03	5.55	39.74	47.32	1	2005
311	3	2	1	3.73	6.58	44.69	55.00	1	2005
404	4	2	1	1.85	7.07	26.78	35.70	1	2005
405	4	2	2	1.58	4.97	31.62	38.17	1	2005
407	4	1	2	1.05	5.26	29.04	35.35	1	2005
412	4	1	1	4.21	8.27	41.64	54.12	1	2005
501	5	2	2	2.11	3.95	33.70	39.76	1	2005
505	5	1	2	2.14	4.40	.	.	1	2005
509	5	1	1	2.30	4.97	25.43	32.71	1	2005
512	5	2	1	2.91	4.27	31.41	38.60	1	2005
602	6	2	2	1.66	5.80	25.52	32.98	1	2005
603	6	1	1	5.89	11.52	56.29	73.70	1	2005
605	6	1	2	9.19	12.54	51.17	72.90	1	2005
606	6	2	1	5.86	8.06	47.15	61.07	1	2005
102	1	1	1	2.86	6.83	36.37	46.05	1	2005
108	1	2	1	5.04	7.73	44.86	57.63	1	2005
109	1	1	2	.	.	.	.	1	2005
111	1	2	2	0.97	3.90	17.29	22.16	1	2005
205	2	2	1	4.45	6.50	31.24	42.19	1	2005
206	2	1	2	4.03	8.10	45.07	57.20	1	2005
208	2	2	2	2.91	6.46	34.67	44.03	1	2005
211	2	1	1	1.42	5.02	22.24	28.68	1	2005
301	3	1	1	3.73	7.57	39.27	50.57	1	2005
303	3	2	2	1.13	5.43	22.50	29.06	1	2005
306	3	1	2	2.99	7.81	33.29	44.09	1	2005
311	3	2	1	2.94	5.96	31.35	40.25	1	2005
404	4	2	1	1.58	4.07	20.10	25.75	1	2005
405	4	2	2	0.99	3.90	23.91	28.81	1	2005
407	4	1	2	1.13	4.03	20.48	25.64	1	2005
412	4	1	1	2.38	4.40	34.58	41.35	1	2005
501	5	2	2	5.33	5.14	37.07	47.54	1	2005
505	5	1	2	7.74	10.69	45.80	64.24	1	2005
509	5	1	1	1.55	5.30	19.69	26.55	1	2005
512	5	2	1	4.37	4.85	31.09	40.31	1	2005
602	6	2	2	2.83	5.34	27.31	35.48	1	2005
603	6	1	1	2.80	8.18	26.34	37.33	1	2005
605	6	1	2	3.47	5.63	36.51	45.61	1	2005
606	6	2	1	1.39	3.49	17.61	22.50	1	2005
102	1	1	1	5.17	6.78	45.01	56.97	2	2005
108	1	2	1	6.74	8.64	40.23	55.61	2	2005
109	1	1	2	3.12	6.54	31.47	41.13	2	2005
111	1	2	2	6.87	8.18	42.87	57.93	2	2005

205	2	2	1	6.71	7.32	43.08	57.11	2	2005
206	2	1	2	4.48	10.40	47.24	62.12	2	2005
208	2	2	2	5.68	6.13	37.89	49.69	2	2005
211	2	1	1	6.15	8.27	45.89	60.31	2	2005
301	3	1	1	8.20	10.53	53.83	72.56	2	2005
303	3	2	2	10.49	13.86	60.92	85.28	2	2005
306	3	1	2	4.64	7.61	42.23	54.47	2	2005
311	3	2	1	2.38	4.81	18.20	25.38	2	2005
404	4	2	1	3.47	8.10	29.13	40.70	2	2005
405	4	2	2	5.49	8.72	45.74	59.95	2	2005
407	4	1	2	7.62	9.83	56.79	74.24	2	2005
412	4	1	1	3.23	5.96	26.87	36.06	2	2005
501	5	2	2	3.57	6.37	32.29	42.24	2	2005
505	5	1	2	5.97	6.62	51.05	63.64	2	2005
509	5	1	1	5.33	6.21	26.05	37.59	2	2005
512	5	2	1	9.67	6.62	35.34	51.63	2	2005
602	6	2	2	6.26	9.21	37.33	52.81	2	2005
603	6	1	1	3.55	6.99	31.15	41.69	2	2005
605	6	1	2	3.79	6.25	35.93	45.96	2	2005
606	6	2	1	4.67	5.39	24.23	34.28	2	2005
102	1	1	1	5.33	7.03	37.33	49.69	2	2005
108	1	2	1	4.21	5.43	23.62	33.26	2	2005
109	1	1	2	3.18	8.96	43.69	55.83	2	2005
111	1	2	2	3.34	7.15	30.36	40.85	2	2005
205	2	2	1	5.20	4.89	34.26	44.34	2	2005
206	2	1	2	3.47	7.94	32.09	43.49	2	2005
208	2	2	2	4.21	4.65	25.41	34.26	2	2005
211	2	1	1	3.84	6.21	33.49	43.54	2	2005
301	3	1	1	3.47	6.21	38.77	48.45	2	2005
303	3	2	2	8.87	9.83	47.74	66.43	2	2005
306	3	1	2	3.12	6.00	32.09	41.21	2	2005
311	3	2	1	5.04	5.26	37.77	48.07	2	2005
404	4	2	1	10.89	8.10	54.10	73.09	2	2005
405	4	2	2	9.40	7.61	45.07	62.08	2	2005
407	4	1	2	6.50	6.17	42.14	54.81	2	2005
412	4	1	1	5.68	5.22	33.64	44.54	2	2005
501	5	2	2	5.62	6.78	31.76	44.17	2	2005
505	5	1	2	4.72	5.92	32.06	42.70	2	2005
509	5	1	1	2.78	4.52	23.27	30.56	2	2005
512	5	2	1	4.03	7.07	32.29	43.39	2	2005
602	6	2	2	9.40	9.66	48.82	67.89	2	2005
603	6	1	1	5.84	5.30	40.41	51.55	2	2005
605	6	1	2	3.97	6.46	31.18	41.61	2	2005
606	6	2	1	7.27	6.17	36.07	49.51	2	2005
102	1	1	1	2.62	5.30	27.43	35.35	2	2005
108	1	2	1	4.69	7.28	23.44	35.41	2	2005
109	1	1	2	2.30	5.53	25.32	33.15	2	2005
111	1	2	2	5.84	7.57	30.77	44.17	2	2005
205	2	2	1	5.12	5.67	31.21	42.00	2	2005
206	2	1	2	2.99	5.30	32.41	40.70	2	2005
208	2	2	2	1.58	4.32	14.18	20.08	2	2005
211	2	1	1	4.00	6.54	26.46	37.00	2	2005
301	3	1	1	3.92	8.31	32.09	44.31	2	2005
303	3	2	2	6.34	6.50	39.79	52.63	2	2005
306	3	1	2	2.72	6.09	29.45	38.26	2	2005
311	3	2	1	6.90	8.31	40.73	55.94	2	2005
404	4	2	1	10.81	9.83	51.99	72.62	2	2005
405	4	2	2	5.60	9.34	39.33	54.26	2	2005
407	4	1	2	3.39	6.83	33.29	43.50	2	2005
412	4	1	1	2.51	5.22	24.70	32.43	2	2005
501	5	2	2	2.22	8.10	30.36	40.68	2	2005
505	5	1	2	5.25	2.22	26.90	34.37	2	2005
509	5	1	1	1.77	3.90	13.68	19.35	2	2005
512	5	2	1	1.39	4.73	17.84	23.96	2	2005
602	6	2	2	6.10	6.58	29.57	42.25	2	2005
603	6	1	1	5.14	3.66	33.87	42.68	2	2005
605	6	1	2	4.61	6.13	33.20	43.94	2	2005
606	6	2	1	6.55	3.16	33.44	43.15	2	2005
102	1	1	1	7.91	9.46	51.69	69.06	2	2005

```
108     1       2       1       7.86    7.20    36.81   51.86   2       2005
109     1       1       2       5.14    6.58    39.30   51.02   2       2005
111     1       2       2       7.41    6.91    47.68   61.99   2       2005
205     2       2       1       11.77   13.57   55.62   80.96   2       2005
206     2       1       2       4.82    9.71    48.21   62.74   2       2005
208     2       2       2       3.39    4.73    38.92   47.03   2       2005
211     2       1       1       4.16    6.58    35.34   46.08   2       2005
301     3       1       1       12.43   11.84   67.25   91.53   2       2005
303     3       2       2       10.44   7.28    56.44   74.16   2       2005
306     3       1       2       5.92    6.66    58.78   71.36   2       2005
311     3       2       1       4.56    3.49    35.05   43.10   2       2005
404     4       2       1       9.11    10.16   45.69   64.95   2       2005
405     4       2       2       8.97    10.90   53.71   73.59   2       2005
407     4       1       2       3.20    6.41    36.42   46.04   2       2005
412     4       1       1       3.23    4.77    25.58   33.58   2       2005
501     5       2       2       4.72    4.77    34.34   43.83   2       2005
505     5       1       2       7.91    5.14    51.96   65.01   2       2005
509     5       1       1       4.13    4.52    24.03   32.68   2       2005
512     5       2       1       6.87    4.56    39.94   51.38   2       2005
602     6       2       2       5.28    5.22    35.93   46.42   2       2005
603     6       1       1       5.78    6.04    46.56   58.39   2       2005
605     6       1       2       1.05    4.23    20.54   25.82   2       2005
606     6       2       1       4.35    3.53    24.99   32.88   2       2005
102     1       1       1       1.90    5.43    31.32   38.65   2       2005
108     1       2       1       8.71    6.46    43.63   58.80   2       2005
109     1       1       2       3.28    5.96    28.95   38.19   2       2005
111     1       2       2       6.10    4.03    44.54   54.67   2       2005
205     2       2       1       6.05    4.60    39.35   50.01   2       2005
206     2       1       2       2.35    6.00    25.84   34.20   2       2005
208     2       2       2       3.26    5.10    28.04   36.40   2       2005
211     2       1       1       2.27    3.62    21.18   27.07   2       2005
301     3       1       1       4.00    6.95    42.14   53.09   2       2005
303     3       2       2       7.30    9.62    51.99   68.91   2       2005
306     3       1       2       3.65    7.11    41.61   52.38   2       2005
311     3       2       1       4.16    6.21    26.40   36.77   2       2005
404     4       2       1       4.32    5.96    36.04   46.32   2       2005
405     4       2       2       7.22    9.09    40.85   57.16   2       2005
407     4       1       2       3.73    6.29    32.09   42.11   2       2005
412     4       1       1       3.71    7.07    36.42   47.20   2       2005
501     5       2       2       5.97    7.69    41.85   55.50   2       2005
505     5       1       2       4.82    6.13    48.06   59.01   2       2005
509     5       1       1       1.58    3.90    19.10   24.59   2       2005
512     5       2       1       8.15    6.78    48.70   63.64   2       2005
602     6       2       2       3.63    7.69    32.12   43.43   2       2005
603     6       1       1       2.22    7.11    30.89   40.22   2       2005
605     6       1       2       2.54    7.81    26.64   36.99   2       2005
606     6       2       1       7.75    5.47    37.74   50.96   2       2005
;

%include'c:\danda.sas';
%mmaov(NKSol,glu,Class=Year Rep Variety K Date, fixed=Year |Variety |K  |Date,
   random = Rep(Year) Variety*K*Rep(Year) Variety*Date*K*rep(year),DDFM=CONTAIN);
%include'c:\danda.sas';
%mmaov(NKSol,fruc,Class=Year Rep Variety K Date,fixed=Year |Variety |K  |Date,
   random = Rep(Year) Variety*K*Rep(Year) Variety*Date*K*rep(year), DDFM=CONTAIN );
%include'c:\danda.sas';
%mmaov(NKSol,suc,Class=Year Rep Variety K Date, fixed=Year |Variety |K  |Date,
   random = Rep(Year) Variety*K*Rep(Year) Variety*Date*K*rep(year), DDFM=CONTAIN );

%include'c:\danda.sas';
%mmaov(NKSol,total, Class=Year Rep Variety K Date,fixed=Year |Variety |K  |Date,
   random = Rep(Year) Variety*K*Rep(Year) Variety*Date*K*rep(year),DDFM=CONTAIN  );
```

N&K Soluble Sugar-
Glucose, Fructose, Sucrose and the sum of all three.
SAS Output

Mixed ANOVA for glu

The Mixed Procedure

Model Information

Data Set	WORK.NKSOL
Dependent Variable	Glu
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
Year	3	2003 2004 2005
Rep	6	1 2 3 4 5 6
Variety	2	1 2
K	2	1 2
Date	2	1 2

Dimensions

Covariance Parameters	4
Columns in X	108
Columns in Z	234
Subjects	1
Max Obs Per Subject	720

Number of Observations

Number of Observations Read	720
Number of Observations Used	718
Number of Observations Not Used	2

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	3028.05162669	
1	3	3021.58570426	0.00002395
2	1	3021.56353181	0.00000023
3	1	3021.56332612	0.00000000

Mixed ANOVA for glu

The Mixed Procedure

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Rep(Year)	0.03838	0.06367	0.60	0.2733
Rep*Variety*K(Year)	0	.	.	.
Rep*Var*K*Date(Year)	0.2667	0.1494	1.79	0.0371

Residual	3.8237	0.2256	16.95	<.0001

Fit Statistics

-2 Res Log Likelihood	3021.6
AIC (smaller is better)	3027.6
AICC (smaller is better)	3027.6
BIC (smaller is better)	3030.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	15	5.25	0.0187
Variety	1	45	39.12	<.0001
Year*Variety	2	45	0.73	0.4863
K	1	45	18.43	<.0001
Year*K	2	45	0.88	0.4202
Variety*K	1	45	0.31	0.5805
Year*Variety*K	2	45	2.87	0.0668
Date	1	60	2.85	0.0966
Year*Date	2	60	30.39	<.0001
Variety*Date	1	60	0.54	0.4664
Year*Variety*Date	2	60	8.57	0.0005
K*Date	1	60	1.45	0.2328
Year*K*Date	2	60	1.14	0.3255
Variety*K*Date	1	60	2.33	0.1323
Year*Variety*K*Date	2	60	0.02	0.9815

---------- Effect=Year Method=LSD(P<.05) Set=1 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
1	2003	_	_	_	4.8867	0.1670	A
2	2004	_	_	_	4.6890	0.1670	A
3	2005	_	_	_	4.1465	0.1674	B

---------- Effect=Variety Method=LSD(P<.05) Set=2 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
4	_	1	_	_	4.0441	0.1284	B
5	_	2	_	_	5.1040	0.1284	A

---------- Effect=Year*Variety Method=LSD(P<.05) Set=3 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
6	2003	1	_	_	4.2335	0.2222	BC
7	2003	2	_	_	5.5400	0.2222	A
8	2004	1	_	_	4.1544	0.2222	BC
9	2004	2	_	_	5.2236	0.2222	A
10	2005	1	_	_	3.7445	0.2229	C
11	2005	2	_	_	4.5485	0.2229	B

---------- Effect=K Method=LSD(P<.05) Set=4 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
12	_	_	1	_	4.9378	0.1283	A
13	_	_	2	_	4.2104	0.1285	B

---------- Effect=Year*K Method=LSD(P<.05) Set=5 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
14	2003	_	1	_	5.2884	0.2222	A
15	2003	_	2	_	4.4851	0.2222	B
16	2004	_	1	_	5.1679	0.2222	A
17	2004	_	2	_	4.2101	0.2222	B
18	2005	_	1	_	4.3572	0.2222	B
19	2005	_	2	_	3.9359	0.2235	B

---------- Effect=Variety*K Method=LSD(P<.05) Set=6 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
20	_	1	1	_	4.3607	0.1755	B
21	_	1	2	_	3.7276	0.1758	C
22	_	2	1	_	5.5149	0.1755	A
23	_	2	2	_	4.6931	0.1758	B

---------- Effect=Year*Variety*K Method=LSD(P<.05) Set=7 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
24	2003	1	1	_	4.8638	0.3039	CD
25	2003	1	2	_	3.6032	0.3039	F
26	2003	2	1	_	5.7130	0.3039	AB
27	2003	2	2	_	5.3670	0.3039	ABC
28	2004	1	1	_	4.3795	0.3039	DEF
29	2004	1	2	_	3.9293	0.3039	EF
30	2004	2	1	_	5.9563	0.3039	A
31	2004	2	2	_	4.4908	0.3039	DE
32	2005	1	1	_	3.8388	0.3039	EF
33	2005	1	2	_	3.6502	0.3058	EF
34	2005	2	1	_	4.8755	0.3039	BCD
35	2005	2	2	_	4.2216	0.3058	DEF

---------- Effect=Date Method=LSD(P<.05) Set=8 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
36	_	_	_	1	4.4311	0.1285	A
37	_	_	_	2	4.7171	0.1283	A

---------- Effect=Year*Date Method=LSD(P<.05) Set=9 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group

38	2003	_	_	1	5.3093	0.2222	A
39	2003	_	_	2	4.4642	0.2222	B
40	2004	_	_	1	4.9081	0.2222	AB
41	2004	_	_	2	4.4699	0.2222	B
42	2005	_	_	1	3.0758	0.2235	C
43	2005	_	_	2	5.2172	0.2222	A

---------- Effect=Variety*Date Method=LSD(P<.05) Set=10 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
44	_	1	_	1	3.9632	0.1758	B
45	_	1	_	2	4.1251	0.1755	B
46	_	2	_	1	4.8989	0.1758	A
47	_	2	_	2	5.3092	0.1755	A

---------- Effect=Year*Variety*Date Method=LSD(P<.05) Set=11 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
48	2003	1	_	1	4.3827	0.3039	CD
49	2003	1	_	2	4.0843	0.3039	CD
50	2003	2	_	1	6.2360	0.3039	A
51	2003	2	_	2	4.8440	0.3039	BCD
52	2004	1	_	1	4.2863	0.3039	CD
53	2004	1	_	2	4.0225	0.3039	DE
54	2004	2	_	1	5.5298	0.3039	AB
55	2004	2	_	2	4.9173	0.3039	BC
56	2005	1	_	1	3.2207	0.3058	EF
57	2005	1	_	2	4.2683	0.3039	CD
58	2005	2	_	1	2.9309	0.3058	F
59	2005	2	_	2	6.1662	0.3039	A

---------- Effect=K*Date Method=LSD(P<.05) Set=12 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
60	_	_	1	1	4.8969	0.1755	AB
61	_	_	1	2	4.9787	0.1755	A
62	_	_	2	1	3.9652	0.1762	C
63	_	_	2	2	4.4555	0.1755	B

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
64	2003	_	1	1	5.9822	0.3039	A
65	2003	_	1	2	4.5947	0.3039	BCD
66	2003	_	2	1	4.6365	0.3039	BCD
67	2003	_	2	2	4.3337	0.3039	CD
68	2004	_	1	1	5.3485	0.3039	AB
69	2004	_	1	2	4.9873	0.3039	BC

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
----

(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
70	2004	_	2	1	4.4677	0.3039	CD
71	2004	_	2	2	3.9525	0.3039	DE
72	2005	_	1	1	3.3602	0.3039	EF
73	2005	_	1	2	5.3542	0.3039	AB
74	2005	_	2	1	2.7914	0.3077	F
75	2005	_	2	2	5.0803	0.3039	BC

---------- Effect=Variety*K*Date Method=LSD(P<.05) Set=14 ----------
----

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
76	_	1	1	1	4.2527	0.2438	CD
77	_	1	1	2	4.4688	0.2438	BC
78	_	1	2	1	3.6738	0.2448	D
79	_	1	2	2	3.7813	0.2438	D
80	_	2	1	1	5.5412	0.2438	A
81	_	2	1	2	5.4887	0.2438	A
82	_	2	2	1	4.2566	0.2448	CD
83	_	2	2	2	5.1297	0.2438	AB

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
----

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
84	2003	1	1	1	5.1433	0.4223	CDEFG
85	2003	1	1	2	4.5843	0.4223	EFGHI
86	2003	1	2	1	3.6220	0.4223	HIJKL
87	2003	1	2	2	3.5843	0.4223	HIJKL
88	2003	2	1	1	6.8210	0.4223	A
89	2003	2	1	2	4.6050	0.4223	EFGHI
90	2003	2	2	1	5.6510	0.4223	ABCDE
91	2003	2	2	2	5.0830	0.4223	DEFG
92	2004	1	1	1	4.3320	0.4223	GHIJK
93	2004	1	1	2	4.4270	0.4223	FGHIJ
94	2004	1	2	1	4.2407	0.4223	GHIJK
95	2004	1	2	2	3.6180	0.4223	HIJKL
96	2004	2	1	1	6.3650	0.4223	AB
97	2004	2	1	2	5.5477	0.4223	BCDEF
98	2004	2	2	1	4.6947	0.4223	EFGH
99	2004	2	2	2	4.2870	0.4223	GHIJK
100	2005	1	1	1	3.2827	0.4223	JKL
101	2005	1	1	2	4.3950	0.4223	FGHIJ

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
---

(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
102	2005	1	2	1	3.1587	0.4277	KL
103	2005	1	2	2	4.1417	0.4223	GHIJK
104	2005	2	1	1	3.4377	0.4223	IJKL
105	2005	2	1	2	6.3133	0.4223	ABC
106	2005	2	2	1	2.4242	0.4277	L
107	2005	2	2	2	6.0190	0.4223	ABCD

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.973936	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.059641	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.68041	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.135247	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-4.82644	668	5.72398	409
-4.53902	440	5.78752	285
-4.45021	77	6.16983	24
-4.28602	433	7.49570	681
-4.11602	361	9.29687	463

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	2	0.28	100.00

```
                    Histogram                       #             Boxplot
  9+*                                               1                *
   .*                                               2                0
   .****                                           22                0
   .***********                                    73                |
   .*********************************             229             +--+--+
   .*******************************************   300             *-----*
   .*************                                   86                |
  -5+*                                              5                |
     ----+----+----+----+----+----+----+----+---
     * may represent up to 7 counts
```

```
                    Check on normality for  glu

                     The UNIVARIATE Procedure
                   Variable:  Resid  (Residual)

                          Normal Probability Plot
                 9+                                                 *
                  |                                                 *
                  |                                          ********
                  |                                   ********+++
                  |                        +***********
                  |                 *************
                  | **************
                -5+*+++
                   +----+----+----+----+----+----+----+----+----+----+
                       -2        -1         0        +1        +2
                       Check equality of stddev for y= glu

                                  rawmean_
Levene
 Obs   Year   Variety   K   Date   nobs      y       stddev_y stderr_y LeveneF_df    P

   1   2003      1      1     1     30     5.14333    1.45028  0.26478 1.33(23,694).14
   2   2003      1      1     2     30     4.58433    2.11409  0.38598               .
   3   2003      1      2     1     30     3.62200    1.25638  0.22938               .
   4   2003      1      2     2     30     3.58433    2.04529  0.37342               .
   5   2003      2      1     1     30     6.82100    2.43115  0.44387               .
   6   2003      2      1     2     30     4.60500    2.13985  0.39068               .
   7   2003      2      2     1     30     5.65100    1.51225  0.27610               .
   8   2003      2      2     2     30     5.08300    1.94589  0.35527               .
   9   2004      1      1     1     30     4.33200    2.18049  0.39810               .
  10   2004      1      1     2     30     4.42700    1.86859  0.34116               .
  11   2004      1      2     1     30     4.24067    2.28205  0.41664               .
  12   2004      1      2     2     30     3.61800    2.22563  0.40634               .
  13   2004      2      1     1     30     6.36500    1.72688  0.31528               .
  14   2004      2      1     2     30     5.54767    2.72752  0.49798               .
  15   2004      2      2     1     30     4.69467    2.00997  0.36697               .
  16   2004      2      2     2     30     4.28700    2.29127  0.41833               .
  17   2005      1      1     1     30     3.28267    1.70390  0.31109               .
  18   2005      1      1     2     30     4.39500    2.26182  0.41295               .
  19   2005      1      2     1     29     3.15759    1.89905  0.35265               .
  20   2005      1      2     2     30     4.14167    1.56164  0.28512               .
  21   2005      2      1     1     30     3.43767    1.69601  0.30965               .
  22   2005      2      1     2     30     6.31333    2.54768  0.46514               .
  23   2005      2      2     1     29     2.42448    1.43898  0.26721               .
  24   2005      2      2     2     30     6.01900    2.34126  0.42745               .

                          Mixed ANOVA for  fruc

                           The Mixed Procedure

                           Model Information

                 Data Set                     WORK.NKSOL
                 Dependent Variable           Fruc
                 Covariance Structure         Variance Components
                 Estimation Method            REML
                 Residual Variance Method     Profile
                 Fixed Effects SE Method      Model-Based
                 Degrees of Freedom Method    Containment


                         Class Level Information

                  Class      Levels    Values

                  Year            3    2003 2004 2005
```

Rep	6	1 2 3 4 5 6
Variety	2	1 2
K	2	1 2
Date	2	1 2

Dimensions

Covariance Parameters	4
Columns in X	108
Columns in Z	234
Subjects	1
Max Obs Per Subject	720

Number of Observations

Number of Observations Read	720
Number of Observations Used	707
Number of Observations Not Used	13

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	3046.45787817	
1	2	3040.49481375	0.00000009
2	1	3040.49472893	0.00000000

Mixed ANOVA for fruc

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Rep(Year)	0.01506	0.06344	0.24	0.4062
Rep*Variety*K(Year)	0	.	.	.
Rep*Var*K*Date(Year)	0.3240	0.1696	1.91	0.0281
Residual	4.2060	0.2506	16.79	<.0001

Fit Statistics

-2 Res Log Likelihood	3040.5
AIC (smaller is better)	3046.5
AICC (smaller is better)	3046.5
BIC (smaller is better)	3049.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	15	141.33	<.0001
Variety	1	45	1.38	0.2459
Year*Variety	2	45	0.79	0.4614
K	1	45	4.51	0.0392
Year*K	2	45	4.63	0.0149
Variety*K	1	45	0.17	0.6856
Year*Variety*K	2	45	1.40	0.2582
Date	1	60	26.70	<.0001
Year*Date	2	60	8.19	0.0007
Variety*Date	1	60	0.57	0.4531

Year*Variety*Date	2	60	4.64	0.0134
K*Date	1	60	0.23	0.6300
Year*K*Date	2	60	0.82	0.4435
Variety*K*Date	1	60	3.08	0.0846
Year*Variety*K*Date	2	60	0.05	0.9533

---------- Effect=Year Method=LSD(P<.05) Set=1 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
1	2003	_	_	_	4.0266	0.1642	B
2	2004	_	_	_	2.4118	0.1659	C
3	2005	_	_	_	6.3138	0.1641	A

---------- Effect=Variety Method=LSD(P<.05) Set=2 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
4	_	1	_	_	4.3572	0.1312	A
5	_	2	_	_	4.1442	0.1316	A

---------- Effect=Year*Variety Method=LSD(P<.05) Set=3 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
6	2003	1	_	_	4.2921	0.2260	B
7	2003	2	_	_	3.7611	0.2275	B
8	2004	1	_	_	2.4189	0.2289	C
9	2004	2	_	_	2.4047	0.2296	C
10	2005	1	_	_	6.3608	0.2267	A
11	2005	2	_	_	6.2668	0.2267	A

---------- Effect=K Method=LSD(P<.05) Set=4 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
12	_	_	1	_	4.4432	0.1309	A
13	_	_	2	_	4.0583	0.1319	B

---------- Effect=Year*K Method=LSD(P<.05) Set=5 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
14	2003	_	1	_	4.5801	0.2260	B
15	2003	_	2	_	3.4731	0.2275	C
16	2004	_	1	_	2.5477	0.2281	D
17	2004	_	2	_	2.2758	0.2304	D
18	2005	_	1	_	6.2017	0.2260	A
19	2005	_	2	_	6.4259	0.2274	A

---------- Effect=Variety*K Method=LSD(P<.05) Set=6 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
20	_	1	1	_	4.5866	0.1826	A
21	_	1	2	_	4.1279	0.1838	AB
22	_	2	1	_	4.2997	0.1830	AB
23	_	2	2	_	3.9886	0.1847	B

---------- Effect=Year*Variety*K Method=LSD(P<.05) Set=7 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
24	2003	1	1	_	5.0895	0.3156	B
25	2003	1	2	_	3.4947	0.3156	CD
26	2003	2	1	_	4.0707	0.3156	C
27	2003	2	2	_	3.4515	0.3200	CD
28	2004	1	1	_	2.4408	0.3176	E
29	2004	1	2	_	2.3969	0.3220	E
30	2004	2	1	_	2.6546	0.3196	DE
31	2004	2	2	_	2.1547	0.3219	E
32	2005	1	1	_	6.2295	0.3156	A
33	2005	1	2	_	6.4921	0.3176	A
34	2005	2	1	_	6.1738	0.3156	A
35	2005	2	2	_	6.3597	0.3176	A

---------- Effect=Date Method=LSD(P<.05) Set=8 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
36	_	_	_	1	3.7824	0.1314	B
37	_	_	_	2	4.7190	0.1313	A

---------- Effect=Year*Date Method=LSD(P<.05) Set=9 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
38	2003	_	_	1	3.0816	0.2275	D
39	2003	_	_	2	4.9716	0.2260	C
40	2004	_	_	1	2.3602	0.2281	E
41	2004	_	_	2	2.4633	0.2304	DE
42	2005	_	_	1	5.9056	0.2274	B
43	2005	_	_	2	6.7220	0.2260	A

---------- Effect=Variety*Date Method=LSD(P<.05) Set=10 ----------
----

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
44	_	1	_	1	3.8205	0.1834	B
45	_	1	_	2	4.8939	0.1831	A
46	_	2	_	1	3.7443	0.1838	B
47	_	2	_	2	4.5440	0.1838	A

---------- Effect=Year*Variety*Date Method=LSD(P<.05) Set=11 ----------
----

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
48	2003	1	_	1	2.9818	0.3156	EF
49	2003	1	_	2	5.6023	0.3156	BC
50	2003	2	_	1	3.1813	0.3200	E
51	2003	2	_	2	4.3408	0.3156	D
52	2004	1	_	1	2.2296	0.3196	F
53	2004	1	_	2	2.6081	0.3200	EF
54	2004	2	_	1	2.4908	0.3176	EF
55	2004	2	_	2	2.3185	0.3239	EF
56	2005	1	_	1	6.2503	0.3176	ABC
57	2005	1	_	2	6.4713	0.3156	AB
58	2005	2	_	1	5.5609	0.3176	C
59	2005	2	_	2	6.9727	0.3156	A

---------- Effect=K*Date Method=LSD(P<.05) Set=12 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
60	_	_	1	1	4.0188	0.1830	B
61	_	_	1	2	4.8675	0.1826	A
62	_	_	2	1	3.5461	0.1842	B
63	_	_	2	2	4.5704	0.1843	A

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
----

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
64	2003	_	1	1	3.6202	0.3156	C
65	2003	_	1	2	5.5400	0.3156	B
66	2003	_	2	1	2.5430	0.3200	D
67	2003	_	2	2	4.4032	0.3156	C
68	2004	_	1	1	2.4365	0.3196	D
69	2004	_	1	2	2.6590	0.3176	D

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
----

(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
70	2004	_	2	1	2.2839	0.3176	D
71	2004	_	2	2	2.2677	0.3262	D
72	2005	_	1	1	5.9997	0.3156	B
73	2005	_	1	2	6.4037	0.3156	AB
74	2005	_	2	1	5.8115	0.3196	B
75	2005	_	2	2	7.0403	0.3156	A

---------- Effect=Variety*K*Date Method=LSD(P<.05) Set=14 ----------
----

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
76	_	1	1	1	3.9349	0.2572	BC
77	_	1	1	2	5.2383	0.2561	A
78	_	1	2	1	3.7062	0.2583	C
79	_	1	2	2	4.5495	0.2585	AB
80	_	2	1	1	4.1026	0.2572	BC
81	_	2	1	2	4.4968	0.2572	B
82	_	2	2	1	3.3860	0.2596	C
83	_	2	2	2	4.5913	0.2595	AB

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
----

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
84	2003	1	1	1	3.5880	0.4435	FGH
85	2003	1	1	2	6.5910	0.4435	AB
86	2003	1	2	1	2.3757	0.4435	HI
87	2003	1	2	2	4.6137	0.4435	DEF
88	2003	2	1	1	3.6523	0.4435	FG
89	2003	2	1	2	4.4890	0.4435	EF
90	2003	2	2	1	2.7103	0.4559	GHI
91	2003	2	2	2	4.1927	0.4435	EF
92	2004	1	1	1	2.0727	0.4492	I
93	2004	1	1	2	2.8090	0.4435	GHI
94	2004	1	2	1	2.3864	0.4492	HI
95	2004	1	2	2	2.4073	0.4559	GHI
96	2004	2	1	1	2.8003	0.4492	GHI
97	2004	2	1	2	2.5089	0.4492	GHI
98	2004	2	2	1	2.1813	0.4435	I
99	2004	2	2	2	2.1281	0.4613	I
100	2005	1	1	1	6.1440	0.4435	BC
101	2005	1	1	2	6.3150	0.4435	ABC

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
----

(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
102	2005	1	2	1	6.3565	0.4492	ABC
103	2005	1	2	2	6.6277	0.4435	AB
104	2005	2	1	1	5.8553	0.4435	BCD
105	2005	2	1	2	6.4923	0.4435	ABC
106	2005	2	2	1	5.2664	0.4492	CDE
107	2005	2	2	2	7.4530	0.4435	A

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.938718	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.086561	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.600962	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	9.135879	Pr > A-Sq	<0.0050

Extreme Observations

------Lowest-----		------Highest-----	
Value	Obs	Value	Obs
-4.99413	184	7.02418	225
-4.99382	163	8.02306	221
-4.95055	176	8.55828	229
-4.47413	160	9.34880	285
-4.08928	166	11.64945	224

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	13	1.81	100.00

```
                    Histogram                          #             Boxplot
11+*                                                   1                *
  .*                                                   3                *
  .*                                                   3                0
  .***                                                19                0
 3+**********                                         70                |
  .******************************                     208             +--+--+
  .*************************************************  321             *-----*
  .***********                                        76                |
-5+*                                                   6                0
   ----+----+----+----+----+----+----+----+----+-
   * may represent up to 7 counts
```

```
                                  Check on normality for  fruc

                                    The UNIVARIATE Procedure
                                  Variable:  Resid  (Residual)

                                         Normal Probability Plot
                        11+                                                  *
                          |                                                  *
                          |                                                 **
                          |                                           ******++
                         3+                                     ********++
                          |                         ++**********
                          |                 ***************
                          | *************+
                        -5+**+++
                           +----+----+----+----+----+----+----+----+----+----+
                               -2        -1         0        +1        +2

                                         The SAS System           13:51 Friday, April
7, 2006  44
                                Check equality of stddev for y= fruc

                                         rawmean_
Levene
 Obs   Year   Variety   K   Date   nobs       y      stddev_y   stderr_y LeveneF_df    P

1   2003      1      1     1     30     3.58800    1.86322    0.34018   4.242(23,683)
2   2003      1      1     2     30     6.59100    4.26037    0.77783                  .
3   2003      1      2     1     30     2.37567    1.68343    0.30735                  .
4   2003      1      2     2     30     4.61367    2.95126    0.53882                  .
5   2003      2      1     1     30     3.65233    1.83292    0.33464                  .
6   2003      2      1     2     30     4.48900    3.35555    0.61264                  .
7   2003      2      2     1     28     2.72214    1.16814    0.22076                  .
8   2003      2      2     2     30     4.19267    2.45168    0.44761                  .
9   2004      1      1     1     29     2.07966    1.33123    0.24720                  .
10  2004      1      1     2     30     2.80900    2.15843    0.39407                  .
11  2004      1      2     1     29     2.39655    2.27497    0.42245                  .
12  2004      1      2     2     28     2.37429    1.58090    0.29876                  .
13  2004      2      1     1     29     2.78931    1.27320    0.23643                  .
14  2004      2      1     2     29     2.49448    1.82749    0.33936                  .
15  2004      2      2     1     30     2.18133    1.41615    0.25855                  .
16  2004      2      2     2     27     2.13370    1.51759    0.29206                  .
17  2005      1      1     1     30     6.14400    1.84190    0.33628                  .
18  2005      1      1     2     30     6.31500    1.94030    0.35425                  .
19  2005      1      2     1     29     6.35448    1.92993    0.35838                  .
20  2005      1      2     2     30     6.62767    1.63173    0.29791                  .
21  2005      2      1     1     30     5.85533    1.89220    0.34547                  .
22  2005      2      1     2     30     6.49233    2.20324    0.40225                  .
23  2005      2      2     1     29     5.26793    1.30128    0.24164                  .
24  2005      2      2     2     30     7.45300    2.19849    0.40139                  .
.
```

Mixed ANOVA for suc

The Mixed Procedure

Model Information

Data Set	WORK.NKSOL
Dependent Variable	Suc
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
Year	3	2003 2004 2005
Rep	6	1 2 3 4 5 6
Variety	2	1 2
K	2	1 2
Date	2	1 2

Dimensions

Covariance Parameters	4
Columns in X	108
Columns in Z	234
Subjects	1
Max Obs Per Subject	720

Number of Observations

Number of Observations Read	720
Number of Observations Used	716
Number of Observations Not Used	4

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	5302.33560979	
1	4	5277.52898886	0.00049260
2	2	5276.79022783	.
3	1	5276.66635690	0.00000127
4	1	5276.66376365	0.00000000

Mixed ANOVA for suc

The Mixed Procedure

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Rep(Year)	0.3626	1.9228	0.19	0.4252
Rep*Variety*K(Year)	0	.	.	.
Rep*Var*K*Date(Year)	17.8190	5.2092	3.42	0.0003
Residual	94.9854	5.6143	16.92	<.0001

Fit Statistics

-2 Res Log Likelihood	5276.7
AIC (smaller is better)	5282.7
AICC (smaller is better)	5282.7
BIC (smaller is better)	5285.3

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	15	2.06	0.1626
Variety	1	45	9.99	0.0028
Year*Variety	2	45	4.57	0.0156
K	1	45	0.69	0.4094
Year*K	2	45	1.00	0.3751
Variety*K	1	45	0.64	0.4285
Year*Variety*K	2	45	2.01	0.1457
Date	1	60	57.06	<.0001
Year*Date	2	60	38.37	<.0001
Variety*Date	1	60	0.99	0.3232
Year*Variety*Date	2	60	4.08	0.0218
K*Date	1	60	0.84	0.3627
Year*K*Date	2	60	0.30	0.7420
Variety*K*Date	1	60	3.27	0.0754
Year*Variety*K*Date	2	60	0.21	0.8088

Mean separation for suc

---------- Effect=Year Method=LSD(P<.05) Set=1 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
1	2003	_	_	_	34.7313	0.9096	A
2	2004	_	_	_	32.4061	0.9107	A
3	2005	_	_	_	34.5984	0.9127	A

---------- Effect=Variety Method=LSD(P<.05) Set=2 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group

4	_	1	_	_	32.3112	0.7302	B
5	_	2	_	_	35.5127	0.7302	A

---------- Effect=Year*Variety Method=LSD(P<.05) Set=3 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
6	2003	1	_	_	32.3832	1.2627	BC
7	2003	2	_	_	37.0794	1.2627	A
8	2004	1	_	_	29.4166	1.2627	C
9	2004	2	_	_	35.3957	1.2657	AB
10	2005	1	_	_	35.1337	1.2687	AB
11	2005	2	_	_	34.0631	1.2657	AB

---------- Effect=K Method=LSD(P<.05) Set=4 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
12	_	_	1	_	33.4902	0.7296	A
13	_	_	2	_	34.3337	0.7307	A

---------- Effect=Year*K Method=LSD(P<.05) Set=5 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
14	2003	_	1	_	33.5682	1.2627	AB
15	2003	_	2	_	35.8944	1.2627	A
16	2004	_	1	_	32.9534	1.2657	AB
17	2004	_	2	_	31.8589	1.2627	B
18	2005	_	1	_	33.9492	1.2627	AB
19	2005	_	2	_	35.2476	1.2716	AB

---------- Effect=Variety*K Method=LSD(P<.05) Set=6 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
20	_	1	1	_	31.4848	1.0212	B
21	_	1	2	_	33.1375	1.0245	AB
22	_	2	1	_	35.4957	1.0228	A
23	_	2	2	_	35.5298	1.0228	A

---------- Effect=Year*Variety*K Method=LSD(P<.05) Set=7 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
24	2003	1	1	_	32.1172	1.7687	CDE
25	2003	1	2	_	32.6492	1.7687	BCDE
26	2003	2	1	_	35.0192	1.7687	ABCD
27	2003	2	2	_	39.1397	1.7687	A
28	2004	1	1	_	28.3853	1.7687	E
29	2004	1	2	_	30.4478	1.7687	DE
30	2004	2	1	_	37.5214	1.7771	AB
31	2004	2	2	_	33.2700	1.7687	BCDE
32	2005	1	1	_	33.9518	1.7687	BCD
33	2005	1	2	_	36.3156	1.7858	ABC

34	2005	2	1	_	33.9465	1.7687	BCD
35	2005	2	2	_	34.1797	1.7771	ABCD

---------- Effect=Date Method=LSD(P<.05) Set=8 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
36	_	_	_	1	37.7375	0.7307	A
37	_	_	_	2	30.0864	0.7296	B

---------- Effect=Year*Date Method=LSD(P<.05) Set=9 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
38	2003	_	_	1	39.5296	1.2627	AB
39	2003	_	_	2	29.9330	1.2627	C
40	2004	_	_	1	41.1188	1.2627	A
41	2004	_	_	2	23.6935	1.2657	D
42	2005	_	_	1	32.5642	1.2716	C
43	2005	_	_	2	36.6326	1.2627	B

---------- Effect=Variety*Date Method=LSD(P<.05) Set=10 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
44	_	1	_	1	35.6323	1.0245	B
45	_	1	_	2	28.9901	1.0212	C
46	_	2	_	1	39.8428	1.0228	A
47	_	2	_	2	31.1827	1.0228	C

---------- Effect=Year*Variety*Date Method=LSD(P<.05) Set=11 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
48	2003	1	_	1	35.1995	1.7687	BC
49	2003	1	_	2	29.5668	1.7687	DE
50	2003	2	_	1	43.8597	1.7687	A
51	2003	2	_	2	30.2992	1.7687	CDE
52	2004	1	_	1	37.1360	1.7687	B
53	2004	1	_	2	21.6972	1.7687	F
54	2004	2	_	1	45.1015	1.7687	A
55	2004	2	_	2	25.6899	1.7771	EF
56	2005	1	_	1	34.5613	1.7858	BCD
57	2005	1	_	2	35.7062	1.7687	B
58	2005	2	_	1	30.5672	1.7771	CDE
59	2005	2	_	2	37.5590	1.7687	B

---------- Effect=K*Date Method=LSD(P<.05) Set=12 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
60	_	_	1	1	37.7804	1.0212	A
61	_	_	1	2	29.2001	1.0228	B
62	_	_	2	1	37.6947	1.0261	A

63	_	_	2	2	30.9727	1.0212	B

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
64	2003	_	1	1	38.3493	1.7687	AB
65	2003	_	1	2	28.7870	1.7687	DE
66	2003	_	2	1	40.7098	1.7687	A
67	2003	_	2	2	31.0790	1.7687	CD
68	2004	_	1	1	42.1330	1.7687	A
69	2004	_	1	2	23.7737	1.7771	EF

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
---

(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
70	2004	_	2	1	40.1045	1.7687	A
71	2004	_	2	2	23.6133	1.7687	F
72	2005	_	1	1	32.8588	1.7687	CD
73	2005	_	1	2	35.0395	1.7687	BC
74	2005	_	2	1	32.2696	1.7942	CD
75	2005	_	2	2	38.2257	1.7687	AB

---------- Effect=Variety*K*Date Method=LSD(P<.05) Set=14 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
76	_	1	1	1	34.3540	1.4372	CD
77	_	1	1	2	28.6156	1.4372	E
78	_	1	2	1	36.9105	1.4465	BC
79	_	1	2	2	29.3646	1.4372	E
80	_	2	1	1	41.2068	1.4372	A
81	_	2	1	2	29.7846	1.4418	E
82	_	2	2	1	38.4788	1.4418	AB
83	_	2	2	2	32.5808	1.4372	DE

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
---

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
84	2003	1	1	1	33.5437	2.4893	EFGHIJK
85	2003	1	1	2	30.6907	2.4893	GHIJKL
86	2003	1	2	1	36.8553	2.4893	CDEFG
87	2003	1	2	2	28.4430	2.4893	IJKLM
88	2003	2	1	1	43.1550	2.4893	ABC
89	2003	2	1	2	26.8833	2.4893	JKLMN
90	2003	2	2	1	44.5643	2.4893	AB
91	2003	2	2	2	33.7150	2.4893	EFGHIJ
92	2004	1	1	1	35.7960	2.4893	DEFGH
93	2004	1	1	2	20.9747	2.4893	N
94	2004	1	2	1	38.4760	2.4893	BCDEF
95	2004	1	2	2	22.4197	2.4893	MN
96	2004	2	1	1	48.4700	2.4893	A
97	2004	2	1	2	26.5728	2.5131	KLMN
98	2004	2	2	1	41.7330	2.4893	ABCD
99	2004	2	2	2	24.8070	2.4893	LMN

```
 100    2005       1       1     1       33.7223      2.4893    EFGHIJ
 101    2005       1       1     2       34.1813      2.4893    EFGHI

-------------------- Effect=Year*Variety*K*Date   Method=LSD(P<.05)   Set=15 -----------
----------
                                        (continued)

                                                                Standard    Letter
  Obs    Year    Variety    K    Date    Estimate     Error      Group

  102    2005       1       2     1       35.4002      2.5376    DEFGHI
  103    2005       1       2     2       37.2310      2.4893    CDEFG
  104    2005       2       1     1       31.9953      2.4893    FGHIJK
  105    2005       2       1     2       35.8977      2.4893    DEFGH
  106    2005       2       2     1       29.1391      2.5131    HIJKLM
  107    2005       2       2     2       39.2203      2.4893    BCDE

                    Check on normality for  suc

                         The UNIVARIATE Procedure
                       Variable:  Resid  (Residual)

                           Tests for Normality

       Test                  --Statistic---    -----p Value------

       Shapiro-Wilk          W     0.995909    Pr < W      0.0578
       Kolmogorov-Smirnov    D     0.031286    Pr > D      0.0876
       Cramer-von Mises      W-Sq  0.104713    Pr > W-Sq   0.0982
       Anderson-Darling      A-Sq   0.62991    Pr > A-Sq   0.1003


                           Extreme Observations

                 ------Lowest-----        -----Highest-----

                    Value      Obs           Value      Obs

                 -26.5398      338         26.8309      284
                 -24.0991      356         26.8674      681
                 -23.9461      339         27.5808      227
                 -22.7597       75         32.7430      463
                 -22.3040      361         32.8770      386


                            Missing Values

                                     -----Percent Of-----
                 Missing                            Missing
                   Value       Count     All Obs         Obs

                       .           4        0.56      100.00


                       Histogram                        #             Boxplot
  32.5+*                                                2                0
      .*                                                4                0
      .**                                               8                |
      .*****                                           20                |
      .****************                                61                |
      .************************                        95             +-----+
   2.5+*********************************************   176             *--+--*
      .**************************************         150             |     |
      .***************************                    108             +-----+
      .**************                                  53                |
      .*******                                         27                |
      .***                                             11                0
 -27.5+*                                                1                0
       ----+----+----+----+----+----+----+----+----
```

```
                    Check on normality for  suc

                         The UNIVARIATE Procedure
                       Variable:  Resid  (Residual)

                              Normal Probability Plot
                 32.5+                                                 *
                     |                                                **
                     |                                             ****+
                     |                                         ****+
                     |                                   *******
                     |                             ******
                  2.5+                        *******
                     |                  *******
                     |             ******
                     |        ******
                     |    ******
                     |*****
                -27.5+*
                      +----+----+----+----+----+----+----+----+----+----+
                          -2        -1         0        +1        +2

                     Check equality of stddev for y= suc

                                     rawmean_
Levene
 Obs   Year   Variety   K   Date   nobs       y      stddev_y  stderr_y LeveneF_df   P
 1   2003      1      1     1     30     33.5437     7.1983    1.31423 1.7(23,692) 0.044
 2   2003      1      1     2     30     30.6907    12.9043    2.35599
 3   2003      1      2     1     30     36.8553     8.1613    1.49004                  .
 4   2003      1      2     2     30     28.4430    13.8019    2.51987                  .
 5   2003      2      1     1     30     43.1550    12.9824    2.37025                  .
 6   2003      2      1     2     30     26.8833    11.8188    2.15780                  .
 7   2003      2      2     1     30     44.5643     8.5949    1.56920                  .
 8   2003      2      2     2     30     33.7150     8.9061    1.62602                  .
 9   2004      1      1     1     30     35.7960    12.1271    2.21409                  .
10   2004      1      1     2     30     20.9747     9.5340    1.74066                  .
11   2004      1      2     1     30     38.4760    12.3902    2.26212                  .
12   2004      1      2     2     30     22.4197     9.6222    1.75677                  .
13   2004      2      1     1     30     48.4700     7.2905    1.33106                  .
14   2004      2      1     2     29     26.6028    12.9531    2.40533                  .
15   2004      2      2     1     30     41.7330    11.0925    2.02520                  .
16   2004      2      2     2     30     24.8070    10.2482    1.87106                  .
17   2005      1      1     1     30     33.7223    10.0807    1.84047                  .
18   2005      1      1     2     30     34.1813    11.4383    2.08834                  .
19   2005      1      2     1     28     35.3571     9.4523    1.78631                  .
20   2005      1      2     2     30     37.2310     9.8934    1.80628                  .
21   2005      2      1     1     30     31.9953     9.3555    1.70807                  .
22   2005      2      1     2     30     35.8977     9.8430    1.79708                  .
23   2005      2      2     1     29     29.2390     8.9268    1.65766                  .
24   2005      2      2     2     30     39.2203    10.1088    1.84560                  .

                                 Mixed ANOVA for  total

                                  The Mixed Procedure

                                  Model Information

                     Data Set                     WORK.NKSOL
                     Dependent Variable           Total
                     Covariance Structure         Variance Components
                     Estimation Method            REML
                     Residual Variance Method     Profile
                     Fixed Effects SE Method      Model-Based
                     Degrees of Freedom Method    Containment


                                Class Level Information
```

Class	Levels	Values
Year	3	2003 2004 2005
Rep	6	1 2 3 4 5 6
Variety	2	1 2
K	2	1 2
Date	2	1 2

Dimensions

Covariance Parameters	4
Columns in X	108
Columns in Z	234
Subjects	1
Max Obs Per Subject	720

Number of Observations

Number of Observations Read	720
Number of Observations Used	705
Number of Observations Not Used	15

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	5564.20689485	
1	4	5547.55716104	0.00043582
2	2	5546.84828665	.
3	1	5546.75311387	0.00000050
4	1	5546.75202553	0.00000000

The Mixed Procedure

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Rep(Year)	0.3882	3.0034	0.13	0.4486
Rep*Variety*K(Year)	0	.	.	.
Rep*Var*K*Date(Year)	24.5553	8.1837	3.00	0.0013
Residual	162.28	9.6887	16.75	<.0001

Fit Statistics

-2 Res Log Likelihood	5546.8
AIC (smaller is better)	5552.8
AICC (smaller is better)	5552.8
BIC (smaller is better)	5555.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	15	6.15	0.0112
Variety	1	45	9.57	0.0034
Year*Variety	2	45	2.94	0.0632
K	1	45	0.04	0.8339

Year*K	2	45	0.80	0.4552
Variety*K	1	45	0.38	0.5428
Year*Variety*K	2	45	2.43	0.0994
Date	1	60	27.90	<.0001
Year*Date	2	60	33.89	<.0001
Variety*Date	1	60	0.61	0.4372
Year*Variety*Date	2	60	5.50	0.0064
K*Date	1	60	0.91	0.3427
Year*K*Date	2	60	0.24	0.7845
Variety*K*Date	1	60	3.36	0.0716
Year*Variety*K*Date	2	60	0.13	0.8823

Mean separation for total

---------- Effect=Year Method=LSD(P<.05) Set=1 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
1	2003	_	_	_	43.7259	1.1223	A
2	2004	_	_	_	39.6930	1.1337	B
3	2005	_	_	_	45.0766	1.1234	A

---------- Effect=Variety Method=LSD(P<.05) Set=2 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
4	_	1	_	_	40.8720	0.9068	B
5	_	2	_	_	44.7916	0.9092	A

---------- Effect=Year*Variety Method=LSD(P<.05) Set=3 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
6	2003	1	_	_	40.9083	1.5621	BC
7	2003	2	_	_	46.5436	1.5712	A
8	2004	1	_	_	36.4355	1.5792	C
9	2004	2	_	_	42.9505	1.5868	AB
10	2005	1	_	_	45.2724	1.5703	AB
11	2005	2	_	_	44.8808	1.5661	AB

---------- Effect=K Method=LSD(P<.05) Set=4 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
12	_	_	1	_	42.9654	0.9050	A
13	_	_	2	_	42.6982	0.9109	A

---------- Effect=Year*K Method=LSD(P<.05) Set=5 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
14	2003	_	1	_	43.4351	1.5621	AB
15	2003	_	2	_	44.0168	1.5712	AB
16	2004	_	1	_	40.9530	1.5783	BC
17	2004	_	2	_	38.4329	1.5877	C
18	2005	_	1	_	44.5082	1.5621	AB
19	2005	_	2	_	45.6450	1.5743	A

Mean separation for total

---------- Effect=Variety*K Method=LSD(P<.05) Set=6 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
20	_	1	1	_	40.6171	1.2692	C
21	_	1	2	_	41.1270	1.2787	BC
22	_	2	1	_	45.3138	1.2737	A
23	_	2	2	_	44.2695	1.2810	AB

---------- Effect=Year*Variety*K Method=LSD(P<.05) Set=7 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
24	2003	1	1	_	42.0692	2.1945	ABC
25	2003	1	2	_	39.7473	2.1945	BCD
26	2003	2	1	_	44.8010	2.1945	AB
27	2003	2	2	_	48.2862	2.2204	A
28	2004	1	1	_	35.7615	2.2059	D
29	2004	1	2	_	37.1094	2.2317	CD
30	2004	2	1	_	46.1445	2.2292	A
31	2004	2	2	_	39.7565	2.2301	BCD
32	2005	1	1	_	44.0205	2.1945	AB
33	2005	1	2	_	46.5242	2.2178	A
34	2005	2	1	_	44.9958	2.1945	AB
35	2005	2	2	_	44.7657	2.2059	AB

---------- Effect=Date Method=LSD(P<.05) Set=8 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
36	_	_	_	1	46.1782	0.9083	A
37	_	_	_	2	39.4854	0.9077	B

---------- Effect=Year*Date Method=LSD(P<.05) Set=9 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
38	2003	_	_	1	48.0838	1.5712	A
39	2003	_	_	2	39.3681	1.5621	B
40	2004	_	_	1	48.8694	1.5742	A
41	2004	_	_	2	30.5166	1.5919	C
42	2005	_	_	1	41.5816	1.5743	B
43	2005	_	_	2	48.5716	1.5621	A

Mean separation for total

---------- Effect=Variety*Date Method=LSD(P<.05) Set=10 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
44	_	1	_	1	43.7229	1.2759	B
45	_	1	_	2	38.0211	1.2720	C
46	_	2	_	1	48.6335	1.2764	A
47	_	2	_	2	40.9497	1.2784	BC

---------- Effect=Year*Variety*Date Method=LSD(P<.05) Set=11 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
48	2003	1	_	1	42.5638	2.1945	CD
49	2003	1	_	2	39.2527	2.1945	D
50	2003	2	_	1	53.6037	2.2204	A
51	2003	2	_	2	39.4835	2.1945	D
52	2004	1	_	1	44.5064	2.2173	BCD
53	2004	1	_	2	28.3645	2.2204	E
54	2004	2	_	1	53.2324	2.2059	A
55	2004	2	_	2	32.6686	2.2531	E
56	2005	1	_	1	44.0985	2.2178	CD
57	2005	1	_	2	46.4462	2.1945	BC
58	2005	2	_	1	39.0646	2.2059	D
59	2005	2	_	2	50.6970	2.1945	AB

---------- Effect=K*Date Method=LSD(P<.05) Set=12 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
60	_	_	1	1	46.9178	1.2714	A
61	_	_	1	2	39.0130	1.2715	B
62	_	_	2	1	45.4386	1.2808	A
63	_	_	2	2	39.9578	1.2789	B

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
64	2003	_	1	1	47.9505	2.1945	AB
65	2003	_	1	2	38.9197	2.1945	D
66	2003	_	2	1	48.2170	2.2204	AB
67	2003	_	2	2	39.8165	2.1945	D
68	2004	_	1	1	50.5842	2.2173	A
69	2004	_	1	2	31.3219	2.2178	E

Mean separation for total

---------- Effect=Year*K*Date Method=LSD(P<.05) Set=13 ----------
(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
70	2004	_	2	1	47.1545	2.2059	ABC
71	2004	_	2	2	29.7113	2.2557	E
72	2005	_	1	1	42.2188	2.1945	BCD
73	2005	_	1	2	46.7975	2.1945	ABC
74	2005	_	2	1	40.9443	2.2291	CD
75	2005	_	2	2	50.3457	2.1945	A

---------- Effect=Variety*K*Date Method=LSD(P<.05) Set=14 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
76	_	1	1	1	42.9118	1.7920	BCD
77	_	1	1	2	38.3223	1.7857	DE
78	_	1	2	1	44.5340	1.8047	BC
79	_	1	2	2	37.7199	1.7999	E
80	_	2	1	1	50.9239	1.7920	A
81	_	2	1	2	39.7037	1.7985	CDE
82	_	2	2	1	46.3432	1.8061	AB
83	_	2	2	2	42.1958	1.8053	BCDE

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
84	2003	1	1	1	42.2743	3.0930	CDEF
85	2003	1	1	2	41.8640	3.0930	CDEF
86	2003	1	2	1	42.8533	3.0930	CDEF
87	2003	1	2	2	36.6413	3.0930	DEFG
88	2003	2	1	1	53.6267	3.0930	AB
89	2003	2	1	2	35.9753	3.0930	EFG
90	2003	2	2	1	53.5808	3.1661	AB
91	2003	2	2	2	42.9917	3.0930	CDEF
92	2004	1	1	1	43.3124	3.1254	CDE
93	2004	1	1	2	28.2107	3.0930	G
94	2004	1	2	1	45.7004	3.1254	BC
95	2004	1	2	2	28.5184	3.1661	G
96	2004	2	1	1	57.8560	3.1254	A
97	2004	2	1	2	34.4330	3.1589	FG
98	2004	2	2	1	48.6087	3.0930	BC
99	2004	2	2	2	30.9043	3.1935	G
100	2005	1	1	1	43.1487	3.0930	CDEF
101	2005	1	1	2	44.8923	3.0930	BCD

Mean separation for total

---------- Effect=Year*Variety*K*Date Method=LSD(P<.05) Set=15 ----------
(continued)

Obs	Year	Variety	K	Date	Estimate	Standard Error	Letter Group
102	2005	1	2	1	45.0484	3.1589	BCD
103	2005	1	2	2	48.0000	3.0930	BC
104	2005	2	1	1	41.2890	3.0930	CDEF
105	2005	2	1	2	48.7027	3.0930	BC
106	2005	2	2	1	36.8401	3.1254	DEFG
107	2005	2	2	2	52.6913	3.0930	AB

Check on normality for total

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.991626	Pr < W	0.0005
Kolmogorov-Smirnov	D	0.037184	Pr > D	0.0188
Cramer-von Mises	W-Sq	0.131652	Pr > W-Sq	0.0435
Anderson-Darling	A-Sq	0.876252	Pr > A-Sq	0.0246

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-29.4235	339	35.8050	227
-28.7923	356	39.1990	681
-28.4457	361	40.7465	285
-28.1357	433	45.1715	386
-27.5195	75	47.1713	463

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	15	2.08	100.00

```
                    Histogram                          #             Boxplot
 45+*                                                  3                0
   .*                                                  5                0
   .******                                            29               0
   .********************                              96               |
   .*******************************************      214            +--+--+
   .*********************************************   223            *-----*
   .********************                              99               |
-25+********                                          36               |
    ----+----+----+----+----+----+----+----+----+
    * may represent up to 5 counts
```

```
                    The UNIVARIATE Procedure
                  Variable:  Resid  (Residual)

                         Normal Probability Plot
 45+                                                    *
   |                                                  ***
   |                                           *******++
   |                                    ********
   |                          **********
   |                 **********
   |          ********
-25+**********
    +----+----+----+----+----+----+----+----+----+----+
        -2        -1         0        +1        +2
       Check equality of stddev for y= total
```

rawmean_

Obs	Year	Variety	K	Date	nobs	y	stddev_y	stderr_y	LeveneF_df	Levene P
1	2003	1	1	1	30	42.2743	9.1364	1.66807	1.5(23,681)	.08
2	2003	1	1	2	30	41.8640	17.5874	3.21100		.
3	2003	1	2	1	30	42.8533	9.9417	1.81509		.
4	2003	1	2	2	30	36.6413	17.7014	3.23182		.
5	2003	2	1	1	30	53.6267	16.0565	2.93150		.
6	2003	2	1	2	30	35.9753	16.1272	2.94442		.
7	2003	2	2	1	28	53.7346	10.4531	1.97546		.
8	2003	2	2	2	30	42.9917	12.3756	2.25946		.
9	2004	1	1	1	29	43.3193	13.5272	2.51194		.
10	2004	1	1	2	30	28.2107	12.5463	2.29064		.
11	2004	1	2	1	29	45.8321	15.7649	2.92747		.
12	2004	1	2	2	28	28.4043	12.9862	2.45416		.
13	2004	2	1	1	29	57.8059	9.4559	1.75592		.
14	2004	2	1	2	28	34.2182	16.3260	3.08532		.
15	2004	2	2	1	30	48.6087	13.6125	2.48529		.
16	2004	2	2	2	27	30.8319	13.4102	2.58079		.
17	2005	1	1	1	30	43.1487	13.0977	2.39131		.
18	2005	1	1	2	30	44.8923	15.1172	2.76000		.
19	2005	1	2	1	28	44.9746	12.5635	2.37427		.
20	2005	1	2	2	30	48.0000	12.0347	2.19723		.
21	2005	2	1	1	30	41.2890	12.0000	2.19089		.
22	2005	2	1	2	30	48.7027	13.6419	2.49065		.
23	2005	2	2	1	29	36.9321	10.8712	2.01873		.
24	2005	2	2	2	30	52.6913	13.7624	2.51267		

N&K Standard Curve Data
-Glucose-

Intercept	-0.00313
Net Abs	0.565566

Regression Statistics

Multiple R	0.99853
R Square	0.997062

Concentration mg/ml	Net ABS
0.1	0.16
0.1	0.16
0.25	0.43
0.25	0.43
0.5	0.87

0.5	0.89
0.8	1.29
0.8	1.31

-Fructose-

Intercept	-0.09182
Net Abs	0.868935

Regression Statistics	
Multiple R	0.997946
R Square	0.995896

Concentration mg/ml	Net ABS
0.1	0.22
0.1	0.21
0.5	0.72
0.5	0.68
0.8	1.00
0.8	0.09

-Sucrose-

Intercept	-0.09477
Net Abs	0.690577

Regression Statistics	
Multiple R	0.998684
R Square	0.99737

Concentration mg/ml	Net ABS
0.1	0.28
0.1	0.27
0.5	0.87
0.5	0.89
0.8	1.26
0.8	1.31

N&K Lint yield
SAS Input

Variety 1= PM1218
2= DP555
K 1= 60lbs K_2O/acre/yr
2= 120lbs K_2O/acre/yr
Date 1= Early Bloom
2= Cutout

```
- Lint yield is in lbs/acre
data lint;
input Plot     Year K  Variety V Rep Lintyield;
cards;
102     2003    60      1       1218    1       1267.3
102     2004    60      2       555     1       1846.7
102     2005    60      1       1218    1       1211.86
108     2003    60      2       555     2       1321.9
108     2004    60      1       1218    1       1722.3
108     2005    60      2       555     1       1630.00
109     2003    120     1       1218    2       1498.5
109     2004    120     2       555     1       2167.0
109     2005    120     1       1218    1       1542.18
111     2003    120     2       555     2       1305.2
```

```
111     2004    120     1       1218    1       2018.9
111     2005    120     2       555     1       1644.89
205     2003    60      2       555     1       1447.2
205     2004    60      1       1218    2       1821.0
205     2005    60      2       555     2       1565.69
206     2003    120     1       1218    1       1599.8
206     2004    120     2       555     2       1954.1
206     2005    120     1       1218    2       1461.20
208     2003    120     2       555     4       1185.26
208     2004    120     1       1218    2       1966.4
208     2005    120     2       555     2       1578.47
211     2003    60      1       1218    2       1261.1
211     2004    60      2       555     2       2070.1
211     2005    60      1       1218    2       1358.33
301     2003    60      1       1218    3       1465.2
301     2004    60      2       555     3       2048.5
301     2005    60      1       1218    3       1396.62
303     2003    120     2       555     1       1348.2
303     2004    120     1       1218    3       1918.4
303     2005    120     2       555     3       1565.50
306     2003    120     1       1218    3       1683.6
306     2004    120     2       555     3       2132.0
306     2005    120     1       1218    3       1532.13
311     2003    60      2       555     4       1531.9
311     2004    60      1       1218    3       1768.2
311     2005    60      2       555     3       1634.02
404     2003    60      2       555     3       1552.2
404     2004    60      1       1218    4       1746.5
404     2005    60      2       555     4       1611.80
405     2003    120     2       555     3       1573.8
405     2004    120     1       1218    4       2030.2
405     2005    120     2       555     4       1761.75
407     2003    120     1       1218    4       1610.6
407     2004    120     2       555     4       2167.2
407     2005    120     1       1218    4       1539.86
412     2003    60      1       1218    4       1224.3
412     2004    60      2       555     4       2160.8
412     2005    60      1       1218    4       1461.50
501     2003    120     2       555     5       1469.1
501     2004    120     1       1218    5       1731.5
501     2005    120     2       555     5       1338.05
505     2003    120     1       1218    5       1427.0
505     2004    120     2       555     5       2103.6
505     2005    120     1       1218    5       1457.19
509     2003    60      1       1218    5       1348.5
509     2004    60      2       555     5       1820.8
509     2005    60      1       1218    5       1461.67
512     2003    60      2       555     5       1216.0
512     2004    60      1       1218    5       1782.2
512     2005    60      2       555     5       1584.04
602     2003    120     2       555     6       1297.2
602     2004    120     1       1218    6       1780.3
602     2005    120     2       555     6       1558.04
603     2003    60      1       1218    6       1427.7
603     2004    60      2       555     6       1968.5
603     2005    60      1       1218    6       1482.09
605     2003    120     1       1218    6       1413.4
605     2004    120     2       555     6       2024.1
605     2005    120     1       1218    6       1449.04
606     2003    60      2       555     6       1578.5
606     2004    60      1       1218    6       1718.4
606     2005    60      2       555     6       1445.22
;
%include"c:\danda.sas";
%mmaov(lint, lintyield, Class=Year Rep Variety K, fixed=Year |Variety |K, random=
Rep(Year) Variety*K*Rep(Year)
   );
```

N&K Lint Yield

SAS Output

Mixed ANOVA for lintyield

The Mixed Procedure

Model Information

Data Set	WORK.LINT
Dependent Variable	Lintyield
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Prasad-Rao-Jeske-Kackar-Harville
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
Year	3	2003 2004 2005
Rep	6	1 2 3 4 5 6
Variety	2	1 2
K	2	60 120

Dimensions

Covariance Parameters	3
Columns in X	36
Columns in Z	90
Subjects	1
Max Obs Per Subject	72

Number of Observations

Number of Observations Read	72
Number of Observations Used	72
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	753.72413377	
1	2	752.25136384	0.00000000

Convergence criteria met but final hessian is not positive definite.

Mixed ANOVA for lintyield

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr Z
Rep(Year)	1604.47	1596.78	1.00	0.1575
Rep*Variety*K(Year)	10077	2124.62	4.74	<.0001
Residual	0.9999	0	.	.

Fit Statistics

-2 Res Log Likelihood	752.3
AIC (smaller is better)	758.3
AICC (smaller is better)	758.7
BIC (smaller is better)	760.9

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	15	110.72	<.0001
Variety	1	45	18.08	0.0001
Year*Variety	2	45	8.85	0.0006
K	1	45	11.39	0.0015
Year*K	2	45	1.01	0.3715
Variety*K	1	45	9.29	0.0039
Year*Variety*K	2	45	2.35	0.1070

Mean separation for lintyield

---------- Effect=Year Method=LSD(P<.05) Set=1 ----------

Obs	Year	Variety	K	Estimate	Standard Error	Letter Group
1	2003	_	_	1418.89	26.2169	C
2	2004	_	_	1936.15	26.2169	A
3	2005	_	_	1511.30	26.2169	B

---------- Effect=Variety Method=LSD(P<.05) Set=2 ----------

Obs	Year	Variety	K	Estimate	Standard Error	Letter Group
4	_	1	_	1571.80	19.2115	B
5	_	2	_	1672.43	19.2115	A

---------- Effect=Year*Variety Method=LSD(P<.05) Set=3 ----------

Obs	Year	Variety	K	Estimate	Standard Error	Letter Group
6	2003	1	_	1435.58	33.2752	D
7	2003	2	_	1402.21	33.2752	D
8	2004	1	_	1833.69	33.2752	B
9	2004	2	_	2038.62	33.2752	A
10	2005	1	_	1446.14	33.2752	D
11	2005	2	_	1576.46	33.2752	C

---------- Effect=K Method=LSD(P<.05) Set=4 ----------

Obs	Year	Variety	K	Estimate	Standard Error	Letter Group
12	_	_	60	1582.18	19.2115	B
13	_	_	120	1662.05	19.2115	A

---------- Effect=Year*K Method=LSD(P<.05) Set=5 ----------

Obs	Year	Variety	K	Estimate	Standard Error	Letter Group
14	2003	_	60	1386.82	33.2752	D

15	2003	_	120	1450.97	33.2752	CD
16	2004	_	60	1872.83	33.2752	B
17	2004	_	120	1999.47	33.2752	A
18	2005	_	60	1486.90	33.2752	C
19	2005	_	120	1535.69	33.2752	C

Mean separation for lintyield

---------- Effect=Variety*K Method=LSD(P<.05) Set=6 ----------

Obs	Year	Variety	K	Estimate	Standard Error	Letter Group
20	_	1	60	1495.82	25.4759	B
21	_	1	120	1647.79	25.4759	A
22	_	2	60	1668.55	25.4759	A
23	_	2	120	1676.30	25.4759	A

---------- Effect=Year*Variety*K Method=LSD(P<.05) Set=7 ----------

Obs	Year	Variety	K	Estimate	Standard Error	Letter Group
24	2003	1	60	1332.35	44.1256	G
25	2003	1	120	1538.82	44.1256	DE
26	2003	2	60	1441.28	44.1256	EFG
27	2003	2	120	1363.13	44.1256	G
28	2004	1	60	1759.77	44.1256	C
29	2004	1	120	1907.62	44.1256	B
30	2004	2	60	1985.90	44.1256	AB
31	2004	2	120	2091.33	44.1256	A
32	2005	1	60	1395.34	44.1256	FG
33	2005	1	120	1496.93	44.1256	DEF
34	2005	2	60	1578.46	44.1256	D
35	2005	2	120	1574.45	44.1256	D

Check on normality for lintyield

The UNIVARIATE Procedure
Variable: Resid (Residual)

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.96722	Pr < W	0.0572
Kolmogorov-Smirnov	D	0.076994	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.116202	Pr > W-Sq	0.0704
Anderson-Darling	A-Sq	0.726163	Pr > A-Sq	0.0574

Extreme Observations

-------Lowest------		------Highest------	
Value	Obs	Value	Obs
-0.0214839	51	0.0125890	49
-0.0202773	58	0.0132164	70
-0.0180479	3	0.0138781	47
-0.0164554	19	0.0151197	40
-0.0145158	50	0.0154014	42

```
Stem Leaf                     #             Boxplot
   1 55                       2                |
   1 001334                   6                |
   0 555555556777889999      18             +-----+
   0 011113333444            12             *--+--*
  -0 44443332221111000       17             +-----+
  -0 99765                    5                |
  -1 4433200                  7                |
```

```
-1 865                    3              |
-2 10                     2              0
   ----+----+----+----+
Multiply Stem.Leaf by 10**-2
```

```
                    Normal Probability Plot
 0.0175+                                        ++*++ *
       |                                   +****+*
       |                            **********
       |                       ******+
-0.0025+                 *******
       |             +***++
       |        ++******
       |   ++++* *
-0.0225++*+  *
        +----+----+----+----+----+----+----+----+----+----+
            -2        -1         0        +1        +2
```

Check equality of stddev for y= lintyield

Obs	Year	Variety	K	nobs	rawmean_ y	stddev_y	stderr_y	LeveneF_df	P
1	2003	1	60	6	1332.35	97.964	39.9935	1.28(11,60)	0.2580
2	2003	1	120	6	1538.82	109.263	44.6063		
3	2003	2	60	6	1441.28	144.487	58.9865		.
4	2003	2	120	6	1363.13	137.967	56.3249		.
5	2004	1	60	6	1759.77	39.025	15.9320		.
6	2004	1	120	6	1907.62	125.067	51.0585		.
7	2004	2	60	6	1985.90	133.068	54.3249		.
8	2004	2	120	6	2091.33	85.602	34.9470		.
9	2005	1	60	6	1395.35	101.330	41.3677		.
10	2005	1	120	6	1496.93	45.341	18.5103		.
11	2005	2	60	6	1578.46	70.430	28.7529		.
12	2005	2	120	6	1574.45	138.776	56.6550		.

Appendix E: Ultra Narrow Row- Pix (UNR-Pix) Study SAS data

UNR-Pix
Starch input

```
MPTrt 1= 40inch rows
      2= 20inch rows
      3= 10inch rows
SPTrt 1= No Pix
      2= Application of Pix


Data UNRP959697s;
input Year Rep MPTrt SPTrt Stem starch;
cards;
1995   1      1      1      6      51.54
1995   1      1      4      6      50.12
1995   1      2      4      6      49.99
1995   1      2      1      6      48.69
1995   1      4      4      6      50.70
1995   1      4      1      6      49.63
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1995   2      4      4      6      51.34
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1995   3      1      1      6      50.79
1995   3      4      4      6      50.83
1995   3      4      1      6      51.63
1995   3      2      4      6      50.18
1995   3      2      1      6      47.95
1995   4      1      4      6      16.23
1995   4      1      1      6      51.18
1995   4      4      1      6      48.89
1995   4      4      4      6      45.27
1995   4      2      1      6      45.08
1995   4      2      4      6      51.05
1995   1      1      1      7      32.58
1995   1      1      4      7      49.95
1995   1      2      4      7      33.19
1995   1      2      1      7      41.72
1995   1      4      4      7      50.02
1995   1      4      1      7      48.92
1995   2      4      1      7      50.08
1995   2      4      4      7      51.25
1995   2      1      1      7      50.24
1995   2      1      4      7      30.80
1995   2      2      1      7      50.21
1995   2      2      4      7      50.41
1995   3      1      4      7      25.99
1995   3      1      1      7      50.18
1995   3      4      4      7      51.08
1995   3      4      1      7      51.41
1995   3      2      4      7      38.84
1995   3      2      1      7      50.76
1995   4      1      4      7      17.23
1995   4      1      1      7      45.17
1995   4      4      1      7      49.79
1995   4      4      4      7      49.82
1995   4      2      1      7      47.92
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1995   1      1      4      8      39.88
1995   1      2      4      8      47.66
1995   1      2      1      8      47.44
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1996	1	4	4	7	49.60
1996	1	4	1	7	49.05
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1996	2	4	4	7	50.02
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1996	3	1	1	8	37.81
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1996	3	2	1	8	50.51
1996	4	1	4	8	24.57
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1996	1	4	1	9	43.53
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1996	2	4	4	9	47.31
1996	2	1	1	9	29.64
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1996	3	2	4	9	21.47
1996	3	2	1	9	48.34
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1996	4	1	1	9	33.13
1996	4	4	1	9	36.55
1996	4	4	4	9	39.78
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1996	1	2	4	10	15.72
1996	1	2	1	10	47.24
1996	1	4	4	10	48.08
1996	1	4	1	10	47.44
1996	2	4	1	10	70.89
1996	2	4	4	10	47.05
1996	2	1	1	10	45.92
1996	2	1	4	10	46.66
1996	2	2	1	10	47.08
1996	2	2	4	10	46.98
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1996	3	4	1	10	47.47
1996	3	2	4	10	44.17
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1996	4	1	4	10	40.14
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1996	4	4	1	10	46.34
1996	4	4	4	10	34.48
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1997	1	2	1	6	46.92
1997	1	4	4	6	47.82
1997	1	4	1	6	47.37
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1997	2	4	4	6	48.24
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1997	4	4	4	7	46.79
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1997	4	2	4	7	34.58
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1997	1	4	1	8	48.23
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1997	2	4	4	8	44.35
1997	2	1	4	8	48.84
1997	2	1	1	8	49.65
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1997	2	2	1	8	46.88
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1997	1	2	4	9	48.60
1997	1	2	1	9	47.72
1997	1	4	4	9	49.21
1997	1	4	1	9	48.53
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1997	2	4	4	9	46.91
1997	2	1	4	9	24.37
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1997	2	2	4	9	48.74
1997	2	2	1	9	48.47
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1997	3	1	4	9	18.77
1997	3	4	1	9	47.96
1997	3	4	4	9	48.50

```
1997    3       2       1       9       44.11
1997    3       2       4       9       49.07
1997    4       1       4       9       48.03
1997    4       1       1       9       11.81
1997    4       4       4       9       29.67
1997    4       4       1       9       48.23
1997    4       2       1       9       49.75
1997    4       2       4       9       49.01
1997    1       1       1       10      37.19
1997    1       1       4       10      26.36
1997    1       2       4       10      48.36
1997    1       2       1       10      46.14
1997    1       4       4       10      46.58
1997    1       4       1       10      48.13
1997    2       4       1       10      47.99
1997    2       4       4       10      46.85
1997    2       1       4       10      46.27
1997    2       1       1       10      44.85
1997    2       2       4       10      46.17
1997    2       2       1       10      46.85
1997    3       1       1       10      47.12
1997    3       1       4       10      47.55
1997    3       4       1       10      46.47
1997    3       4       4       10      47.35
1997    3       2       1       10      50.46
1997    3       2       4       10      50.96
1997    4       1       4       10      50.15
1997    4       1       1       10      50.12
1997    4       4       4       10      49.44
1997    4       4       1       10      49.78
1997    4       2       1       10      51.20
1997    4       2       4       10      37.90
;
run;
Proc   glm   data =UNRP9598;
Class  Year Rep MPTrt SPTrt Stem;
Model  Starch=Year Rep(Year) MPTrt Year*MPTrt MPTrt*Rep(Year) SPTrt Year*SPTrt
MPTrt*SPTrt Year*MPTrt*SPTrt;
Test   h=MPTrt e=MPTrt*Rep(Year);
Lsmeans  MPTrt SPTrt MPTrt*SPTrt/ pdiff ;
Run ;
```

UNR Starch
SAS Output

```
                              The Mixed Procedure

                              Model Information

Data Set                     WORK.UNRP9598
Dependent Variable           starch
Covariance Structure         Diagonal
Estimation Method            REML
Residual Variance Method     Profile
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Residual


                           Class Level Information

   Class    Levels    Values

   Year          3    1995 1996 1997
   Rep           4    1 2 3 4
   MPTrt         3    1 2 4
   SPTrt         2    1 4


                              Dimensions
```

Covariance Parameters	1
Columns in X	96
Columns in Z	0
Subjects	1
Max Obs Per Subject	360

Number of Observations

Number of Observations Read	360
Number of Observations Used	358
Number of Observations Not Used	2

Covariance Parameter Estimates

Cov Parm	Estimate
Residual	95.2062

Fit Statistics

-2 Res Log Likelihood	2417.6
AIC (smaller is better)	2419.6
AICC (smaller is better)	2419.7
BIC (smaller is better)	2423.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	313	1.70	0.1837
Rep(Year)	9	313	0.90	0.5243
MPTrt	2	313	7.74	0.0005
Year*MPTrt	4	313	1.42	0.2278
Rep*MPTrt(Year)	18	313	0.74	0.7704
SPTrt	1	313	5.86	0.0161
Year*SPTrt	2	313	1.02	0.3602
MPTrt*SPTrt	2	313	0.87	0.4214
Year*MPTrt*SPTrt	4	313	0.34	0.8527

Least Squares Means

Effect	MPTrt	SPTrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPTrt	1		40.6178	0.8950	313	45.39	<.0001
MPTrt	2		44.2354	0.8950	313	49.43	<.0001
MPTrt	4		45.3810	0.8907	313	50.95	<.0001
SPTrt		1	44.6599	0.7296	313	61.21	<.0001
SPTrt		4	42.1628	0.7296	313	57.79	<.0001
MPTrt*SPTrt	1	1	42.8215	1.2597	313	33.99	<.0001
MPTrt*SPTrt	1	4	38.4140	1.2716	313	30.21	<.0001
MPTrt*SPTrt	2	1	44.9110	1.2716	313	35.32	<.0001
MPTrt*SPTrt	2	4	43.5598	1.2597	313	34.58	<.0001
MPTrt*SPTrt	4	1	46.2473	1.2597	313	36.71	<.0001
MPTrt*SPTrt	4	4	44.5147	1.2597	313	35.34	<.0001

Differences of Least Squares Means

Effect	MPTrt	SPTrt	_MPTrt	_SPTrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPTrt	1		2		-3.6176	1.2657	313	-2.86	0.0045
MPTrt	1		4		-4.7632	1.2627	313	-3.77	0.0002
MPTrt	2		4		-1.1456	1.2627	313	-0.91	0.3650
SPTrt		1		4	2.4971	1.0318	313	2.42	0.0161
MPTrt*SPTrt	1	1	1	4	4.4075	1.7899	313	2.46	0.0143
MPTrt*SPTrt	1	1	2	1	-2.0895	1.7899	313	-1.17	0.2439
MPTrt*SPTrt	1	1	2	4	-0.7383	1.7814	313	-0.41	0.678
MPTrt*SPTrt	1	1	4	1	-3.4258	1.7814	313	-1.92	0.0554
MPTrt*SPTrt	1	1	4	4	-1.6932	1.7814	313	-0.95	0.3426
MPTrt*SPTrt	1	4	2	1	-6.4970	1.7983	313	-3.61	0.0004
MPTrt*SPTrt	1	4	2	4	-5.1458	1.7899	313	-2.87	0.0043
MPTrt*SPTrt	1	4	4	1	-7.8333	1.7899	313	-4.38	<.0001

Differences of Least Squares Means

Effect	MPTrt	SPTrt	MPTrt	SPTrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPTrt*SPTrt	1	4	4	4	-6.1006	1.7899	313	-3.41	0.0007
MPTrt*SPTrt	2	1	2	4	1.3512	1.7899	313	0.75	0.4509
MPTrt*SPTrt	2	1	4	1	-1.3363	1.7899	313	-0.75	0.4559
MPTrt*SPTrt	2	1	4	4	0.3963	1.7899	313	0.22	0.8249
MPTrt*SPTrt	2	4	4	1	-2.6875	1.7814	313	-1.51	0.1324
MPTrt*SPTrt	2	4	4	4	-0.9548	1.7814	313	-0.54	0.5923
MPTrt*SPTrt	4	1	4	4	1.7327	1.7814	313	0.97	0.3315

Glucose Standard Curve

Intercept	-0.00805
Abs	0.538385

Regression Statistics

Multiple R	0.986878
R Square	0.973929

UNR- Pix Soluble Sugar-
Glucose, Fructose, Sucrose and the sum of all three
SAS Input

```
MPTrt 1= 40inch rows
      2= 20inch rows
      3= 10inch rows
SPTrt 1= No Pix
      2= Application of Pix
Sugars are in mg/g dry weight

Data UNR959697;
input Batch    Year Plot  Rep  MPtrt  SPtrt  Glu  Fru Suc TSS;
cards;
1      1995   101    1      1      1      8.37   9.98   25.85  43.87
1      1995   104    1      1      4      6.23   9.83   29.15  46.09
1      1995   105    1      2      4      7.56   8.44   61.61  78.37
1      1995   106    1      2      1      14.37  13.84  39.07  69.28
1      1995   110    1      4      4      8.08   12.60  34.86  56.36
1      1995   112    1      4      1      7.61   12.10  28.25  49.20
1      1995   205    2      4      1      13.37  13.27  44.18  70.99
1      1995   208    2      4      4      8.56   10.62  27.05  46.72
1      1995   210    2      1      1      18.47  15.22  23.74  57.51
1      1995   211    2      1      4      6.84   11.18  9.62   28.10
1      1995   215    2      2      1      13.13  13.90  25.25  53.44
1      1995   216    2      2      4      5.42   8.82   9.32   24.10
```

1	1995	302	3	1	4	11.37	13.24	28.55	53.06
1	1995	303	3	1	1	8.94	12.42	20.14	44.66
1	1995	309	3	4	4	10.51	12.98	17.73	42.73
1	1995	311	3	4	1	22.18	18.03	21.64	62.09
1	1995	315	3	2	4	14.32	11.03	33.96	59.83
1	1995	316	3	2	1	16.09	13.65	30.66	59.48
1	1995	401	4	1	4	9.04	10.90	27.05	48.34
1	1995	404	4	1	1	9.32	12.48	24.95	47.75
1	1995	406	4	4	1	13.23	13.27	.	.
1	1995	407	4	4	4	12.32	11.56	0.00	17.72
1	1995	409	4	2	1	19.23	11.59	12.62	33.61
1	1995	410	4	2	4	7.23	12.48	24.34	44.69
1	1995	101	1	1	1	7.70	11.31	17.13	36.83
1	1995	104	1	1	4	7.75	8.94	20.44	37.34
1	1995	105	1	2	4	9.56	12.19	24.04	47.04
1	1995	106	1	2	1	11.27	11.69	27.05	48.61
1	1995	110	1	4	4	6.08	12.57	32.46	51.45
1	1995	112	1	4	1	8.80	10.65	32.76	53.06
1	1995	205	2	4	1	11.99	14.69	41.18	67.54
1	1995	208	2	4	4	11.56	12.89	30.66	55.39
1	1995	210	2	1	1	9.70	12.86	10.52	33.05
1	1995	211	2	1	4	11.66	13.84	11.72	38.62
1	1995	215	2	2	1	13.04	15.89	33.36	64.62
1	1995	216	2	2	4	7.27	11.25	9.92	30.18
1	1995	302	3	1	4	3.22	10.36	38.17	52.59
1	1995	303	3	1	1	8.32	11.34	32.16	50.58
1	1995	309	3	4	4	3.99	9.67	18.93	33.80
1	1995	311	3	4	1	18.85	17.25	25.25	64.48
1	1995	315	3	2	4	4.65	9.64	.	.
1	1995	316	3	2	1	8.37	10.71	39.37	58.88
1	1995	401	4	1	4	10.27	15.54	10.22	38.20
1	1995	404	4	1	1	8.32	11.75	33.06	54.63
1	1995	406	4	4	1	5.89	10.39	51.09	70.64
1	1995	407	4	4	4	5.75	11.63	40.27	59.89
1	1995	409	4	2	1	4.08	10.84	36.97	54.86
1	1995	410	4	2	4	10.56	13.20	45.08	68.51
2	1995	101	1	1	1	18.18	16.30	39.37	74.73
2	1995	104	1	1	4	9.70	14.25	.	.
2	1995	105	1	2	4	6.84	12.16	3.01	22.75
2	1995	106	1	2	1	11.04	12.89	8.42	33.01
2	1995	110	1	4	4	13.51	11.91	32.76	57.83
2	1995	112	1	4	1	12.37	11.85	34.56	58.14
2	1995	205	2	4	1	11.94	13.99	21.34	47.54
2	1995	208	2	4	4	9.46	11.75	28.85	50.85
2	1995	210	2	1	1	6.75	9.51	20.14	36.02
2	1995	211	2	1	4	9.99	14.44	20.74	45.57
2	1995	215	2	2	1	13.51	14.85	27.35	56.64
2	1995	216	2	2	4	8.46	13.65	6.91	28.86
2	1995	302	3	1	4	7.51	10.39	24.04	43.24
2	1995	303	3	1	1	10.32	12.95	32.46	57.23
2	1995	309	3	4	4	15.85	19.46	40.27	74.27
2	1995	311	3	4	1	13.27	15.98	23.44	53.96
2	1995	315	3	2	4	8.99	14.85	18.63	43.33
2	1995	316	3	2	1	12.04	15.10	22.54	49.08
2	1995	401	4	1	4	6.75	12.32	.	.
2	1995	404	4	1	1	16.56	16.68	18.93	53.39
2	1995	406	4	4	1	13.94	16.27	29.15	60.67
2	1995	407	4	4	4	13.75	11.97	28.85	54.39
2	1995	409	4	2	1	4.89	9.26	11.12	25.60
2	1995	410	4	2	4	13.18	12.89	31.56	58.70
2	1995	101	1	1	1	6.13	7.08	70.33	83.49
2	1995	104	1	1	4	6.56	7.90	33.06	47.88
2	1995	105	1	2	4	5.56	8.82	30.06	44.57
2	1995	106	1	2	1	12.51	12.64	73.33	98.51
2	1995	110	1	4	4	5.84	8.66	18.93	33.41
2	1995	112	1	4	1	21.28	12.57	141.26	178.13
2	1995	205	2	4	1	11.80	8.69	70.33	90.39
2	1995	208	2	4	4	7.89	7.33	62.81	78.71
2	1995	210	2	1	1	9.32	11.53	55.60	75.79

2	1995	211	2	1	4	5.89	9.95	26.45	43.36
2	1995	215	2	2	1	7.89	12.45	7.51	29.42
2	1995	216	2	2	4	12.42	10.84	57.71	80.36
2	1995	302	3	1	4	7.61	10.93	40.87	59.84
2	1995	303	3	1	1	13.04	17.78	35.77	67.39
2	1995	309	3	4	4	3.89	10.84	27.05	43.40
2	1995	311	3	4	1	15.23	15.41	27.65	58.72
2	1995	315	3	2	4	7.80	9.32	23.74	41.50
2	1995	316	3	2	1	7.65	10.65	14.73	33.77
2	1995	401	4	1	4	9.70	12.73	14.43	38.36
2	1995	404	4	1	1	12.89	15.38	9.92	40.96
2	1995	406	4	4	1	15.80	17.15	50.79	86.03
2	1995	407	4	4	4	7.37	11.59	22.84	43.73
2	1995	409	4	2	1	15.23	17.66	54.10	88.51
2	1995	410	4	2	4	6.13	11.56	32.16	52.19
3	1995	101	1	1	1	12.94	17.59	41.18	71.30
3	1995	104	1	1	4	9.85	12.98	14.73	38.03
3	1995	105	1	2	4	7.99	12.32	24.95	45.66
3	1995	106	1	2	1	5.75	9.07	9.92	24.85
3	1995	110	1	4	4	6.99	10.36	30.96	46.73
3	1995	112	1	4	1	14.18	14.72	41.18	70.72
3	1995	205	2	4	1	9.85	12.51	21.94	43.96
3	1995	208	2	4	4	8.46	10.71	33.96	53.97
3	1995	210	2	1	1	3.56	9.04	14.73	27.75
3	1995	211	2	1	4	9.08	10.58	48.39	69.01
3	1995	215	2	2	1	8.18	11.63	15.93	36.26
3	1995	216	2	2	4	8.56	11.06	4.51	23.67
3	1995	302	3	1	4	6.46	10.05	45.98	63.59
3	1995	303	3	1	1	8.18	12.19	18.33	40.25
3	1995	309	3	4	4	5.99	11.09	18.93	36.84
3	1995	311	3	4	1	18.75	17.47	49.59	85.86
3	1995	315	3	2	4	9.61	10.77	23.74	45.53
3	1995	316	3	2	1	16.32	12.95	9.92	38.41
3	1995	401	4	1	4	18.56	13.24	17.73	48.39
3	1995	404	4	1	1	9.08	11.56	2.70	24.21
3	1995	406	4	4	1	6.51	12.89	18.93	41.41
3	1995	407	4	4	4	12.08	8.85	9.32	28.51
3	1995	409	4	2	1	13.51	13.39	24.95	51.19
3	1995	410	4	2	4	9.27	11.75	25.55	45.93
3	1996	101	1	1	1	4.51	8.88	31.56	45.28
3	1996	104	1	1	4	4.80	8.69	13.52	27.18
3	1996	105	1	2	4	6.46	8.75	9.92	25.99
3	1996	106	1	2	1	7.99	10.62	.	.
3	1996	110	1	4	4	5.13	7.68	12.32	26.13
3	1996	112	1	4	1	5.75	5.69	22.84	33.90
3	1996	205	2	4	1	6.65	8.34	15.03	30.05
3	1996	208	2	4	4	5.46	7.46	25.85	39.10
3	1996	210	2	1	1	4.22	9.07	14.43	28.55
3	1996	211	2	1	4	4.32	8.37	4.81	18.03
3	1996	215	2	2	1	4.22	7.96	11.42	23.58
3	1996	216	2	2	4	4.89	8.22	7.51	21.10
3	1996	302	3	1	4	5.32	8.41	19.84	33.56
3	1996	303	3	1	1	5.08	8.44	7.21	20.92
3	1996	309	3	4	4	4.65	7.77	11.12	23.62
3	1996	311	3	4	1	3.80	8.91	9.02	23.03
3	1996	315	3	2	4	4.65	8.25	14.43	27.64
3	1996	316	3	2	1	5.18	9.67	10.22	25.37
3	1996	401	4	1	4	6.56	10.30	12.02	28.93
3	1996	404	4	1	1	4.18	8.72	18.63	32.06
3	1996	406	4	4	1	5.08	7.46	29.45	42.68
3	1996	407	4	4	4	4.65	7.62	13.52	26.22
3	1996	409	4	2	1	3.51	8.97	17.13	30.71
3	1996	410	4	2	4	4.32	10.36	4.81	19.97
4	1996	101	1	1	1	7.51	10.52	15.03	33.13
4	1996	104	1	1	4	9.04	12.67	16.23	37.72
4	1996	105	1	2	4	3.75	9.89	10.82	25.31
4	1996	106	1	2	1	6.32	10.02	16.23	33.40
4	1996	110	1	4	4	5.51	8.18	16.53	30.34
4	1996	112	1	4	1	9.08	10.27	19.24	38.68

4	1996	205	2	4	1	6.70	9.48	16.23	32.84
4	1996	208	2	4	4	6.27	8.25	9.62	24.21
4	1996	210	2	1	1	4.18	8.66	13.52	26.67
4	1996	211	2	1	4	4.80	9.54	13.22	27.85
4	1996	215	2	2	1	4.51	8.50	15.63	29.19
4	1996	216	2	2	4	5.65	8.41	9.92	22.02
4	1996	302	3	1	4	7.23	11.78	.	.
4	1996	303	3	1	1	6.46	10.68	2.70	20.01
4	1996	309	3	4	4	4.51	8.75	6.61	20.07
4	1996	311	3	4	1	5.51	8.03	15.33	29.03
4	1996	315	3	2	4	4.99	10.27	9.62	24.85
4	1996	316	3	2	1	2.22	8.50	11.42	24.69
4	1996	401	4	1	4	4.70	9.70	8.72	23.21
4	1996	404	4	1	1	4.80	7.93	12.92	26.20
4	1996	406	4	4	1	6.23	9.70	0.90	17.42
4	1996	407	4	4	4	3.51	7.11	3.91	14.53
4	1996	409	4	2	1	6.32	9.86	6.61	22.96
4	1996	410	4	2	4	6.37	10.08	9.02	25.25
4	1996	101	1	1	1	5.37	8.22	6.31	18.13
4	1996	104	1	1	4	7.13	10.27	11.12	28.26
4	1996	105	1	2	4	5.75	9.23	10.82	26.44
4	1996	106	1	2	1	5.37	9.35	13.22	28.97
4	1996	110	1	4	4	8.18	8.66	3.61	19.87
4	1996	112	1	4	1	4.61	7.52	12.62	25.39
4	1996	205	2	4	1	8.23	9.92	9.92	27.76
4	1996	208	2	4	4	7.32	9.13	10.82	27.53
4	1996	210	2	1	1	5.94	9.01	18.93	33.24
4	1996	211	2	1	4	6.13	8.28	15.63	30.13
4	1996	215	2	2	1	4.75	7.08	26.45	38.63
4	1996	216	2	2	4	4.22	8.25	15.93	28.78
4	1996	302	3	1	4	5.89	8.94	.	.
4	1996	303	3	1	1	5.03	8.78	.	.
4	1996	309	3	4	4	4.65	7.93	12.02	24.85
4	1996	311	3	4	1	6.42	7.30	36.67	51.00
4	1996	315	3	2	4	4.99	9.04	10.52	25.09
4	1996	316	3	2	1	3.03	9.23	8.11	21.61
4	1996	401	4	1	4	3.41	9.35	1.50	15.01
4	1996	404	4	1	1	3.99	9.16	12.62	26.56
4	1996	406	4	4	1	5.56	10.87	.	.
4	1996	407	4	4	4	5.61	10.43	.	.
4	1996	409	4	2	1	9.37	11.66	1.20	21.73
4	1996	410	4	2	4	9.23	12.32	11.12	32.50
5	1996	101	1	1	1	7.80	9.70	21.34	38.60
5	1996	104	1	1	4	7.13	8.72	13.83	30.08
5	1996	105	1	2	4	7.70	10.05	22.24	40.49
5	1996	106	1	2	1	6.18	9.35	21.94	37.95
5	1996	110	1	4	4	6.08	7.81	39.07	53.03
5	1996	112	1	4	1	6.99	9.29	26.75	44.74
5	1996	205	2	4	1	3.18	7.17	15.33	25.65
5	1996	208	2	4	4	3.89	7.71	18.63	30.38
5	1996	210	2	1	1	6.13	9.23	16.53	31.93
5	1996	211	2	1	4	4.70	8.88	17.13	31.88
5	1996	215	2	2	1	8.61	8.44	22.54	39.92
5	1996	216	2	2	4	4.51	8.85	11.42	25.11
5	1996	302	3	1	4	6.32	9.32	21.34	36.72
5	1996	303	3	1	1	7.70	10.52	18.93	37.40
5	1996	309	3	4	4	8.84	4.74	16.53	27.95
5	1996	311	3	4	1	5.27	7.96	17.73	31.28
5	1996	315	3	2	4	4.75	8.82	15.63	29.72
5	1996	316	3	2	1	3.65	8.09	18.63	31.52
5	1996	401	4	1	4	3.80	8.72	12.62	25.66
5	1996	404	4	1	1	6.08	8.94	16.83	32.19
5	1996	406	4	4	1	4.18	8.44	26.45	39.56
5	1996	407	4	4	4	3.89	7.96	22.24	34.17
5	1996	409	4	2	1	7.46	8.94	17.13	32.23
5	1996	410	4	2	4	3.51	8.03	9.02	21.05
5	1996	101	1	1	1	8.65	10.58	21.64	41.35
5	1996	104	1	1	4	6.94	9.07	18.03	34.14
5	1996	105	1	2	4	5.13	9.26	11.12	25.13

5	1996	106	1	2	1	7.37	9.48	25.55	43.20
5	1996	110	1	4	4	3.89	8.03	24.65	36.97
5	1996	112	1	4	1	11.56	10.08	33.36	55.45
5	1996	205	2	4	1	10.04	10.52	37.27	58.21
5	1996	208	2	4	4	5.13	7.30	22.54	35.02
5	1996	210	2	1	1	4.84	10.30	12.32	28.30
5	1996	211	2	1	4	4.03	8.03	15.63	28.02
5	1996	215	2	2	1	7.70	8.59	26.15	42.49
5	1996	216	2	2	4	7.03	9.01	21.34	37.36
5	1996	302	3	1	4	5.70	10.62	26.15	45.18
5	1996	303	3	1	1	5.94	9.67	18.33	33.56
5	1996	309	3	4	4	5.94	8.53	16.23	31.39
5	1996	311	3	4	1	4.37	7.52	14.73	26.78
5	1996	315	3	2	4	7.61	10.21	13.83	31.30
5	1996	316	3	2	1	4.99	8.97	11.42	25.12
5	1996	401	4	1	4	4.46	8.85	9.62	23.00
5	1996	404	4	1	1	4.94	9.38	17.13	31.81
5	1996	406	4	4	1	5.18	8.31	27.95	41.51
5	1996	407	4	4	4	7.32	10.36	29.15	48.89
5	1996	409	4	2	1	4.89	8.94	29.75	44.40
5	1996	410	4	2	4	8.27	11.18	16.23	37.09
6	1997	101	1	1	1	3.70	8.09	9.32	21.04
6	1997	104	1	1	4	7.37	8.31	11.72	27.35
6	1997	105	1	2	4	4.32	9.10	9.02	22.01
6	1997	108	1	2	1	4.41	6.67	8.42	19.74
6	1997	110	1	4	4	5.75	7.55	20.14	33.20
6	1997	111	1	4	1	5.70	9.26	17.73	32.74
6	1997	206	2	4	1	5.13	6.67	14.43	25.15
6	1997	208	2	4	4	4.80	6.64	11.72	23.11
6	1997	209	2	1	4	5.56	8.31	9.62	23.25
6	1997	211	2	1	1	4.32	7.68	12.32	25.54
6	1997	214	2	2	4	5.80	7.33	17.73	31.19
6	1997	215	2	2	1	5.42	7.30	24.04	37.00
6	1997	302	3	1	1	5.42	6.29	13.52	24.71
6	1997	303	3	1	4	5.51	7.52	15.03	28.77
6	1997	309	3	4	1	7.42	7.02	29.15	44.01
6	1997	311	3	4	4	4.94	4.81	16.83	27.46
6	1997	313	3	2	1	8.84	8.59	49.89	68.05
6	1997	315	3	2	4	7.65	7.74	27.95	43.97
6	1997	402	4	1	4	6.13	5.72	31.26	43.11
6	1997	404	4	1	1	5.89	6.89	26.15	39.52
6	1997	405	4	4	4	4.65	6.26	34.56	45.71
6	1997	408	4	4	1	7.51	6.35	38.47	52.57
6	1997	410	4	2	1	7.18	6.48	28.85	42.27
6	1997	412	4	2	4	4.51	6.32	24.95	35.56
6	1997	101	1	1	1	6.08	6.95	27.05	39.75
6	1997	104	1	1	4	4.80	6.70	11.72	23.12
6	1997	105	1	2	4	4.51	6.54	24.65	36.13
6	1997	108	1	2	1	5.70	6.64	22.54	35.12
6	1997	110	1	4	4	4.61	5.50	29.75	39.67
6	1997	111	1	4	1	4.75	5.28	26.75	36.21
6	1997	206	2	4	1	5.80	5.41	28.85	39.94
6	1997	208	2	4	4	5.61	6.51	24.95	37.23
6	1997	209	2	1	4	3.89	6.29	13.83	24.15
6	1997	211	2	1	1	7.56	8.28	26.15	42.06
6	1997	214	2	2	4	5.56	7.14	30.06	42.99
6	1997	215	2	2	1	6.37	7.21	29.75	43.73
6	1997	302	3	1	1	5.13	6.10	34.56	46.01
6	1997	303	3	1	4	4.41	6.10	19.84	30.52
6	1997	309	3	4	1	6.99	5.34	40.87	53.66
6	1997	311	3	4	4	4.94	5.79	29.45	40.32
6	1997	313	3	2	1	5.75	6.92	31.56	45.06
6	1997	315	3	2	4	5.46	7.21	72.13	84.63
6	1997	402	4	1	4	5.89	6.73	31.26	44.33
6	1997	404	4	1	1	7.61	8.53	33.66	50.70
6	1997	405	4	4	4	5.27	6.45	39.67	51.73
6	1997	408	4	4	1	6.03	7.84	26.15	40.61
6	1997	410	4	2	1	10.08	7.93	55.00	72.09
6	1997	412	4	2	4	6.65	4.52	16.83	28.13

7	1997	101	1	1	1	9.03	10.92	57.89	77.87
7	1997	104	1	1	4	7.06	10.78	50.92	69.04
7	1997	105	1	2	4	6.78	9.64	51.96	68.15
7	1997	108	1	2	1	8.92	11.30	56.99	77.74
7	1997	110	1	4	4	5.99	10.36	43.33	59.86
7	1997	111	1	4	1	4.92	9.01	52.16	65.87
7	1997	206	2	4	1	6.50	9.53	56.79	73.13
7	1997	208	2	4	4	9.14	9.98	62.45	81.91
7	1997	209	2	1	4	6.38	9.67	44.99	61.30
7	1997	211	2	1	1	6.22	9.71	51.41	67.75
7	1997	214	2	2	4	4.98	8.70	48.02	61.62
7	1997	215	2	2	1	4.87	8.49	50.16	63.30
7	1997	302	3	1	1	8.92	10.02	62.58	81.24
7	1997	303	3	1	4	3.40	9.15	31.33	44.05
7	1997	309	3	4	1	5.15	8.39	54.99	68.70
7	1997	311	3	4	4	6.72	9.22	55.75	72.20
7	1997	313	3	2	1	7.17	9.19	47.96	64.54
7	1997	315	3	2	4	6.05	9.29	47.68	63.41
7	1997	402	4	1	4	5.82	9.29	46.44	61.80
7	1997	404	4	1	1	5.65	9.29	65.76	81.46
7	1997	405	4	4	4	7.23	9.36	74.45	92.28
7	1997	408	4	4	1	11.11	12.24	48.85	70.90
7	1997	410	4	2	1	5.82	10.54	46.78	62.86
7	1997	412	4	2	4	5.54	10.54	38.92	54.80
7	1997	101	1	1	1	6.67	9.81	52.16	68.44
7	1997	104	1	1	4	5.43	9.50	41.47	55.83
7	1997	105	1	2	4	3.85	8.46	41.95	54.46
7	1997	108	1	2	1	3.46	8.60	46.58	58.35
7	1997	110	1	4	4	5.77	8.60	63.62	78.15
7	1997	111	1	4	1	4.92	8.94	53.54	67.75
7	1997	206	2	4	1	4.92	8.53	44.71	58.58
7	1997	208	2	4	4	3.63	8.42	50.78	62.84
7	1997	209	2	1	4	4.64	8.87	44.51	58.47
7	1997	211	2	1	1	4.75	8.98	60.03	73.85
7	1997	214	2	2	4	4.30	9.08	46.02	59.49
7	1997	215	2	2	1	6.38	9.39	35.67	51.14
7	1997	302	3	1	1	6.50	9.19	90.46	106.99
7	1997	303	3	1	4	3.80	8.70	39.12	51.28
7	1997	309	3	4	1	3.97	7.56	58.31	69.77
7	1997	311	3	4	4	5.48	8.74	61.89	76.34
7	1997	313	3	2	1	3.46	8.22	51.47	65.60
7	1997	315	3	2	4	1.38	7.90	34.29	45.29
7	1997	402	4	1	4	2.17	8.80	40.78	53.80
7	1997	404	4	1	1	4.81	9.98	44.99	60.46
7	1997	405	4	4	4	4.36	9.05	47.27	62.28
7	1997	408	4	4	1	3.80	8.18	46.71	59.76
7	1997	410	4	2	1	7.12	9.78	43.95	61.83
7	1997	412	4	2	4	3.80	8.15	54.79	66.84
8	1997	101	1	1	1	4.91	9.60	7.59	22.78
8	1997	104	1	1	4	6.37	11.47	20.63	38.59
8	1997	105	1	2	4	3.90	11.34	10.35	25.42
8	1997	108	1	2	1	7.67	10.82	37.47	56.65
8	1997	110	1	4	4	2.66	8.56	24.43	35.31
8	1997	111	1	4	1	5.08	9.88	24.63	39.90
8	1997	206	2	4	1	5.98	10.05	37.12	52.71
8	1997	208	2	4	4	5.42	6.10	31.05	41.98
8	1997	209	2	1	4	5.08	11.06	11.25	27.13
8	1997	211	2	1	1	4.63	8.60	24.98	38.37
8	1997	214	2	2	4	4.18	9.84	32.22	45.88
8	1997	215	2	2	1	4.46	9.46	28.57	42.15
8	1997	302	3	1	1	7.27	11.58	22.84	41.64
8	1997	303	3	1	4	4.07	12.62	21.25	37.94
8	1997	309	3	4	1	6.21	9.53	35.05	51.47
8	1997	311	3	4	4	6.94	11.09	33.81	52.51
8	1997	313	3	2	1	9.19	12.13	34.22	56.02
8	1997	315	3	2	4	4.01	9.22	19.18	32.98
8	1997	402	4	1	4	6.54	12.13	24.91	43.47
8	1997	404	4	1	1	4.29	10.23	31.88	47.07
8	1997	405	4	4	4	2.72	13.42	12.70	28.94

```
8       1997    408     4       4       1       5.87    10.40   30.02   46.40
8       1997    410     4       2       1       5.08    10.36   30.50   46.14
8       1997    412     4       2       4       6.21    9.88    38.64   54.92

;
Proc mixed data=UNR959697;
Class Year Rep MPTrt SPTrt;
Model Glu= Year Rep(Year) MPTrt Year*MPTrt MPTrt*Rep(Year) SPTrt Year*SPTrt MPTrt*SPTrt
Year*MPTrt*SPTrt;
Lsmeans  MPTrt SPTrt MPTrt*SPTrt/pdiff;
Run;
Proc mixed data=UNR959697;
Class Year Rep MPTrt SPTrt;
Model Fru= Year Rep(Year) MPTrt Year*MPTrt MPTrt*Rep(Year) SPTrt Year*SPTrt MPTrt*SPTrt
Year*MPTrt*SPTrt;
Lsmeans MPTrt SPTrt MPTrt*SPTrt/pdiff;
Proc mixed data=UNR959697;
Class Year Rep MPTrt SPTrt;
Model Suc= Year Rep(Year) MPTrt Year*MPTrt MPTrt*Rep(Year) SPTrt Year*SPTrt MPTrt*SPTrt
Year*MPTrt*SPTrt;
Lsmeans  MPTrt SPTrt MPTrt*SPTrt/pdiff;
Run;
Proc mixed data=UNR959697;
Class Year Rep MPTrt SPTrt;
Model TSS= Year Rep(Year) MPTrt Year*MPTrt MPTrt*Rep(Year) SPTrt Year*SPTrt MPTrt*SPTrt
Year*MPTrt*SPTrt;
Lsmeans MPTrt SPTrt MPTrt*SPTrt/pdiff;
Run;
```

UNR-Pix Soluble Sugar

SAS Output

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                    Model Information

Data Set                     WORK.UNR959697
Dependent Variable           Glu
Covariance Structure         Diagonal
Estimation Method            REML
Residual Variance Method     Profile
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Residual


                Class Level Information

   Class    Levels    Values

   Year          3    1995 1996 1997
   Rep           4    1 2 3 4
   MPtrt         3    1 2 4
   SPtrt         2    1 4


                     Dimensions

          Covariance Parameters            1
          Columns in X                    96
          Columns in Z                     0
          Subjects                         1
          Max Obs Per Subject            360


                Number of Observations

      Number of Observations Read            360
      Number of Observations Used            360
      Number of Observations Not Used          0


                Covariance Parameter
                      Estimates
```

Cov Parm	Estimate
Residual	6.2067

Fit Statistics

-2 Res Log Likelihood	1572.6
AIC (smaller is better)	1574.6
AICC (smaller is better)	1574.6
BIC (smaller is better)	1578.4

The Mixed Procedure

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	315	131.99	<.0001
Rep(Year)	9	315	1.07	0.3856
MPtrt	2	315	1.94	0.1461
Year*MPtrt	4	315	1.30	0.2694
Rep*MPtrt(Year)	18	315	0.97	0.4955
SPtrt	1	315	27.20	<.0001
Year*SPtrt	2	315	9.70	<.0001
MPtrt*SPtrt	2	315	1.47	0.2324
Year*MPtrt*SPtrt	4	315	1.18	0.3180

Least Squares Means

Effect	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt	1		6.9131	0.2274	315	30.40	<.0001
MPtrt	2		7.1141	0.2274	315	31.28	<.0001
MPtrt	4		7.5332	0.2274	315	33.12	<.0001
SPtrt		1	7.8716	0.1857	315	42.39	<.0001
SPtrt		4	6.5020	0.1857	315	35.01	<.0001
MPtrt*SPtrt	1	1	7.3133	0.3216	315	22.74	<.0001
MPtrt*SPtrt	1	4	6.5128	0.3216	315	20.25	<.0001
MPtrt*SPtrt	2	1	7.8182	0.3216	315	24.31	<.0001
MPtrt*SPtrt	2	4	6.4100	0.3216	315	19.93	<.0001
MPtrt*SPtrt	4	1	8.4832	0.3216	315	26.38	<.0001
MPtrt*SPtrt	4	4	6.5832	0.3216	315	20.47	<.0001

Differences of Least Squares Means

Effect	MPtrt	SPtrt	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr>|t|
MPtrt	1		2		-0.2010	0.3216	315	-0.62	0.5325
MPtrt	1		4		-0.6201	0.3216	315	-1.93	0.0548
MPtrt	2		4		-0.4191	0.3216	315	-1.30	0.1935
SPtrt		1	4		1.3696	0.2626	315	5.22	<.0001
MPtrt*SPtrt	1	1	1	4	0.8005	0.4549	315	1.76	0.0794
MPtrt*SPtrt	1	1	2	1	-0.5048	0.4549	315	- 1.11	0.2679
MPtrt*SPtrt	1	1	2	4	0.9033	0.4549	315	1.99	0.0479
MPtrt*SPtrt	1	1	4	1	-1.1698	0.4549	315	- 2.57	0.0106
MPtrt*SPtrt	1	1	4	4	0.7302	0.4549	315	1.61	0.1094
MPtrt*SPtrt	1	4	2	1	-1.3053	0.4549	315	- 2.80	0.0044
MPtrt*SPtrt	1	4	2	4	0.1028	0.4549	315	0.23	0.8213
MPtrt*SPtrt	1	4	4	1	-1.9703	0.4549	315	- 4.33	<.0001

The Mixed Procedure

Differences of Least Squares Means

Effect	MPtrt	SPtrt	_MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt*SPtrt	1	4	4	4	-0.07033	0.4549	315	-0.15	0.8772
MPtrt*SPtrt	2	1	2	4	1.4082	0.4549	315	3.10	0.0021
MPtrt*SPtrt	2	1	4	1	-0.6650	0.4549	315	-1.46	0.1447
MPtrt*SPtrt	2	1	4	4	1.2350	0.4549	315	2.72	0.0070
MPtrt*SPtrt	2	4	4	1	-2.0732	0.4549	315	-4.56	<.0001
MPtrt*SPtrt	2	4	4	4	-0.1732	0.4549	315	-0.38	0.7037
MPtrt*SPtrt	4	1	4	4	1.9000	0.4549	315	4.18	<.0001

The Mixed Procedure
Model Information

Data Set	WORK.UNR959697
Dependent Variable	Fru
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Class Level Information

Class	Levels	Values
Year	3	1995 1996 1997
Rep	4	1 2 3 4
MPtrt	3	1 2 4
SPtrt	2	1 4

Dimensions

Covariance Parameters	1
Columns in X	96
Columns in Z	0
Subjects	1
Max Obs Per Subject	360

Number of Observations

Number of Observations Read	360
Number of Observations Used	360
Number of Observations Not Used	0

Covariance Parameter
Estimates

Cov Parm	Estimate
Residual	3.2259

Fit Statistics

-2 Res Log Likelihood	1366.5
AIC (smaller is better)	1368.5
AICC (smaller is better)	1368.5
BIC (smaller is better)	1372.2

The Mixed Procedure

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	315	157.69	<.0001
Rep(Year)	9	315	1.80	0.0674
MPtrt	2	315	1.47	0.2309
Year*MPtrt	4	315	2.64	0.0341
Rep*MPtrt(Year)	18	315	1.31	0.1798
SPtrt	1	315	10.83	0.0011
Year*SPtrt	2	315	7.41	0.0007
MPtrt*SPtrt	2	315	1.50	0.2240
Year*MPtrt*SPtrt	4	315	0.54	0.7037

Least Squares Means

Effect	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt	1		10.1490	0.1640	315	61.90	<.0001
MPtrt	2		9.9696	0.1640	315	60.81	<.0001
MPtrt	4		9.7517	0.1640	315	59.48	<.0001
SPtrt		1	10.2683	0.1339	315	76.70	<.0001
SPtrt		4	9.6452	0.1339	315	72.05	<.0001
MPtrt*SPtrt	1	1	10.3010	0.2319	315	44.43	<.0001
MPtrt*SPtrt	1	4	9.9970	0.2319	315	43.11	<.0001
MPtrt*SPtrt	2	1	10.2148	0.2319	315	44.05	<.0001
MPtrt*SPtrt	2	4	9.7243	0.2319	315	41.94	<.0001
MPtrt*SPtrt	4	1	10.2890	0.2319	315	44.37	<.0001
MPtrt*SPtrt	4		9.2143	0.2319	315	39.74	<.0001

Differences of Least Squares Means

Effect	MPtrt	SPtrt	_MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt	1		2		0.1794	0.2319	315	0.77	0.4396
MPtrt	1		4		0.3973	0.2319	315	1.71	0.0876
MPtrt	2		4		0.2179	0.2319	315	0.94	0.3480
SPtrt		1		4	0.6231	0.1893	315	3.29	0.0011
MPtrt*SPtrt	1	1	1	4	0.3040	0.3279	315	0.93	0.3546
MPtrt*SPtrt	1	1	2	1	0.08617	0.3279	315	0.26	0.7929
MPtrt*SPtrt	1	1	2	4	0.5767	0.3279	315	1.76	0.0796
MPtrt*SPtrt	1	1	4	1	0.01200	0.3279	315	0.04	0.9708
MPtrt*SPtrt	1	1	4	4	1.0867	0.3279	315	3.31	0.0010
MPtrt*SPtrt	1	4	2	1	-0.2178	0.3279	315	-0.66	0.5070
MPtrt*SPtrt	1	4	2	4	0.2727	0.3279	315	0.83	0.4063
MPtrt*SPtrt	1	4	4	1	-0.2920	0.3279	315	-0.89	0.3739

The Mixed Procedure

Differences of Least Squares Means

Effect	MPtrt	SPtrt	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt*SPtrt	1	4	4	4	0.7827	0.3279	315	2.39	0.0176
MPtrt*SPtrt	2	1	2	4	0.4905	0.3279	315	1.50	0.1357
MPtrt*SPtrt	2	1	4	1	-0.07417	0.3279	315	-0.23	0.8212
MPtrt*SPtrt	2	1	4	4	1.0005	0.3279	315	3.05	0.0025
MPtrt*SPtrt	2	4	4	1	-0.5647	0.3279	315	-1.72	0.0861
MPtrt*SPtrt	2	4	4	4	0.5100	0.3279	315	1.56	0.1209
MPtrt*SPtrt	4	1	4	4	1.0747	0.3279	315	3.28	0.0012

Model Information

Data Set	WORK.UNR959697
Dependent Variable	Suc
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Class Level Information

Class	Levels	Values
Year	3	1995 1996 1997
Rep	4	1 2 3 4
MPtrt	3	1 2 4
SPtrt	2	1 4

Dimensions

Covariance Parameters	1
Columns in X	96
Columns in Z	0
Subjects	1
Max Obs Per Subject	360

Number of Observations

Number of Observations Read	360
Number of Observations Used	350
Number of Observations Not Used	10

Covariance Parameter Estimates

Cov Parm	Estimate
Residual	215.53

Fit Statistics

-2 Res Log Likelihood	2606.6
AIC (smaller is better)	2608.6
AICC (smaller is better)	2608.6
BIC (smaller is better)	2612.3

The Mixed Procedure

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	305	54.64	<.0001
Rep(Year)	9	305	1.56	0.1266
MPtrt	2	305	4.96	0.0076
Year*MPtrt	4	305	0.56	0.6935
Rep*MPtrt(Year)	18	305	0.67	0.8402
SPtrt	1	305	7.10	0.0081
Year*SPtrt	2	305	0.11	0.8947
MPtrt*SPtrt	2	305	0.24	0.7863
Year*MPtrt*SPtrt	4	305	1.48	0.2073

Least Squares Means

Effect	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt	1		24.7438	1.3770	305	17.97	<.0001
MPtrt	2		25.5055	1.3529	305	18.85	<.0001
MPtrt	4		30.3415	1.3604	305	22.30	<.0001
SPtrt		1	28.9569	1.1081	305	26.13	<.0001
SPtrt		4	24.7702	1.1164	305	22.19	<.0001
MPtrt*SPtrt	1	1	26.9378	1.9136	305	14.08	<.0001
MPtrt*SPtrt	1	4	22.5498	1.9737	305	11.43	<.0001
MPtrt*SPtrt	2	1	26.8896	1.9133	305	14.05	<.0001
MPtrt*SPtrt	2	4	24.1215	1.9133	305	12.61	<.0001
MPtrt*SPtrt	4	1	33.0435	1.9312	305	17.11	<.0001
MPtrt*SPtrt	4	4	27.6394	1.9134	305	14.45	<.0001

Differences of Least Squares Means

Effect	MPtrt	SPtrt	_MPtrt	_SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt	1		2		-0.7617	1.9304	305	-0.39	0.6934
MPtrt	1		4		-5.5977	1.9357	305	-2.89	0.0041
MPtrt	2		4		-4.8359	1.9186	305	-2.52	0.0122
SPtrt		1		4	4.1867	1.5716	305	2.66	0.0081
MPtrt*SPtrt	1	1	1	4	4.3880	2.7440	305	1.60	0.1108
MPtrt*SPtrt	1	1	2	1	0.04820	2.7060	305	0.02	0.9858
MPtrt*SPtrt	1	1	2	4	2.8163	2.7060	305	1.04	0.2988
MPtrt*SPtrt	1	1	4	1	-6.1058	2.7187	305	-2.25	0.0254
MPtrt*SPtrt	1	1	4	4	-0.7017	2.7061	305	-0.26	0.7956
MPtrt*SPtrt	1	4	2	1	-4.3398	2.7488	305	-1.58	0.1154
MPtrt*SPtrt	1	4	2	4	-1.5717	2.7488	305	-0.57	0.5679
MPtrt*SPtrt	1	4	4	1	-10.4937	2.7613	305	-3.80	0.0002

The Mixed Procedure

Differences of Least Squares Means

Effect	MPtrt	SPtrt	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt*SPtrt	1	4	4	4	-5.0896	2.7489	305	-1.85	0.0651
MPtrt*SPtrt	2	1	2	4	2.7681	2.7057	305	1.02	0.3071
MPtrt*SPtrt	2	1	4	1	-6.1540	2.7185	305	-2.26	0.0243
MPtrt*SPtrt	2	1	4	4	-0.7499	2.7058	305	-0.28	0.7819
MPtrt*SPtrt	2	4	4	1	-8.9220	2.7185	305	-3.28	0.0012
MPtrt*SPtrt	2	4	4	4	-3.5179	2.7058	305	-1.30	0.1945
MPtrt*SPtrt	4	1	4	4	5.4041	2.7164	305	1.99	0.0475

The Mixed Procedure

Model Information

Data Set	WORK.UNR959697
Dependent Variable	TSS
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Class Level Information

Class	Levels	Values
Year	3	1995 1996 1997
Rep	4	1 2 3 4
MPtrt	3	1 2 4
SPtrt	2	1 4

Dimensions

Covariance Parameters	1
Columns in X	96
Columns in Z	0
Subjects	1
Max Obs Per Subject	360

Number of Observations

Number of Observations Read	360
Number of Observations Used	350
Number of Observations Not Used	10

Covariance Parameter Estimates

Cov Parm	Estimate
Residual	254.78

Fit Statistics

-2 Res Log Likelihood	2657.6
AIC (smaller is better)	2659.6
AICC (smaller is better)	2659.6
BIC (smaller is better)	2663.3

The Mixed Procedure

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	305	61.23	<.0001
Rep(Year)	9	305	1.24	0.2726
MPtrt	2	305	4.43	0.0127
Year*MPtrt	4	305	0.95	0.4371
Rep*MPtrt(Year)	18	305	0.38	0.9900
SPtrt	1	305	13.29	0.0003
Year*SPtrt	2	305	1.06	0.3481
MPtrt*SPtrt	2	305	0.56	0.5712
Year*MPtrt*SPtrt	4	305	2.00	0.0949

Least Squares Means

Effect	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt	1		42.2035	1.4972	305	28.19	<.0001
MPtrt	2		42.9219	1.4709	305	29.18	<.0001
MPtrt	4		47.9282	1.4791	305	32.40	<.0001
SPtrt		1	47.4653	1.2048	305	39.40	<.0001
SPtrt		4	41.2371	1.2138	305	33.97	<.0001
MPtrt*SPtrt	1	1	44.9613	2.0805	305	21.61	<.0001
MPtrt*SPtrt	1	4	39.4457	2.1459	305	18.38	<.0001
MPtrt*SPtrt	2	1	45.1528	2.0802	305	21.71	<.0001
MPtrt*SPtrt	2	4	40.6910	2.0802	305	19.56	<.0001
MPtrt*SPtrt	4	1	52.2819	2.0997	305	24.90	<.0001
MPtrt*SPtrt	4	4	43.5745	2.0803	305	20.95	<.0001

Differences of Least Squares Means

Effect	MPtrt	SPtrt	MPtrt	SPtrt	Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt	1		2		-0.7183	2.0988	305	-0.34	0.7324
MPtrt	1		4		-5.7247	2.1046	305	-2.72	0.0069
MPtrt	2		4		-5.0064	2.0859	305	-2.40	0.0170
SPtrt		1		4	6.2283	1.7087	305	3.64	0.0003
MPtrt*SPtrt	1	1	1	4	5.5156	2.9834	305	1.85	0.0655
MPtrt*SPtrt	1	1	2	1	-0.1914	2.9421	305	-0.07	0.9482
MPtrt*SPtrt	1	1	2	4	4.2704	2.9421	305	1.45	0.1477
MPtrt*SPtrt	1	1	4	1	-7.3206	2.9559	305	-2.48	0.0138
MPtrt*SPtrt	1	1	4	4	1.3868	2.9422	305	0.47	0.6377
MPtrt*SPtrt	1	4	2	1	-5.7070	2.9886	305	-1.91	0.0571
MPtrt*SPtrt	1	4	2	4	-1.2452	2.9886	305	-0.42	0.6772
MPtrt*SPtrt	1	4	4	1	-12.8362	3.0022	305	-4.28	<.0001

The Mixed Procedure

Differences of Least Squares Means

Effect	MPtrt	SPtrt	MPtrt_SPtrt		Estimate	Standard Error	DF	t Value	Pr > |t|
MPtrt*SPtrt	1	4	4	4	-4.1288	2.9887	305	-1.38	0.1682
MPtrt*SPtrt	2	1	2	4	4.4618	2.9418	305	1.52	0.1304
MPtrt*SPtrt	2	1	4	1	-7.1292	2.9556	305	-2.41	0.0165
MPtrt*SPtrt	2	1	4	4	1.5782	2.9419	305	0.54	0.5920
MPtrt*SPtrt	2	4	4	1	-11.5909	2.9556	305	-3.92	0.0001
MPtrt*SPtrt	2	4	4	4	-2.8836	2.9419	305	-0.98	0.3278
MPtrt*SPtrt	4	1	4	4	8.7074	2.9534	305	2.95	0.0034

Standard Curves for UNR- Pix Soluble Sugars

Glucose-

Intercept	-0.01347
Net Abs	0.5326

Regression Statistics	
Multiple R	0.99827
R Square	0.997052

Fructose-

Intercept	0.0121
Net Abs	0.5271

Regression Statistics	
Multiple R	0.997946
R Square	0.996894

Sucrose-

Intercept	-0.0084
Net Abs	0.05145

Regression Statistics	
Multiple R	0.99763
R Square	0.99777

Appendix F: Plant Population Density (PPD) Study SAS data

PPD Starch
SAS input

Treatment 1= 18,900-30,710 plants/plot
2= 33,323-46,391 plants/plot
3= 66,647-84,289 plants/plot
4= 99,970-128,720 plants/plot
5= 133,294- 194,713 plants/plot

```
Starch concentrations are mg/g dry weight
Data PPD;
input Year Trt Rep Plot Starch;
cards;

1998    1       1       101     49.95
1998    4       1       102     50.51
1998    3       1       103     46.20
1998    2       1       104     47.54
1998    2       2       201     51.67
1998    3       2       202     51.12
1998    4       2       203     50.93
1998    1       2       205     44.84
1998    1       3       301     35.83
1998    2       3       302     51.61
1998    3       3       303     51.25
1998    4       3       305     30.04
1998    3       4       401     27.83
1998    1       4       402     51.15
1998    2       4       404     51.32
1998    4       4       405     9.15
1998    2       5       501     29.80
1998    1       5       502     50.91
1998    4       5       503     51.66
1998    3       5       504     51.20
1998    1       1       101     51.20
1998    4       1       102     85.50
1998    3       1       103     57.13
1998    2       1       104     44.09
1998    2       2       201     82.63
1998    3       2       202     14.33
1998    4       2       203     47.92
1998    1       2       205     46.11
1998    1       3       301     68.93
1998    2       3       302     60.27
1998    3       3       303     62.47
1998    4       3       305     59.66
1998    3       4       401     21.66
1998    1       4       402     95.19
1998    2       4       404     75.48
1998    4       4       405     56.58
1998    2       5       501     20.15
1998    1       5       502     35.39
1998    4       5       503     88.21
1998    3       5       504     105.24
1998    1       1       101     75.05
1998    4       1       102     31.02
1998    3       1       103     45.45
1998    2       1       104     36.63
1998    2       2       201     93.47
1998    3       2       202     23.96
1998    4       2       203     104.09
1998    1       2       205     46.23
1998    1       3       301     53.84
1998    2       3       302     39.44
1998    3       3       303     44.63
```

1998	4	3	305	19.52
1998	3	4	401	29.36
1998	1	4	402	11.85
1998	2	4	404	89.39
1998	4	4	405	20.70
1998	2	5	501	31.56
1998	1	5	502	56.95
1998	4	5	503	38.05
1998	3	5	504	102.31
1998	1	1	101	45.17
1998	4	1	102	33.89
1998	3	1	103	44.72
1998	2	1	104	20.57
1998	2	2	201	60.63
1998	3	2	202	49.76
1998	4	2	203	86.65
1998	1	2	205	94.61
1998	1	3	301	63.53
1998	2	3	302	81.63
1998	3	3	303	56.19
1998	4	3	305	61.02
1998	3	4	401	28.00
1998	1	4	402	28.15
1998	2	4	404	28.51
1998	4	4	405	28.27
1998	2	5	501	24.95
1998	1	5	502	26.25
1998	4	5	503	51.57
1998	3	5	504	28.57
1998	1	1	101	54.05
1998	4	1	102	77.47
1998	3	1	103	50.34
1998	2	1	104	81.66
1998	2	2	201	45.54
1998	3	2	202	25.31
1998	4	2	203	9.74
1998	1	2	205	60.54
1998	1	3	301	44.78
1998	2	3	302	64.07
1998	3	3	303	53.41
1998	4	3	305	90.57
1998	3	4	401	62.05
1998	1	4	402	54.77
1998	2	4	404	42.40
1998	4	4	405	35.97
1998	2	5	501	53.53
1998	1	5	502	37.90
1998	4	5	503	6.36
1998	3	5	504	79.01
1999	4	1	601	35.67
1999	3	1	602	63.95
1999	2	1	603	103.76
1999	5	1	604	77.05
1999	1	1	605	87.22
1999	2	2	701	103.34
1999	4	2	702	30.29
1999	1	2	703	103.97
1999	3	2	704	92.95
1999	5	2	705	100.86
1999	3	3	801	81.30
1999	1	3	802	102.01
1999	2	3	803	24.56
1999	4	3	804	92.44
1999	5	3	805	103.46
1999	1	4	901	99.08
1999	2	4	902	103.64
1999	4	4	903	70.98
1999	5	4	904	80.16
1999	3	4	905	105.66

1999	2	5	1001	47.26
1999	3	5	1002	32.07
1999	5	5	1003	78.07
1999	1	5	1004	105.33
1999	4	5	1005	101.62
1999	4	1	601	104.15
1999	3	1	602	54.29
1999	2	1	603	105.60
1999	5	1	604	83.17
1999	1	1	605	105.15
1999	2	2	701	104.91
1999	4	2	702	106.84
1999	1	2	703	75.05
1999	3	2	704	101.25
1999	5	2	705	85.47
1999	3	3	801	36.15
1999	1	3	802	85.89
1999	2	3	803	90.39
1999	4	3	804	76.68
1999	5	3	805	84.35
1999	1	4	901	92.05
1999	2	4	902	60.48
1999	4	4	903	102.91
1999	5	4	904	104.63
1999	3	4	905	69.56
1999	2	5	1001	96.51
1999	3	5	1002	87.34
1999	5	5	1003	97.99
1999	1	5	1004	97.39
1999	4	5	1005	98.11
1999	4	1	601	60.52
1999	3	1	602	91.39
1999	2	1	603	33.50
1999	5	1	604	99.96
1999	1	1	605	71.57
1999	2	2	701	29.65
1999	4	2	702	98.14
1999	1	2	703	50.80
1999	3	2	704	86.85
1999	5	2	705	67.65
1999	3	3	801	106.67
1999	1	3	802	87.83
1999	2	3	803	31.78
1999	4	3	804	97.27
1999	5	3	805	60.00
1999	1	4	901	106.50
1999	2	4	902	36.08
1999	4	4	903	106.81
1999	5	4	904	47.34
1999	3	4	905	74.23
1999	2	5	1001	112.83
1999	3	5	1002	33.99
1999	5	5	1003	56.08
1999	1	5	1004	109.82
1999	4	5	1005	108.88
1999	4	1	601	89.09
1999	3	1	602	88.42
1999	2	1	603	109.96
1999	5	1	604	71.29
1999	1	1	605	58.21
1999	2	2	701	8.01
1999	4	2	702	75.56
1999	1	2	703	29.89
1999	3	2	704	109.40
1999	5	2	705	89.68
1999	3	3	801	.
1999	1	3	802	95.24
1999	2	3	803	58.25
1999	4	3	804	93.74

1999	5	3	805	112.02
1999	1	4	901	49.33
1999	2	4	902	48.18
1999	4	4	903	61.54
1999	5	4	904	84.05
1999	3	4	905	99.05
1999	2	5	1001	73.18
1999	3	5	1002	112.65
1999	5	5	1003	33.95
1999	1	5	1004	103.49
1999	4	5	1005	100.94
1999	4	1	601	30.91
1999	3	1	602	104.33
1999	2	1	603	74.61
1999	5	1	604	51.47
1999	1	1	605	101.18
1999	2	2	701	100.97
1999	4	2	702	15.11
1999	1	2	703	95.45
1999	3	2	704	98.04
1999	5	2	705	41.08
1999	3	3	801	26.85
1999	1	3	802	104.05
1999	2	3	803	74.30
1999	4	3	804	104.26
1999	5	3	805	77.20
1999	1	4	901	82.62
1999	2	4	902	96.74
1999	4	4	903	43.50
1999	5	4	904	108.70
1999	3	4	905	104.75
1999	2	5	1001	106.22
1999	3	5	1002	52.27
1999	5	5	1003	107.06
1999	1	5	1004	79.16
1999	4	5	1005	106.04
2000	2	1	601	36.57
2000	4	1	602	44.51
2000	3	1	603	74.51
2000	5	1	604	92.20
2000	1	1	605	55.94
2000	2	2	701	95.31
2000	3	2	702	29.55
2000	5	2	703	38.92
2000	1	2	704	47.97
2000	4	2	705	35.07
2000	1	3	801	35.73
2000	5	3	802	65.98
2000	2	3	803	94.40
2000	4	3	804	20.98
2000	3	3	805	55.94
2000	5	4	901	42.69
2000	1	4	902	59.33
2000	3	4	903	48.81
2000	4	4	904	28.88
2000	2	4	905	21.43
2000	4	5	1001	45.87
2000	3	5	1002	67.09
2000	2	5	1003	56.89
2000	5	5	1004	50.28
2000	1	5	1005	57.03
2000	2	1	601	68.49
2000	4	1	602	43.53
2000	3	1	603	62.37
2000	5	1	604	94.75
2000	1	1	605	105.62
2000	2	2	701	104.30
2000	3	2	702	103.25
2000	5	2	703	31.12

2000	1	2	704	92.76
2000	4	2	705	63.60
2000	1	3	801	95.38
2000	5	3	802	54.26
2000	2	3	803	44.12
2000	4	3	804	49.54
2000	3	3	805	104.47
2000	5	4	901	41.26
2000	1	4	902	78.28
2000	3	4	903	73.18
2000	4	4	904	28.92
2000	2	4	905	96.36
2000	4	5	1001	57.93
2000	3	5	1002	37.31
2000	2	5	1003	58.91
2000	5	5	1004	106.81
2000	1	5	1005	80.35
2000	2	1	601	81.36
2000	4	1	602	93.81
2000	3	1	603	101.22
2000	5	1	604	48.39
2000	1	1	605	106.60
2000	2	2	701	71.81
2000	3	2	702	54.40
2000	5	2	703	48.98
2000	1	2	704	77.62
2000	4	2	705	46.71
2000	1	3	801	103.18
2000	5	3	802	108.70
2000	2	3	803	48.29
2000	4	3	804	58.14
2000	3	3	805	93.77
2000	5	4	901	31.26
2000	1	4	902	85.76
2000	3	4	903	98.21
2000	4	4	904	87.58
2000	2	4	905	57.24
2000	4	5	1001	39.82
2000	3	5	1002	48.04
2000	2	5	1003	97.93
2000	5	5	1004	48.11
2000	1	5	1005	93.42
2000	2	1	601	53.91
2000	4	1	602	86.85
2000	3	1	603	96.36
2000	5	1	604	49.72
2000	1	1	605	56.54
2000	2	2	701	66.61
2000	3	2	702	58.21
2000	5	2	703	78.95
2000	1	2	704	85.00
2000	4	2	705	47.48
2000	1	3	801	71.19
2000	5	3	802	106.95
2000	2	3	803	89.54
2000	4	3	804	72.93
2000	3	3	805	88.84
2000	5	4	901	19.48
2000	1	4	902	96.85
2000	3	4	903	90.52
2000	4	4	904	57.72
2000	2	4	905	32.73
2000	4	5	1001	32.17
2000	3	5	1002	47.13
2000	2	5	1003	56.57
2000	5	5	1004	42.69
2000	1	5	1005	101.92
2000	2	1	601	47.38
2000	4	1	602	48.53

```
2000    3       1       603     29.37
2000    5       1       604     78.67
2000    1       1       605     78.11
2000    2       2       701     85.28
2000    3       2       702     26.19
2000    5       2       703     74.19
2000    1       2       704     81.53
2000    4       2       705     84.51
2000    1       3       801     99.12
2000    5       3       802     62.55
2000    2       3       803     81.15
2000    4       3       804     59.33
2000    3       3       805     75.35
2000    5       4       901     48.15
2000    1       4       902     84.37
2000    3       4       903     25.80
2000    4       4       904     90.73
2000    2       4       905     64.96
2000    4       5       1001    97.55
2000    3       5       1002    64.05
2000    2       5       1003    61.82
2000    5       5       1004    39.89
2000    1       5       1005    94.58
;

Proc mixed data=PPD;
Class Year Rep Trt;
Model Starch=Year Trt Year*Trt Rep(Year);
Random Year Rep(Year);
Lsmeans Trt/pdiff;
Run;
```

PPD Starch
SAS Output

The Mixed Procedure

Model Information

Data Set	WORK.PPD
Dependent Variable	Starch
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
Year	3	1998 1999 2000
Rep	5	1 2 3 4 5
Trt	5	1 2 3 4 5

Dimensions

Covariance Parameters	3
Columns in X	38
Columns in Z	18
Subjects	1
Max Obs Per Subject	350

Number of Observations

Number of Observations Read	350
Number of Observations Used	349
Number of Observations Not Used	1

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	3062.83099824	
1	1	3608.70577745	0.00000000

Convergence criteria met but final hessian is not positive definite.

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate
Year	1.262E16
Rep(Year)	8.349E15
Residual	603.90

Fit Statistics

-2 Res Log Likelihood	3608.7
AIC (smaller is better)	3614.7
AICC (smaller is better)	3614.8
BIC (smaller is better)	3612.0

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	0	40.78	.
Trt	4	323	2.43	0.0474
Year*Trt	7	323	1.25	0.2761
Rep(Year)	12	0	0.87	.

Least Squares Means

Effect	Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	73.1417	2.8376	323	25.78	<.0001
Trt	2	64.2215	2.8376	323	22.63	<.0001
Trt	3	64.7708	2.8579	323	22.66	<.0001
Trt	4	62.1299	2.8376	323	21.90	<.0001
Trt	5	Non-est	.	.	.	.

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	2	8.9203	4.0130	323	2.22	0.0269
Trt	1	3	8.3709	4.0274	323	2.08	0.0385
Trt	1	4	11.0119	4.0130	323	2.74	0.0064
Trt	1	5	Non-est	.	.	.	.
Trt	2	3	-0.5493	4.0274	323	-0.14	0.8916

The Mixed Procedure

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	2	4	2.0916	4.0130	323	0.52	0.6026
Trt	2	5	Non-est	.	.	.	.
Trt	3	4	2.6409	4.0274	323	0.66	0.5125
Trt	3	5	Non-est	.	.	.	.
Trt	4	5	Non-est	.	.	.	.

Glucose Standard Curve for PPD Starch

Intercept 0.02809

Net Abs 0.503046

Regression Statistics

Multiple R 0.995556

R Square 0.991132

PPD Soluble Sugar-
Glucose, Fructose, Sucrose and the sum of all three
SAS Input

Treatment 1= 18,900-30,710 plants/plot
2= 33,323-46,391 plants/plot
3= 66,647-84,289 plants/plot
4= 99,970-128,720 plants/plot
5= 133,294- 194,713 plants/plot
Sugars are in mg/g dry weight

```
Data PPD;
input Year Trt Stem Rep Glu Fru Suc Totsug;
cards;

1998   1      6      1      5.6    14.1   14.5   34.2
1998   4      6      1      5.4    12.1   19.7   37.2
1998   3      6      1      7.0    13.7   23.2   43.9
1998   2      6      1      5.2    12.0   18.8   36.0
1998   2      6      2      6.8    14.4   24.6   45.8
1998   3      6      2      4.8    13.3   18.1   36.2
1998   4      6      2      6.9    14.1   33.6   54.6
1998   1      6      2      9.9    16.2   33.7   59.8
1998   1      6      3      6.6    13.5   15.1   35.2
1998   2      6      3      5.4    13.3   14.0   32.7
1998   3      6      3      3.3    10.7   12.4   26.4
1998   4      6      3      5.8    13.0   16.7   35.6
1998   3      6      4      7.4    15.1   25.6   48.0
1998   1      6      4      8.9    6.0        46.5       61.4
1998   2      6      4      5.3    5.8        33.3       44.3
1998   4      6      4      7.5    14.0   25.7   47.2
1998   2      6      5      8.6    16.3   20.5   45.4
1998   1      6      5      4.4    12.0   13.1   29.4
1998   4      6      5      3.6    10.0   30.4   43.9
1998   3      6      5      5.1    8.4        32.2       45.7
1998   1      7      1      7.8    14.0   32.0   53.7
1998   4      7      1      6.5    8.8    17.7   33.0
1998   3      7      1      1.9    7.1    2.0        10.9
1998   2      7      1      2.9    5.8        5.4    14.1
1998   2      7      2      1.5    3.4        4.4     9.4
1998   3      7      2      1.7    6.7        0.3     8.8
1998   4      7      2      3.1    7.4        3.8        14.3
1998   1      7      2      3.3    6.3        3.2        12.7
```

1998	1	7	3	4.8	10.0	8.9		23.8	
1998	2	7	3	3.0	4.8		5.1		12.8
1998	3	7	3	1.8	3.8		.	.	
1998	4	7	3	1.7	4.1	2.7	8.6		
1998	3	7	4	2.3	3.9	1.1	7.3		
1998	1	7	4	3.9	5.3	6.7	15.9		
1998	2	7	4	1.0	3.0	5.2	9.3		
1998	4	7	4	2.6	6.3	10.3	19.2		
1998	2	7	5	3.7	7.1	1.8	12.6		
1998	1	7	5	2.6	4.5	1.7	8.7		
1998	4	7	5	1.8	6.3	5.0	13.2		
1998	3	7	5	3.4	4.7	3.1	11.3		
1998	1	8	1	1.6	4.0	0.0	5.6		
1998	4	8	1	4.1	5.3	2.5	11.9		
1998	3	8	1	3.1	5.1	3.7	11.9		
1998	2	8	1	5.0	5.8	6.1	16.9		
1998	2	8	2	2.9	5.0	4.5	12.3		
1998	3	8	2	2.2	6.5	.	.		
1998	4	8	2	1.5	3.1	4.8	9.4		
1998	1	8	2	5.8	9.8	8.4	24.0		
1998	1	8	3	2.8	4.2	0.6	7.7		
1998	2	8	3	2.1	6.3	0.5	8.9		
1998	3	8	3	1.9	4.5	0.1	6.4		
1998	4	8	3	3.1	4.7	.	.		
1998	3	8	4	0.7	3.0	1.7	5.4		
1998	1	8	4	3.5	5.3	3.3	12.1		
1998	2	8	4	3.9	6.2	6.0	16.1		
1998	4	8	4	6.4	8.0	10.4	24.7		
1998	2	8	5	3.7	6.1	2.7	12.5		
1998	1	8	5	7.9	11.5	12.8	32.1		
1998	4	8	5	2.9	6.2	5.3	14.3		
1998	3	8	5	5.6	8.9	15.9	30.4		
1998	1	9	1	4.4	5.5	13.7	23.6		
1998	4	9	1	8.2	10.8	9.4	28.4		
1998	3	9	1	5.9	8.5	6.9	21.4		
1998	2	9	1	5.7	7.4	2.9	16.0		
1998	2	9	2	6.1	7.8	6.8	20.8		
1998	3	9	2	7.1	8.6	12.8	28.5		
1998	4	9	2	6.0	7.0	7.4	20.4		
1998	1	9	2	4.8	5.7	3.8	14.3		
1998	1	9	3	8.4	10.5	8.5	27.4		
1998	2	9	3	5.9	7.8	6.0	19.7		
1998	3	9	3	4.0	5.6	4.1	13.7		
1998	4	9	3	5.3	6.2	11.1	22.7		
1998	3	9	4	6.8	9.8	6.2	22.8		
1998	1	9	4	9.0	11.7	13.1	33.8		
1998	2	9	4	8.8	12.0	9.0	29.7		
1998	4	9	4	5.6	8.2	7.2	20.9		
1998	2	9	5	8.4	10.3	17.5	36.3		
1998	1	9	5	5.2	6.3	6.1	17.6		
1998	4	9	5	5.4	7.7	5.0	18.1		
1998	3	9	5	5.1	6.0	6.0	17.2		
1998	1	10	1	6.6	8.3	14.0	29.0		
1998	4	10	1	7.2	6.8	12.3	26.3		
1998	3	10	1	4.6	7.2	4.7	16.5		
1998	2	10	1	5.5	8.5	6.9	20.9		
1998	2	10	2	6.9	9.5	9.8	26.2		
1998	3	10	2	6.4	10.2	8.0	24.5		
1998	4	10	2	3.3	8.8	1.3	13.4		
1998	1	10	2	2.7	8.8	7.0	18.4		
1998	1	10	3	7.4	10.4	7.9	25.8		
1998	2	10	3	7.1	9.7	10.1	26.8		
1998	3	10	3	3.2	5.3	.	.		
1998	4	10	3	4.9	6.3	16.4	27.6		
1998	3	10	4	4.2	9.6	7.6	21.4		
1998	1	10	4	4.9	7.6	7.6	20.1		
1998	2	10	4	3.8	7.5	5.2	16.5		
1998	4	10	4	4.0	7.5	4.3	15.9		
1998	2	10	5	7.1	8.3	10.4	25.9		

1998	1	10	5	4.7	6.6	7.2	18.6
1998	4	10	5	4.1	5.7	0.3	10.1
1998	3	10	5	4.8	5.4	5.4	15.5
1999	4	6	1	3.0	5.9	21.6	30.6
1999	3	6	1	4.6	4.8	30.4	39.8
1999	2	6	1	2.3	3.0	20.8	26.1
1999	5	6	1	6.0	6.5	29.7	42.3
1999	1	6	1	5.7	3.9	34.2	43.8
1999	2	6	2	4.4	4.3	27.9	36.6
1999	4	6	2	6.9	8.6	39.8	55.3
1999	1	6	2	5.6	4.7	41.4	51.8
1999	3	6	2	4.4	6.4	21.7	32.4
1999	5	6	2	5.4	6.1	25.5	37.0
1999	3	6	3	3.2	8.5	22.0	33.7
1999	1	6	3	5.5	6.6	33.8	46.0
1999	2	6	3	1.5	1.8	0.4	3.7
1999	4	6	3	3.7	10.3	22.0	36.0
1999	5	6	3	3.4	7.1	15.4	25.8
1999	1	6	4	4.8	7.9	26.0	38.7
1999	2	6	4	5.1	4.6	25.1	34.9
1999	4	6	4	5.9	8.3	27.3	41.5
1999	5	6	4	3.4	9.0	21.4	33.9
1999	3	6	4	2.8	9.8	16.1	28.8
1999	2	6	5	4.2	9.0	19.9	33.0
1999	3	6	5	4.5	9.7	19.0	33.2
1999	5	6	5	4.5	9.6	19.7	33.8
1999	1	6	5	4.2	6.9	26.6	37.7
1999	4	6	5	7.0	10.5	34.2	51.8
1999	4	7	1	3.7	4.4	20.1	28.2
1999	3	7	1	3.8	5.5	20.4	29.6
1999	2	7	1	3.3	8.0	18.2	29.5
1999	5	7	1	6.0	9.6	24.6	40.2
1999	1	7	1	3.5	3.9	23.3	30.6
1999	2	7	2	4.9	5.8	25.3	36.1
1999	4	7	2	4.4	6.2	20.7	31.4
1999	1	7	2	3.1	3.5	19.2	25.8
1999	3	7	2	2.2	2.9	19.6	24.7
1999	5	7	2	3.6	5.0	15.4	24.0
1999	3	7	3	4.0	9.4	17.0	30.4
1999	1	7	3	5.4	3.0	27.2	35.7
1999	2	7	3	3.7	3.7	18.8	26.3
1999	4	7	3	5.6	6.0	18.2	29.9
1999	5	7	3	3.7	9.3	17.1	30.0
1999	1	7	4	6.4	6.7	35.7	48.8
1999	2	7	4	8.1	5.8	31.2	45.1
1999	4	7	4	6.4	7.8	28.8	42.9
1999	5	7	4	5.7	6.6	27.9	40.2
1999	3	7	4	6.5	7.6	20.0	34.1
1999	2	7	5	5.1	2.6	24.6	32.3
1999	3	7	5	4.9	8.2	22.2	35.3
1999	5	7	5	7.4	5.2	44.7	57.2
1999	1	7	5	4.1	4.8	30.8	39.7
1999	4	7	5	6.9	7.1	35.0	49.0
1999	4	8	1	4.4	8.7	22.8	35.9
1999	3	8	1	7.6	9.3	40.4	57.4
1999	2	8	1	4.5	7.1	25.0	36.7
1999	5	8	1	2.2	2.4	17.5	22.0
1999	1	8	1	4.1	4.2	41.4	49.8
1999	2	8	2	5.8	3.6	32.4	41.8
1999	4	8	2	2.6	4.4	18.5	25.5
1999	1	8	2	5.4	5.5	40.5	51.4
1999	3	8	2	4.5	6.8	27.6	38.9
1999	5	8	2	6.1	6.8	28.8	41.6
1999	3	8	3	3.6	6.8	25.5	35.8
1999	1	8	3	3.5	7.2	21.5	32.2
1999	2	8	3	6.7	5.2	35.9	47.9
1999	4	8	3	7.1	6.4	30.8	44.2
1999	5	8	3	5.7	8.2	25.3	39.2
1999	1	8	4	3.2	6.1	17.8	27.1

1999	2	8	4	4.2	7.3	24.1	35.6
1999	4	8	4	5.1	6.4	26.4	37.9
1999	5	8	4	4.7	9.5	21.5	35.7
1999	3	8	4	6.1	4.4	27.2	37.7
1999	2	8	5	6.3	7.4	23.8	37.6
1999	3	8	5	4.9	10.6	21.7	37.2
1999	5	8	5	5.3	11.2	21.0	37.5
1999	1	8	5	4.4	7.2	13.4	25.0
1999	4	8	5	4.3	9.5	25.5	39.3
1999	4	9	1	3.9	6.7	26.8	37.4
1999	3	9	1	5.4	6.2	31.5	43.1
1999	2	9	1	4.7	5.0	28.4	38.0
1999	5	9	1	5.8	3.0	27.9	36.7
1999	1	9	1	5.1	3.1	30.3	38.4
1999	2	9	2	4.5	8.0	21.7	34.2
1999	4	9	2	3.4	8.5	17.3	29.1
1999	1	9	2	4.3	4.8	32.2	41.3
1999	3	9	2	5.0	7.4	24.7	37.1
1999	5	9	2	3.9	6.4	18.5	28.9
1999	3	9	3	3.6	9.9	18.9	32.5
1999	1	9	3	6.8	10.5	0.4	17.6
1999	2	9	3	6.4	5.1	27.8	39.2
1999	4	9	3	7.2	6.1	23.3	36.5
1999	5	9	3	7.8	5.6	29.8	43.2
1999	1	9	4	7.6	5.9	28.3	41.8
1999	2	9	4	5.1	8.1	22.1	35.3
1999	4	9	4	7.2	1.8	33.0	42.0
1999	5	9	4	5.5	6.4	19.3	31.1
1999	3	9	4	7.0	6.9	22.6	36.6
1999	2	9	5	5.5	7.7	21.7	34.9
1999	3	9	5	5.8	6.3	24.0	36.1
1999	5	9	5	5.0	8.7	22.4	36.1
1999	1	9	5	6.2	7.8	37.1	51.1
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1999	3	10	1	3.1	6.2	31.1	40.4
1999	2	10	1	4.7	1.9	21.2	27.7
1999	5	10	1	3.6	5.2	15.3	24.2
1999	1	10	1	4.9	0.9	18.7	24.4
1999	2	10	2	4.6	1.5	15.3	21.4
1999	4	10	2	2.4	4.8	14.9	22.0
1999	1	10	2	4.6	3.5	26.0	34.1
1999	3	10	2	5.9	.	.	.
1999	5	10	2	5.9	1.1	19.1	26.1
1999	3	10	3	3.1	3.0	18.2	24.4
1999	1	10	3	4.0	5.0	31.0	40.0
1999	2	10	3	4.4	4.2	22.9	31.5
1999	4	10	3	1.7	5.5	11.0	18.2
1999	5	10	3	3.4	4.0	8.5	15.9
1999	1	10	4	4.2	2.7	17.6	24.5
1999	2	10	4	4.9	1.4	15.9	22.3
1999	4	10	4	4.8	4.5	19.2	28.6
1999	5	10	4	1.1	5.1	11.6	17.8
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1999	2	10	5	3.2	3.9	16.9	24.0
1999	3	10	5	3.3	6.8	25.8	35.9
1999	5	10	5	2.5	6.7	17.0	26.3
1999	1	10	5	3.4	6.7	24.4	34.5
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2000	4	6	1	2.3	3.9	14.1	20.3
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2000	5	6	1	4.2	1.7	13.5	19.4
2000	1	6	1	3.1	1.9	13.4	18.5
2000	2	6	2	3.8	2.4	18.0	24.3
2000	3	6	2	3.4	5.5	18.8	27.7
2000	5	6	2	3.9	2.0	14.7	20.6
2000	1	6	2	4.2	1.7	15.2	21.0
2000	4	6	2	2.1	6.2	12.0	20.2

2000	1	6	3	3.2	3.4	12.0	18.5
2000	5	6	3	3.9	5.2	23.7	32.9
2000	2	6	3	1.6	4.7	11.8	18.1
2000	4	6	3	2.3	4.4	14.8	21.5
2000	3	6	3	4.8	2.0	15.6	22.4
2000	5	6	4	5.3	0.5	14.0	19.8
2000	1	6	4	4.2	3.2	13.3	20.8
2000	3	6	4	3.8	5.3	17.5	26.6
2000	4	6	4	2.8	4.8	9.8	17.4
2000	2	6	4	4.7	2.6	14.6	21.9
2000	4	6	5	3.1	3.2	13.0	19.3
2000	3	6	5	3.6	3.6	23.0	30.2
2000	2	6	5	4.3	5.7	19.9	30.0
2000	5	6	5	2.6	3.4	17.6	23.5
2000	1	6	5	5.0	5.1	33.1	43.2
2000	2	7	1	3.4	4.9	16.0	24.2
2000	4	7	1	5.7	4.3	12.5	22.6
2000	3	7	1	3.7	7.8	15.3	26.8
2000	5	7	1	4.2	5.8	15.3	25.2
2000	1	7	1	3.6	4.4	17.4	25.5
2000	2	7	2	2.8	7.1	15.6	25.5
2000	3	7	2	3.8	5.3	8.9	17.9
2000	5	7	2	4.5	4.5	21.8	30.8
2000	1	7	2	1.9	9.2	17.7	28.8
2000	4	7	2	3.3	5.3	13.2	21.9
2000	1	7	3	4.4	5.4	10.6	20.3
2000	5	7	3	6.5	4.2	17.7	28.3
2000	2	7	3	2.9	8.1	9.5	20.5
2000	4	7	3	3.6	0.6	8.7	13.0
2000	3	7	3	3.4	6.1	13.2	22.7
2000	5	7	4	3.5	6.7	22.2	32.4
2000	1	7	4	3.9	7.4	14.5	25.8
2000	3	7	4	5.6	2.2	14.4	22.2
2000	4	7	4	3.7	.	.	.
2000	2	7	4	3.0	2.8	10.4	16.2
2000	4	7	5	3.5	3.2	10.9	17.5
2000	3	7	5	6.5	0.4	11.5	18.3
2000	2	7	5	5.1	0.8	13.6	19.5
2000	5	7	5	6.0	0.1	16.7	22.8
2000	1	7	5	3.4	7.8	10.7	21.9
2000	2	8	1	2.6	2.1	9.8	14.5
2000	4	8	1	3.2	2.0	9.4	14.5
2000	3	8	1	2.4	2.9	11.4	16.8
2000	5	8	1	2.6	6.6	13.3	22.5
2000	1	8	1	2.5	4.7	11.4	18.6
2000	2	8	2	3.5	4.1	13.1	20.6
2000	3	8	2	4.3	3.4	15.1	22.8
2000	5	8	2	3.6	2.9	18.4	24.9
2000	1	8	2	3.6	7.0	14.9	25.5
2000	4	8	2	4.3	0.1	11.5	15.9
2000	1	8	3	3.8	2.8	9.3	15.9
2000	5	8	3	6.0	1.3	17.9	25.2
2000	2	8	3	2.9	1.3	4.2	8.4
2000	4	8	3	3.2	1.8	8.3	13.3
2000	3	8	3	3.5	3.0	13.9	20.4
2000	5	8	4	3.8	15.3	19.2	38.3
2000	1	8	4	4.5	4.9	13.6	23.0
2000	3	8	4	5.8	1.4	16.4	23.6
2000	4	8	4	4.3	1.8	9.5	15.5
2000	2	8	4	4.5	4.6	15.1	24.2
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2000	3	8	5	3.3	5.6	11.3	20.1
2000	2	8	5	4.5	2.7	16.3	23.5
2000	5	8	5	4.9	3.4	22.1	30.4
2000	1	8	5	6.8	6.0	22.0	34.8
2000	2	9	1	4.4	4.6	21.4	30.4
2000	4	9	1	7.6	.	.	.
2000	3	9	1	4.5	7.2	23.4	35.1
2000	5	9	1	2.2	7.6	32.8	42.5

```
2000    1       9       1       4.1     3.0     17.3    24.5
2000    2       9       2       5.8     4.2     18.4    28.4
2000    3       9       2       2.6     6.8     28.3    37.7
2000    5       9       2       5.4     8.3     26.0    39.7
2000    1       9       2       4.5     3.9     20.7    29.2
2000    4       9       2       6.1     1.2     22.1    29.3
2000    1       9       3       3.6     6.2     20.3    30.0
2000    5       9       3       3.5     8.4     24.0    36.0
2000    2       9       3       6.7     4.5     17.1    28.3
2000    4       9       3       7.1     2.3     14.9    24.3
2000    3       9       3       5.7     8.7     25.9    40.3
2000    5       9       4       3.2     5.8     21.9    30.9
2000    1       9       4       4.2     8.2     11.2    23.7
2000    3       9       4       5.1     7.1     18.8    31.0
2000    4       9       4       4.7     7.6     12.4    24.7
2000    2       9       4       6.1     4.4     17.5    28.1
2000    4       9       5       6.3     3.9     31.4    41.6
2000    3       9       5       4.9     1.9     22.7    29.5
2000    2       9       5       5.3     6.9     20.1    32.3
2000    5       9       5       4.4     7.7     25.4    37.5
2000    1       9       5       4.3     4.6     15.9    24.8
2000    2       10      1       3.9     5.7     17.8    27.4
2000    4       10      1       5.4     2.2     22.7    30.3
2000    3       10      1       4.7     1.5     29.5    35.7
2000    5       10      1       5.8     2.1     23.1    31.0
2000    1       10      1       5.1     1.3     15.0    21.3
2000    2       10      2       4.5     3.7     18.7    26.9
2000    3       10      2       3.4     6.3     16.0    25.6
2000    5       10      2       4.3     3.8     20.8    28.9
2000    1       10      2       5.0     4.4     17.3    26.8
2000    4       10      2       3.9     5.3     13.2    22.4
2000    1       10      3       3.6     5.4     19.7    28.7
2000    5       10      3       6.8     4.3     1.5     12.5
2000    2       10      3       6.4     3.8     23.3    33.4
2000    4       10      3       7.2     .       .       .
2000    3       10      3       7.8     5.5     23.6    36.9
2000    5       10      4       7.6     3.4     18.9    29.9
2000    1       10      4       5.1     7.8     23.4    36.3
2000    3       10      4       7.2     0.1     22.1    29.4
2000    4       10      4       5.5     4.4     18.4    28.2
2000    2       10      4       7.0     0.9     18.5    26.5
2000    4       10      5       5.5     3.5     18.9    27.8
2000    3       10      5       5.8     2.1     21.1    29.0
2000    2       10      5       5.0     4.5     14.5    24.0
2000    5       10      5       6.2     2.9     13.2    22.3
2000    1       10      5       6.6     0.4     11.3    18.4
;
Proc mixed data=PPD;
Class Year Rep Trt;
Model Glu=Year Trt Year*Trt Rep(Year) ;
Random Year Rep(Year);
Lsmeans Trt/pdiff;
Run;
Proc mixed data=PPD;
Class Year Rep Trt;
Model Fru=Year Trt Year*Trt Rep(Year);
Random Year Rep(Year);
Lsmeans Trt/pdiff;
Proc mixed data=PPD;
Class Year Rep Trt;
Model Suc=Year Trt Year*Trt Rep(Year);
Random Year Rep(Year);
Lsmeans Trt/pdiff;
Run;
Proc mixed data=PPD;
Class Year Rep Trt;
Model TotSug=Year Trt Year*Trt Rep(Year);
Random Year Rep(Year);
Lsmeans Trt/pdiff;
```

```
Run;
```

PPD Soluble Sugars
SAS Output - Glucose, Fructose, Sucrose and the Total
Sugars are in mg/g dry weight

Model Information

Data Set	WORK.PPD
Dependent Variable	Glu
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
Year	3	1998 1999 2000
Rep	5	1 2 3 4 5
Trt	5	1 2 3 4 5

Dimensions

Covariance Parameters	3
Columns in X	38
Columns in Z	18
Subjects	1
Max Obs Per Subject	350

Number of Observations

Number of Observations Read	350
Number of Observations Used	350
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	1320.41547493	
1	1	1536.48603032	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate
Year	5.156E31
Rep(Year)	0
Residual	2.7097

Fit Statistics

-2 Res Log Likelihood	1536.5
AIC (smaller is better)	1540.5
AICC (smaller is better)	1540.5

BIC (smaller is better) 1538.7

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	0	2.67	.
Trt	4	324	0.79	0.5322
Year*Trt	7	324	1.06	0.3911
Rep(Year)	12	0	1.19	.

Least Squares Means

Effect	Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	4.8227	0.1901	324	25.37	<.0001
Trt	2	4.6827	0.1901	324	24.64	<.0001
Trt	3	4.3747	0.1901	324	23.02	<.0001
Trt	4	4.6400	0.1901	324	24.41	<.0001
Trt	5	Non-est	.	.	.	.

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	2	0.1400	0.2688	324	0.52	0.6029
Trt	1	3	0.4480	0.2688	324	1.67	0.0966
Trt	1	4	0.1827	0.2688	324	0.68	0.4973
Trt	1	5	Non-est	.	.	.	.
Trt	2	3	0.3080	0.2688	324	1.15	0.2527

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	2	4	0.04267	0.2688	324	0.16	0.8740
Trt	2	5	Non-est	.	.	.	.
Trt	3	4	-0.2653	0.2688	324	-0.99	0.3243
Trt	3	5	Non-est	.	.	.	.
Trt	4	5	Non-est	.	.	.	.

Model Information

Data Set	WORK.PPD
Dependent Variable	Fru
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
Year	3	1998 1999 2000
Rep	5	1 2 3 4 5
Trt	5	1 2 3 4 5

Dimensions

Covariance Parameters	3
Columns in X	38
Columns in Z	18
Subjects	1
Max Obs Per Subject	350

Number of Observations

Number of Observations Read	350
Number of Observations Used	346
Number of Observations Not Used	4

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	1604.85590316	
1	1	1604.85590316	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate
Year	162388
Rep(Year)	0
Residual	6.9212

Fit Statistics

-2 Res Log Likelihood	1604.9
AIC (smaller is better)	1608.9
AICC (smaller is better)	1608.9
BIC (smaller is better)	1607.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	0	0.00	.
Trt	4	320	1.02	0.3967
Year*Trt	7	320	1.76	0.0941
Rep(Year)	12	0	1.36	.

Least Squares Means

Effect	Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	6.2827	232.66	320	0.03	0.9785
Trt	2	5.7693	232.66	320	0.02	0.9802
Trt	3	6.2798	232.66	320	0.03	0.9785
Trt	4	5.9637	232.66	320	0.03	0.9796
Trt	5	Non-est	.	.	.	.

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	2	0.5133	0.4296	320	1.19	0.2330
Trt	1	3	0.002851	0.4312	320	0.01	0.9947
Trt	1	4	0.3190	0.4346	320	0.73	0.4634
Trt	1	5	Non-est	.	.	.	.
Trt	2	3	-0.5105	0.4312	320	-1.18	0.2373

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	2	4	-0.1943	0.4346	320	-0.45	0.6551
Trt	2	5	Non-est	.	.	.	.
Trt	3	4	0.3162	0.4361	320	0.73	0.4690
Trt	3	5	Non-est	.	.	.	.
Trt	4	5	Non-est	.	.	.	.

The Mixed Procedure

Model Information

Data Set	WORK.PPD
Dependent Variable	Suc
Covariance Structure	Variance Components
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
Year	3	1998 1999 2000
Rep	5	1 2 3 4 5
Trt	5	1 2 3 4 5

Dimensions

Covariance Parameters	3
Columns in X	38
Columns in Z	18
Subjects	1
Max Obs Per Subject	350

Number of Observations

Number of Observations Read	350
Number of Observations Used	342
Number of Observations Not Used	8

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	2242.93966964	
1	1	2242.93966964	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate
Year	0
Rep(Year)	0
Residual	55.4427

Fit Statistics

-2 Res Log Likelihood	2242.9
AIC (smaller is better)	2244.9
AICC (smaller is better)	2245.0
BIC (smaller is better)	2244.0

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	0	86.95	.
Trt	4	316	1.07	0.3730
Year*Trt	7	316	1.73	0.1022
Rep(Year)	12	0	0.94	.

Least Squares Means

Effect	Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	18.2587	0.8598	316	21.24	<.0001
Trt	2	15.8707	0.8598	316	18.46	<.0001
Trt	3	16.7385	0.8864	316	18.88	<.0001
Trt	4	16.4392	0.8856	316	18.56	<.0001
Trt	5	Non-est	.	.	.	.

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	2	2.3880	1.2159	316	1.96	0.0504
Trt	1	3	1.5202	1.2349	316	1.23	0.2192
Trt	1	4	1.8194	1.2343	316	1.47	0.1415
Trt	1	5	Non-est	.	.	.	.
Trt	2	3	-0.8678	1.2349	316	-0.70	0.4827

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	2	4	-0.5686	1.2343	316	-0.46	0.6454
Trt	2	5	Non-est	.	.	.	.
Trt	3	4	0.2992	1.2522	316	0.24	0.8113
Trt	3	5	Non-est	.	.	.	.
Trt	4	5	Non-est	.	.	.	.

Model Information

Data Set	WORK.PPD
Dependent Variable	Totsug
Covariance Structure	Variance Components
Estimation Method	REML

Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
Year	3	1998 1999 2000
Rep	5	1 2 3 4 5
Trt	5	1 2 3 4 5

Dimensions

Covariance Parameters	3
Columns in X	38
Columns in Z	18
Subjects	1
Max Obs Per Subject	350

Number of Observations

Number of Observations Read	350
Number of Observations Used	342
Number of Observations Not Used	8

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	2414.19926023	
1	1	2414.19926023	0.00000000

Convergence criteria met but final hessian is not positive definite.

Covariance Parameter Estimates

Cov Parm	Estimate
Year	0
Rep(Year)	0
Residual	95.3268

Fit Statistics

-2 Res Log Likelihood	2414.2
AIC (smaller is better)	2416.2
AICC (smaller is better)	2416.2
BIC (smaller is better)	2415.3

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Year	2	0	42.77	.
Trt	4	316	1.11	0.3538
Year*Trt	7	316	1.25	0.2727
Rep(Year)	12	0	0.56	.

Least Squares Means

Effect	Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	29.3667	1.1274	316	26.05	<.0001
Trt	2	26.3267	1.1274	316	23.35	<.0001
Trt	3	27.5596	1.1623	316	23.71	<.0001
Trt	4	27.0209	1.1612	316	23.27	<.0001
Trt	5	Non-est	.	.	.	.

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	1	2	3.0400	1.5944	316	1.91	0.0575
Trt	1	3	1.8071	1.6193	316	1.12	0.2653
Trt	1	4	2.3458	1.6185	316	1.45	0.1482
Trt	1	5	Non-est	.	.	.	.
Trt	2	3	-1.2329	1.6193	316	-0.76	0.4470

Differences of Least Squares Means

Effect	Trt	_Trt	Estimate	Standard Error	DF	t Value	Pr > |t|
Trt	2	4	-0.6942	1.6185	316	-0.43	0.6683
Trt	2	5	Non-est	.	.	.	.
Trt	3	4	0.5387	1.6420	316	0.33	0.7431
Trt	3	5	Non-est	.	.	.	.
Trt	4	5	Non-est	.	.	.	.

Standard Curves for PPD Soluble Sugars

Glucose-

Intercept	0.011775
Net Abs	0.482578

Regression Statistics

Multiple R	0.995556
R Square	0.991132

Fructose-

Intercept	-0.02998
Net Abs	0.5169

Regression Statistics

Multiple R	0.994019
R Square	0.988075

Sucrose-

Intercept	-0.05703
Net Abs	0.518444

Regression Statistics

Multiple R	0.997947
R Square	0.995898

VITA

Jenny Dale Clement was born in Jackson, TN on April 8, 1980. She was the oldest of five girls in a very close family. She attended Trinity Christian Academy where she received her high school diploma in 1998. She received her Associate of Science from Jackson State Community College in 2000. She then attended the University of Tennessee at Chattanooga where she received her Bachelor of Science specializing in general biology and minored in chemistry in 2002. She is currently at the University of Tennessee where she is pursuing her Masters of Science with emphasis in crop physiology.