# Effect of Primo on Sod Tensile Strength

Dr. John Stier, Mr. Stephen Pearson and Mr. Roger Blair
University of Wisconsin-Madison, Dept. Horticulture, and Jasperson Sod Farm
December 2000

## INTRODUCTION

The objective of the project was to determine if sequential applications of trinexapac-ethyl (Primo) enhanced sod development, thereby decreasing the harvest interval.

## EXPERIMENTAL METHODS

The study was conducted at Jasperson's Sod Farm in Franklin, WI. Primo (trinexapac-ethyl) was applied in a single strip, several hundred feet in length, in each of three fields. Fields were seeded to a Kentucky bluegrass blend (NuGlade, Freedom II, NuBlue, Chicago, Award) between August-September of 1999: Field 1 was seeded on August 20$^{th}$, Field 2 was seeded on September 1$^{st}$, and Field 3 was seeded on September 15$^{th}$. Field soils were muck. Primo treatments (0.25 oz/1000 ft$^2$ in 40 gal/A spray volume) were applied by Mr. Blair on May 8$^{th}$, June 9$^{th}$, and July 13$^{th}$. Primo was applied as a single strip, approximately 1000 ft length, in each of the three fields. Turf was fertilized 5/24, 6/23, and 7/18 using 46-0-0 at 100 lb/A.

Turf color and quality were rated visually by UW personnel on June 8$^{th}$, July 12$^{th}$, and August 23$^{rd}$. One set of ratings were collected from each field using a one to nine scale (color: 1=brown turf, 9=dark green turf; quality: 1=necrotic turf, 9=dense, ideal turf). Sod tensile strength measurements were collected on the same dates. A walk-behind Ryan sod cutter was used to cut nine sod pieces each from treated and untreated areas. Depth settings were kept uniform throughout the trial. Three pieces of sod, approximately 5ft length x 1.5 ft width, were collected from each of three different areas separated by approximately 150 ft in each field for a total of nine untreated samples per field (Fig. 1). A second set of nine samples were collected from the Primo-treated strips from sites parallel to the untreated sample sites in each field. Tensile strength of sod pieces was determined with a mechanical sod stretcher device outfitted with a hydraulic control lever (Fig. 2) (Sorochan et al., 1999). The peak values required to tear each piece in half were determined using a digital force gauge (Chatillon Model DS).

Sod tensile strength data were analyzed as a paired t-test using the nine samples from each treatment within a field (MSTAT, 1988). Color and quality data were analyzed as a randomized complete block with three replications with fields as blocks. Weather data were obtained from General Mitchell Airport (Milwaukee, WI) approximately 15 miles NW of Jasperson sod farms.

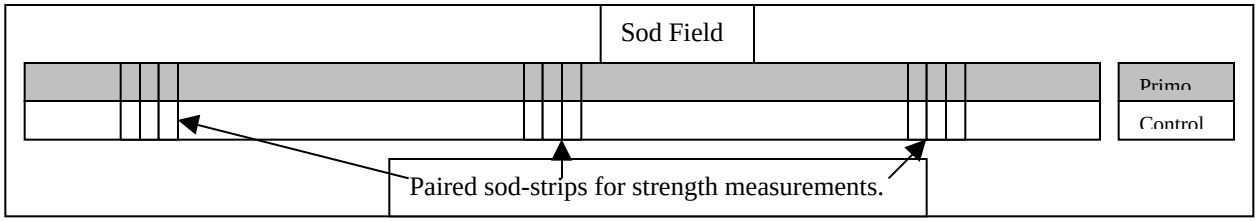


Fig. 1. Field map of sod harvesting for tensile strength measurements.

**RESULTS AND DISCUSSION**

Sod tensile strength was significantly improved by Primo applications in four of nine tests (Table 1 and Fig. 3, 4, 5). Primo did not affect sod strength on the other five test dates/sites. There were tremendous differences in sod strength among the three fields, with strengths ranging from 60 lbs in Field 2 to a high of 184 lb in Field 1 on the 23 August. Primo applications did not significantly affect turf color of quality (Table 2).

Sod was of harvestable quality in all three fields at all times. Sod that had values of less than 60 lbs of tensile strength were noticeably more prone to breakage than sod that had greater tensile strengths. Sod tensile strength in fields 1 and 2 increased over time, particularly between July and August. Sod tensile strength and establishment in field 2 actually decreased slightly throughout the growing season. This field appeared to stay wetter than fields one and three. In June it had significantly more leaf spot than fields 1 and 3. Although soil moisture was not monitored during the study, if the soil in field 2 was consistently saturated we would expect reduced root and rhizome growth regardless of growth regulator treatment as roots and rhizomes need oxygen for growth.

Climatic conditions were quite good for sod production from time of planting through end of the test period. Autumn growing conditions were unseasonably long with visible turf growth through mid-December. Winter conditions were fairly mild and spring arrived earlier than usual. Consistent, ample rainfall and moderate temperatures during the growing season produced little if any stress (Figs. 2 and 3).

The favorable environmental conditions were probably responsible for the apparent lack of Primo effect on sod color or quality. Although the Primo-treated turf often appeared darker in color than the untreated turf to the UW researchers, the differences were not apparent to Mr. Blair and were not statistically signficant. We have found Primo often has more significant improvements on turf color and quality when conditions are less favorable for turf growth, particularly in shaded conditions (Stier, 1999).

Primo should be most likely to have an effect on sod production during the spring when carbohydrate production and leaf sink strength for carbohydrates is high. During the fall, leaves photosynthesize but do not act as strong carbohydrate sinks, while roots and rhizomes continue to grow until the soil is frozen. Rhizomes are a greater sink for carbohydrates during the fall than at any other time of the year. Primo appears to alter photosynthate partitioning in the plant, resulting in more tiller, root, and rhizome production rather than leaf expansion (Stier, 1999). This effect would enhance sod formation. If the autumn of 1999 had been shorter, with less time

for root and rhizome production, the effects of Primo on sod strength would likely have been even more dramatic.

It is questionable whether fall application of Primo would benefit sod production because rhizomes are already strong carbohydrate sinks and leaf sink strength is minimal. Furthermore, although the sod was already fairly stable by June, sod strength increased dramatically between July and August in two of the three fields. We have also seen Primo treatments delay spring greenup of Kentucky bluegrass when applied four weeks before snowfall (J. Stier, unpublished data).

The significant differences in tensile strength between treated and untreated sod indicated Primo could be useful for decreasing the time interval necessary for sod production and for enhancing the strength of sod during handling. If the test is to be repeated in the future, Mr. Blair has agreed to apply the treatments in a randomized block design which would increase the power to detect treatment differences by accounting for field/site variations. Since we have had a more "typical" autumn, with air temperatures decreasing earlier and earlier snowfall, a repetition of the study in 2001 would likely yield more dramatic results than observed in 2000.

Table 1. Tensile strength of Kentucky bluegrass sod treated with Primo (trinexapac-ethyl , Franklin, WI, 2000.

| | Force to tear turf (lbs) | | | | | |
|---|---|---|---|---|---|---|
| | 18 June | | | | | |
| | Field 1 | | Field 2 | | Field 3 | |
| | Control | Treated | Control | Treated | Control | Treated |
| | 75.3 | 83.4 | 73.2 | 72.7 | **38.4** | **50.7** |
| p-value† | 0.29 | | 0.93 | | **0.04** | |
| | 21 July | | | | | |
| | Field 1 | | Field 2 | | Field 3 | |
| | Control | Treated | Control | Treated | Control | Treated |
| | **73.6** | **91.4** | **55.9** | **68.4** | 91.7 | 79.1 |
| p-value | **0.04** | | **0.006** | | 0.125 | |
| | 23 August | | | | | |
| | Field 1 | | Field 2 | | Field 3 | |
| | Control | Treated | Control | Treated | Control | Treated |
| | **132.4** | **184.0** | 62.7 | 60.4 | 132.8 | 128.8 |
| p-value | **0.0001** | | 0.39 | | 0.85 | |

† **Bold type** indicates results are statistically significant at $p<0.05$. Treatment means derived from nine samples per field ($n$=9) and analyzed as a paired t-test.

Table 2. Trinexapac-ethyl (Primo) effects on sod color and quality prior to harvest, Franklin, WI, 2000.

| | 18 June | | 21 July | | 23 August | |
|---|---|---|---|---|---|---|
| **Treatment** | **Color** | **Quality** | **Color** | **Quality** | **Color** | **Quality** |
| Untreated control | 5.7 | 5.3 | 5.7 | 5.8 | 5.5 | 5.5 |
| Primo-treated | 6.2 | 5.8 | 5.5 | 5.7 | 6.2 | 6.2 |
| Level of signficance | ns | ns | ns | ns | ns | ns |

ns = Not significant at p= 0.05. Data were analyzed as a randomized complete block with each of the three fields as a block.

## CONCLUSIONS

1) Three sequential applications of Primo during spring and summer significantly increased sod tensile strength on four of nine test dates/sites.
2) Turf color and quality were not significantly affected probably due to excellent growing conditions.
3) Results would likely be more dramatic under less favorable growing conditions, particularly under more typical autumn conditions following seeding.
4) The study is worth repeating in 2001.

## Literature Cited

Sorochan, J.C., R.N. Calhoun, J.N. Rogers, III. 1999. Apparatus to measure turfgrass sod strength. Agron. abstracts 91:137.

Stier, J.C. 1999. Growing grass in the shade. UW-Ext. bull. A3700.

Fig. 2. The sod stretch unit used in the study was operated with a hydraulic lever powered by an automobile battery. A force gauge was inserted between a pulley on the upright (vertical) unit and the stretching table (horizontal unit). Two clamps on the stretching table were used to hold the sod in place during stretching.

**Fig. 3. Primo Effects on Sod Strength, Field 1 Seeded 15 Aug 1999, Franklin, WI (2000).**

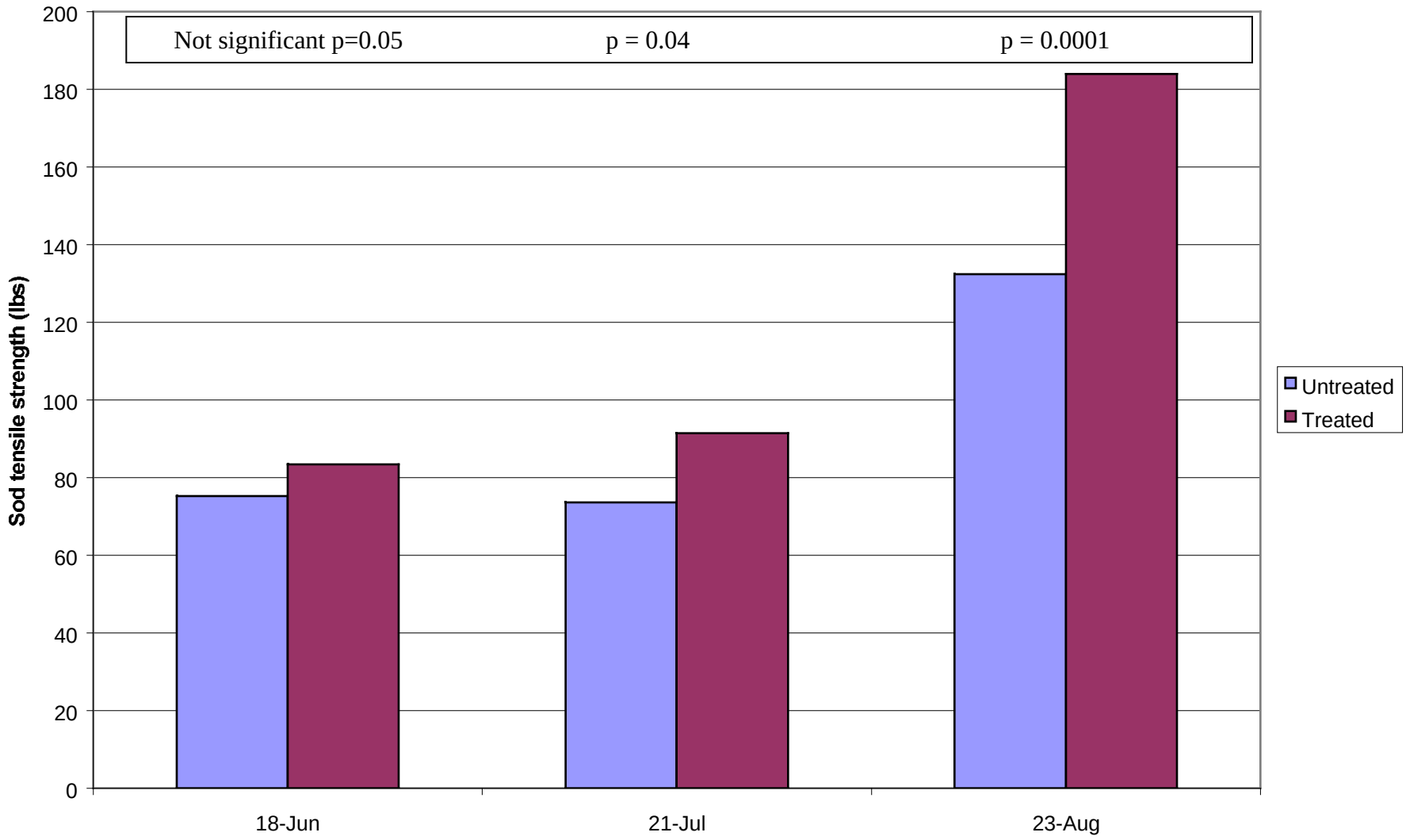


**Fig. 4. Primo Effects on Sod Strength, Field 2 Seeded 1 Sept. 1999, Franklin, WI (2000).**

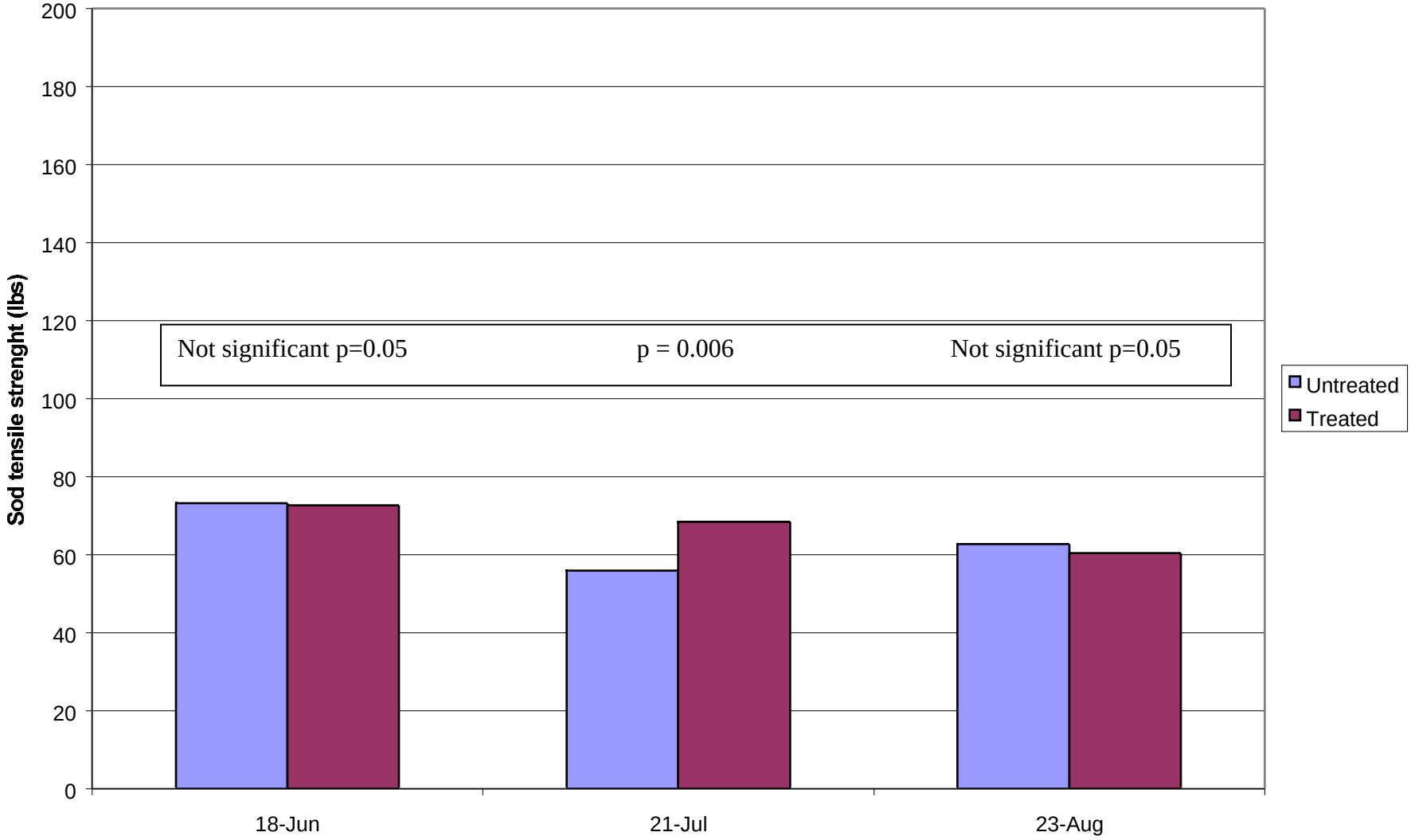


**Fig. 5. Primo Effects on Sod Strength, Field 3 Seeded 15 Sept. 1999, Franklin, WI (2000)**

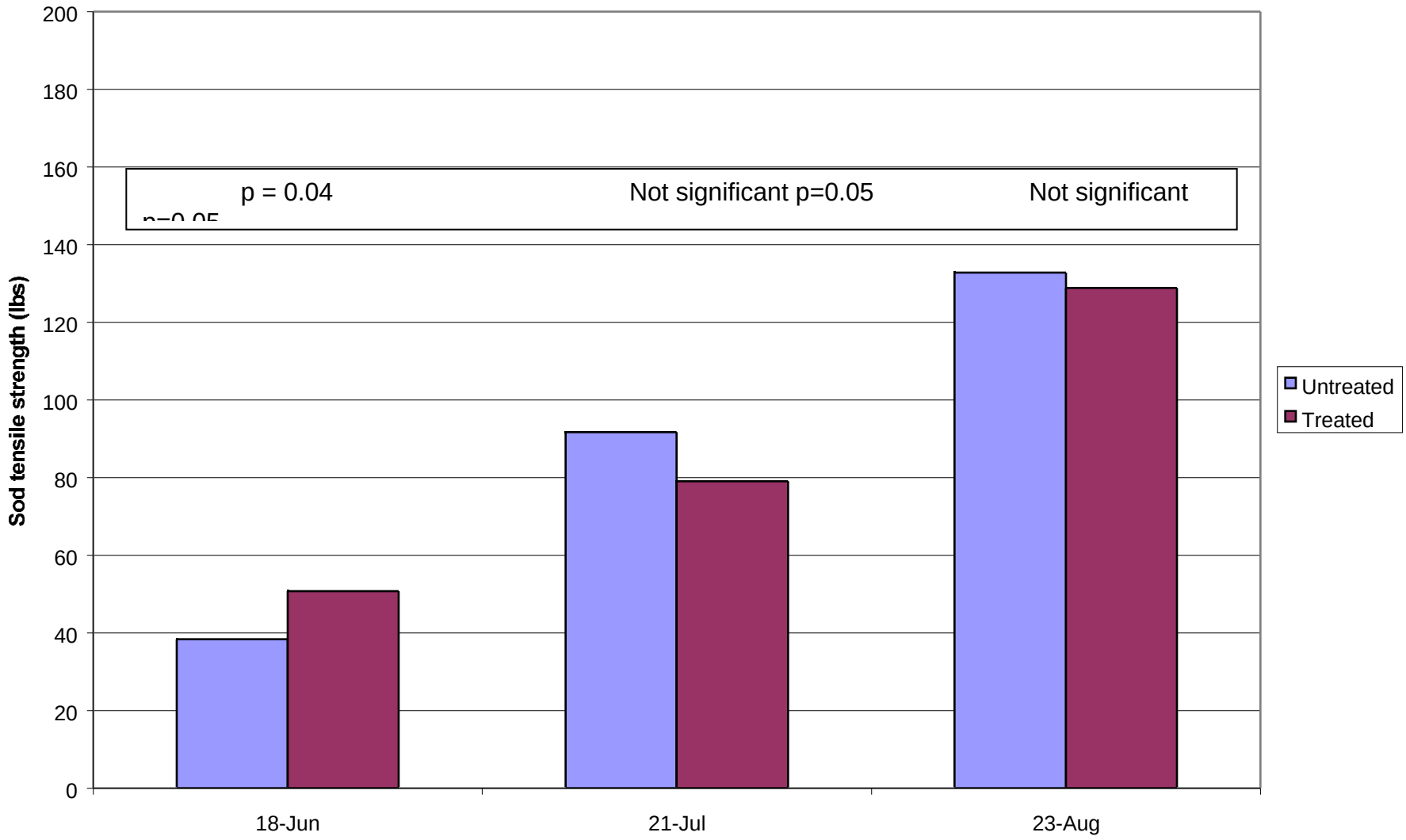


Fig. 6 Spring and SummerTemperatures for Sod Establishment Study with Primo, WI.

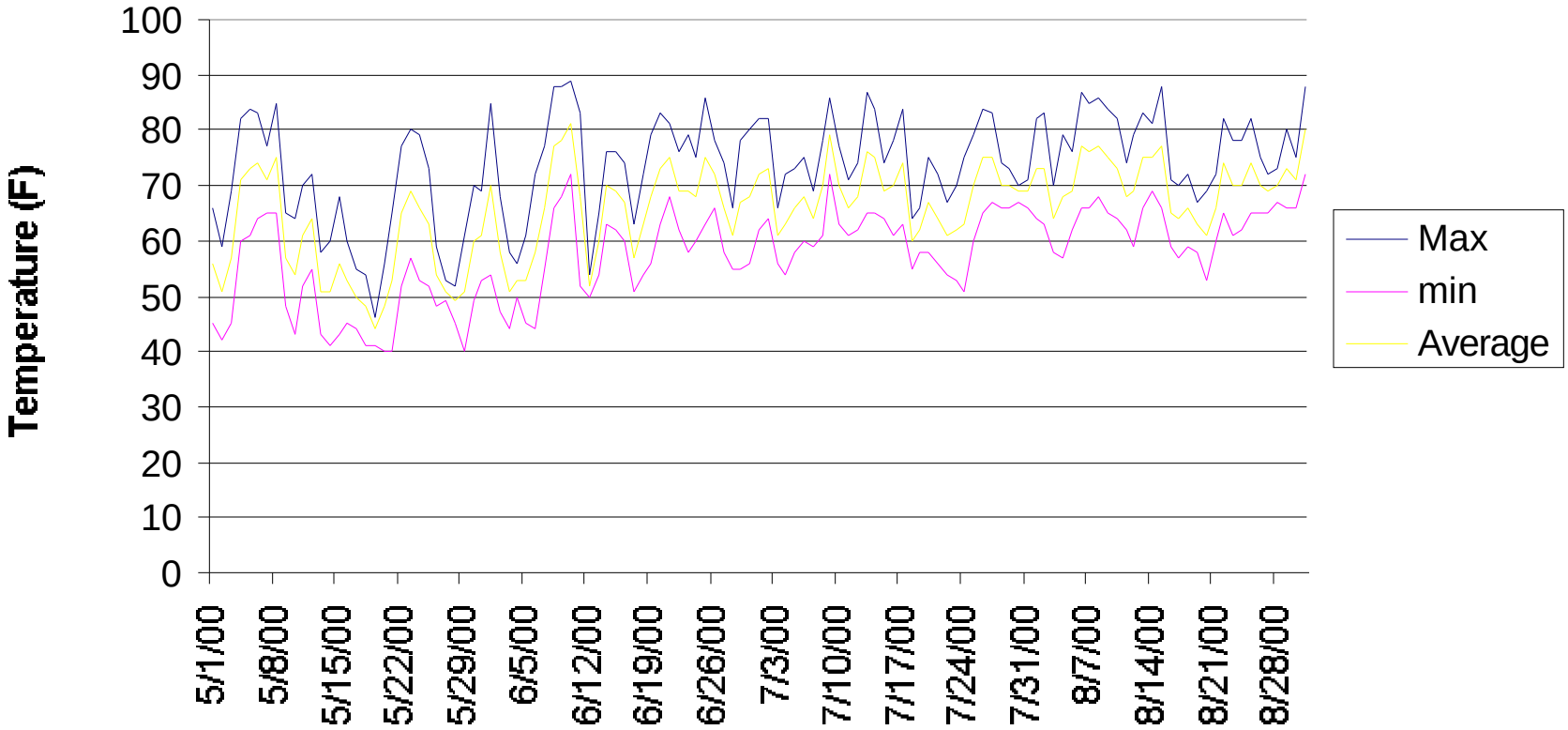
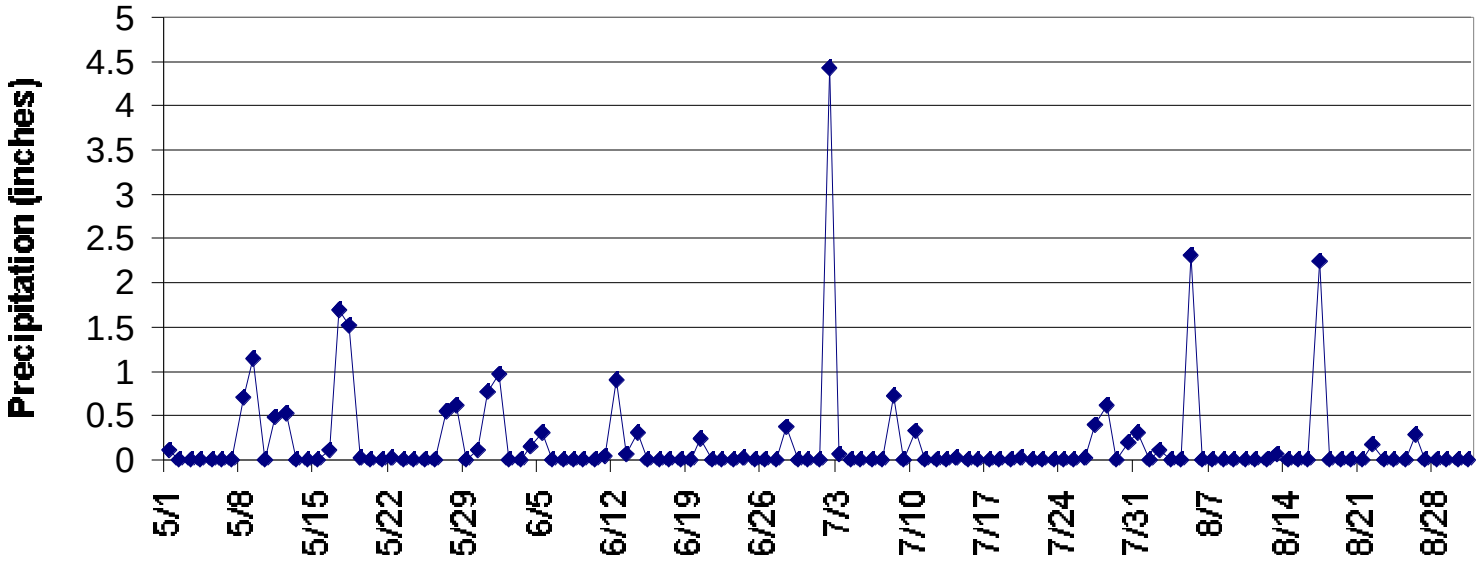


Fig. 7. Precipitation during 2000 Growing Season, General Mitchell Airport, Milwaukee, WI.



APPENDIX

# T-test results of Primo effects on sod tensile strength.

Field 1, 18 June 2000

| Untreated | Treated |
|---|---|
| Mean: 75.27 | Mean: 83.36 |
| Variance: 413.54 | Variance: 49.07 |
| Standard deviation: 20.34 | Standard deviation: 7.00 |

F-test for hypothesis “Mean 1 = Mean 2”

| | |
|---|---|
| Variance of the difference between means: | 51.5401 |
| Standard deviation of the difference: | 7.1791 |
| t’ value: | -1.1267 |
| Effective degrees of freedom: | 8 |
| Probability of t’: | 0.2925 |

Result: Non-significant t; Accept the hypothesis.

Field 2, 18 June 2000

| Untreated | Treated |
|---|---|
| Mean: 73.24 | Mean: 72.71 |
| Variance: 165.92 | Variance: 254.20 |
| Standard deviation: 12.88 | Standard deviation: 15.94 |

F-test for hypothesis “Mean 1 = Mean 2”

| | |
|---|---|
| Variance of the difference between means: | 33.8256 |
| Standard deviation of the difference: | 5.8160 |
| t’ value: | 0.0917 |
| Effective degrees of freedom: | 8 |
| Probability of t’: | 0.9292 |

Result: Non-significant t; Accept the hypothesis.

Field 3, 18 June 2000

| Untreated | Treated |
|---|---|
| Mean: 38.38 | Mean: 50.73 |
| Variance: 59.17 | Variance: 94.80 |
| Standard deviation: 7.69 | Standard deviation: 9.74 |

F-test for hypothesis “Mean 1 = Mean 2”

| | |
|---|---|
| Variance of the difference between means: | 25.5186 |
| Standard deviation of the difference: | 5.0516 |
| t’ value: | -2.4459 |
| Effective degrees of freedom: | 8 |
| **Probability of t’:** | **0.0402** |

Result: Significant t; Reject the hypothesis.

Field 1, 21 July 2000

| Untreated | Treated |
|---|---|
| Mean: 73.58 | Mean: 91.40 |
| Variance: 161.48 | Variance: 227.66 |
| Standard deviation: 12.71 | Standard deviation: 15.09 |

F-test for hypothesis “Mean 1 = Mean 2”

| | |
|---|---|
| Variance of the difference between means: | 54.2560 |
| Standard deviation of the difference: | 7.3659 |
| t’ value: | -2.4196 |
| Effective degrees of freedom: | 8 |
| **Probability of t’:** | **0.0419** |

Result: Significant t; Reject the hypothesis.

Field 2, 21 July 2000

| Untreated | Treated |
|---|---|
| Mean: 55.89 | Mean: 68.36 |
| Variance: 32.86 | Variance: 85.22 |
| Standard deviation: 5.73 | Standard deviation: 9.23 |

F-test for hypothesis “Mean 1 = Mean 2”

| | |
|---|---|
| Variance of the difference between means: | 11.4844 |
| Standard deviation of the difference: | 3.3889 |
| t’ value: | -3.6787 |
| Effective degrees of freedom: | 8 |
| **Probability of t’:** | **0.0062** |

Result: Significant t; Reject the hypothesis.

Field 3, 21 July 2000

| Untreated | Treated |
|---|---|
| Mean: 91.71 | Mean: 79.09 |
| Variance: 211.67 | Variance: 205.92 |
| Standard deviation: 14.55 | Standard deviation: 14.35 |

F-test for hypothesis "Mean 1 = Mean 2"

| | |
|---|---|
| Variance of the difference between means: | 54.3772 |
| Standard deviation of the difference: | 7.3741 |
| t' value: | 1.7117 |
| Effective degrees of freedom: | 8 |
| Probability of t': | 0.1253 |

Result: Non-Significant t; Accept the hypothesis.

Field 1, 23 August 2000

| Untreated | Treated |
|---|---|
| Mean: 132.40 | Mean: 184.04 |
| Variance: 457.42 | Variance: 572.12 |
| Standard deviation: 21.39 | Standard deviation: 23.92 |

F-test for hypothesis "Mean 1 = Mean 2"

| | |
|---|---|
| Variance of the difference between means: | 51.4753 |
| Standard deviation of the difference: | 7.1746 |
| t' value: | -7.1982 |
| Effective degrees of freedom: | 8 |
| **Probability of t':** | **0.0001** |

Result: Significant t; Reject the hypothesis.

Field 2, 23 August 2000

| Untreated | Treated |
|---|---|
| Mean: 62.73 | Mean: 60.42 |
| Variance: 55.92 | Variance: 59.28 |
| Standard deviation: 7.48 | Standard deviation: 7.70 |

F-test for hypothesis "Mean 1 = Mean 2"

| | |
|---|---|
| Variance of the difference between means: | 6.5757 |
| Standard deviation of the difference: | 2.5643 |
| t' value: | 0.9013 |
| Effective degrees of freedom: | 8 |

Probability of t': 0.3938

Result: Non-Significant t; Accept the hypothesis.

Field 3, 23 August 2000

| Untreated | Treated |
|---|---|
| Mean: 132.82 | Mean: 128.78 |
| Variance: 740.99 | Variance: 1850.20 |
| Standard deviation: 27.22 | Standard deviation: 43.01 |

F-test for hypothesis "Mean 1 = Mean 2"

Variance of the difference between means: 444.4164
Standard deviation of the difference: 21.0812
t' value: 0.1919
Effective degrees of freedom: 8
Probability of t': 0.8526

Result: Non-significant t; Accept the hypothesis.

Analysis of variance table for Primo effects on sod quality and color, summer 2000, Franklin, WI.

| Source | Degrees of freedom | Mean square | F-value | Probability |
|---|---|---|---|---|
| | Turf quality, 18 June 2000 | | | |
| Replication | 2 | 0.542 | 1.44 | 0.4091 |
| Treatment | 1 | 0.375 | 1.00 | 0.4226 |
| Error | 2 | 0.375 | | |
| Non-additive | 1 | 0.058 | 0.08 | |
| Residual | 1 | 0.692 | | |
| Total | 5 | | | |
| | Turf color, 18 June 2000 | | | |
| Replication | 2 | 1.042 | 2.78 | 0.2647 |
| Treatment | 1 | 0.375 | 1.00 | 0.4226 |
| Error | 2 | 0.375 | | |
| Non-additive | 1 | 0.75 | $-3.9 \times 10^{13}$ | |
| Residual | 1 | 0 | | |
| Total | 5 | | | |
| | Turf quality, 21 July 2000 | | | |
| **Replication** | 2 | 0.875 | 21.00 | 0.0455 |
| Treatment | 1 | 0.042 | 1.00 | 0.4226 |
| Error | 2 | 0.042 | | |

| | | | | |
|---|---|---|---|---|
| Non-additive | 1 | 0.036 | 0.75 | |
| Residual | 1 | 0.048 | | |
| Total | 5 | | | |
| | Turf color, 21 July 2000 | | | |
| Replication | 2 | 1.042 | 25.00 | 0.0385 |
| Treatment | 1 | 0.042 | 1.00 | 0.4226 |
| Error | 2 | 0.042 | | |
| Non-additive | 1 | 0.083 | $-5.8 \times 10^{12}$ | |
| Residual | 1 | 0.00 | | |
| Total | 5 | | | |
| | Turf quality, 23 August 2000 | | | |
| Replication | 2 | 0.292 | | 0.1250 |
| Treatment | 1 | 0.667 | | 0.0572 |
| Error | 2 | 0.042 | | |
| Non-additive | 1 | 0.048 | 1.33 | 0.4544 |
| Residual | 1 | 0.036 | | |
| Total | 5 | | | |
| | Turf color, 23 August 2000 | | | |
| Replication | 2 | 0.292 | 7.00 | 0.1250 |
| Treatment | 1 | 0.667 | 16.00 | 0.0572 |
| Error | 2 | 0.042 | | |
| Non-additive | 1 | 0.048 | 1.33 | 0.4544 |
| Residual | 1 | 0.036 | | |
| Total | 5 | | | |

# RAW DATA

*Sod Strength, lbs*

**6/8/00**

| | FIELD 1 | | | FIELD 2 | | | FIELD 3 | |
|---|---|---|---|---|---|---|---|---|
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 79.6 | 64.8 | | 51.4 | 80 | | 40.2 | 40.6 |
| South | 81.2 | 69.4 | South | 54.2 | 66.2 | West | 44.8 | 56.2 |
| | 84 | 68.4 | | 52 | 64.8 | | 45.8 | 38 |
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 84.8 | 86.4 | | 81.2 | 81.2 | | 56.4 | 40 |
| Central | 81.2 | 57.4 | Central | 79.2 | 46.8 | Central | 60 | 28.6 |
| | 75 | 54.2 | | 89 | 72.8 | | 70.2 | 32.4 |
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 94.6 | 85.8 | | 81.4 | 81.4 | | 44.2 | 34.8 |
| North | 75.8 | 121 | North | 91.4 | 91.4 | East | 51.2 | 36.4 |
| | 94 | 70 | | 74.6 | 74.6 | | 43.8 | 38.4 |
| quality | 6.5 | 5 | quality | 5 | 5 | quality | 6 | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| color | 6 | 5 | color | 6.5 | 7 | color | 6 | 5 |

**7/12/00**

| | FIELD 1 | | | FIELD 2 | | | FIELD 3 | |
|---|---|---|---|---|---|---|---|---|
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 99.8 | 82 | | 64 | 52.8 | | 92.4 | 120 |
| North | 109.4 | 69.4 | West | 76 | 57.6 | North | 93.2 | 76.8 |
| | 75.6 | 58.8 | | 72.6 | 47.6 | | 84.2 | 86.2 |
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 83.8 | 86.4 | | 75.6 | 52.6 | | 88.2 | 86.6 |
| Central | 72.4 | 68.8 | Central | 82.2 | 67.6 | Central | 79.6 | 88.6 |
| | 76.4 | 91.2 | | 66 | 54.8 | | 88.4 | 72.4 |
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 109.4 | 70.8 | | 57.2 | 56.2 | | 70.4 | 104.8 |
| South | 90 | 81.6 | East | 53.8 | 60.8 | South | 64.2 | 99.4 |
| | 105.8 | 53.2 | | 67.8 | 53 | | 51.2 | 90.6 |
| quality | 6 | 6.5 | quality | 6 | 6 | quality | 5 | 5 |
| color | 6 | 6 | color | 6 | 6 | color | 4.5 | 5 |

**8/23/00**

| | FIELD 1 | | | FIELD 2 | | | FIELD 3 | |
|---|---|---|---|---|---|---|---|---|
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 191.8 | 144.4 | | 49.6 | 57.6 | | 118.2 | 174.8 |
| North | 181.2 | 140.4 | West | 60.6 | 52.6 | North | 126.4 | 149.2 |
| | 177.8 | 113 | | 60.2 | 62 | | 110.8 | 152.8 |
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 202.4 | 150 | | 72 | 73.8 | | 95.4 | 151.6 |
| Central | 188.8 | 117.6 | Central | 55.4 | 67.4 | Central | 67.2 | 122 |
| | 207.8 | 174.6 | | 71.8 | 63.4 | | 100 | 129.2 |
| | treated | untreated | | treated | untreated | | treated | untreated |
| | 211.4 | 117.6 | | 52.2 | 55.8 | | 187.4 | 93 |
| South | 139.2 | 111 | East | 61.2 | 58.8 | South | 159.8 | 127.4 |
| | 156 | 123 | | 60.8 | 73.2 | | 193.8 | 95.4 |
| quality | 6 | 5.5 | quality | 6.5 | 6 | quality | 6 | 5 |
| color | 6 | 5.5 | color | 6.5 | 6 | color | 6 | 5 |

all units are in lbs.
peak values were recorded