SCOTTS CONTEC FERTILIZER STUDY-1998

University of Arizona Karsten Turfgrass Research Facility
Gilbert, Jeffrey J., and David M. Kopec

ABSTRACT

Three slow release fertilizers were evaluated (Contec O.M. Scotts) for turfgrass performance on an overseeded Tifway bermudagrass green from May to October 1998. Products were applied on four dates at the rate of 0.5 and 1.50 lbs. actual -N- per thousand square feet. All fertilizer regime showed little response from June-July for turfgrass clippings, color and quality. After July, differences in color and clippings were detected on X out of X evaluation dates. In general, release/conversion responses occurred approximately one month after application. When coupled with subsequent series applications, the combination of released nitrogen with the water soluble component (approximately 10%) caused the greatest turf response. Clipping production was greatest for the X at the rate of X. Transition from ryegrass to bermudagrass was not affected by fertilizer rate. Additional rates should be tested to investigate seasonal performance of these fertilizers on bermudagrass turfs.

INTRODUCTION

An important aspect of any turfgrass cultural management program involves the use of fertilizers. Whether the turf is in a home lawn or at a golf course, fertilizers can enhance turfgrass growth. Some fertilizers produce very rapid growth soon after application, and just a quickly seem to run their course. This excessive turfgrass growth is often unwanted and may necessitate more frequent mowing and can also increase total water use. These types of fertilizers usually contain rapidly available nitrogen as a major compound. Use of these fertilizers requires light and frequent applications in order to avoid excessive turf growth. Fertilizers with slowly available nitrogen provide an alternative to light and frequent fertilizer application, but may also have some limitations. Nitrogen release is often dependent on temperature and can make availability too slow. Also, where multiple grass species are grown, such as in the southwest, nitrogen carry over and lack of fertilizer control can be a problem.

MATERIALS and METHODS:

A seven year old 'Tifgreen' Bermudagrass established on a United States Golf Association (USGA) specified sand-based green served as the sight for this fertilizer trial. Perennial ryegrass overseed was established at 35 lb. per 1000 ft^2 during the previous fall of 1997. The turfgrass was mowed at a putting green height of 5/32" six days per week. All other management practices (i.e., topdressing & aeration) were consistent with high quality golf course greens. Three *Scotts Contec* fertilizer formulations, '*19-3-19*', '*19-2-15*' and '*18-9-18*' were applied monthly at rates of 0.5 or 1.0 lb. nitrogen per 1000 ft^2. Initial fertilizer applications were made on 27 May, 1998, and were followed by

---

This is a part of the University of Arizona College of Agriculture 2001 Turfgrass and Ornamental Research Report, index at: http://ag.arizona.edu/pubs/crops/az1246/

applications on 30 June, 28 July, 28 August and 1 October, 1998. Individual experimental units were 3'wide by 7'long and were arranged in a completely randomized design with four replications (28 plots total). Data collection consisted of visual estimates for color, quality, density, uniformity and percent ryegrass. For these data, the National Turfgrass Evaluation Program (NTEP) scale of 1-9 was utilized. Values of 6 or better are considered acceptable for putting green quality turfgrass with scores of 9 being the most desirable. Biomass production was determined by collecting clippings on a weekly basis from plots which had no more than two days growth. All clipping data were normalized for analysis and represent grams per square meter per day. Data were subjected to analysis of variance and Duncan's multiple range test was used for means separation when treatment F value occurred at P=0.05, or less. Orthogonal polynomial contrasts were utilized to test the main effects of fertilizer 'formulation type' and 'application rate' levels and any interaction between the two.

RESULTS

COLOR:

Color is a commonly used visual indicator of turfgrass response to applied fertilizer. Turfgrass color was significantly affected by applied fertilizer on six dates (Table 1). Four of these dates occurred after the fourth fertilizer application series in September. There were also significant treatment affects on 3 August, six days after the third fertilizer treatment series (6 DAT #3) and on the last day visual observations were made on the fifth treatment series (10 DAT #5).There were no visible differences in turfgrass color from either of the first two applications, starting from the end of May to the end of July. On the six dates, '*19-3-19*' at the one lb. per 1000 ft^2 rate provided color scores from 6.5 - 8, giving a medium to dark green turf. The average seasonal color score for '*19-3-19*' at 1 lb. was 6.7, ranking second overall (Table 1). Although non-significant, '*19-2-15*' at 1 lb. per 1000 ft^2 showed slightly better color on most dates with the highest average overall score of 6.8 (Table 1). On 3,10 and 17 of September and 9 and 11 October, the non-fertilized control showed significantly lower color scores compared to turf receiving any of the three fertilizer formulations applied at either rate.

Color scores observed on 3 August showed the non-treated control to have significantly darker turf appearance than turf receiving fertilizer. These observations may have resulted from a temporary salt effect. On 25 September (28 DAT #4), the non-fertilized control had similar color to '*19-2-15*' and '*18-9-18*', both applied at 0.5 lb., and ranked significantly lower to either '*18-9-18*' or '*19-3-19*' at the 1.0 lb. rate. The darker color response of the non-fertilized control, although non-significant, also occurred on 25 June (29 DAT #1), 16 July (16 DAT #2) 28 July (28 DAT #2) and 14 August (17 DAT #3). Of the five dates in which the non-fertilized control showed darker turf color, three occur within the first seventeen days following a fertilizer application series (Table 1). This may suggest that turfgrass discoloration is brought on by a fast release of available nitrogen present in these fertilizer formulations, causing some salt effect. This conclusion is also reinforced by the slightly lower color scores (lighter colored turf) observed on these same five dates for '*18-9-18*' especially at the one lb. per 1000 ft^2 rate. This formulation ('*18-9-18*') contained the highest percentage of fast release nitrogen (63%) of the fertilizers tested. The two remaining dates in which darker color response was noted for the non-fertilized control (25 June & 28 July) occurred on the last day observations were made for a given treatment series. In June, day/night temperatures reached 107° and 70° F, respectively, resulting in high evaporative demand. However, the non-fertilized control plots still had approximately 18% ryegrass on 25 June (Table 3). The combination of high temperatures and a slow transition to Bermudagrass may explain the slightly darker color scores observed (ryegrass has a darker genetic green color than Bermudagrass) as well as the significantly increased clipping production on 25 June (Tables 1&2).It is also noted that fertilizer applications and formulations did not affect transition at any time (Table 3). On 28 July, increased clipping production on turf receiving fertilizer (as compared to non-fertilized control) resulted in slight chlorosis, possibly due to a deficiency in both iron and manganese. However, the '*19-2-15*' fertilizer formulation which contains several micronutrients ,including both iron and manganese showed better color scores throughout the trial, indicating that a deficiency or imbalance in iron and manganese may have occurred on 28 July. Soil or tissue tests would be required to confirm this hypothesis.

On most dates turfgrass color was acceptable under all fertilizer regimes used, including no fertilizer application at all. Color scores below six would be considered less than acceptable and occurred infrequently throughout the trial. Contrasts made between the two fertilizer rates used (0.5 Vs. 1.0 lb. N per 1000 ft^2) was significant on four dates (Table 1). Here turf receiving the higher fertilizer rate showed significant color improvement over turf fertilized at

0.5 lb. N per 1000 ft^2. The trend for darker color scores with application of 1.0 lb. N per 1000 ft^2 can be seen on several observation dates (Table 1). No significant affects were observed when contrasting formulation or formula-by-rate. Contrast coefficients were applied to fertilized plots only, and were orthogonal in order to have the highest possible power to estimate the main effects (formulation and rate) and any potential interactions between the two.

CLIPPINGS:

Clipping production was significantly affected by fertilizer regimes on seven evaluation dates (Table 2). There were also significant differences when clippings were summed over the entire growing season (Table 2). The majority of significant treatment affects for clipping biomass production generally occurred from 28 days after fertilizer application series #2 through series #5. The remaining two dates occurred on 25 June (29 DAT #1) and 2 July (2 DAT #2), showing significant differences for treatment and a formulation-by-rate interaction, respectively. Interactions as well as the significance observed for total grams will be discussed later.

As explained in the discussion for color responses, 25 June occurred during a period marked by high temperatures and high evapotranspiration (ETo) with non-fertilized controls having the most (although non-significantly different) visible ryegrass present. High air temperatures and more importantly high soil temperatures cause cool-season grasses to respire, resulting in a decrease in root growth in favor of shoot growth. Therefore, weather conditions most likely resulted in the production of significantly greater biomass on the non-fertilized (high ryegrass) control plots on 25 June (Table 2). Anticipated response of a nitrogen enhanced transition from ryegrass to Bermudagrass was not realized at any time during the test (Table 3).

Fertilizer formula-by-rate interactions (at p=0.1) were observed on 2 July (2 DAT #2), 28 July (28 DAT #2) and on 12 August (15 DAT #3). The interactions on 2 July were caused by a decrease in clipping production from '*19-3-19*' at the 1.0 lb. rate compared to the 0.5 lb. rate of the same formulation. This was most likely due to a slight salt effect from the rapidly released nitrogen in '*19-3-19*' which made up 57% of the total available nitrogen. Similar observations may have been noted had data been collected within two to four days after fertilizers were applied throughout the experiment. Formula-by-rate interactions on 28 July and 12 August show increases in clipping production with application of the 1.0 lb. rate of '*19-2-15*' and '*18-9-18*', respectively (Table 2). This trend was expected, however on these dates increasing application rates of the remaining formulations from 0.5 to 1.0 lb. produced less biomass, causing the interaction. Contrast made for overall fertilizer rates were significant at P=0.10 on 22 July (22 DAT #2). As expected, increases in the applied nitrogen resulted in increases in biomass (clippings). This trend, although non-significant can be observed on most dates with the few exceptions described earlier.

For the remaining five dates in which there were significant treatment affects, the non-fertilized control produced the least clippings. On 28 July (28 DAT #2), '*19-3-19*' at the 0.5 lb. rate produced significantly more clippings than either '*19-2-15*' at 0.5 lb. or the non-fertilized control (Table 2). The 0.5 lb. rate of '*19-3-19*' again showed significantly greater clippings compared to the same formulation at the 1 lb. rate and the non-fertilized control on 12 August (15 DAT #3) (Table 2). On 5 September (8 DAT #4) and 17 September (20 DAT #4) '*19-3-19*' at the 1.0 lb. rate showed significant increases in clippings compared to the non-fertilized control. At 8 DAT #5 on 9 October all fertilizer regimes produced significantly more clippings than did the non-fertilized control (Table 2). Differences in clipping production at this time is probably the result of a conversion of the accumulated slow-release component from each these fertilizers. On 9 October there was also a contrast (P=0.1) for fertilizer formulation in which '*18-9-18*' showed slightly greater clipping production (Table 2).

Seasonal totals for collected clippings demonstrate that '*19-3-19*' at the 0.5 lb. rate produced significantly more clippings than '*19-2-15*', also at the 0.5 lb. application rate (Table 2). Both '*19-3-19*' and '*18-9-18*' show somewhat less, but nonsignificantly different, total seasonal clippings when applied at the 1.0 lb. rate as compared to the 0.5 lb. rate (Table 2). Only '*19-2-15*' showed an increase in total clipping production when applied at the 1.0 lb. rate. Ratios of slow to fast release nitrogen in the three formulations tested may provide insight as to the slowed growth rate with applications of the fertilizers having the lowest ratios of slow release nitrogen. Both '*18-9-18*' and '*19-3-19*' had the highest percentages of rapidly available nitrogen at 11.3% and 10.8%, respectively. '*19-2-15*' had the lowest percentage of fast release nitrogen at 10.4%. As mentioned, there may have been a slight initial salt affect when these fertilizers were applied. This salt affect may have caused a stress response in the turfgrass, slowing shoot growth. In contrast, larger percentages of slowly available nitrogen as in '*19-2-15*' may have provided more consistent turfgrass growth over the entire season.

Overall, clipping production for all fertilizer regimes peaked during late June and early July. A few cycles of increased clipping production can be seen throughout the season and are attributed to either fertilizer availability, environmental conditions, or both. In some instances, for example on 25 June, 28 July and 18 August (Table 2), increased growth occurred at the end of a given fertilizer series. The explanation for observed growth on 25 June has already been discussed and is most likely due to the large presence of ryegrass. Both the accumulation of slow release fertilizer components from previous application series as well as the quick release components are responsible for increases in clipping production observed later in the season. As mentioned , significant treatment affects for clipping production were more apparent during the last half of the test. This was probably due to increased available nitrogen from accumulated conversion of the slow-release component coupled with subsequent series applications providing quick-release nitrogen. These two component features resulted in increased available nitrogen to the turfgrass. Recent rains and a general increase in the relative humidity (monsoons) can also be associated with increased clippings on 28 July and 18 August.

QUALITY:

Overall turfgrass quality was not affected to any great extent by the fertilizer regimes tested here (Table 4). No adverse affects were detected visually from the application of these fertilizers applied at rates and/or frequencies utilized in this trial. Significant treatment affects were observed on 10 September and 9 October. On both dates, the non-fertilized control provided quality scores that were slightly less than acceptable and significantly lower than turf plots receiving any of the fertilizers. These dates were also the only two times during the trial in which visual quality was lower than six (6) for any fertilizer regime. This decrease in quality is not unexpected for the non-fertilized control, which by the end of the experiment had not received nitrogen or any other fertilizer for over five months. The contrast for fertilizer rate was significant on three dates and showed an expected trend for increased quality with increases in applied nitrogen (Table 4).

CONCLUSIONS:

Growth curves based on clipping production for all fertilizer regimes observed over the early summer season from 4 June to 22 July differed very little and were not substantially different from that of the non-fertilized control. Turfgrass appearance (color & quality) was also minimally affected, either positively or negatively by individual fertilizer regimes. Fertilizer affects took place more so at the end of the summer and were probably a result of the accumulation of slow-release fertilizer components and their conversion as well as more favorable Bermudagrass growing conditions. Based on these criteria (color & clippings) there seems to be a justification for either (1) shortening the interval between fertilizer applications and/or (2) possibly changing the nitrogen application rates. Enhanced fertilizer application rates should be evaluated . Bermudagrass, especially on sand-based greens may benefit from as much as four or more pounds of nitrogen per 1000 ft^2 per growing month. Further investigation of rate affects are also warranted and should include sampling dates for clippings within a few days of fertilizer application. Soil and tissue testing for nitrogen may assist in modeling release patterns of fertilizer-N and the potential for nutrition imbalance in turfgrass.

Table 1	Î				Ï			Ð			Ñ					Ò		
COLOR	***27-May*** 0 DAT	***3-Jun*** 7 DAT #1	***10-Jun*** 14 DAT #1	***25-Jun*** 29 DAT #1	***9-Jul*** 9 DAT #2	***16-Jul*** 16 DAT #2	***22-Jul*** 22 DAT #2	***28-Jul*** 28 DAT #2	***3-Aug*** 6 DAT #3	***14-Aug*** 17 DAT #3	***28-Aug*** 31 DAT #3	***3-Sep*** 6 DAT #4	***10-Sep*** 13 DAT #4	***17-Sep*** 20 DAT #4	***25-Sep*** 28 DAT #4	***1-Oct*** 33 DAT #4	***9-Oct*** 8 DAT #5	***avg. color***
19-3-19 @ 0.5	7.0	6.5	6.3	6.3	6.3	5.5	6.8	6.3	6.0	6.3	5.8	6.8	6.8	7.3	6.5	6.3	7.0	***6.4***
19-3-19 @ 1.0	7.0	6.5	6.3	6.0	6.5	5.8	6.5	6.8	6.5	6.8	6.3	7.0	6.8	7.8	7.0	6.8	8.0	***6.7***
18-9-18 @ 0.5	7.0	6.8	6.3	6.5	6.5	6.0	6.5	6.5	6.8	7.0	6.3	6.3	6.8	7.0	6.3	6.5	6.8	***6.6***
18-9-18 @ 1.0	7.0	6.3	6.0	5.8	6.3	5.5	6.8	6.5	5.8	6.5	6.5	6.8	6.8	7.3	7.0	6.3	7.8	***6.5***
19-2-15 @ 0.5	7.0	6.5	5.8	6.0	6.8	5.8	6.5	6.3	6.3	6.5	6.3	6.5	6.3	6.8	6.3	6.8	6.8	***6.4***
19-2-15 @ 1.0	7.0	7.0	6.3	6.0	6.5	6.0	6.8	7.0	6.8	7.0	6.8	6.5	7.0	7.3	6.5	6.8	7.8	***6.8***
Control	7.0	6.5	6.0	6.8	6.5	6.3	6.8	7.3	7.3	7.3	6.0	6.0	6.0	6.5	6.0	6.0	5.5	***6.4***
Test Mean	***7.0***	***6.6***	***6.1***	***6.2***	***6.5***	***5.8***	***6.6***	***6.6***	***6.5***	***6.8***	***6.3***	***6.5***	***6.6***	***7.1***	***6.5***	***6.5***	***7.1***	***6.5***
LSD	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*1.23*	*N/A*	*N/A*	*0.66*	*0.62*	*0.95*	*0.6*	*N/A*	*0.64*	*N/A*

Contrast and Significance

Formulation	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
Rate	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	r	*n.s.*	*n.s.*	r	*n.s.*	*n.s.*	*n.s.*	r r	*n.s.*	r r
F x R	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*

r = 0.1 level of significance   r r = 0.05 level of significance

Î initial fertilizer applied 5-27-98.
Ï second fertilizer series 6-30-98
Ð third fertilizer series 7-28-98
Ñ fourth fertilizer series 8-28-98
Ò fifth fertilizer series 10-1-98

Table 2

CLIPPINGS	Î 4-Jun 8 DAT #1	10-Jun 14 DAT #1	25-Jun 29 DAT #1	Ï 2-Jul 2 DAT #2	8-Jul 8 DAT #2	15-Jul 15 DAT #2	22-Jul 22 DAT #2	Ð 28-Jul 28 DAT #2	12-Aug 15 DAT #3	18-Aug 21 DAT #3	Ñ 5-Sep 8 DAT #4	17-Aug 20 DAT #4	23-Sep 26 DAT #4	30-Sep 33 DAT #4	Ò 9-Oct 8 DAT #5	Total grams
19-3-19 @ 0.5	4.78	8.18	11.44	9.99	11.97	6.40	6.51	10.46	5.10	9.00	4.64	3.17	3.04	3.19	3.28	**101.13**
19-3-19 @ 1.0	5.02	7.86	11.52	9.45	12.09	6.03	6.79	8.33	3.41	9.25	5.00	3.59	3.27	2.83	3.31	**97.72**
18-9-18 @ 0.5	5.28	8.24	12.32	9.38	12.20	5.53	6.25	9.00	3.52	7.71	4.63	3.55	3.26	2.91	3.77	**97.55**
18-9-18 @ 1.0	4.63	7.52	12.43	9.61	11.30	5.80	6.66	8.72	4.33	7.40	4.83	3.47	3.40	3.00	3.74	**96.83**
19-2-15 @ 0.5	4.49	7.19	11.01	9.25	11.89	5.87	6.10	7.58	3.57	6.88	3.96	3.13	2.94	2.56	3.49	**89.85**
19-2-15 @ 1.0	5.65	7.87	12.20	9.98	12.21	5.70	6.50	8.84	3.60	8.70	4.81	3.28	3.15	2.97	3.27	**98.70**
Control	4.49	7.32	14.07	9.75	11.14	5.67	6.12	7.30	3.09	7.79	3.41	2.85	2.64	3.01	2.37	**91.01**
Test Mean	**4.91**	**7.74**	**12.14**	**9.63**	**11.83**	**5.86**	**6.41**	**8.60**	**3.80**	**8.10**	**4.47**	**3.29**	**3.10**	**2.92**	**3.32**	**96.11**
LSD	*N/A*	*N/A*	*2.58*	*N/A*	*N/A*	*N/A*	*N/A*	*1.99*	*1.46*	*N/A*	*1.37*	*0.63*	*N/A*	*N/A*	*0.64*	*9.89*
Contrast and Significance																
Formulation	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*r*	
Rate	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*r*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	
F x R	*n.s.*	*n.s.*	*n.s.*	*r*	*n.s.*	*n.s.*	*n.s.*	*r*	*r*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	

r = 0.1 level of significance
r r = 0.05 level of significance

Î initial fertilizer applied 5-27-98
Ï second fertilizer series 6-30-98
Ð third fertilizer series 7-28-98
Ñ fourth fertilizer series 8-28-98
Ò fifth fertilizer series 10-1-98

Table 3 Ï

%-RYE	*3-Jun*	*10-Jun*	*25-Jun*	*9-Jul*	*16-Jul*
	7 DAT #1	14 DAT #1	29 DAT #1	9 DAT #2	16 DAT #2
19-3-19 @ 0.5	66.3	38.8	15.3	7.8	3.8
19-3-19 @ 1.0	68.8	36.3	14.3	5.8	3.8
18-9-18 @ 0.5	68.8	42.5	17.3	7.0	3.5
18-9-18 @ 1.0	66.3	37.5	12.8	7.3	3.5
19-2-15 @ 0.5	68.8	37.5	13.0	6.3	3.5
19-2-15 @ 1.0	71.3	45.0	15.8	7.5	4.3
Control	67.5	38.8	17.8	5.8	4.5
Test Mean	***68.2***	***39.5***	***15.1***	***6.8***	***3.8***
LSD	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Contrast and Significance					
Formulation	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
Rate	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
F x R	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*

r = 0.1 level of significance
r r = 0.05 level of significance

Î initial fertilizer applied 5-27-98.
Ï second fertilizer series 6-30-98
Ð third fertilizer series 7-28-98
Ñ fourth fertilizer series 8-28-98
Ò fifth fertilizer series 10-1-98

Table 4

QUALITY	Î				Ï			Ð			Ñ					Ò		
	27-May 0 DAT	***3-Jun*** 7 DAT #1	***10-Jun*** 14 DAT #1	***25-Jun*** 29 DAT #1	***9-Jul*** 9 DAT #2	***16-Jul*** 16 DAT #2	***22-Jul*** 22 DAT #2	***28-Jul*** 28 DAT #2	***3-Aug*** 6 DAT #3	***14-Aug*** 17 DAT #3	***28-Aug*** 31 DAT #3	***3-Sep*** 6 DAT #4	***10-Sep*** 13 DAT #4	***17-Sep*** 20 DAT #4	***25-Sep*** 28 DAT #4	***1-Oct*** 33 DAT #4	***9-Oct*** 8 DAT #5	**avg. quality**
19-3-19 @ 0.5	7.8	8.0	7.0	6.8	6.3	6.3	6.3	5.8	6.3	6.3	6.0	6.3	6.8	6.5	6.5	6.0	6.0	***6.5***
19-3-19 @ 1.0	7.5	8.0	6.5	6.5	7.0	6.5	6.3	5.8	6.5	6.5	6.0	6.3	6.8	7.0	6.8	6.5	6.3	***6.6***
18-9-18 @ 0.5	7.8	8.0	7.0	6.8	6.3	6.0	6.3	6.3	6.3	6.8	6.5	6.5	6.8	6.5	6.3	5.8	6.3	***6.6***
18-9-18 @ 1.0	7.5	7.8	6.3	6.0	6.8	6.3	6.3	5.8	5.5	6.3	6.3	6.3	7.0	7.0	6.5	6.5	6.0	***6.5***
19-2-15 @ 0.5	7.8	7.8	6.5	5.8	6.5	6.5	5.8	5.5	6.0	6.0	6.3	6.0	6.0	6.5	6.5	6.3	5.8	***6.3***
19-2-15 @ 1.0	7.5	8.3	6.3	6.5	6.8	6.3	6.8	6.0	6.3	7.0	6.5	6.8	6.8	7.0	6.5	6.5	6.5	***6.7***
Control	7.5	7.8	6.5	7.0	6.5	7.0	6.5	6.3	6.5	6.8	6.8	6.3	5.8	6.5	6.5	6.3	5.3	***6.6***
Test Mean	***7.6***	***7.9***	***6.6***	***6.5***	***6.6***	***6.4***	***6.3***	***5.9***	***6.2***	***6.5***	***6.3***	***6.3***	***6.5***	***6.7***	***6.5***	***6.3***	***6.0***	***6.5***
LSD	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*0.77*	*N/A*	*N/A*	*N/A*	*0.79*	*N/A*
Contrast and Significance																		
Formulation	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	
Rate	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*r r*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*r*	*n.s.*	*r*	*n.s.*	
F x R	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	

r = 0.1 level of significance
r r = 0.05 level of significance

Î initial fertilizer applied 5-27-98.
Ï second fertilizer series 6-30-98
Ð third fertilizer series 7-28-98
Ñ fourth fertilizer series 8-28-98
Ò fifth fertilizer series 10-1-98

Appendix Table A. Contec Fertilizer Formulation Percentage of Nitrogen

	Slow-Release		Fast-Release	
Formulation	%-N by weight	%-of total -N	%-N by weight	%-of total -N
18-9-18	6.7	37.2	11.3	62.8
19-3-19	8.2	43.2	10.8	56.8
19-2-15	8.6	45.3	10.4	54.7