STRIP TILLAGE – N MANAGEMENT FOR EARLY FALL N APPLICATIONS

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Introduction/Objectives

For sugarbeet growers considering strip-tillage, nitrogen (N) management is an important concern. When to apply N and what source of N to use in strip tillage systems are questions that have not been addressed specifically for the soils of the Red River Valley. Timing of N fertilizer in the fall is a management issue that requires some understanding of the biological transformations that convert anhydrous ammonia and urea to nitrate. Nitrogen in the form of nitrate is much more susceptible to leaching and denitrification than nitrogen in other forms. In the Red River Valley, soils are cold enough during winter to prevent urea and ammonia from converting to nitrate and subsequently leaching or denitrifying, but early fall applications are not recommended. Spring flooding and snow melt make spring leaching and denitrification possible as well. Therefore, it is currently not recommended to apply nitrate fertilizers until spring in this area. Fall application of anhydrous ammonia and urea is effective in the Red River Valley except on sandy soils, soils near rivers and streams, and soils with high water tables (Franzen, 2003). Recommendations for fall anhydrous ammonia application stipulate application only after October 1st (later for urea) and only then when soil temperature at four inch depth is below 50º F between 6am and 8am. It is understandable that early fall application of N fertilizer is tempting because growers have a relatively slow labor period after harvesting small grain crops. Because of this convenient time-gap in early fall after small grain harvest, recommendations for N application timing are not always followed.

Slow-release fertilizer formulations have become easier to handle and more affordable in recent years. Methylated urea products, in particular, are showing promise for wheat cropping systems in the Palouse region of Washington. A representative for one of the slow-release products indicated that their product is about the same price per unit of usable N as anhydrous ammonia. A representative from another slow-release company indicated that the price per unit of N is higher than for anhydrous ammonia, but that its use on wheat in the Palouse region of Washington state should be an indication that the price point is feasible for small grain producers. If this is the case across the slow-release market, then using these products should not be cost-prohibitive for sugarbeet production. **The objective of this study was to determine if slow release fertilizers may allow farmers to apply N fertilizer to fields earlier in the fall without risk of denitrification or leaching because the slow release materials inhibit nitrification.** If this were shown to be the case, then farmers would have a more flexible window for N fertilization and could take advantage of the relatively slow time following small grain harvest to apply slow release fertilizers without the risk of economic and environmental loss resulting from N loss from fields. If these products can be used in strip tillage systems earlier in the fall without loss of N to leaching and denitrification, it would make strip tillage a more attractive system for Red River Valley sugarbeet producers. This is because tillage and fertilization could be done at the same time and on a more flexible schedule, rather than waiting for the soil temperatures to become low enough to avoid substantial N losses inherent to anhydrous ammonia and urea fertilizers. It could also reduce the risk of losing N to leaching and denitrification in the early spring, when soils are saturated.

In this study, we tested 3 slow-release fertilizer formulations (GP 30/70, GP 20/80, and KQXRN) against 4 non-slow release N fertilizer sources (urea, UAN, 10-34-0, and 15-16-2) along with one non-N fertilizer (K Thiosulfate) at three different application times (early fall with strip-tillage, late fall with strip-tillage, and at planting). Treatments are identified as below:

1. GP 20/80 Early Fall application
2. GP 20/80 Late Fall application
3. GP 20/80 Spring application
4. GP 30/70 Early Fall application
5. GP 30/70 Late Fall application
6. GP 30/70 Spring application
7. KQXRN Early Fall application
8. KQXRN Late Fall application
9. KQXRN Spring application
10. Urea Late Fall application
11. Urea Spring application
12. 10-34-0 + UAN spring application

13. 15-16-2 + UAN spring application
14. K Thiosulfate spring application
15. UAN 28% spring application

Materials and Methods

The field experiment was established on a Beardon-Perella silt loam (coarse-silty, frigid Aeric Calciaquoll) near Prosper, ND. Soil test N, P, and K levels averaged 44 lb N/a, 27 ppm P, and 246 ppm K. In fall 2007, strips were made into wheat stubble. Nitrogen fertilizer was applied at a rate of 85 lb N/a for all treatments. Fertilizer application was made in the same operation with strip tillage for fall fertilizer applications. Strip tillage was applied at two timings, early fall (September 6) and late fall (October 24), to test the effect of fertilizer applications made earlier and later in the fall. To test the effect of applying N fertilizer in the spring, we made strips in the fall, but did not apply fertilizers at that time. Spring fertilizer treatments were applied at planting using a *fertiplacer*, a shoe pulled behind the planter that applies liquid fertilizer in a shallow slot above and approximately two inches to the side of the seed.

The slow release products used in this study were liquid fertilizers, not urease inhibitors, nitrification inhibitors, or dry products with coatings. The slow release property of the fertilizers used in this study is the result of a relatively complex molecular structure, which take longer to transform to plant-available forms of N. Most slow release fertilizers used for row crop production are not 100% slow release, but rather a blend of a slow-release component and a conventional urea, ammonium, or nitrate component. The GP products have a fertilizer formulation of 30-0-0 and are produced by Georgia Pacific; the slow release component of the fertilizer is a methylated urea formaldehyde compound and also incorporates a triazone ring structure. The 30/70 GP product has a 30% slow-release component and the balance is liquid urea. Likewise, the 20/80 GP product has a 20% slow-release component and the balance is liquid urea. KQXRN is a slow release product with a formulation of 28-0-0 produced by Kuglers Fertilizer Company and has a 70% slow release component comprised of a polymethylene urea compound. Urea (treatments 10 and 11) was applied as liquid urea with 20% N content. 10-34-0 and 15-16-2 are starter materials that were applied at planting at a rate of 3 gal/a along with 28% UAN to satisfy the N fertilization requirement. 15-16-2 is a Kugler's Fertilizer Company product that can be used similarly to 10-34-0, but without the high potential for burning young seedlings. The UAN treatment is urea ammonium nitrate with a fertilizer formulation of 28-0-0. Treatment number 14, K Thiosulfate, is a potassium thiosulfate product produced by Kuglers Fertilizer Company with no N component; this treatment was applied at 2 gall/a along with 28% UAN applied to supply the necessary amount of N for sugarbeet production. The K Thiosulfate treatment was included to test the effect of potassium (K) and sulfate with N application on soils that are normally considered sufficient for both K and sulfate.

Strips were oriented in a north-south direction. Individual treatment plots measured 11 feet wide and 30 feet long. Planting was arranged in a randomized complete block design with 4 replications. Rhizomania resistant variety, Crystal 434R, regular pellet was planted at 4 mph on May 07, 2008 with a John Deere MaxEmerge II planter. Sugarbeet was placed 1.25 inches deep, and was planted to stand at a 5-inch in-row seed spacing. A 22-inch wide row spacing was used. Counter insecticide was surface band applied at 10.9 lbs/A, and incorporated with a drag chain at planting. Stand counts were taken two weeks after germination and again on May 28 and June 19. Four post emergence micro-rate herbicides, two cultivations and hand labor was used as needed for weed control. Three fungicide applications, Eminent, Supertin/Topsin and Headline were applied for Cercospora leaf spot control.

Soil samples were taken in spring and throughout the growing season to determine relative rate of loss between N treatments. Emergence and vigor ratings were made early in the growing season to determine fertilizer burn or seedling injury. Petiole nitrate samples are considered the standard for determination of sugarbeet tissue N levels and are more sensitive than other methods for early detection of N deficiency (Sexton and Carroll, 2002; Wu et al. 2007). Petiole nitrate samples were taken on July 14th from the 6th fully emerged leaf for determination of differences in sugarbeet tissue nitrate levels.

Harvest of the two middle rows of each six row plot, was completed on October 02, 2008. Yield determinations were made and quality analysis performed at the American Crystal Sugar Quality Lab, East Grand Forks, MN.

Results and Discussion

Table 1 displays sugarbeet yield, quality, and sugarbeet tissue nitrogen content for each treatment. Treatment 14 receiving liquid urea plus potassium (K) thiosulfate, resulted in the greatest root yield; net sugar was similar to other treatments, resulting in a recoverable sugar per acre (RSA) that is significantly greater than for 25% of the treatments. The K Thiosulfate treatment imparted a yield advantage of 4.2 tons over the average study yield of 28.1 ton/a. Given the high soil test potassium levels (>200 ppm) determined by soil testing, we conclude that the sulfate in the K Thiosulfate treatment provided the yield advantage. Root yield was significantly reduced for the KQXRN treatments relative to almost all other treatments. This corresponded with lower petiole nitrate values in the XRN treatments. Based on soil samples taken throughout the growing season (Fig. 1), soil test nitrate levels were lower for the XRN treatments for the 0-6 inch depth and also for the 6-24 inch depth (not shown). Since lower soil test nitrate values were observed for the XRN treatments during the May and July samplings as well as the early season sampling dates, it is unlikely that the low values are solely due to the slow release properties of the fertilizer. As a result of the slow release nature of the material an "efficiency factor" of 4 was applied to the XRN fertilizer rate, resulting in the amount of fertilizer applied being reduced by 75%. The reduced yields and nitrate content in the XRN treatments suggest that the efficiency factor was too high and might not have been appropriate to use at all. Another possible explanation for the reduced yield and nitrate levels in the XRN treatments is that the material, which was substantially more viscous than other materials, may not have been applied at the desired rate, despite efforts to calibrate the equipment to apply it correctly. Using water to thin the fertilizer material to a more acceptable viscosity may have solved this issue. The late fall application of urea also resulted in significantly lower root yields than most other treatments. Late fall applied urea also resulted in lower net sugar than half of the other treatments. Greater soil test nitrate concentrations were determined for the fall-applied urea treatment, indicating that urea may have been mineralized to the nitrate form more rapidly in this treatment compared to the spring-applied urea treatment, which may have led to greater N loss from the soil in the fall-applied urea treatment. Sugarbeet plants sampled for petiole nitrate did not demonstrate N deficiency when sampled in July, so if N deficiency occurred as a result of greater N mineralization, it resulted in tonnage and sugar losses between mid-July and the end of the growing season. Neither petiole nitrate concentrations nor stand counts indicated that fall-applied urea resulted in lower values relative to other treatments, indicating that reduced stand and/or reduced plant N uptake were not problems.

Petiole nitrate values (Table 1, Figure 1) demonstrate that Treatment 3 (Spring-applied GP20/80) had greater plant tissue nitrogen concentrations at the time of sampling than other treatments and was significantly greater than the three XRN treatments (treatment numbers 7, 8, and 9). The increased petiole nitrate concentration did not result in significantly greater loss to molasses for Treatment 3. Figure 1 displays soil test nitrate concentrations on four sampling dates throughout the growing season. The first date, April 4, was the earliest spring date at which soils could be sampled at the 0-6 inch depth. The frost layer began at about 7 inches below the soil surface at that date. The April 4 values can be used to deduce how much fertilizer-applied N was lost from the early- and late-fall fertilizer applications. The fall of 2007 was warmer and longer (as a measure of date to ground freezing) than commonly experienced in this area. North Dakota Agricultural Weather Network (NDAWN) records from the study location indicate that average air temperature was 1º to 5º warmer than average from September to November and average soil temperature in September 2007, when the early-fall fertilizer application was applied, was 63º F, substantially warmer than the 50º F recommendation for N fertilizer application in North Dakota. The average soil temperature in October was 50º F, so the late-fall fertilizer application followed NDSU fertilizer application recommendations. Average soil temperature for November was still above freezing, so N mineralization was still occurring at a reduced rate. Rainfall in the fall of 2007 was slightly higher than average. Overall, the fall of 2007 provided good conditions to test the slow-release fertilizer products for their effectiveness at inhibiting N conversion to the nitrate form between early-fall applications and soil freeze up. Relative differences between treatments for soil test nitrate values are evident between fertilizer sources for the early- and late-fall application dates. The early-fall applied slow-release fertilizer treatments (treatments 1, 4, and 7) demonstrate that soil nitrate values are lower in these treatments compared to the late-fall applied slow-release fertilizer treatments (treatments 2, 5, and 8), indicating that the slow release fertilizers lost N to leaching and denitrification in the fall between September 6 (early application date) and October 24 (late application date). Soil samples taken on April 4, 2008 determined that GP 20/80 measured three-fold more soil nitrate in the late-fall applied treatment compared to the early-fall applications (45 vs. 15 lb N/a, respectively). Similarly, GP 30/70 demonstrated 2.2 times greater soil nitrate in the late-fall vs. early-fall application for the same sampling date. XRN revealed 1.7 times more soil nitrate in the late fall vs. early-fall application for the April 4 sampling date, but the values were much lower overall compared to the

GP products. These data alone indicate that the slow release products used in this study were not suitable for early fall application of N fertilizer in strip tillage systems. These products, while effective as slow release products applied within the same growing season for the crop of interest, have too little slow-release component (for the GP products) to sufficiently inhibit the rate of N mineralization to the nitrate form.

Table 2 displays seedling emergence rate and stand for each treatment at three different dates. An interesting observation among treatments with fall- and spring-fertilization dates reveals that early season emergence is generally greatest for the fall-fertilized treatments. Fall fertilized treatments also usually had non-significantly greater stand at harvest compared to spring fertilized plots; this did not result in greater yield at harvest, however. Slighter better emergence for fall fertilized treatments might be the result of reduced salt injury or more favorable osmotic potential since the salt concentration would have been lower in fall fertilized fields.

An examination of the effect of early application of three slow release fertilizers indicated that root yield and recoverable sugar were lower for the early fall-applied slow release materials compared to the late fall- and spring-applied slow release materials. Based on this, it must be concluded that the slow release formulations of N fertilizer tested in this study are not suitable for early fall fertilizer applications. It is likely that the 20% and 30% slow release components in the GP products were not sufficient to maintain sufficient N for crop growth. Although the XRN product contained a greater proportion of the slow-release component, the yields were reduced relative to other treatments, perhaps due to the “efficiency factor” used or because the materials were not applied accurately due to the viscous nature of the liquid. There was no root yield difference between the late fall- and spring-applied slow release fertilizers, but the spring-applied urea treatment yielded statistically better yield and recoverable sugar than the late-fall applied, suggesting that fall-applied urea may result in late-season N loss relative to spring-applied urea.

In conclusion, early fall application of fertilizers can result in substantial loss of fertilizer applied nitrogen, even when the fertilizer source is in a slow-release form. Until suitable, affordable formulations of slow release fertilizer are available for row crop application, we continue to support NDSU fall fertilizer application recommendations. We stress that slow release fertilizers are suitable for many cropping applications when applied during the crop growing season.

References

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Acknowledgement-

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Table 1. Sugarbeet yield and quality parameters resulting from different nitrogen (N) management treatments. Descriptions for each treatment number can be determined in the Introduction section, above. LSD values provide the least significant difference for statistical discrimination of treatments at the P<0.10 level.

Treatment No.	**Fertilizer Timing**	**N Source**	**Root Yield (Tons/a)**	**SLMº (%)**	**Net Sugar (%)**	**RSA* (lb/a)**	**RST** (lb/ton)**	**Stand (Beets/100ft)**	**Petiole Nitrate (ppm NO_3^-)**
1	Early Fall	GP 20/80	25.95	1.1655	14.57	7615	291.39	156	3773.89
2	Late Fall	GP 20/80	29.57	1.2300	14.94	8841	298.75	177	3649.07
3	Spring	GP 20/80	29.57	1.1900	14.92	8845	298.35	140	4521.96
4	Early Fall	GP 30/70	27.04	1.2636	14.75	8000	295.03	145	3986.41
5	Late Fall	GP 30/70	29.32	1.1834	15.29	9014	305.83	163	3713.85
6	Spring	GP 30/70	29.17	1.2033	14.94	8742	298.73	143	3712.45
7	Early Fall	XRN	22.63	1.1041	15.35	6994	307.07	135	3236.76
8	Late Fall	XRN	25.08	1.1043	15.38	7719	307.46	167	3368.35
9	Spring	XRN	26.33	1.1365	15.78	8301	315.62	143	3356.84
10	Late Fall	Urea	25.28	1.1495	14.40	7322	288.06	166	3983.12
11	Spring	Urea	29.34	1.1568	15.26	8969	305.16	153	3515.93
12	Spring	10-34-0	30.10	1.1218	15.46	9316	309.21	154	4186.20
13	Spring	15-16-2	29.82	1.1828	14.70	8823	294.09	157	3645.01
14	Spring	K Thiosulf	32.29	1.2650	14.77	9524	295.45	161	3458.90
15	Spring	UAN 28%	30.05	1.2110	14.92	8988	298.48	165	3952.67
LSD			**3.67**	**0.1033**	**0.62**	**1224**	**12.10**	**22.3**	**1146**

º Sugar Loss to Molasses; * Recoverable Sugar per Acre; ** Recoverable Sugar per Ton

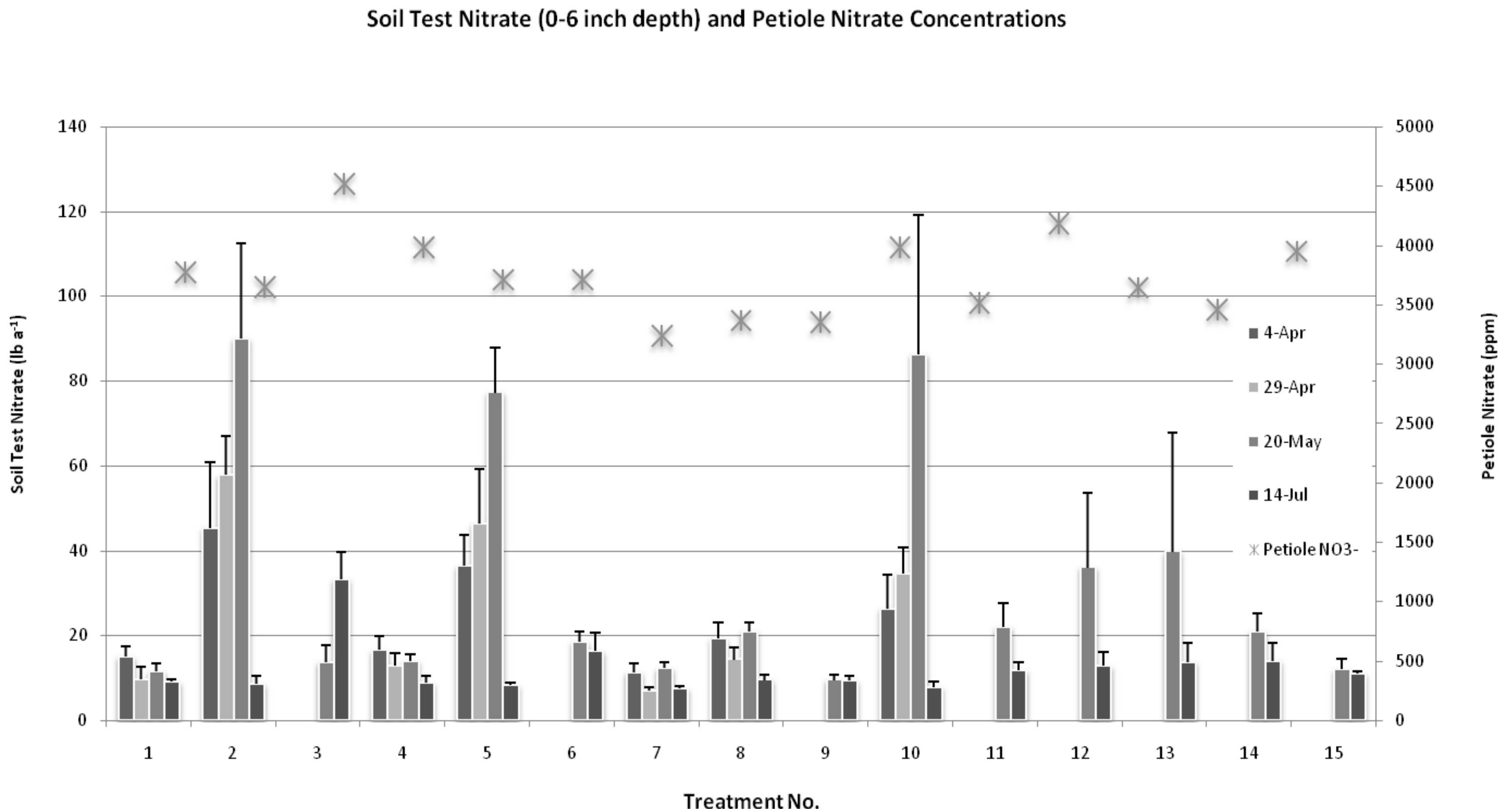

Figure 1. Soil test nitrate levels for four sampling dates are displayed as bars referencing the left vertical axis. Error bars provide mean standard error. Treatment numbers are given on the horizontal axis. Treatment descriptions are given in the Introduction and in Table 1. Note that soil test nitrate values are not represented for the April 4th or 29th sampling dates for Spring-applied treatments because the treatments had not been implemented yet. As a reference, average soil test nitrate values sampled in the fall prior to treatment application were 12.75 lb N/a and 13.5 lb N/a for the 0-6 inch depth and 6-24 inch depth. Petiole nitrate values from sugarbeet tissue sampled from the 6th fully emerged leaf are displayed as symbols above the treatment numbers and are referenced by the right vertical axis.

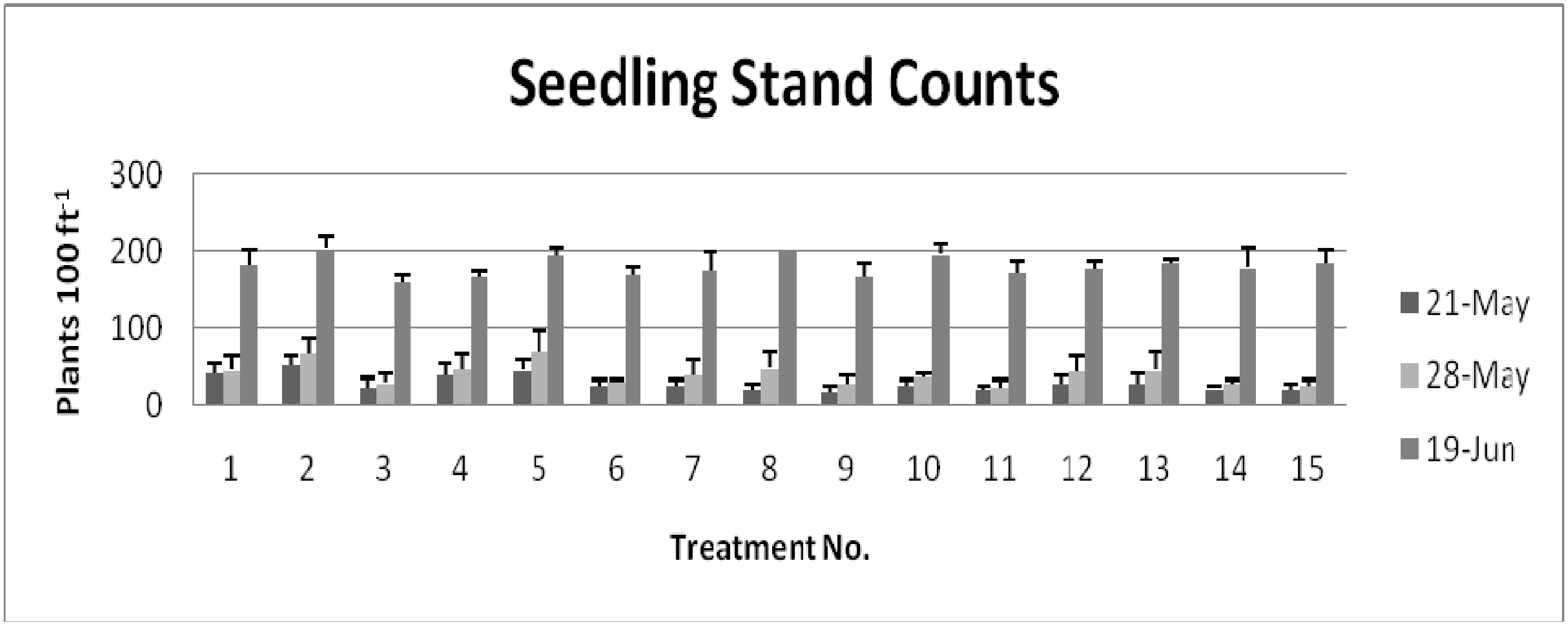

Figure 2. Seedling emergence rates for all treatments (see treatment descriptions in Table 1 and introduction) on three dates. Error bars represent mean standard error.