EFFECT OF DELAYED EMERGENCE

ON CORN GRAIN YIELDS

By

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ON CORN GRAIN YIELDS

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GRAIN YIELDS

Abstract

Crops with uniform stands have the advantage of producing higher grain yield under good growing conditions and management systems than crops with poor stands. Delayed emergence and complete failure of seed emergence are causes of uneven crop stand early in the season. The objectives of this study were to determine corn (*Zea mays* L.) grain yield reduction as a function of interplant competition arising from delayed emergence and to evaluate yield levels associated with 3 plant sequences, with and without delayed emergence. These variables were investigated at two experimental sites established in the spring of 2005, near Stillwater, OK at the Lake Carl Blackwell Agronomy Research Farm under irrigation and at the Efaw Agronomy Research Farm in a rain-fed environment. Pioneer (33B51) Bt corn hybrid was planted late March or early April at a seeding rate of 73779 plants ha^{-1}. Each 2.7 m-row was planted by hand to maintain 18 cm inter-row spacing. A total of 15 plants within a row were divided into five subgroups. Each subgroup contained three plants, two plants planted on the same day and a delayed plant planted between the two plants. The delayed plants were planted 2, 5, 8, 12 days after the initial planting (to simulate various delayed emergence scenarios). At the irrigated site, 2-year average grain yields decreased when the center plant of three plants seeding

date was delayed 2, 5, 8, and 12 days, by 3, 10, 19 and 25%, respectively. At the rainfed site, average grain yields decreased when the center plant of three plants was delay planted at 2, 5, 8, and 12 days, by 14, 25, 23, and 11%, respectively. This suggests that the overall effects of delayed planting (emergence) on resultant grain yields were greater where irrigation was not available. Over both sites and years, for each day delay emergence (estimated using delayed planting), grain yield depression could be expected to exceed 225 kg ha^{-1} using the slope components reported at each site.

I. Introduction

Delayed emergence research can provide farmers with the tools needed to produce higher crop yields. Limited research has been done that looks at days delayed at the by-plant level; this study will. Profit and the environment are two important issues to the majority of corn producers. To maintain these at acceptable levels, yield should be optimized using modest amounts of agricultural inputs. It is well documented that crop stand is important in determining final grain yield (Evans and Fisher, 1999; Tollenaar and Wu, 1999). Crops with uniform stands have the advantage of producing higher grain yield under good growing conditions and management systems than crops with poor stands. Thus for farmers, replanting is necessary for stands they visually evaluated as poor before further investment in fertilizer, herbicide and irrigation. So what can farmers do to homogenize plant stands? Maybe they could drive slower and at a constant speed, or they could better prepare the seed bed.

Delayed emergence and complete failure of seed emergence are causes of uneven crop growth early in the season. This behavior can be attributed to irregular planting depth, seed quality, soil compaction, and limited moisture (Ford and Hicks, 1992; Dwyer et al. 1999). Murungu (2003) found that seed priming (soaking seeds in water before planting) improved emergence and early growth in drying soils. Harris et al. (1999) also concluded that there was a direct benefit in faster emergence, better stands and a lower incidence of re-sowing. A study by Triplet and Tesar (1960) showed that improved emergence of alfalfa seedlings was attributed to increased soil water and seed-contact as a result of increased planting depth from 0 to 1 inches and soil compaction. Despite improved agricultural practices and land management, complete eradication of seed emergence related problems is still not achievable. There have been numerous studies done on the causes of delayed emergence although there has not been much on the effect of delayed emergence on corn grain yields. This could be useful in variable rate application in corn.

II. Literature Review

Nitrogen use efficiency (NUE) in cereal crop production is currently 33% worldwide with an estimated average of 29% and 42% for the developing and the developed countries, respectively (Raun and Johnson, 1999). These low NUE values can be attributed to plant nitrogen (N) loss by NH_3 (Francis et al, 1993) , >10% denitrification loss (Hilton et al., 1994), N fertilizer applied in excess of crop needs (Johnson and Raun, 1995), and surface runoff of N fertilizer ranging between 1 and 13% (Blevins et al.,1996 ; Chichester and Richardson, 1992). A

1% global increase in NUE would result in an estimated savings of $234,658,462 (Raun and Johnson, 1999).

The importance of improving NUE for the environment is explained by Dwivedi et al. (2003) and Cassman et al. (2002). Nitrogen use efficiency is important to the environment due to the run-off of N into fields and ponds affecting the water quality. Many studies showed that delayed plant emergence reduced yield, thus in theory if you could fertilize each plant individually you could increase NUE and reduce the cost of fertilizer. This would also help to reduce the impact of N on the environment. By finding out how many days plant emergence is delayed, you can identify which plants need to be fertilized and which ones do not and this could help to increase NUE.

Nielsen (2001) reported that plants that are next to a gap produced larger ears. Martin et al. (2005) found an average difference equivalent to 2765 kg ha^{-1} plant to plant difference in corn yield. They further noted that production methods that homogenize plant stands and emergence, should decrease plant-to-plant variation and will likely lead to increased yields. Plant spacing is important in precision farming. If there is a section that has plants that are crowded, they will produce smaller ears than a section that has bigger gaps in it. While plants near the gap produced larger ears, this did not compensate for the yield lost due smaller ears that were produced in the crowded sections (Nielsen 2001). If two plants are crowded, one being bigger and one being smaller, the smaller plant will likely compete less for sunlight and nutrients. In this case, the smaller plant will not be able to catch up resulting in a smaller ear at harvest

(Nielsen, 2001). Nielsen (2001) further discussed the variability between plants in a row by using the term plant spacing variability (PSV). The PSV is the standard deviation of the plant spacing within a representative row in a field. Nielsen noted that in 350 production corn fields in Indiana and Ohio, 16% had a PSV of three inches or less, 60% had a PSV of three to five inches, and 24% of the fields had a PSV of six inches or greater. Further research showed that for every one inch in PSV about 157 kg ha^{-1} of yield loss occurred.

Nafziger et al. (1991) found that delayed emergence can reduce grain yields of corn from 6 to 22%. Ford and Hicks (1992) concluded that delayed emergence is often caused by many factors such as environmental conditions (limited moisture, drier colder climate), as well as agricultural practices and land management (seed depth, soil compaction, and residue left on top of the seed).

Corn grain yields were reduced by 546 kg ha^{-1} and 1179 kg ha^{-1} with planting dates delayed 7 and 14 days respectively (Ford and Hicks 1992). They also observed reduced yields when non uniform (mixed) stands were simulated by planting corn plants at different distances within the row.

Imholte and Carter (1987) found that delayed planting decreased yields in both conventional and no-till corn systems; the highest corn grain yields of conventional and no-till achieved when planting was completed by early May. Alessi and Power (1971) observed that each 10 mm increase in planting depth delayed corn emergence for about one day at a constant temperature of 13.3 ^{o}C. They concluded that at least 68 growing degree days (GDD) with temperatures above 13.3 ^{o}C and adequate soil moisture are necessary to achieve 80%

emergence in corn. Lindstrom et al. (1976) showed that a combination of factors including water potential, the lowering of soil temperature from 25° C, or with the increasing of planting depth decreased corn emergence rate. Grant and Buckle (1974) reported that adverse conditions may cause a reduction in plumule length. Helms et al. (1997) found that if soil water content is sufficient for germination and persists for 18 days after planting, emergence will not be reduced.

Temperature-Activated Polymer (TAP) is a seed coating that is designed to impede the water absorption to the seed until an adequate soil temperature is reached. Gesh and Archer (2005) found that 60-90% of TAP coated seeds emerged where only 49-68% of uncoated seeds emerged. TAP protects the seeds from extended cold soil temperatures and helps with emergence.

Lithourgidis et al. (2005) noted that delayed emergence and reduced plant populations are problems associated with corn production in conservation tillage. They also found that when soil moisture levels were sufficient, the emergence rate did not differ in conventional till and no-till systems. Dry soil conditions, however, were associated with a 16% decrease in emergence in no-till corn. They found that there was no significant difference in delayed plants in reduced till, and they noted that the presence of delayed plants did not reduce silage yield in no-till systems. Seedling emergence 2 to 3 weeks after planting was lower in no-till, compared to conventional till and reduced-till (Burgess et al. 1996).

Drury et al. (1999) found that red clover (Trifolium pretence L.) helped with some of the problems associated with corn production in no-till practices. They found that no-till increased soil water by 2 to 5% and reduced soil temperature by 1 to 2° which was expected to decrease emergence. Corn emergence in no-till was shortened by 3 to 4 days without red clover as a cover crop and the total plant stand was reduced by 24% compared with conventional tillage.

Graven and Carter (1991) found that emergence rate strongly depends on the corn seed quality. They observed a 4 to 6% decrease in emergence associated with medium and low seed quality, and that lower seed quality decreased emergence when fields were planted earlier. When planting date was delayed, seed quality did not have a significant effect on emergence. In late planted fields seed quality did not have an effect on emergence. With low and medium quality seed they found a 1 day delayed emergence compared to high quality seed. Graven and Carter (1990) found that seed size and shape had an effect on emergence. They achieved higher emergence rates with large flat and small round seeds compared to large round and small flat seeds under temporal and moisture stress environments.

III. Objectives

The objectives of this study were: I. determine corn grain yield reduction as a function of interplant competition arising from delayed emergence; and II. evaluate yield levels associated with 3 plant sequences, with and without delayed emergence.

IV. Materials and Methods

Two experimental sites established in the spring 2005: one near Perry, OK at the Lake Carl Blackwell irrigated research station, and one at Efaw Research Station, near Stillwater, OK. Lake Carl Blackwell research station soil series is a

Pulaski fine sandy loam (Fine Sandy Loam, Coarse-loamy, mixed, nonacid, thermic Typic Ustifluvent) and Efaw Research Station has a soil series of Easpur loam (fine-loamy, mixed, superactive, thermic Fluventic Haplustoll). Results from composite pre-plant soil sample analysis at each site are reported in Table 1.

Pioneer (33B51) Bt corn hybrid was planted late March or early April at a seeding rate of 73779 seeds/ha. With corn planted at 76.2 cm row spacing, the distance between plants is 17.8 cm. This 17.8 cm seed spacing was achieved by hand planting. Equal inter-row spacing is essential for the analysis of this experiment; therefore each row was planted by hand.

A planting device was made from 3.81 cm square tubing to make sure that the planting depth of 5.08cm and spacing (17.78 cm apart) was achieved. Bolts positioned 0.95cm deep where every 17.78 cm apart along the tube. This was then used to create fixed depressions in the soil and ensuring specific planting points for each of the seeds (Figure 1).

The experiment employed a randomized complete block design (RCBD) with 11 treatments and 3 replications. The treatment structure is reported in Table 2. Each row contained 15 plants in total. From the total number of plants there were five subgroups. Each subgroup contained three plants, two plants planted on the same day and a delayed plant planted in the middle of the two plants. The delayed plants were planted on a specific day 2, 5, 8, and 12 days (to simulate various delayed emergence scenarios). Each plot consisted of 1 row that was hand planted with 1 border row on each side. Row, and plant configuration are illustrated in Figure 2. Border rows were machine planted on the same day on each side of the rows which contained the delayed plants at a similar population. For each treatment a total of 15 3-plant sequences were evaluated. Because in some cases, plants did not emerge at all, or damage was incurred from insects and/or other factors, only 9 of the 3-plant sequences were used for treatment averages. Each plant occupied 0.13548 m^2, thus yield expressed in kg ha^{-1} was determined by divided the collected values in grams per plant by 0.13548, then multiplied by 10 to obtain kg ha^{-1}.

Two preplant nitrogen fertilizer rates (56 and 168 kg ha $^{-1}$) were applied broadcast before planting using urea (46-0-0). Bicep Lite II Magnum® Syngenta (Greensboro, North Carolina) was applied preplant at a rate of 2338 ml/ha to control broadleaf weeds and grasses at each site.

The groups were tagged in sets of three plants and were hand harvested. In each treatment three of the five subgroups were selected for harvest. For each of the three subgroups, each plant was harvested and bagged separately. Each bag was individually weighed wet, dried in an air forced oven at 66^0 C and weighed again for moisture determination. Percent moisture was determined by taking the wet weight minus the dry weight and dividing by the wet weight. Grain yield for all treatments was expressed using 15.5% moisture. Analysis of variance to determine treatment effects were determined using SAS (2002) significant differences between treatments was determined using the standard error of the difference (SED) between two equally replicated means.

V. Results and Discussion

Analysis of variance reporting the significance of treatment effects on corn grain yield (average of the 9, 3-plant sequences) is reported in Table 3. The main effect of treatment was significant at the 0.05 level or less for both years at both locations. Even though planting depth, method of planting, and seed cover/compaction were held constant, there were minor discrepancies concerning emergence. Data was not collected documenting exact day of emergence for all 9, 3-plant sequences that comprised individual treatments, but the large number of sub-sets collected was expected to deliver accurate and precise estimates of the average (yield, yield depression, and/or percent of maximum grain yield).

Averaged over years, grain yields decreased when the center plant of three plants was delay planted at 2, 5, 8, and 12 days, by 3, 10, 19 and 25%, respectively (Table 4). For the rainfed site, average grain yields decreased when the center plant of three plants was delay planted at 2, 5, 8, and 12 days, by 14, 25, 23, and 11%, respectively. In terms of percent yield reduction, the overall effects of delayed planting (emergence) on resultant grain yields were greater where irrigation was not available.

<u>Grain Yield by Plant in 3 Plant Sequence</u>

Grain yields for each plant (average of 9, 3-plant sequences) where plants 1 and 3 were planted at the same time, and plant 2 was delay planted by 2, 5, 8, and 12 days are reported in Figures 3-10 for Efaw and Lake Carl Blackwell, with 56 and 168 kg N ha^{-1} applied preplant in both 2005 and 2006, respectively. The standard error of the difference between two equally replicated means (SED) is reported on each graph (Figures 3-10). No differences in grain yield were found in the 3 plant sequences when planted on the same day at Efaw, 2005 for the 56 kg N ha^{-1} rate (Figure 3). However, when delayed by 2 or more days, the center plant had significantly lower yields, and the yield reduction exceeded 2000 kg ha^{-1}. These yield reductions were primarily due to a center plant not producing when averaged over the 3 plant sequences. It is important to note that there were also yield reductions in the border plants when the center plant was delay planted by 2, 5, and 8 days (compared to no delay). However, for the 12 day delay the center plant had significantly lower yields but the border plants yields tended to be higher than 2,5, and 8 day. This suggests that at 2, 5, and 8 days the center plant competed with the border plants, but for the 12 day delay there was less competition since border plants yielded slightly more.

At the 168 kg N ha^{-1} rate, at Efaw in 2005, results were highly variable, especially when noting the depression in yield for plant #2 when no delay was imposed (Figure 4). It is likely that the 2, 5 and 8 delay could have increased yields because competition between the plants was less. This may have been caused by the high seeding rate used at this rainfed site. In other words there was likely less competition between plants, at this high N rate, evidenced in the higher yields when compared to those at the 56 kg N ha^{-1} rate (Figure 3 versus Figure 4).

Results at LCB in 2005 for the 56 and 168 kg N ha^{-1} rates (Figures 5 and 6), similar trends were observed as that reported for Efaw. However, at this site, there was no significant effect of delay planting by 2 days at the 56 kg N ha^{-1} rate. By 5 days, the center plant had significantly lower yields versus the 0 and 2 day delay sequence (Figure 5). At the 168 kg N ha^{-1} rate the 2 and 5 day delayed plants were not different from the 0-day delay treatment. By applying more N, the 5 day delay was in effect not different from the 0 and 2 day delay treatments, yet at the low N rate the yield decrease was notable (Figures 5 and 6). It is not biologically understood as to exactly why this happened.

Results for the Efaw site in 2006 at the 56 and 168 kg N ha^{-1} rates are reported in Figures 7 and 8, respectively. Extreme temperatures was encountered throughout the season at this site, and as a result, yields were highly variable. In general, limited differences were noted for the 0, 2, 5, and 8 day delays at the 56 kg N ha^{-1} rate (Figure 7). By the 12 day delay, the center plant yielded significantly less than the border plants. Furthermore, the two non delayed plants for the 12 day delay tended to have higher yields when compared to the 0, 5, and 8 day delayed plantings. At the 168 kg N ha^{-1} rate, yields were higher and the separation of yields due to treatment was wider (Figure 8). The more the center plant was delayed the greater the yield reduction was when compared to the two non-delayed plants.

In 2006 at LCB the 56 and 168 kg N ha^{-1} rates (Figures 9 and 10, respectively) resulted in highly variable treatment results. At the 56 kg N ha^{-1} rate, the 8 and 12 day delayed planting had lower yields for the center plant. At the 168 kg N ha^{-1} rate, yields were higher, but more variable. The center plants for the 8 and 12 day delayed planting tended to have lower yields while the border plants had higher yields, similar to results for Efaw in 2005 and 2006. As was noted for Efaw in 2006, the severe heat contributed to the variable yield results at LCB. The high temperate occurred during flowering which further depressed final grain yield results due to incomplete pollination.

Grain Yield Depression, kg/ha

Grain yield depression is reported as a function of planting delay in days for Efaw and Lake Carl Blackwell in 2005 and 2006 in Figures 11-14, respectively. At Efaw in 2005 (Figure 11) the grain yield depression increased significantly as planting was delayed from 2 to 12 days. As has been noted, the delayed planting was used to simulate delayed emergence.

At Efaw in 2005, when the planting delay was 5 days grain yield reduction was estimated to exceed 2400 kg ha^{-1} predicted by the linear relationship (Figure 11). With 8 and 12 day delay the grain yield depression exceeded 3000 kg ha^{-1}, for both N rates.

In 2006 at Efaw (Figure 12), the grain yield depression as a function of delayed planting was actually greater for both N rates, noting the increased slope when compared to the 2005 data (Figure 12 versus Figure 11). However, for 2006, limited differences were noted between the 2 and 5 day delay planting (Figure 12). This trend was generally similar for the 56 and 168 kg N ha^{-1} rates.

At LCB in 2005, the grain yield depression was highly significant as a function of planting delay, more so than that observed at the other sites and/or years (Figure 13). This was partly due to the increased yield levels recorded at LCB in 2005. However, in 2006, the effect of planting delay on grain yield depression was less significant, partly due to the lower yields encountered in this heat stressed year (Figure 14).

Over both sites and years, for each day of delay emergence (estimated using delayed planting), grain yield depression could be expected to exceed 225 kg ha^{-1} using the slope components reported at each site (Figures 11-14).

Percent of Maximum Corn Grain Yield

The percent of maximum corn grain yield expressed as a function of planting delay in days for Efaw and Lake Carl Blackwell, in 2005 and 2006 are reported in Figures 15-18, respectively. At Efaw in 2005 the percent of maximum grain yield was reduced by 3 and 15% at the 56 and 168 kg N ha^{-1} preplant rates, respectively when delayed planting took place at 2 days (Figure 15). Percent of maximum corn grain yield continued to decline gradually when the delay went from 2 to 8 days. By the 12 day delay, grain yields were significantly reduced beyond that seen for the 2, 5, and 8 day delayed planting (Figure 15). This relationship between percent of maximum corn grain yield and planting delay was much clearer at Efaw in 2006, whereby a distinct linear relationship was observed, and similar for both N rates (Figure 16). For the 12 day delay, the percent of maximum corn grain yield declined to less than 20% of the average of the 2 border plants (Figure 15).

At LCB in 2005 grain yields declined significantly in a linear fashion as planting was delayed from 2 to 12 days late (Figure 17). However, there was a trend for limited yield reduction when the center plant was only 2 days late. By 5 days, the percent maximum corn grain yield was estimated at 21 and 24% less using the linear function reported (Figure 17). In general, limited differences due to the fertilizer N rate were found at this site. In 2006 at LCB there were varying results due to the severe heat stress encountered from July 14 to August 18 when > 30 consecutive above 37°C days were present (Figure 18). Despite the heat stress, the linear relationship of percent of maximum corn grain yield expressed as planting day delays were similar to that noted in 2005 (Figures 17 and 18).

VI. Conclusions

Delayed planting to simulate delayed emergence was used in this experiment to determine the adverse effects on final corn grain yield. When comparing 3 plant sequences, the results show that delayed emerging plants result in decreased corn grain yields. Over both sites and years, data showed that when the days of delayed planting was greater than 5 days there was almost always a significant yield reduction. When looking at the three plant sequences the delayed plant by 2, 5, and 8 days continued to compete with the two non delayed plants. By 12 days these plants competed less with the two non delayed plants and that then tended to have higher by-plant yields. Results from this study will assist those groups interested in improving by-plant N fertilization by knowing how much a plant is delayed and how that ultimately affects final corn grain yields. This information will in turn be used to estimate N removal based on yield level (or projected yield decrease) based on how much each plant is or is not delayed versus neighboring plants. When evaluating both sites and years, for each day delay emergence (estimated using delayed planting), grain yield depression ranged from 225 kg ha^{-1} to 1379 kg ha^{-1}.

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Table 1. Initial surface (0-30.48 cm) soil test results prior to experiment initiation at Efaw and Lake Carl Blackwell (LCB) OK.

Location, depth	K mg/kg	P mg/kg	NH4-N mg/kg	NO3-N mg/kg	Nitrogen g/kg	Carbon g/kg	pH
EFAW S. 0-15.24	99	22	9	3.5	0.72	10.69	5.05
EFAW S. 15.24-30.48	76	17	16	4.3	0.65	10.23	5.71
EFAW N. 0-15.24	105	20	17	3.2	0.64	10.93	6.15
EFAW N. 15.24-30.48	76	19	11	3.7	0.57	9.09	6.56
LCB SW. 0-15.24	144	45	28	4.3	0.77	9.87	5.63

NH_4-N and NO_3-N – 2 M KCL extract; P and K – Mehlich-3 extraction; pH – 1:1 soil:deionized water

Table 2. Treatment structure employed at Lake Carl Blackwell, and EFAW, 2005 and 2006 evaluating delayed planting on resultant corn grain yields.

Treatment No.	Delay in planting	N rate, kg ha^{-1}
1	All 3 plants planted on the same day	0
2	All 3 plants planted on the same day	56
3	Middle plant planted 2 days late	56
4	Middle plant planted 5 days late	56
5	Middle plant planted 8 days late	56
6	Middle plant planted 12 days late	56
7	All 3 plants planted on the same day	168
8	Middle plant planted 2 days late	168
9	Middle plant planted 5 days late	168
10	Middle plant planted 8 days late	168
11	Middle plant planted 12 days late	168

Table 3. Analysis of variance for corn grain yield as influenced by days of delayed planting, and N rate, Efaw and Lake Carl Blackwell, 2005 and 2006.

Source of variation	df	Mean Squares
Efaw 2005		
Rep	2	2518882
Treatment	10	20805968**
Error	20	1658846
Efaw 2006		
Rep	2	6922497
Treatment	10	19137337*
Error	20	6301307
LCB 2005		
Rep	2	176267
Treatment	10	13129722**
Error	20	2081393
LCB 2006		
Rep	2	1756683
Treatment	10	6202754*
Error	20	1953488

**, * significant at the 0.01 and 0.05 probability levels respectively.

Table 4. Treatment, preplant N, Days delay, planting, Mean grain yields for Efaw, Lake Carl Blackwell, 2005

	Preplant N	Days Delay	Mean grain yields kg ha^{-1}					
Treatment	kg ha^{-1}	Planting	Efaw 2005	Efaw 2006	Avg.	LCB 2005	LCB 2006	Avg.
1	0	0	4095	4010	4053	15579	2146	8863
2	56	0	9084	6326	7705	16058	5021	10540
3	56	2	5830	7443	6637	16805	3691	10248
4	56	5	6233	5222	5728	15251	3904	9578
5	56	8	6653	5265	5959	13614	3549	8582
6	56	12	7109	6705	6907	11173	4618	7896
7	168	0	9653	11532	10593	15130	5476	10303
8	168	2	11307	9141	10224	16118	6404	11261
9	168	5	11564	10717	11141	16361	5636	10999
10	168	8	11581	10241	10911	11676	6999	9338
11	168	12	10476	9329	9903	11674	6156	8915
SED			1051	2049		1178	1141	

SED – standard error of the difference between two equally replicated means

Figure 1. Planting device constructed to establish fixed depths, and distances between plants for all sites, 2005-2006.

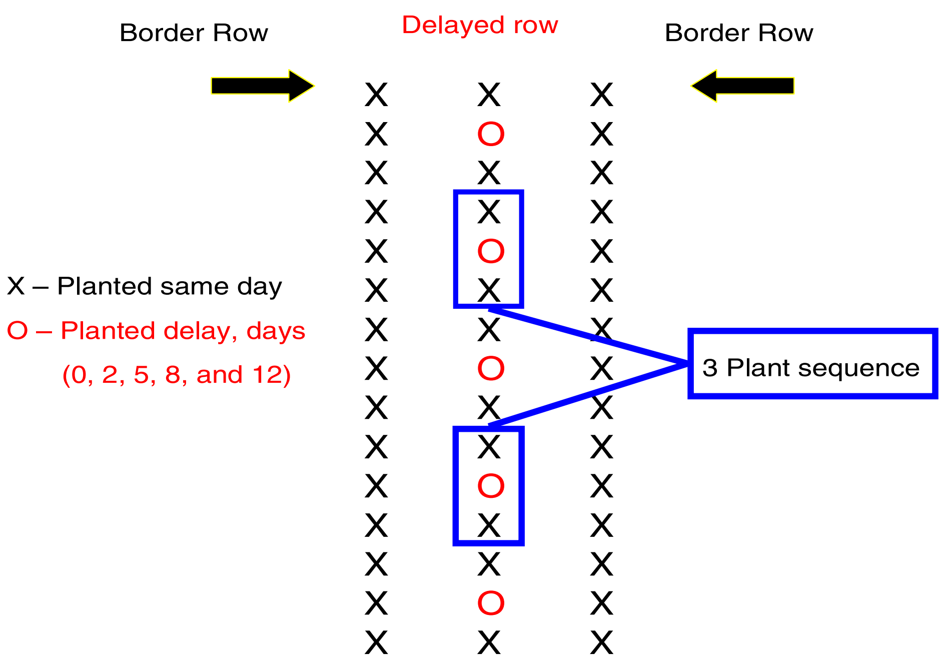

Figure 2. Schematic diagram illustrating a single plot whereby the center row had 5, 3-plant sequences between two border rows. Each treatment was replicated three times, thus, 15, 3-plant sequences were used to determine each treatment average.

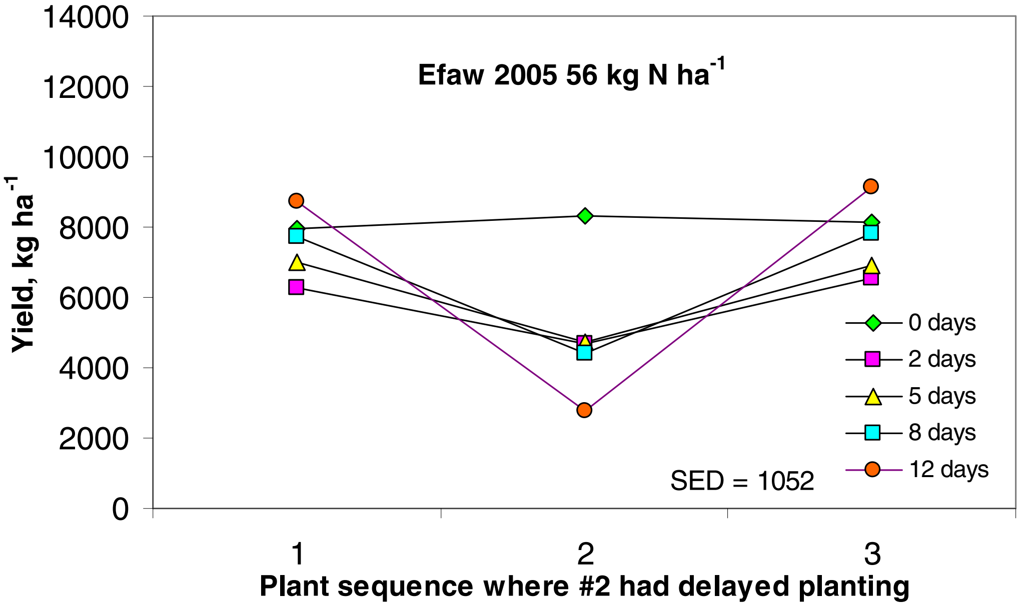

Figure 3. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 56 kg N ha^{-1} applied preplant, Efaw 2005 (each point represents the average of nine plants repeated in these 3-plant sequences).

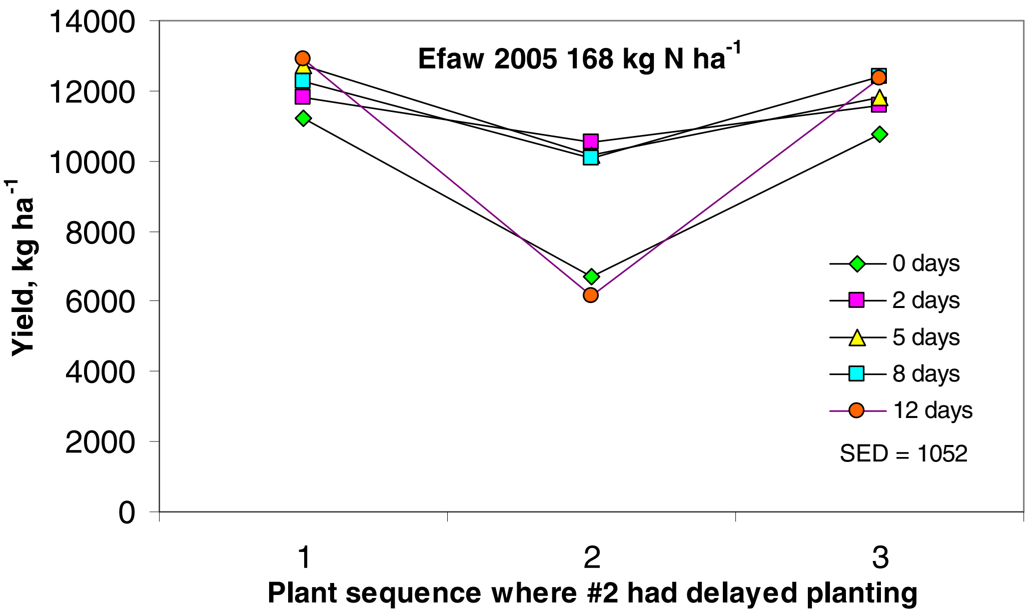

Figure 4. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 168 kg N ha^{-1} applied preplant, Efaw 2005 (each point represents the average of nine plants repeated in these 3-plant sequences).

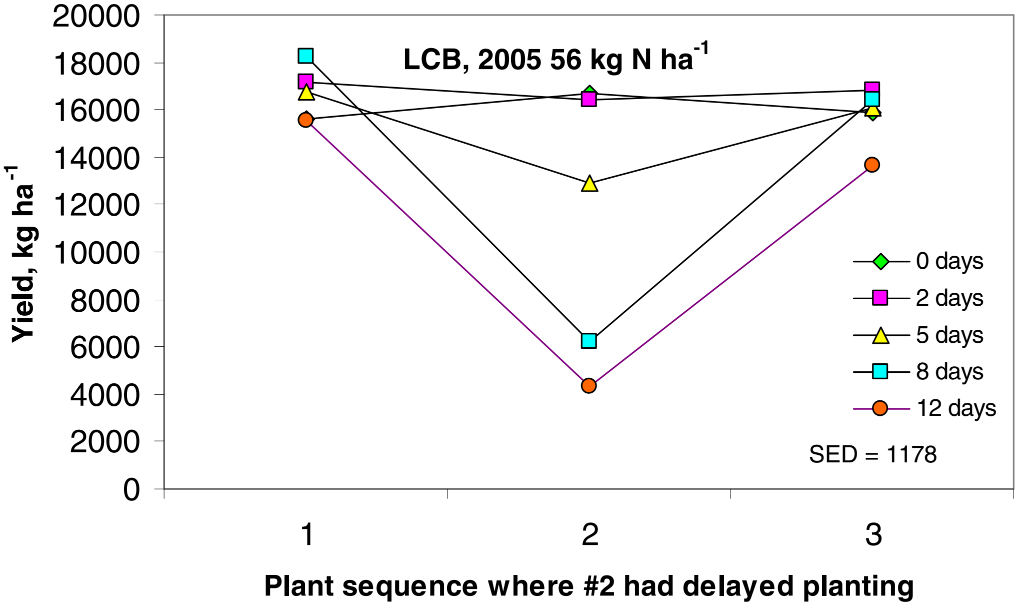

Figure 5. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 56 kg N ha^{-1} applied preplant, Lake Carl Blackwell 2005 (each point represents the average of nine plants repeated in these 3-plant sequences).

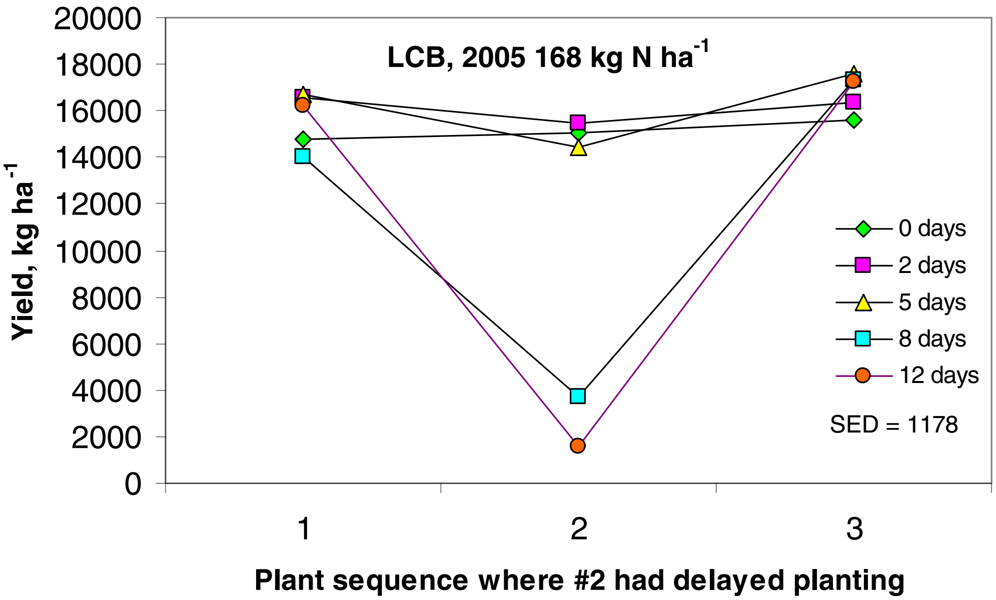

Figure 6. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 168 kg N ha^{-1} applied preplant, Lake Carl Blackwell 2005 (each point represents the average of nine plants repeated in these 3-plant sequences).

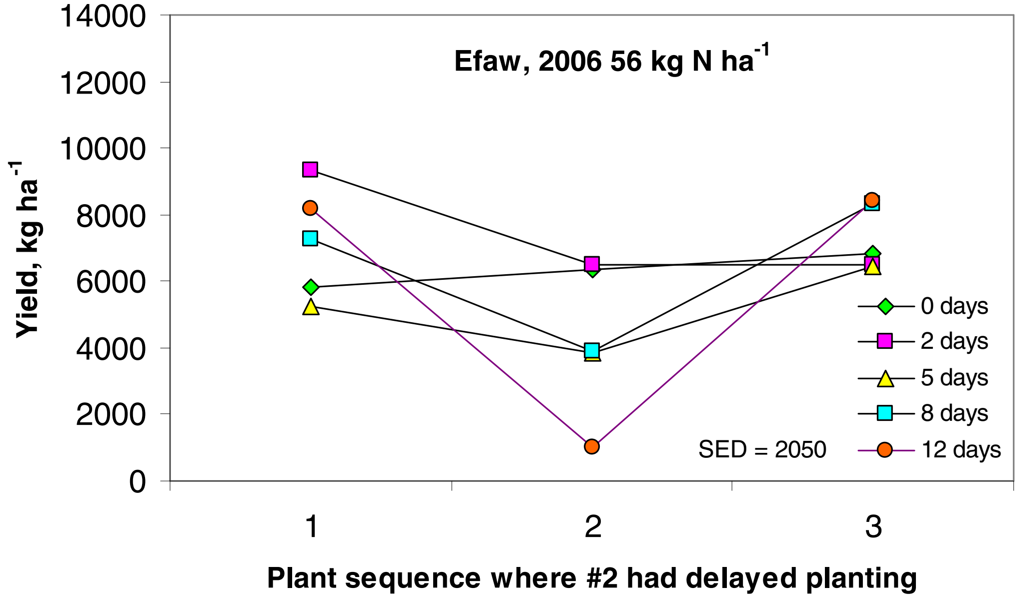

Figure 7. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 56 kg N ha^{-1} applied preplant, Efaw 2006 (each point represents the average of nine plants repeated in these 3-plant sequences).

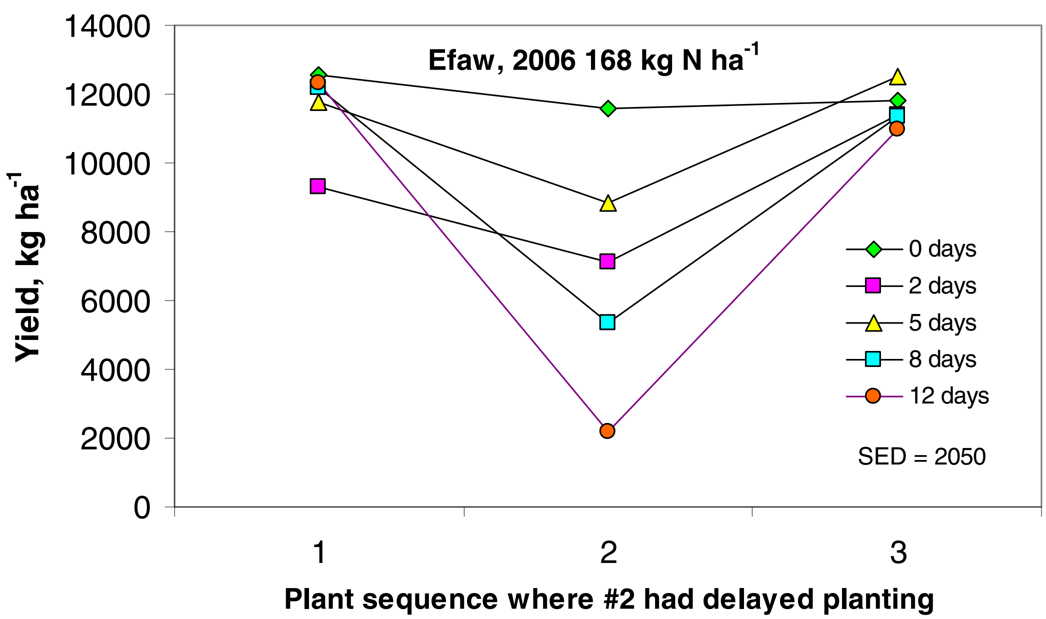

Figure 8. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 168 kg N ha^{-1} applied preplant, Efaw 2006 (each point represents the average of nine plants repeated in these 3-plant sequences).

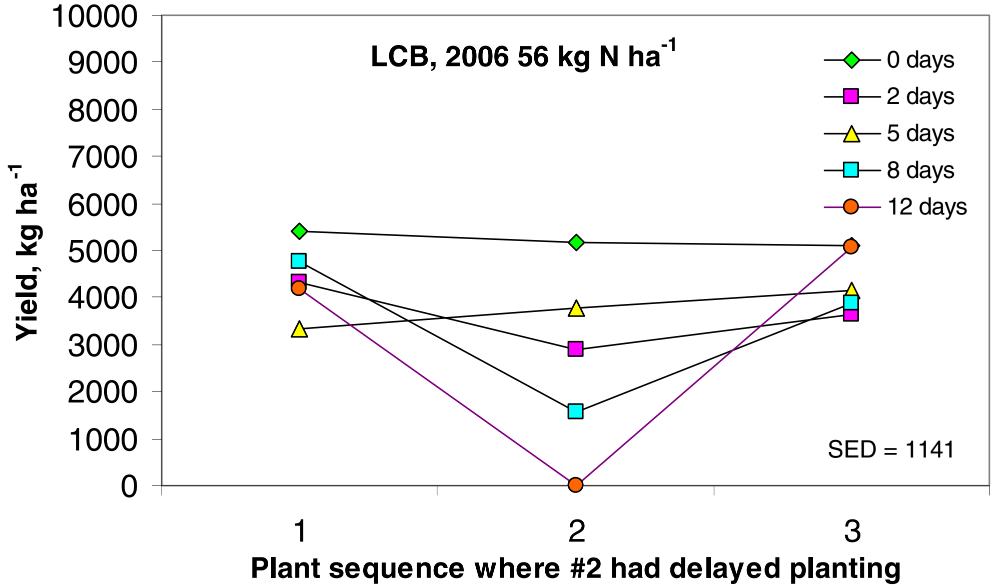

Figure 9. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 56 kg N ha^{-1} applied preplant, Lake Carl Blackwell 2006 (each point represents the average of nine plants repeated in these 3-plant sequences).

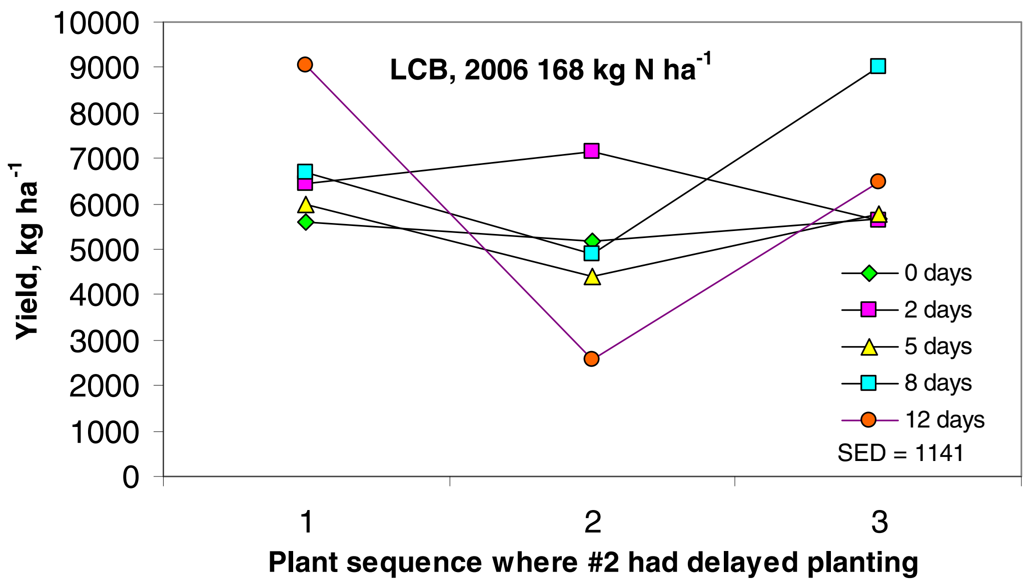

Figure 10. Three plant sequence where #2 was planted 0, 2, 5, 8, and 12 days later, 168 kg N ha^{-1} applied preplant, Lake Carl Blackwell 2006 (each point represents the average of nine plants repeated in these 3-plant sequences).

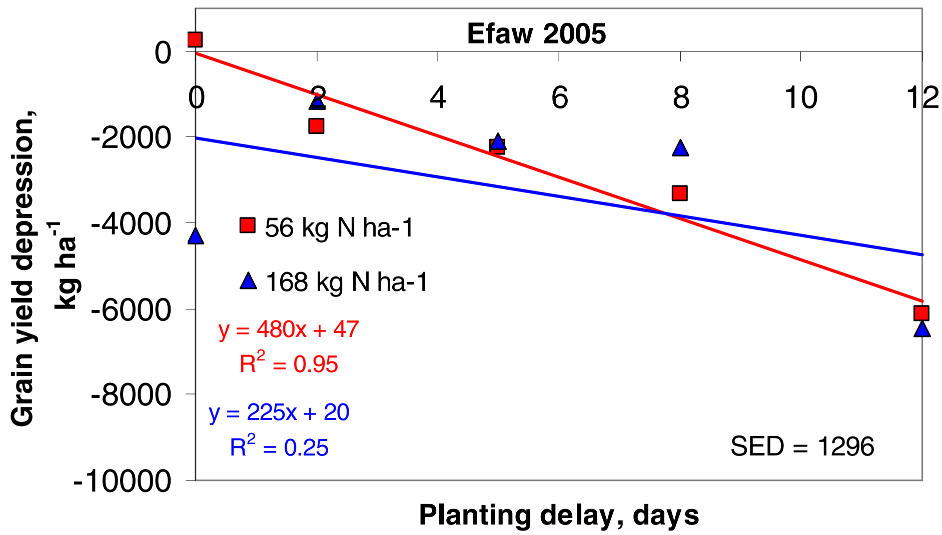

Figure 11. Corn grain yield depression in kg ha^{-1} when the center plant was delayed 0, 2, 5, 8, and 12 days, Efaw 2005.

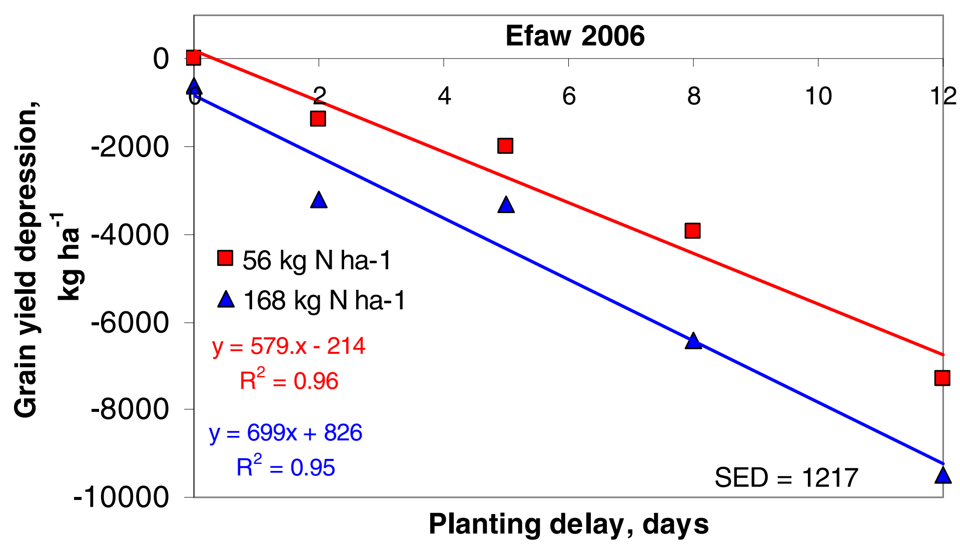

Figure 12. Corn grain yield depression in kg ha^{-1} when the center plant was delayed 0, 2, 5, 8, and 12 days, Efaw 2006.

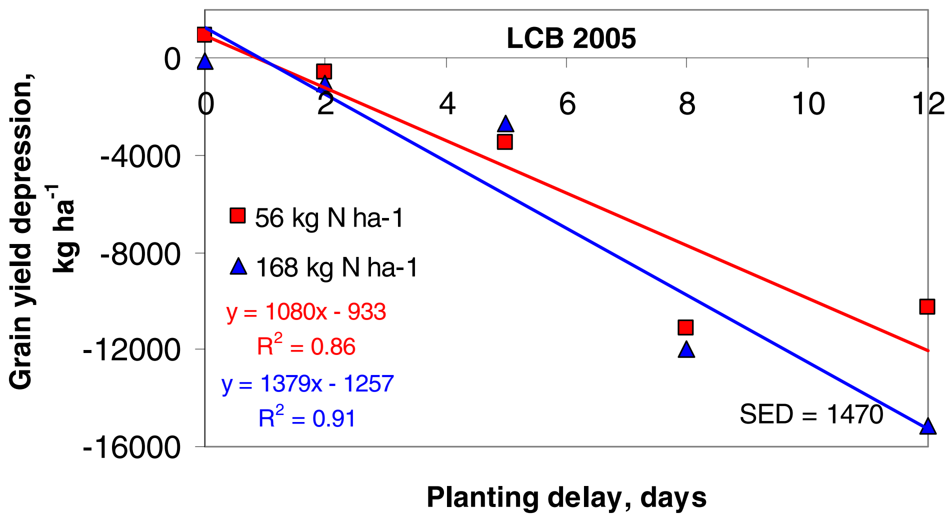

Figure 13. Corn grain yield depression in kg ha^{-1} when the center plant was delayed 0, 2, 5, 8, and 12 days, LCB 2005.

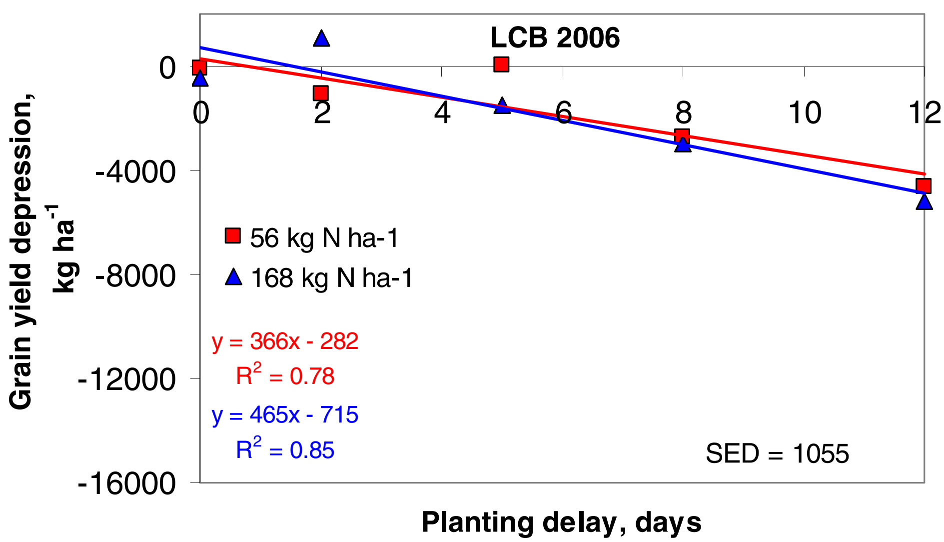

Figure 14. Corn grain yield depression in kg ha^{-1} when the center plant was delayed 0, 2, 5, 8, and 12 days, LCB 2006.

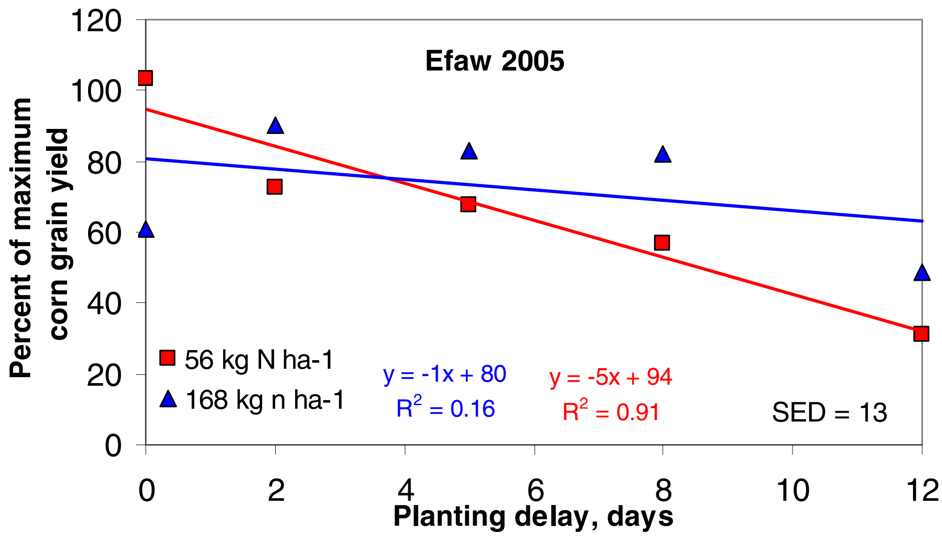

Figure 15. Three plant average when the center plant was delayed 0, 2, 5, 8, and 12 days expressed as percent of maximum corn grain yields, Efaw 2005.

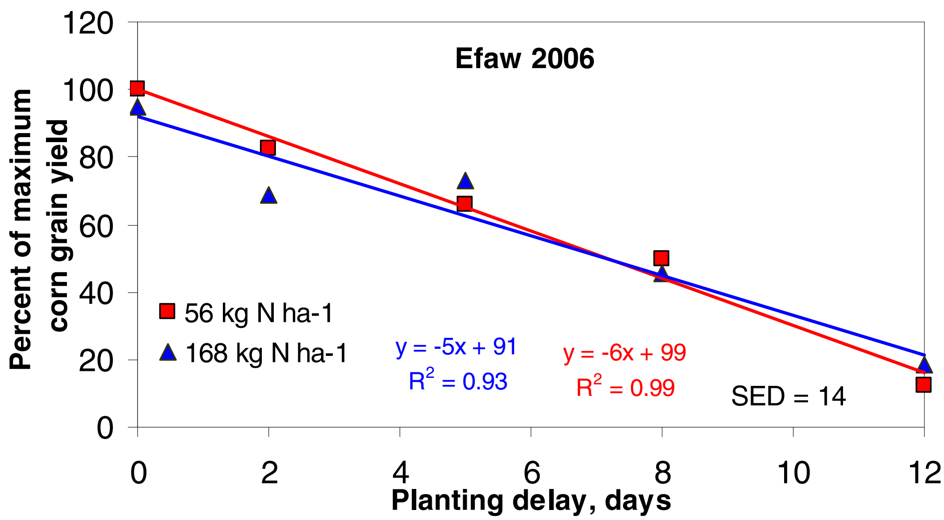

Figure 16. Three plant average when the center plant was delayed 0, 2, 5, 8, and 12 days expressed as percent of maximum corn grain yields, Efaw 2006.

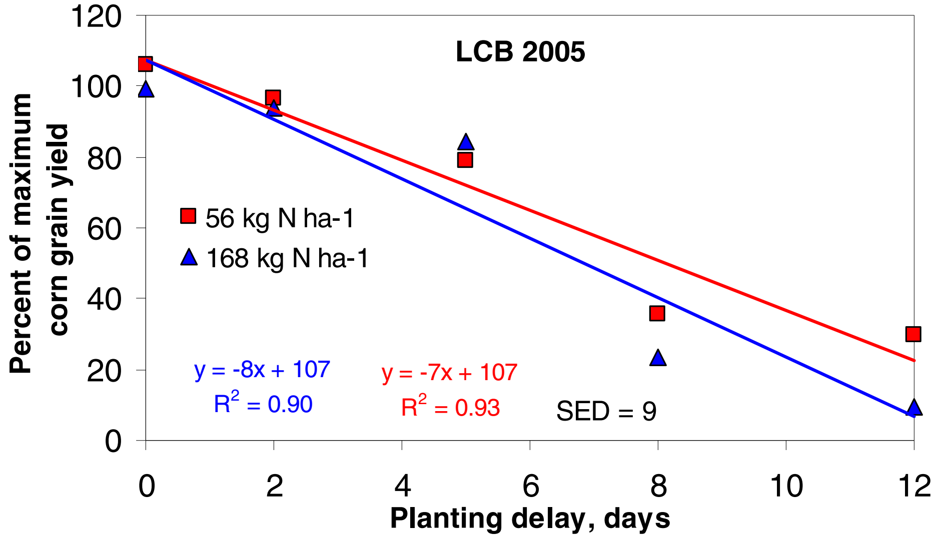

Figure 17. Three plant average when the center plant was delayed 0, 2, 5, 8, and 12 days expressed as percent of maximum corn grain yields, LCB 2005.

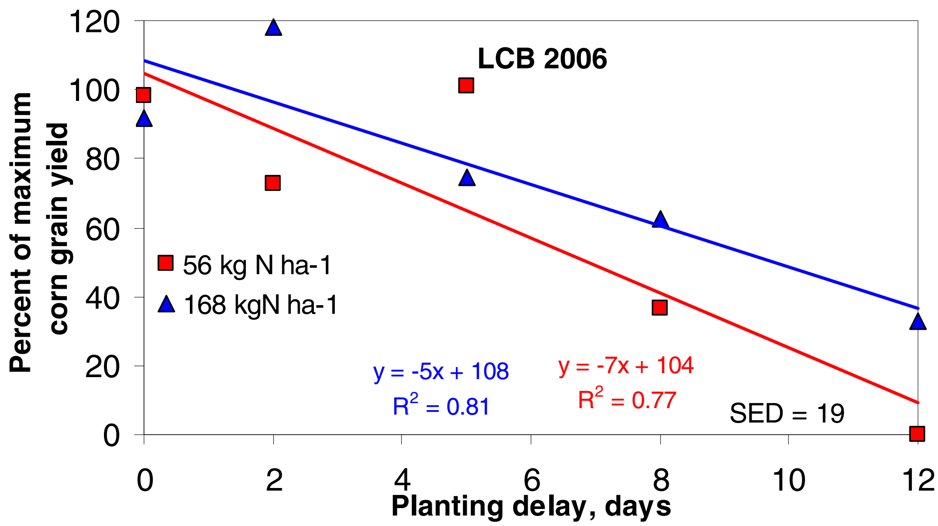

Figure 18. Three plant average when the center plant was delayed 0, 2, 5, 8, and 12 days expressed as percent of maximum corn grain yields, LCB 2006.

VITA

Kyle Don Lawles

Candidate for the Degree of

Masters of Science

Thesis: EFFECT OF DELAYED EMERGENCE ON CORN GRAIN YIELDS

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Pages in Study: 30

Candidates for the Degree of Masters of Science

Major Field: Plant and Soil Science

Scope and Method of Study:
The purpose of this study was to determine corn grain yield reduction as a function of interplant competition arising from delayed emergence and to evaluate yield levels associated with 3 plant sequences, with and without delayed emergence.

Findings and Conclusions:

Delayed planting to simulate delayed emergence was used in this experiment to determine the adverse effects on final corn grain yield. When comparing 3 plant sequences, the results show that delayed emerging plants result in decreased corn grain yields. Over both sites and years, data showed that when the days of delayed planting was greater than 5 days there was almost always a significant yield reduction. When looking at the three plant sequences the delayed plant by 2,5, and 8 days continued to compete with the two non delayed plants. By 12 days these plants competed less with the two non delayed plants and that then tended to have higher by-plant yields. Results from this study will assist those groups interested in improving by-plant N fertilization by knowing how much a plant is delayed and how that ultimately affects final corn grain yields. This information will in turn be used to estimate N removal based on yield level (or projected yield decrease) based on how much each plant is or is not delayed versus neighboring plants. When evaluating both sites and years, for each day delay emergence (estimated using delayed planting), grain yield depression ranged from 225 kg ha^{-1} to 1379 kg ha^{-1}.

ADVISER'S APPROVAL:___________ Dr. Bill Raun ______________________________