RELATIONSHIP OF CORN SEED VIGOR TO PERFORMANCE UNDER NO-TILLAGE PRODUCTION.

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No-tillage research over the past two decades has shown that corn can be produced successfully without yield loss in the southern and south-central United States (Blevins. 1970; Moody, et al., 1961; Shear and Moschler. 1969) while yield reductions frequently occur following minimum tillage planting in the more northern areas of the corn belt (Griffith, et al., 1973; Ritchey, et al., 1977; Mock and Erbach. 1977). Early investigations in Kentucky and Virginia reported that corn could be no till planted into grass sod and produced without yield losses. However. few acres of perennial grass remain in the major grain production areas and establishment of sod is not feasible for grain producers. Fortunately winter cover crops such as small grains, annual ryegrass andfor legumes have also shown excellent potential for no-tillage planting (Mitchell and Teel, 1977; Frye et al., 1980). It appears that these cover crops will reduce soil erosion and provide an excellent alternative to sod for no-till planting of corn.

Much evidence has accumulated showing that the surface mulch associated with no-tillage lowers soil temperatures at depths ranging from 2.5 to 10 cm. The mulch reduces the diurnal fluctuation in soil temperature with the greatest difference compared to bare soil occurring in the daily maximum temperature (Phillips, 1974; Moody et al., 1963). Lower emergence and growth rate of corn seedlings have been directly related to reduction in soil temperatures in no-till production (Griffith et al., 1977; Moody et al., 1963 and Burrows and Larson. 1962). Even though, slower initial growth of corn has been shown under mulch, Moody. et al. (1963) concluded that later in the growing season growth rates were superior for no-tillage (mulch) compared to bare soil.

Seedling vigor in corn is commonly measured in the laboratory by the cold test (Funk, et al., 1962; Burris and Navratil, 1979) andfor seedling dry weight evaluation (Eurris, 1975) with both tests able to detect vigor differences among seed lots. Dungan and Koehler (1944). using naturally-aged (carryover) corn seed, found that both stand and yield declined as the seed aged. They reported that with identical field stands, three year old seed was weaker and less vigorous than 1 year old seed and caused a 4.84; reduction in yield. Similar studies, with uniform field stands, reported lower yields using low vigor seed that had been naturally or artificially aged prior to planting compared to high vigor seed (Grabe, 1967; Funk, et al., 1962). Funk et a1.(1962) concluded that the low vigor seed were slow to emerge, had less seedling vigor and lower competitive ability and were of greater concern in some hybrids than others. After several investigations Burris (1975) concluded that no consistent response due to vigor could be demonstrated for corn seedling emergence or yield.

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The studies reported here were conducted to investigate the influence of seed vigor on seedling emergence, growth and yield in no-tillage planting systems. If seed vigor relates directly to improved performance in no-tillage systems, this parameter could be used by seed companies when evaluating genotypes for no-tillage use. Seed vigor can also be used by seed companies as an "in house" marketing tool to determine the ultimate destination of seed lots, with high vigor seed lots being sold in areas where early planting stress might be a problem. Knowledge gained may also be used by plant breeders when identifying genetic traits for improved planting seed performance.

METHODS:

Several corn seed lots were selected from the single cross **B73** X M017 that had acceptable germination but a range in seed vigor. The seed were tested for vigor using the cold test and seedling dry weight (AOSA. 1983) and for germination using the standard germination test (AOSA, 1982). Four seed lots were planted in 1982 and 1984 under four tillage systems and at three planting dates in a Maury silt loam soil on Spindletop Experimental Farm near Lexington, KY. The experiment was arranged in a split, split plot design with tillage treatments as main plots, planting dates as sub plots and seed vigor as sub, sub plots with three replications.

The three planting dates were April 15, May 5 and May 25, 1982 and April 21, May 12 and June 5. 1984. The four tillage systems used were:

1. Conventional tillage (CONV) - Soil was fall plowed and a seedbed prepared in the spring by discing and planted using conventional cultural practices.
2. No-till corn stalks (CSNT) – Corn was produced the previous year and the stalks were chopped after harvest to form a mulch. The soil was not tilled prior to no till planting of corn the following spring.
3. No-till wheat (WNT) - Soil was fall plowed, and planted in mid-October to soft red winter wheat at the rate of 2 bu/A and disced to cover the seed. Corn was no-till planted into standing wheat which was sprayed 1-3 days before planting, except for the last planting date which was sprayed with paraquat approximately 20 days prior to planting to conserve moisture.
4. No till tall fescue (TFNT) - The area where the plots were established had been in tall fescue sod for at least three years prior to planting. Corn was no-till planted into sod which had been sprayed at the same time intervals as described above for WNT.

A tank mixture of Lasso, Atrazine and Paraquat plus spreader was used to kill cover crops and control weeds in all tillage treatments. All seed lots were treated with the fungicide Captan. Mesural and Furadan were applied at planting to control rodents and soil insects. Soil samples were taken in the fall and lime was applied as recommended in November of each year. Ammonium nitrate was applied by hand to each treatment at the rate of 175 lb N/A 1 to 2 days prior to planting. Potassium was applied to the entire plot area as potassium chloride at 250 lb/A in mid-April of each year.

A two row Allis-Chalmers planter equipped with fluted coulters and cone planting units was used to plant all the plots. All treatments were extablished in four row plots 40 feet long with a 38" row spacing. The planting depth was 2 inches and the planting rate was 26.000 viable seeds per acre.

The following field evaluations were made for each treatment:

1. Soil temperature - Prior to and after each planting date for each tillage system, soil temperature was monitored at the seed planting depth with copper-constantan thermocouples with a minimum of 3 thermocouples in each planting date-tillage system.
2. Field Emergence – Emergence counts were made at first emergence and at regular intervals until 50% emergence. Those seedlings that had the first plumule unrolled from the emerged coleoptile were considered emerged.
3. Stand - Final stand counts were made for all treatments approximately two weeks after 50% emergence.
4. Growth rate - Three samples were taken for the measurements of plant height, dry weight and leaf area at the following growth stages: Sample 1 - Fourth collar growth stage according to Hanway (1963); Sample 2 - When one-half of the growing degree days (GDD) between 50% emergence and anthesis had accumulated for each treatment (not taken in 1984); and Sample 3 - When 50% of the plants had silks exposed. Ten consecutive plants were harvested in each vigor level for the first sample date. Five consecutive plants were harvested for the other sample dates.
5. Soil Moisture - Soil samples were taken at planting, at weekly intervals until 50% emergence and at each sample date for growth rate measurements at a depth of 0-3" (emergence period) and 0-6" (growth stages).
6. Grain Yield – Determined by hand harvesting a 15 foot section of two middle rows in each treatment. The number of ears per plant was recorded, the ears were dried. weighed, the moisture determined and the yield adjusted to 15.5% seed moisture.

RESULTS AND DISCUSSION

A range of environmental conditions occurred following the three planting dates in four tillage systems in both years with a wide range in 1982. Soil conditions varied from cool and wet at the April 15, 1982 planting date to warm and dry at later plantings in both years (especially WNT in 1982 and CSNT in 1984). Excellent seed placement was achieved in all plantings and in all tillage systems allowing adequate stand establishment under favorable conditions. All significant differences presented for field emergence, plant growth and yield treatment means are at the a = 0.05 level using the Least Significant Difference (LSD) test.

Seed Vigor

Four seed lots were selected in 1982 and 1984 which had acceptable standard germination (≥ 88%) but a range in seed vigor (Table 1). All seed lots in both years were of similar seed size (220–270 mg seed^{-1}) and shape (medium flat). In 1982 seed lot 1L had a low cold test germination (68%), low seedling growth, and a vigor rating of 5.3 which was classified as low vigor. Even though seed lot 2M had a slightly lower cold test germination (64%). it had a much higher seedling growth rate and a medium vigor rating of 6.3. Seed lots 3H and 4H had high vigor ratings (10.0 and 9.7. respectively) because of high cold test and seedling vigor results. In 1984, seed lots 2L and 4L had the lowest cold test germinations and seedling growth rate scores and were both classified at low vigor (Table 1) In contrast, seed lots 1H and 3H had high cold test germination and seedling growth rate which resulted in high vigor ratings of 9.7 and 9.0 respectively.

Table 1 Seed lots of the single cross B73 x M017 used in 1982 and 1984

Seed lot (Vigor)[1]	Standard Germination	Cold Test	Shoot and Root Weight	Vigor Index
	---------- %	------	mg/seedling	Rating
		1982		
1L	88	68	47	5.3
2M	94	64	62	6.3
3H	96	94	81	10.0
4H	94	94	83	9.7
		1984		
1H	98	97	78	9.7
2L	93	45	39	3.3
3H	94	97	71	9.0
4L	88	57	47	4.7

1 Relative vigor was determined used vigor rating system previously described by TeKrony et al., 1977 where High(H), Medium(M) and Low(L) vigor seed lots had a rating of > 8.0, 610 to 8.0 and < 6.0 respectively.

Soil Temperature

The pattern of soil temperature at planting depth was similar in both 1982 and 1984. Maximum! ranges in the mean maximum and minimum soil temperature were seen at the first planting date both years. The fluctuations in temperature decreased while the average minimum and maximum temperature increased with each successive delay in planting each year. Since the first planting date had the greatest effect on seedling emergence and the temperature pattern was similar in 1982 and 1984 only soil temperature data recorded for an 8 day interval following the April 15, 1982 planting will be presented (Figure 1). The average soil temperature of CONV, CSNT, and WNT was 13C for the period from April 20 to April 28, 1982 (time to mean 50% emergence across tillage systems and seed lots) while the average soil temperature of TFNT was 12C. The minimum soil temperature of CONV on April 20 was 1OC and remained below this level for the next four days (Figure 1). During the same period the maximum soil temperature of CONV ranged from 13 to 22C. Minimum soil temperature in TFNT was higher than CONV and varied less ranging from 7 to 12C over the period from April 20 to April 28 while maximum soil temperature in TFNT varied from 12 to 16C over the same period. Soil temperatures recorded in WNT and CSNT were similar to CONV (Figure 1).

Decreased average soil temperature under mulch and in no-tillage has been reported by several workers (McCalla and Duley, 1946; Van Wijk et al., 1959; and Lal, 1974), and the magnitude of the decrease observed was related to the amount of mulch present. Burrows and Larson (1962) reported an average decrease in soil temperature of 0.4C for each 811 lb/A of mulch added to the soil surface. The amount of mulch present in TFNT in 1982 was 1924 lb/A which would correspond to an average 1C decrease in soil temperature compared to COMV according to Burrows and Larson. There was less mulch in WNT (1175 lb/A) and the mulch was less dense than the tall fescue sod so the amount of mulch present did not affect soil temperature as much as in TFNT.

Field Emergence

A wide range in final field emergence was observed between and within vigor levels, tillage systems and planting dates. The widest range in final emergence was seen in 1982, from 36% for the low vigor seed lot (1L) planted into tall fescue on April 15 to 96% for the two high vigor seed lots (3H and 4H) planted into CONV on May 25 (Table 2). In 1984 field emergence ranged from 55% for the low vigor seed lot (2L) planted into TFNT on April 27 to 95% for the high vigor seed lot (1H) planted into CONV on May 12 (Table 3). The range in field emergence decreased with each successive delay in planting in 1982 while the narrowest range in field emergence was observed at the second (May 12) planting date in 1984.

The lowest final field emergence averaged across tillage systems and vigor levels was observed at the first plating date each year which indicates a negative response of all seed lots to the stressful planting conditions. Differences in both soil temperature and soil moisture contributed to the differences seen between the final field emergence results across planting dates and tillage systems. TFNT had the most stressful planting conditions at the first planting date each year which resulted in the lowest, average final emergence for all vigor levels. Conversely CONV had the most favorable planting conditions for each planting date each year which resulted in the highest field emergence for all vigor levels. Soil temperature in WNT and CSNT was similar to CONV and average time to 50% emergence was also similar (14and 12 days, respectively). These results agree with previous studies which showed that lower field emergence and slower rates of emergence were related to reduced soil temperature in no till production (Griffith et al., 1977; and Moody et al., 1963).

Low soil moisture at planting and during the period from planting to 50% emergence contributed to the low final stands observed for WNT at the May 5 planting date in 1982 and for CSNT and TFNT at the June 4 planting date in 1984. Soil moisture for WNT was 10% at the May 5, 1982 planting due to moisture depletion in the root zone by the actively growing wheat crop. This extremely low soil moisture at planting reduced the final stand for WNT. The TFNT and CSNT treatments had soil moisture levels of 19 and 206, respectively, compared to 23% for WNT and 25% for CONV one week after the June 4 planting date in 1984. This lower soil moisture combined with poor rainfall distribution during the emergence period reduced the final stands for TFNT and CSNT at the third planting date in 1984.

Final emergence of the low vigor seed lots averaged across tillage systems was less than 80% and significantly lower than the medium and high vigor seed lots at all three planting dates both years (Table **2).** Similar results were found in 1984 for the low vigor versus the high vigor seed lots. The range in field emergence averaged across tillage systems for the low vigor lots over all three planting dates was 66 to 14% compared to a range of 82 to 87% for the high vigor lots (Tab1e 3). These results are similar to previous reports which show that high vigor seed lots have a better emergence potential than low vigor lots in both stressful and more optimum emergence conditions (Funk et al., 1962; Johnson and Wax, 1981).

Plant Growth

Plant height, dry weight and leaf area were measured at three plant growth stages (fourth collar, one half of GDD to anthesis (1982 only) and 50% silking). Plant growth was measured at these growth stages rather than at a certain time interval after planting to reduce the effect of differences in emergence rate on growth measurements. Since the results of all three measurements followed similar trends, only the average of plant height and dry weight across seed lots will be presented (Tables 4 and 5) and the seed vigor levels will be compared only for the April 15, 1982 planting date. Plant dry weight will be reported as weight per meter^2 to examine the relationship of seed vigor to plant dry weight over a given area which reflects plant stand as well as plant size.

In 1982 the greatest difference in plant height between seed lots and tillage systems at the fourth collar growth stage occurred in the first (April 15) planting date. The plant height when averaged across seed lots was significantly lower than the other tillage systems for WNT at the first and second sampling stages (Table 4). Differences in dry weight in 1982 were also most evident at the April 15 planting date and WNT was significantly lower than most other tillage systems when averaged across seed vigor levels at all three sampling stages (Table 5). The lower plant height and dry weight for WNT was also evident at the 2nd and 3rd sampling dates for the May 5 planting date. The average soil temperature of WNT was slightly less than CONV. but not as low as TFNT in 1982, thus, decreases in plant height and dry weight were not related to soil temperature. Even though there was little difference in soil moisture between tillage systems at the April 15 planting date in 1982, the soil moisture in WNT was approximately **5** percentage points lower at the May 5 and May 25 planting dates. Since little rainfall occurred prior to the first and second sampling stages in 1982, the lower plant growth of WNT may be due to less soil moisture due to the growth of wheat prior to planting.

In 1984 at the first sample date (fourth collar stage) there were consistent trends for both plant height and dry weight to be lowest for CSNT when averaged across all seed lots at all three planting dates (Tables 4 and 5). Inversely, plants in TFNT were consistently taller and cf greater dry weight than all other tillage systems at the same growth stage for the April 27 and May 12 planting dates. Since there was less difference in soil temperatures between tillage systems in 1984 than in 1982, the differences in early plant growth were again primarily related to differences in soil moisture. The average soil moisture for approximately one month prior to the fourth collar sample was 3 to 5 percentage points higher for TFNT than CSNT with WNT at an intermediate level across all planting dates.

Few differences in plant height were recorded at the third sampling date (50% silking) between tillage systems or seed lots at any planting date in 1982 or 1984 (Table 4). There were also few differences in dry weight at 50% silking between tillage systems and seed vigor levels in 1982 and 1984 across the three planting dates (Table 5). In 1984 when averaged across seed lots the dry weight of TFNT was significantly greater than all other tillage systems at the last two planting dates. The increased growth at 50% silking in TFNT was primarily related to increased soil moisture in both years.

It has previously been reported that soil moisture under killed tall fescue sod is greater than in conventional tillage to a depth of 20 inches and has been related to yield increases over conventional tillage (Hill and Blevins, 1973). Moody et al. (1963) found that corn grown in mulched plots was taller at silking than that in conventional tillage, while Jones et al. (1969) found average plant height to be greater under mulch and attributed it to increased soil moisture under the mulch. In these experiments no significant differences in plant height were recorded at 50% silking between seed lots in any tillage system. Glenn et al. (1974) also observed that differences in plant height due to initial differences in seedling vigor usually decreased as the plants matured.

Plants from the low vigor seed lots were shorter and lower in dry weight at the first sampling date (fourth collar stage) in both years. This difference was largest at the first and second planting dates, however, it was still evident at the last planting date. Since similar trends occurred between seed vigor levels in both years only the 1982 results will be presented for the April 15 planting date (Figures 2 and 3). Even though these differences occurred early in growth, there was little difference in plant height between vigor levels at the last sampling date (50% silking) and low vigor seed lots also had higher dry weight per plant than medium and high vigor seed lots. However, when expressed as total dry weight on a area basis (g m^2) the low vigor seed lots had lower dry weight especially at the first and second planting dates of TFNT and WNT where stands were slightly lower than for medium and high vigor levels.

Yield

Average grain yield of all tillage systems (across seed lots and years) ranged from 85 bu/A for late planted CONV to 145 bu/A for the early planted TFNT (Table 6). The highest average yields across both years occurred for TFNT followed by WNT and CSNT with CONV having the lowest yields. In 1982 there was no significant difference in average yield (across seed lots) between the three no-till planting systems at any planting date (Table 6) and all were consistently equal to or higher than CONV. In 1984 there was no significant difference in average yield between CONV and CSNT, however, both were significantly lower than TFNT at the April 27 and May 12 planting dates. The lower yields in WNT at the May 5, 1982 planting date and in CSNT at the April 27 and May 12, 1984 planting dates were primarily associated with moisture stress in these tillage systems. In the WNT treatment in 1982 the wheat plants were killed just prior to the May **5** planting date and little rainfall occurred immediately before and after planting. In 1984 there was less mulch in CSNT than in TFNT and WNT. however, the differences were similar to 1982. Thus, the lower soil moistures in the CSNT in 1984 may possibly be related to soil compaction in the previous plot area and the extremely dry conditions which occurred during corn production the previous year. Since the CSNT treatment was not tilled in the fall or spring prior to no-till planting, there may have been less movement of water into the soil profile following rainfall in 1984 than for the other tillage treatments. Thus, later in the growing season as moisture become limiting there was less soil moisture available for plant growth which eventually resulted in lower yields for CSNT than occurred in 1982.

Grain yields of the four seed lots were variable across the two years, however, they were generally influenced more by planting date and tillage system than seed vigor. The greatest differences in yield between seed lots was recorded in WNT and TFNT at the early planting date in 1982 where yields of seed lot 1L were 91 bu/A which was significantly lower than medium and high vigor seed lots which ranged from 132 to 157 buIA. Similarly the greatest difference in yield in 1984 occurred for seed lot 2L in TFNT which was 22 and 40 buIA lower than the high vigor seed lots 1H and 3H which yielded 144 and 162 bu/A, respectively. Little to no difference in yield occurred between seed vigor levels at the second and third planting dates across all tillage systems in either year, except that seed lot 1L was significantly lower than all other seed lots in WNT at the May 5, 1982 planting date.

The reductions in yield of the low vigor seed lots (1L in WNT and TFNT in 1982 and 2L in TFNT in 1984) were associated with decreased stands of these seed lots at the earliest planting date. Stands of both low vigor seed lots were reduced to less than 16,000 plants/acre in both WNT and TFNT in 1982 and to less than 17,000 plants/acre in TFNT in 1984, which caused a significant reduction in yield. There was little difference in yield between vigor levels at other planting dates and tillage systems when stands were similar. Except for seed lot 1L of WNT at the second planting date in 1982, there was little difference in stand or yield between vigor levels within the second and third planting dates in either year. These results agree with Burris (1975) who found that there was little effect of seed vigor on grain yield in conventionally planted corn when stands were equal. Thus, while seedling emergence was reduced for the low vigor seed lots under the more stressful planting conditions, reductions in final stand that could affect yield were avoided in most cases due to the high initial seeding rate of 26,000 seed per acre. At lower seeding rates (i.e. 22,000 seed per acre) it is possible that the plant stands of low vigor seed lots could have been reduced to a level that yield reductions would occur.

SUMMARY

The results of this investigation indicate that there was no relationship of seed vigor to yield if stand differences were not recorded. However, stands of low vigor seed lots were lower than all other seed lots at the early planting date in certain no-till systems and these reduced stands caused lower yields. Therefore, the use of high vigor seed would be beneficial to achieve adequate stands if no-tillage corn was planted early especially into tall fescue or wheat. There is presently no requirement to label corn seed for vigor, thus the purchaser cannot assess the vigor of the seed at the time of purchase. There are several reasons for not labelling seed vigor on the seed tag as is done with standard germination. There is no standardized vigor test for use on corn seed due to variability in methods and materials used to test for vigor. This lack of standardization complicates the interpretation of vigor testing results between different seed laboratories and makes the information less useful to the purchaser.

Although the vigor information is not printed on the tag, the purchaser can have the seed tested for vigor at a public or private agency and use the results to help make decisions about planting rates and tillage options. Results of vigor tests could also be used by plant breeders and seed companies to identify genotypes and seed lots that will be more tolerant to cold soil. Mock (1982) has identified cold tolerance as one of the most important characteristics for profitable no-tillage corn production, thus, the use of seed vigor testing could become an important tool in the future success of corn no-tillage systems.

The results of this study indicate that no-tillage corn can be planted as early as conventionally tilled corn without reductions in yield if adequate stands are achieved. The use of wheat as a cover crop appears to be a viable alternative to conventional tillage. However, the wheat needs to be managed carefully to assure adequate soil moisture for the corn crop. Planting corn with no-tillage directly into corn stubble from the previous crop is also an alternative to conventional tillage, however, disease and insect problems can occur when using this practice.

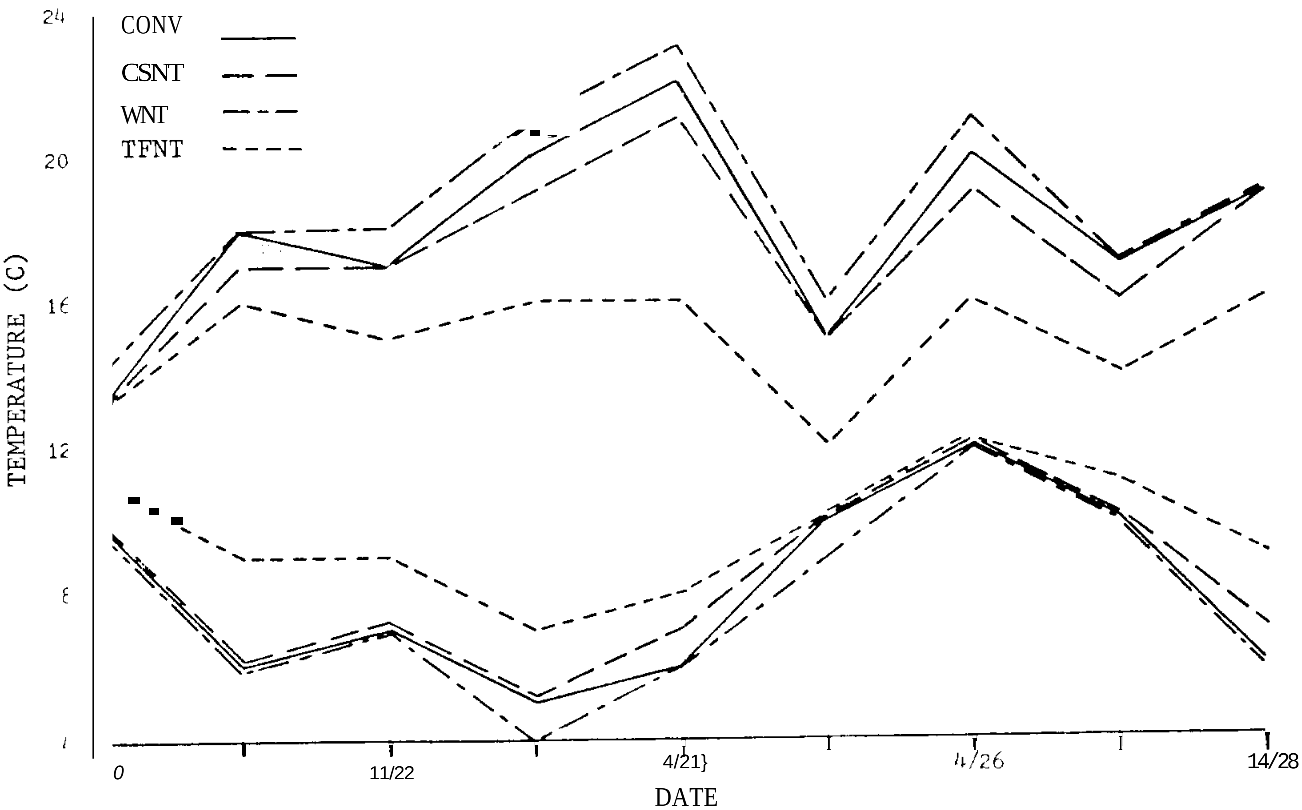

Figure 1, Minimum and maximum soil temperatures in four tillage systems for the period from April 20 to April 28 following planting on April 15, 1982.

Table 2. Final emergence of four seed lots in four tillage systems at three planting dates in 1982.

Planting Date	Tillage System	Seed Lot‡§ 1L	2M	3H	4H	Tillage Mean†
		---------- % ----------				
April 15	CONV	49	85	89	93	79
	CSNT	61	78	87	91	79
	WNT	37	61	67	73	60
	TFNT	36	69	81	82	67
	Mean	46	73	81	85	
May 5	CONV	64	88	91	92	84
	CSNT	55	80	81	80	74
	WNT	46	63	68	76	63
	TFNT	57	87	88	91	81
	Mean	56	80	82	85	
May 25	CONV	70	95	96	96	89
	CSNT	70	88	93	94	86
	WNT	72	85	89	93	85
	TFNT	63	84	88	89	81
	Mean	69	88	92	93	

† LSD 0.05 = 5 Comparing tillage system means averaged across seed lots.

‡ LSD 0.05 = 7 Comparing seed lots in the same tillage system at one planting date.

§ LSD 0.05 = 3 Comparing seed lots averaged across tillage systems at one planting date.

Table 3. Final emergence of four seed lots in four tillage systems at three planting dates in 1984.

Planting Date	Tillage System	Seed Lot‡ § 1H	2L	3H	4L	Tillage Mean†
		----------		%	----------	
April 27	CONV	95	71	91	75	83
	CSNT	88	75	88	73	81
	WNT	77	64	77	73	73
	TFNT	85	55	74	61	69
	Mean	86	66	82	70	
May 12	CONV	95	80	93	82	81
	CSNT	84	68	79	66	74
	WNT	78	72	87	69	77
	TFNT	91	77	92	75	84
	Mean	81	74	88	73	
June 4	CONV	91	82	93	79	86
	CSNT	73	66	82	71	73
	WNT	89	76	91	74	83
	TFNT	88	61	83	67	15
	Mean	85	71	81	73	

† $LSD_{0.05} = 5$ Comparing tillage system means averaged across seed lots.

‡ $LSD_{0.05} = 10$ Comparing seed lots in the same tillage system at one planting date.

§ $LSD_{0.05} = 5$ Comparing seed lots averaged across tillage systems at one planting date.

Table 4 Plant height averaged across four seed lots in four tillage systems and three planting dates in 1982 and 1984.

Tillage System	Planting Date †	Sampling Dates ‡ 1	2	3	1	3
		cm				
CONV	1	54	125	241	61	249
	2	53	141	239	70	253
	3	49	129	252	73	253
CSNT	1	52	125	261	51	252
	2	52	143	254	64	245
	3	43	139	219	55	---
WNT	1	39	94	241	68	257
	2	53	99	243	74	218
	3	54	121	213	74	261
TFNT	1	52	129	215	85	289
	2	59	128	269	93	296
	3	51	152	286	67	212
LSD 0.05		7	14	14	6	32

† Planting dates were: 1982 (April 15, Hay 5 and May 25).
1984 (April 27, May 12 and June 4).

‡ Sampling dates: 1-fourth collar leaf stage, 2-one half of GDD and 3-502 silking.

Table 5 Plant dry weight (g m^{-2}) averaged across four seed lots in four tillage systems and three planting dates in 1982 and 1984.

Tillage System	Planting Date†	Sampling Dates‡ 1982 1	2	3	1984 1	3
		---------------- g m^{-2}	------------			
CONV	1	31	211	843	25	912
	2	25	211	907	31	926
	3	26	258	993	38	1046
CSNT	1	28	210	993	21	1002
	2	21	251	870	14	787
	3	25	214	1011	23	---
WNT	1	16	105	195	29	900
	2	19	124	135	29	982
	3	21	201	949	40	1052
TFNT	1	27	210	1119	31	946
	2	28	234	993	52	1122
	3	26	218	913	32	1256
LSD 0.05		9	50	170	7	115

† The planting dates were: 1982 (April 15, May 5 and May 25)
1984 (April 27, May 12 and June 4)

‡ Sampling dates: 1– fourth collar leaf stage, 2–one half of GDD and 3-50% silking.

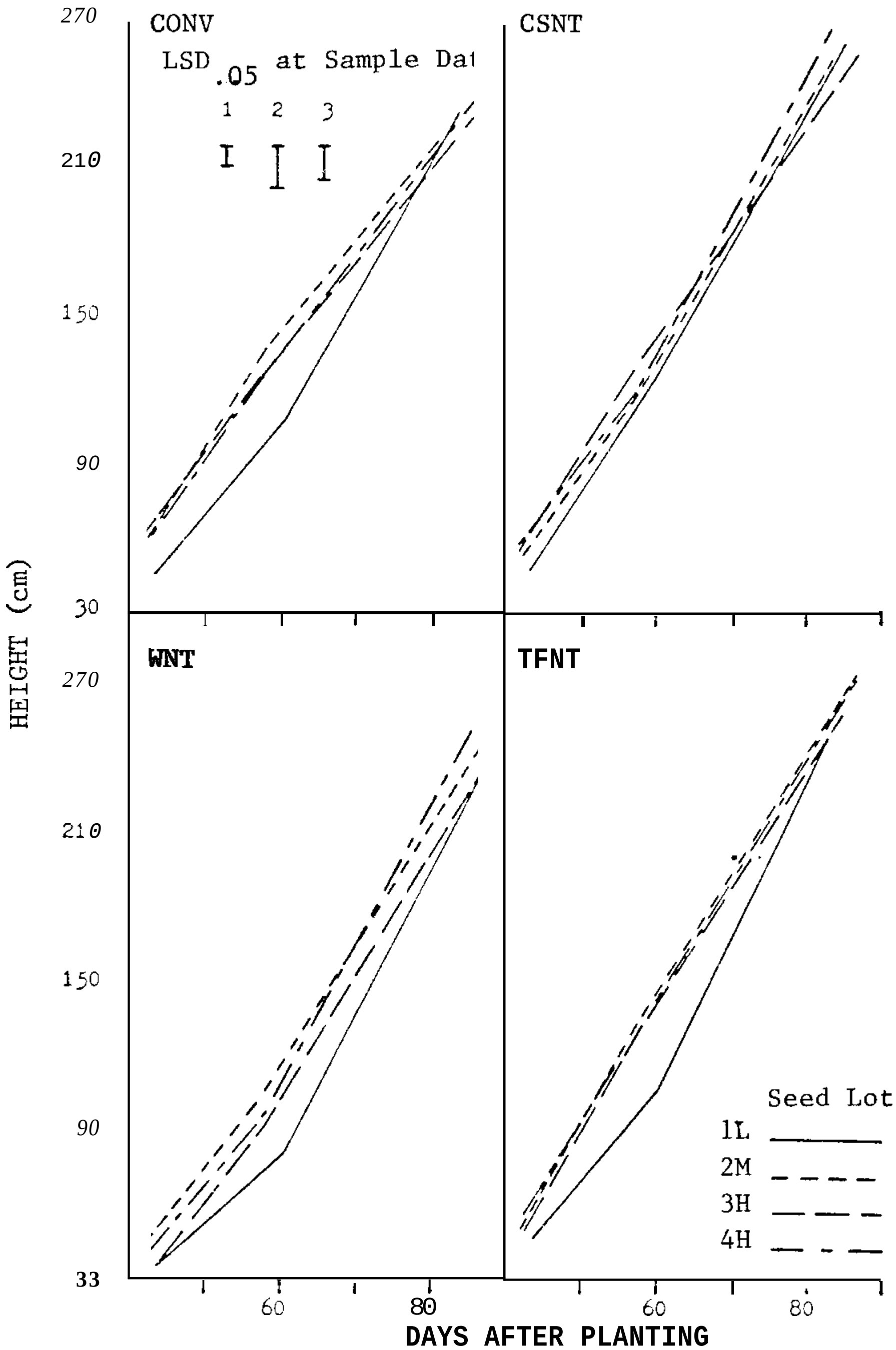

Figure 2. Plant height of four seed lots in four tillage systems of the April 15 planting date in 1982 at three sample dates.

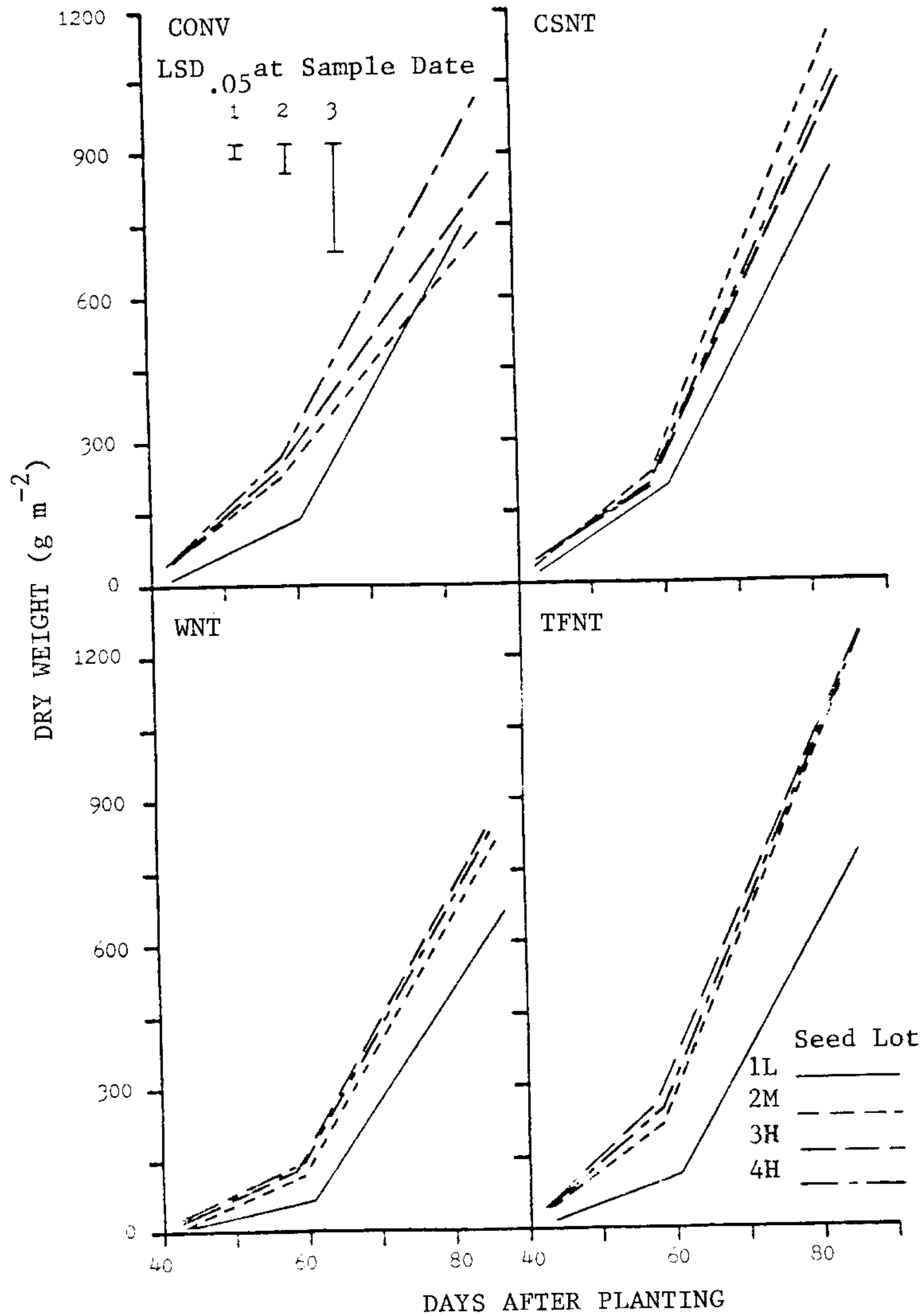

Figure 3. Plant dry weight (g m^{-2}) of four seed lots in four tillage **systems** of the April 15 planting date in 1982 at three sample dates.

Table 6 Grain yield averaged across seed lots in four tillage systems at three planting dates in 1982 and 1984.

Tillage System	Planting Date †	Yield 1982	Yield 1984	2 YR Mean
		-------- Bu/A	--------	
CONV	1	129	110	119
	2	132	112	112
	3	99	72	72
CSNT	1	154	102	128
	2	146	102	124
	3	112	---	---
WNT	1	149	121	135
	2	132	133	133
	3	131	82	106
TFNT	1	144	146	145
	2	151	134	142
	3	129	82	105
LSD 0.05		22	18	

† The planting dates were: 1982 (April 15, May 5 and May 25)

1984 (April 21, May 12 and June 4)

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