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Institution: Oklahoma State University

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Title of Study: GRAIN SORGHUM PRODUCTION UNDER LO-TILL AND NO-TILL FARMING SYSTEMS

Pages in study: 58   Candidate for Degree of Master of Science

Major Field: Agronomy

Scope and Method of Study: A three year Lo-till and No-till field experiment was conducted at the Oklahoma State University Agronomy Research Station near Perkins to determine comperative grain yield and agronomic characteristics of sorghum hybrid "ACCO BR-Y93". A laboratory experiment was conducted to determine protein in grain by the Udy dye binding procedure. Treatments consisted of 3x3x3 factorial arrangements of three row spacings (RS) (25, 50, and 75 cm), three plant spacings (PS) (10, 15, and 30 cm), and three Nitrogen (N) rates (0, 90, and 180 kg/ha) in a randomized complete block design with three replications.

Findings and Conclusions: In all years tillage (T) affected most of the variables measured. Nitrogen had a significant effect on most variables throughout the experiment. Many interactions were significant but most involved characteristics of reduced economic importance. There was no significant effect of plant population on grain yield. In all instance increased N applied increased plant lodging. No-till plots produced more grain than Lo-till in 1982 and 1983 but Lo-till produced more grain in 1984. Competition from weeds became an increasing problem in No-till plots as the experiment progressed. Best average grain yields were obtained with 50 cm row spacing, 30 cm plant spacing, and a nitrogen rate of 90 kg/ha.

ADVISER'S APPROVAL ______________________________

GRAIN SORGHUM PRODUCTION UNDER
LO-TILL AND NO-TILL
FARMING SYSTEMS

By

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Bachelor of Science in Agriculture

Oklahoma State University

Stillwater, Oklahoma

1983

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the degree of
MASTER OF SCIENCE
May, 1985

GRAIN SORGHUM PRODUCTION UNDER

LO-TILL AND NO-TILL

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ACKNOWLEDGEMENTS

With all sincerity I do acknowledge all aids, efforts, and encouragements expressed by my major adviser, Professor Charles E. Denman, throughout the duration of this research. The same gratitude is extended to all friends, faculty, and staff of Agronomy Department.

I do appreciate the indiscriminate sponsorship of the Agronomy Department from the birth to the completion of this research project.

My gratefulness to the efficient members of my committee, Dr. D.E. Weibel, Dr. J.Q. Lynd, and Dr. P.L. Claypool, for their seasoned advice and help.

My deep love to my wife, Uduak Ekpin, and my four children: Ubong, Inemesit, Udoro, and Jacob for their patience, support, and encouragement throughout this research exercise.

To crown it all, I must not forget my Father, Jehovah God, who has granted me favor with him as well as with men through his son Jesus Christ. May I say thank you God for making something out of nothing. To God be the GLORY!!

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CHAPTER I

INTRODUCTION

Tillage, the act of loosening the soil for optimum seed germination and plant establishment, along with proper seeding date, plant population, and fertilizer rates are often considered essential crop production practices. Suggested advantages of tillage include weed control, plant residue burial, reduction in incidence of disease and insect pests, incorporation of surface applied plant nutrients, and increased rate of decomposition of soil organic matter. Tillage may be disadvantageous in terms of exposing soil surfaces to wind and water erosion. Tillage also requires time and energy.

Research has indicated that not all tillage practices require excessive time and energy, nor do they expose land surfaces to erosion. Reduced tillage-, no tillage, and minimum tillage methods seem to have confirmed this contention in recent years. No-tillage is the introduction of seed into untilled soil by opening a narrow slot, trench, or band of sufficient width and depth for seed coverage and soil contact. Lo-till (minimum tillage) involves minimal amount of tillage required to create the proper soil condition for seed germination and establishment. As already stated, because of increasing cost of fuel, and labor, soil compaction resulting from several trips by farm machinery, and vulnerability of farm lands to both wind and water erosion encountered with conventional tillage, the need for reduced tillage seems evident.

A three year Lo-till, and No-till experiment was conducted at the Oklahoma State University Agronomy Experiment Station near Perkins to determine grain yield and other agronomic characteristics of the sorghum hybrid "ACCO BR-Y93".

CHAPTER II

LITERATURE REVIEW

Tillage can be categorized into conventional, minimum, and zero tillage. Conventional tillage is referred to as a primary tillage operation involving plowing, chiseling, or heavy disking, plus secondary tillage operations such as disking, field cultivations, and harrowing before planting. Under conventional tillage the surface residue is completely buried, and soil particles are finely ground resulting in small pore spaces between particles. Minimum tillage tends to leave some residue on the surface. Minimum tillage can also be referred to as stubble mulch, reduced tillage, or lo-till. No tillage can be refered to as No-till, till plant, chisel-plant, and rotary tillage.

Conventional tillage exposes land surface to atmospheric hazards such as wind and water erosion, increases fuel and labor costs, causes soil compaction with resulting undesirable effect on germination and early growth of plants. No-tillage reduces both water and wind erosion, conserves soil moisture, saves fuel and labor costs, and improves land use and soil structure (4, 5, 19, 21). Reseachers at Kansas State University studied simulated wind tunnel effects on conventional tillage versus no-tillage (28) and observed a high degree of wind erosion on conventionally tilled soil. High intensity row crops may be produced on hilly terrain under no tillage method (4). The No-till method enhances planting of a second crop directly behind the combine in wheat-soybean or wheat-grain sorghum cropping systems (14, 16, 26).

Successful productivity under no-till is highly dependent upon effective and timely use of herbicides (26, 30). Reports indicate (33) that plant residue on the soil surface increases the amount of water stored in the soil by increasing infiltration and lowering soil temperature thus reducing evaporation. There is some evidence (9) that disease and insect problems increase with reduced tillage operations. The use of herbicides for weed control under minimum and no-tillage farming methods eliminate tillage as the main reason for weed control (34).

Excessive tillage practices can destroy soil physical properties favorable for plant growth (8, 17, 18). Researchers studied the effect of reduced tillage on physical properties of the soil in corn production (29) and deduced that reduced tillage improves soil physical conditions, increases rate of infiltration, and reduces soil compaction. They also found fewer weeds, less plant mortality due to cultivation, more root growth, better vegetative development, and a subsequent increase in yield. Ackerson (1) and Hansen et al. (15) reported higher yield under reduced tilllage while other reports (2, 10, 27, 32) indicate equal yield between reduced tillage and conventional tillage. Van Doren and Ryder (12) reported higher corn yield obtained under reduced tillage in years of low rainfall than high rainfall. They also reported less yield on heavy clay soil than on coarse medium textured soils. Another report (6) indicated equal yield on fine or medium textured soil. Ackerson (1) suggested that the largest grain yield for reduced tillage occured on the fine textured soil. Blevins et al. (5) reported increased yield on sandy to medium textured, well drained soils with no-tillage. Bennett et al. (4) reported yield increase in areas with moderate to high slope under no-tillage.

Workers in North Dakota (11) reported a saving of twenty dollars per acre in planting cost with the use of reduced tillage. Wittmus et al. (36) reported a similar savings on planting cost under reduced tillage methods. No-tillage in wheat-sorghum-fallow in the southern Great Plains resulted in higher yields for both crops when compared to conventional tillage methods (20, 33). The yield advantage was attributed to increased infiltration of water and reduced evaporation of soil moisture due to residue cover. Unger and Wiese (33) also reported that the plants in the non-tilled plots definetly grew taller than plants in conventionally tilled plots. They attributed most of the increased growth to additional stored soil moisture. They maintained that in no-tillage systems, because of the increased residue on the soil surface, there is more water infiltration into the soil from precipitation or irrigation water throughout the growing season. Workers in the southern U.S. reported instances of no-tillage sorghum producing from 84% to 100% as much grain as conventionally tilled plots (25, 31).

Cook et al. (9) reported that the incidence of disease is often increased from soil surface residues because many pathogens depend on plant residues for growth and reproduction. Doupnik, et al. (13) in Nebraska reported that reduced tillage decreased the incidence of Fusarium stalk rot in sorghum grown in winter wheat-sorghum-fallow rotations. Musick and Beasley (24) stated that soil residues in no-tillage operations often increase the incidence of harmful insects and rodents. Van Doren and Allmaras (35) reported that soil residue reduces soil temperature. This is considered disadvantageous in some northern areas where soil temperature warms up slowly in the spring. Similarly, it could however be advantageous in the southern Great Plains where soil temperatures become very high during the summer growing season.

Moschler and Martens (22) and Moschler et al. (23) reported that corn utilizes more applied phosphorus and potassium under reduced tillage than conventional tillage. Belcher and Rayland (3) studied phosphorus adsorption of surface-applied phosphorus versus banding in row and found that they were equally effective.

Burnside (7) suggested that our finite energy supply and diminishing farm labor supply makes it imperative for us to be concerned about reduced operations in crop production.

CHAPTER III

METHODS AND MATERIALS

The experiment was conducted on a Teller loam soil. The Lo-till plot area and No-till plot area lay side-by-side with an alley (approximately 4 m wide) seperating them. Plot size was 5x12 m. Each area had 81 plots with a total of 162 plots for the two areas combined.

Three experimental factors were used: three between-row-spacings (25, 50, and 75 cm), three plant-spacings (10, 15, and 30 cm), and three levels of nitrogen fertilizer (0,90,and 180 kg/ha). The experimental design was a randomized complete block with three replications arranged as 3x3x3 factorial resulting in 27 treatments. Each treatment site was the same for all years. The three between row-spacings, and the three between plant-spacings resulted in seven different plant populations with a minimum of 43,000 plants per hectare, and a maximum of 390,000 plants per hectare (Table I).

Seedbed preparation for Lo-till was similar to that of the conventional tillage whereas there was no tillage for No-till. There was much residue on the soil surface in 1984 under No-till due to continuous accumulation. The plots were planted on June 9 in 1982 for both Lo-till and No-till, June 8 in 1983 for both Lo-till and No-till, and June 12 in 1984 for both systems. Planting rate was 10 kg/ha. A John Deere 25 cm Sod drill was used for planting.

Preemerge herbicides were applied as follows: propazine (2-chlora-4.6 bis (isopropylamino)-s-triazine), and propachlor

TABLE I

EXPERIMENTAL FACTORS

Between row spacing (cm)	Between plant spacing (cm)	N-level (kg/ha)	Plant population (plants/ha)
25	10	0	390,000
	10	90	
	10	180	
25	15	0	260,000
	15	90	
	15	180	
25	30	0	130,000
	30	90	
	30	180	
50	10	0	184,000
	10	90	
	10	180	
50	15	0	129,000
	15	90	
	15	180	
50	30	0	65,000
	30	90	
	30	180	
75	10	0	129,000
	10	90	
	10	180	
75	15	0	86,000
	15	90	
	15	180	
75	30	0	43,000
	30	90	
	30	180	

(2-chloro-N-isopropylactanilide) at the rate of 1.12, and 1.62 kg/ha active ingredient, respectively. In addition, paraquat (1, 1-dimethyl-4, 4-bipyridinium ion) at the rate of 1.12 kg/ha, and 2.24 kg/ha were applied to No-till plots in 1982 and 1983 respectively. In mid May of 1983 1.12 kg/ha rate of paraquat was applied to weeds on No-till plots while spot applications of glyphosate [N-(phosphonomethyl) glycine] was hand-sprayed to paraquat-resistant weeds prior to grain sorghum emergence.

Thinning to desired plant population was done manually soon after emergence. In 1982 unwanted rows were hand pulled while unwanted rows were eliminated by application of glyphosate through a moist sponge attached to the end of a hoe in 1983 and 1984. Nitrogen fertilizer was applied according to treatment five weeks after thinning, Ammonium nitrate (NH4 NO3) was used as the carrier. A Cyclone Seed spreader was used to spread the ammonium nitrate from 1982 through 1984. Because of dry weather during late July and August, 2 inches of irrigation water was applied, first in the vegetative stage of the plants while the second application was between late boot and bloom stage to ensure crop stand and yield. From the middle of August each year 9 Sybron/Taylor soil test thermometers were set out to monitor soil temperature from late boot to full bloom stages of plant growth. Plots were randomly selected to represent each treatment combination for temperature data collection. Soil temperature readings were taken at two o'clock every other day. Bloom notes were also taken and days to midbloom were computed.

A 6-m middle row was marked from each plot for data collection prior to havest. Plant height was taken from marked rows. Four random plants were measured and averaged for height. Plants were harvested using hand pruning shears. Total number of plants standing and those lodged were recorded. Harvested heads, were allowed to air-dry prior to threshing. A stationary Vogel type plot thresher was used. A dial type spring scale was used to measure head weight and grain weight while a Toledo scale was used to measure test weight. In 1982 through 1983 100-kernels were obtained from an electronic seed counter while seeds were counted manually in 1984 to elimimate cracked seeds.

A Mettler electronic balance was used to obtain weight for 100-kernels. The Udy dye binding technique was used to determine grain protein percent.

CHAPTER IV

RESULTS AND DISCUSSION

Yield Variables

The variables analyzed were grain yield, days to midbloom, plant height, plant lodging, test weight, kernel weight, and percent protein in grain. Tables II, III, and IV show analyses of variance for yield variables for 1982, 1983, and 1984 respectively. Table V presents the effect of plant population on yield variables from 1982 to 1984. The mean effect of tillage on yield variables for 1982, 1983, and 1984 is shown on Tables XV, XVI, and XVII respectively.

Observation of the analyses of variance of yield variables showed significance for certain main effects. In 1982 tillage had a significant effect on grain yield, midbloom, and test weight. Row spacing had a significant effect on all variables except days to midbloom, and plant lodging, and percent protein. Plant spacing had a significant effect only on days to midbloom. Nitrogen had a significant effect on all variables (Table II). All interactions showed significant effects for one or more varables. RSxN affected plant height, and test weight. PSxN had a significant effect on days to midbloom, and test weight. RSxPSxN affected test weight. TxRS had significant effect on percent protein, plant lodging, test weight, and kernel weight. TxPS affected plant height, plant lodging, and test weight. TxN significantly affected grain yield, days to midbloom, plant height,

TABLE II

ANALYSIS OF VARIANCE FOR YIELD DATA 1982

Source	DF	Grain Yield (kg/ha) SS	Mid Bloom Days SS	Plant Height (cm) SS	Plant Lodge % SS	Test Weight (kg/L) SS	Kernel Weight (g)/100 SS	Protein % SS
TILL (T)	1	4393636*	1556*	1363	1631	1922*	0.06	264.30
ERROR A	4	1844954	853	1900	6226	48	1.60	213.96
ROWCM (RS)	2	4885465*	62	2077*	2074	239*	1.60*	9.96
PLTCM (PS)	2	927044	134*	28	364	7	0.39	10.41
RSXPS	4	2661579	134	154	2399	11	0.57	9.82
NKGH (N)	2	27872547*	751*	2241*	5943*	33*	13.74*	184.25*
RSXN	4	3483229	19	1725	332	113	0.63	12.21
PSXN	4	363932	203*	470	3732	62	0.28	4.76
RSXPSXN	8	6338927	290	361	556	139	0.33	8.16
ERROR B	54	44595721	2870	3800	38927	275	3.97	164.74
TXRS	2	2578627	69	42	3771*	51*	0.47*	12.67*
TXPS	2	1515022	69	92*	9849*	22*	0.04	10.68
TXN	2	3878810*	179*	1296*	3050*	214*	2.32*	8.06
TXRSXPS	4	3483897	234*	154*	1605	42*	0.11	9.12
TXRSXN	4	1165516	169	35	386	55*	0.09	7.42
TXPSXN	4	346875	132	26	3546	55*	0.42	6.79
TXRSXPSXN	8	2438682	324*	224*	2429	52*	0.42	10.58
ERROR C	50	471657	18.39	10.55	483.21	2.77	0.04	4.29

* Significant at .05 level of probability

TABLE III

ANALYSES OF VARIANCE FOR YIELD DATA 1983

Source	DF	Grain Yield (kg/ha) SS	Mid-bloom (Days) SS	Plant Height (cm) SS	Plant Lodging % SS	Test Weight (kg/L) SS	Kernel Weight (g)/100 SS	Protein % SS
TILL (T)	1	4069646*	293*	246*	882	1147*	0.01	30.85*
ERROR A	4	2018064	87	143	1730	380	0.38	82.75
ROWCM (RS)	2	356663957*	1439*	6938*	1467*	2734*	2.61*	0.89
PLTCM (PS)	2	6245651*	70*	649*	444	114*	0.21*	0.95
RSXPS	4	1712588	75	189	663	24	0.19	7.28
NKGH (N)	2	32726813*	2174*	402*	581*	67	0.16	667.01*
RSXN	4	855282	497*	255*	109	90	0.34*	88.65*
PSXN	4	2140290	98	87	122	44	0.11	7.81
RSXPSXN	8	3651525	56	125	742	83	0.15	15.37
ERROR B	54	24230959	531	1392	5243	855	1.61	273.65
TXRS	2	630296	49	257	305	792	0.03	1.18
TXPS	2	2485939	16	42	295	114*	0.09	0.17
TXN	2	4922988*	284	23	3	4	0.05	4.11
TXRSXPS	4	1893909	16	40	474	44	0.15	4.75
TXRSXN	4	1868145	69	72	303	51	0.20	31.59
TXPSXN	4	150933	9	27	317	15	0.08	3.00
TXRSXPSXN	8	4700813	77	44	345	114	0.20	22.22
ERROR C	50	501713.87	18.11	26.25	55.42	9.62	0.03	0.55

* Significant at .05 level of probability.

TABLE IV

ANALYSES OF VARIANCE FOR YIELD DATA 1984

Source	DF	Grain Yield (kg/ha) SS	Mid Bloom (Days) SS	Plant Height (cm) SS	Plant Lodging (%) SS	Test Weight (kg/L) SS	Kernel Weight (g)/100 SS	Protein (%) SS
TILL (T)	1	68481665*	1352	2610	1399	5247*	0.03	460.73*
ERROR A	4	19490220	3262	8777	1631	2930	5.62	36.17
ROWCM (RS)	2	26545994*	1774	2136	198	389	1.41	272.60*
PLTCM (PS)	2	684275	450	646	52	422	0.41	92.28*
RSXPS	4	1999888	1008	1729	473	317	1.11	61.52
NKGH (N)	2	6846019	256	1630	817*	1315	0.93	14.06
RSXN	4	2499144	442	1368	192	326	1.71	15.06
PSXN	4	5052774	552	1828	79	298	1.65	7.08
RSXPSXN	8	3357516	3061	6344	591	1781	5.36	56.41
ERROR B	54	78629518	25914	72198	4150	19682	38.90	646.29
TXRS	2	1641851*	823	3030	88	471	1.84	52.89*
TXPS	2	1559168*	30	308	0.23	19	0.37	17.25
TXN	2	639068	295	2543	259*	758	0.47	26.16
TXRSXPS	4	2638246*	161	694	368*	197	0.16	4.63
TXRSXN	4	4227913*	365	2187	390*	810	0.67	19.43
TXPSXN	4	1653026	941	2257	131	484	1.19	17.80
TXRSXPSXN	8	5875086*	2223	1889	555*	935	2.35	80.40
ERROR C	50	236104.09	295.92	589.20	31.91	141.49	0.55	7.46

* Significant at .05 probability.

TABLE V

MEAN EFFECT OF PLANT POPULATION ON YIELD VARIABLES 1982-1984

Plants Per Hectare (1000)	RS-PS (cm)-(cm)		Grain Yield (kg/ha)	Days To Midbloom	Plant Height (cm)	Plants Lodged (%)	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %	Nitrogen Level (kg/ha)
390	25	10	2123	69	81	11	51	1.72	8.00	0
260	25	15	2417	69	79	9	51	1.81	7.44	90
130	25	30	2465	69	82	13	51	1.78	7.45	180
184	50	10	2416	66	85	9	54	1.84	7.45	0
129	50	15	2569	61	81	9	52	1.74	7.68	90
65	50	30	2624	63	83	6	53	1.83	7.51	180
129	75	10	2415	63	85	7	54	1.92	7.40	0
86	75	15	2544	63	87	10	55	1.89	9.33	90
43	75	30	2470	63	88	12	55	2.00	7.64	180
LSD .05			NS	NS	NS	NS	NS	NS	NS	NS

plant lodging, test weight, and kernel weight. TxRSxPS affected days to midbloom, plant height, and test weight. TxRSxN, and TxPSxN affected test weight. TxRSxPSxN significantly affected days to midbloom, plant height, and test weight.

Tillage had a significant effect on all variables except kernel weight, and plant lodging in 1983. Other treatments which had significant effect on yield variables in 1983 were RS for all variables except percent protein; PS for grain yield, plant height, midbloom, test weight, and kernel weight; N for all variables except test weight, and kernel weight respectively (Table III). Interactions which showed significant effect on yield and other variables in 1983 were RSxPS, RSxN, PSxN, RSxPSxN, TxRS, TxPS, TxN, TxRSxN, and TxRSxPSxN. RSxPS affected percent protein. RSxN had significant effect on days to midbloom, plant height, kernel weight, and percent protein. TxRSxN, and TxRSxPSxN significantly affected percent protein. TxRS affected plant height,and test weight. TxPS affected test weight. TxN affected grain yield, days to midbloom, and percent protein.

In 1984 tillage had a significant effect on grain yield, test weight, and percent protein. RS significantly affected grain yield, and percent protein. PS had significant effect on percent protein. Nitrogen had a significant effect on plant lodging (Table IV). Several interactions had significant effect on yield and other agronomic variables in 1984. Other interactions with their individual effects were TxN for plant lodging, TxPS for grain yield, TxRS for grain yield, and percent protein, TxRSxN, TxRSxPS, and TxRSxPSxN for grain yield, and plant lodging.

The highest plant population of 390,000 was obtained from a combination of 25 cm row spacing, and 10 cm plant spacing (Table V) while the lowest plant population was obtained from a combination of 75 cm row spacing, and 30 cm plant spacing. Plant populations of 129,000 were obtained from 50 cm row spacing by 15 cm plant spacing, and from 75 cm row spacing by 10 cm plant spacing. There was no significant grain yield increase due to plant population. A plant population of 65,000 obtained from 50 cm row spacing by 30 cm plant spacing produced the highest grain yield although it was not significantly different from others. Thickly populated plots tended to delay blooming, whereas, thinly populated plots bloomed relatively earlier in all years. There was no significant difference in plant height due to plant population. The same result follows regarding plant lodging, test weight, and percent protein in grain for all years.

A combination of 50 cm row spacing, and 30 cm plant spacing resulted in higher grain yield over other combinations in 1982 (Table VI). Wider row spacings of 50 cm, and 75 cm by wider plant spacing of 15 cm, and 30 cm resulted in earlier blooming over the narrow row spacing, and narrow plant spacing combinations in 1982. Plant height was influenced by wider row spacings with the corresponding plant spacings. Plant lodging seemed to be induced more by narrow row spacing and narrow plant spacing. Wider row spacing and corresponding plant spacing combinations resulted in increased test weight. Fifty X 15 cm through 75 X 30 cm row spacing, and plant spacing combination had an increase in 100-kernel weight over 25 cm row spacing and its plant spacing combinations. The highest percent protein in grain was obtained from 25 cm row spacing by 10 cm plant spacing.

The effect of row spacing and Nitrogen fertilizer was evident on

TABLE VI

MEAN EFFECT OF ROW SPACING AND PLANT SPACING ON YIELD DATA 1982

RS (cm)	PS (cm)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
25	10	2927	72	89	26	55	1.99	12.14
25	15	2960	72	85	20	54	2.14	11.01
25	30	2830	68	86	23	55	2.01	10.86
50	10	3074	70	93	21	57	2.06	10.97
50	15	3204	69	94	17	57	2.12	11.33
50	30	3651	70	94	12	58	2.29	10.84
75	10	3160	69	95	10	57	2.26	10.51
75	15	3274	69	94	10	58	2.23	10.99
75	30	3236	69	96	22	58	2.38	10.87
LSD .05		460	3	2	15	1	0.13	1.39

all row spacing combination with 90, and 180 kg/ha having significant grain yield increase over the 0 kg/ha N (Table VII). In all combination 90 kg/ha N produced higher grain yields over the 180 kg/ha N except with 75 cm row spacing in 1982. Plants tended to bloom earlier under the combination of all row spacings with 180 kg/ha N, whereas, 0 kg/ha N caused plants to bloom later. Higher rate of Nitrogen fertilizer with the combination of all row spacings resulted in increased plant height. The same result seemed to follow regarding plant lodging. Increased rate of Nitrogen fertilizer seemed to depress test weight, and kernel weight with all combination of row spacings in 1982. Higher rate of Nitrogen fertilizer with all combination of row spacings resulted in higher percent protein in grain advantage.

There was significant grain yield increase at 90 kg/ha N over the 0 kg/ha N in all levels of plant spacing (Table VIII). Although not significant, 90 kg/ha N produced more grain than 180 kg/ha N in all levels of plant spacing. Days to midbloom was delayed under 0 kg/ha N, whereas, other levels of Nitrogen hastened blooming under all levels of plant spacings. As Nitrogen level increased, plant height increased as well under all levels of plant spacings. Plant lodging seemed to increase with increase in Nitrogen level at all levels of plant spacing. Nitrogen fertilizer application did influence test weight, and kernel weight at all levels of plant spacing combinations. Increased rate of nitrogen increased percent protein significantly.

In 1983 there was no significant effect of row spacing, and plant spacing combinations on grain yield (Table IX). Narrow row spacing and all combinations of plant spacing did influence days to midbloom. Plant height was influenced by wider row spacings, and all levels of plant

TABLE VII

MEAN EFFECT OF ROW SPACING AND NITROGEN ON YIELD DATA 1982

RS (cm)	N (kg/ha)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
25	0	2114	74	75	14	54	2.50	7.41
25	90	3448	70	94	26	56	1.88	12.02
25	180	3155	69	91	28	55	1.76	14.57
50	0	2968	73	92	11	59	2.61	8.04
50	90	3659	68	94	20	57	2.04	11.28
50	180	3302	68	95	20	56	1.83	13.82
75	0	2634	72	93	4	58	2.61	7.78
75	90	3507	69	96	17	58	2.09	11.26
75	180	3529	67	96	22	57	2.16	13.33
LSD .05		460	3	2	15	1	0.13	1.39

TABLE VIII

MEAN EFFECT OF PLANT SPACING AND NITROGEN ON YIELD DATA 1982

PS (cm)	N (kg/ha)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
10	0	2532	75	84	11	58	2.59	7.25
10	90	3480	69	96	23	57	1.91	12.14
10	180	3149	68	96	23	55	1.82	14.22
15	0	2521	74	86	12	56	2.51	8.21
15	90	3551	69	94	21	57	2.04	11.22
15	180	3366	68	93	14	56	1.94	13.90
30	0	2664	69	90	5	57	2.62	7.77
30	90	3583	68	94	19	57	2.06	11.20
30	180	3469	68	92	33	57	1.99	13.60
LSD .05		460	3	2	15	1	0.13	1.39

TABLE IX

MEAN EFFECT OF ROW SPACING AND PLANT SPACING
ON YIELD DATA 1983

RS (cm)	PS (kg/ha)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
25	10	975	71	61	2	47	0.97	10.86
25	15	1562	71	64	8	48	1.01	10.32
25	30	1762	68	69	9	50	1.16	10.49
50	10	2126	64	72	3	55	1.24	10.37
50	15	2469	65	76	7	56	1.24	10.89
50	30	2479	65	78	5	57	1.23	10.70
75	10	2358	63	80	8	57	1.33	10.71
75	15	2523	64	79	13	58	1.33	10.46
75	30	2578	62	82	11	58	1.39	11.04
LSD .05		476	3	3	5	2	0.12	0.50

spacings. Plant lodging was influenced more by row spacing, and plant spacings of 25 by 30 cm, 75 by 15 cm, and 75 by 30 cm. Test weight was influenced more by wider row spacing combinations. Kernel weight responded more to wider row spacing and all plant spacing combinations. Percent protein in grain was relatively the same in all row spacing by plant spacing combinations.

There was no significant effect of row spacing and nitrogen on grain yield (Table X). Days to midbloom was delayed more at 25 cm row spacing by 0 k/ha N, while plant height, plant lodging, and test weight were influenced more by wider row spacing and higher rates of Nitrogen fertilizer. Kernel weight responed more to 90 kg/ha N at 75 cm row spacing, while percent protein in grain increased due to increased rate of Nitrogen fertilizer at wider levels of row spacings.

The effect of plant spacing and Nitrogen on grain yield was not significant (Table XI), although higher grain yield was obtained at higher rates of Nitrogen fertilizer application with wider plant spacings. Midbloom, and plant height were significantly influenced by 0 kg/ha N with all levels of plant spacings. Plant lodging was significantly influenced by 180 kg/ha N at 30 cm plant spacing. Test weight was significant at 15 cm by 90 kg/ha N, 30 cm by 90 kg/ha N, and 30 cm by 180 kg/ha N. Kernel weight was influenced by plant spacings, and Nitrogen rates of 10 cm by 90 kg/ha N, 30 cm by 90 kg/ha N, and 30 cm by 180 kg/ha N. Higher rates of Nitrogen increase percent protein significantly.

In 1984 grain yield was significant at 25 cm row spacing and 30 cm plant spacing (Table XII). Days to midbloom, and plant height were not influenced by any factor. Plant lodging was significant at row spacing,

TABLE X

MEAN EFFECT OF ROW SPACING AND NITROGEN
ON YIELD DATA 1983

RS (cm)	N (kg/ha)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
25	0	836	80	65	2	47	1.03	6.42
25	90	1734	66	67	2	49	1.08	12.16
25	180	1729	65	62	8	49	1.02	13.09
50	0	1787	70	78	3	55	1.19	7.91
50	90	2476	62	75	5	57	1.21	11.61
50	180	2810	62	72	6	57	1.31	12.44
75	0	1776	67	83	8	58	1.31	9.16
75	90	2720	62	79	11	58	1.46	11.04
75	180	2964	61	80	13	56	1.29	12.02
LSD .05		476	3	3	5	2	0.12	0.50

TABLE XI

MEAN EFFECT OF PLANT SPACING AND NITROGEN ON YIELD DATA 1983

PS (cm)	N (kg/ha)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
10	0	1344	72	74	3	52	1.14	7.52
10	90	2057	63	71	3	53	1.27	11.94
10	180	2057	62	69	6	53	1.13	12.47
15	0	1374	74	74	5	53	1.15	8.02
15	90	2481	63	74	7	55	1.22	11.15
15	180	2699	63	71	9	53	1.21	12.51
30	0	1681	70	78	5	54	1.23	7.95
30	90	2392	63	75	7	55	1.27	11.72
30	180	2747	63	74	12	56	1.28	12.57
LSD .05		476	3	3	5	2	0.12	0.50

TABLE XII

MEAN EFFECT OF ROW SPACING AND PLANT SPACING ON YIELD DATA 1984

RS (cm)	PS (cm)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
25	10	2469	63	92	4	51	2.20	9.36
25	15	2730	64	88	4	50	2.28	9.94
25	30	2803	61	90	8	48	2.19	8.27
50	10	2048	62	89	4	51	2.22	9.07
50	15	2033	50	75	3	43	1.84	6.32
50	30	1743	54	78	2	44	1.96	6.60
75	10	1727	57	83	2	50	2.18	6.68
75	15	1834	57	88	7	49	2.11	6.67
75	30	1597	57	85	3	49	2.22	4.73
LSD .05		326	12	16	4	8	0.50	2

and plant spacing of 25 cm by 30 cm, and 75 cm by 15 cm. Test weight and kernel weight were not influenced by any factor. Percent protein was influenced more by row spacing, and plant spacing of 25 cm by 10 cm, 25 cm by 15 cm, 25 cm by 30 cm, and 50 cm by 10 cm.

The effect of row spacing and nitrogen (Table VIII) on grain yield was significant at row spacing, and Nitrogen level of 25 cm by 90 kg/ha N, 25 cm by 180 kg/ha N, and 50 cm by 90 kg/ha N over the 0 kg/ha N. None of the factors had any significant effect on days to midbloom, and plant height. Plant lodging was significantly influenced more by 25 cm row spacing and 180 kg/ha N. Test weight was significantly influenced more by row spacing and Nitrogen rate of 25 cm by 90 kg/ha N, and 75 cm by 90 kg/ha N. Kernel weight was not significantly affected by any of the factors. Percent protein in grain was influenced more by 25 cm row spacing and all levels of Nitrogen rate.

The significant effect of plant spacing and Nitrogen on grain yield was obtained at plant spacing and Nitrogen of 15 cm and 90 kg/ha N (Table IX). None of the factors had any significant effect on days to midbloom, plant height, test weight, kernel weight, and percent protein in grain. Plant lodging was influenced more by plant spacing and Nitrogen rate of 10 cm by 180 kg/ha N, 15 cm by 90 kg/ha N, and 180 kg/ha N.

From Table XV, XVI, and XVII No-till grain yielded more than Lo-till grain by 329 kg/ha in 1982, and 317 kg/ha in 1983, but a reverse trend followed in 1984 as Lo-till grain out-yielded No-till grain by 1300 kg/ha. Plants bloomed ealier under Lo-till in 1982, and 1983 but later in 1984. In 1982 and 1984 plants were taller under Lo-till than No-till, whereas the reverse was obtained in 1983. Plant lodging was

TABLE XIII

MEAN EFFECT ROW SPACING AND NITROGEN ON

YIELD DATA 1984

RS (cm)	N (kg/ha)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
25	0	2178	62	84	1	45	2.21	8.93
25	90	2919	64	92	7	53	2.27	9.93
25	180	2904	62	94	9	51	2.21	9.29
50	0	1743	54	80	2	44	2.11	6.84
50	90	2171	54	81	2	46	1.96	7.37
50	180	1910	58	82	7	48	1.95	7.77
75	0	1602	54	80	2	44	2.08	5.64
75	90	1931	61	94	5	54	2.46	6.88
75	180	1626	57	83	5	50	1.97	5.56
LSD .05		326	12	16	4	8	0.50	2

TABLE XIV

MEAN EFFECT OF PLANT SPACING AND NITROGEN ON YIELD DATA 1984

PS (cm)	N (kg/ha)	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
10	0	2014	62	89	1	49	2.34	7.86
10	90	2183	61	91	3	52	2.28	8.96
10	180	2047	60	84	7	51	1.98	8.28
15	0	1718	54	77	1	42	1.99	7.46
15	90	1744	61	89	7	52	2.28	8.04
15	180	2135	56	85	8	48	1.97	7.43
30	0	1791	54	77	2	42	2.06	6.10
30	90	2093	57	86	5	49	2.12	6.59
30	180	2258	61	90	6	50	2.18	6.91
LSD .05		326	12	16	4	8	0.50	2

TABLE XV

MEAN EFFECT OF TILLAGE ON YIELD DATA 1982

Tillage	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
Lo-till	2982	67	95	21	53	2.14	11.15
No-till	3311	73	89	15	60	2.18	10.97
LSD .05	217	1	1	NS	0.53	0.06	NS

TABLE XVI

MEAN EFFECT OF TILLAGE ON YIELD DATA 1983

Tillage	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
Lo-till	1934	65	72	9	51	1.22	11.09
No-till	2251	67	75	4	57	1.20	10.21
LSD .05	224	1	2	2	1	NS	0.23

TABLE XVII

MEAN EFFECT OF TILLAGE ON YIELD DATA 1984

Tillage	Grain Yield (kg/ha)	Mid Bloom (Days)	Plant Height (cm)	Plant Lodging %	Test Weight (kg/L)	Kernel Weight (g)/100	Protein %
Lo-till	2759	61	89	7	54	2.15	9.20
No-till	1459	55	81	1	43	2.12	5.83
LSD .05	153	5	8	2	4	NS	0.86

TABLE XVIII

MEAN EFFECT OF TILLAGE ON GRAIN YIELD
1982-1984 - LO-TILL VS NO-TILL

Tillage	Years 1982	1983	1984
	kg/ha		
Lo-till	2982	1934	2759
No-till	3311	2251	1459
Average	3147	2093	2109
LSD .05	217	224	153

TABLE XIX

MEAN EFFECT OF ROW SPACING (RS) ON GRAIN YIELD,
FOR LO-TILL AND NO-TILL 1982-1984

Treatment	Years					
	1982		1983		1984	
	LT	NT	LT	NT	LT	NT
RS(cm)	-kg/ha-					
25	2906	2906	1191	1675	3195	2140
50	3004	3616	2265	2450	2590	1292
75	3035	3412	2345	2627	2494	945
LSD .05	376		387		266	

greater under Lo-till than No-till in all years. No-till produced higher test weight than Lo-till in 1982 and 1983, but lower in 1984. Kernel weight was relatively the same for both tillage systems in all years. In 1982 percent protein in grain was the same for both tillage systems, whereas, greater percentage of protein in grain was obtained under Lo-till in 1983, and 1984.

Grain Yield

Tables XV, XV1, XVII, and XVIII showed that No-till had yield advantage over Lo-till in 1982 and 1983 with a difference of 329 and 317 kg/ha respectively. Lo-till had a yield advantage over No-till in 1984 with a difference of 1300 kg/ha. The decrease in yield under No-till in 1984 was due primarily to weed and grass infestation, and low seed germination. In Table XIX the data showed that a significant yield increase was obtained in 1982 from row spacings of 50 and 75 cm for No-till over Lo-till with a yield difference of 612 and 377 kg/ha. In 1983 No-till out-yielded Lo-till in all levels of row spacing with a yield difference of 484, 185, and 282 kg/ha for 25, 50, and 75 cm respectively. There was a significant yield increase for Lo-till over No-till in 1984 from all levels of row spacing with the 25 cm row spacing showing higher yield advantage for both systems (Table XIX). In 1982 (Table XX) 10 cm plant spacing for No-till had significant yield advantage over Lo-till, the yield from 15 and 30 cm plant spacings for No-till were relatively the same, but different from Lo-till by 354, and 82 kg/ha, respectively. In 1983, 10 and 15 cm plant spacings produced significantly more grain from No-till over Lo-till, while grain yield

TABLE XX

MEAN EFFECT OF PLANT SPACING (PS) ON GRAIN YIELD
FOR LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
PS (cm)	- - - - - - - - - - - - - - kg/ha - - - - - - - - - - - - - -					
10	2777	3330	1584	2055	2633	1530
15	2969	3323	1928	2441	2983	1415
30	3198	3280	2290	2290	2257	1433
LSD .05	376		387		266	

TABLE XXI

MEAN EFFECT OF NITROGEN (N) ON GRAIN YIELD FOR
LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
(N-kg/ha)	- - - - - - - - - - - - - - kg/ha - - - - - - - - - - - - - -					
0	2611	2533	1551	1383	2573	1109
90	3202	3874	2068	2552	2920	1760
180	3132	3525	2183	2819	2785	1509
LSD .05	372		387		266	

from 30 cm plant spacing from Lo-till and No-till were the same. In 1984 all plant spacings had significant grain yield increases under Lo-till compared to No-till.

Generally there was a yield response due to an increased rate of nitrogen for both systems in all years (Table XXI). In 1982, 90 and 180 kg/ha N had significant grain yield increase for No-till over Lo-till. In 1982, 90 kg/ha N produced more grain by 100 and 300 kg/ha for Lo-till and No-till, respectively. In 1983, 180 kg/ha N had a yield advantage over 90 kg/ha N but both 90 and 180 kg/ha N had significant yield difference from 0 kg/ha N for both systems. Ninety, and 180 kg/ha N supported grain yield of 484, and 636 kg/ha under No-till over Lo-till. In 1984 a yield advantage was realized from Lo-till at all levels of nitrogen rate over No-till. Ninety and 180 kg/ha N had significant yield advantage over 0 kg/ha N.

Table V presents the mean effect of plant population on yield variable for all years. The table reveals that plant population had no significant influence on grain yield. The lowest grain yield of 2123 kg/ha was obtained from a plant population of 390,000 under 25 cm RS, and 10 cm PS. While the highest yield of 2624 kg/ha was obtained from a plant population of 65,000 under 50 cm RS, and 30 cm PS. Table XXII shows the mean effect of row spacing (RS) and plant spacing (PS) on grain yield for all years. In 1982, 50 cm RS by 30 cm produced the highest grain yield with 25 cm RS and 30 cm PS producing the lowest grain yield. 25 cm RS by 10 cm PS produced the lowest grain yield in 1983 with the highest yield from 75 cm RS by 30 cm PS. In 1984 the highest yield was from 25 cm RS by 30 cm PS. While the lowest yield was from 75 cm RS by 30 cm PS.

TABLE XXII

MEAN EFFECT OF ROW SPACING (RS) AND PLANT SPACING (PS) ON GRAIN YIELD 1982-1984

Treatment		Years		
		1982	1983	1984
RS(cm)	PS(cm)	kg/ha		
25	10	2927	975	2469
25	15	2960	1562	2730
25	30	2830	1762	2803
50	10	3074	2126	2048
50	15	3204	2469	2033
50	30	3651	2479	1743
75	10	3160	2358	1727
75	15	3274	2523	1834
75	30	3236	2578	1597
LSD .05		460	475	326

TABLE XXIII

MEAN EFFECT OF ROW SPACING (RS) AND NITROGEN (N) ON GRAIN YIELD 1982-1984

Treatment		Years		
		1982	1983	1984
RS(cm)	N(kg/ha)	kg/ha		
25	0	2114	836	2178
25	90	2448	1734	2919
25	180	3155	1729	2904
50	0	2968	1787	1743
50	90	3659	2476	2171
50	180	3302	2810	1910
75	0	2634	1776	1602
75	90	3507	2720	1931
75	180	3529	2964	1626
LSD .05		460	475	326

In 1982 the mean effect of Row spacing and nitrogen (N) on grain yield (Table XXIII) shows that the highest yield was obtained from 50 cm RS and 90 kg/ha N while the lowest yield was from 25 cm RS and 0 kg/ha N. In 1983, 25 cm RS and 0 kg/ha N produced the lowest yield while 75 cm RS and 180 kg/ha N produced the highest grain yield. In 1984 the highest grain yield came from 25 cm RS and 90 kg/ha N and the lowest yield was obtained from 75 cm RS and 0 kg/ha N.

Test Weight

Table XXIV presents the mean effect of row spacing on test weight for Lo-till, and No-till for all years. Test weight increased significantly with increase in row spacing on both tillage systems in all years except in 1984 where 25, and 75 cm row spacing showed test weight difference over 50 cm row spacing although not significant. No-till produced higher test weight over Lo-till in all years except in 1984 where Lo-till had significant lead over No-till.

The mean effect of plant spacing on test weight for Lo-till and No-till for 1982 through 1984 is shown on table XXV. In 1982 there was a significant increase in test weight of 30 over 10 and 15 cm PS under Lo-till while 10 cm PS had a significant test weight over 15, and 30 cm PS under No-till. In 1983, 30 cm PS had a significant increase over 10 and 15 cm PS under Lo-till, whereas, all levels of plant spacing produced equal test weight under No-till. Although not significant, in 1984 10 cm PS resulted in higher test weight over 15, and 30 cm PS on both systems.

Table XXVI shows the mean effect of nitrogen on test weight for

TABLE XXIV

MEAN EFFECT OF ROW SPACING (RS) ON GRAIN TEST WEIGHT FOR LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
RS (cm)	kg/L					
25	52	58	43	54	53	46
50	53	61	54	58	52	40
75	54	61	57	58	57	42
LSD .05	0.91		1.7		NS	

TABLE XXV

MEAN EFFECT OF PLANT SPACING (PS) ON GRAIN TEST WEIGHT FOR LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
PS (cm)	kg/L					
10	53	61	59	57	56	45
15	53	60	51	57	53	41
30	54	60	53	57	53	41
LSD .05	.91		1.7		6.51	

Lo-till, and No-till for 1982 through 1984. In 1982 increased N had an adverse effect on test weight under Lo-till, whereas, under No-till test weight increased. In 1983 N rate of 90 and 180 kg/ha had significant influence on test weight under Lo-till while there was no significant difference in test weight for all levels of N under No-till. In 1984 both 90 and 180 kg/ha N rates significantly increased test weight over the 0 rate.

Kernel Weight

Although plant population had no significant effect on kernel weight, the lowest plant population of 43,000 produced the highest kernel weight over 390,000 plant population (Table V). In 1982 No-till produced higher kernel weight than Lo-till although it was not significant (Table XV). The reverse was the case in 1983 and 1984 as higher but not significant kernel weight was obtained from Lo-till (Tables XVI and XVII), respectively.

Table XXVII presents the mean effct of row spacing on kernel weight for Lo-till, and No-till in 1982 through 1984. Kernel weight increased significantly as row spacing increased under No-till, whereas, a significant increase was obtained from 75 cm row spacing under Lo-till in 1982. In 1983 kernel weight increased as row spacing increased beyond 25 cm. There was no significant effect of row spacing on kernel weight in 1984. The mean effect of plant spacing on kernel weight is shown in table XXVIII. In all years 30 cm PS produced more kernel weight over other plant spacings. The mean effect of nitrogen on kernel weight is presented on table XXIX. Nitrogen rate of 90 kg/ha influeced

TABLE XXVI

MEAN EFFECT OF NITROGEN ON GRAIN TEST WEIGHT
FOR LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
N(kg/ha)	kg/L					
0	55	59	50	56	53	36
90	53	61	52	57	54	48
180	52	61	52	57	55	44
LSD .05	0.11		0.09		0.41	

TABLE XXVII

MEAN EFFECT OF ROW SPACING (RS) ON KERNEL WEIGHT
FOR LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
RS(cm)	g/100					
25	2.10	1.98	1.03	1.05	2.11	2.34
50	2.10	2.21	1.25	1.22	2.01	1.99
75	2.22	2.34	1.37	1.33	2.31	2.02
LSD .05	0.11		0.09		0.41	

TABLE XXVIII

MEAN EFFECT OF PLANT SPACING (PS) ON KERNEL WEIGHT
FOR LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
PS(cm)	g/100					
10	2.07	2.14	1.16	1.20	2.16	2.24
15	2.16	2.16	1.23	1.16	1.08	2.08
30	2.20	2.24	1.27	1.25	2.20	2.04
LSD .05	0.11		0.09		0.41	

TABLE XXIX

MEAN EFFECT OF NITROGEN ON KERNEL WEIGHT
FOR LO-TILL AND NO-TILL 1982-1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
N(kg/ha)	g/100					
0	2.72	2.43	1.19	1.16	2.20	2.06
90	1.93	2.07	1.28	1.23	2.17	2.29
180	1.78	2.05	1.19	1.22	2.07	2.02
LSD .05	0.11		0.09		0.41	

kernel weight more than N rate of 180 kg/ha in all years for both tillage systems.

Percent Protein

The mean effect of tillage on percent protein (Table XXX) showed no difference in 1982, but significant increases for Lo-till in 1983 and 1984. This indicates that Lo-till seemed to have an increasing effect on percent protein in all years.

From Table XXXI, Row spacing did not influence percent protein under Lo-till in 1982, while 25 cm RS resulted in a significant increase in percent protein over 50, and 75 cm RS. In 1983 75 cm RS showed a significant increase in percent protein over other row spacings under Lo-till while there was no effect due to row spacing under No-till. In 1984 25 cm RS had a significant advantage over 50, and 75 cm RS. Analyses of variance (Table II, III, and IV) for 1982, 1983 and 1984 show that tillage and nitrogen affect percent protein in 1982, and 1983; Row spacing affected percent protein in 1982 and 1984; tillage and Plant spacing affected percent protein in 1984. Interactions which affected yield were TxRS, and RSxN in 1982; RSxPS, RSxN, PSxN, RSxPSxN, TxN, TxRSxN, and TxRSxPxN in 1983. There were no treatment interactions in 1984. The mean effect of PS and N on percent protein (Table XXXII) indicates that percent protein increased at all plant spacing levels as N-rate increased beyond 0 kg/ha with 180 kg/ha N having a significant lead over 90 kg/ha N in 1982, and 1983. In 1984 there were no difference. This result tends to indicate that nitrogen was well utilized by plants regardless of their respective spacings.

TABLE XXX

MEAN EFFECT OF TILLAGE ON GRAIN PROTEIN FOR 1982-1984 LO-TILL VS. NO-TILL

Tillage	Years 1982	1983	1984
		%	
Lo-till	11.15	11.08	9.45
No-till	10.97	10.21	6.01
Average	11.06	10.65	7.73
LSD .05	0.65	0.23	0.86

TABLE XXXI

MEAN EFFECT OF ROW SPACING (RS) ON GRAIN PROTEIN FOR 1982-1984 LO-TILL VS. NO-TILL

Treatment	1982		1983		1984	
	LT	NT	LT	NT	LT	NT
RS (cm)			%			
25	11.06	11.60	10.90	10.21	11.68	6.69
50	11.19	10.90	11.20	10.10	9.32	6.00
75	11.19	10.39	14.86	10.32	6.92	4.95
LSD .05	1.13		0.41		1.49	

TABLE XXXII

MEAN EFFECT OF PLANT SPACING (PS) AND NITROGEN ON GRAIN PROTEIN FOR 1982-1984

Treatment		Years		
PS(cm)	N(kg/ha)	1982	1983	1984
		%		
10	0	7.25	7.52	7.86
10	90	12.14	11.94	8.96
10	180	14.22	12.47	8.28
15	0	8.21	8.02	7.48
15	90	11.22	11.15	8.04
15	180	13.90	12.51	7.43
30	0	7.77	7.95	6.10
30	90	11.20	11.72	6.59
30	180	13.60	12.57	6.91
LSD .05		1.39	0.50	1.83

Days to Midbloom

Days to midbloom decreased generally with increase in Row spacing (Table XXXIII). Plants reached midbloom earlier under 75 cm row spacing in 1982 Lo-till, 1983 Lo-till and No-till, and in 1984 No-till. In general 25 cm RS delayed blooming in both systems. The mean effect of plant spacing on days to midbloom is found on table XXXIV. In 1982 both 10 and 15 cm PS delayed blooming over 30 cm PS under No-till. In 1983 15 cm PS caused delayed blooming compared to 30 cm PS. There were no differences in 1984.

Table XXXV shows the mean effect of nitrogen on days to midbloom. Days to midbloom was significantly delayed with 0 rate of N in 1982 Lo-till and 1983 Lo-till and No-till. There was no significant effect of N on days to midbloom in 1984. Tables II, III, and IV show that tillage affected days to midbloom in all years. Row spacing had a significant effect on days to midbloom in 1983, and 1984 while PS, and N significantly influenced days to midbloom in 1982 and 1983, respectively. Significant interactions which affected days to midbloom in 1982 were PSxN, TxN, TxRSxPS, and TxRSxPSxN. In 1983 RSxN and TxN affected days to midbloom.

Plant Height

Tables XV, XVI, and XVII present the mean effect of tillage on agronomic variable for 1982, 1983 and 1984, respectively. Plants were significantly taller under Lo-till in 1982 and 1984 while No-till produced taller plants in 1983. Plant height is a response to efficient

TABLE XXXIII

MEAN EFFECT OF ROW SPACING (RS) ON DAYS TO MIDBLOOM FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
(cm)	DAYS					
25	68	73	68	72	62	63
50	66	73	63	66	58	52
75	65	73	62	64	62	51
LSD .05	2.3		2.3		9.4	

TABLE XXXIV

MEAN EFFECT OF PLANT SPACING (PS) ON DAYS TO MIDBLOOM FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
(cm)	DAYS					
10	67	74	64	67	63	58
15	67	74	66	68	60	54
30	66	71	63	67	60	63
LSD .05	2.3		2.3		9.4	

TABLE XXXV

MEAN EFFECT OF NITROGEN ON DAYS TO MIDBLOOM
FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
(kg/ha)	DAYS					
0	71	74	69	75	60	53
90	65	73	63	63	61	59
180	64	72	62	63	63	55
LSD .05	2.3		2.3		9.4	

TABLE XXXVI

MEAN EFFECT OF ROW SPACING (RS) ON PLANT HEIGHT
FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
RS (cm)	cm					
25	90	83	65	64	88	91
50	96	91	74	76	85	77
75	97	92	78	83	95	76
LSD .05	2		3		13	

use of water and the necessary nutrients. Plant population can also influence height of individual plants. In this study plant population had no effect on plant height (Table V). It appears plants made more efficient use of water and nutrients under Lo-till than under No-till. Table XXXVI shows that plant height increased with increase in row spacing from 25 to 50 cm in 1982 and from 25 to 50 to 75 cm in 1983 under both tillage systems. In 1984 25 cm row spacing produced taller plants under No-till, but there was no significant effect of row spacing on plant height under Lo-till.

The mean effect of plant spacing on plant height is shown on Table XXXVII. Plant height increased as plant spacing increased from 10 cm in 1983 on both tillage systems. There was no significant influence of plant spacing on plant height in 1982 or 1984. An increased rate of nitrogen increased plant height under Lo-till while 90 kg/ha nitrogen increased plant height under No-till in 1982 (Table XXXVIII). In 1983 and 1984 there were no difference under Lo-till. Plants grew taller under No-till with 0 rate of N over 180 kg/ha N rate in 1983. N rate of 90 kg/ha significantly increased plant height over 0 N rate under No-till in 1984.

Plant Lodging

In 1982 plant lodging was significantly increased at 25 cm row spacing compared to 75 cm row spacing (Table XXXIX). Narrow row spacing of 25 cm significantly increased plant lodging over wider rows under Lo-till while there was no effect of row spacing on plant lodging under No-till in 1982. In 1983 75 cm row spacing produced increased plant

TABLE XXXVII

MEAN EFFECT OF PLANT SPACING (PS) ON PLANT HEIGHT
FOR LO-TILL AND NO-TILL 1982 to 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
PS (cm)	cm					
10	95	89	70	72	90	86
15	95	88	72	74	89	78
30	94	90	74	78	89	80
LSD .05	2		3		13	

TABLE XXXVIII

MEAN EFFECT OF NITROGEN ON PLANT HEIGHT FOR
FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
N-(kg/ha)	cm					
0	86	87	73	77	90	72
90	98	91	73	74	88	90
180	100	88	70	72	91	82
LSD .05	2		3		13	

TABLE XXXIX

MEAN EFFECT OF ROW SPACING (RS) ON PLANT LODGING FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
RS (cm)	%					
25	32	14	7	1	10	1
50	20	13	5	4	5	1
75	11	17	14	7	6	1
LSD .05	12		4		3	

TABLE XXXX

MEAN EFFECT OF PLANT SPACING (PS) ON PLANT LODGING FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
PS (cm)	%					
10	30	9	6	3	6	1
15	21	10	8	5	8	2
30	12	26	12	4	7	1
LSD .05	12		4		3	

lodging over narrow rows under both tillage systems. In 1984 plant lodging was significantly higher at 25 cm under Lo-till whereas there was no influence of row spacing on plant lodging under No-till.

Plant lodging was significantly increased at 10 cm under Lo-till and at 30 cm PS under No-till in 1982, respectively (Table XXXX). In 1983 30 cm plant spacing resulted in increased plant lodging over 10 and 15 cm under Lo-till. There was no effect of plant spacing on plant lodging in 1984.

The effect of N rate on plant height is shown in Table XXXXI. In 1982 there was no significant influence of N rate on plant lodging under Lo-till. N rate of 180 kg/ha caused more plants to lodge under No-till in 1982, and in Lo-till in 1983 through 1984.

From tables VI, VII, and VIII for 1982, 1983, and 1984 respectively, it can be seen that plants lodged more under Lo-till than No-till.

TABLE XXXXI

MEAN EFFECT OF NITROGEN ON PLANT LODGING FOR LO-TILL AND NO-TILL 1982 TO 1984

	Years					
	1982		1983		1984	
Treatment	LT	NT	LT	NT	LT	NT
N-(kg/ha)	%					
0	16	3	7	2	2	0
90	27	15	8	4	8	1
180	20	26	11	6	11	3
LSD .05	12		4		3	

CHAPTER V

SUMMARY AND CONCLUSIONS

A three year field (Lo-till, and No-till) experiment was conducted at the Oklahoma State University Agronomy Research Station near Perkins, Oklahoma during the cropping seasons of 1982 through 1984. The primary objective of this study was to determine the effect of tillage on yield performance of the sorghum hybrid "ACCO BR-Y93" along with other agronomic characteristics.

The experiment was conducted on a Teller loam soil with 81 plots in each tillage system. A randomized complete block design with three replications was used. The treatments consisted of three row spacings (RS) of 25, 50, and 75 cm, three plant spacings (PS) of 10, 15, and 30 cm, and three nitrogen (N) rates of 0, 90, and 180 kg/ha. The combination of RS, and PS resulted in seven plant populations. The highest plant population was 390,000 obtained from 25 by 10 cm row, and plant spacing, while the lowest plant population of 43,000 plants/ha was obtained from 75 cm row spacing, and 30 cm plant spacing.

Seven agronomic variables were collected for analysis: grain yield, test weight, percent protein, 100-kernel weight, plant height, plant lodging, and days to midbloom.

Tillage (T) affected all variables except plant height, plant lodging, and kernel weight in 1982. RS had significant effect on grain yield, plant height, test weight, and kernel weight in 1982, all variables except percent protein in 1983, grain yield, and percent protein in 1984. PS significantly affected days to midbloom in 1982, and percent protein in 1984. There was no significant effect of PS on plant lodging, and percent protein in 1983. Nitrogen had significant effect on all variables in 1982, and in 1983 except test weight, and kernel weight. In 1984 N affected plant lodging. Interactions which had significant effects on yield variables were: RSxPS for percent protein in 1983, RSxN for plant height, and test weight in 1982, midbloom, plant height, kernel,and percent protein in 1983; PSxN for midbloom, and test weight in 1982, percent protein in 1983; RSxPSxN for test weight in 1982; TxRS for all variables except grain yield, midbloom, and plant height in 1982, plant height, and test weight in 1983, grain yield, and percent protein in 1984; TxPS for plant height, plant lodging, and test weight in 1982, test weight in 1983, and grain yield in 1984; TxN for all variables except percent protein in 1982, grain yield, midbloom, and percent protein in 1984; TxRSxPS for midbloom, plant height, and test weight in 1982, grain yield, and plant lodging in 1984; TxRSxN for test weight in 1982, percent protein in 1983, and grain yield, and plant lodging in 1984; TxPSxN for test weight in 1982; TxRSxPSxN for midbloom, plant height, and test weight in 1982, percent protein in 1983, and grain yield, and plant lodging in 1984. There was no significant effect of plant population on yield variables.

Yield response was not consistent for one tillage system every year. For instance, No-till produced more grain yield than Lo-till in 1982, and 1983, but in 1984 Lo-till took the lead over No-till. Plants took more days to bloom in 1982, and 1983, but fewer in 1984 under No-till. Plants were taller under Lo-till in 1982, and 1984, but shorter in 1983. Plant lodging was uniformly greater under Lo-till in all years. No-till produced higher test weight in 1982, and 1983, but lower in 1984. Kernel weight was higher under No-till in 1982, lower in 1983, but the same in 1984. Percent protein was higher under Lo-till all years. Significant yield response was realized with the application of 90 kg/ha N over 180 kg/ha N on both tillage systems. N-rate of 180 kg/ha was in most cases yield depressor while 90 kg/ha enhanced yield. Yield response seemed to be consistent under 50 cm row spacing and 30 cm plant spacing.

Finally, it is worth mentioning that the primary reasons for less grain return under No-till especially in 1984 was due to weed infestation despite herbicide application. Another reason was low seed germination in that same year. Quite a few sorghum greenbug were found but they had no significant effect on yield. Therefore, this study tends to inform us that in order to maximize grain yield return under No-till, weed problem must be considered and solved. This study also tends to indicate that 50 cm row spacing, 30 cm plant spacng, and N-rate of 90 kg/ha should be considered for efficient grain sorghum production.

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