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PHYSIOLOGICAL AND ECONOMICAL ASPECTS OF REDUCED TILLAGE ON DOUBLE CROP SORGHUM GRAIN PRODUCTION AFTER BARLEY IN CENTRAL ARIZONA

by

Paul Bimpolo

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STATEMENT BY AUTHOR

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APPROVAL BY THESIS DIRECTOR

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23 April 1984
Date

DEDICATION

This thesis is dedicated to my mother

Elizabeth Ndoulou Kibiti

and late father

Edouard Mberi Ngomo

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ABSTRACT

The production of grain sorghum under a double crop rotation after winter barley was evaluated under full tillage and a reduced tillage seedbed preparation at Marana (Arizona) in 1982. Eight commercial grain sorghum varieties were selected as the plant test materials. The physiological differences among the sorghum plants produced by the eight varieties within and across the seedbeds and their economical implications on the general farm management were investigated. No significant difference in grain yields and in other agronomic and physiological variables such as seedling emergence, days to 50% bloom, number of heads produced, head length, length of head exsertions, total plant height, seed weight, seed density, and number of seeds/head was found at the 0.05 level between the two tillage treatments. However, there was more plant competition in the full tillage seedbed and differences among the eight sorghum varieties within and across seedbeds were significant at the 0.01 level. Economically, the reduced tillage seedbed produced a smaller gross income but larger profit than the full tillage seedbed and these economical differences varied greatly according to the variety. Thus, gains from reduced tillage may best be realized by selection of a proper variety adapted to reduced tillage seedbed environment.

CHAPTER 1

INTRODUCTION

Conventional tillage which has usually included intensive plowing and the subsequent use of many other cultivating implements has been widely practiced by Arizonan farmers. This has resulted in high energy use and production costs for the farmer. Despite the high yields which tend to hide these disadvantages, where some special precautions are not taken, this intensive cultivation may also result in a degradation and irreversible loss of rich and fertile top soil by erosion. This is especially true of wind erosion in Arizona, and perhaps of water erosion as well, in areas where the annual rainfall allows this phenomenon to occur.

Plowing is the cultural operation which consists of cutting, fragmentizing, inverting, and returning the soil plow layer so that the inner layers come up to the top and become exposed to the sun, rain, and other weather factors and surface materials are buried to plow depth. This common field operation has proven very useful for years in farm management because it has allowed the farmer to kill weeds and subterranean insects and pathogens, to incorporate fertilizers and pesticides into the soil, to plow under the natural vegetation or the remnants of a previous crop, and to create a favorable seedbed for root growth and development. Reduced tillage simply refers to reducing the number of tillage operations the farmer performs by one or more. As Fenster (1977, 1960), Williamson et al. (1975) and Woodruff et al.

(1972) stated, no one set of tillage tools is best for all conditions. The kind, quantity, or quality of residues; number, kind, and size of weeds present; moisture conditions; soil texture; length of fallow; and time of operation must be considered in selecting tillage tools.

The objectives of reduced tillage are to maintain or improve crop production while conserving soil, water, and energy. Reduction in tillage may be associated with the disadvantage of requiring greater amounts of herbicides and pesticides, not killing the insect life stages hibernating in the soil, and leaving large quantities of plant debris which harbor insects and disease agents on the soil surface. On the other hand, reduced tillage is an important means of making the food production process less expensive and a way of saving the soil potentialities. Maximum crop production balanced against some level of minimum tillage is a procedure of importance to lessor developed countries who have scarcities of energy and other resource inputs.

The objective of this research was to evaluate the effect of a form of reduced tillage on yield of grain sorghum grown double crop after winter barley in south central Arizona.

CHAPTER 2

LITERATURE REVIEW

The Importance of Tillage

How important is tillage? Is tillage necessary? Some scientists studying this question said that tillage was not necessary because it wastes water, since "soil dries out to the depth to which it is tilled" (Hanway, 1976). According to Reicosky et al. (1977), and Phillips (1974), evaporation of soil water from a conventionally tilled Maury silt loam from May through September was 2.4 times greater than from the same soil with no-tillage. Hanway (1976) suggested that farmers save as much water as they can, especially where there is limited rainfall and a high potential for evaporation and transpiration of moisture by plants. He pointed out the role played by crop residues and crop cover in doing this, for they increase water infiltration into the soil, decrease runoff and diminish evaporation. Ojeniyi and Dexter (1979) in their study about soil structural changes during multiple pass tillage quoted Russell (1961) who concluded that one pass of a tillage implement is not enough to form a good seedbed from settled soil and that several implement passes are used to break the soil down in the necessary 1 to 5 mm aggregate size range. However, Ojeniyi and Dexter (1979) warn agriculturalists about the excessive use of tillage implements. According to them, the first and second passes of an implement produce most of the soil break-up and should be sufficient.

Mechanical tillage operations are commonly employed by farmers to incorporate plant debris and chemicals such as fertilizers and pesticides into the soil at a depth where nutrients released from them can be easily used by plant roots (Brejcha, 1979).

Disadvantages of Tillage

Associated with tillage are a number of disadvantages. Some of these are erosion and production costs. Richardson (1982) quoted Lyle Bauer, President of the National Association of Conservation Districts, who warned that "Despite a significant investment in conservation practices by the federal government and by private landlords, erosion from agricultural lands continues at a massive rate", and asserted that "Between four and six billion tons of topsoil are moved each year by all the various forms of soil erosion with half the losses occurring on croplands." A Council for Agricultural Science and Technology reviewed the soil erosion problem and reported that the average annual loss of soil by erosion in the United States was about five tons per acre (1982). This means that on the average, U.S. cropland is losing soil almost as fast as it is being formed under the very best conditions. Some of the best farmland is losing soil much faster than it is being formed.

Associated with the loss of soil due to erosion is the loss of agricultural chemicals (Johnson et al., 1979; Baker and Johnson, 1979). Richardson (1982) estimated these to be valued at 1 to 3.50 dollars per acre per year and reported a study conducted with corn in Georgia that revealed a difference of 34 bushels per acre between uneroded areas and similarly treated eroded areas of the same land. Wischmeier (1973, 1975), reported by Sloneker and Moldenhauer (1977), discussed the effectiveness of surface residue in reducing soil erosion and showed that if 50 percent of the surface is covered, soil loss will be reduced to 32 percent of that without mulch present and that 100 percent cover will practically eliminate soil loss. Sloneker and Moldenhauer (1977) also estimated soil loss from surface oat and corn residue cover remaining in the spring to be about 25 percent of that without surface residue and explained that "after spring disking, however, soil loss would increase to between 40 and 50 percent of that with no surface residue."

Reduced Tillage and Its Consequences

According to Bennett (1977); Blake and Aldrich (1955); Free (1953, 1960); and Free and Bay (1964), reduced tillage planting began in the early 1940's in New York with the substitution of a disking or modified form of plowing for mold-board plowing. Corn yields were about two thirds those obtained with conventional seedbed preparation. In 1956 Musgrave developed a tillage system for corn that combined turn-plowing with planting in one operation (Bennett, 1977; Musgrave, 1956). Corn yields compared favorably with those from conventional practices, and soil erosion with the system was as little as one-sixth that with conventional tillage (Bennett, 1977; Free, 1970; Free and Bay, 1964 and 1969). In 1952, Sprague introduced the concept of reduced tillage by substituting chemical (herbicides) for tillage in pasture renovation (Bennett, 1977; Sprague, 1952). In 1954 Davidson and

and Barrons proposed a similar concept for corn following sod with emphasis on the resulting mulch protection to provide soil and water conservation (Bennett, 1977; Davidson and Barrons, 1954).

Reduced tillage developed rapidly during the 1960's. With new herbicides available, many researchers investigated the use of reduced tillage or no-tillage for corn production (Bennett, 1977, 1970; Bandel, Bell, and Parochetti, 1975; Bandel et al., 1975; Bayer and Ferrant, 1975; Bennett, Mathias, and Lundberg, 1973, 1976; Bennett, Mathias, and Sperow, 1976; Boys et al., 1972; Free, Lamb, and Carleton, 1947; Mathias et al., 1971; Stanford, Bennett, and Powers, 1973). In fact, by the early 1960's, in the eastern Corn Belt, research had shown that much of the secondary tillage was not necessary and in some cases may even reduce yields (Cook, Turk, and McColby, 1953). By the mid-1960's or earlier, farm innovators and some researchers reported success with various tillage techniques that did not include the moldboard plow (Griffith, Mannering, and Moldenhauer, 1977).

In the Pacific Northwest, Papendick and Miller (1977) reported that there was intense research and grower interest in minimum tillage systems for small grains. The primary motives were erosion control and energy conservation. At Pendleton, Oregon, a rough, cloddy seedbed for winter wheat following green peas gave excellent erosion control and good yields comparable to those with conventionally prepared seedbeds (Horning and Ovenson, 1962). Johnson et al. (1979) found that reduced tillage reduced runoff about 40 percent and reduced soil loss from 60 to 90 percent. The amount of plant debris left by reduced tillage plays an important role in reducing soil loss. Moomaw and Martin (1977) considered that reduced tillage corn (Zea mays L.) production systems involve managing surface residues to minimize soil erosion and water loss. Hinesly et al. (1967), Triplett and Lytle (1972) and Wimer (1946), quoted by Moomaw and Martin (1977), have shown that in the absence of weeds, tillage does not affect crop yields.

The organic matter content of a soil is another good point recorded with the practice of reduced tillage or minimum tillage. Lynch and Panting (1980) reported that the soil biomass was significantly greater where the soil had been direct-drilled than where it had been plowed maybe because plant roots were more abundant after direct drilling. They stated that "The surface layers of direct-drilled soils can be richer in organic matter (Baker and Standell, 1977; Douglas, 1977) and inorganic nutrients (Drew and Saker, 1978) than plowed soil, and therefore they may be expected to have greater biological activity." Barnes and Ellis (1979) pointed out the importance of earthworms in direct-drilled soils where they create continuous channels which facilitate the penetration of roots to depth in otherwise compacted soils. They quoted Low (1972) and Russell (1973) who found that plowing of established grass swords diminished the lumbricid population. Edwards and Lofty (1969) and Schwerdtle (1969) reported by Barnes and Ellis (1979) showed that when an established pasture was destroyed with herbicide and direct-drilled with cereals the earth worm population was relatively unaltered, compared with the decrease in the population that followed plowing.

Reduced tillage is an important way of saving energy, another precious commodity in farming. As Romander (1982) stated, although fuel requirements vary widely from one area to the next, and even from one farm to the next, it takes less than 1 gallon of fuel per acre to plant and apply chemicals to a no-till crop, compared to the 5 to 7 gallons per acre for soil preparation and planting required in a full tillage program. Reduction of tillage is a key feature of conservation production systems because disadvantages of tillage including increased soil and water loss and greater energy and labor requirement frequently exceed benefits (Moomaw and Martin, 1977; Tompkins and Bledsoe, 1979). Richardson (1982) and Johnson (1977) suggested that "farmers must cut costs at the same time they control erosion; the most obvious solution is reduced tillage which cuts a number of trips over the field and saves energy and time." Johnson (1977) reported average savings of 5 gallons of tractor fuel per acre per year in Texas, resulting from a switch from conventional tillage to minimum tillage.

Another advantage of reduced tillage is less machinery wear and tear by the very sandy soil which is abrasive to machinery (Agrichemical Age, April 1982). Reduction of soil compaction and retention of water in the soil also is a consequence of reduced tillage; once the ground gets compacted from the wheels of the tractor with regular tillage, then water will just run off the rows and does not seep into the ground and of course does not get utilized by the crop (Agrichemical Age, 1982). Dowdel et al. (1979) furthermore reported higher oxygen concentrations associated with a system of continuous large pores and channels which would otherwise be destroyed by annual intensive plowing.

Two major problems have been found to be related to the use of no-tillage and reduced tillage: the presence of plant residues in the field creates conditions favorable to the contamination of the new crop by pests from the previous year especially when monoculturing (Doupnik and Boosalis, 1980). Seasonal insect populations on cotton and tobacco plants in reduced and conventional tillage systems have been found not to be significantly different in a study done by Roach (1981) in South Carolina; however, more insects emerged from soil in reduced tillage plots. On the other hand, the accumulation of crop residue on the soil surface induces a change in soil environment. As a consequence, lower soil temperatures negatively affects growth rates of a seed (Mock and Erbach, 1977), and weed, insect, and nematodes actively require changes in pest control practices.

Tillage Effects on Yield

Crop responses to tillage systems vary with time and location. Reports in the late 1960s from Ohio (Van Doren, Triplett and Henry, 1975) and Illinois (McKibben, 1975) showed equal or better yields with no-tillage corn compared with conventional tillage on certain soils (Griffith et al., 1977). A seven year Indiana study (Griffith, Mannering, and Richey, 1976) compared conventional, chisel, till plant, and no-tillage systems for corn; in northern Indiana yields for the three no-plow systems were as good or better than conventional tillage on a well-drained sandy loam; on a poorly drained dark loam at the same location, no-tillage corn yielded at least 15 bushels per acre less than the other three systems; on a poorly drained eastern Indiana soil, chisel, and till-plant corn yields were slightly below conventional while no-tillage yields were drastically reduced; on a sloping southern Indiana soil, all three no-plow systems produced higher yields than conventional tillage. Griffith et al. (1977) reported a study done by Oschwald and Siemans (1976) who compared fall and spring plowing, several types of chisel systems, disk, and no-till planting on the two central Illinois soils between 1973 and 1975. Fall plowing had a slight advantage on Flanagan silt loam, a somewhat poorly drained soil. Chop plant (no-till) yields were lower, compared with other systems, on Catlin silt loam, a moderately well drained soil.

The previous crop significantly influenced corn response to tillage in Ohio (Van Doren, Triplett, and Henry, 1975). No-tillage and conventional tillage were compared over 12 years for continuous corn, corn after soybeans, and corn after meadow in a 3 year rotation. In continuous row crops, no-tillage produced better corn yields on Wooster silt loam (unstable surface structure), while conventional tillage was best on Hoytville silty clay loam, a poorly drained soil. However, yield differences were much less on the Hoytville soil when corn followed soybeans than when corn followed corn. When corn followed meadow, there were no significant yield differences due to tillage.

Research so far in the eastern Corn Belt indicates that the following factors are likely to influence crop yield response to tillage when weeds and other pests are controlled:

Soil drainage Shallow tillage and/or surface residue systems are more likely to succeed on well-drained soils.

Previous crop Shallow tillage and no-tillage for corn are more likely to succeed on poorly drained soils when corn follows anything but corn.

Soil Structure Corn on poorly structured soils with low organic matter is likely to react positively to surface residue tillage.

Length of season Surface residue systems are more likely to succeed with the longer growing seasons in the southern half of the Corn Belt.

Double cropping Soybeans, corn, and grain sorghum have proven successful as second crops following winter wheat in the eastern Corn Belt (Griffith et al., 1977). The no-till yield potential for double cropping is at least as good as with other forms of tillage and better in dry seasons (Beuerlein, 1974; McKibben, 1970; Swearingin et al., 1974).

In Iowa, studies associated the effectiveness of tillage methods with weather and soil water conditions. For example, severe water deficits occurred in 6 of 11 years on a Moody silt loam in northwest Iowa during the period from 1956 through 1966 (Amemiya, 1975). In those 6 years, lister planted corn outyielded conventionally planted corn by as much as 41 bushels per acre. Other tillage methods, including wheel-track planting, subsurface tillage, ridge planting, and cultivator planting, produced intermediate crop responses. Under favorable weather conditions, there was little difference among the varieties. Subsequent studies in northwest Iowa compared four tillage treatments: conventional planting, cultivator planting (moldboard plowing, followed by a field cultivator ahead of the planter), listing, and till planting. Again, yield responses to tillage depended on soil water in the profile at planting and the amount and pattern of precipitation during the growing season. Long-term averages, however, showed no significant differences in corn and soybean yields attributable to tillage practices. Using computerized modeling techniques, Miller and Shrader (1976) developed a yield response curve for soil moisture and for estimating the potential effect of conservation tillage systems on corn yields in western Iowa. Their data showed that when soil moisture levels were at 100 percent of plant-available water capacity, tillage practices had little effect on yields. At mean and low spring soil moisture levels, conservation tillage effectively increased yield estimates over those obtained with conventional tillage. Amemiya (1977) reported data obtained in Iowa, Minnesota, Nebraska, and South Dakota. In most cases, these data showed that crop yields with conservation tillage did not differ significantly from those with conventional tillage. Observed yield reductions related to changes in the crop environment were associated with surface residues and soil microrelief. Unger, Wiese, and Allen (1977) found that crops yielded more with no-tillage than with clean tillage in several promising double-cropping systems in the Southern Great Plains (Texas). When double-cropped after wheat harvest for grain, grain sorghum seedlings on no-tillage plots emerged faster, grew taller, and matured up to 5 days sooner than seedlings on clean tillage plots. Sorghum grain yields averaged 5,080 and 4,520 pounds per acre with no-tillage and clean tillage, respectively. Double cropped sorghum yielded about 2,000 pounds per acre less grain than a longer season hybrid planted 4 to 6 weeks earlier (Allen et al., 1975). At Hays, Kansas, tillage methods ranging from conventional to near-zero tillage failed to increase soil moisture consistently in a wheat-sorghum fallow rotation. Despite this lack of influence on moisture storage, sorghum grain yields averaged 2,870 and 3,030 pounds per acre on conventional and near-zero-tillage plots, respectively (Unger et al., 1977). In contrast to sorghum, average wheat yield differences were small and yearly variations were large. No reduced tillage system produced yields as high as conventional tillage (Phillips, Unger, and Greer, 1976; Unger et al., 1977). These authors reported another wheat-sorghum-fallow system in Kansas with conventional tillage between sorghum and wheat and reduced tillage between wheat and sorghum. Early results of that study showed that no-tillage sorghum production was practical. Later results, however, revealed inconsistent yields with no-tillage and herbicides had to be supplemented with some tillage for adequate weed control. One herbicide application and one tillage operation soon after wheat harvest and one additional tillage operation just before planting sorghum kept the wheat stubble weed-free, maintained residues for erosion protection, provided a satisfactory seedbed, and controlled weeds in the sorghum crop. Sorghum emergence was better on reduced tillage plots than on conventional tillage plots. Grain yields averaged 3,320 and 2,050 pounds per acre on reduced and conventional tillage plots, respectively (Phillips et al., 1976; Unger et al., 1977). Unger et al. (1977) reported a study in which clean tillage, stubble mulch, combination stubble mulch and herbicides, and no-tillage with herbicides were the treatments tested in a wheat-fallow rotation in Oklahoma. Despite the equal or higher soil moisture, average wheat yields were less than with clean tillage. Reasons for the lower yields were not identified, but the authors thought that stand establishment might have been a problem, for surfaces of the no-tillage plots were hard and difficult to penetrate with a drill. Another cause for the lower yields on no-tillage plots probably was the residues remaining in the spring after wheat planting the previous fall, since wheat plants were found to be chlorotic when large amounts of residues were present.

In a study where corn and grain sorghum were planted without tillage following winter wheat or barley and with conventional tillage following previous summer crop at two locations in Georgia for 4 years with and without irrigation, Nelson, Gallaher, Bruce, and Holmes (1977) found that corn and grain sorghum yields did not differ significantly for conventional tillage and no-till plantings made on the same date. They also found that no-till corn and grain sorghum produced higher yields when early planted than when late planted.

During an experiment conducted for 2 years on a loam soil in Iowa with several corn genotypes, Mock and Erbach (1977) showed that with a relatively normal planting date and equal final plant densities, grain yields were not affected by tillage treatments. There was no interaction between tillage method and corn genotype.

In a study on tillage effects on winter wheat production, Unger (1977) found that in the southwestern Great Plains, dry land wheat yields with sweep and disk tillage were similar, averaging 2,250 and 2,330 kg/ha, respectively. Yields for both were significantly higher than the 2,120 kg/ha no-tillage average. He also showed that irrigated wheat yielded 4,650 with sweep, 4,390 with disk, and 4,220 kg/ha with no tillage. According to this researcher, the differences were significant.

Reduced tillage and other various sytems of conservation tillage are being adopted more and more by farmers across the United States (Agrichemical Age, 1982). For example, Mock and Erbach (1977) mentioned that in 1968, slightly less than 480,000 ha of cropland in Iowa were under minimum or conservation tillage methods; by 1972, about 1.2 million ha were planted by these methods, and in 1975, 2.5 million ha were planted with some form of conservation tillage. Soil Conservation Service estimates that farmers in the United States use conservation tillage, including no-till, on 3 million additional acres a year. About 39 million acres were farmed under some form of conservation tillage in 1976. According to Tompkins and Bledsoe (1979), minimum tillage production is expected to continue at an accelerated rate through the next quarter century (USDA, 1975).

CHAPTER 3

MATERIALS AND METHODS

The production of grain sorghum under a double crop rotation after winter barley was evaluated under (A) full tillage and (B) a reduced tillage seedbed preparation at the University of Arizona Agricultural Experiment Station at Marana (Pima County) Arizona in 1982. The primary objectives of this research were to determine the differences between full tillage and a reduced tillage seedbed preparation on the physiological performance of the grain sorghum varieties evaluated and the resulting economic production returns. The reduced tillage seedbed preparation regime (B) differed from the full tillage regime (A) by omission of plowing and packing the plowed soil. Plowing is one of the most energy-intensive and costly field operations which is why it was selected for omission for a reduced tillage seedbed preparation regime.

Eight commercial grain sorghum varieties with a range in maturity from early to full season were selected as the plant test materials. Seeds of these items were furnished by Asgrow Seed Company of Texas. Table 1 gives the list of these eight varieties. Statistically the experiment consisted of a split plot design with two blocks, two seedbed preparation methods or main treatments, and eight varieties or subplot treatments. The subplots were replicated four times within each main treatment. The whole plots were 30.5 m long and 8.128 m wide. Each subplot consisted of four rows on raised beds (1.016 m apart and 7.625 m long), but only the two center rows were considered in evaluating the seedbed preparation methods and the varieties.

Table 1. List of 8 grain sorghum varieties used in the reduced tillage experiment at Marana, Arizona in 1982.*

Entry Number	Name	Asgrow Lot Number
1	Dorado E	ATY 372
2	Corral	ATY 9837
3	H 8012	ATY 395
4	H 796	ATY 380
5	Mustang	ATY 3774
6	Topaz	ATY 341L
7	Double TX	ATU 5624
8	Colt	ATY 378

*These varieties, according to their originator, Asgrow Seed Company, range from early (variety number 1) to late (variety number 8) maturity.

The test was grown on an Entisol with a top-soil plow layer of about 30.5 to 35.5 cm deep from which about 75% of the plant nutrients are obtained, and depending on the rooting system of the crop, from 30 to 50% (or more) of the water is taken (Post, Hendricks, and Pereira, 1978). This soil, with a clay loam texture, is a relatively heavy soil and quite suitable for sorghum grain production. Soil samples were taken from the experimental field on June 22 at a depth of 15 to 30 cm before applying one or the other of the tillage treatments. They were analyzed in the Soil, Water, and Plant Testing Laboratory of the University of Arizona, Tucson. While the pH was quite uniform and equal to more or less 7.5 across the whole field, variations were considerable concerning soluble salts, sodium, potassium, NO_3, and PO_4 (Appendix D, Table 60). This might be due to the livestock manure which was left in piles too long in the field the year before and was spread before planting the previous barley crop. This livestock manure did not decompose rapidly and resulted in uneven plant emergence and early growth.

A seeding rate of 33 viable seed per meter was determined from germination tests of seed of each of the eight sorghum varieties. For the varieties Dorado E, Corral, and Colt of which seeds germinated 97%, 516 seeds were planted per plot, resulting in 332,991 seeds/ha; 520 seeds per plot were used for the variety H8012, that is 335,572 seeds/ha; seeds of that variety germinated 96%; 562 seeds of the varieties H796 and Mustang were planted per plot giving 362,676 seeds/ha; the viability of the seeds of those varieties was 89%. The varieties Topaz and Double TX required 510 and 548 seeds per plot, respectively, giving 329,119 and 353,641 seeds/ha, respectively; seeds of those varieties germinated 98 and 91%, respectively. The plots were planted with cone planters mounted on International Harvester 185 planter units with disc openers.

The test area was preirrigated and the experiment planted in moist soil. The experiment was irrigated and fertilized as needed. Normal weed and insect control procedures were used to promote optimum plant growth. Data recorded for the purpose of evaluating differences between the seedbed preparation methods and among varieties were: emergence counts, days to 50 percent bloom, head counts, plant height to top of head, head exsertion, head length, height to upper leaf collar, percent moisture of the grain, bushel test weight of the grain (seed density), number of seeds per head, and weight per 300 seeds of the grains (Appendix E Tables 61 and 62). Emergence counts and head counts were adjusted for skips within the plot rows. Sorghum plants can adjust yields quite well for occasional skips in plots up to about 30 cm without loss of plot yield. Skips above this size were measured to the nearest 30 cm but not counting about 15 cm on each end of the skips. Harvested plot yields were then adjusted upward for any measured skips. Plot yields were also adjusted for grain moisture and bird damage. A chronological listing of all field operations and field test data collection occurrences is presented in Table 2. The economic costs of all tillage operations and other normal crop production items were taken from the Pima County (Arizona) Crop Budget (Hathorn and Armstrong, 1982). The budgetary difference in grain production under the two seedbed preparation regimes is paramount in determining the practicality of either regime.

Table 2. A calendar of field operations as they occurred during the experiment at Marana, Arizona in 1982.

Date (1982)	Field Operations
15 June	Winter barley harvested
22 June	Chop stubble
22 June	Soil Samples
22 June	Disc with furrows
22 June	Disc across furrows
24-28 June	*Plow across furrows (full tillage only)
29 June	*Packer over plowed portion of field (full tillage only)
30 June	Furrow out
1-2-3 July	Pre-irrigation (number 1) (30.48 cm)
7 July	" " " "
6 July	Rain (2.84 cm)
12 + 14 July	Mulch beds
13 + 14 July	Planting
16-17 July	Irrigation (number 2) (10.16 cm)
19 July	Count emergence
2 August	Cultivate
6-7-8 August	Irrigation (number 3) + fertilizer (10.16 cm)
16 August	Cultivate
23 August	Irrigation (number 4) (10.16 cm)
23 August	Rain (0.25 cm)
24 August	Rain (1.78 cm)
25 August	Rain (0.28 cm)
3 September	Irrigation (number 5) (10.16 cm)
27 October-4 November	Harvest

*These two field operations carried out only under the full tillage seedbed preparation.

CHAPTER 4

RESULTS AND DISCUSSION

The physiological aspects of this study are examined first and in their chronological order. Despite their importance in the farm management or in the conception and execution of agricultural activities, the economical aspects are treated towards the end of this chapter, since they depend for the most part upon the yield which can be considered as the final consequence of the combination of all the agronomic and physiological parameters. All the agronomic and physiological data were statistically analyzed by using the F test of significance. These data and the analysis of variance tables are presented in the appendix A (Tables 27 through 54).

Percent Emergence

The two seedbed preparation methods and the plant test materials of eight grain sorghum varieties were evaluated for percent emergence. This is the ratio of emergence plant counts per unit area over the number of seed planted per unit area multiplied by 100. For each of the eight varieties utilized, the two seedbeds did not differ significantly, even though some varieties gave somewhat better emergence under one or the other of the seedbeds (Table 3). For the varieties Dorado E, Corral, H8012, and Double TX, the results on plant emergence agreed with those from other studies (Phillips et al.,

Table 3. Mean percent emergence based on number of seeds planted of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

	Percent Emergence			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	64.44 cd	77.32 a	70.88 ab	+19.99
Corral	67.64 bc	68.60 b	68.12 bc	+ 1.42
H 8012	59.71 d	69.42 b	64.57 cd	+16.26
H 796	63.96 cd	61.20 c	62.58 d	- 4.31
Mustang	61.30 d	60.14 c	60.72 d	- 1.89
Topaz	75.58 a	70.10 b	72.84 a	- 7.25
Double TX	68.89 bc	69.70 b	69.30 ab	+ 1.18
Colt	72.58 ab	70.74 b	71.66 ab	- 2.54
All 8 varieties	66.76	68.40	67.58	+ 2.46

$LSD_{0.05}$ for differences among variety means across seedbeds = 4.32%

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 6.11%

1976; Unger et al., 1977). However, highly significant differences existed among varieties within and across the seedbeds; the varieties Dorado E, and H8012 emerged better in the reduced tillage seedbed than in the full tillage seedbed, producing, respectively 20 and 16% fewer plants when planted in the full tillage rather than in the reduced tillage seedbed. It also appeared that the varieties Topaz, H796, and Colt were better adapted for emerging in a full tillage seedbed, giving 7, 4, and 2.5% more plants, respectively. Furthermore, there was a highly significant seedbed X variety interaction for plant emergence. So, the simple effects among the eight varieties within each seedbed were examined and it was found that for the reduced tillage seedbed, the increase in plant emergence of variety Dorado E over the varieties Corral, H8012, H796, Mustang, Topaz, and Colt was significant at the 0.05 level; the increase of variety Double TX over H796 and Mustang was also significant. For the full tillage method, the increases in plant emergence of the varieties Topaz, Double TX, and Colt over Dorado E, the increase of Corral over H8012; and the increase of Topaz over Corral were significant. Other significant increases were those of H796, Mustang, Topaz, Double TX, and Colt over H8012 and those of Topaz and Double TX over Mustang.

Days to 50 Percent Bloom

Unlike Unger et al's. study (1977) conducted on double cropped sorghum after wheat harvest for grain, statistically there was no significant difference in days to 50 percent bloom due to the seedbed preparation method for each of the eight sorghum varieties (Tables 18

Table 4. Mean days to 50 percent bloom of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	52 bc	52 cd	52.00 cd	0.00
Corral	52 bc	52 cd	52.00 cd	0.00
H 8012	52 bc	51 d	51.50 d	-1.92
H 796	58 a	56 b	57.00 b	-3.45
Mustang	53 b	53 c	53.00 c	0.00
Topaz	51 c	52 cd	51.50 d	+1.96
Double TX	51 c	51 d	51.00 d	0.00
Colt	58 a	59 a	58.50 a	+1.72
All 8 varieties	53.40	53.25	53.31	-0.28

$LSD_{0.05}$ for differences among variety means across seedbeds = 1.34 days

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 1.89 days and 43) despite 1.92 and 3.45% more days for H8012 and H796, respectively, and 1.96 and 1.72% fewer days for Topaz and Colt, respectively, in the full tillage seedbed (Table 4). However, differences among varieties were highly significant (Tables 18 and 43). This was expected since the eight varieties had been characterized by their originator, Asgrow Seed Co., as varying in maturity from early to full season. Nevertheless, the two seedbeds gave two maturity groupings of the varieties which did not match well with each other or with the seed company's maturity characterization (Table 5). This suggested that these varieties would bloom in a different order depending upon the type of seedbed and the environment in which they are grown.

Head Counts

Most varieties produced more heads in the reduced tillage seed beds (Dorado E produced 10.93% more heads, Corral 4.69, H8012 14.18 H796 2.4, Double TX 4.84, and Colt 1.87% more heads in the reduced tillage seedbed). Only Topaz and Mustang produced 4.92 and 3.42% more heads in the full tillage seedbed, respectively (Table 6), but these differences for the same varieties between the seedbeds were not significant at the 0.05 level (Table 44). Differences among varieties were significant at the 1% level (Tables 18 and 44). Table 6 also gives the grouping of varieties into plant populations within and across seedbeds.

Percentage of Head Production

This is the number of heads per unit area compared to the plant emergence counts per unit area. The varieties Dorado E, H8012, and Mustang were more able to produce heads in the full tillage than in the reduced tillage seedbeds, with differences of 7.84, 2.13 and 1.63%,

Table 5. Order of maturity from early to late of the eight varieties as given by Asgrow Seed Company and as found under the full tillage and reduced tillage treatments at Marana, Arizona in 1982.

Variety	Asgrow	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean of A and B
Dorado E	1	2	2	3
Corral	2	2	2	3
H 8012	3	2	1	2
H 796	4	4	4	5
Mustang	5	3	3	4
Topaz	6	1	2	2
Double TX	7	1	1	1
Colt	8	4	5	6

Table 6. Mean head counts per hectare of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona, in 1982.

	Head Counts per Hectare			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	200698 a	222639 a	211668.00 a	+10.93
Corral	199407 a	208765 abc	204086.00 ab	+ 4.69
H 8012	177466 bc	202634 abc	190050.00 bc	+14.18
H 796	174885 c	179079 d	176982.00 c	+ 2.40
Mustang	198117 ab	191341 cd	194729.00 b	- 3.42
Topaz	209733 a	199407 bcd	204570.00 ab	- 4.92
Double TX	206506 a	216509 ab	211507.50 a	+ 4.84
Colt	189405 abc	192954 cd	191179.50 b	+ 1.87
All 8 varieties	194527.13	201666.00	198096.56	+ 3.67

$LSD_{0.05}$ for differences among variety means across seedbeds = 14890 heads per hectare.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 21057 heads per hectare.

Table 7. Mean percentage of head production based on emergence plant counts of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

	Percentage of Head Production			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	94.04 a	86.67 ab	90.35 a	- 7.84
Corral	88.93 ab	91.60 a	90.26 a	+ 3.00
H 8012	88.93 ab	87.04 ab	87.98 a	- 2.13
H 796	75.40 d	80.65 b	78.02 c	+ 6.96
Mustang	89.33 ab	87.87 ab	88.60 a	- 1.63
Topaz	84.44 bc	86.44 ab	85.44 ab	+ 2.37
Double TX	85.02 bc	87.82 ab	86.42 ab	+ 3.29
Colt	78.60 cd	82.00 b	80.30 bc	+ 4.32
All 8 varieties	85.59	86.26	85.92	+ 0.78

$LSD_{0.05}$ for differences among variety means across seedbeds = 6.27%.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 8.87%.

respectively. On the contrary, the percentage of head production was higher for the varieties Corral, H796, Topaz, Double TX, and Colt in the reduced tillage seedbed (Table 7), but these differences were not significant at the 0.05 level (Table 45). Highly significant differences were found among varieties within and across seedbeds (Tables 18 and 45). Under the full tillage conditions, the variety Dorado E was the most able to produce heads whereas in the reduced tillage environment, the variety Corral gave the highest percentage of production. H796 was the least able to produce heads under both seedbeds conditions.

Head Length

All the varieties except H8012 produced bigger heads in the full tillage seedbeds (Table 8) but the differences in head length between the two seedbeds for the same variety were not statistically significant at the 0.05 level (Table 46). Differences among varieties within and across seedbeds were significant at the 0.01 level (Tables 18 and 46). In the full tillage treatment, the variety Corral produced longer heads whereas the variety H8012 produced the biggest heads in the reduced tillage seedbed. Double TX produced the shortest heads in both situations.

Head Exsertion

Although the statistical analysis showed no significant difference in head exsertion between the two methods, the reduced tillage caused slightly greater average head exsertions across all genotypes creating the potential for greater-lodging by peduncle breakage. The varieties

Table 8. Mean head length of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

	Head Length (cm)			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	28.62 ab	28.50 ab	28.56 ab	- 0.42
Corral	30.00 a	28.75 ab	29.38 a	- 4.17
H 8012	28.88 ab	30.00 a	29.44 a	+ 3.88
H 796	28.50 ab	27.25 bc	27.88 b	- 4.38
Mustang	29.00 ab	28.38 ab	28.69 ab	- 2.14
Topaz	28.25 bc	27.62 b	27.94 b	- 2.23
Double TX	26.62 c	25.62 c	26.12 c	- 3.76
Colt	28.00 bc	27.12 bc	27.56 b	- 3.14
All 8 varieties	28.48	27.91	28.20	- 2.00

$LSD_{0.05}$ for differences among variety means across seedbeds = 1.17 cm.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 1.65 cm.

Table 9. Mean head exsertions of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

	Head Exsertion (cm)			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	17.00 ab	18.25 bc	17.63 b	+ 7.35
Corral	19.62 a	23.50 a	21.56 a	+19.78
H 8012	16.75 abc	16.62 c	16.69 b	- 0.78
H 796	16.00 bc	16.88 c	16.44 b	+ 5.50
Mustang	17.25 ab	18.12 bc	17.69 b	+ 5.04
Topaz	13.88 c	12.38 d	13.13 c	-10.81
Double TX	17.00 ab	19.88 b	18.44 b	+16.94
Colt	10.50 d	9.88 d	10.19 d	- 5.90
All 8 varieties	16.00	16.94	16.47	+ 5.88

$LSD_{0.05}$ for differences among variety means across seedbeds = 2.07 cm.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 2.92 cm.

Dorado E, Corral, H796, Mustang, and Double TX were found to produce longer head exsertions with the reduced tillage than with the full tillage methods, the differences being 7.35, 19.77, 5.50, 5.04, and 16.94%, respectively. On the other hand, the varieties H8012, Topaz, and Colt produced longer head exsertions in the full tillage seedbed (Table 9). Highly significant differences were found among varieties within and across seedbeds (Tables 18 and 47). In all three cases, the variety Corral gave the longest head exsertions while the variety Colt the shortest.

Height to Upper Leaf Collar

For all the varieties except Colt, the sorghum plants showed a tendency to grow taller in the full tillage seedbed. The sorghum plants of the variety Colt grew 5.16% taller in the reduced tillage environment (Table 10), but these differences between the seedbeds did not reach the 0.05 level of significance (Table 48). Among varieties, differences were significant at the 1% level (Table 48). In the full tillage seedbed, the height to the upper leaf collar was greater for the variety Double TX while this height was greater for the variety Colt in the reduced tillage conditions. Within and across seedbeds, this height was smaller for the variety Mustang (Table 10). The average shorter height of the culm to the upper leaf collar of all varieties under reduced tillage is desirable because of the potential for less lodging.

Height to the Top of the Head

The total plant height was greater for all varieties except for Colt and H8012 under the full tillage conditions. For the variety Colt,

Table 10. Mean height to upper leaf collar of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

Variety	Height to Upper Leaf Collar (cm) Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	72.62 d	71.38 de	72.00 e	- 1.71
Corral	80.75 bc	76.75 cd	78.75 cd	- 4.95
H 8012	78.12 cd	77.12 cd	77.62 d	- 1.28
H 796	83.62 bc	83.25 bc	83.44 c	- 0.44
Mustang	71.38 d	67.12 e	69.25 e	- 5.97
Topaz	86.00 ab	82.00 bc	84.00 bc	- 4.65
Double TX	92.25 a	89.38 ab	90.81 a	- 3.11
Colt	87.12 ab	91.62 a	89.37 ab	+ 5.16
All 8 varieties	81.48	79.83	80.66	- 2.02

$LSD_{0.05}$ for differences among variety means across seedbeds = 5.40 cm.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 7.64 cm.

the plants were 2.39% taller in the reduced tillage seedbed (Table 11), but the differences between the two seedbeds were not significant at the 0.05 level (Table 49). For the variety H8012, no difference in total plant height was noticed between the two seedbed preparation methods (Table 11). These results mostly disagreed with those from Unger, et al's. study (1977) which found that when double cropped after wheat harvest for grain, grain sorghum seedlings on no-tillage plots grew taller than seedlings on clean tillage plots.

The average shorter total plant height under reduced tillage is desirable because of the lower probability of lodging. However too short of head exsertions may cause more leaves and plant debris to be run through the combine during harvest thus increasing harvest expense. Within seedbeds, the differences among varieties were signifiant at the 0.01 level (Table 49) and variety Double TX produced the tallest plants in both situations whereas the variety Mustang the shortest plants in both situations (Table 11).

Mean Grain Yield per Head

Most varieties produced more grain yield per head under the full tillage treatment (Table 12). This might be expected since full tillage produced fewer heads (Table 6) necessitating that each head then contain more grain. Fewer heads create less competition resulting in larger and more productive heads. The varieties Dorado E, H8012, Mustang, and Double TX produced 10.21, 25.83, 11.85, and 9.68% more grain per head, respectively, under full tillage. Only the varieties Corral and Colt produced more grain per head under the reduced tillage treatment, with

Table 11. Mean height to top of head of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

	Height to Top of Head (cm)			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	118.25 c	118.12 de	118.19 d	- 0.11
Corral	130.38 ab	129.00 ab	129.69 b	- 1.06
H 8012	123.75 bc	123.75 bcd	123.75 c	0.00
H 796	128.12 b	127.38 bc	127.75 bc	- 0.58
Mustang	117.62 c	113.62 e	115.62 d	- 3.40
Topaz	128.12 b	122.00 cd	125.06 bc	- 4.78
Double TX	135.88 a	134.88 a	135.38 a	- 0.74
Colt	125.62 b	128.62 abc	127.12 bc	+ 2.39
All 8 varieties	125.97	124.67	125.32	- 1.03

$LSD_{0.05}$ for differences among variety means across seedbeds = 4.85 cm.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 6.87 cm.

Table 12. Mean grain yield per head of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

	Mean Grain Yield per Head (g)			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	31.72 de	28.48 d	30.10 de	-10.21
Corral	29.56 e	29.92 cd	29.74 e	+ 1.22
H 8012	40.26 ab	29.86 cd	35.06 bc	-25.83
H 796	40.52 a	40.24 a	40.38 a	- 0.69
Mustang	35.60 bcd	31.38 cd	33.49 cd	-11.85
Topaz	34.46 cd	34.14 bc	34.30 c	- 0.93
Double TX	30.98 de	27.98 d	29.48 e	- 9.68
Colt	37.56 abc	38.40 ab	37.98 ab	+ 2.24
All 8 varieties	35.08	32.55	33.82	- 7.21

$LSD_{0.05}$ for differences among variety means across seedbeds = 3.41 g.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 4.82 g.

1.22 and 2.24% difference, respectively. Differences did exist among varieties within and across seedbeds (Tables 12 and 50).

Weight of 300 Seeds

For most varieties, the seeds produced from the reduced tillage seedbed were heavier than those produced from the other seedbed. Corral gave a difference of 0.68%, H796 4.63%, Mustang 2.96%, Topaz 4.44%, Double TX 4.61%, and Colt 10.31%. However, Dorado E and H8012 produced heavier seeds in the full tillage seedbed with 1.07 and 8.55% difference, respectively (Table 13). However, these differences between the seedbeds were not significant at the 0.05 level (Table 51). Among varieties differences were significant at the 0.01 level (Tables 18 and 51). Table 13 also gives the grouping of the varieties into populations within and across seedbeds.

Number of Seeds per Head

All varieties except Corral produced more seeds per head in the full tillage environment (Table 14). This is not unexpected since the full tillage treatment produced more grain yield per head for most varieties (Table 12). Apparently more of this increased grain yield by weight was produced through more seeds per head rather than through seed weight since most varieties produced heavier seeds under reduced tillage. Dorado E produced 9.30% more seeds per head in the full tillage seedbed, H8012 18.32% more seeds per head, H796 4.85%, Mustang 14.18%, Topaz 4.87%, Double TX 13.58%, and Colt 7.39% more seeds per head (Table 14). These differences between the seedbed preparation methods were not significant at the 0.05 level (Table 52). When differences among varieties

Table 13. Mean weight of 300 seeds of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

Variety	Weight of 300 Seeds (grams)			
	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	7.48 b	7.40 bc	7.44 bc	- 1.07
Corral	7.39 b	7.44 bc	7.42 bc	+ 0.68
H 8012	7.02 b	6.42 d	6.72 d	- 8.55
H 796	9.06 a	9.48 a	9.27 a	+ 4.63
Mustang	7.43 b	7.65 bc	7.54 b	+ 2.96
Topaz	6.98 b	7.29 c	7.14 c	+ 4.44
Double TX	6.94 b	7.26 c	7.10 cd	+ 4.61
Colt	7.18 b	7.92 b	7.55 b	+10.31
All 8 varieties	7.44	7.61	7.52	+ 2.28

$LSD_{0.05}$ for differences among variety means across seedbeds = 0.39 g.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 0.55 g.

Table 14. Mean number of seeds per head of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

Variety	Number of Seeds per Head			
	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	1268 de	1150 d	1209 c	- 9.30
Corral	1199 e	1206 cd	1203 c	+ 0.58
H 8012	1708 a	1395 abc	1552 a	-18.32
H 796	1341 cde	1276 a-d	1309 bc	- 4.85
Mustang	1432 bcd	1229 bcd	1331 bc	-14.18
Topaz	1478 bc	1406 ab	1442 ab	- 4.87
Double TX	1340 cde	1158 d	1249 c	-13.58
Colt	1570 ab	1454 a	1512 a	- 7.39
All 8 varieties	1417	1284	1351	- 9.39

$LSD_{0.05}$ for differences among variety means across seedbeds = 135 seeds.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 191 seeds were examined, it was found that in the full tillage seedbed, the variety H 8012 produced more seeds per head than the others. With the reduced tillage method, Colt produced the greatest number of seeds per head. Table 52 also shows that those differences among varieties were significant at the 0.01 level.

Seed Density

The difference between the two seedbed preparation methods did not reach the 0.05 level of significance in spite of the tendency for the varieties Dorado E, Corral, H 8012, and H 796 to give a higher seed density under the reduced tillage method and the tendency for the varieties Mustang, Topaz and Colt to give a lower seed density under that method (Tables 15 and 53). Among varieties, differences were significant at the 0.01 level (Tables 18 and 53).

Grain Yield

Some varieties appeared to be more adapted to the full tillage environment than to the other seedbed. For example, the varieties H8012, Mustang, Topaz, and Double TX produced, respectively, 15.27, 14.79, 5.96, and 5.44% more grain under the full tillage conditions. For these varieties, results were in agreement with those obtained by Oschwald and Siemans (1976) in Central Illinois (Griffith et al., 1977). On the other hand, the varieties Corral, H796, and Colt were found to be more productive and more appropriate for the reduced tillage seedbed. They gave differences of 3.72, 1.82, and 4.03%, respectively (Table 16). Unger et al. (1977) reported similar results from a study done at Hays,

Table 15. Mean seed density of the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

	Seed Density (kg/hl)			
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	76.121 b	76.635 bc	76.378 c	+ 0.67
Corral	76.473 ab	77.013 bc	76.743 bc	+ 0.71
H 8012	78.159 a	79.273 a	78.716 a	+ 1.42
H 796	71.856 c	75.528 cd	73.692 e	+ 5.11
Mustang	76.323 ab	75.411 cd	75.867 cd	- 1.19
Topaz	78.036 a	78.016 ab	78.026 ab	- 0.02
Double TX	75.763 b	75.763 cd	75.763 cd	0.00
Colt	74.695 b	74.682 d	74.688 de	- 0.02
All 8 varieties	75.928	76.540	76.234	+ 0.81

$LSD_{0.05}$ for differences among variety means across seedbeds = 1.328 kg/hl

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 1.875 kg/hl

Table 16. Mean grain yields of the eight sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

Variety	Grain Yields (kg/ha) Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Dorado E	6388.552 ab	6343.181 bc	6365.867 d	- 0.71
Corral	6025.583 b	6249.511 c	6137.547 d	+ 3.72
H 8012	7148.153 a	6056.318 c	6602.236 bcd	-15.27
H 796	7083.755 a	7212.551 ab	7148.153 ab	+ 1.82
Mustang	7007.649 a	5971.430 c	6489.539 cd	-14.79
Topaz	7221.332 a	6791.038 abc	7006.185 abc	- 5.96
Double TX	6404.651 ab	6056.318 c	6230.484 d	- 5.44
Colt	7124.737 a	7411.598 a	7268.167 a	+ 4.03
All 8 varieties	6800.552	6511.493	6656.022	- 4.25

$LSD_{0.05}$ for differences among variety means across seedbeds = 625 kg/ha.

$LSD_{0.05}$ for differences among variety means for the same seedbed level = 884 kg/ha.

Kansas. Despite these differences due to the genotype, average yields from both seedbeds did not differ significantly. Amemiya (1977) obtained the same results in Iowa, Minnesota, Nebraska and South Dakota. Allen et al. (1975) also reported similar results with double cropped sorghum. Among varieties, highly significant differences were found within and across seedbeds. In the full tillage seedbed, the variety Topaz yielded more than the others, but statistically it belonged to the same population as the varieties Dorado E, H 8012, H796, Mustang, Double TX, and Colt. In the reduced tillage seedbed, the variety Colt yielded more than the others, statistically it belonged to the same population as Topaz and H796. Two plant populations were found among the eight varieties in the full tillage seedbed, three populations were found within the reduced tillage seedbed, and four populations were found across the seedbeds (Table 16). There was no seedbed X variety interaction. This was in agreement with the study done by Mock and Erbach (1977) in Iowa with several corn genotypes. A ranking of the eight varieties according to their performances in producting grain yield within and across seedbeds is given in Table 17. Tables 18 and 19 give an idea on the comparison of the two seedbeds and on the statistical analysis of the data of this experiment.

Correlation and Regression

There was no linear relationship between grain yield and emergence plant counts in either seedbed (Table 20). Neither the correlation nor the regression coefficients were statistically significant.

Table 17. Ranking for yield of the eight grain sorghum varieties under the reduced tillage and the standard (full) tillage treatments at Marana, Arizona in 1982.

Variety	Rank: Full Tillage Seedbed (A)	Rank: Reduced Tillage Seedbed (B)	Mean
Dorado E	7	4	6
Corral	8	5	8
H 8012	2	6	4
H 796	4	2	2
Mustang	5	8	5
Topaz	1	3	3
Double TX	6	6 (7)	7
Colt	3	1	1

Table 18. Observed F values of yield and other agronomic data for the 8 grain sorghum varieties under full tillage and reduced tillage treatments at Marana, Arizona in 1982.

Variable Considered	Source of Variation Seedbeds df:1	 Varieties df:7	 Seedbed x Variety df:7
Yield	1.534	4.380**	1.727
Emergence counts	0.417	4.414**	4.926**
Percent emergence	0.430	9.820**	4.977**
Days to 50 percent bloom	1.360	42.816**	1.044
Head counts	8.346	5.999**	1.618
Percentage of head production	0.099	4.822**	0.956
Yield per head	7.123	12.610**	2.690
Head length	0.676	7.835**	1.026
Head exsertion	1.562	25.641**	1.692
Height to upper leaf collar	0.499	18.737**	0.668
Height to top of head	0.319	15.433**	0.732
Seed density	0.787	7.068**	1.231
Weight of 300 seeds	7.196	35.679**	2.429
Number of seeds per head	27.260	9.340**	1.230

**Significant at the 0.01 level.

Table 19. Comparison of the two seedbeds for each variable during the experiment at Marana, Arizona in 1982.

Variable	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference (% of Full Tillage)
Yield (kg/ha)	6800.552	6511.493	6656.022	- 4.25
Percent emergence	66.76	68.40	67.58	+ 2.46
Days to 50% bloom	53.40	53.25	53.31	- 0.28
Head counts per hectare	194527.13	201666.00	198096.56	+ 3.67
Percentage of head production	85.59	86.26	85.92	+ 0.78
Yield per head (g)	35.08	32.55	33.82	- 7.21
Head length (cm)	28.48	27.91	28.20	- 2.00
Head exsertion (cm)	16.00	16.94	16.47	+ 5.88
Height to upper leaf collar (cm)	81.48	79.83	80.66	- 2.02
Height to top of head (cm)	125.97	124.67	125.32	- 1.03
Weight of 300 seeds (g)	7.44	7.61	7.52	+ 2.28
Number of seeds per head	1417	1284	1350	- 9.39
Seed density (kg/hl)	75.928	76.540	76.240	+ 0.81
Costs of growing 1 hectare ($)	728.24	668.78	698.51	- 8.16
Receipts (U.S. $/ha)	899.56	861.32	880.44	- 4.25
Profits (U.S. $/ha)	171.32	192.54	181.93	+12.39

Table 20. Correlation coefficient (r) and regression coefficient (b) of morphological characteristics of the mean of eight grain sorghum varieties under the reduced tillage and the standard (full) tillage treatments at Marana, Arizona in 1982.

Variables	Full Tillage Seedbed		Reduced Tillage Seedbed	
	r	b	r	b
Yield vs. emergence counts	+0.076	+0.0036	-0.061	-0.0025
Yield vs. head counts	-0.190	-0.0106	-0.160	-0.0076
Yield vs. head length	+0.110	+0.2600	+0.080	+0.1100
Yield vs. head exsertion	-0.400**	-0.4350**	-0.400**	-0.2180**
Yield vs. plant height	-0.120	-0.0570	+0.310**	+0.1060**
Head counts vs. emergence counts	+0.840**	+0.6940**	+0.840**	+0.7080**
Head counts vs. plant height	+0.240*	+1.9630*	+0.150	+1.0610
Plant height vs. emergence counts	+0.360**	+0.0370**	+0.160	+0.0200
Plant height vs. head exsertion	+0.040	+0.0980	+0.150	+0.2500
Head length vs. emergence counts	-0.320**	-0.0063**	-0.150	-0.0044
Head length vs. head counts	-0.220*	-0.0054*	-0.180	-0.0066
Head length vs. head exsertion	+0.180	+0.0850	-0.014	-0.0057
Head length vs. plant height	-0.270*	-0.0520*	-0.200	-0.0500
Head exsertion vs. emergence counts	-0.053	-0.0022	+0.092	+0.0066
Head exsertion vs. head counts	+0.160	+0.0079	+0.230*	+0.0200*

* Significant at the 0.05 level
**Significant at the 0.01 level

When the number of sorghum heads per hectare varied from 74,258 up to 272,330 among plots, the grain yield decreased slightly. This decrease did not reach a significant level. Both correlation and regression coefficients were negative and non significant (Table 20). An increase in the head length from 24 to 38 cm led to a slight and non significant increase in yield (Table 20). Under the conditions of this experiment, there was a strong negative linear relationship between the grain yield and the amount of the head exsertion. In both seedbeds the grain yield decreased significantly when the length of the head exsertion increased from 6 up to 33 cm among plots. Both correlation and regression coefficients were negative and highly significant (Table 20). The grain yield and the height to the top of the sorghum head were linearly and positively related in the case of the reduced tillage seedbed, where this height varied between 105 and 143 cm among plots. Between those limits, as the plant height increased by 1 cm, the grain yield increased by 0.106 kg (Table 20). There was no linear relationship between these two variables in the case of the full tillage seedbed.

In both seedbeds the head counts increased significantly as plant emergence increased between 130,357 and 312,340 plants/ha on a plot basis. The correlation and regression coefficients were positive and highly significant indicating a strong linear relationship between these two variables (Table 20). A tendency of the head counts to increase as plant height increased was noticed in both seedbeds but this linear relationship between the number of heads and plant height increases was noticed in both seedbeds but this linear relationship between the number of heads and plant height was significant only in the case of full tillage (Table 20). When the full tillage seedbed preparation method was applied, plant height increased significantly with the emergence plant counts per hectare within the limits of this experiment. Plant height increased with increased emergence plant counts under reduced tillage but the magnitude of this relationship was not significant (Table 20). This suggests that there was probably more competition among sorghum plants when the seedbed had received full tillage. Similarly, under full tillage, the plant height increased significantly with the head counts (Table 20). This increase in plant height as a function of head counts was not significant in the case of the reduced tillage method. No significant linear relationship was found between plant height and length of the head exsertion under either tillage treatment (Table 20). The head length and emergence counts were negatively and highly related in the case of the full tillage seedbed (Table 20). As emergence counts increased, head length decreased significantly which probably resulted from increased competition among sorghum plants. In the case of the reduced tillage treatment, the negative correlation between the head length and emergence counts was less and non significant. It could be concluded that competition among plants was a little more pronounced in the full tillage than in the reduced tillage seedbeds. This same phenomenon was observed between head length and head counts (Table 20) where under full tillage there was a significant decrease in head length as head counts increased.

This same correlation under reduced tillage was less and non-significant. Here again, there appeared to be greater plant competition where the seedbed had received full tillage. A low non-significant correlation was observed between head length and head exsertion in both seedbeds (Table 20). A significant negative correlation was found between head length and plant height under full tillage (Table 20) where plant height increased as head length decreased, the negative correlation between plant height and head length under reduced tillage was nearly of the same magnitude but not quite significant. There was no linear relationship between head exsertion and emergence counts in either seedbed (Table 20).

The correlation between head exsertion and head counts was positive under both seedbeds, but the magnitude was great enough to be considered significant only under reduced tillage (Table 20).

Economical Aspects

The Arizona field crop budgets for Pima County (Hathorn and Armstrong, 1980, 1981, 1982, and 1983) were used as a basis to examine the economical implications of this study. Table 21 gives the detailed costs of growing one hectare of grain sorghum under full tillage and reduced tillage treatments at Marana, Arizona in 1980, 1981, 1982, and 1983. Table 55 (Appendix B) presents the machinery fixed costs in Pima County for different operations in different years. From 1980 to 1981, the production costs per hectare increased by 5.22% for the full tillage method and by 4.74% for the reduced tillage method.

Table 21. Costs of growing one hectare of grain sorghum under full tillage and reduced tillage treatments at Marana, Arizona, in 1980, 1981, 1982, and 1983. (Adapted from Hathorn and Armstrong.)

Economical Item	Costs ($/ha) Years 1980	1981	1982	1983
Chop stubble	10.57	12.05	13.43	13.73
Disc with furrows	15.70	17.46	19.36	18.94
Disc across furrows	15.70	17.46	19.36	18.94
Plow across furrows (full tillage only)	22.32	25.38	28.52	27.53
Packer over plowed portion (full tillage only)	13.58	14.57	15.26	14.81
Furrow out	12.94	14.72	16.59	16.20
Preirrigate (number 1)	35.26	35.56	35.53	37.18
Mulch beds	17.21	19.33	21.53	20.99
Planting	27.56	29.63	35.53	39.75
Irrigation (number 2)	26.44	26.67	26.67	27.90
Cultivate	9.53	10.07	11.06	10.96
Irrigation (number 3) + fertilizer	60.12	46.25	49.33	50.22
Cultivate	6.64	7.53	8.34	8.67
Irrigation (number 4)	26.44	26.67	26.67	27.90
Irrigation (number 5)	26.44	26.67	26.67	27.90
Harvest	56.79	62.96	56.79	68.89
Hauling	25.88	25.88	33.33	35.85
Pick up use	25.60	25.58	28.62	27.28
Credit interest for operating capital	20.72	20.86	22.52	14.47
Machinery fixed costs	56.50	61.61	71.54	75.15
General farm maintenance costs	17.28	17.28	17.28	17.28
Taxes	21.88	21.88	17.65	18.17
Interest on farm value	66.67	80.00	93.33	86.67
Management Services (grower profit)	30.57	36.12	33.33	41.04
Total full tillage	648.34(5.22)*	682.19(6.75)	728.24(2.50)	746.42
Total reduced tillage	599.92(4.74)	628.37(6.43)	668.78(2.97)	688.63
Mean	624.13(4.99)	655.28(6.60)	698.51(2.72)	717.52

*Numbers between parentheses are increase percentages of production costs from one year to the next. The increase in production costs from 1980 to 1983 for full tillage, reduced tillage, and the mean are 15.13, 14.79, and 14.96%, respectively.

From 1981 to 1982, these costs increased by 6.75% for the full tillage and by 6.43% for the reduced tillage methods. The increases in production costs from 1982 to 1983 for the full tillage and reduced tillage seedbeds were 2.50 and 2.97%, respectively.

The actual receipts obtained from the sale of this study's sorghum grain yields in 1982 and the theoretical receipts that would have been obtained in 1980, 1981, and 1983 can be found in the Appendix C (Tables 56, 57, 58, and 59). In terms of percentages (of full tillage) these receipts per hectare followed strictly the variations obtained in grain yields per hectare (Table 16). This was due to the fact that the same yields (in kg/ha) obtained during this study at Marana were multiplied by the price of 1 kg of sorghum grain for each of the 4 years. When the means of the eight varieties were considered, it was determined that in 1982 (the year of this experiment) 59.46 U.S. dollars more were spent in growing one hectare of grain sorghum in a full tillage seedbed versus 38.24 U.S. dollars more obtained in receipts, giving a deficit of 21.22 U.S. dollars per hectare. The deficit per hectare when using the full tillage seedbed preparation method rather than the reduced tillage method would have been 13.37 dollars for the year 1980, 12.40 dollars for the year 1981, and 23.70 dollars for 1983. So, from an economical viewpoint, the reduced tillage method was better than the standard full tillage method. However, things appeared different when the profits per hectare were examined for individual varieties, within each seedbed and among years (Tables 22, 23, 24, and

Table 22. Profits obtained with the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.

Variety	Profits ($/ha)				
	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference	
				B-A	% of Full Tillage
Dorado E	116.82	170.28	143.55	+53.46	+45.76
Corral	68.81	157.89	113.35	+89.08	+129.46
H 8012	217.30	132.33	174.82	-84.97	-39.10
H 796	208.78	285.28	247.03	+76.50	+36.64
Mustang	198.71	121.10	159.90	-77.61	-39.06
Topaz	226.98	229.52	228.25	+ 2.54	+ 1.12
Double TX	118.95	132.33	125.64	+13.38	+11.25
Colt	214.20	311.61	262.90	+97.41	+45.48
All 8 varieties	171.32	192.54	181.93	+21.22	+12.39

Table 23. Theoretical profits that would have been obtained for 1980 using the actual grain yields of 1982.

	Profits ($ per Hectare)				
Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference B-A	Difference % of Full Tillage
Dorado E	126.30	169.22	147.76	+42.92	+33.98
Corral	82.29	157.86	120.08	+75.57	+91.83
H 8012	218.40	134.43	176.42	-83.97	-38.45
H 796	210.60	274.63	242.62	+64.03	+30.40
Mustang	201.37	124.14	162.76	-77.23	-38.35
Topaz	227.28	223.52	225.40	- 3.76	- 1.65
Double TX	128.25	134.43	131.34	+ 6.18	+ 4.82
Colt	215.56	298.77	257.16	+83.21	+38.60
All 8 varieties	176.26	189.62	182.94	+13.36	+ 7.58

Table 24. Theoretical profits that would have been obtained for 1981 using the actual grain yields of 1982.

Variety	Profits ($/ha)				
	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference	
				B-A	% of Full Tillage
Dorado E	233.29	280.61	256.95	+47.32	+20.28
Corral	181.28	267.19	224.24	+85.91	+47.39
H 8012	342.14	239.50	290.82	-102.64	-30.00
H 796	332.92	405.19	369.06	+72.27	+21.71
Mustang	322.01	227.34	274.68	-94.67	-29.40
Topaz	352.63	344.79	348.71	- 7.84	- 2.22
Double TX	235.60	239.50	237.55	+ 3.90	+ 1.66
Colt	338.79	433.71	386.25	+94.92	+28.02
All 8 varieties	292.33	304.73	298.53	+12.40	+ 4.24

25). Individual varieties behaved differently in one or the other of the tillage environments. It was found that in 1982 the varieties Dorado E, Corral, H 796, Double TX, and Colt gave considerably more profits under the reduced tillage, whereas the varieties H 8012 and Mustang would have given considerably more profits to the farmer under the full tillage seedbed preparation method, with differences of about 39% (Table 22). The variety Topaz behaved almost the same in both seedbeds with a difference of 1% in favor of the reduced tillage seedbed. In 1980, the trend would have been the same as in 1982, but the profits would have been a little bit less than in 1982 for most varieties (Table 23). Also, the variety Topaz in 1980 would have behaved better in the full tillage seedbed with a difference of 1.6%. By examining the profits in 1981, it appeared that the same varieties that were more adapted in one or the other of the seedbeds were once again more adapted in those respective seedbeds (Table 24). The only differences of 1981 with the years 1980 and 1982 were that the profits were considerably less in 1981 for most varieties. Paradoxically, the variety Topaz which gave 1.65 and 2.2% less profit in 1980 and 1981, respectively, under reduced tillage gave 1.1 and 6.7% more profit in 1982 and 1983, respectively, under reduced tillage. When the year 1983 was considered, it was also found that only the varieties H8012 and Mustang gave more profits under the full tillage treatment with differences of 73 and 80%, respectively (Table 25). All the other varieties gave more profits under the reduced tillage treatments with differences of 740% for Dorado E, 236% for Corral, 186% for Double TX, 97% for Colt, 82% for H796, and 6.7% for Topaz.

Table 25. Theoretical profits that would have been obtained with the yields of 1982 during the year 1983.

Variety	Profits ($/ha) Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference B-A	Difference % of Full Tillage
Dorado E	7.09	59.53	33.31	+52.44	+739.63
Corral	-35.72	48.48	6.38	+84.2	+235.72
H 8012	96.68	25.70	61.19	-70.98	-73.42
H 796	89.09	162.07	125.58	+72.98	+81.92
Mustang	80.11	15.68	47.90	-64.43	-80.43
Topaz	105.32	112.35	108.84	+ 7.03	+ 6.67
Double TX	8.99	25.70	17.34	+16.71	+185.87
Colt	93.92	185.55	139.74	+91.63	+97.56
All 8 varieties	55.68	79.38	67.53	+23.70	+42.56

Economic calculations for these 4 years indicated that the farmer could profit by selecting proper grain sorghum varieties to be grown under particular seedbed preparation regimes. According to this study, it might be recommended to the farmer in Pima County (Arizona) to use the varieties H8012 and Mustang in the full tillage seedbed and the varieties Dorado E, Corral, H796, Double TX, and Colt in the reduced tillage seedbed. The variety Topaz could be used under either seedbed preparation method. Examining only the grain yield (Table 16) or the receipts (Tables 55, 56, 57, and 58) would have been somewhat misleading. According to those tables, the varieties Dorado E, H8012, Mustang, Topaz, and Double TX yielded more and gave more receipts under full tillage while the varieties Corral, H796, and Colt behaved better under reduced tillage. Additionally, it was found by comparing the change in production costs per hectare from year to year (Table 21) with the change in profits per hectare from year to year for each variety (Tables 22, 23, 24, and 25), that the high differences in profits noticed from one year to the other were probably mainly due to the differences in production costs and in the price received for the grain.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Eight commercial grain sorghum varieties were used as plant test material to study the agronomic, physiological, and economical differences between two seedbed preparation methods: the standard full tillage method and a reduced tillage method characterized by the omission of plowing and packing the plowed soil. Generally from an agronomic and physiological viewpoint, sorghum test varieties grown in the reduced tillage seedbed had 2.46% greater seedling emergence, bloomed 0.28% earlier, produced 3.67% more heads, 2% shorter head lengths, 5.88% longer head exsertions, were 1% shorter in total plant height, gave 2.28% heavier seeds, 9.4% fewer seeds/head, 7.2% less grain yield/head, and produced 4.25% less grain yield/unit area than those in the full tillage seedbed (Table 19). Statistically, none of these differences between the two seedbeds reached the 0.05 level of significance despite the fact that less plant competition was noticed in the reduced tillage seedbed. However, when the economical implications of the two methods were investigated, it was found that the reduced tillage method was a little better than the full tillage method giving 8.16% less costs of growing 1 ha, 4.25% less receipts (corresponding to 4.25% less grain yield/unit area), but 12.4% more profits to the farmer (Table 19).

It was also determined that the agronomic and physiological responses of grain sorghum to the tillage treatments varied greatly according to the sorghum cultivar being grown, for differences among varieties within and across seedbeds were significant at the 0.01 level (Table 18). Similarly, the economical responses varied according to the variety. For example, it was found that in 1982, six varieties (Dorado E, Corral, H796, Topaz, Double TX, and Colt) gave significantly more profits under reduced tillage than under the full tillage treatment, the other two varieties gave more profits under the full tillage treatment (Table 22).

These results suggest that the farmer should be careful in selecting a grain sorghum genotype to be grown under his particular seedbed preparation method. Table 26 gives the number of sorghum varieties out of eight that gave the specific difference between the two seedbeds.

Table 26. Number of varieties out of eight that produced differences between the two seedbeds.

Agronomic, Physiological or Economical Difference	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)
Higher percent emergence*	4	4
Bloomed earlier	2	2
More heads	2	6
Greater % of head production	3	5
Bigger heads	7	1
Longer head exsertions	3	5
Shorter plants	1	6
Higher grain yields/head	6	2
Heavier seeds	2	6
More seeds/head	7	1
Higher seed density	3	4
Higher grain yields/unit area	5	3
More receipts in 1982	5	3
More profits in 1982	2	6

*on the same line, the sum of both numbers should be 8; if it is not 8, the difference gives the number of varieties that behaved the same in both seedbeds.

APPENDIX A

AGRONOMIC AND PHYSIOLOGICAL DATA AND ANALYSIS OF VARIANCE TABLES

Table 27. Sorghum plant emergence counts at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	379	419	798	399.00
	2	336	372	708	354.00
	3	346	376	722	361.00
	4	332	356	688	344.00
	5	332	344	676	338.00
	6	357	358	715	357.50
	7	384	380	764	382.00
	8	374	356	730	365.00
Main plot total (Yi1.)		2840	2961	5801	362.56
Full tillage	1	303	362	665	332.50
	2	324	374	698	349.00
	3	290	331	621	310.50
	4	356	363	719	359.50
	5	334	355	689	344.50
	6	372	399	771	385.50
	7	344	411	755	377.50
	8	345	404	749	374.50
Main plot total (Yi2.)		2668	2999	5667	354.19
Block total (Yi..)		5508	5960	11468	358.38

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	1463	1406	1343	1407	1365	1486	1519	1479
Means ($\bar{Y}$..k)	365.75	351.50	335.75	351.75	341.25	371.50	379.75	369.75

Table 28. Percent emergence ($\frac{\text{Emergence count per plot}}{\text{seed planted per plot}}$ x 100) Marana, Arizona, 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	73.45	81.20	154.65	77.32
	2	65.12	72.09	137.21	68.60
	3	66.54	72.31	138.85	69.42
	4	59.07	63.34	122.41	61.20
	5	59.07	61.21	120.28	60.14
	6	70.00	70.20	140.20	70.10
	7	70.07	69.34	139.41	69.70
	8	72.48	68.99	141.47	70.74
Main plot total (Yi1.)		535.80	558.68	1094.48	68.40
Full tillage	1	58.72	70.16	128.88	64.44
	2	62.79	72.48	135.27	67.64
	3	55.77	63.65	119.42	59.71
	4	63.34	64.59	127.93	63.96
	5	59.43	63.17	122.60	61.30
	6	72.94	78.23	151.17	75.58
	7	62.77	75.00	137.77	68.89
	8	66.86	78.29	145.15	72.58
Main plot total (Yi2.)		502.62	565.57	1068.19	66.76
Block total (Yi..)		1038.42	1124.25	2162.67	67.58

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	283.53	272.48	258.27	250.34	242.88	291.37	277.18	286.62
Means ($\bar{Y}$..k)	70.88	68.12	64.57	62.58	60.72	72.84	69.30	71.66

Table 29. Days to 50 percent bloom for grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	52	52	104	52
	2	51	52	103	52
	3	50	52	102	51
	4	54	57	111	56
	5	53	53	106	53
	6	52	53	105	52
	7	50	52	102	51
	8	59	59	118	59
Main plot total (Yi1.)		421	430	851	53
Full tillage	1	52	53	105	52
	2	52	52	104	52
	3	50	53	103	52
	4	56	59	115	58
	5	53	53	106	53
	6	51	51	102	51
	7	51	51	102	51
	8	59	58	117	58
Main plot total (Yi2.)		424	430	854	53
Block totals (Yi..)		845	860	1705	53

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	209	207	205	226	212	207	204	235
Means ($\bar{Y}$..k)	52	52	51	56	53	52	51	59

Table 30. Head counts per plot of grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	344	346	690	345.00
	2	322	325	647	323.50
	3	306	322	628	314.00
	4	266	289	555	277.50
	5	320	273	593	296.50
	6	320	298	618	309.00
	7	338	333	671	335.50
	8	293	305	598	299.00
Main plot total (Yi1.)		2509	2491	5000	312.50
Full tillage	1	302	320	622	311.00
	2	306	312	618	309.00
	3	274	276	550	275.00
	4	274	268	542	271.00
	5	322	292	614	307.00
	6	328	322	650	325.00
	7	302	338	640	320.00
	8	281	306	587	293.50
Main plot total (Yi2.)		2389	2434	4823	301.44
Block total (Yi..)		4898	4925	9823	306.97

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	1312	1265	1178	1097	1207	1268	1311	1185
Means ($\bar{Y}$..k)	328	316.25	294.50	274.25	301.75	317	327.75	296.25

Table 31. Percentage of head production ($\frac{\text{Head count}}{\text{Emergence count}}$ x 100) at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	90.76	82.58	173.34	86.67
	2	95.83	87.36	183.19	91.60
	3	88.44	85.64	174.08	87.04
	4	80.12	81.18	161.30	80.65
	5	96.38	79.36	175.74	87.87
	6	89.64	83.24	172.88	86.44
	7	88.02	87.63	175.65	87.82
	8	78.34	85.67	164.01	82.00
Main plot total (Yi1.)		707.53	672.66	1380.19	86.26
Full tillage	1	99.67	88.40	188.07	94.04
	2	94.44	83.42	177.86	88.93
	3	94.48	83.38	177.86	88.93
	4	76.97	73.83	150.80	75.40
	5	96.41	82.25	178.66	89.33
	6	88.17	80.70	168.87	84.44
	7	87.79	82.24	170.03	85.02
	8	81.45	75.74	157.19	78.60
Main plot total (Yi2.)		719.38	649.96	1369.34	85.59
Block total (Yi..)		1426.91	1322.62	2749.53	85.92

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	361.41	361.05	351.94	312.10	354.40	341.75	345.68	321.20
Means ($\bar{Y}$..k)	90.35	90.26	87.98	78.02	88.60	85.44	86.42	80.30

Table 32. Sorghum head length (cm) at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	27.75	29.25	57.00	28.50
	2	27.50	30.00	57.50	28.75
	3	28.00	32.00	60.00	30.00
	4	27.00	27.50	54.50	27.25
	5	27.00	29.75	56.75	28.38
	6	27.00	28.25	55.25	27.62
	7	25.50	25.75	51.25	25.62
	8	27.00	27.25	54.25	27.12
Main plot total (Yi1.)		216.75	229.75	446.50	27.91
Full tillage	1	28.50	28.75	57.25	28.62
	2	29.75	30.25	60.00	30.00
	3	28.75	29.00	57.75	28.88
	4	28.25	28.75	57.00	28.50
	5	28.50	29.50	58.00	29.00
	6	28.00	28.50	56.50	28.25
	7	26.50	26.75	53.25	26.62
	8	28.75	27.25	56.00	28.00
Main plot total (Yi2.)		227.00	228.75	455.75	28.48
Block total (Yi..)		443.75	458.50	902.25	28.20

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	114.25	117.50	117.75	111.50	114.75	111.75	104.50	110.25
Means ($\bar{Y}$..k)	28.56	29.38	29.44	27.88	28.69	27.94	26.12	27.56

Table 33. Sorghum head exsertion (cm) at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	19.75	16.75	36.50	18.25
	2	23.50	23.50	47.00	23.50
	3	19.00	14.25	33.25	16.62
	4	17.50	16.25	33.75	16.88
	5	18.75	17.50	36.25	18.12
	6	12.75	12.00	24.75	12.38
	7	22.25	17.50	39.75	19.88
	8	8.50	11.25	19.75	9.88
Main plot total (Yi1.)		142.00	129.00	271.00	16.94
Full tillage	1	17.25	16.75	34.00	17.00
	2	19.25	20.00	39.25	19.62
	3	17.25	16.25	33.50	16.75
	4	15.50	16.50	32.00	16.00
	5	18.00	16.50	34.50	17.25
	6	14.50	13.25	27.75	13.88
	7	16.50	17.50	34.00	17.00
	8	10.25	10.75	21.00	10.50
Main plot (Yi2.)		128.50	127.50	256.00	16.00
Block total (Yi..)		270.50	256.50	527.00	16.47

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	70.50	86.25	66.75	65.75	70.75	52.50	73.75	40.75
Means ($\bar{Y}$..k)	17.625	21.5625	16.6875	16.4375	17.6875	13.125	18.4375	10.1875

Table 34. Plant height to upper leaf collar (cm) of grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments: Seedbeds (j)	Treatments: Varieties (k)	Blocks (i): I	Blocks (i): II	Totals	Means
Reduced tillage	1	69.00	73.75	142.75	71.38
	2	74.50	79.00	153.50	76.75
	3	77.00	77.25	154.25	77.12
	4	81.50	85.00	166.50	83.25
	5	64.50	69.75	134.25	67.12
	6	80.75	83.25	164.00	82.00
	7	81.50	97.25	178.75	89.38
	8	87.75	95.50	183.25	91.62
Main plot total (Yi1.)		616.50	660.75	1277.25	79.83
Full tillage	1	71.00	74.25	145.25	72.62
	2	84.75	76.75	161.50	80.75
	3	79.50	76.75	156.25	78.12
	4	82.00	85.25	167.25	83.62
	5	67.75	75.00	142.75	71.38
	6	85.00	87.00	172.00	86.00
	7	94.50	90.00	184.50	92.25
	8	84.00	90.25	174.25	87.12
Main plot total (Yi2.)		648.50	655.25	1303.75	81.48
Block total (Yi..)		1265	1316	2581	80.66

	Varieties: 1	2	3	4	5	6	7	8
Totals (Y..k)	288.00	315.00	310.50	333.75	277.00	336.00	363.25	357.50
Means ($\bar{Y}$..k)	72.00	78.75	77.62	83.44	69.25	84.00	90.81	89.38

Table 35. Plant height to top of head (cm) of grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments: Seedbeds (j)	Treatments: Varieties (k)	Blocks (i): I	Blocks (i): II	Totals	Means
Reduced tillage	1	116.50	119.75	236.25	118.12
	2	125.50	132.50	258.00	129.00
	3	124.00	123.50	247.50	123.75
	4	126.00	128.75	254.75	127.38
	5	110.25	117.00	227.25	113.62
	6	120.50	123.50	244.00	122.00
	7	129.25	140.50	269.75	134.88
	8	123.25	134.00	257.25	128.62
Main plot total (Yi1.)		975.25	1019.50	1994.75	124.67
Full tillage	1	116.75	119.75	236.50	118.25
	2	133.75	127.00	260.75	130.38
	3	125.50	122.00	247.50	123.75
	4	125.75	130.50	256.25	128.12
	5	114.25	121.00	235.25	117.62
	6	127.50	128.75	256.25	128.12
	7	137.50	134.25	271.75	135.88
	8	123.00	128.25	251.25	125.62
Main plot total (Yi2.)		1004.00	1011.50	2015.50	125.97
Block total (Yi..)		1979.25	2031.00	4010.25	125.32

	Varieties: 1	2	3	4	5	6	7	8
Totals (Y..k)	472.75	518.75	495.00	511.00	462.50	500.25	541.50	508.50
Means ($\bar{Y}$..k)	118.19	129.69	123.75	127.75	115.62	125.06	135.38	127.12

Table 36. Mean grain yield (g) per head of grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	25.17	31.79	56.96	28.48
	2	27.00	32.84	59.84	29.92
	3	28.73	30.99	59.72	29.86
	4	39.63	40.85	80.48	40.24
	5	29.40	33.35	62.75	31.38
	6	31.76	36.53	68.29	34.14
	7	26.03	29.94	55.97	27.98
	8	37.80	38.99	76.79	38.40
Main plot total (Yi1.)		245.52	275.28	520.80	32.55
Full tillage	1	27.94	35.51	63.45	31.72
	2	27.57	31.56	59.13	29.56
	3	33.69	46.82	80.51	40.26
	4	38.89	42.14	81.03	40.52
	5	30.82	40.37	71.19	35.60
	6	31.57	37.34	68.91	34.46
	7	30.23	31.72	61.95	30.98
	8	36.48	38.64	75.12	37.56
Main plot total (Yi2.)		257.19	304.10	561.29	35.08
Block total (Yi..)		502.71	579.38	1082.09	33.82

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	120.41	118.97	140.23	161.51	133.94	137.20	117.92	151.91
Means ($\bar{Y}$..k)	30.10	29.74	35.06	40.38	33.48	34.30	29.48	37.98

Table 37. Eight of 300 seeds (grams) of grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments: Seedbeds (j)	Treatments: Varieties (k)	Blocks (i): I	Blocks (i): II	Totals	Means
Reduced tillage	1	6.97	7.84	14.81	7.40
	2	7.39	7.49	14.88	7.44
	3	6.39	6.45	12.84	6.42
	4	8.98	9.97	18.95	9.48
	5	7.46	7.84	15.30	7.65
	6	6.73	7.85	14.58	7.29
	7	7.26	7.25	14.51	7.26
	8	7.62	8.23	15.85	7.92
Main plot total (Yi1.)		58.80	62.92	121.72	7.61
Full tillage	1	7.08	7.88	14.96	7.48
	2	7.08	7.70	14.78	7.39
	3	6.53	7.52	14.05	7.02
	4	8.67	9.46	18.13	9.06
	5	7.21	7.65	14.86	7.43
	6	6.64	7.32	13.96	6.98
	7	6.84	7.03	13.87	6.94
	8	6.87	7.50	14.37	7.18
Main plot total (Yi2.)		56.92	62.06	118.98	7.44
Block total (Yi..)		115.72	124.98	240.70	7.52

	Varieties: 1	2	3	4	5	6	7	8
Totals (Y..k)	29.77	29.66	26.89	37.08	30.16	28.54	28.38	30.22
Means ($\bar{Y}$..k)	7.44	7.42	6.72	9.27	7.54	7.14	7.10	7.56

Table 38. Number of seeds per head in grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	1083	1216	2299	1150
	2	1096	1315	2411	1206
	3	1349	1441	2790	1395
	4	1324	1229	2553	1276
	5	1182	1276	2458	1229
	6	1416	1396	2812	1406
	7	1076	1239	2315	1158
	8	1488	1421	2909	1454
Main plot total (Yi1.)		10014	10533	20547	1284
Full tillage	1	1184	1352	2536	1268
	2	1168	1230	2398	1199
	3	1548	1868	3416	1708
	4	1346	1336	2682	1341
	5	1282	1583	2865	1432
	6	1426	1530	2956	1478
	7	1326	1354	2680	1340
	8	1593	1546	3139	1570
Main plot (Yi2.)		10873	11799	22672	1417
Block total (Yi..)		20887	22332	43219	1350

	Varieties							
	1	2	3	4	5	6	7	8
Total (Y..k)	4835	4809	6206	5235	5323	5768	4995	6048
Means ($\bar{Y}$..k)	1209	1202	1552	1309	1331	1442	1249	1512

Table 39. Seed density or bushel test weight (lbs/bushel) of grain sorghum at Marana, Arizona in 1982 (Means of 2 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	58.84	58.84	117.68	58.84
	2	59.20	59.06	118.26	59.13
	3	60.98	60.75	121.73	60.86
	4	57.90	58.08	115.98	57.99
	5	58.34	57.46	115.80	57.90
	6	60.12	59.68	119.80	59.90
	7	58.77	57.57	116.34	58.17
	8	57.10	57.58	114.68	57.34
Main plot total (Yi1.)		471.25	469.02	940.27	58.77
Full tillage	1	58.67	58.22	116.89	58.44
	2	59.22	58.21	117.43	58.72
	3	60.72	59.30	120.02	60.01
	4	57.88	52.46	110.34	55.17
	5	58.70	58.50	117.20	58.60
	6	59.95	59.88	119.83	59.92
	7	58.16	58.18	116.34	58.17
	8	58.48	56.22	114.70	57.35
Main plot total (Yi2.)		471.78	460.97	932.75	58.30
Block total (Yi..)		943.03	929.99	1873.02	58.53

	Varieties							
	1	2	3	4	5	6	7	8
Total (Y..k)	234.57	235.69	241.75	226.32	233.00	239.63	232.68	229.38
Means ($\bar{Y}$..k)	58.64	58.92	60.44	56.58	58.25	59.91	58.17	57.34

Table 40. Grain yield per plot (lbs) of grain sorghum at Marana, Arizona in 1982 (Means of 4 replications).

Treatments		Blocks (i)			
Seedbeds (j)	Varieties (k)	I	II	Totals	Means
Reduced tillage	1	19.09	24.25	43.34	21.67
	2	19.17	23.53	42.70	21.35
	3	19.38	22.00	41.38	20.69
	4	23.24	26.03	49.27	24.64
	5	20.74	20.07	40.81	20.40
	6	22.41	24.00	46.41	23.20
	7	19.40	21.98	41.38	20.69
	8	24.42	26.22	50.64	25.32
Main plot total (Yi1.)		167.85	188.08	355.93	22.25
Full tillage	1	18.60	25.05	43.65	21.825
	2	19.46	21.71	41.17	20.585
	3	20.35	28.49	48.84	24.42
	4	23.49	24.90	48.39	24.20
	5	21.88	25.99	47.87	23.94
	6	22.83	26.51	49.34	24.67
	7	20.13	23.64	43.77	21.88
	8	22.60	26.07	48.67	24.34
Main plot total (Yi2.)		169.34	202.36	371.70	23.23
Block total (Yi..)		337.19	390.44	727.63	22.74

	Varieties							
	1	2	3	4	5	6	7	8
Totals (Y..k)	86.99	83.87	90.22	97.66	88.68	95.75	85.15	99.31
Means ($\bar{Y}$..k)	21.75	20.97	22.56	24.42	22.17	23.94	21.29	24.83

Table 41. Analysis of variance (emergence plant counts).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	25900.219				
Main plots (MP)	3	8305.2656				
Blocks (B)	1	6398.6328	6398.6328			
Seedbeds (SB)	1	561.125	561.125	0.417(NS)	161	4,052
Main plot error (MPE)	1	1345.5078	1345.5078			
Varieties (V)	7	6848.6563	978.3795	4.414**	2.76	4.28
Seedbeds x Varieties	7	7643.2500	1091.8929	4.926**	2.76	4.28
Sub plot error (SPE)	14	3103.0470	221.6462			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 42. Analysis of variance (percent emergence).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	1256.61				
Main plots (MP)	3	301.99				
Blocks (B)	1	230.21	230.21			
Seedbeds (SB)	1	21.60	21.60	0.43(NS)	161	4,052
Main plot error (MPE)	1	50.18	50.18			
Varieties (V)	7	558.10	79.7286	9.8196**	2.76	4.28
Seedbeds x Varieties	7	282.85	40.407	4.977**	2.76	4.28
Sub plot error (SPE)	14	113.67	8.1193			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 43. Analysis of variance (days to 50% bloom).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	262.74219				
Main plots (MP)	3	11.94531				
Blocks (B)	1	11.28125	11.28125			
Seedbeds (SB)	1	0.38281	0.38281	1.36(NS)	161	4,052
Main plot error (MPE)	1	0.28125	0.28125			
Varieties (V)	7	234.14844	33.44978	42.816**	2.76	4.28
Seedbeds x Varieties	7	5.71094	0.81585	1.044(NS)	2.76	4.28
Sub plot error (SPE)	14	10.9375	0.78125			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 44. Analysis of variance (head counts).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	16760.2420				
Main plots (MP)	3	1181.1016				
Blocks (B)	1	21.9453	21.9453			
Seedbeds (SB)	1	1035.1250	1035.125	8.346(NS)	161	4,052
Main plot error (MPE)	1	124.03125	124.03125			
Varieties (V)	7	9718.2110	1388.3159	5.999**	2.76	4.28
Seedbeds x Varieties	7	2621.0313	374.43304	1.618(NS)	2.76	4.28
Sub plot error (SPE)	14	3239.8985	231.42132			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 45. Analysis of variance (percentage of head production).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	1312.24				
Main plots (MP)	3	380.8703				
Blocks (B)	1	339.888	339.888			
Seedbeds (SB)	1	3.68	3.68	0.0986(NS)	161	4,052
Main plot error (MPE)	1	37.3023	37.3023			
Varieties (V)	7	577.40	82.4857	4.822**	2.76	4.28
Seedbeds x Varieties	7	114.470	16.35286	0.9559(NS)	2.76	4.28
Subplot Error (SPE)	14	239.4997	17.107121			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 46. Analysis of variance (head length).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	58.7168				
Main plots (MP)	3	13.42774				
Blocks (B)	1	6.79883	6.79883			
Seedbeds (SB)	1	2.67383	2.67383	0.676(NS)	161	4,052
Main plot error (MPE)	1	3.95508	3.95508			
Varieties (V)	7	32.66992	4.66713	7.835**	2.76	4.28
Seedbeds x Varieties	7	4.27930	0.61133	1.026(NS)	2.76	4.28
Sub plot error (SPE)	14	8.33984	0.5957			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 47. Analysis of variance (head exsertion).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	398.9687				
Main plots (MP)	3	17.6562				
Blocks (B)	1	6.12495	6.12495			
Seedbeds (SB)	1	7.0312	7.0312	1.5624889 (NS)	161	4,052
Main plot error (MPE)	1	4.50	4.50			
Varieties (V)	7	333.31245	47.616064	25.64139**	2.76	4.28
Seedbeds x Varieties	7	22.000	3.1428	1.6924(NS)	2.76	4.28
Sub plot error (SPE)	14	26.000	1.857			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 48. Analysis of variance (height to leaf upper collar).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	2047.8438				
Main plots (MP)	3	147.17187				
Blocks (B)	1	81.28125	81.28125			
Seedbeds (SB)	1	21.94531	21.94531	0.499(NS)	161	4,052
Main plot error (MPE)	1	43.94531	43.94531			
Varieties (V)	7	1663.7500	237.67857	18.737**	2.76	4.28
Seedbeds x Varieties	7	59.33594	8.47656	0.668(NS)	2.76	4.28
Sub plot error (SPE)	14	177.58594	12.68471			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 49. Analysis of variance (height to top of head).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	1442.2793				
Main plots (MP)	3	139.34961				
Blocks (B)	1	83.68945	83.68945			
Seedbeds (SB)	1	13.45508	13.45508	0.319(NS)	161	4,052
Main plot error (MPE)	1	42.20508	42.20508			
Varieties (V)	7	1106.9512	158.13588	15.433**	2.76	4.28
Seedbeds x Varieties	7	52.52930	7.50418	0.732(NS)	2.76	4.28
Sub plot error (SPE)	14	143.44922	10.24637			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 50. Analysis of variance (mean grain yield per head).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	855.668				
Main plots (MP)	3	244.12				
Blocks (B)	1	183.696	183.696			
Seedbeds (SB)	1	51.232	51.232	7.123(NS)	161	4,052
Main plot error (MPE)	1	7.192	7.192			
Varieties (V)	7	445.763	63.6804	12.61**	2.76	4.28
Seedbeds x Varieties	7	95.098	13.5854	2.69(NS)	2.76	4.28
Sub plot error (SPE)	14	70.687	5.0491			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 51. Analysis of variance (weight of 300 seeds).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	21.1403				
Main plots (MP)	3	2.9468				
Blocks (B)	1	2.6796	2.6796			
Seedbeds (SB)	1	0.2346	0.2346	7.196(NS)	161	4,052
Main plot error (MPE)	1	0.0326	0.0326			
Varieties (V)	7	16.184	2.312	35.679**	2.76	4.28
Seedbeds x Varieties	7	1.1021	0.1574	2.429(NS)	2.76	4.28
Sub plot error (SPE)	14	0.9074	0.0648			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 52. Analysis of variance (number of seeds per head).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	908198				
Main plots (MP)	3	211541				
Blocks (B)	1	65251	65251			
Seedbeds (SB)	1	141114	141114	27.26(NS)	161	4,052
Main plot error (MPE)	1	5176	5176			
Varieties (V)	7	517651	73950.143	9.34**	2.76	4.28
Seedbeds x Varieties	7	68228	9746.8571	1.23(NS)	2.76	4.28
Sub plot error (SPE)	14	110778	7912.7143			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 53. Analysis of variance (seed density).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	37.08746				
Main plots (MP)	3	4.69136				
Blocks (B)	1	2.66914	2.66914			
Seedbeds (SB)	1	0.89066	0.89066	0.787(NS)	161	4,052
Main plot error (MPE)	1	1.13156	1.13156			
Varieties (V)	7	22.23328	3.17618	7.068**	2.76	4.28
Seedbeds x Varieties	7	3.87195	0.55314	1.231(NS)	2.76	4.28
Sub plot error (SPE)	14	6.29087	0.44935			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

Table 54. Analysis of variance (grain yield per plot).

Source of Variation	df	SS	MS	Observed F	Required F 5%	Required F 1%
Sub plots (SP)	31	214.01582				
Main plots (MP)	3	101.52343				
Blocks (B)	1	88.61133	88.61133			
Seedbeds (SB)	1	7.81607	7.81607	1.534(NS)	161	4,052
Main plot error (MPE)	1	5.09603	5.09603			
Varieties (V)	7	60.79234	8.68462	4.38**	2.76	4.28
Seedbeds x Varieties	7	23.95767	3.42252	1.727(NS)	2.76	4.28
Sub plot error (SPE)	14	27.74238	1.9816			

NS - Not significant at the 0.05 level
** - Significant at the 0.01 level

APPENDIX B

MACHINERY FIXED COSTS IN PIMA COUNTY

(ARIZONA)

Table 55. Machinery fixed costs in Pima County (Arizona) during the years 1980, 1981, 1982, and 1983. (Adapted from Hathorn and Armstrong).

	Machinery Fixed Costs ($/ha) Years			
Operation	1980	1981	1982	1983
Chop stubble	3.95	4.44	4.94	5.04
Disc	5.90	6.44	7.41	7.46
Disc	5.90	6.44	7.41	7.46
Plow (full tillage)	7.68	8.69	10.25	10.17
Packer (full tillage)	4.84	5.18	5.43	5.28
Furrow out	3.95	4.47	5.36	5.46
Preirrigate	0.00	0.00	0.00	0.00
Mulch beds	5.51	6.12	7.11	7.23
Planting	4.99	5.14	6.42	9.14
Cultivate	2.89	2.86	3.31	3.46
Cultivate	1.88	2.15	2.57	2.89
Pick up use	9.01	9.68	11.33	11.56
Total	56.50	61.61	71.54	75.15

APPENDIX C

RECEIPTS OBTAINED IN 1982 AND THEORETICAL RECEIPTS THAT WOULD HAVE BEEN OBTAINED IN 1980, 1981, AND 1983

Table 56. Theoretical receipts (U.S. dollars per hectare) that would have been obtained from the yields of the 1982 experiment if they had been sold in 1980.*

Variety	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference	
				B-A	% of Full Tillage
Dorado E	774.64	769.14	771.89	- 5.50	- 0.71
Corral	730.63	757.78	744.20	+27.15	+ 3.72
H 8012	866.74	734.35	800.54	-132.39	-15.27
H 796	858.94	874.55	866.75	+15.61	+ 1.82
Mustang	849.71	724.06	786.88	-125.65	-14.79
Topaz	875.62	823.44	849.53	-52.18	- 5.96
Double TX	776.59	734.35	755.47	-42.24	- 5.44
Colt	863.90	898.69	881.29	+34.79	+ 4.03
All 8 varieties	824.60	789.54	807.07	-35.05	- 4.25

*Price of one kilogram of grain = $0.1212542. (After Hathorn and Armstrong, 1980).

Table 57. Theoretical receipts that would have been obtained from the yields of the 1982 experiment if they had been sold in 1981.*

Variety	Receipts (U.S. dollars per hectare)				
	Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference B-A	Difference % of Full Tillage
Dorado E	915.48	908.98	912.23	- 6.50	- 0.71
Corral	863.47	895.56	879.52	+32.09	+ 3.72
H 8012	1024.33	867.87	946.10	-156.46	-15.27
H 796	1015.11	1033.56	1024.34	+18.45	+ 1.82
Mustang	1004.20	855.71	929.96	-148.49	-14.79
Topaz	1034.82	973.16	1003.99	-61.66	- 5.96
Double TX	917.79	867.87	892.83	-49.92	- 5.44
Colt	1020.98	1062.08	1041.53	+41.10	+ 4.03
All 8 varieties	974.52	933.10	953.81	-41.42	- 4.25

*Price of one kilogram of grain = $0.1433005. (After Hathorn and Armstrong, 1981).

Table 58. Receipts obtained with the eight grain sorghum varieties under the reduced tillage treatment as compared to the standard (full) tillage treatment at Marana, Arizona in 1982.*

Variety	Receipts (U.S. Dollars per Hectare) Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference B-A	Difference % of Full Tillage
Dorado E	845.06	839.06	842.06	- 6.00	- 0.71
Corral	797.05	826.67	811.86	+29.62	+ 3.72
H 8012	945.54	801.11	873.33	-144.43	-15.27
H 796	937.02	954.06	945.54	+17.04	+ 1.82
Mustang	926.95	789.88	858.42	-137.07	-14.79
Topaz	955.22	898.30	926.76	-56.92	- 5.96
Double TX	847.19	801.11	824.15	-46.08	- 5.44
Colt	942.44	980.39	961.41	+37.95	+ 4.03
All 8 varieties	899.56	861.32	880.44	-38.24	- 4.25

*Price of one kilogram of grain = $0.1322774. (After Hathorn and Armstrong, 1982).

Table 59. Theoretical receipts that would have been obtained from the yields of the 1982 experiment if they had been sold in 1983.*

Variety	Receipts (U.S. Dollars per Hectare) Full Tillage Seedbed (A)	Reduced Tillage Seedbed (B)	Mean	Difference B-A	% of Full Tillage
Dorado E	753.51	748.16	750.84	- 5.35	- 0.71
Corral	710.70	737.11	723.90	+26.41	+ 3.72
H 8012	843.10	714.33	778.72	-128.77	-15.27
H 796	835.51	850.70	843.10	+15.19	+ 1.82
Mustang	826.53	704.31	765.42	-122.22	-14.79
Topaz	851.74	800.98	826.36	-50.76	- 5.96
Double TX	755.41	714.33	734.87	-41.08	- 5.44
Colt	840.34	874.18	857.26	+33.84	+ 4.03
All 8 varieties	802.10	768.01	785.06	-34.09	- 4.25

*Price of one kilogram of grain = $0.1179473. (After Hathorn and Armstrong, 1983).

APPENDIX D

SOIL CHARACTERISTICS

Table 60. Soil samples analysis (results).

Chemical Characteristic of the Soil	Block 1		Block 2	
	Reduced Tillage Seedbed	Full Tillage Seedbed	Full Tillage Seedbed	Reduced Tillage Seedbed
(a) Replication Number One				
pH	7.5	7.2	7.3	7.7
+Ece x 10^3	0.97	2.95	7.06	1.06
Soluble salts (ppm)	679	2065	4942	742
Na (meq/L)	3.55	7.53	10.66	4.46
K (meq/L)	1.98	3.03	8.90	1.88
*ESP	2.3	2.28	1.81	3.13
NO_3 (ppm)	38.6	383.8	419.1	58.4
PO_4 (ppm)	113.4	91.8	150.4	76.4

Chemical Characteristic of the Soil	Block 1		Block 2	
	Reduced Tillage Seedbed	Full Tillage Seedbed	Full Tillage Seedbed	Reduced Tillage Seedbed
(b) Replication Number Two				
pH	7.5	7.5	7.6	7.9
+Ece x 10^3	6.0	1.43	1.2	0.69
Soluble salts (ppm)	4200	1001	840	483
Na (meq/L)	375.0	149.05	4.87	3.45
K (meq/L)	463.0	100.87	3.01	0.99
*ESP	4.53	4.43	3.6	3.21
NO_3 (ppm)	115.8	39.2	87.1	55.0
PO_4 (ppm)	130.7	146.5	126.8	29.5

Table 60, Continued.

Chemical Characteristic of the Soil	Block 1		Block 2	
	Reduced Tillage Seedbed	Full Tillage Seedbed	Full Tillage Seedbed	Reduced Tillage Seedbed
(c) Replication Number Three				
pH	7.35	7.5	7.6	7.55
+Ece x 10^3	9.12	3.65	1.87	1.92
Soluble salts (ppm)	6384	2555	1311.10	1344
Na (meq/L)	460.0	244.0	185.13	225.17
K (meq/L)	453.0	211.0	118.69	82.72
*ESP	3.96	3.49	4.58	5.91
NO_3 (ppm)	134.7	54.5	63.4	63.4
PO_4 (ppm)	127.4	120.9	62.0	30.2

Chemical Characteristic of the Soil	Block 1		Block 2	
	Reduced Tillage Seedbed	Full Tillage Seedbed	Full Tillage Seedbed	Reduced Tillage Seedbed
(d) Replication Number Four				
pH	7.5	7.2	7.65	7.05
+Ece x 10^3	1.58	3.45	1.2	13.49
Soluble salts (ppm)	1106	2415	840	9443
Na (meq/L)	5.92	8.89	4.19	15.44
K (meq/L)	3.10	3.80	2.92	5.04
*ESP	3.36	2.62	2.61	1.71
NO_3 (ppm)	84.9	445.7	98.2	1923.7
PO_4 (ppm)	108.8	92.6	122.7	61.0

+Electrical conductivity

*ESP = Estimated exchangeable sodium percentage

APPENDIX E

DATA COLLECTED ON INDIVIDUAL PLOTS

Table 61. Data as they were collected on each individual plot during the reduced tillage experiment at Marana, Arizona in 1982.

Plot	TR	BL	V	RP	EC	HC	BD	LG	PG	HT
1	1.00	1.00	1.00	1.00	409.00	422.00	52.00	0	16.46	119.00
2	1.00	1.00	1.00	2.00	321.00	273.00	51.00	0	18.99	114.00
3	1.00	1.00	1.00	3.00	416.00	352.00	51.00	0	21.25	118.00
4	1.00	1.00	1.00	4.00	370.00	329.00	53.00	0	19.65	115.00
5	1.00	1.00	2.00	1.00	435.00	387.00	49.00	0	17.04	128.00
6	1.00	1.00	2.00	2.00	275.00	281.00	52.00	0	19.92	118.00
7	1.00	1.00	2.00	3.00	216.00	257.00	52.00	0	21.06	127.00
8	1.00	1.00	2.00	4.00	419.00	364.00	50.00	0	18.66	129.00
9	1.00	1.00	3.00	1.00	424.00	363.00	49.00	0	17.88	130.00
10	1.00	1.00	3.00	2.00	336.00	303.00	49.00	0	18.52	123.00
11	1.00	1.00	3.00	3.00	326.00	276.00	50.00	0	21.29	124.00
12	1.00	1.00	3.00	4.00	298.00	283.00	50.00	0	19.81	119.00
13	1.00	1.00	4.00	1.00	414.00	320.00	54.00	0	20.03	124.00
14	1.00	1.00	4.00	2.00	240.00	207.00	54.00	0	24.77	128.00
15	1.00	1.00	4.00	3.00	404.00	308.00	55.00	0	23.96	126.00
16	1.00	1.00	4.00	4.00	272.00	231.00	52.00	0	24.18	126.00
17	1.00	1.00	5.00	1.00	247.00	254.00	54.00	0	19.52	105.00
18	1.00	1.00	5.00	2.00	391.00	366.00	53.00	0	20.20	107.00
19	1.00	1.00	5.00	3.00	300.00	310.00	53.00	0	21.92	110.00
20	1.00	1.00	5.00	4.00	388.00	350.00	51.00	0	21.33	119.00
21	1.00	1.00	6.00	1.00	280.00	267.00	53.00	0	19.47	114.00
22	1.00	1.00	6.00	2.00	360.00	352.00	51.00	0	22.06	124.00
23	1.00	1.00	6.00	3.00	468.00	396.00	50.00	5.00	24.46	123.00
24	1.00	1.00	6.00	4.00	320.00	267.00	53.00	0	23.64	121.00
25	1.00	1.00	7.00	1.00	340.00	297.00	52.00	35.00	20.32	123.00
26	1.00	1.00	7.00	2.00	319.00	292.00	50.00	25.00	20.43	127.00
27	1.00	1.00	7.00	3.00	433.00	365.00	49.00	80.00	20.30	138.00
28	1.00	1.00	7.00	4.00	443.00	399.00	50.00	95.00	16.54	129.00

Table 61, Continued.

Plot	TR	BL	V	RP	EC	HC	BD	LG	PG	HT
29	1.00	1.00	8.00	1.00	288.00	233.00	57.00	0	23.72	125.00
30	1.00	1.00	8.00	2.00	304.00	239.00	61.00	0	24.43	114.00
31	1.00	1.00	8.00	3.00	445.00	337.00	57.00	0	24.17	127.00
32	1.00	1.00	8.00	4.00	459.00	362.00	61.00	0	25.37	127.00
33	1.00	2.00	1.00	1.00	396.00	357.00	54.00	0	25.77	127.00
34	1.00	2.00	1.00	2.00	450.00	380.00	52.00	0	24.65	118.00
35	1.00	2.00	1.00	3.00	437.00	309.00	52.00	0	22.24	118.00
36	1.00	2.00	1.00	4.00	394.00	338.00	51.00	0	24.35	116.00
37	1.00	2.00	2.00	1.00	370.00	328.00	52.00	0	23.43	132.00
38	1.00	2.00	2.00	2.00	388.00	327.00	52.00	20.00	26.20	140.00
39	1.00	2.00	2.00	3.00	365.00	345.00	52.00	15.00	22.14	132.00
40	1.00	2.00	2.00	4.00	364.00	300.00	51.00	0	22.35	126.00
41	1.00	2.00	3.00	1.00	400.00	353.00	52.00	0	22.95	127.00
42	1.00	2.00	3.00	2.00	442.00	401.00	52.00	0	21.65	130.00
43	1.00	2.00	3.00	3.00	320.00	279.00	52.00	0	22.37	124.00
44	1.00	2.00	3.00	4.00	343.00	256.00	52.00	0	21.02	113.00
45	1.00	2.00	4.00	1.00	410.00	344.00	56.00	0	26.42	130.00
46	1.00	2.00	4.00	2.00	324.00	254.00	61.00	0	27.15	132.00
47	1.00	2.00	4.00	3.00	404.00	333.00	56.00	0	23.31	131.00
48	1.00	2.00	4.00	4.00	288.00	225.00	56.00	0	27.25	122.00
49	1.00	2.00	5.00	1.00	202.00	223.00	53.00	0	22.28	120.00
50	1.00	2.00	5.00	2.00	434.00	394.00	53.00	0	20.95	119.00
51	1.00	2.00	5.00	3.00	382.00	168.00	52.00	0	18.84	117.00
52	1.00	2.00	5.00	4.00	360.00	308.00	53.00	0	18.20	112.00
53	1.00	2.00	6.00	1.00	242.00	231.00	56.00	0	24.17	132.00
54	1.00	2.00	6.00	2.00	430.00	366.00	52.00	0	27.25	124.00
55	1.00	2.00	6.00	3.00	372.00	283.00	52.00	0	22.85	125.00
56	1.00	2.00	6.00	4.00	390.00	314.00	52.00	0	21.72	113.00
57	1.00	2.00	7.00	1.00	296.00	278.00	53.00	40.00	24.77	142.00
58	1.00	2.00	7.00	2.00	388.00	309.00	53.00	95.00	21.10	143.00

Table 61, Continued.

Plot	TR	BL	V	RP	EC	HC	BD	LG	PG	HT
59	1.00	2.00	7.00	3.00	363.00	346.00	51.00	70.00	24.54	137.00
60	1.00	2.00	7.00	4.00	472.00	399.00	52.00	95.00	17.50	140.00
61	1.00	2.00	8.00	1.00	226.00	198.00	62.00	0	24.40	137.00
62	1.00	2.00	8.00	2.00	270.00	231.00	62.00	0	26.28	132.00
63	1.00	2.00	8.00	3.00	458.00	396.00	57.00	0	27.16	136.00
64	1.00	2.00	8.00	4.00	470.00	396.00	56.00	25.00	27.05	131.00
65	2.00	1.00	1.00	1.00	331.00	318.00	52.00	0	18.85	117.00
66	2.00	1.00	1.00	2.00	368.00	355.00	52.00	0	15.50	111.00
67	2.00	1.00	1.00	3.00	294.00	289.00	51.00	0	20.38	125.00
68	2.00	1.00	1.00	4.00	218.00	245.00	52.00	0	19.69	114.00
69	2.00	1.00	2.00	1.00	337.00	313.00	53.00	5.00	17.31	137.00
70	2.00	1.00	2.00	2.00	379.00	304.00	51.00	0	21.99	134.00
71	2.00	1.00	2.00	3.00	320.00	334.00	51.00	0	19.41	132.00
72	2.00	1.00	2.00	4.00	260.00	273.00	51.00	0	19.15	132.00
73	2.00	1.00	3.00	1.00	331.00	309.00	49.00	0	18.96	126.00
74	2.00	1.00	3.00	2.00	298.00	277.00	49.00	0	18.28	125.00
75	2.00	1.00	3.00	3.00	233.00	237.00	51.00	0	22.48	124.00
76	2.00	1.00	3.00	4.00	298.00	271.00	50.00	0	21.68	127.00
77	2.00	1.00	4.00	1.00	380.00	309.00	56.00	0	21.90	122.00
78	2.00	1.00	4.00	2.00	317.00	257.00	56.00	0	21.82	127.00
79	2.00	1.00	4.00	3.00	409.00	276.00	57.00	0	25.30	128.00
80	2.00	1.00	4.00	4.00	318.00	253.00	55.00	0	24.94	126.00
81	2.00	1.00	5.00	1.00	352.00	341.00	53.00	0	22.56	115.00
82	2.00	1.00	5.00	2.00	322.00	326.00	54.00	0	20.77	114.00
83	2.00	1.00	5.00	3.00	292.00	286.00	53.00	0	23.80	112.00
84	2.00	1.00	5.00	4.00	372.00	334.00	52.00	0	20.40	116.00
85	2.00	1.00	6.00	1.00	376.00	350.00	54.00	0	23.19	131.00
86	2.00	1.00	6.00	2.00	379.00	325.00	50.00	0	20.68	125.00
87	2.00	1.00	6.00	3.00	327.00	279.00	50.00	0	24.05	128.00

Table 61, Continued.

Plot	TR	BL	V	RP	EC	HC	BD	LG	PG	HT
88	2.00	1.00	6.00	4.00	408.00	357.00	50.00	0	23.40	126.00
89	2.00	1.00	7.00	1.00	356.00	327.00	51.00	60.00	19.60	138.00
90	2.00	1.00	7.00	2.00	277.00	241.00	51.00	10.00	21.57	140.00
91	2.00	1.00	7.00	3.00	338.00	305.00	51.00	60.00	19.66	130.00
92	2.00	1.00	7.00	4.00	406.00	336.00	50.00	30.00	19.70	142.00
93	2.00	1.00	8.00	1.00	369.00	307.00	57.00	5.00	22.23	125.00
94	2.00	1.00	8.00	2.00	300.00	250.00	59.00	0	20.76	122.00
95	2.00	1.00	8.00	3.00	368.00	275.00	61.00	0	21.61	123.00
96	2.00	1.00	8.00	4.00	344.00	293.00	59.00	0	25.82	122.00
97	2.00	2.00	1.00	1.00	278.00	265.00	56.00	0	25.74	117.00
98	2.00	2.00	1.00	2.00	253.00	228.00	52.00	0	25.26	118.00
99	2.00	2.00	1.00	3.00	454.00	394.00	53.00	0	25.25	124.00
100	2.00	2.00	1.00	4.00	464.00	391.00	52.00	0	23.95	120.00
101	2.00	2.00	2.00	1.00	306.00	250.00	54.00	0	23.05	125.00
102	2.00	2.00	2.00	2.00	385.00	306.00	51.00	0	19.90	121.00
103	2.00	2.00	2.00	3.00	428.00	355.00	52.00	20.00	21.14	131.00
104	2.00	2.00	2.00	4.00	378.00	336.00	51.00	0	22.75	131.00
105	2.00	2.00	3.00	1.00	250.00	225.00	57.00	0	34.08	114.00
106	2.00	2.00	3.00	2.00	239.00	146.00	53.00	0	30.92	117.00
107	2.00	2.00	3.00	3.00	424.00	382.00	50.00	0	24.42	127.00
108	2.00	2.00	3.00	4.00	410.00	349.00	51.00	0	24.55	130.00
109	2.00	2.00	4.00	1.00	210.00	116.00	61.00	0	24.21	124.00
110	2.00	2.00	4.00	2.00	416.00	314.00	59.00	0	24.65	130.00
111	2.00	2.00	4.00	3.00	420.00	315.00	58.00	0	23.93	135.00
112	2.00	2.00	4.00	4.00	406.00	325.00	57.00	0	26.82	133.00
113	2.00	2.00	5.00	1.00	398.00	367.00	52.00	0	26.94	122.00
114	2.00	2.00	5.00	2.00	215.00	179.00	56.00	0	26.61	120.00
115	2.00	2.00	5.00	3.00	424.00	368.00	53.00	0	24.15	124.00
116	2.00	2.00	5.00	4.00	382.00	256.00	51.00	0	26.25	118.00
117	2.00	2.00	6.00	1.00	442.00	338.00	52.00	0	26.71	130.00

Table 61, Continued.

Plot	TR	BL	V	RP	EC	HC	BD	LG	PG	HT
118	2.00	2.00	6.00	2.00	234.00	221.00	51.00	0	25.35	124.00
119	2.00	2.00	6.00	3.00	437.00	367.00	51.00	0	26.74	129.00
120	2.00	2.00	6.00	4.00	484.00	363.00	51.00	0	27.25	132.00
121	2.00	2.00	7.00	1.00	412.00	338.00	52.00	30.00	26.54	129.00
122	2.00	2.00	7.00	2.00	444.00	346.00	51.00	50.00	20.35	136.00
123	2.00	2.00	7.00	3.00	361.00	328.00	51.00	75.00	23.28	137.00
124	2.00	2.00	7.00	4.00	428.00	338.00	51.00	65.00	24.40	135.00
125	2.00	2.00	8.00	1.00	440.00	340.00	61.00	0	27.12	129.00
126	2.00	2.00	8.00	2.00	464.00	381.00	57.00	25.00	24.45	127.00
127	2.00	2.00	8.00	3.00	321.00	198.00	59.00	0	24.77	129.00
128	2.00	2.00	8.00	4.00	390.00	306.00	57.00	0	27.95	128.00

TR = Tillage treatment (1 = reduced tillage; 2 = full tillage)
BL = Block (2 blocks)
V = Varieties (8 varieties)
RP = Replications (4 replications)
EC = Emergence plant counts
HC = Head counts
BD = Days to 50% bloom
PG = Grain yield (lbs)
HT = Height to top of head (cm)
LG = Lodging (%)

Table 62. Data as they were collected on each individual plot during the reduced tillage experiment at Marana, Arizona in 1982.

Plot	TR	BL	V	RP	HE	HL	LF	BT	PM
1	1.00	1.00	1.00	1.00	20.00	28.00	71.00	58.24	1.30
2	1.00	1.00	1.00	2.00	22.00	29.00	63.00		
3	1.00	1.00	1.00	3.00	18.00	27.00	73.00	59.52	1.10
4	1.00	1.00	1.00	4.00	19.00	27.00	69.00		
5	1.00	1.00	2.00	1.00	25.00	26.00	77.00	58.72	1.30
6	1.00	1.00	2.00	2.00	20.00	30.00	68.00		
7	1.00	1.00	2.00	3.00	22.00	27.00	78.00	59.68	2.00
8	1.00	1.00	2.00	4.00	27.00	27.00	75.00		
9	1.00	1.00	3.00	1.00	26.00	27.00	77.00	61.12	1.80
10	1.00	1.00	3.00	2.00	21.00	28.00	74.00		
11	1.00	1.00	3.00	3.00	16.00	28.00	80.00	60.83	2.00
12	1.00	1.00	3.00	4.00	13.00	29.00	77.00		
13	1.00	1.00	4.00	1.00	15.00	27.00	82.00	56.83	11.70
14	1.00	1.00	4.00	2.00	21.00	25.00	82.00		
15	1.00	1.00	4.00	3.00	16.00	27.00	83.00	58.98	3.70
16	1.00	1.00	4.00	4.00	18.00	29.00	79.00		
17	1.00	1.00	5.00	1.00	15.00	29.00	61.00	57.57	11.50
18	1.00	1.00	5.00	2.00	15.00	25.00	67.00		
19	1.00	1.00	5.00	3.00	23.00	28.00	59.00	59.10	2.90
20	1.00	1.00	5.00	4.00	22.00	26.00	71.00		
21	1.00	1.00	6.00	1.00	17.00	27.00	70.00	59.23	2.70
22	1.00	1.00	6.00	2.00	9.00	29.00	86.00		
23	1.00	1.00	6.00	3.00	16.00	27.00	80.00	61.02	1.20
24	1.00	1.00	6.00	4.00	9.00	25.00	87.00		
25	1.00	1.00	7.00	1.00	27.00	27.00	69.00	58.24	2.10
26	1.00	1.00	7.00	2.00	18.00	25.00	84.00		
27	1.00	1.00	7.00	3.00	21.00	26.00	91.00	59.30	.90

Table 62, Continued.

Plot	TR	BL	V	RP	HE	HL	LF	BT	PM
28	1.00	1.00	7.00	4.00	23.00	24.00	82.00		
29	1.00	1.00	8.00	1.00	7.00	28.00	90.00	55.26	21.00
30	1.00	1.00	8.00	2.00	6.00	26.00	82.00		
31	1.00	1.00	8.00	3.00	11.00	28.00	88.00	58.94	4.90
32	1.00	1.00	8.00	4.00	10.00	26.00	91.00		
33	1.00	2.00	1.00	1.00	17.00	29.00	81.00	58.67	2.30
34	1.00	2.00	1.00	2.00	17.00	29.00	72.00		
35	1.00	2.00	1.00	3.00	17.00	29.00	72.00	59.00	1.80
36	1.00	2.00	1.00	4.00	16.00	30.00	70.00		
37	1.00	2.00	2.00	1.00	21.00	30.00	81.00	58.94	2.50
38	1.00	2.00	2.00	2.00	33.00	31.00	76.00		
39	1.00	2.00	2.00	3.00	21.00	29.00	82.00	59.17	2.00
40	1.00	2.00	2.00	4.00	19.00	30.00	77.00		
41	1.00	2.00	3.00	1.00	15.00	30.00	82.00	60.70	2.20
42	1.00	2.00	3.00	2.00	15.00	30.00	85.00		
43	1.00	2.00	3.00	3.00	16.00	38.00	70.00	60.80	1.70
44	1.00	2.00	3.00	4.00	11.00	30.00	72.00		
45	1.00	2.00	4.00	1.00	17.00	26.00	87.00	58.05	9.00
46	1.00	2.00	4.00	2.00	16.00	30.00	86.00		
47	1.00	2.00	4.00	3.00	16.00	27.00	88.00	58.11	5.80
48	1.00	2.00	4.00	4.00	16.00	27.00	79.00		
49	1.00	2.00	5.00	1.00	17.00	30.00	73.00	57.02	13.20
50	1.00	2.00	5.00	2.00	19.00	29.00	71.00		
51	1.00	2.00	5.00	3.00	17.00	30.00	70.00	57.89	2.80
52	1.00	2.00	5.00	4.00	17.00	30.00	65.00		
53	1.00	2.00	6.00	1.00	15.00	27.00	90.00	59.87	8.20
54	1.00	2.00	6.00	2.00	12.00	29.00	83.00		
55	1.00	2.00	6.00	3.00	9.00	28.00	88.00	59.49	6.90
56	1.00	2.00	6.00	4.00	12.00	29.00	72.00		
57	1.00	2.00	7.00	1.00	18.00	26.00	98.00	56.64	11.40
58	1.00	2.00	7.00	2.00	17.00	26.00	100.00		

Table 62, Continued.

Plot	TR	BL	V	RP	HE	HL	LF	BT	PM
59	1.00	2.00	7.00	3.00	18.00	26.00	93.00	58.50	1.20
60	1.00	2.00	7.00	4.00	17.00	25.00	98.00		
61	1.00	2.00	8.00	1.00	11.00	28.00	98.00	55.94	17.20
62	1.00	2.00	8.00	2.00	8.00	28.00	96.00		
63	1.00	2.00	8.00	3.00	14.00	26.00	96.00	59.23	4.20
64	1.00	2.00	8.00	4.00	12.00	27.00	92.00		
65	2.00	1.00	1.00	1.00	17.00	28.00	72.00	58.14	.80
66	2.00	1.00	1.00	2.00	18.00	27.00	66.00		
67	2.00	1.00	1.00	3.00	17.00	28.00	80.00	59.20	1.00
68	2.00	1.00	1.00	4.00	17.00	31.00	66.00		
69	2.00	1.00	2.00	1.00	18.00	29.00	90.00	59.01	.70
70	2.00	1.00	2.00	2.00	21.00	30.00	83.00		
71	2.00	1.00	2.00	3.00	18.00	30.00	84.00	59.42	1.20
72	2.00	1.00	2.00	4.00	20.00	30.00	82.00		
73	2.00	1.00	3.00	1.00	18.00	28.00	80.00	60.64	.40
74	2.00	1.00	3.00	2.00	18.00	28.00	79.00		
75	2.00	1.00	3.00	3.00	17.00	30.00	77.00	60.80	1.50
76	2.00	1.00	3.00	4.00	16.00	29.00	82.00		
77	2.00	1.00	4.00	1.00	18.00	28.00	76.00	58.21	2.70
78	2.00	1.00	4.00	2.00	15.00	27.00	85.00		
79	2.00	1.00	4.00	3.00	15.00	28.00	85.00	57.54	2.70
80	2.00	1.00	4.00	4.00	14.00	30.00	82.00		
81	2.00	1.00	5.00	1.00	19.00	29.00	67.00	58.46	2.40
82	2.00	1.00	5.00	2.00	18.00	29.00	67.00		
83	2.00	1.00	5.00	3.00	16.00	29.00	67.00	58.94	1.70
84	2.00	1.00	5.00	4.00	19.00	27.00	70.00		
85	2.00	1.00	6.00	1.00	14.00	28.00	89.00	59.68	1.60
86	2.00	1.00	6.00	2.00	14.00	27.00	84.00		
87	2.00	1.00	6.00	3.00	14.00	27.00	87.00	60.22	1.10
88	2.00	1.00	6.00	4.00	16.00	30.00	80.00		
89	2.00	1.00	7.00	1.00	19.00	26.00	93.00	58.53	.60

Table 62, Continued.

Plot	TR	BL	V	RP	HE	HL	LF	BT	PM
90	2.00	1.00	7.00	2.00	16.00	28.00	96.00		
91	2.00	1.00	7.00	3.00	15.00	27.00	88.00	57.79	.80
92	2.00	1.00	7.00	4.00	16.00	25.00	101.00		
93	2.00	1.00	8.00	1.00	12.00	28.00	85.00	58.27	2.80
94	2.00	1.00	8.00	2.00	9.00	29.00	84.00		
95	2.00	1.00	8.00	3.00	11.00	28.00	84.00	58.69	2.40
96	2.00	1.00	8.00	4.00	9.00	30.00	83.00		
97	2.00	2.00	1.00	1.00	15.00	28.00	74.00	57.66	13.10
98	2.00	2.00	1.00	2.00	17.00	29.00	72.00		
99	2.00	2.00	1.00	3.00	18.00	29.00	77.00	58.78	2.40
100	2.00	2.00	1.00	4.00	17.00	29.00	74.00		
101	2.00	2.00	2.00	1.00	20.00	29.00	76.00	57.09	14.40
102	2.00	2.00	2.00	2.00	22.00	29.00	70.00		
103	2.00	2.00	2.00	3.00	20.00	31.00	80.00	59.33	1.60
104	2.00	2.00	2.00	4.00	18.00	32.00	81.00		
105	2.00	2.00	3.00	1.00	15.00	30.00	69.00	57.17	14.50
106	2.00	2.00	3.00	2.00	15.00	28.00	74.00		
107	2.00	2.00	3.00	3.00	16.00	29.00	82.00	61.44	1.70
108	2.00	2.00	3.00	4.00	19.00	29.00	82.00		
109	2.00	2.00	4.00	1.00	17.00	30.00	77.00	48.83	25.00
110	2.00	2.00	4.00	2.00	16.00	28.00	86.00		
111	2.00	2.00	4.00	3.00	16.00	29.00	90.00	56.10	12.00
112	2.00	2.00	4.00	4.00	17.00	28.00	88.00		
113	2.00	2.00	5.00	1.00	18.00	30.00	74.00	58.30	3.10
114	2.00	2.00	5.00	2.00	16.00	29.00	75.00		
115	2.00	2.00	5.00	3.00	18.00	30.00	76.00	58.69	2.40
116	2.00	2.00	5.00	4.00	14.00	29.00	75.00		
117	2.00	2.00	6.00	1.00	15.00	28.00	87.00	60.54	2.40
118	2.00	2.00	6.00	2.00	13.00	30.00	81.00		
119	2.00	2.00	6.00	3.00	12.00	28.00	89.00	59.23	4.20

Table 62, Continued.

Plot	TR	BL	V	RP	HE	HL	LF	BT	PM
120	2.00	2.00	6.00	4.00	13.00	28.00	91.00		
121	2.00	2.00	7.00	1.00	16.00	27.00	86.00	58.53	2.40
122	2.00	2.00	7.00	2.00	16.00	27.00	93.00		
123	2.00	2.00	7.00	3.00	20.00	27.00	90.00	57.82	3.20
124	2.00	2.00	7.00	4.00	18.00	26.00	91.00		
125	2.00	2.00	8.00	1.00	9.00	28.00	92.00	58.66	2.90
126	2.00	2.00	8.00	2.00	12.00	25.00	90.00		
127	2.00	2.00	8.00	3.00	11.00	29.00	89.00	53.79	21.10
128	2.00	2.00	8.00	4.00	11.00	27.00	90.00		

TR = Tillage treatment (1 = reduced tillage; 2 = full tillage)
BL = Block (2 blocks)
V = Varieties (8 varieties)
RP = Replications (4 replications)
HE = Head exertion (cm)
HL = Head length (cm)
LF = Height to upper leaf collar (cm)
BT = Bushel test weight (lbs/bushel)
PM = Percent moisture

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