

DEVELOPMENT OF THE KANSAS STATE UNIVERSITY  
MULCH TILLAGE PLANTER

by

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## INTRODUCTION

The practice of minimum tillage as a profitable production practice is gaining a great deal of interest as on-farm production costs continue to increase. Things such as reducing energy requirements, protecting the soil from erosion, and increasing water intake into the soil have brought about considerable enthusiasm for minimum tillage. But minimum tillage also requires a high degree of management and weed control, and its effectiveness in a particular region or on a particular farm should be given a careful evaluation.

In 1976, the Department of Agricultural Engineering at Kansas State University undertook a study which dealt with energy conservation in Kansas. This study concluded that a minimum tillage planter was needed primarily for the conditions in the High Plains region of Kansas. In evaluating the needs and current equipment available, it became obvious that a planter was needed which would handle heavy amounts of residue, have few moving parts, band fertilizer with the seed, accurately control the depth of planting, and have adjustable compaction from the press wheels. This resulted in Herron (1978) beginning the development of a planter which used an undercutter plow to kill existing weeds at the time of planting and an International Cyclo system to meter the seeds and distribute the seeds beneath the undercutter blade. Satisfactory performance was achieved but several problems still existed such as depth control and press wheel configuration.

In an attempt to alleviate some of the problems of the original planter, the project was continued in 1979. After evaluating the

results of the original project and the recommendations made therein a new concept was conceived for development and testing.

## LITERATURE SURVEY

### Evaluation of Minimum Tillage

Minimum tillage may be one of the more controversial farming practices under discussion by farmers and researchers today. Some researchers claim tremendous energy savings while others show substantial yield decreases. The term "minimum tillage" itself has very broad connotations. Fenster and Wicks (1976) state that minimum tillage is a relatively new concept of farming designed to reduce energy requirements, to protect the soil from erosion, and to increase water intake into the soil without reducing crop yields. Phillips and Young (1973) define it as "reducing tillage to only those operations that are timely and essential to producing the crop and avoiding damage to the soil". But this could include everything from plowing and planting in two operations to strip-till planting to stubble-mulch planting to aerial seeding.

Whether or not an individual has success, may in the end depend on two things, management and weed control. No matter which type of minimum tillage is used, a high degree of management is essential. It is harder to cover up a mistake using cultivation with minimum tillage than with conventional tillage practices.

Minimum tillage deserves a careful evaluation when determining its effectiveness in a particular region. Seven points that will be considered are: moisture conservation, soil type and yield, machinery investment, weed control, insect control, energy consumption, soil conservation, and soil fertility.

## Moisture Conservation

Increasing surface residue will increase the infiltration rates, the snow trapping ability, and the moisture storage potential of the soil. Separate tests run in Colorado, Montana, and Nebraska by Fenster (1960) and Greb, Smika, and Block (1967) have shown significant increases in moisture storage when surface wheat residue was increased from 1500 to 6000 lb. per acre. A Wyoming test by Barnes and Bohmont (1958) showed that water infiltration for bare fallow and stubble mulch fallow was 0.30 and 2.26 inches per hour respectively.

Fenster (1960) has shown that mulch is more important than soil organic matter in increasing water infiltration. Infiltration rates, as reported by Fenster (1960), were 0.76 and 0.44 inches per hour for mulched and unmulched subsoil that was sprinkled for three hours. The infiltration rates were 1.62 and 0.55 inches per hour for mulched and unmulched topsoil in the same test. The increased water infiltration seen with mulching, in turn effectively reduces runoff rates.

## Soil Type and Yields

There are several elements that affect yields from the soil's perspective. Soil type and its drainage ability are important factors that can have an effect. Minimum tillage used in tight clay soils may lead to increased soil compaction and drainage problems. Drainage problems, along with the crop residue left on the surface, lower soil temperatures which lead to slower germination, slower plant growth and more severe weed problems. On the other hand, minimum tillage appears to be very promising in sandy loam soils, loam soils with well-drained subsoils or

well drained hillsides.

Seedbed conditions with minimum tillage are often less than optimum, so care must be taken when planting. When this is the case, good seed-to-soil contact is desirable, along with uniform depth and placement of the seed in the row. Care must also be taken in applying fertilizers, especially the immobile elements (P and K), so that they will be located in the root zone for better plant utilization.

#### Machinery Investment

Actual machinery investments will have considerable variability depending upon the type of minimum tillage practiced. Since minimum tillage is not profitable on all types of soil, it will be highly unlikely that the overall machinery investment will decrease. One's first thoughts would indicate that a tractor, planter, sprayer, and combine would be all the equipment required. But since a farmer will probably have areas where minimum tillage won't work, his total inventory of equipment will actually increase.

In 1976, energy-use records from Kansas farms were compiled along with custom rates charged for particular operations. This information was then used by Herron (1978) to evaluate a variety of tillage systems. It can also be used to evaluate the costs of a particular system relative to a farmer's present machinery inventory. One alternative to the usual increase in machinery inventory is to have one or more of the operations done by a custom operator. This may be beneficial when beginning a minimum tillage program to help determine the type of system which is best for a particular area and the type of investments that

should eventually be made.

#### Weed Control

One of the major problems with minimum tillage is weed control. Less tillage means more dependence on herbicides for weed control in an environment with a buildup of crop residue. Crop residues can prevent the contact herbicides from reaching the weeds and the preemergent herbicides from reaching the soil. This results in herbicides being more dependent on rainfall with minimum tillage than with conventional tillage. When beginning a minimum tillage program, certain weeds may enter the system that even a wide spectrum herbicide can not control. Varying treatments every few years or occasional tillage may be a tremendous aid to weed control. In some instances, herbicides may not control the problems such as downy brome or cheat in wheat or Johnsongrass in row crops. In these instances, occasional tillage, crop rotation, or even plowing may be the only effective methods of control.

Here again, management plays an important role in what herbicide to apply, when to apply them, and at what depth to apply them. Products like Butylate and Trifuralin should be incorporated; if left on the surface, they'll volatilize or be deteriorated by the sunlight. But products like Paraquat can be adsorbed by clay or organic matter and be tied-up if incorporated and therefore, should only be surface applied. For some herbicides like Atrazine or Metribuzin, incorporation is optional. If the weather could be predicted, then the optimum application method could be selected. Directions should always be followed to assure proper usage and for reasons of safety.

Figuring out when to apply herbicides depends upon the type to be used, the crop being planted, and the climate. As a general rule, long lasting chemicals can be applied weeks in advance, but generally the application should be kept to within a week or two of planting. A very complete reference to the type of herbicide and application dates for various crops is given in the Chemical Weed Control Report by Russ (1979).

Application methods are dependent on the herbicide and the weeds to be controlled. Contact herbicides kill upon contact with the plant tissue rather than as a result of translocation. Preemergent herbicides are applied before planting and should have a shallow incorporation. Most weeds germinate in the top two inches of soil and so placement of the herbicide there, by either incorporation or rainfall, is important. Again refer to the Chemical Weed Control Report by Russ (1979) for specific details.

#### Insect Control

Protective mulch, cooler soil, and slow crop emergence provide conditions that are favorable for the growth and survival of insects. Corn is probably more susceptible than other row crops are to soil insects. The most bothersome insects include wireworms, seed corn maggots, seed corn beetles, cutworms, white grubs, and rootworms. Above ground pests in corn include the European corn borer, armyworm, and earworm. Insecticide application at the time of planting and throughout the season may be required with minimum tillage.

In milo stands, the chinch bug is becoming one of the most devastating insects known, they can virtually eliminate top growth. Here again, insecticide application at the time of planting is necessary if the chinch bug is present. Carbofuran is probably the only effective insecticide to use in these situations. Application of insecticides for minimum tillage is, in most cases, very similar to that of conventional tillage.

Minimum tillage may also invites some non-insect pests. Field mice, slugs, and bird control may become an important factor for a profitable program.

#### Energy Consumption

When talking about the total energy saved because of minimum tillage, most people agree it's a trade off. Evaluations done by Herron (1978) on various tillage practices showed an energy savings with reduced tillage. The amount of on-farm usage of fuel in order to produce a crop may decrease from one-third to one-half while using minimum tillage. Actual fuel savings will depend upon the type of system being used. However, the extra herbicides used with minimum tillage have also required energy for their production. Some of the money saved on fuel costs can be expected to be spent on herbicides. Actual energy consumption calculations on specific practices can be calculated using Herron's (1978) method.

#### Soil Conservation

Water and wind erosion are robbing us of one of our most expensive

resources, land. Former Secretary of Agriculture Bob Bergland (Hanson, 1979) has stated that "we are losing fifteen tons of topsoil out of the mouth of the Mississippi every second". Soil Conservation Service officials (Hanson, 1979) still list ten million acres damaged by wind erosion - annually losing fifteen or more tons of soil per acre.

As a result of the dust bowl in the 1930's, work was started by the Soil Conservation Service in Nebraska to develop new farming techniques to alleviate these problems. One of the researchers was J. C. Russell (1976) who stated, "a soil somehow should be protected against the disruptive pattern of raindrops with joint consequences of reduced intake and enhanced runoff". To them the best approach seemed to be to leave all the crop residue on the surface. Russell was working on, "how to leave residue on the surface to enhance intake and reduce evaporation, and at the same time reduce soil losses through the agency of wind". The concept of stubble mulch tillage soon followed.

In past years, tillage operations were done to control weeds and prepare a suitable seedbed. The weeds had to be controlled to conserve the moisture for the crops. Due to the development of herbicides, more of the crop residue can be left on the surface to protect the soil. Fenster and Wicks (1976) have stated that tillage equipment should be selected for weed control and maintenance of residue. In addition, planting equipment must place the seed firmly into moist soil while maintaining a protective cover of residue on the soil surface.

The concept of minimum tillage has several advantages such as surface residue maintenance, moisture conservation, and reduced fuel

requirements, but the greatest advantage of all, in many areas, may be wind and water erosion control.

### Soil Fertility

Fee (1981) presents the idea that fertilizing minimum tillage crops is not necessarily harder but is different than with conventional tillage programs. He points to three areas of which a farmer should be aware when switching to a minimum tillage or no-till operation: nutrient availability, soil acidity, and managing nitrogen losses.

Conventional tillage mixes the fertilizer in the soil, but when tillage is eliminated, fertilizer accumulates in the top one or two inches. The problem comes from potassium (K) and phosphorus (P) which move little relative to the location of application. This problem becomes more severe with time since the crops use the nutrients in the root zone and deposit them on the surface in the form of residue. After several years, the nutrient level is so low in the deeper soil that the feeder roots are forced to develop in very shallow soil which may cause moisture stress during dry periods. These problems can be reduced if the P and K levels are raised before switching to minimum tillage or if the fertilizer can be placed at or below the seed level at the time of planting.

Fee (1981) continues by stating that surface application of nitrogen can lower the pH of the top two to three inches of soil. An acid layer of soil impedes root development, reduces the availability of nutrients, and lowers the effectiveness of triazine herbicides. Several solutions to this problem include the application of lime or plowing

every three to five years to prevent the acid build-up.

Another problem suggested by Fee (1981) is the loss of nitrogen when urea-based nitrogen is left on the soil surface when minimum tillage practices are used. This loss results from the interaction of the crop residue with the urea-based nitrogen resulting in ammonia being released to the atmosphere. Two methods to alleviate this problem are to increase the amount of nitrogen applied or to knife the ammonia or nitrogen solution into the soil.

The type and method of fertilizer application in a minimum tillage program vary with the crop being planted. But one concept should be kept in mind, that is to place the fertilizer in a location for optimum plant utilization and not to feed the weeds. Most weeds germinate in the top inch of soil. Placing the fertilizer at or below the seed when planting may be an effective aid in reducing the weed pressures which seem to be amplified when switching to minimum tillage.

#### Edaphic Factors Affecting Plant Emergence

Understanding the physical environment of the seedbed helps design minimum tillage planters that can improve emergence rates. Present planters and tillage practices have significantly modified the environment in which the seed is placed. Surface profile modification, the seed placement within the profile, modifications to the soil structure, and the application of chemicals have all been attempts to provide a more optimum plant environment. Shaw (1952) divided the seed environment into three distinct parts: the chemical environment - consisting of all the important chemicals such as N, P, and K, soil pH and freedom

from toxic materials; the biological environment - consisting of all biological pests such as insects, weeds and disease; and the soil physical environment - consisting of the soil temperature, soil moisture, soil aeration and soil mechanical impedance.

Bowen (1966) states that the physical environment of a germinating seed and emerging seedling can only be adequately described in terms of the histories of the four recognized edaphic factors: the soil temperature, the soil moisture, the soil aeration, and the soil impedance. A careful evaluation of each of these four factors can provide information to aid in the design and development of a minimum tillage planter.

The relationship between soil temperature and seed germination is usually given by the number of degree-hours necessary to germinate the seed. The number of these heat units required varies for different crops and combines with the other physical factors for the germination of the seed. Temperature, in itself, has little effect on the germination rate if one or more of the other factors, such as moisture content, is severely lacking. Parker and Taylor (1965) state that if the soil temperatures are between 21 to 25 °C, the temperature will not affect total seedling emergence. Early crops planted in heavy residue conditions encounter lower temperature below that of conventionally-tilled soils because of residue shading.

The moisture that seeds require for germination has to be absorbed from the soil surrounding it. Drying patterns, compaction rates, and initial moisture content all influence the seed's ability to obtain the required moisture. One of the real problems is that planters disturb

the soil and some press residue into the seed zone. Wiegand (1962) suggests that if the soil can be placed over the seed in the same order it was removed, the seed will be surrounded by moist soil and the drier surface soil will reduce evaporative loss of moisture.

Soil compaction can also improve the ability of a seed to absorb moisture. Bowen's (1966) research showed that surface compaction of 1 to 5 psi was an aid to emergence due to the improvement in moisture conditions. This increased the length of time for favorable moisture conditions as much as two days over no compaction when soil moisture is limited. Bowen (1966) and Wiegand (1962) suggest that the top one-fourth to one-half inch of soil dries out quite rapidly under usual conditions at planting time. The drying front then proceeds downward at a constant rate of one-eighth to one-fourth inch per day. From this data, the importance of adequate soil compaction and the proper planting depth is apparent.

Air permeability is another essential factor for optimum plant growth. Williamson (1964) states that this is necessary for respiration and for water and mineral absorption by the plant roots. In addition, the rate at which oxygen can be supplied to the roots is of utmost importance to a rapidly growing plant. Bowen (1966) suggests that here again surface compaction and moisture content of the soil at planting can greatly affect air permeability.

Soil impedance can significantly alter the emergence rate when moist soil is compacted directly above the seed. Work by Morton and Buchele (1960) shows that the emergence energy (the energy required for

emergence of the seedling) increases directly with the compaction pressure. Bowen (1966) shows that in moist conditions, even 1 psi pressure may retard emergence. The addition of compaction to moist soil has a crusting effect as the soil dries. Carnes (1934), in his study of soil crusting, showed that the slower the drying rate, the harder the crust. He also stated that a firm root base assisted the seedling in breaking through the crust and resulted in more efficient use of the moisture present in the soil. A more complete review of the effects that press wheels have on soil compaction will be given in the following section.

Much of the research shows that there is no one best way to design a planter to work in all conditions because of the variability of these edaphic factors and the inability of man to predict the weather accurately. Neither, as Morton and Buchele (1960) state, is there an optimum condition for germination and seedling emergence. Because of this, there will always be a wide variety of planters developed for various tillage practices.

#### Soil Compaction by Press Wheels

Press wheels are some of the most important components on planters and considerable research has been devoted to their effect. As was seen in the previous section, press wheels affect many of the edaphic factors and their relation to plant emergence. In addition to the work already cited, several researchers have worked exclusively on compaction.

Fisher (1952), French (1952), and Barmington (1950) have shown beneficial effects in sugar beet emergence from press wheels firming the soil around and below the seed zone. A relationship was shown between

the firmness of the soil, the moisture in the seed zone, and emergence.

Johnson and Henry (1964) found that a compacted layer one inch above the seed created a diffusion barrier to moisture which reduced the overall drying rate, yet allowed favorable emergence because the drying of the compacted soil was delayed. It was also concluded that this diffusion barrier would have to be wider than one inch to be effective.

Press wheel evaluation is hindered by the lack of information concerning the pressure distribution in the soil beneath the press wheels. Soehne (1958) has developed a very complete method to analyze the pressure distribution under tractor tires. He states that the pressure stress-field under a tractor tire depends on the amount of load, the size of the contact area between the tire and soil, and the distribution of surface pressure within this contact area, along with the nature of the soil, its moisture content and density. Two important concepts presented by Soehne are that the compressive stress in the soil has a tendency to concentrate around the load axis and that the looser the soil is, the more elongated the pressure bulbs become.

The soil moisture content in the seed zone is more important for the seedling than any other factor. Also, it is necessary to firm the soil around the seed, while leaving a loose surface layer, to both slow the advancing drying front and to aid the seed in absorbing moisture. Lastly, it is important to leave the soil surface directly above the seed loose to provide low resistance as the seedling develops.

### Commercially Available Planter Components

The increased interest in recent years in minimum tillage has brought forth a variety of planters, each with unique features for planting the crops. Except for a few exceptions, all of these planters have been developed from a basic set of planter components, each of which serves a particular function. Manufacturers have tried to combine various sets of these basic components in order to alleviate as many of the problems associated with minimum tillage as possible.

Morrison and Abrams (1972) have done a tremendous amount of work with no-till planters which, in many respects, encounter the same problems as minimum tillage planters. They have made a thorough analysis of these problems and have evaluated how effective various components are in these situations. Some of the main problems include : soil penetration, trash accumulation, furrow opener depth control, uniformity of planting depth, seed placement, furrow closure, component tracking, and the application of fertilizer.

Morrison and Abrams (1972) have also shown how the different components are used to accomplish each distinct planter function. An expanded list of these components is shown in the following figures: initial penetration - Figure 1, furrow opening and seed placement - Figure 2, seed embedding - Figure 3, depth control - Figure 4, and furrow closure - Figure 5.

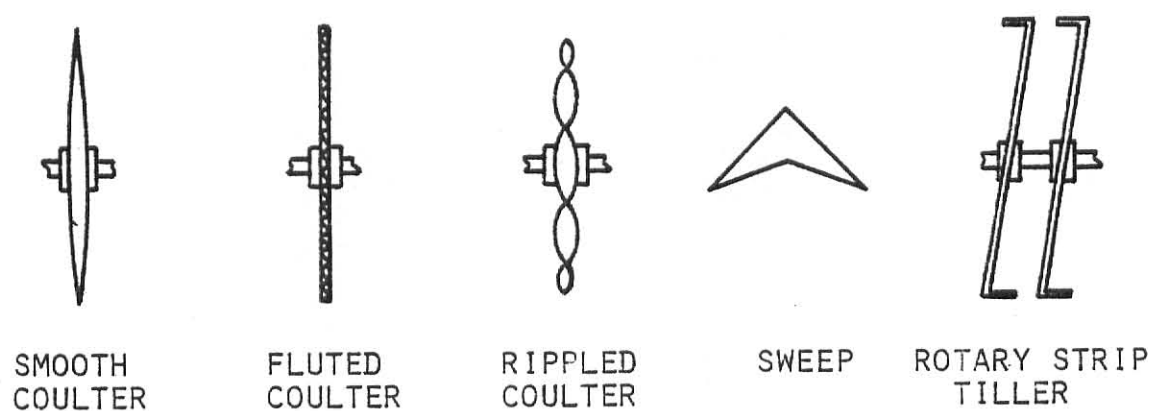


Figure 1. Components Used to Perform Initial Penetration.



Figure 2. Methods Used for Furrow Opening and Seed Placement.

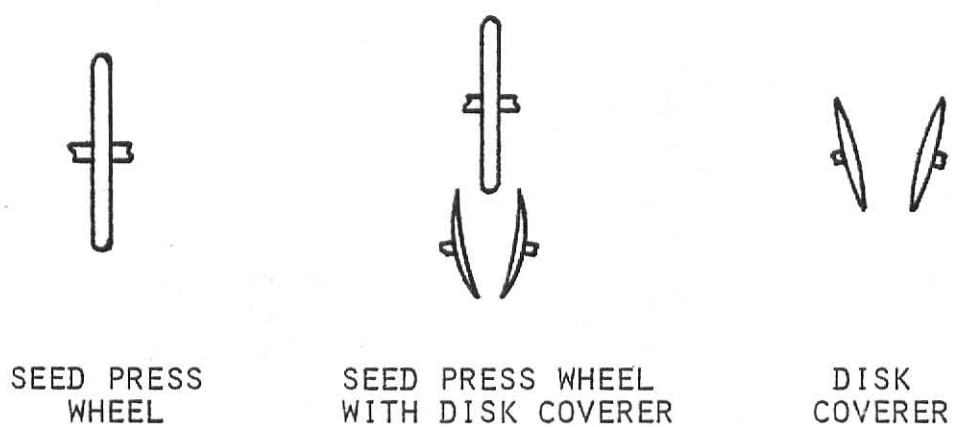


Figure 3. Components Used for Seed Imbedding.

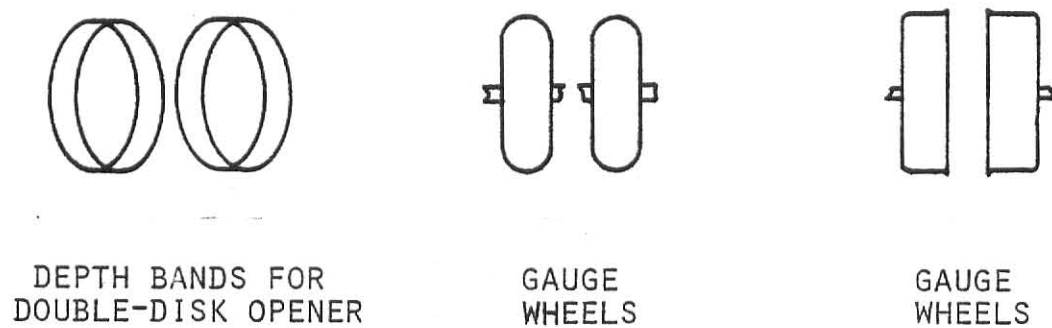


Figure 4. Methods Used to Provide Depth Control.

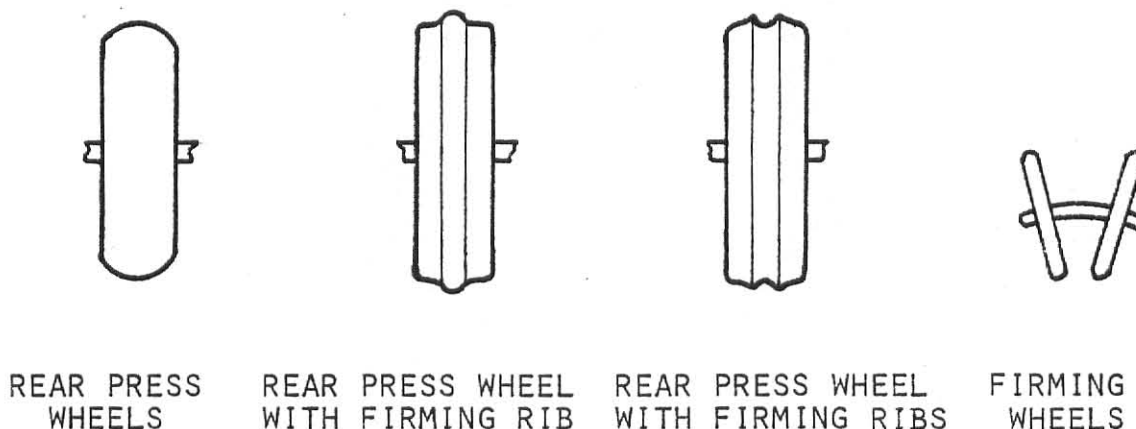


Figure 5. Types of Wheels Used for Furrow Closure.

When working with as many variables as nature provides us, there is naturally no planter available that will accomplish planting that is acceptable under all conditions. The designer should not limit himself to the basic components described; he should strive to be creative, resourceful, and persistent in developing a more versatile planter that can meet these diversified design parameters.

#### Power Requirements for Undercutters

One of the primary reasons behind the minimum tillage concept is that of energy conservation. If we are to achieve this objective we should be concerned with the energy consumption of the undercutter planting concept. Work was done here at Kansas State in 1977 to measure the fuel consumption, draft, wheel slippage, and travel speed while operating in various field conditions. It is obvious that considerable variation can be expected. The variations are due to the previous crop and changing soil conditions throughout a season. The variation may be

different from one season to the next.

A summary of the data was presented by Herron (1978) on tests run in alfalfa sod, brome sod, wheat stubble, and sorghum stubble. Also included in the summary are data taken on these requirements for a Buffalo Till-Planter.

## INVESTIGATION

### Design Objectives

The objective of this project was to continue the undercutter planter work which was started by Herron (1978) in 1976. The project was done in conjunction with the Federal Energy Administration Energy Conservation project here at Kansas State University. The basic goal was to design, build, and test a minimum tillage planter which would utilize an undercutter plow to kill existing vegetation at the time of planting. The planter was to provide significant improvements over currently available minimum tillage planters used under conditions common to the High Plains region of the United States.

The results of the Herron (1978) tillage-planter work proved to be quite promising. An undercutter planter was built and tested in 1977 by planting various row crops in a variety of soil types and residue cover. But several major problems were yet to be solved in regards to depth control and press wheel configuration. Under the new project, a planter was to be designed and built with the following specific design objectives:

1. Combine an undercutter plow which would be capable of killing existing vegetation with a planter.
2. The planter should be capable of planting grain sorghum, corn, soybeans, and wheat.
3. Provide a means of accurately setting and adjusting the depth control for seed placement.

4. Provide a press wheel arrangement in which the soil compaction at seed level could be adjustable.
5. Should perform equally well in either conventionally prepared seedbeds or in no-tilled residue covered soils.
6. Develop a fertilizer application system for the planter that will place fertilizer in the optimum location for plant use.
7. Provide a system on the planter for effectively applying and locating insecticides for optimum plant utilization.
8. Field test the planter on several soil types with different degrees of residue cover.

The design and building of the prototype was to be completed by May of 1980 in order to begin functional testing during the spring planting season.

#### Initial Design

The basic concept of using an undercutter plow as a planter was shown to work by Herron (1978). But Herron's tests also showed that further considerations should be given to two areas; that of depth control of seed placement and press wheel configuration with respect to seed placement. In an attempt to alleviate these problems, a rather unique design was conceived as shown in Figure 6.

#### Metering and Distribution of Seed

An International Model 500 Cyclo system was used for the metering and delivering the seed to the individual row placement tubes. This was

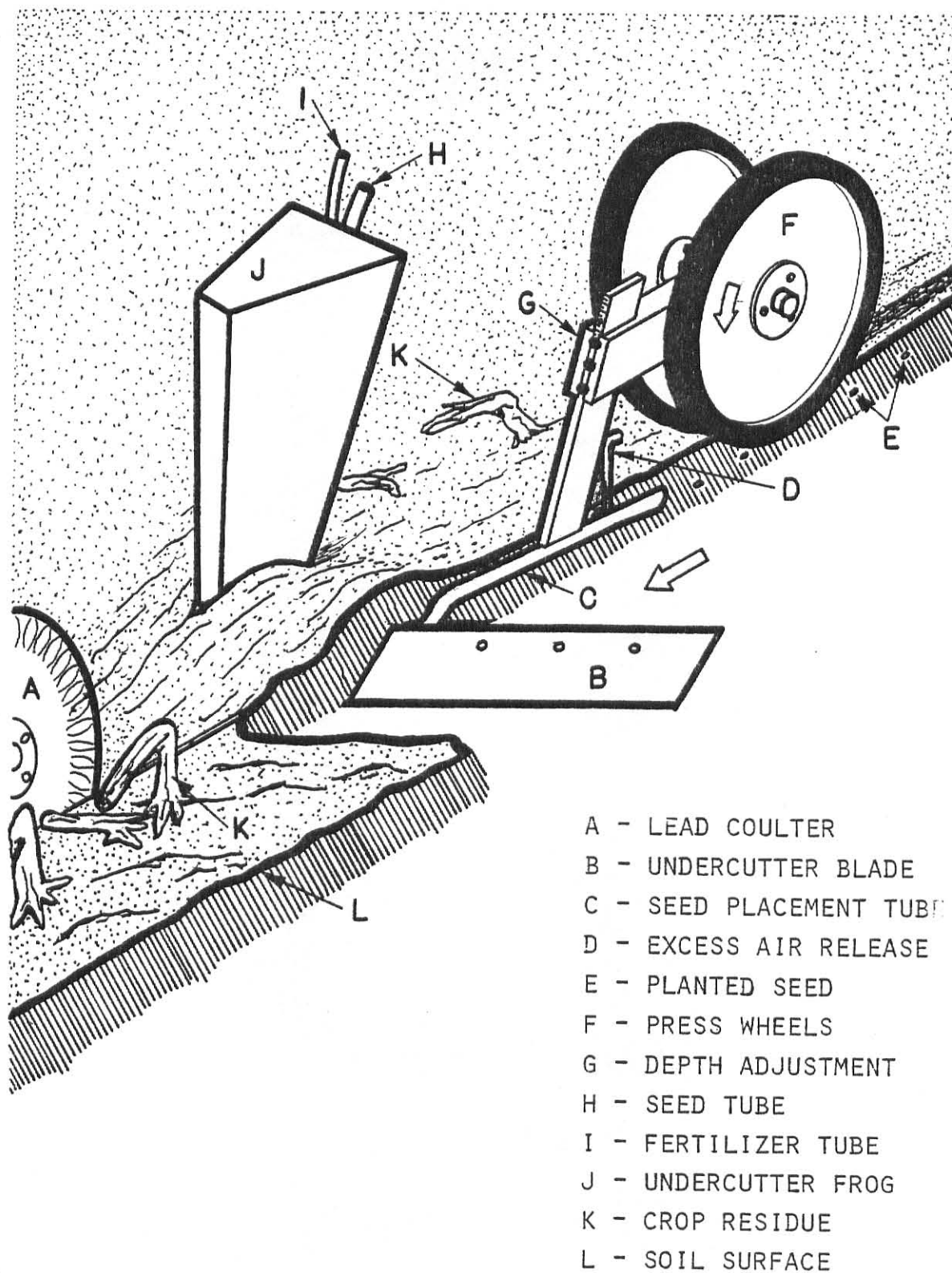


Figure 6. Schematic Diagram of Seed Placement Tube Concept.

the same system used and developed by Herron (1978). The Cyclo system was mounted on the center frame of the three section, 4.6 m [15 ft.] undercutter plow. The Cyclo system was selected because it is designed to plant a wide variety of crops including corn, milo, soybeans, and wheat. The central seed hopper, the wide range of seeding rates, and the hydraulically driven air supply were also advantages for the overall planter development.

The Cyclo system utilizes air as the transporting medium to carry the seeds from the centralized metering drum to individual row placement tubes. This air system allows the innovative design of the placement tubes to function as well as they do. The air system also allows the rows to be placed at any desired spacing.

#### Seed Placement Tube

The original work that Herron (1978) did used the concept of placing the seed in the void beneath the undercutter blade. The new concept proposed utilizes a seed placement tube. The tube is pulled through the soil behind the undercutter blade; press wheels are attached to the seed placement tube to accurately control depth (Figure 6). The tube is connected to the "frog" of the undercutter by a hinge that provides both vertical and horizontal rotation. The tube itself is shaped to form a firm seed bed as it is pulled through the soil. An air pressure release (an excess air release tube) is provided to slow the seed velocity as it approaches the end of the placement tube.

The hinge that connects the seed placement tube to the frog of the undercutter blade is shown in figure 7. The hinge has two degrees of

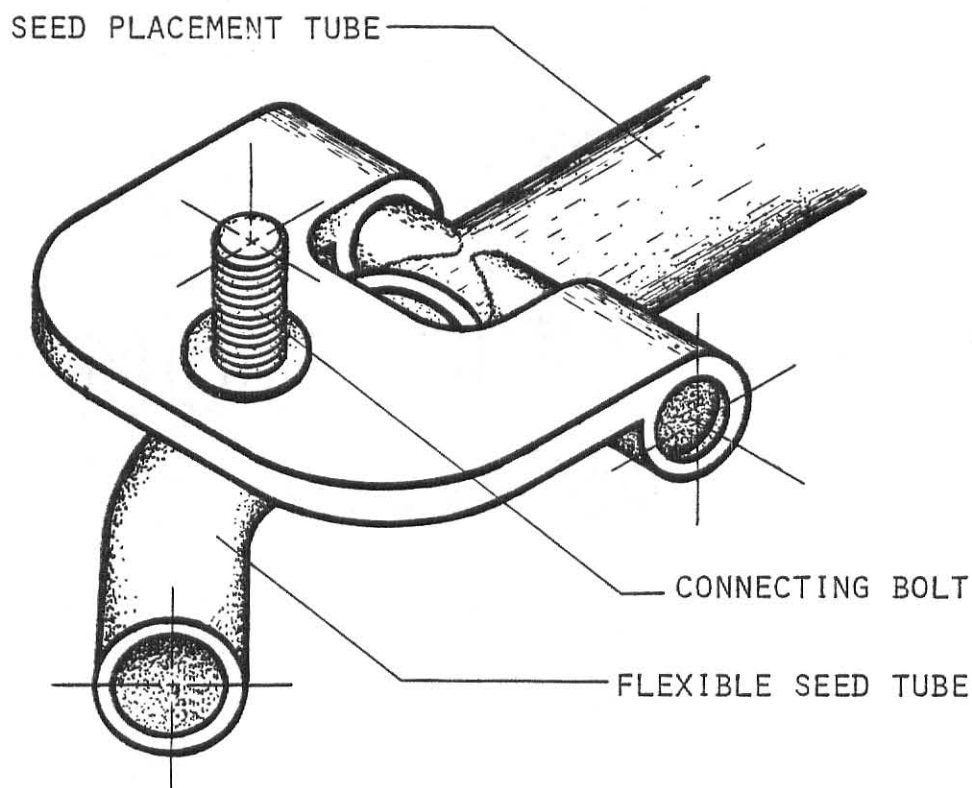


Figure 7. Initial Hinge Used to Connect the Seed Placement Tube to the Undercutter Blade.

freedom which permits the seed placement tube to rotate in both the vertical and horizontal planes. The horizontal degree allows the placement tube to follow the sweep blade around corners or along terraces. The vertical degree enables the placement tube to float at the set depth under the varying contour of the soil surface. This type of hinge is an essential element in achieving accurate and consistent depth control, which aids in uniform plant emergence.

The seed placement tube itself has several characteristics which are important to its functional design. The tube is formed from 25.4 mm [1.00 in] i.d. pipe which has a length of 610 mm [24.0 in]. The length

of the tube is important to allow time for the soil to flow over the blade, down and beneath the tube. The flow of soil back beneath the tube is aided by the bends placed in the tube behind the hinge (Figure 6). These two bends provide for the remainder of the tube to slope downward towards the point of seed release. The soil flows back over the end of the placement tube, returning to some what of the original soil profile. This eliminates dry surface soil and residue from falling into the seed zone. The end of the placement tube has been given a "V" shape and is hard-surfaced for wear protection (Figure 8). The downward sloping tube, combined with the shape of the end of the tube, results in the formation of a firm "V" channel in the soil. The "V" channel aids in seed placement. Since the tube is pulled beneath the soil surface, the seed is trapped in the channel, thus eliminating any chance of the seed bouncing around. This trapping action aids in maintaining the seed spacing. Since the seed is trapped against the firm groove in the bottom of the channel and not in loose soil, air pockets which hinder seed germination are eliminated. It is also believed that the firm groove provides easier access to moisture, nutrients, and a firm root base for the seedling. This eliminates the need for closing devices such as knives, disks, or closing wheels.

The transporting medium for the seed is air, which is supplied from the pressurized system. Since soil covers the end of the placement tube it is important to provide a pressure release tube which is located 180 mm [7.1 in] from the end of the placement tube (Figure 8). The pressure release tube is perpendicularly connected to the placement tube, rises to a level above the soil, and bends rearward to prevent soil or residue

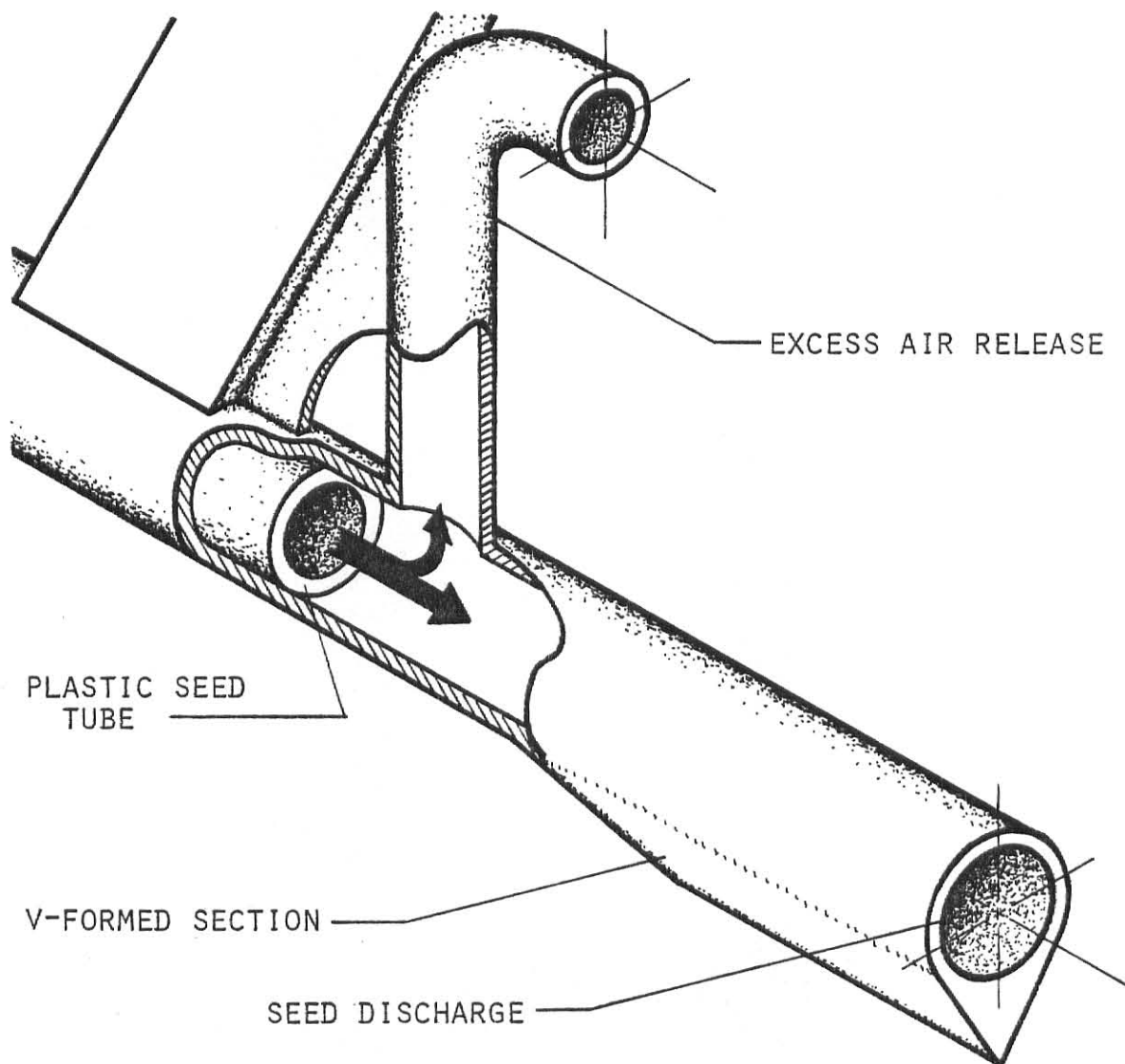


Figure 8. The Rear Portion of the Seed Placement Tube Showing: Expansion Chamber, Excess Air Release, and V-Formed End.

from plugging it when in operation. It is believed that the plastic seed connecting tube, the placement tube, the pressure release tube, and their relative dimensions aid in the final seed deceleration and placement (Figure 8). This deceleration occurs when the seed enters the

expansion chamber and aids in placing the seed in the firmed groove formed for it.

A support member is used to connect the placement tube to the press wheel assembly (Figure 6). On the lower end it is connected to the seed placement tube at a 60° angle to aid in splitting the soil and residue as it flows around the vertical portion of the unit. The upper portion of the member has four holes which are tapped to receive cap screws for clamping the press wheel assembly (Figure 9). Also located on the upper portion of the support member are reference depth slots which aid the operator in setting the depth of seed placement.

#### Press Wheel Assembly

The dual-function design of the press wheel assembly is essential to the concept being used. Being directly connected to the seed placement tube, the assembly functions as gauge wheels to maintain depth control. The geometric configuration also enable the assembly to function as press wheels to firm the soil around the seed. The selection of the wheels was based on the function which they would serve relative to the crop being planted. The varying requirements for soil firmness and row spacing dictate the need for a different press wheel assembly design for wheat relative to row crops.

Herron (1978) recommended the use of large diameter press wheels behind the undercutter since they were less sensitive to soil firmness and to heavy amounts of crop residue. Smaller wheels tended to slide along in soft soils or in corn residue. The press wheels that were selected for this project were John Deere heavy clincher-rim, semi-

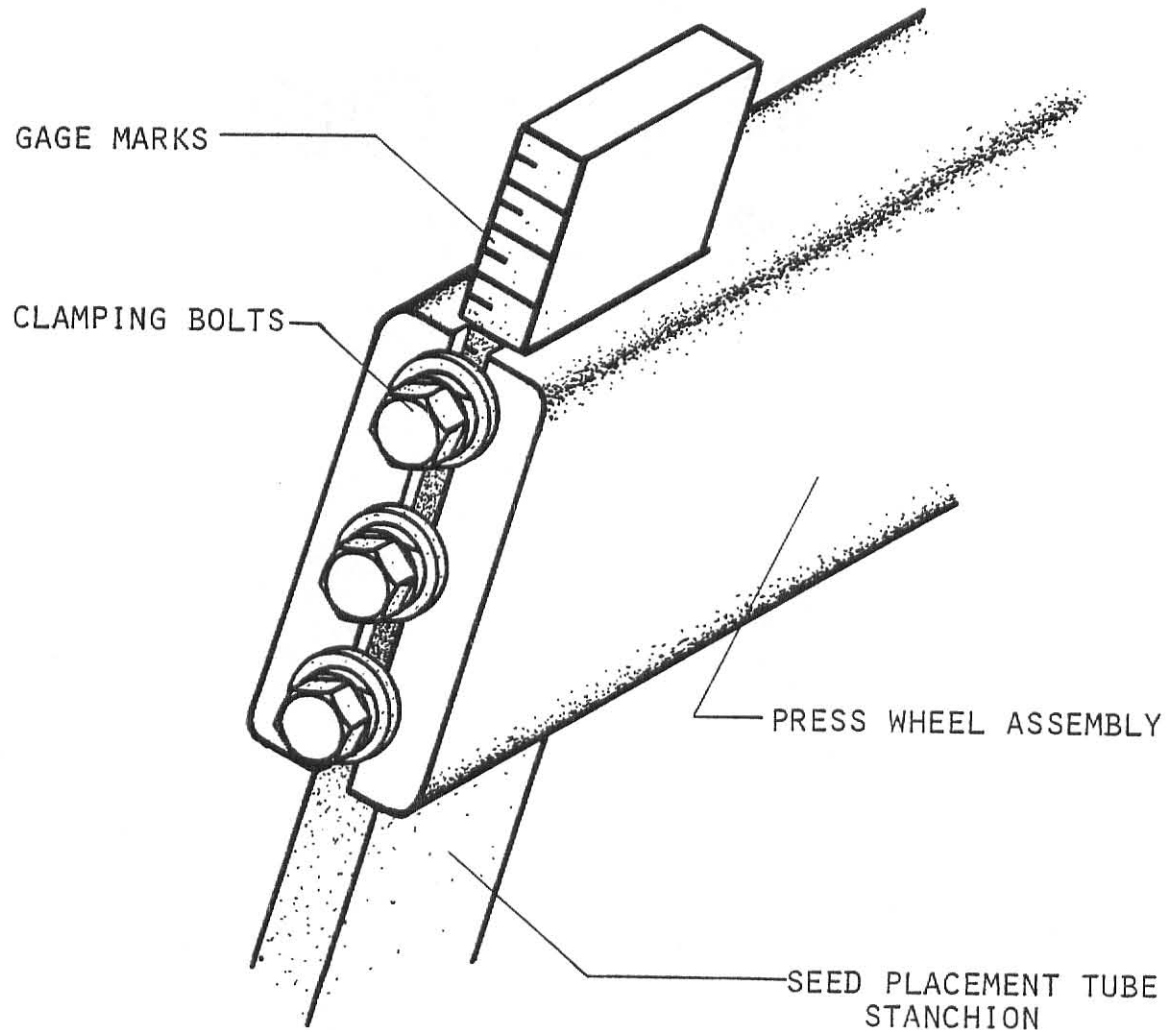


Figure 9. Depth Adjustment Clamp.

pneumatic wheels which are 660 mm [26 in] in diameter and are 50 mm [2 in] wide. The semi-pneumatic designed tire flexes to prevent ball-up in wet or sticky conditions. The wheel is a hollow design which will give a weight of 14.5 kg [32 lbs] for use when planting wheat and 36.2 kg [80 lbs] when filled with sand for use in row crops. An effective contact

area of  $155 \text{ cm}^2$  [ $24 \text{ in}^2$ ] for the individual wheel gives an average surface pressure of  $21 \text{ kPa}$  [ $3 \text{ psi}$ ] for the heavy wheel and  $9 \text{ kPa}$  [ $1.3 \text{ psi}$ ] for the light wheels. This value is somewhat higher than is actually seen, since the seed placement tube carries some of this weight.

The press wheel assembly for row crops uses the concept of V-type wheels (Figure 10). The angled press wheels direct the pressure diagonally toward the seed, optimizing the soil-to-seed contact. The soil in the seed zone is well firmed, while the soil surface directly above the seed is loose. This low mechanical impedance above the seed provides the weak seedlings a better chance for emergence.

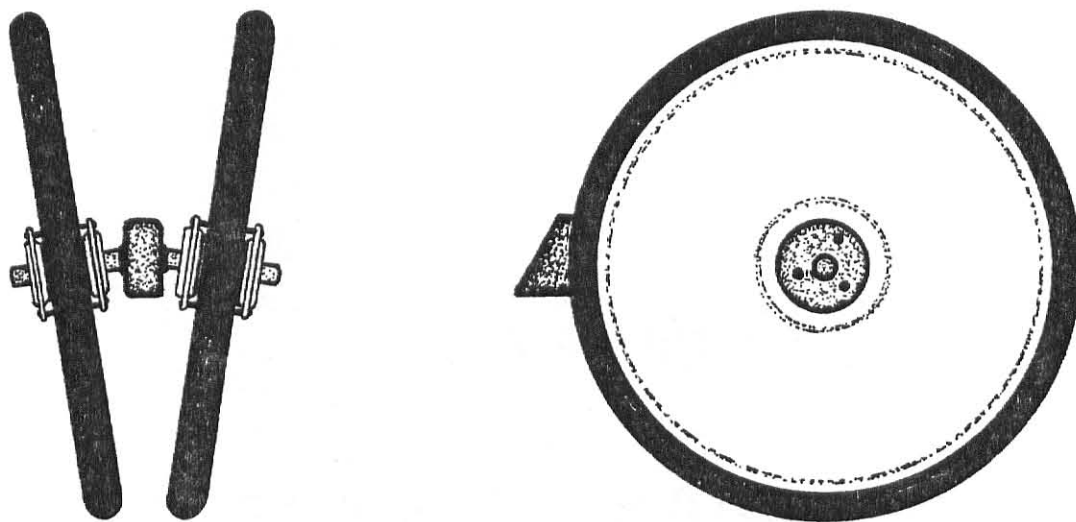


Figure 10. Row Crop Press Wheel Assembly.

On many conventional planters, the press wheels carry part of the

weight of the planter unit. This concept utilizes a constant pressure from the weight of the press wheel alone. As soil conditions vary, the width at which the press wheels are set can be adjusted to vary the location of the compaction in the seed zone. This is done by moving the wheels out or in on the axles of each row unit.

The press wheel assembly for planting wheat consists of a single wheel (Figure 11), the same wheel as used for row crops except lighter in weight. The major consideration given to the wheat assembly is for it to provide accurate and consistent depth control. The weight of the wheel is approximately 15 kg [33 lbs], which is considerably less than for row crops.

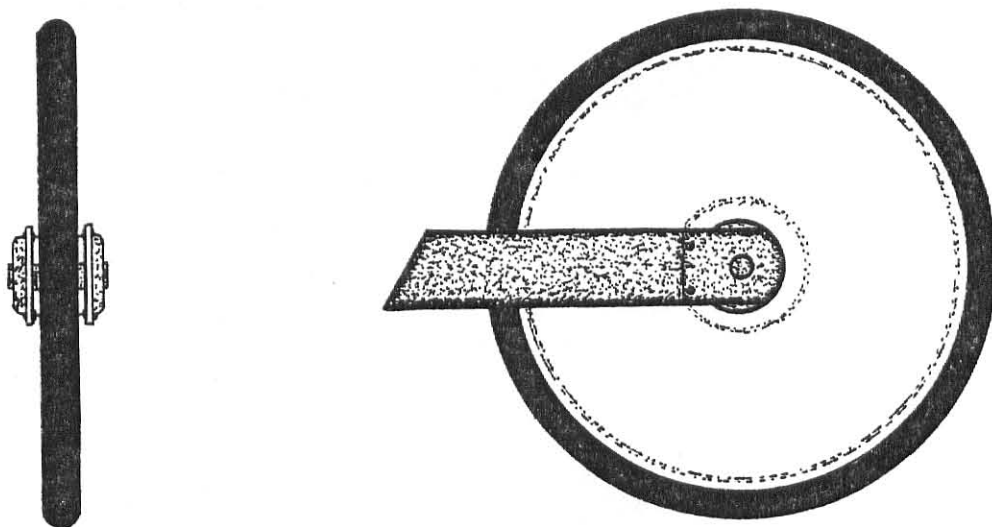


Figure 11. Small Grain Press Wheel Assembly.

The wheel is supported from both sides to aid in stability and it is connected by the same means to the same seed placement tube as that used for row crops.

The connection between the press wheel assembly and the connecting member of the seed placement tube is of the sliding clamp design (Figure 9). When a depth adjustment is needed, the bolts are loosened and the press wheel assembly is raised or lowered relative to the gauge marks. The bolts are then tightened, which clamps the bracket to the seed placement tube.

#### Undercutter Frame Modification

The undercutter frame required only minimal amount of modification for the first prototype. The center section of the Richardson AE-4-15-1 undercutter was used for the two row prototype. Framework had been added to mount the Cyclo system on the frame. A hole was drilled through the rear portion of the frog for each hinge for connecting the seed placement tubes. Each hole was located a lateral distance of 380 mm [15 in] out from the undercutter shank to provide a 760 mm [30 in] row spacing. For road travel, the prototype was equipped with cantilever type arms to support the press wheels and the seed delivery tube assembly (Figure 16). The arms are clamped onto the main undercutter frame and are hinged to follow the delivery tube when turning (Figure 12).

#### Coulter Assembly

A coulter supported from the undercutter frame is placed in front

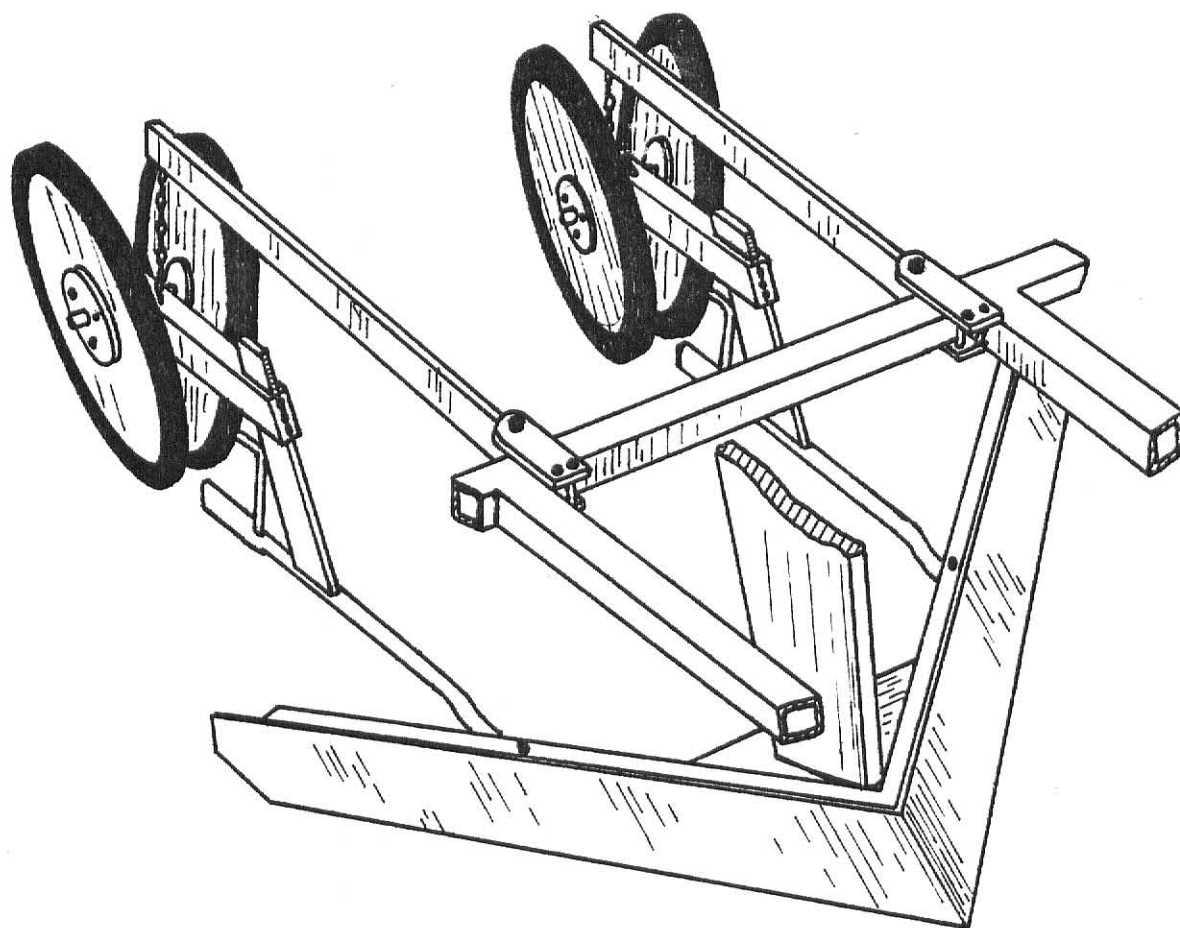


Figure 12. Cantilever Arm Supports for Transport.

of each sweep shank to cut the residue to obtain smooth soil-residue flow around either side of the shank. It is also important to obtain this type of soil-residue flow around the shanks of the seed placement tubes. To do this, additional coulter assemblies are mounted to the leading portion of the undercutter frame in order to lead each of the seed placement tube. These additional coulter assemblies are important

in heavy residue conditions, such as planting milo or soybeans in wheat stubble, but can be left off when planting in relatively clean conditions. The fluted coulters were selected because of their ability to stay sharp as they wear.

#### Test Procedure

In May of 1980, the first two-row prototype was finished and functional tests were set up to evaluate the concept. The first tests were run in a field which sorghum had been harvested (silt loam) north of Manhattan, Kansas. These tests were to evaluate several basic functional requirements. The first was to determine if the undercutter blade would, in fact, pull the seed placement tube beneath the ground and deposit the seeds at a uniform spacing. The second item was to determine if the seed was being placed in moist soil with loose soil above it representing the original soil profile. The third item was to evaluate the press wheels' ability to not only firm the soil around the seed, but to roll consistently in residue or loose soil. Lastly, the fourth requirement was to determine whether the planter could be left in the ground while turning corners. Corn seed was used in these tests because of the ease at finding the kernels.

After several minor modifications were made, the planter was then taken to Newton, Kansas for further evaluation. Several fields were selected to provide a variety of residue and soil conditions. The planting conditions represented included: standing immature wheat (silty clay), brome sod (silty clay), both tilled and non-tilled sorghum ground (silty clay loam), and wheat stubble (silty clay loam) following

the harvest of 40 bushel per acre wheat. These tests were run to gain more information concerning the functional requirements of the earlier tests and to determine the ability of the planter to produce a stand of milo. These tests were also designed to give the planter its most severe test of its residue handling ability.

In September of 1980, the planter was then returned to Manhattan, Kansas for some quantitative comparison tests. Test plots were set up to check plant emergence for various ground speeds, blade depths, and air pressures. A Buffalo Till-Planter was also run in side-by-side comparison tests.

These tests were run in corn silage ground (silt loam) which had been cut the previous month. Moisture was present at a depth of 40 mm [1.5 in]; no additional moisture was received until after emergence checks were made. The exact moisture content of the soil was not determined.

### Results

Even though the summer of 1980 was too dry for row crops in south-central Kansas, some important information was collected. An excellent milo stand was produced by the planter in the non-tilled milo stubble. However, as the drought lengthened, the milo showed moisture stress. The plot tests also revealed that there was a distinct need to apply insecticide at the time of planting to control chinch bugs.

By July, the wheat ground had become very dry and hard. The additional weight of the Cyclo seed metering unit on the undercutter enabled

the blade to penetrate the soil. Considerable optimism was gained by the ability of the planter to handle the wheat stubble. The milo was planted in this dry soil in hopes of a rain. Even after the seed laid in the soil for over a month before the rain came, a good stand of milo emerged. The stand showed considerably more foliage than other double cropped milo in the area.

The quantitative comparison tests run at the Kansas State University Agronomy Farm in Manhattan gave additional optimism to the project. The data of the comparison with the Buffalo Till-Planter is shown in Table 1. The comparison work of the undercutter planter run at various ground speeds, blade depths, and operating pressures is shown in Table 2. All planting depths for these comparisons were set at 50 mm [2 in].

### Final Design

The final design included major changes to the seed placement tube, some minor frame modifications, the addition of insecticide equipment, and the addition of a fertilizer distribution system. The final planter is shown in Figure 13.

#### Seed Placement Tube

Modifications in the seed placement tube were made for three reasons: to eliminate problems associated with running the seed tubes under the undercutter blade, to provide the capability for introducing a granular insecticide into the air stream, and to provide a stronger hinge to attach the seed placement tube to the frog. Both the insecticide and the seed are now deposited together in the underground channel

|                                    | BUFFALO TILL-PLANTER |              | UNDERCUTTER PLANTER |              |              |
|------------------------------------|----------------------|--------------|---------------------|--------------|--------------|
| Operating Speed,<br>km/hr (mph).   | 6.4<br>(4)           | 9.7<br>(6)   | 6.4<br>(4)          | 6.4<br>(4)   | 9.7<br>(6)   |
| Blade Depth,<br>mm (in).           |                      |              | 90<br>(3.5)         | 150<br>(6)   | 90<br>(3.5)  |
| Set Seed Rate,<br>Seeds per Acre   | 57,000               | 57,000       | 56,500              | 56,500       | 56,500       |
| Emergence Rate<br>Plants per Acre. | 28,700               | 33,200       | 49,170              | 47,000       | 47,400       |
| % Emergence.                       | 50                   | 58           | 87                  | 83           | 84           |
| Average Spacing<br>X, mm (in).     | 185<br>(7.3)         | 160<br>(6.3) | 108<br>(4.3)        | 113<br>(4.4) | 112<br>(4.4) |
| Standard Dev.<br>S, mm (in).       | 180<br>(7.1)         | 127<br>(5.0) | 86<br>(3.4)         | 113<br>(4.4) | 98<br>(3.9)  |

TABLE 1. Comparison Tests Between the Undercutter Planter and the Buffalo Till-Planter (Planted Sept. 10, Emergence Count Sept. 26).

formed by the seed placement tube.

Figure 14 shows that the seed delivery tube and the insecticide tube attach to the seed placement tube from on top of the press wheel assembly. The seed travels down the seed placement tube, past the excess air release tube, and is deposited in the channel formed by the placement tube itself. The insecticide enters the seed tube after the excess air release and is carried out by the residual air flow to be deposited with the seed in the channel.

To improve the stability of the seed placement tube and the press wheels, the connecting hinge was redesigned. Figure 15 shows the rein-

|                                             |              |              |              |              |              |
|---------------------------------------------|--------------|--------------|--------------|--------------|--------------|
| Operating Speed,<br>km/hr (mph).            | 9.7<br>(6)   | 6.4<br>(4)   | 6.4<br>(4)   | 6.4<br>(4)   | 6.4<br>(4)   |
| Blade Depth,<br>mm (in).                    | 90<br>(3.5)  | 90<br>(3.5)  | 150<br>(6)   | 90<br>(3.5)  | 90<br>(3.5)  |
| Air Pressure,<br>kPa (in H <sub>2</sub> O). | 1.2<br>(5)   | 1.2<br>(5)   | 1.2<br>(5)   | 0.8<br>(3)   | 2.2<br>(9)   |
| Set Seed Rate<br>Seeds per Acre             | 56,500       | 56,500       | 56,500       | 56,500       | 56,500       |
| Emergence Rate<br>Plants per Acre.          | 47,000       | 49,170       | 47,400       | 36,830       | 46,830       |
| % Emergence.                                | 83           | 87           | 83           | 65           | 83           |
| Average Spacing,<br>$\bar{X}$ , mm (in).    | 113<br>(4.4) | 108<br>(4.3) | 112<br>(4.4) | 144<br>(5.7) | 113<br>(4.4) |
| Standard Dev.<br>S, mm (in).                | 113<br>(4.4) | 86<br>(3.4)  | 98<br>(3.9)  | 149<br>(5.9) | 86<br>(3.4)  |

TABLE 2. Comparison Tests of the Undercutter Planter at Various Ground Speeds, Blade Depths, and Operating Air Pressures (Planted Sept. 10, Emergence Count Sept. 26).

forced hinge that connects the seed placement tube to the frog.

#### Insecticide Equipment

Gandy insecticide boxes were purchased to meter the insecticide. The boxes were mounted on the walkway railing directly above the seed placement tubes, which permits the insecticide to fall by gravity down into the seed placement tube (Figure 16). Adjustment is provided on the boxes to set various application rates. The boxes are mounted in pairs which are driven by electric motors; this eliminates many of the problems associated with drive chains and a flexible frame.

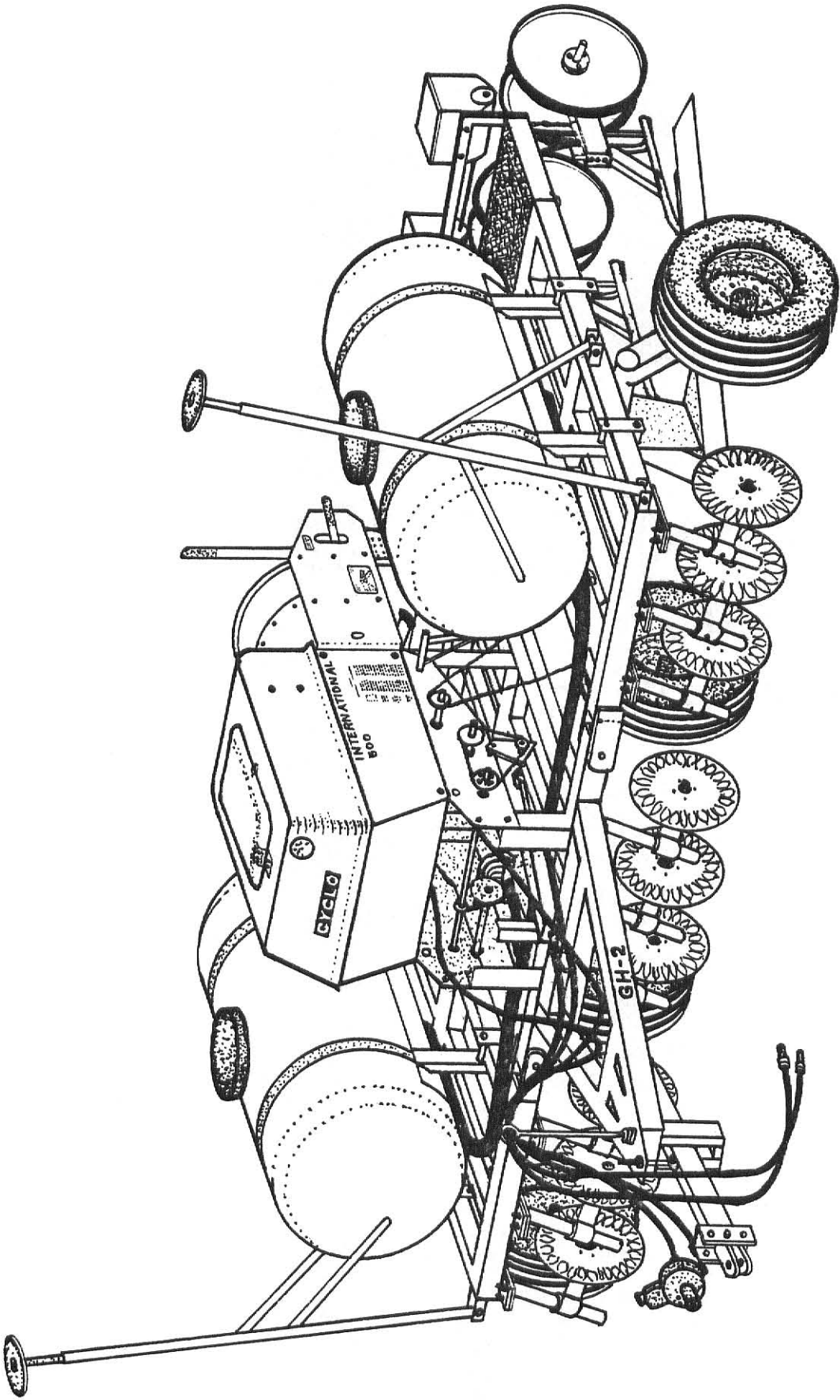


Figure 13. Final Design of the Completed Planter.

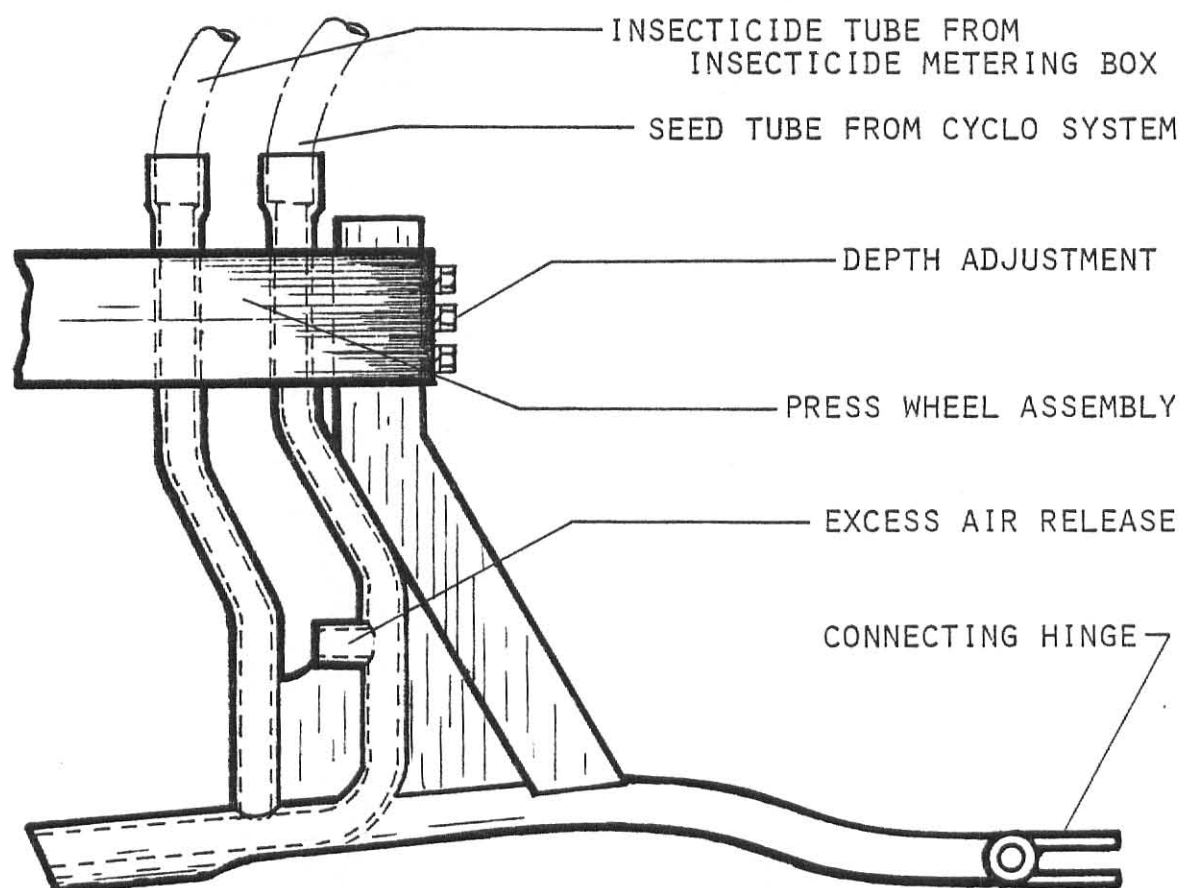


Figure 14. Final Design of the Seed Placement Tube.

#### Fertilizer Distribution

A fertilizer distribution system was also added to the final design. A John Blue liquid fertilizer squeeze pump was used for metering and for pumping the fertilizer beneath the undercutter blades. A 200 gallon liquid fertilizer tank was mounted on each wing of the three section frame. The pump and the tanks are the same as those used in

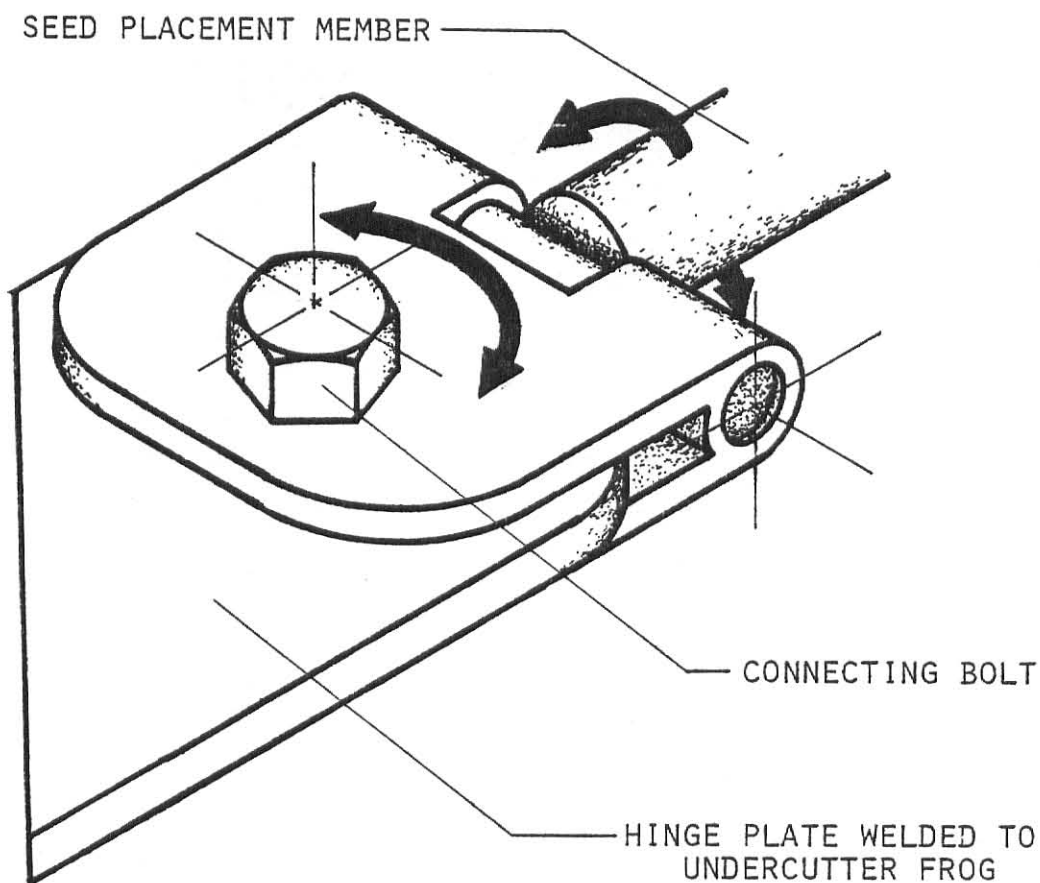


Figure 15. Final Hinge Including the Plate Which is Welded to the Undercutter Frog.

earlier work done by Herron (1978).

Liquid fertilizer was selected due to ease of metering and distribution, and because of the basic design of the seed placement tube. The only possible way of putting a starter fertilizer at or below the seed level involved the use of a liquid fertilizer. It was also desirable to have the option to either use a starter fertilizer or a complete liquid fertilizer. The final design permits switching from a starter to a

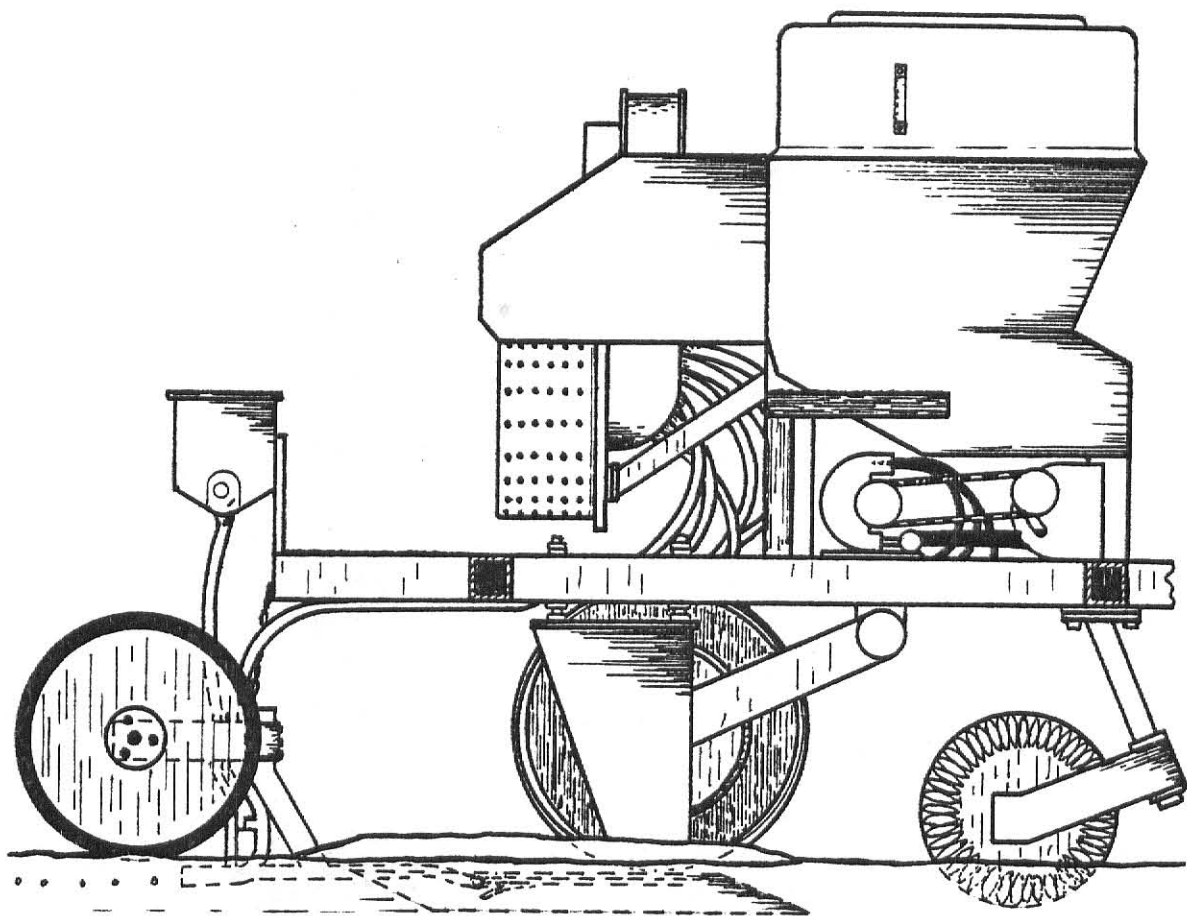


Figure 16. Schematic of Final Design with Rear Walkway and Mounted Insecticide Boxes.

complete fertilizer by only changing a small plate connected to the hinge of the seed placement tube.

Figure 17 shows the starter fertilizer plate bolted to the hinge, which allows the starter fertilizer to be placed approximately 35 mm [1.5 in] below the seed. Figure 18 shows the complete fertilizer plate bolted to the hinge; this allows for half of the fertilizer to be placed about 50 mm [2 in] to each side and 50 mm [2 in] below the seed. The

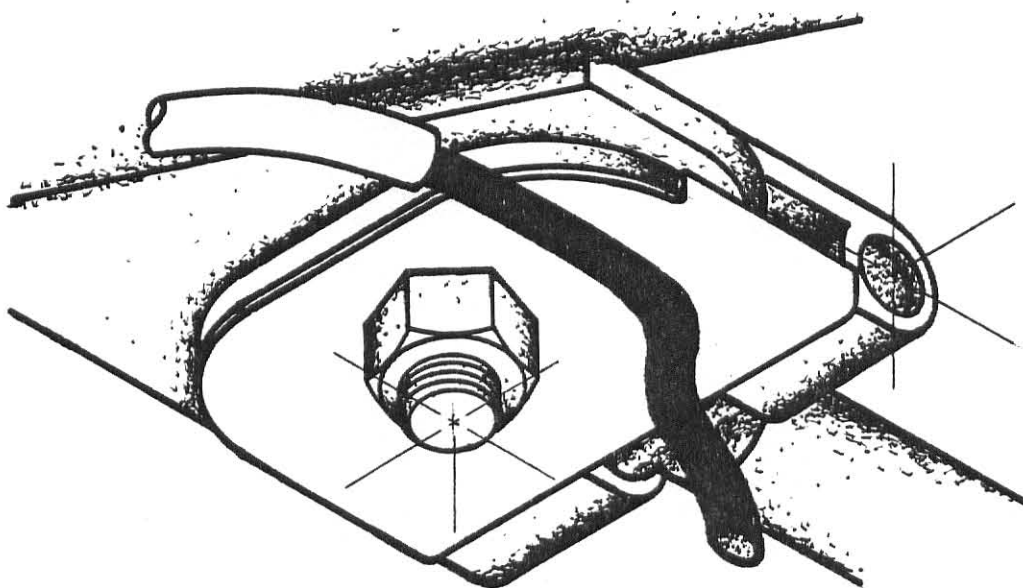


Figure 17. Bottom View of Starter Fertilizer Plate.

fertilizer will always be pointed in the direction of the seed discharge, even when pulling the planter around a corner, because of the location of the plate attachment.

#### Frame Modifications

The original design had cantilevered members extending rearward to support the seed placement tube and press wheels while in the transport position. These same members can be used in areas where insecticides are not necessary. But for areas where insecticides are essential, a walkway was considered essential. It was constructed from tubular steel and connected to the rear of the planter. The insecticide boxes are mounted on the walkway frame (Figure 13). This walkway provides a safe

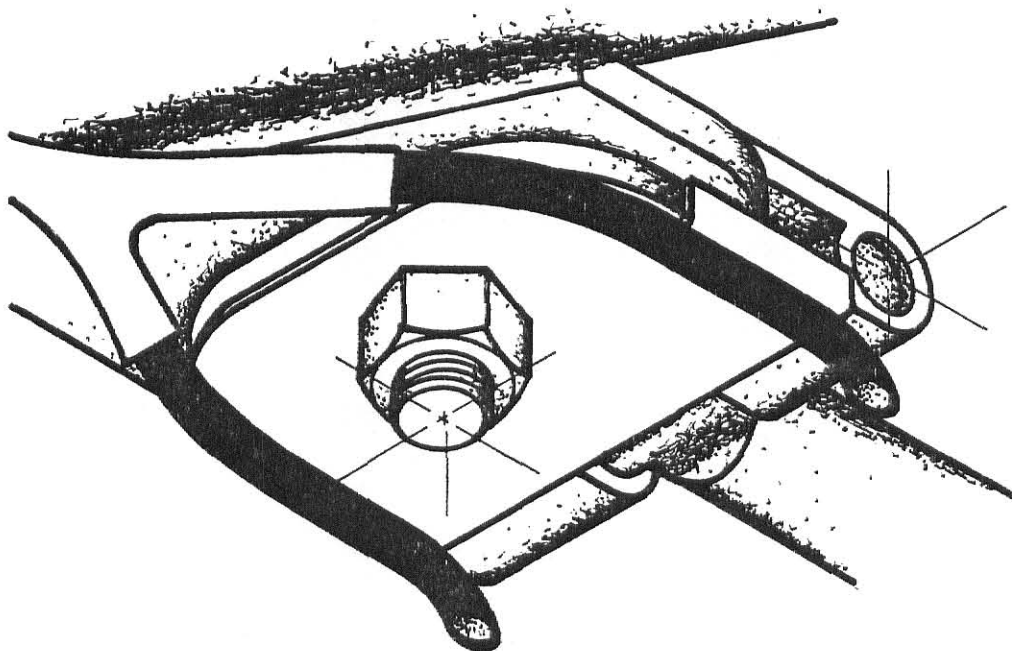


Figure 18. Bottom View of Complete Fertilizer Plate.

access to the insecticide boxes, the Cyclo hopper, and the fertilizer tanks. Steps are provided to the walkway on the right side of the planter.

The other modification to the frame involved the addition of plates to the "frog" for attachment of the seed placement tubes. Figure 15 shows the plate installation. This plate is the center member of the connecting hinge. For planting wheat, this plate would consist of a long narrow plate welded to the rear of the frog, or incorporated into the frog, with holes spaced to accommodate the additional seed placement tubes.

## DISCUSSION OF RESULTS

Results of the functional tests from various soil and crop residue conditions were used in the final development of the planter. This discussion will be broken down into four primary functions of a planter, which are: seed distribution and placement, soil firming, depth control, and residue handling ability.

### Seed Distribution and Placement

The International Cyclo system is a proven method for accurately metering seed. It is also a very easy and quick procedure to not only change the seeding rate, but also to meter different crop seeds. But as with any metering system, seed spacing can only be as accurate as the total seed delivery system permits.

The comparison tests with the Buffalo Till-Planter showed that we obtained better seed spacing than the Buffalo planter. However it was felt that the spacing accuracy was being affected by the irregular path the seed tubes took beneath the undercutter blade which included several elbows. This may have been the reason for the doubles and gaps seen in the emergence tests. This resulted in changing the design to that seen in Figure 14. The modification changed many of the seed tube irregularities into a smooth flowing stream.

Earlier work done by Herron (1978) suggested that seed spacing did not vary when air supply pressure varied between .5 and 1.7 kPa [2 and 7 inches water]. Results from Table 2 indicate a significant reduction in population at .7 kPa [3 inches water]. It also showed that between 1.2

and 2.2 kPa [5 and 9 inches water] no significant difference in population existed. These results are in agreement with the International recommendations.

Figure 19 shows the placement of the seed relative to the soil

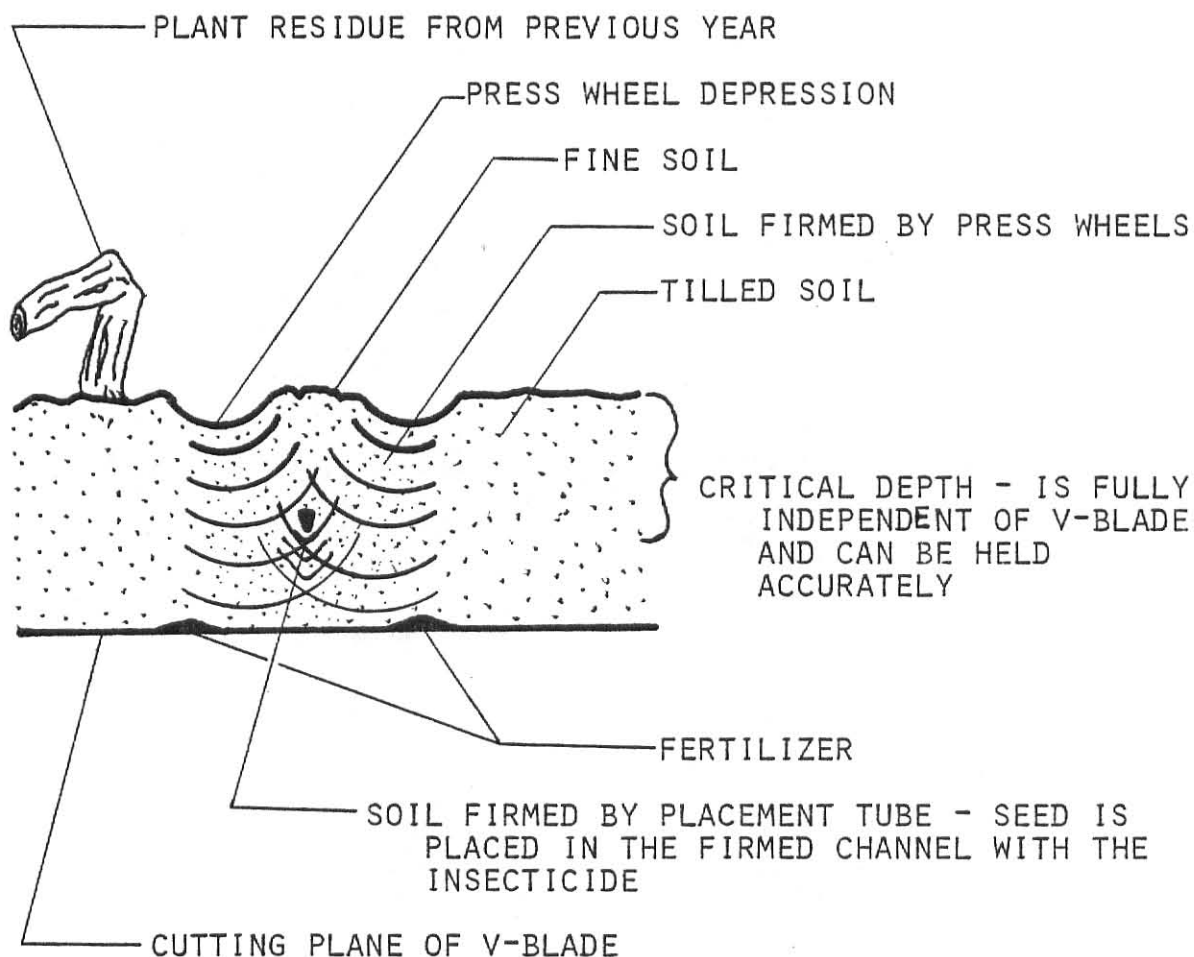


Figure 19. Schematic Diagram of Soil Profile After Planting Row Crops with a Complete Fertilizer.

profile. Even though the seed is placed in soil which has been tilled by flowing over the undercutter blade, the soil has not been mixed and

the seed is placed in an environment free of surface residue.

Placement of the seed relative to the fertilizer seems to be an additional advantage of the undercutter planter concept. Placing the fertilizer on the plane cut by the undercutter blade enables the fertilizer to be located below the seed. This seems to have two distinct advantages. The fertilizer is placed in the root zone for optimum plant utilization. Since roots are drawn toward the fertilizer, it draws them downward, resulting in less moisture stress during extended dry periods. In addition, placing the fertilizer below the seed starves the weeds which normally germinate in the top 3 cm [1 in] of soil. This provides a distinct advantage over conventional surface application of phosphorus and potassium or even with band application into the seed slot.

Figure 19 shows the location of the seed relative to the fertilizer for row crops when using a complete liquid fertilizer. Half of the fertilizer is placed 5 cm [2 in] to each side and 4 to 8 cm [1.5 to 3 in] below the seed depending upon the depth at which the undercutter blade is set.

Figure 20 shows the profile for row crops when using a starter fertilizer. The fertilizer is placed directly below the seed at a distance selected by the operator. This distance can vary between 3 to 8 cm [1 to 3 in] below the seed depending upon various depth settings.

#### Soil Firming

The concept of soil firming is very important to achieve high germination rates and seedling emergence. Soil firming is important to

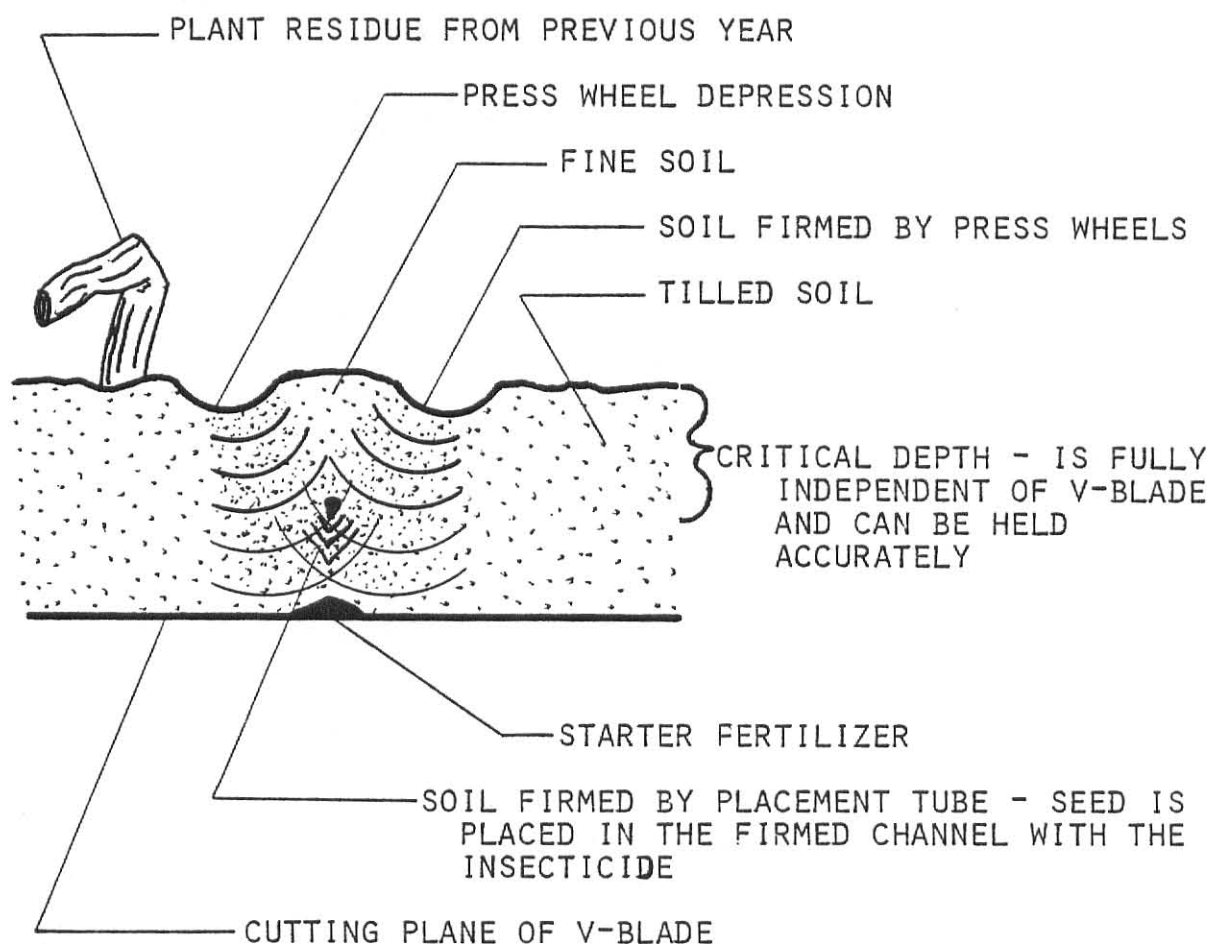


Figure 20. Schematic Diagram of Soil Profile After Planting Row Crops with a Starter Fertilizer.

obtain good soil to seed contact, low impedance above the seed, to increase the bulk density around and below the seed to aid capillary movement of moisture into the seed zone, and to slow the drying front as it moves down toward the seed.

Figure 19 shows two components which are used in this concept to firm the soil around and below the seed. The initial firming is done by the seed placement tube as it is pulled through the soil. This creates

a firm V-groove to place the seed into, which not only aids in the soil to seed contact, but also helps maintain accurate depth control. The final firming of the soil around the seed is done by the press wheels. Results from Table 1 and Table 2 support the idea that excellent soil to seed contact is being achieved with this configuration. Not only were the comparison results significantly better than with the Buffalo planter, but the percent emergences were relatively high themselves.

Soil impedance refers to the density or restriction of the soil directly above the seed. This is the route the seedling will take as it emerges through the soil surface. Surface compaction has little effect on impedance or crusting when the soil at planting is air-dry, but as the moisture content of the soil increases, so does the soil impedance and the crust strength. The double angled press wheels for row crops firm the soil around the seed, while leaving the soil toward the surface above the seed relatively loose (Figure 19). The press wheels can also be adjusted on their axles to vary the bulk density of the soil surrounding the seed. This should be kept in mind when operating in relatively moist soil conditions.

For planting small grains, the soil profile configuration is shown in Figure 21. Some grain drill manufactures believe that in certain locations press wheels are optional. The single press wheel in the small grain configuration is used solely as a gage wheel to maintain the depth of planting. Because the light weight wheels would be used, there is very little compaction taking place.

Increasing the bulk density of the soil around and below the seed

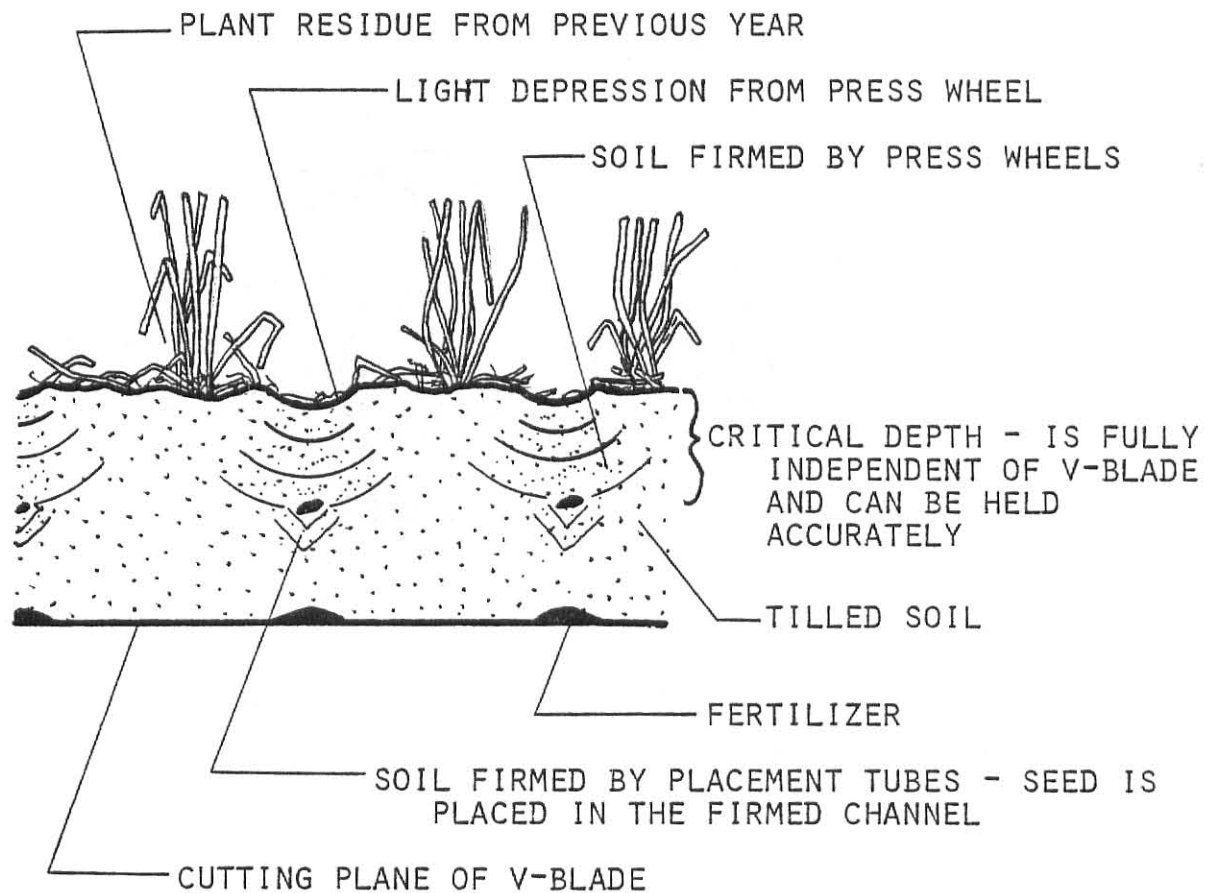


Figure 21. Schematic Diagram of Soil Profile for Small Grains.

also aids in capillary movement of moisture into the seed zone. This is especially important since the seed is placed into tilled soil and not into non-tilled soil as is done with conventional planters. This moisture is drawn up from below the cutting plane of the V-blade as seen in Figure 19. This may not be important if the seed is planted in relatively moist soil, but is very important if the moisture content of the soil in the seed zone is low.

As mentioned in the literature review, firming the soil around the seed slows the drying front as it moves down toward the seed. The moisture required by seeds for germination is absorbed from the surrounding soil. Thus, if the drying front could be slowed, giving the seed additional time to germinate, the population and the uniformity of plant emergence could be improved. This phenomenon is believed to be occurring in the profile shown in Figure 19. It is also believed that if soil can be placed back over the seed in the original profile, the seed will be surrounded by moist soil. The drier surface soil will reduce evaporative loss of moisture from the seed placement zone.

#### Depth Control

Accurate depth control and adjustment is one of the most important attributes of a planter that affects seed germination and emergence. This was also one of the major reasons for continuation of the planter development in 1979. Qualitative results of seed depth relative to the soil surface were not taken, but theoretically the design seems to be very sound. One of the major improvements since the undercutter planter developed by Herron (1978) is that the critical depth, as shown in Figure 19, is maintained independently of the V-blade depth.

The hinge that connects the seed placement tube to the undercutter blade allows individual row units to float with the contour of the soil. Accurate and consistent depth control is maintained over humps and dips because the seed discharge is located below the press wheels (gage wheels). The seed placement tube discharge follows the terrain which helps maintain seed placement depth; this results in a more uniform rate

of emergence.

The press wheels used are John Deere semi-pneumatic rubber tires. These were selected because of their ability to continually flex to avoid soil buildup, which also helps maintain accurate depth control.

Adjusting the depth of planting proved to be simple; the bolts shown in Figure 9 are loosened to allow the adjustment to be made. It is recommended that the minimum depth for operating the undercutter plow is 8 cm [3 in]. This leaves a relatively wide range of depth adjustment between 4 and 8 cm [1.5 and 3 in] for planting. Deeper planting depths are possible when operating the undercutter blade deeper than 8 cm [3 in]. This may be essential to provide the proper depth for fertilizer application.

Results from Table 2 showed that increasing the blade depth to 15 cm [6 in] did not significantly affect plant populations.

#### Residue Handling Ability

One of the original reasons for starting the undercutter planter project was the inability of existing minimum tillage planters to handle large amounts of residue. Two important dimensions when referring to any type of tillage or planter equipment and its ability to handle residue are vertical clearance and width between shanks. The undercutter planter seems to possess these features.

With the undercutter planter, the ability to handle residue begins with the leading coulter. Additional mass was added to the leading edge of the undercutter frame to help achieve good penetration. The mass is

important to slice the residue instead of pushing the residue into the soil, or prevent riding on top of the soil surface because of the lack of adequate weight. It is also important to have the coulters set deep enough to function properly. There are conditions such as planting in milo residue, where the leading coulter may not be essential to satisfactory planter operation.

The wheat stubble testing which was done pointed to another feature which aids in the planter's ability to go through large amounts of loose residue. As is seen in Figure 6, the press wheels are located fairly close to the point at which the connecting shank comes out of the ground. What seems to happen is that when residue hooks around the shank the press wheels pull it off. This is accomplished because of their relation to each other and the relative motion of the press wheels to the shank. Because of this, the distance between connecting shank and the press wheels was decreased in the final design.

One of the disadvantages of this concept is the distance between the leading coulter and the seed placement tube. Turning a corner while the planter is in the ground or planting around a terrace in heavy amounts of residue does create residue problems because the seed placement tube does not follow the penetration or slice of the coulter.

## CONCLUSIONS

An undercutter plow can be successfully combined with planter components to produce a satisfactory crop stand. Given adequate moisture conditions, the undercutter planter should produce stands comparable or superior to conventional minimum tillage planters.

The undercutter planter has proven its ability to plant corn and grain sorghum. It is also felt that the present design is capable of planting soybeans and wheat.

The seed placement tube concept provided a consistent and accurate means for setting and adjusting the depth of seed placement. Field tests have indicated that it is possible to maintain seed depth independently of the depth of the undercutter blade in a variety of field conditions.

Field tests indicated that the present double press wheel configuration provides excellent soil-to-seed contact when planting row crops. This was indicated by the high emergence rates achieved during the comparison tests. The concept also provides a satisfactory means of adjusting the soil compaction at the seed level.

The undercutter planter performed well in both conventionally prepared seedbeds and in non-tilled heavy residue conditions. Its ability to plant in heavy residue conditions may be one of its strongest assets.

The fertilizer application system developed promises to be another real advantage of the planter over conventional minimum tillage

planters. Placement of the fertilizer below the seedling can be successfully accomplished with the undercutter concept.

It is felt that this planter can effectively place insecticides with the seed for optimum plant utilization.

The author feels that significant improvements have been made, not only over the original undercutter planter, but in regards to conventional minimum tillage planters available to farmers today.

## SUGGESTIONS FOR FUTURE RESEARCH

A sizeable amount of additional development and testing should be done before a planter of this type could be marketed. Some of this development has to do with structural analysis and manufacturing processes. Another part of it has to do with additional development associated with planting small grains, refinements in fertilizer application methods, and component wear patterns.

Planting small grains such as wheat has some tremendous advantages when done in heavy residue conditions. The present concept provides this potential capability, but additional development and testing is needed. This would be a very large project in itself.

The application of anhydrous ammonia concurrently with planting would provide a real advantage for this type of planter over conventional minimum tillage planters. Undercutters have commonly been adapted for the application of anhydrous ammonia, so little additional work would be required. This ammonia application would be in addition to the liquid starter fertilizer being placed beneath the seed.

Further testing needs to be done concerning several areas of the basic seed delivery tube. An evaluation needs to be made to determine how well the pneumatic system will place the insecticide with the seed. Further evaluation needs to be done concerning the accuracy of fertilizer placement below the seed. Also of concern is the ability of the seed placement tube to resist wear over an extended period of time, especially the V-formed section.

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DEVELOPMENT OF THE KANSAS STATE UNIVERSITY  
MULCH TILLAGE PLANTER

by

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B.S., Kansas State University, 1978

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AN ABSTRACT OF A MASTER'S THESIS

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## ABSTRACT

Conventional row-crop planters or small grain drills, whether designed for conventional tillage, minimum tillage, or no-till, are commonly equipped with disk or shoe type openers which form an open slot for receiving seeds which are deposited from a seed metering mechanism. A fluted or rippled coulter is used to slice through the trash and soil ahead of the opener so that the opener is better able to form a firm slot for the seeds. One or more press wheels are also commonly provided to press the seed firmly into the soil, and usually to close the soil around the seed, for the purpose of obtaining better germination and emergence.

The objective of this study was to provide a planter which maximizes emergence with a minimum amount of tillage, thereby producing results superior to those of presently available minimum tillage planters, while at the same time reducing energy consumption, erosion problems, and compaction problems. The planter is combined with an undercutter plow so that the seeds are planted at set intervals behind the plow without the formation of exposed slots or furrows in the soil. The seeds are delivered directly to their planting sites beneath the surface of the soil, immediately following, and as part of, an undercutter plowing operation. The soil is firmed along the lower portion of the underground channel, just prior to seed placement within the channel, in addition to being firmed around the seed by the press wheels immediately after placement.

The undercutter seed planter takes the form of an elongated tubular

seed placement member adapted to be pulled beneath the soil behind the blade of an undercutter plow. A Cyclo air metering system supplies seeds to the seed placement member which are released at set intervals beneath the soil surface from a discharge opening at the member's trailing end. The trailing end portion of the member is formed to create a V-shaped channel to receive the discharged seeds, and a gage wheel assembly connected to the member's trailing end rides upon the surface of the soil and maintains the seed discharge opening at a predetermined depth beneath the surface. A two-way hinge connects the leading end of the seed placement member to the undercutter blade to permit vertical and horizontal movement of the member's trailing end with respect to the blade.

Also provided with the planter are auxiliary tubes which are located at, and connected to, the hinge below the undercutter blade. These are used for injecting liquid fertilizer below the seed channel in the form of a starter or a complete fertilizer.

In regions where insecticides are essential, insecticide equipment is available to place insecticide with the seed in the channel beneath the soil surface.