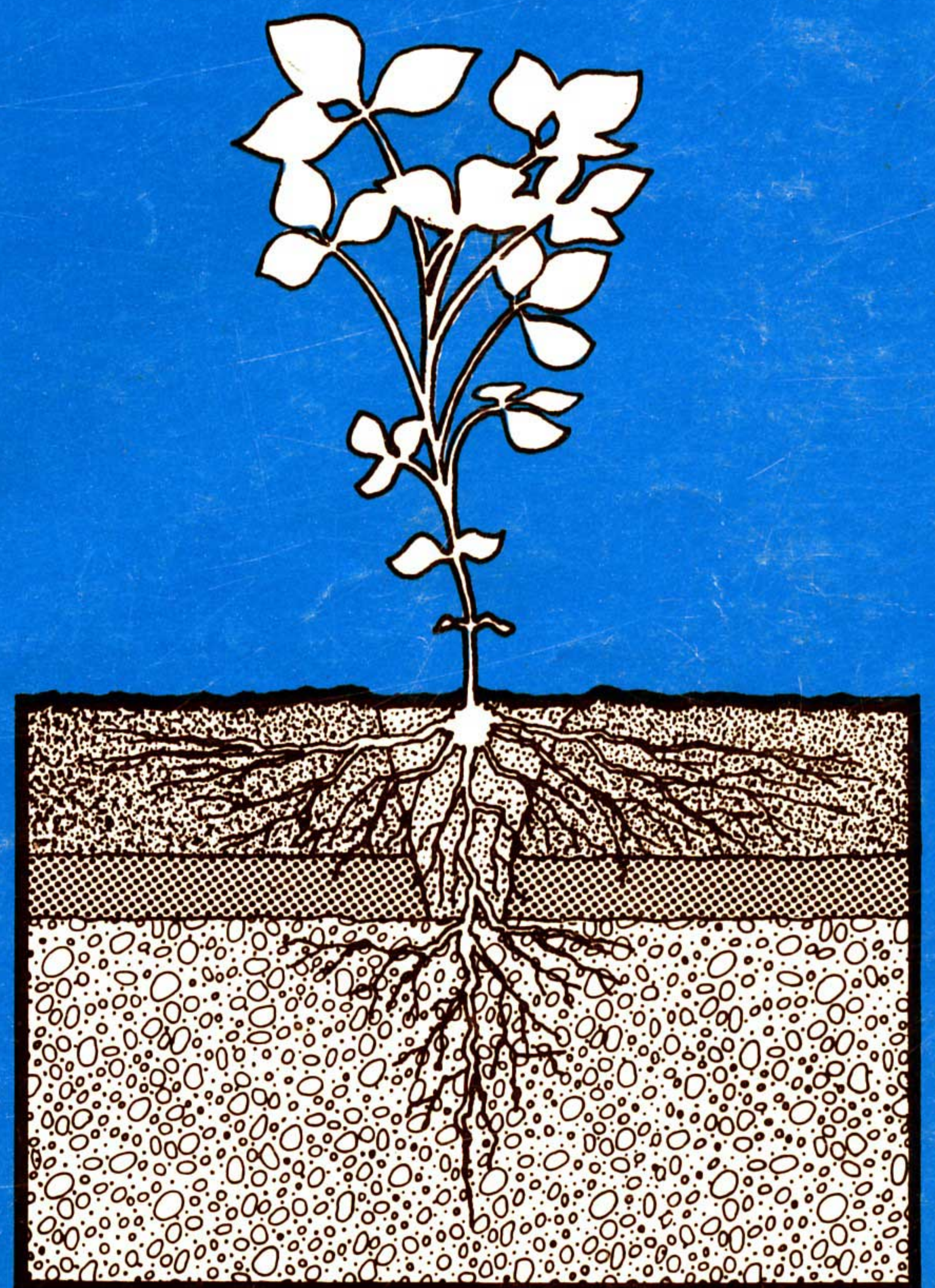
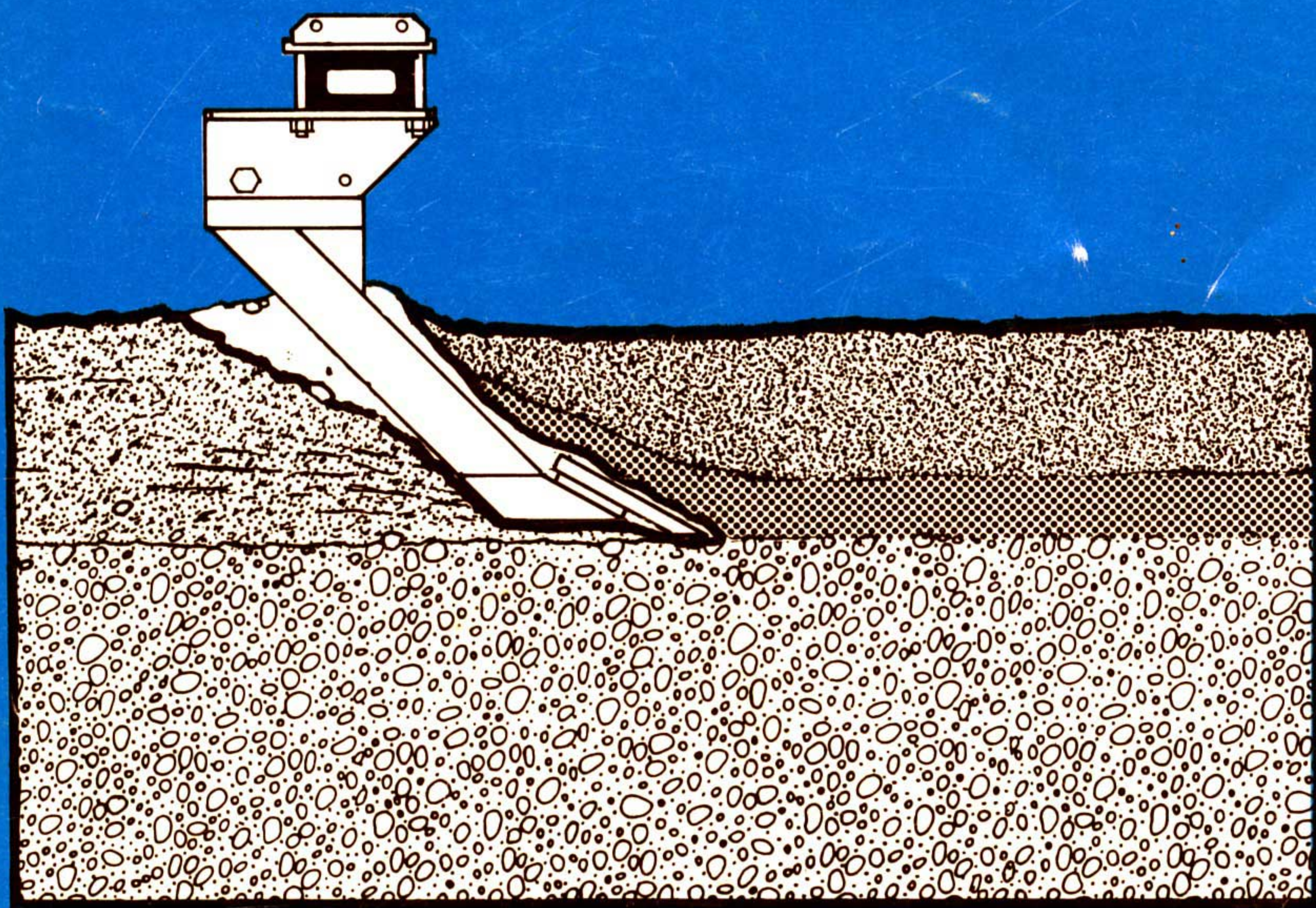


Subsurface Compaction & Subsoiling in North Carolina

An Overview



An Overview

Subsurface Compaction and Subsoiling in North Carolina

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Use of specific brands of seeds, pesticides and tillage equipment by the North Carolina Agricultural Extension Service or North Carolina Agricultural Research Service does not imply endorsement of them nor criticism of similar products not mentioned.

An Overview

Subsurface Compaction and Subsoiling in North Carolina

THE LOCATION, NATURE AND CAUSES OF COMPACTED LAYERS

Soils with certain sandy characteristics tend to develop a dense, compacted layer beneath the surface. This dense layer—at a depth from 6 to 8 inches, where it occurs—frequently restricts root development as though this layer were an impenetrable pan in the soil. For at least 50 years farmers and soil scientists in the Southeastern United States have

recognized this condition and generally referred to it as a “pan layer,” “hard pan,” or “tillage pan.” This problem is common across much of the Coastal Plain of the Southeastern United States. Figure 1 shows the general regions where substantial areas of soils have developed pan layers.

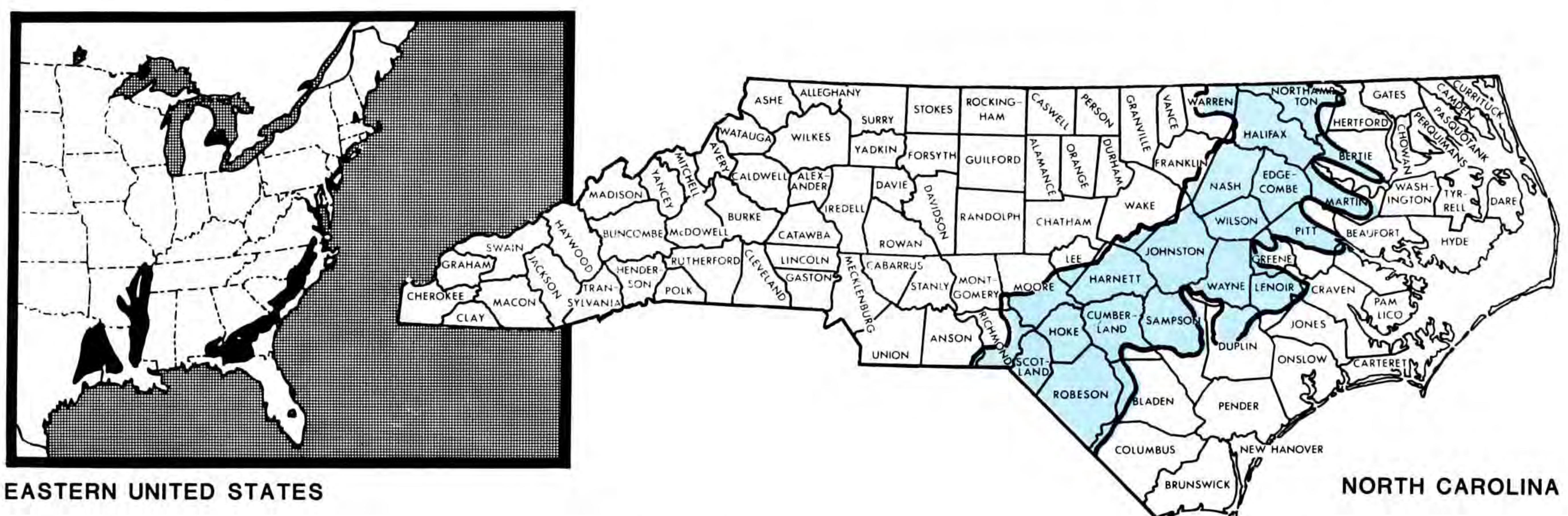


FIGURE 1. Problem Regions for Pan Layers. In the shaded region of North Carolina large acreages of sandy soils are especially susceptible to formation of the pan layers described here. This problem also occurs in certain soils of other areas.

In most seasons annual crops produce little or no root development within or below a pan layer. A typical example of this and the resulting rooting pattern in a sandy soil is shown in Figure 2. Since the dense, root-restricting zone generally does not extend into the more clayey subsoil beneath it, one must know the approximate subsoil depth throughout the field in order to properly adjust the operating depth of deep tillage equipment.

The density and hardness of a pan layer varies within its thickness. Typically, the maximum hardness occurs within the upper 2 inches of the layer and gradually decreases with depth. The overall thickness of pan layers varies from about 2 to 12 inches. Thicker pan layers develop from increased heavy wheel traffic under wet conditions and in soils with thick sandy surface horizons.

These dense layers form due to the combined effects of soil properties, machinery traffic, the action of tillage tools and the weight of the surface soil itself. This problem becomes more severe when certain soil properties are present. It is related to the

- influence of sand in the soil,
- roughness of the sand particles, and
- effects of changing moisture levels during the year.

As farm equipment has become larger and heavier, the likelihood of its compacting the soil deeper into the profile has increased. Modern tractor and harvester tires impose massive forces onto the soil because of their weight and tractive effects. Figure 3 shows how these compactive forces of tractor weight are distributed in the soil under the wheels. These results indicate that for a given tractor and soil, using dual tires somewhat reduces the depth of compaction, although the amount of compacted soil is almost doubled under the dual tires. Also, potentially serious compacting forces will extend somewhat deeper when heavy equipment is operated on wet soil (before enough of the soil profile has drained).

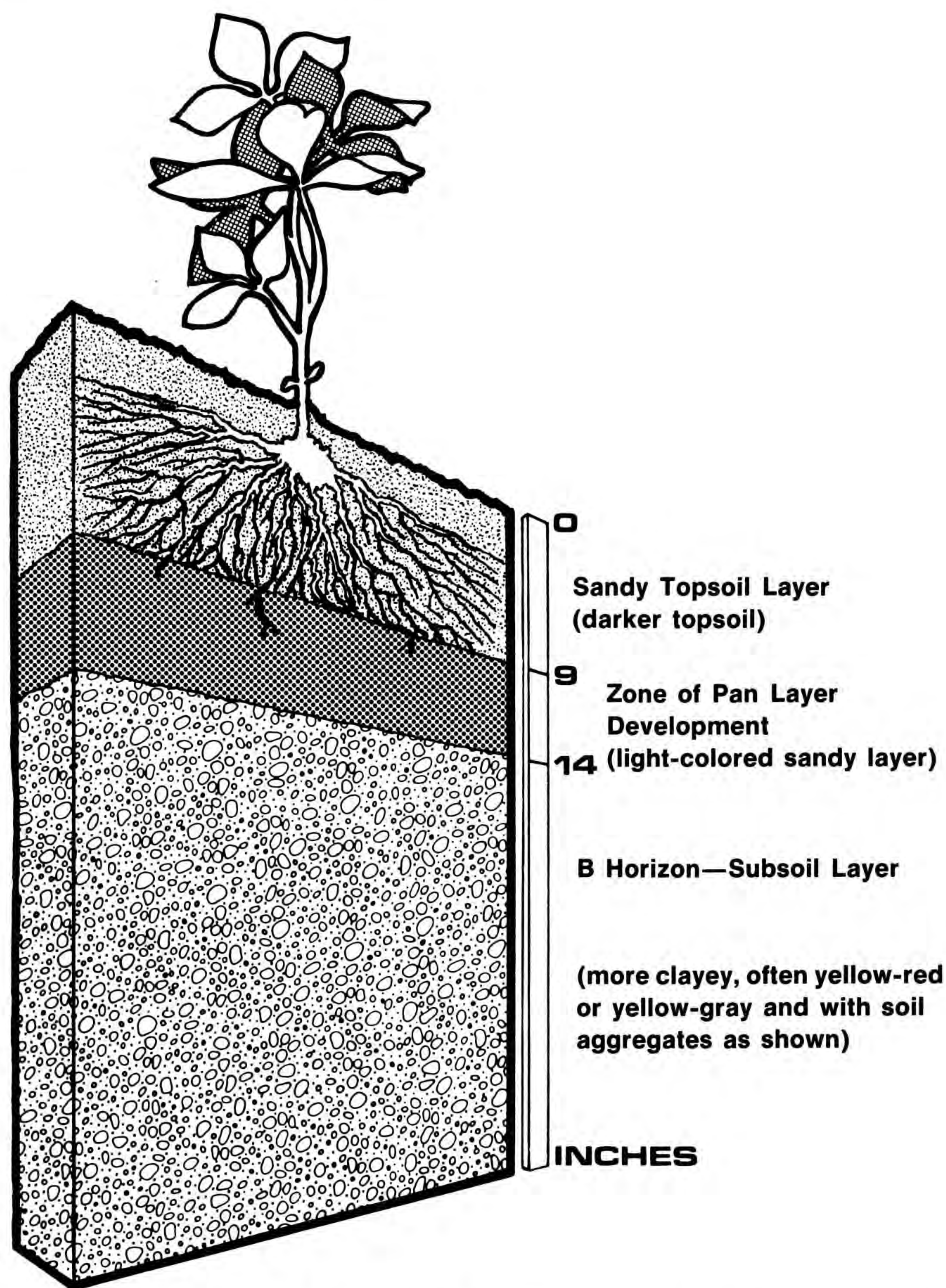


FIGURE 2. Typical Pan Layer in Soil Profile. The pan layer begins near the base of the darker topsoil layer and extends through several inches of lighter colored sandy soil beneath.

Pan layers vary in thickness and hardness. The few roots growing within this zone are sparse and thickened with little branching. The presence of pan layers often causes crop root systems and water uptake to be confined to the topsoil zone.

In this example, the pan layer forms in the bottom inch of the topsoil layer and includes a zone of 9 to 14 inches. The pan layer would not usually extend into the B horizon which begins in this example at the 14-inch depth.

Compaction from heavy equipment is probably the most important contributing factor to pan formation today. Interestingly, the estimated depth of compacting forces in Figure 3 closely resembles the depth at which pan layers are observed. In view of the current need to use large equipment, be aware of sub-surface compaction and management practices that are needed to correct the problem, especially in soils which commonly develop pan layers.

The process of soil compaction also occurs both *at* the surface as well as *just below* the surface. Unprotected surface soil may be compacted by rainfall, resulting in a surface crust in severe cases. Also, severe compaction within the upper 6 inches may take place when disc blades and wheels operate on wet soil (see Figure 3). These forms of soil compaction can best be handled by use of cropping practices which maintain soil cover as much as possible and by normal surface tillage practices.

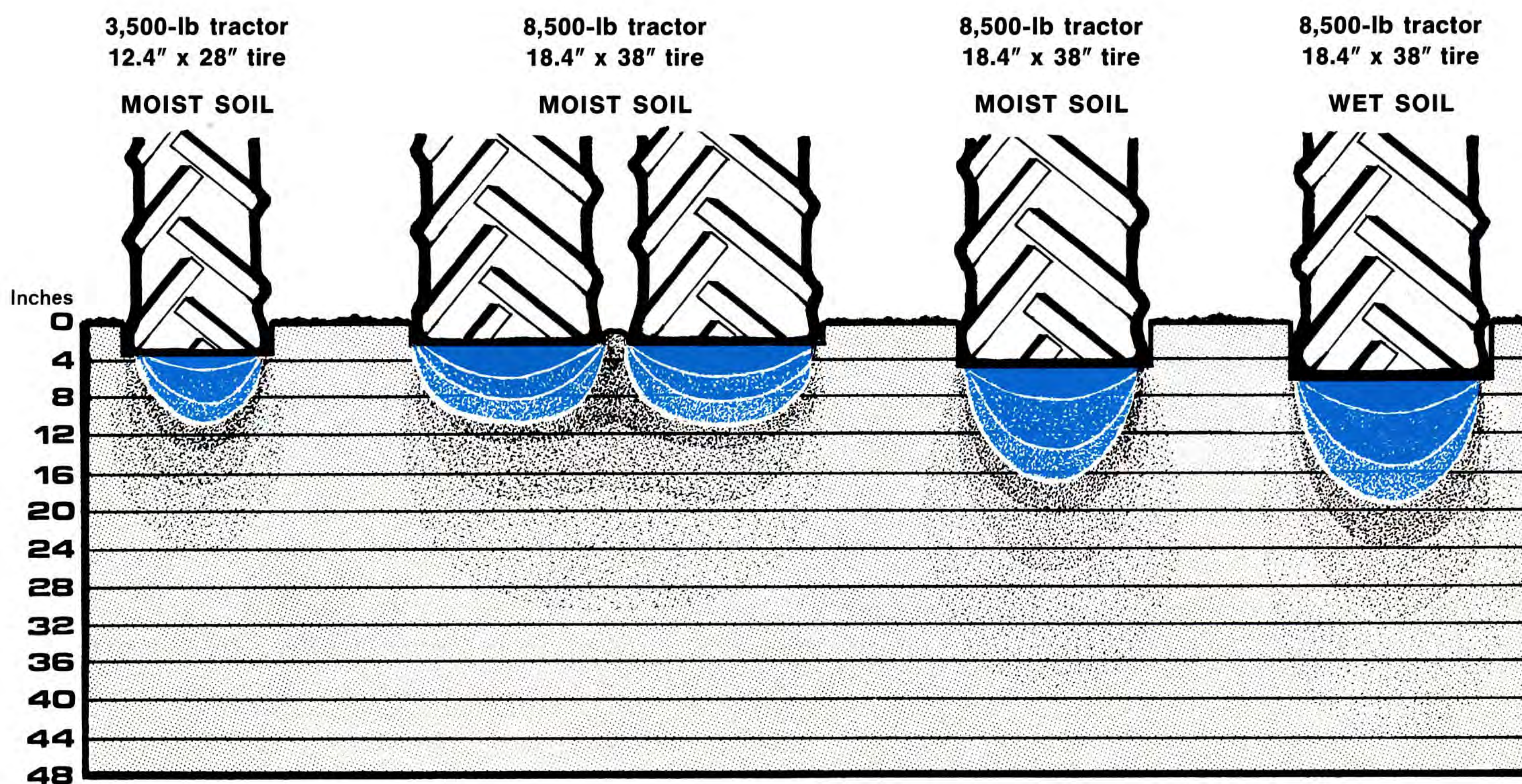


FIGURE 3. Zones of Compactive Pressures (PSI) Under Tractor Wheels. Zones shown in blue could receive enough pressure to cause compaction (8 PSI or greater) under the conditions assumed. Many tractors and combines today are even heavier than the weights shown and, therefore, would compact more deeply. Even for heavier equipment, dual tires or wet soil would cause similar changes of compaction zones.

General assumptions:

- 75% of the given tractor weight was on the rear axle with half of this applied to each wheel as shown; tires were inflated at 12 PSI.
- Predictions are based on tests conducted in Wagram Sand soil at Clayton, North Carolina, after the soil had been thoroughly loosened to a 14-inch depth; tire ruts shown are based on observations during the study.
- The successive zones of decreasing dot density are predicted to receive pressures of 12, 10, 8, 6, 4 and 2 PSI.

Source: Bowen, H.D., J. Jaafari and P.D. Ayers. "An application of Bossinesq's equation to soil dynamics." Presented at the 1984 Summer Meeting, ASAE, Knoxville, TN.

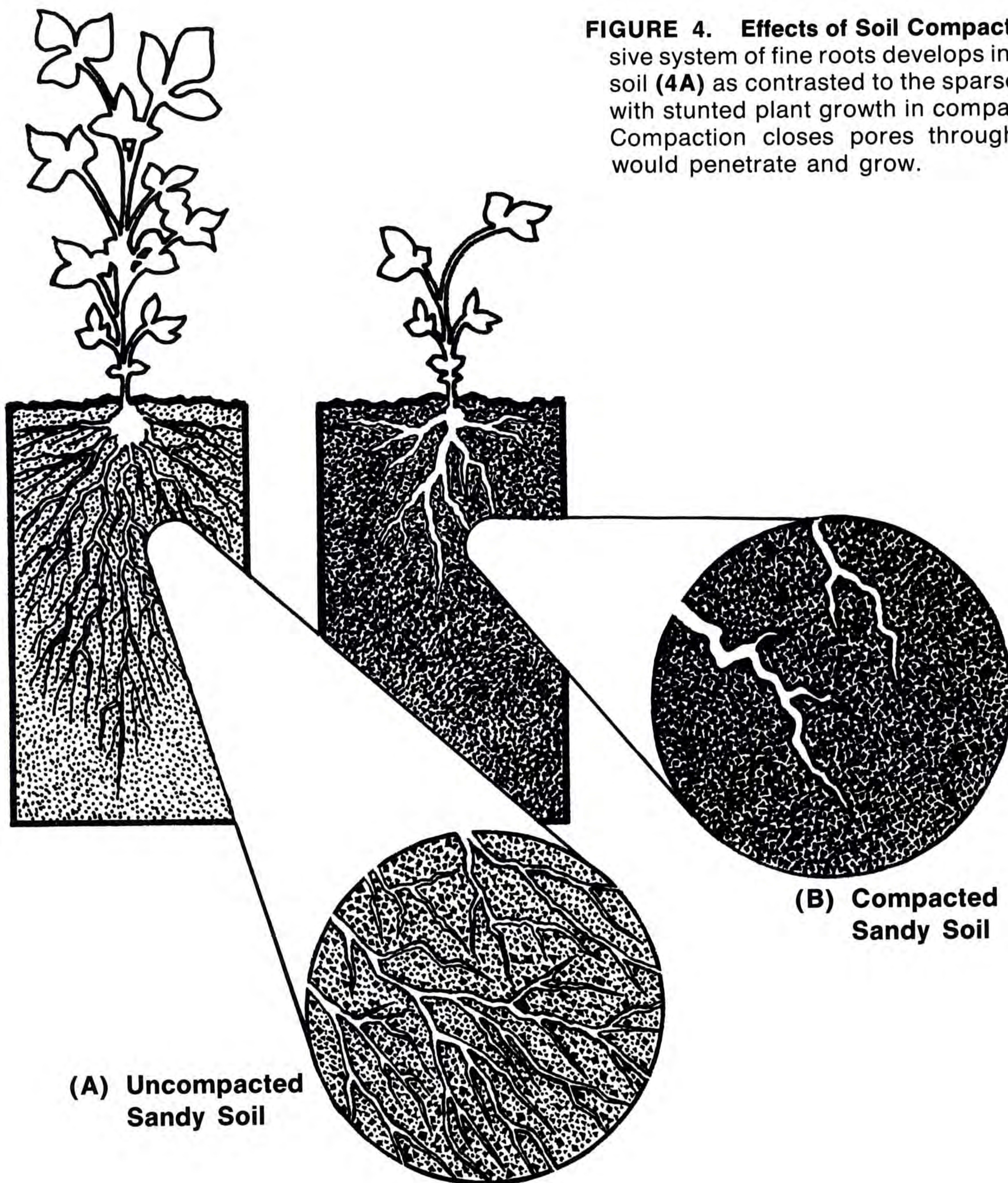


FIGURE 4. Effects of Soil Compaction. An extensive system of fine roots develops in uncompacted soil (4A) as contrasted to the sparse, coarse roots with stunted plant growth in compacted soil (4B). Compaction closes pores through which roots would penetrate and grow.

Soil compaction reduces pore space—so essential for air, water movement and root development. The soil then becomes more dense. This condition greatly hinders the ability of roots to penetrate and grow rapidly enough to supply the water and nutrient needs of developing plants. Such problems, for example, can be seen in compacted turn areas or well-used foot paths, where even weeds grow poorly.

Sandy soils often have less pore space than finer textured soils. *Compacted sandy soils* have even less porosity, and few of those pores are large enough to permit root penetration. Figure 4 shows this idea, including close-ups of soil pores and plant roots. The

finer textured soils, however, often have better developed aggregates so that even after moderate compaction, these soils still offer adequate pore space for roots to develop.

Over time, some correction of compacted soil may occur through wetting and drying cycles together with activities of worms and small organisms. This natural correction of compaction is less likely in sandy soils than in soils having a greater clay content and stronger aggregates. Although compaction reduces the productivity of most soils, its effects are probably more accumulative and longer lasting in sandy soils.

Subsoiling Equipment

Deep tillage is often beneficial in sandy soils with dense pan layers. The recommended depth of such tillage varies by soils and ranges from 10 to 18 inches. **Chisel plows** can operate down to about 11 to 12 inches but have a very high draft requirement when operated at this depth. **Subsoilers** (commonly known as “rippers”) perform efficiently in this depth range and, in addition, offer the advantages of minimizing topsoil inversion and the mixing of topsoil with subsoil.

Subsoilers of various types are marketed to meet differing uses. Currently, two popular models include those with shanks mounted at approximately 45° forward of vertical and those with curved shanks. Also, specially curved, parabolic shanks have been designed to reduce the draft requirement, but this particular shank commonly is operated much deeper. Several types of subsoiling equipment are shown in this publication.

Various manufacturers offer equipment designed to subsoil exactly where the row will be planted. Known as **“in-row” or “under-the-row” subsoiling**, this procedure offers the best chance for the crop to respond to subsoiling where pan layer problems exist. However, this practice usually does not loosen the entire width between the rows. Subsoilers spaced more closely and attached to a straight or V tool bar are designed to loosen the entire soil area between the shanks. In this case, however, disking or other secondary tillage is needed to level and smooth the land, a step that results in some recompaction and extra tillage trips. Some of the favorable effects of subsoiling will be reduced if subsoiling is done some distance to the side of the row position or if serious recompaction develops from further tillage before planting.

In-row subsoiling must be combined with some method to prevent plants from settling deeply into the loose soil slit left by the subsoiler. In the case of the commercial **“ripper-bedder,”** this is achieved by the ridge or bed formed above the soil slit. However,

the bed should be left at a 4- to 6-inch height after planting so that enough soil is available to compensate for the natural settling. Also, in that case the bed itself may provide additional drainage benefits during wet periods, especially for early planted crops in dark, flat land that normally drains slowly.

Where deep tillage is necessary but bedding is not, other devices can be used to close the subsoiler slit. These include:

- “spider gangs” (curved rolling tines)
- fluted coulters
- concave discs
- wheels (especially for no-till conditions).

These specially mounted closing devices require that the position, angle and spring tension be adjusted based on subsoiler depth and the soil and residue conditions.

These approaches to subsoiling without bedding also provide substantial in-row seedbed preparation; therefore, very little preparatory tillage is usually necessary. When possible, attaching planters directly onto the ripper toolbar makes this a highly efficient **“ripper-planter” unit**. Several manufacturers offer these ripper-planter units with designs for both clean tillage and no-till conditions. Ripper-planter units normally require less draft than ripper-bedders but have a substantial drawbar lift requirement. The choice of the tillage tool and depth of operation depends on the thickness of the pan layer and other practical details specific to each farm situation. Efficient use of in-row subsoiling in any form should substitute for plowing and part of the secondary tillage for that particular growing season.

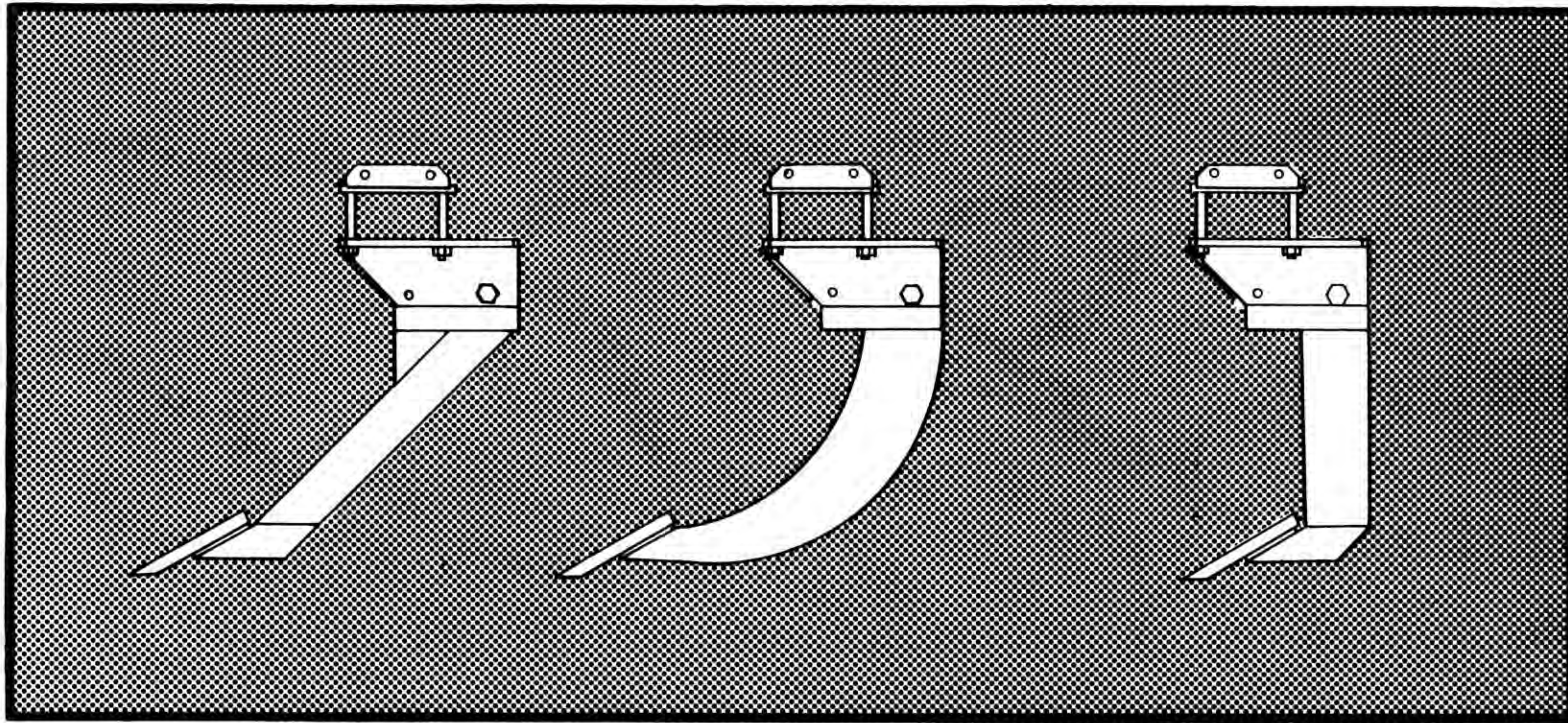
Common Types of Subsoiling Equipment

Subsoiling is an important practice for farm operations that involve soils having somewhat sandy properties to a depth of at least 10 inches.

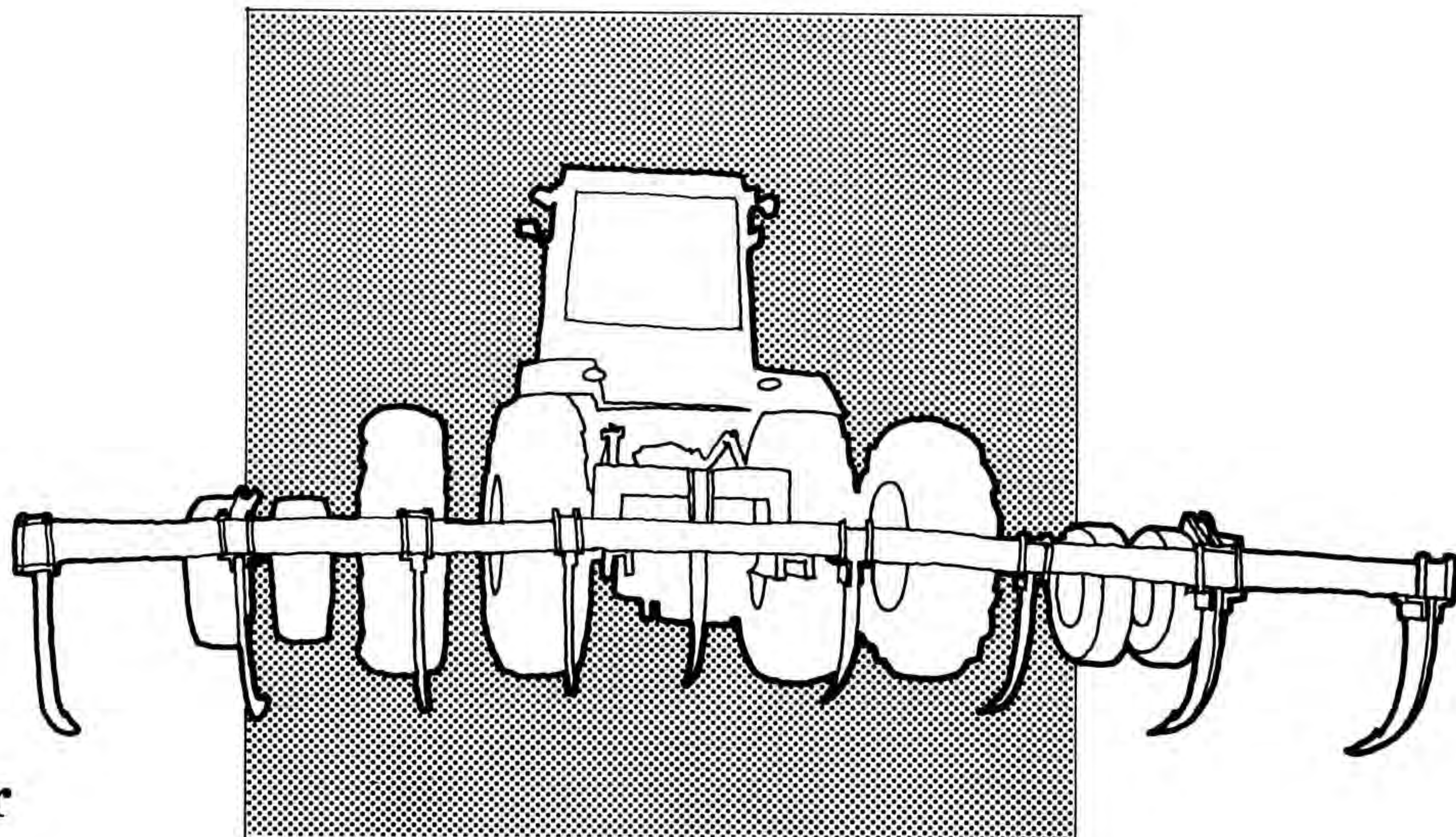
In selecting such equipment, consider the following:

- the residue-handling capability desired;
- the bedding capability desired;
- tractor size and lift capability;
- feasibility of using planting equipment that already exists;
- ways to use subsoiling equipment and reduce or eliminate some existing tillage operations.

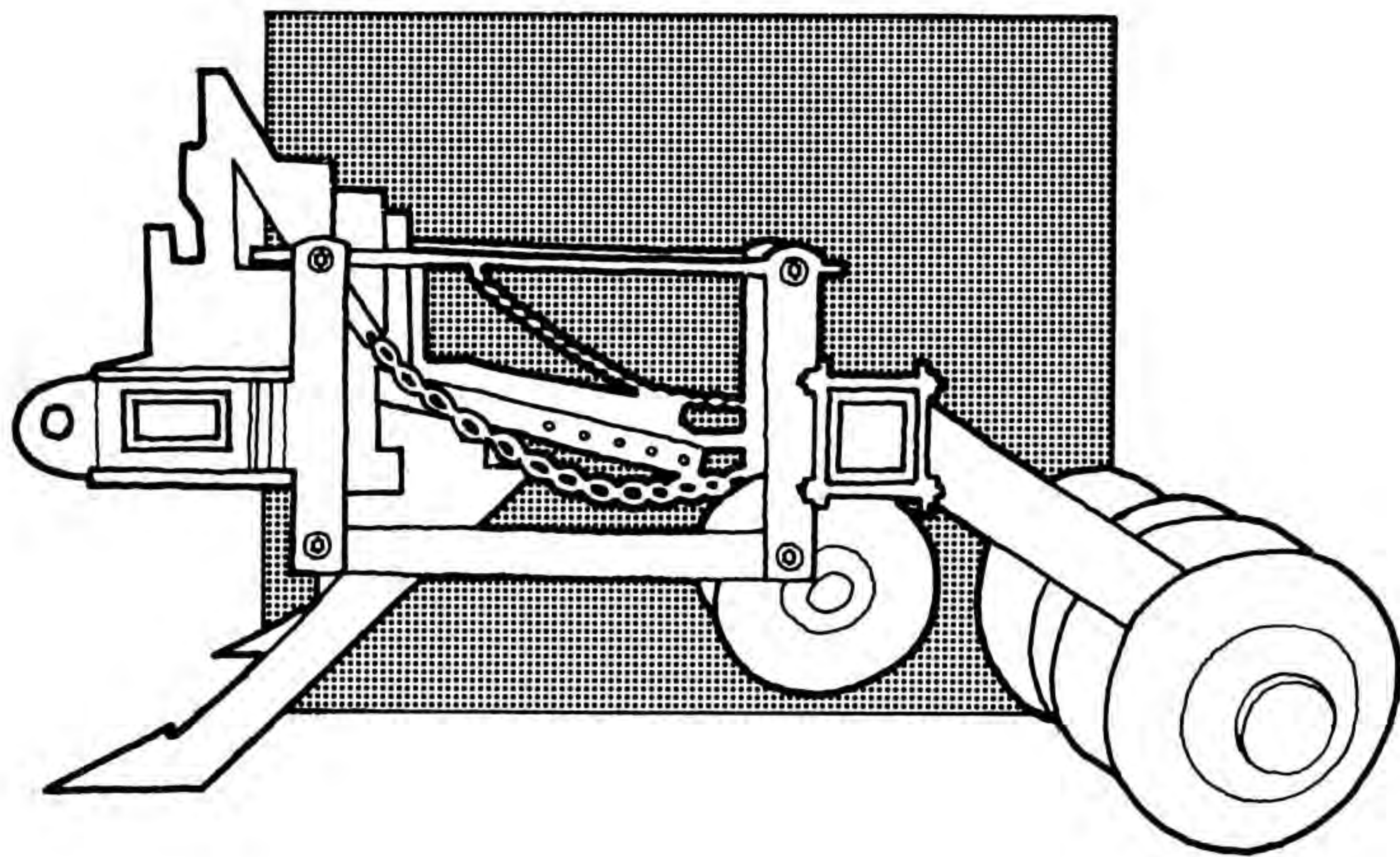
Several types of subsoiling equipment are shown here.



Subsoiler Types

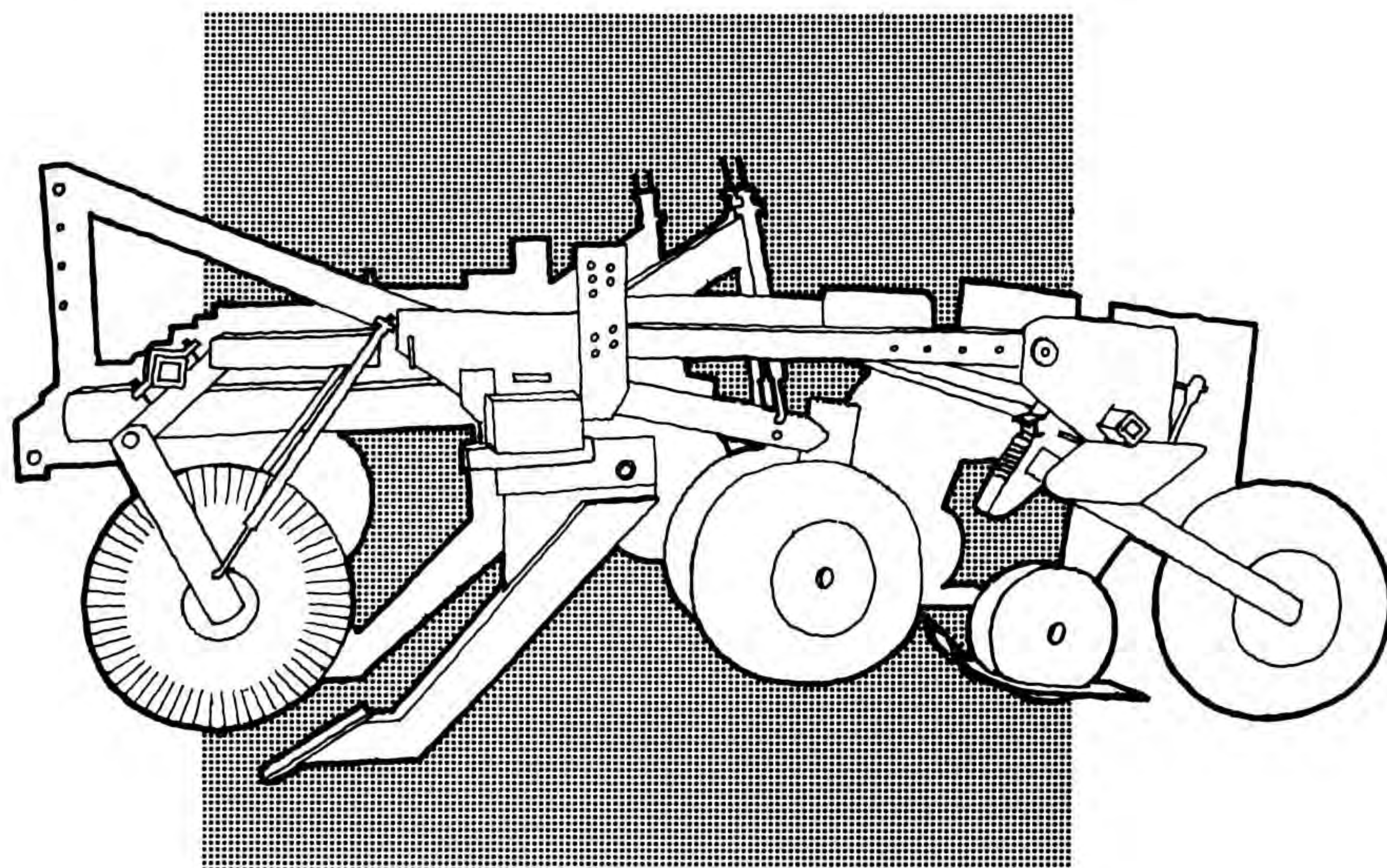


“V” Ripper

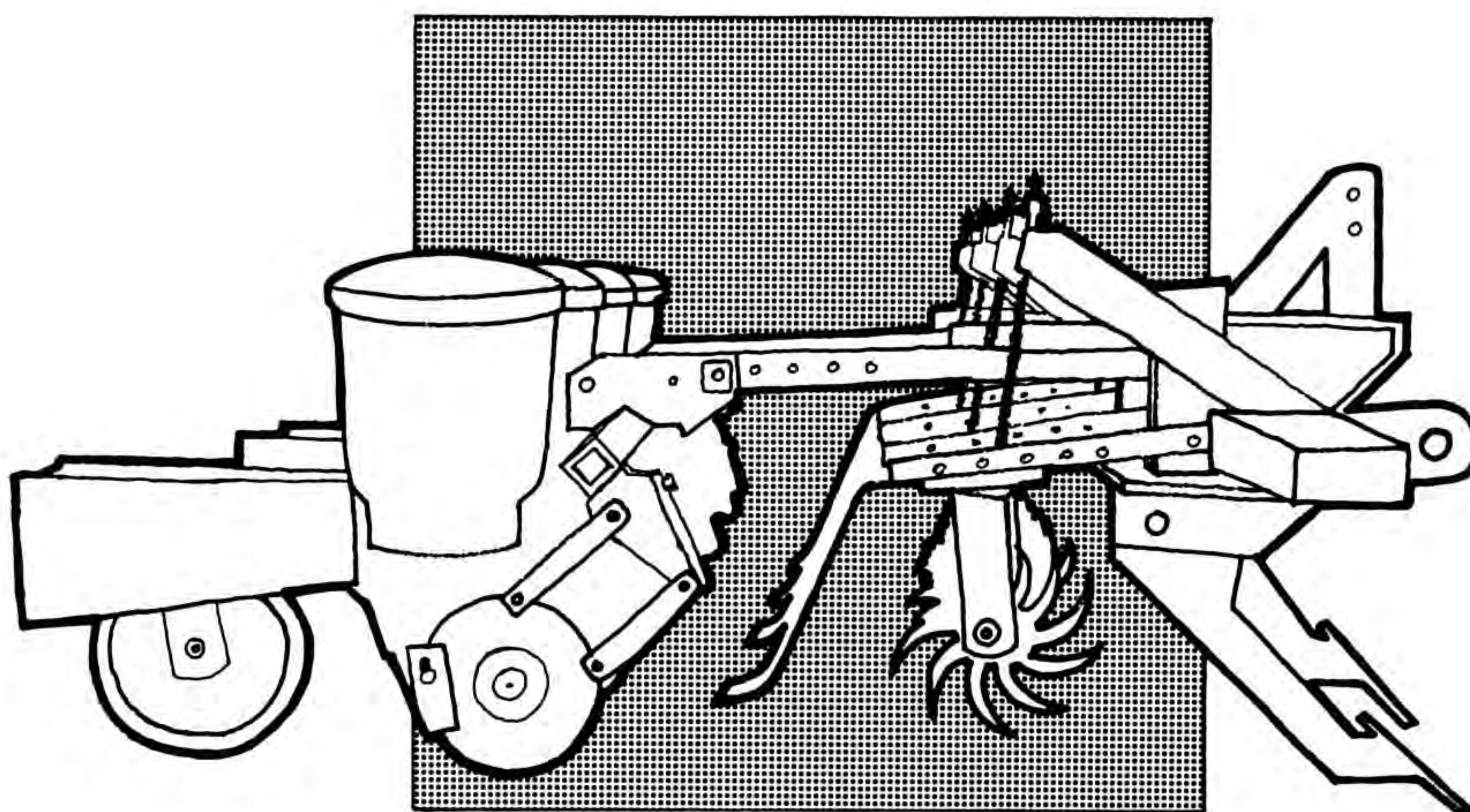


Ripper Bedder

Ripper-Planter Units



Rubber Press Wheels—to close subsoiler slit (no-till conditions)



Spider Gangs—to close subsoiler slit (clean tillage in the row zones)

Subsoiler Operation

Figures 5A and 6A show the proper operation of subsoilers in two typical situations of sandy surfaced soils that have pan layers. The subsoiler point runs below the pan layer but above the finer textured subsoil beneath. As the subsoiler moves forward, soil above the point is lifted, an action that breaks up the pan layer. The width and shape of the loosened zone varies according to the

- texture and wetness of the soil and
- depth and speed of operation.

Under typical conditions in the spring, the cross-section of the loosened zone of soil forms a V with somewhat curved sides (see Figures 5B and 6B). When subsoiling under the row position, this loosened zone encourages normal rooting patterns, instead of the shallow depth found when the pan layer is present (see Figure 2). This effect then permits the crop to use additional water from deeper in the soil. During some seasons the deeper rooting may also permit crops such as corn and tobacco to recover additional nitrogen in the case of deep sandy soils.

Operation of the subsoiler into the clayey layer is

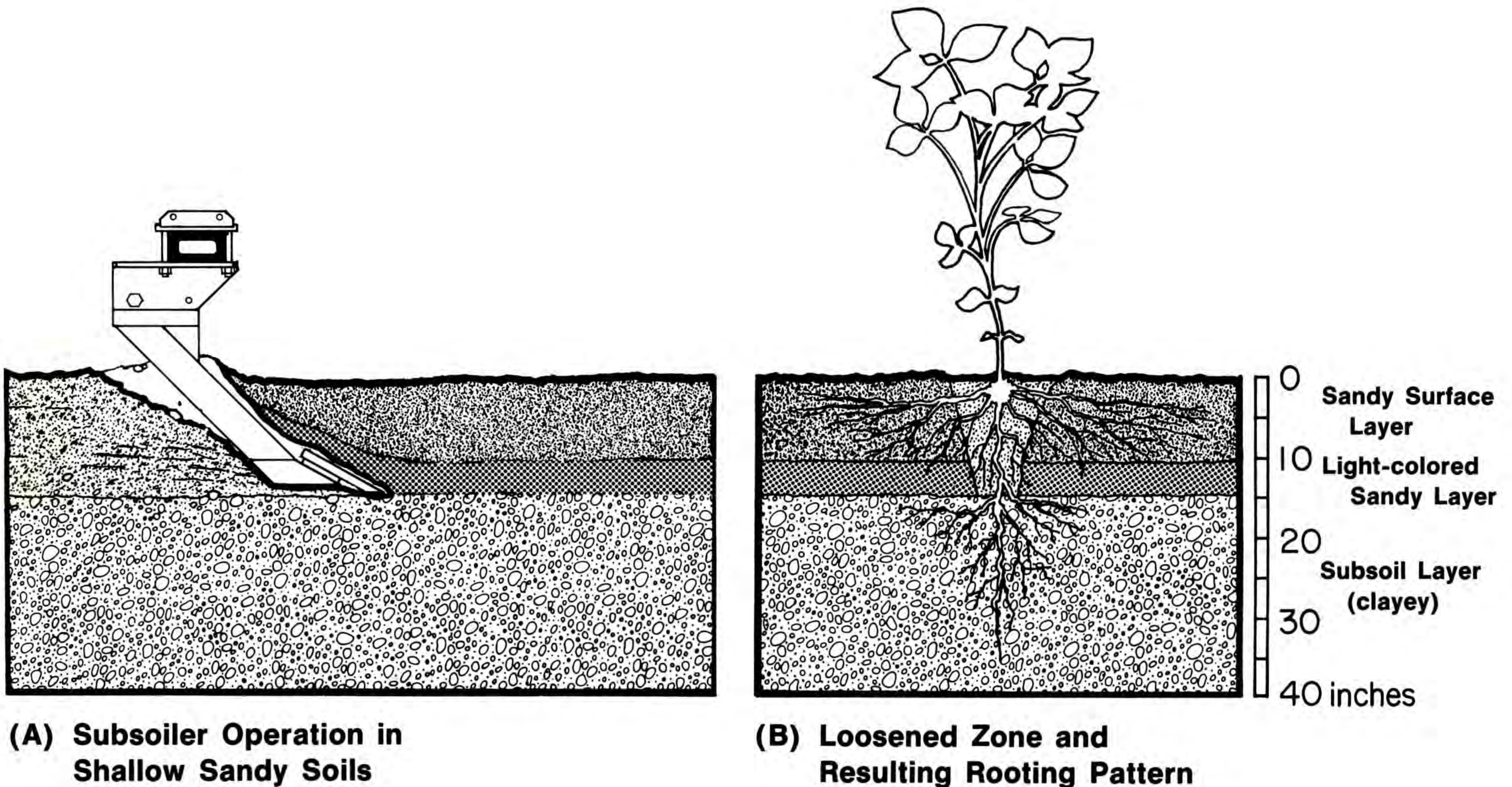


FIGURE 5. Shallow Sandy Soils. (5A) Where the clayey layer is at a 10- to 15-inch depth, operate the subsoiler about 12 inches deep. Note that this loosens the pan layer without running the subsoiler deeply into the subsoil layer (beginning here at a 15-inch depth).

This practice is recommended for corn or soybeans on light-colored sandy soils, or for corn on

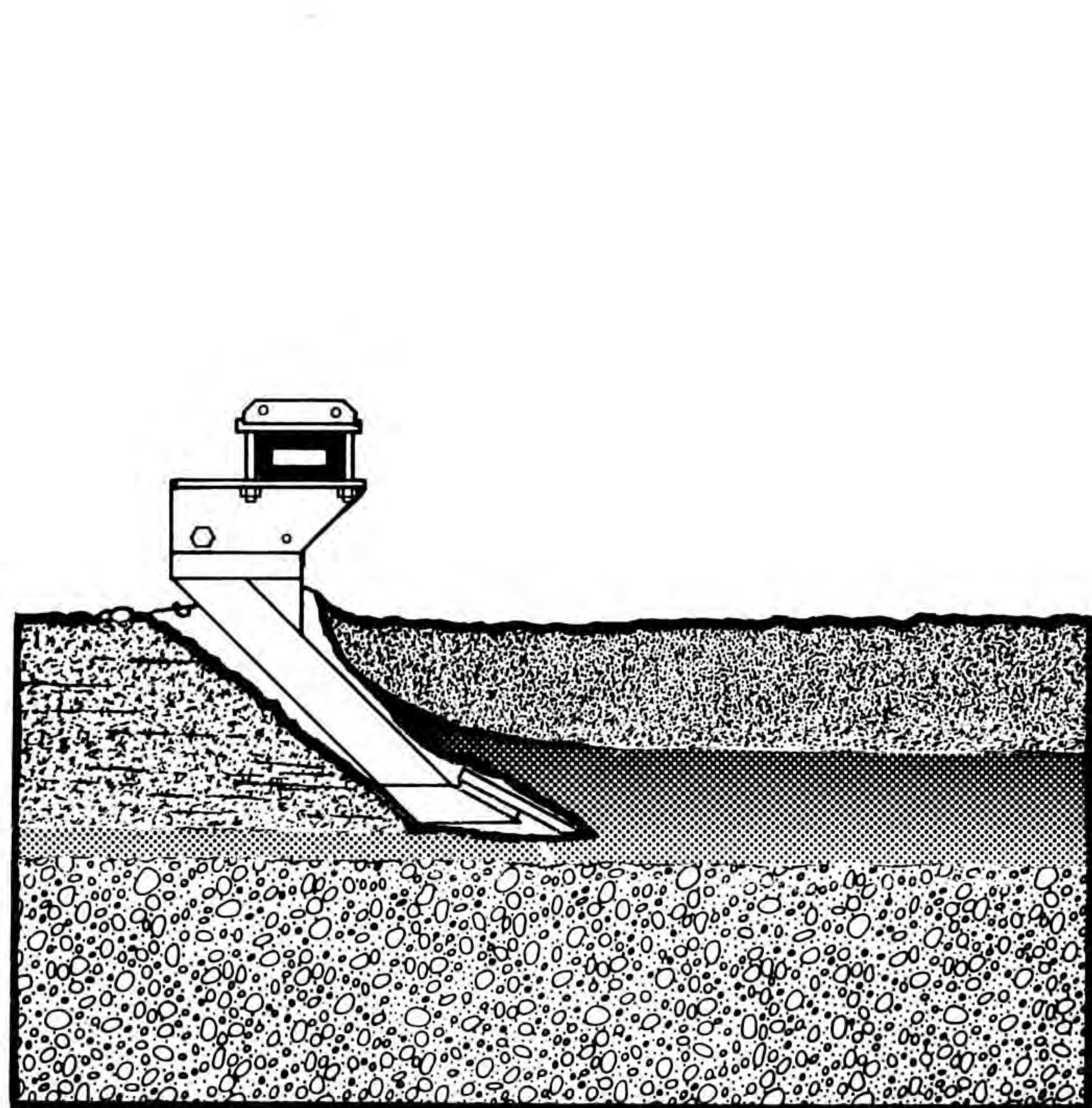
certain dark soils of medium texture. (See section **Practical Considerations and Recommendations** for Soil Groups 2 and 3.)

(5B) Subsoiling under the row loosens a portion of the pan layer, permitting root development in this zone and in the underlying subsoil.

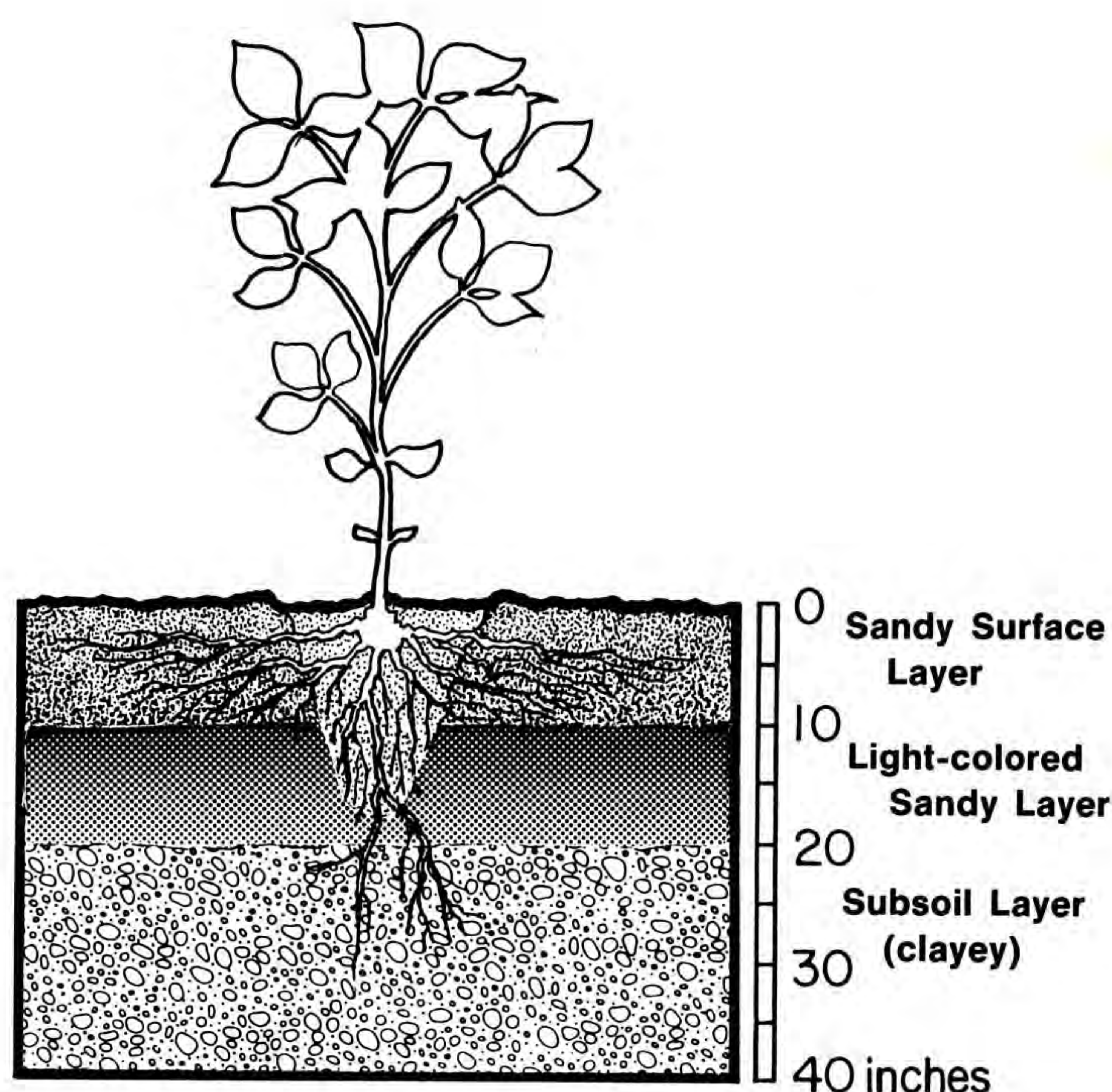
not recommended. When the clayey layer is within reach of the subsoiler point (see Figure 5A), run the unit at a shallower depth (about 12 inches). In deeper sandy soils where the subsoiler will not reach the clayey layer, subsoiling 16 to 18 inches deep (see Figure 6A) has produced highly profitable yield increases.

Test plot results indicate that when shallower soils exhibit pan layers, the complete crop response to this tillage practice can be realized without running the subsoiler deeply into the clayey subsoil layer. Shallower subsoiling in these cases not only reduces

the cost of operation and power requirements but also minimizes uplift of soil from the clayey layer below. Bringing up the clayey subsoil should be avoided because this material is usually acid and strongly infertile, and it may permanently increase the cloddiness of the surface soil.



(A) Subsoiler Operation in Deep Sandy Soils



(B) Loosened Zone and Resulting Rooting Pattern

FIGURE 6. Deep Sandy Soils. (6A) In the deeper sandy soils (over 15 inches to clayey layer) subsoiling at 16 to 18 inches is desirable for corn and soybeans. (See section **Practical Considerations and Recommendations** for Soil Group 1.) Although the subsoiler does not reach the more clayey subsoil layer shown at 20 inches, it adequately loosens the more dense portion of the light-colored sandy layer.

(6B) In-row subsoiling allows roots to utilize the loosened V zone in the deep sandy layer and, to some extent, the subsoil layer below. Root development into the subsoil is very beneficial but depends upon the depth to this layer and the chemical properties of the soil therein.

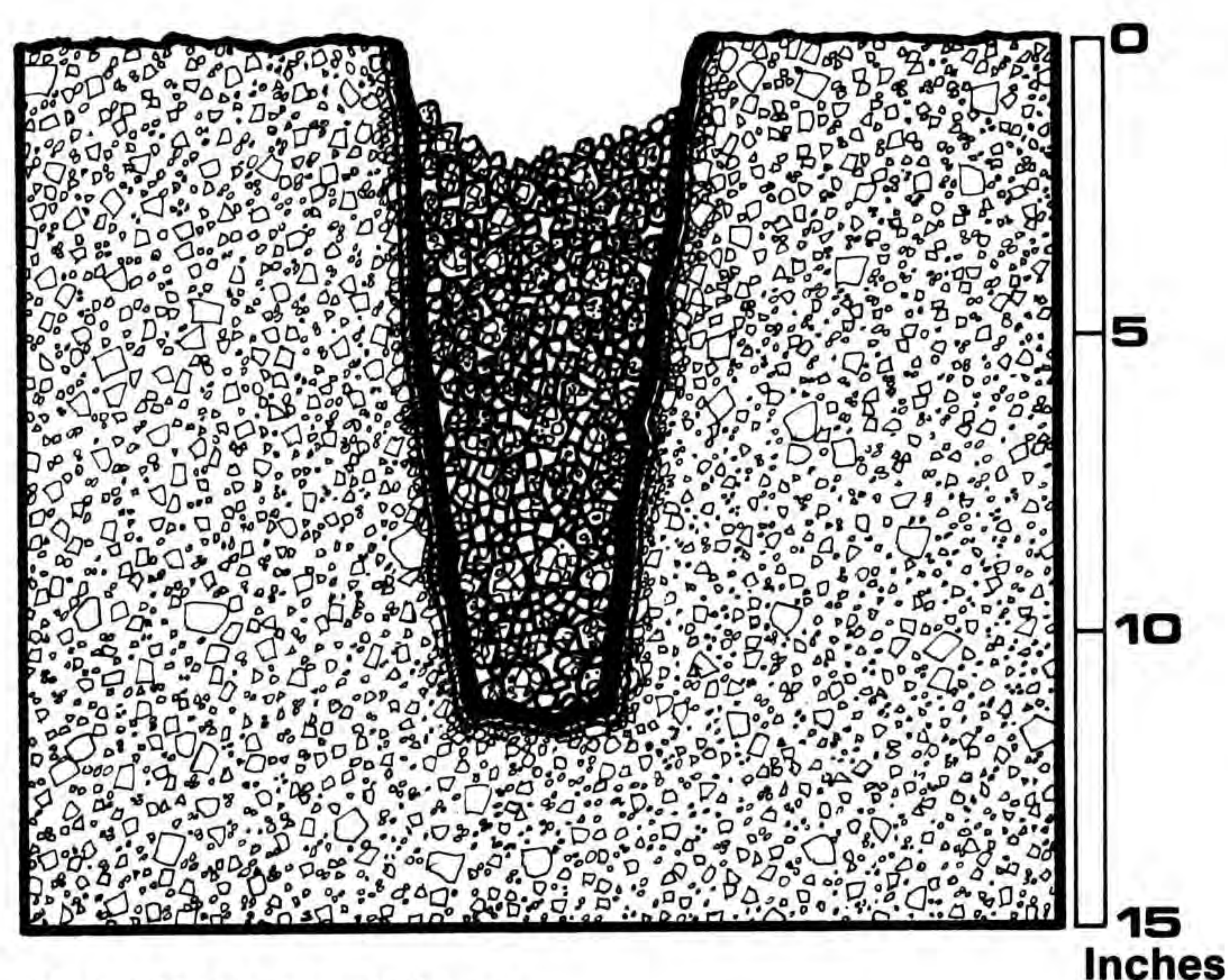
Substantial yield increases of both crops were consistently produced in deep sandy soils by subsoiling as shown (**see Figure 8**).

The fine- and medium-textured soils which predominate in the rolling uplands of the Piedmont and Mountains of North Carolina offer special complications to subsoiling. This is because these soils are soft and plastic when wet. Operating a subsoiler under such conditions is similar to pushing a pencil through modeling clay; the subsoiler simply pushes the soil aside leaving a large cavity. Instead of loosening adjacent soil, some additional lateral compaction of the soil wall may occur under these wet conditions. A close-up of this effect, including the compressed wall of the subsoiler track, is shown in Figure 7A. Such moist-to-wet conditions would generally be found in these soils at planting time in the spring as well as during wet periods any other time of the year.

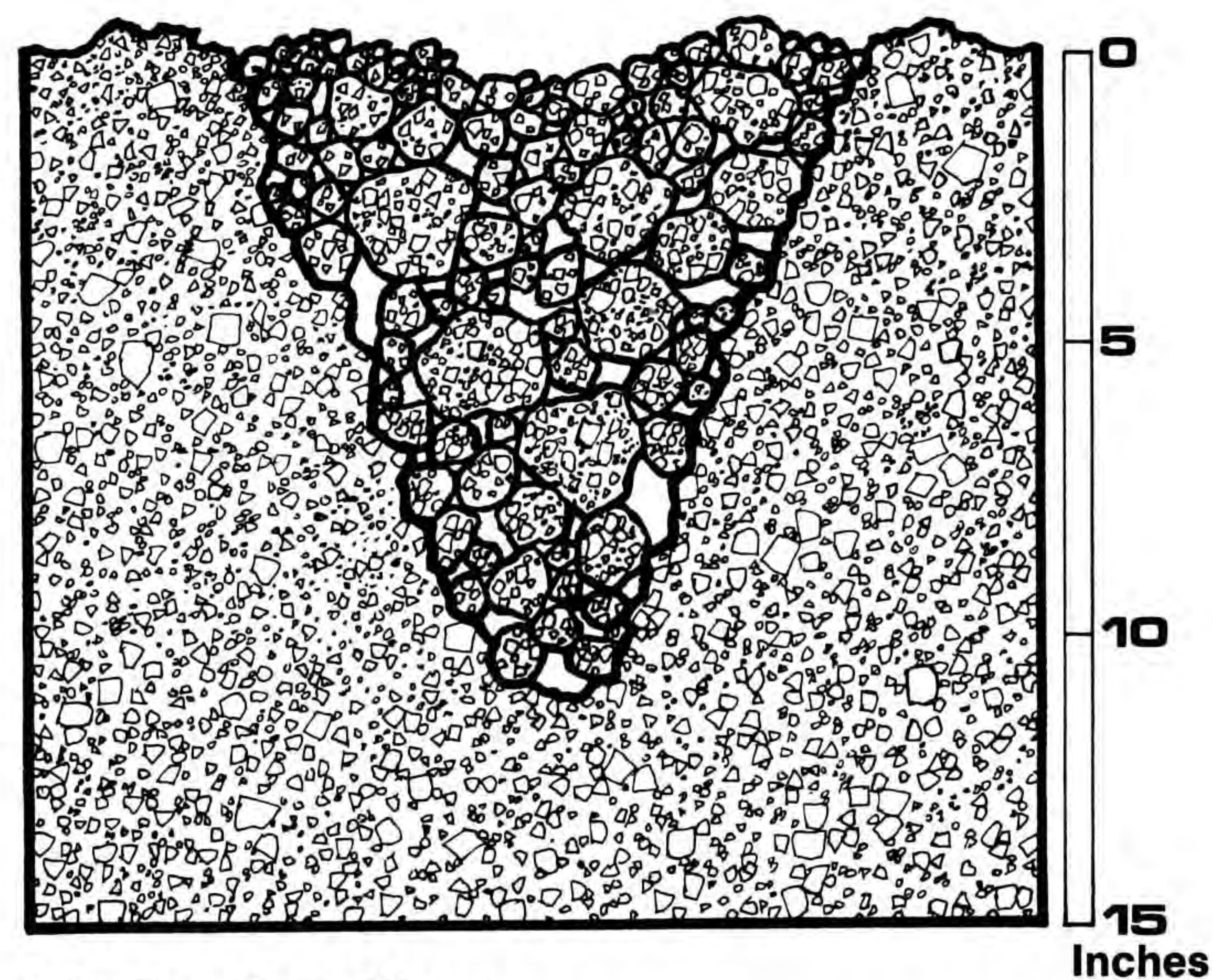
On the other hand, subsoiling these clayey soils

when dry produces a cloddy surface with large voids between clods (see Figure 7B). Subsoiling under these conditions usually has a very high draft requirement. Such dry conditions sometimes develop in late summer and fall following corn harvest. Although the clods left by subsoiling will soften and diminish in size over the winter, large voids are not desirable for root development or seedling establishment.

Although certain forms of compaction problems are present in the Piedmont, the root-restricting pan layers described earlier have not been observed. Little or no yield benefit was produced by subsoiling clayey soils at planting time, even when done under ideal moisture conditions. The yield results which follow indicate that for the Piedmont neither in-row subsoiling or chiseling before planting was generally beneficial, and sometimes these actually produced lower yields.



(A) Wet Conditions



(B) Dry Conditions

FIGURE 7. Undesirable Subsoiler Effects—Fine-Textured Soils (Piedmont). In the fine-textured, clayey soils of the Piedmont in-row subsoiling may leave unfavorable soil conditions for seedling development, as these close-ups show. (7A) When these soils are wet and soft, the forces of the subsoiler cause compression on the sidewalls of the slit. This compression is associated with a reduced volume of uplifted and loosened soil. Often the subsoiler slit under the row is poorly closed resulting in a rough and unsuitable seedbed zone.

(7B) When these clayey soils are dry, the subsoiler loosens a much larger zone but may leave mostly big soil aggregates and clods. Unless these aggregates are further broken down in size over time by secondary tillage, this loosened zone will have many excessively large pores which are undesirable for root development and seedling growth.

YIELD RESPONSE TO IN-ROW SUBSOILING

Research and on-farm trials in North Carolina and elsewhere have clarified many features of pan layers and crop response to subsoiling. On-farm tillage trials have shown the importance of the concepts presented earlier. The results of 50 trials (31 corn, 19 soybeans) conducted in the Coastal Plain and Piedmont during 1977 through 1981 will be discussed in this section.

In these trials yields varied considerably due to soil differences and weather patterns over the five growing seasons. For the growing conditions in each trial the best estimate of yield difference caused by each tillage treatment was determined. These results were grouped according to the nature of soils present in each trial (see **Soil Grouping**). Then the differences produced by each tillage treatment were averaged for all plots having similar soils. Only the results of clean tillage treatments and of full-season soybean crops are presented here.

All plots were installed with the same commercial tillage and planting equipment (see Table 1). Locally used tillage practices were included for comparison. Recommendations of the North Carolina Agricultural Extension Service were followed regarding weed control, varieties and other cultural practices. Throughout this work uniformity of application within the plot was emphasized.

Soil Grouping

The results are given according to four broad soil categories present in the plots (see Figure 8). For the Coastal Plain these included three categories of soils based on sandiness, depth to the clayey subsoil layer and darkness of soil color (natural drainage). In addition, for corn the dark soils of the Coastal Plain were further subdivided according to fineness of the soil texture. The plot results from finer textured, generally eroded soils of the Piedmont made up the fourth category.

The soil groups of the **Coastal Plain** include:

Group 1—light-colored soils classed as well or moderately well drained, with loamy sand or sandy loam texture to a depth greater than 15 inches

Examples: Wagram, Lucy, Kenansville, Conetoe as well as those Norfolk and Goldsboro soils with at least 15 inches of surface horizon.

Group 2—well- or moderately well-drained soils, typically sandy loam in texture to a depth of 10 to 15 inches

Examples: Norfolk and Goldsboro soils with subsoil horizons within 15 inches as well as Orangeburg and State soils. These soils are substantially more productive than those in **Group 1**.

Group 3—darker soils having natural drainage classed as somewhat poorly to poorly drained

Examples: *medium-textured subgroup*—Lynchburg, Rains, Pasquotank, Tomotley, Augusta, Tetotum
finer textured subgroup—Nahunta, Grantham, Lenoir, Roanoke, Wahee, Argent.

In these trials the textural difference among the dark soils was closely related to the corn yield response to subsoiling but was not related to the soybean response to subsoiling.

Soils in the **Piedmont**:

Group 4—Piedmont trials were conducted on typical upland, sloping soils that were generally slightly to moderately eroded.

Examples: Georgeville, Herndon, Nason, Pacolet, Vance, Helena, Sedgfield.

Yield Differences

The average yield responses of corn and soybeans to subsoiling and other practices for each soil group are shown in Figure 8. From an overall comparison of the bar graphs, it is apparent that the yield responses to subsoiling or 11-inch chisel plowing depend on the nature of the soil present and on which crop is being grown. These differences in yield response reflect the varying degree of yield limitation caused by dense pan layers in the different soils. Also, a general comparison between the two crops reveals that yield responses to these forms of deep tillage are much greater for corn than for soybeans. Compared to discing alone, yield increases in the most responsive sandy soils averaged 15 to 25 bu/a for corn versus 3 to 4 bu/a for soybeans.

More specific conclusions can be drawn for each soil group. For soils of **Group 1** in the Coastal Plain, both corn and soybeans gave profitable yield increases in response to subsoiling with or without bedding. To a lesser degree, 11-inch chisel plowing of these soils also produced strong yield increases. For **Group 2** soils in the Coastal Plain, corn gave very profitable yield increases (23 to 28 bu/a) from subsoiling with or without bedding. In these soils corn responded equally well to the chisel/plant treatment. Moldboard plowing at 8 to 10 inches followed by discing also increased corn yields by 17 bu/a compared with discing alone. For soybeans in **Group 2** soils, however, the limited information available suggests that discing alone may be adequate tillage, since the other practices did not increase yield.

In the **medium-textured dark soils of Group 3** in the Coastal Plain, corn responded well to any of the

treatments used (subsoiling with or without bedding, chisel/planting or bedding alone). In the **finer textured dark soils of Group 3**, however, the corn response to the different tillage treatments was smaller and more variable than in the medium-textured dark soils. In general, for these finer textured soils bedding alone or chisel or moldboard plowing with discing produced 5 to 10 bu/a more corn than plots which had been disced only. Subsoiling with or without bedding added little benefit compared with bedding alone.

For soybeans on dark-colored soils of the Coastal Plain (**Group 3—both medium and finer textures**), deep tillage appears to offer little advantage. In several of these trials subsoiling and bedding produced soybean yields slightly lower than those produced with discing alone. Also, for the method used in these studies (see Table 1), bedding alone resulted in a slight yield decrease as compared with discing alone.

For Piedmont soils the 11-inch chisel plowing and 12- to 16-inch subsoiling treatments performed poorly compared with discing alone. In two of the three locations subsoiling with bedding decreased corn yields by 14 and 19 bu/a compared with discing. In no case did subsoiling produce a definite increase in corn yields among the five test plots conducted. Chisel/planting benefited one of three plots tested but also gave lower yields in one.

For soybeans in the Piedmont trials, subsoiling without bedding brought about a yield increase of 3 to 4 bu/a in two of the three plots conducted and a slight decrease in the third plot. Subsoiling with bedding or chisel/planting produced smaller, generally nonprofitable yield increases.

Table 1. Description of tillage treatments and equipment used.

Treatment Code	Tillage Treatment	Equipment Used
S/B	Subsoil/Bed	Ripper-Bedder with flex-planters mounted directly behind. Rows were planted on a soft, flat bed about 8 inches above the middle.
S/NB	Subsoil/No Bed	Same as S/B except that spider gangs were used instead of disc bedders. Rows planted flat.
C/P	Chisel Plow/Plant	Double tool bar, 28-inch chisel plow. Chisel penetration to 11 inches in all cases. Same flex planters were attached directly behind plow and operated between chisel tine positions. Rows planted flat.
Bed	Bedding Alone	Same equipment as S/B, except that rippers were removed. Rows were planted on a soft, flat bed about 8 inches above the middle.
MBP/D	Moldboard Plow Disc immediately	Same flex-planters were used after land had been plowed and disced. Rows planted flat.
Disc Only	Discing alone	Same flex-planters were used after discing. Rows planted flat.

CORN

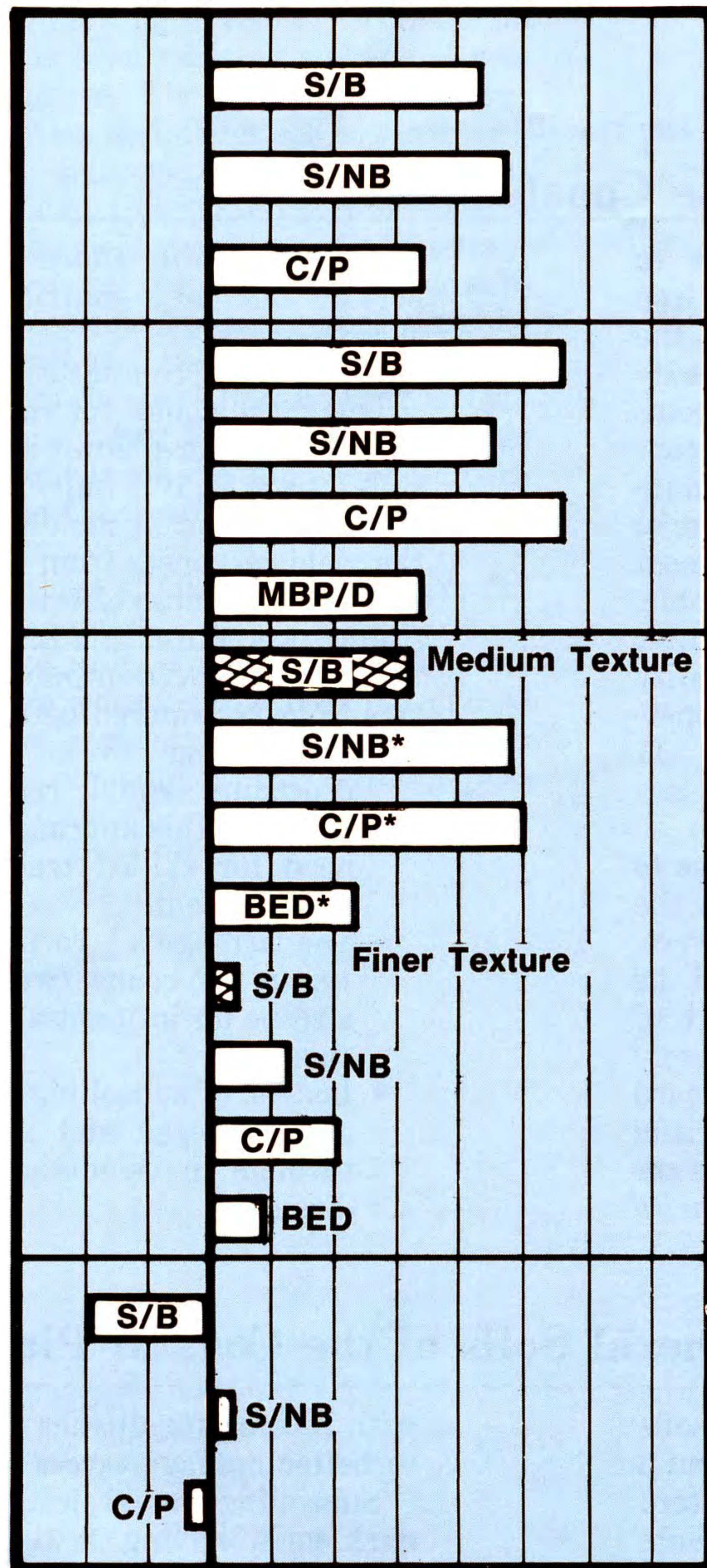
Average difference from check (bu/A)
-10 -5 0 5 10 15 20 25 30

Soil Group 1
15 inches, light,
sandy soil
Coastal Plain

Soil Group 2
10-15 inches,
sandy soil
Coastal Plain

Soil Group 3
dark soils, limited
natural drainage
Coastal Plain

Soil Group 4
upland soils
Piedmont



* Indicates results from only one trial.



Comparison with discing alone.



Comparison with discing + bedding, rather than with discing alone.



Comparison with MBP/Disc, rather than with discing alone.

SOYBEANS

Average difference from check (bu/A)
-4 -2 0 2 4 6 8

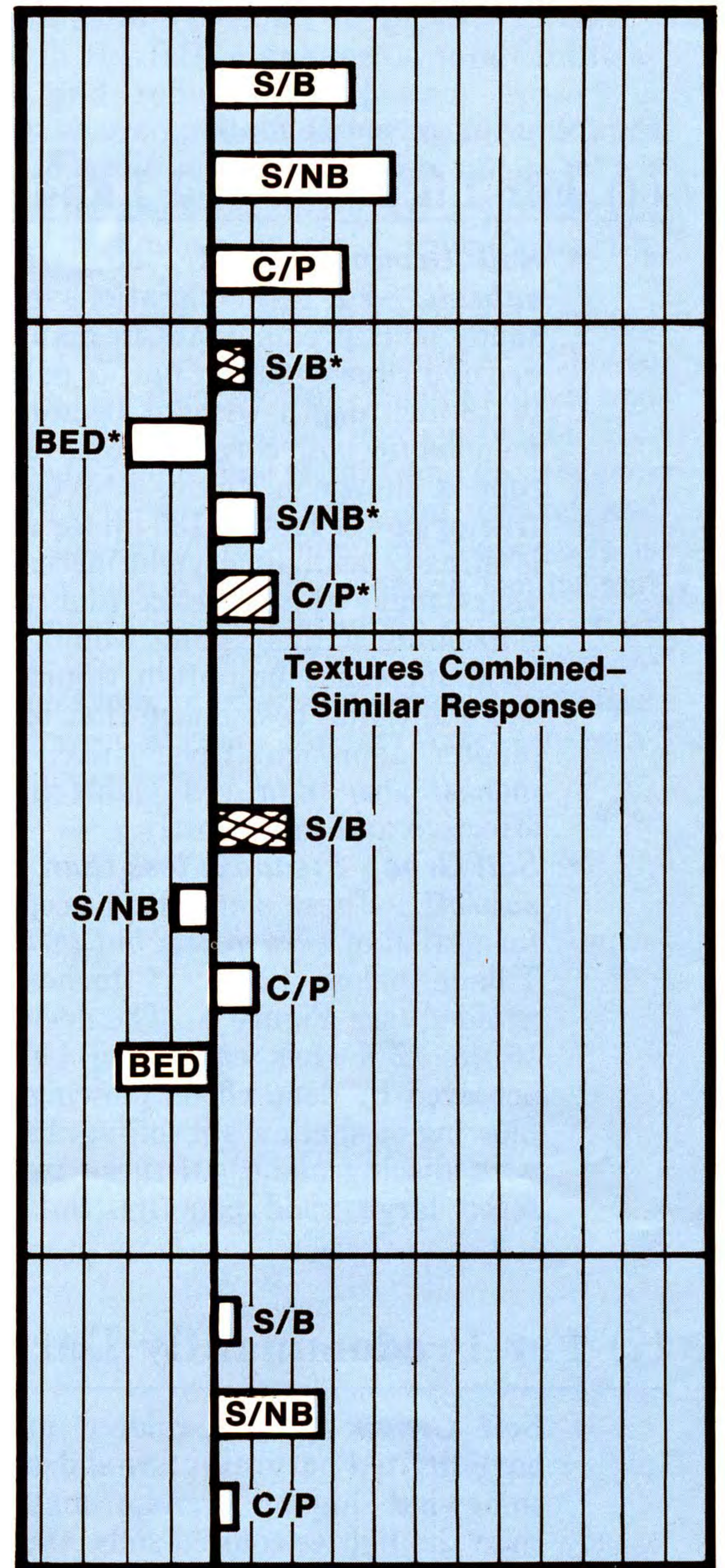


FIGURE 8. Average Yield Responses to Tillage Practices in Different Soil Groups (see Table 1 for tillage codes). This figure shows yield results of on-farm tillage studies (31 trials with corn and 19 trials with soybeans) conducted in North Carolina during the five growing seasons of 1977 through 1981. For each crop the results from all trials with

similar soils were grouped. (See section **Yield Response to In-row Subsoiling.**)

Each bar graph shows the average yield increase (or decrease) for the indicated practice compared with the check treatment. The check treatment consisted of discing only, except as shown by the cross-hatched bars.

PRACTICAL CONSIDERATIONS AND RECOMMENDATIONS

The following recommendations are based upon the results shown in Figure 8.

(1) For Light-colored Land of the Coastal Plain

- **Soil Group 1 (sandy; over 15 inches to subsoil)**—For farm operations in which deep sandy soils predominate in many fields, the use of a ripper-planter unit to subsoil at a 16- to 18-inch depth without bedding is recommended for both corn and soybeans. This concept is shown in Figure 6. Where adequate tractor power (100 to 130 hp for a 4-row unit) is already available, yield increases in most years make this practice highly profitable. Subsoiling with bedding would give similar yield increases but often would not justify the additional cost above that of the ripper-planter approach. Deep chisel plowing (11 inches) also improved yields but was less effective and more costly.
- **Soil Group 2 (sandy; less than 15 inches to subsoil)**—These soils are susceptible to the formation of *very dense, but thin* pan layers. Tillage below 12 to 14 inches should be avoided (see Figure 5). The desired depth of 10 to 12 inches can often be adequately achieved by deep chisel plowing, moldboard plowing or shallow subsoiling. In comparison with discing alone, all these treatments offered large yield benefits. Subsoiling *with*

bedding may offer added benefits during wet periods but may contribute to erosion on sloping areas.

In terms of comparative expense and efficiency, the choice for this soil group would also be a ripper-planter approach. For these soils, however, it is important to consider the options of chisel or moldboard plowing, since the yield responses from these practices may be similar to those effects gained from a subsoiling procedure. In a farm operation where these soils predominate, several points should be considered before changing:

- The change to an in-row subsoiling procedure could reduce tillage trips, although this approach may increase the need for skilled tractor operators and management.
- The acreage of corn (strong response) versus soybeans (weak response) may also be an influential factor in the decision.
- Instead of subsoiling another option is to chisel deeper and avoid recompaction through the reduction or elimination of discing.

(2) For Predominantly Dark Mineral Soils of the Coastal Plain

- **Soil Group 3**—Dark-colored mineral soils have limited natural internal drainage and a somewhat higher organic matter content than the lighter colored soils. With adequate liming and drainage these soils often are more productive than the previous soil groups because of their reduced likelihood of drought stress. The differing response of corn to deep tillage among these dark soils depends on the fineness of texture throughout the profile and the general ability of the soils to drain.

Farms where dark-colored mineral soils predominate should follow the same suggestions for careful tillage decisions given for the light-colored soils of **Group 2**. (Consider the chiseling already being done; base the decisions primarily on the better-draining, medium-textured dark land being planted in corn.) An additional consideration for dark soils should include using bedding together

with interceptor ditches and/or tile systems to better manage excess water.

Subsoiling should definitely be avoided in dark soils having a tight, clayey subsoil within 12 inches of the surface and in soils with silty surface layers. Moldboard or chisel plowing with minimal discing, or discing with bedding are suggested for corn. For soybeans, any tillage procedure, including discing alone, which results in optimum plant population and weed control generally produces similar yields in these heavy-textured, dark soils.

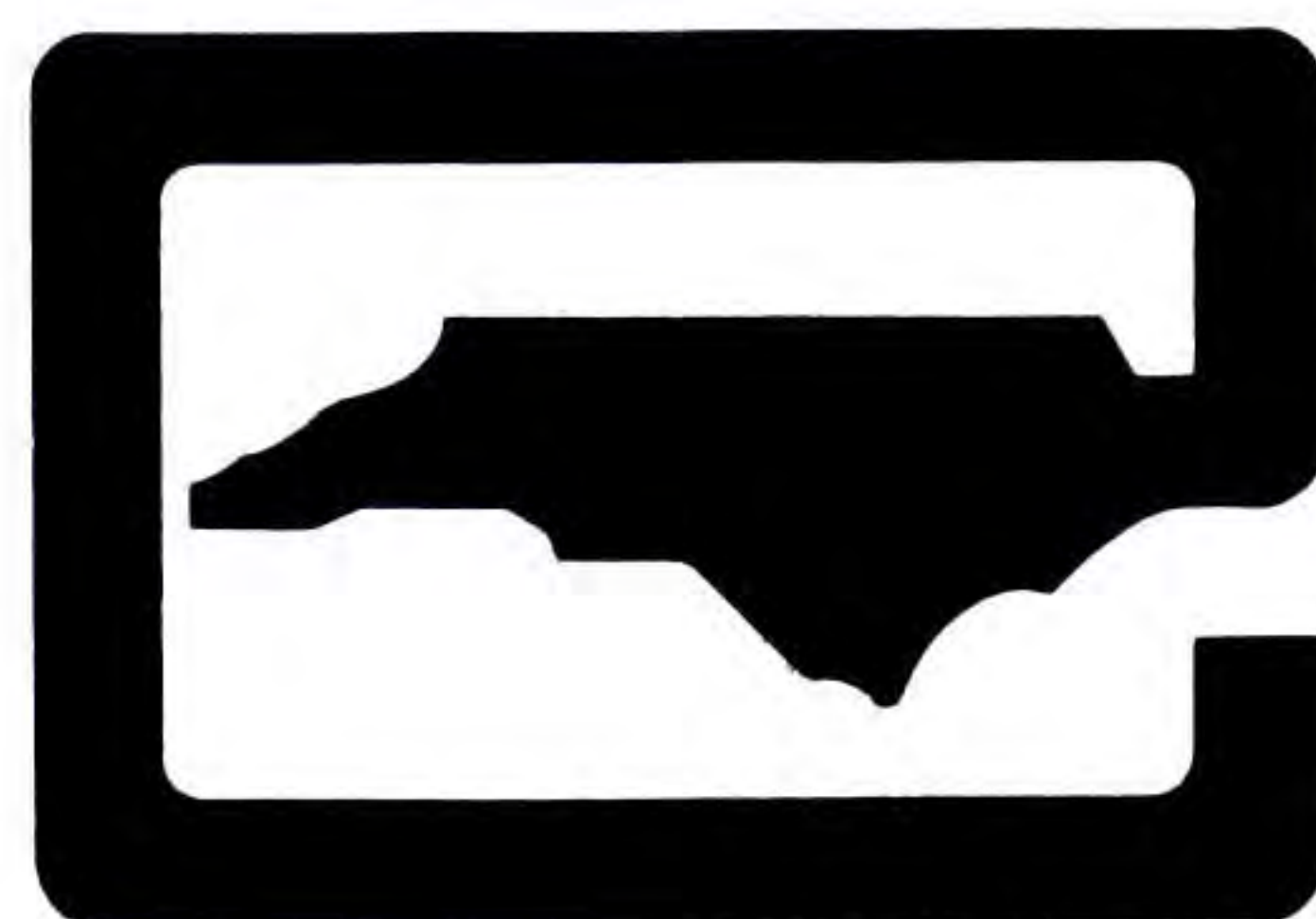
(3) For the Eroded Soils of the Piedmont

- **Soil Group 4**—The corn response to in-row subsoiling at planting in five experiments on these soils has been variable and sometimes strongly negative. The practice was never associated with a definite corn yield increase, even during seasons of extreme drought stress. In fact, this practice was clearly detrimental to yield in some cases. Furthermore, the soybean responses to in-row subsoiling and deep chisel plowing were variable, generally small and, therefore, of little practical use. From these results and the concepts presented earlier (see Figure 7), deep tillage at planting time is not recommended for corn or soybeans in the upland, eroded soils of the Piedmont.

Note that these studies did not involve fall subsoiling or mulch chiseling (a procedure done by tillage units with heavy coulters and twisted chisels designed to leave a rough land surface). These results, therefore, neither detract from nor support the recommenda-

tion of those practices. However, the potential value of loosening dense, silty or clayey soils in the fall to enhance rainfall infiltration and reduce runoff and erosion is generally recognized. Such practices should aim to avoid excessively deep tillage which would tend to bring up clayey, sticky subsoil, slatey fragments or rocks from below the surface.

The medium- and fine-textured upland soils of the Piedmont are also susceptible to compaction damage from tractor wheels and heavy tillage or harvesting equipment. Excessively fine tillage of this land greatly contributes to water runoff, soil erosion and yield losses. Management of these soils is more a matter of judgement in timing and number of tillage trips than in any particular tillage practice. For these soils successful no-tillage systems offer the greatest potential for increasing yields through water conservation and erosion control.



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