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Heavy Plains Soil Moisture Problems

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HEAVY PLAINS SOIL MOISTURE PROBLEMS

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The observations and suggestions given in this bulletin apply to the heavy soils of Panhandle Oklahoma and the adjacent region. The soil referred to is commonly known as hard land, tight land, black land, wheat land, clay soil, or heavy soil to distinguish it from the sandy or loam soils also found in this region.

This type of soil is celebrated for a high producing power under favorable moisture conditions and at the same time for difficulties of moisture management.

The information upon which these recommendations are based was obtained from moisture and crop experiments in progress at the Panhandle Agricultural Experiment Station, Goodwell, Oklahoma.

GETTING MOISTURE INTO THE SOIL

What Becomes of Rainfall?

The disposition of a seventeen inch rainfall on what is termed level land of the heavy soil type has been roughly determined by a series of experiments carried so that accurate measurements could be made.

An average of 31.3% of the rainfall comes in showers too small to add anything to the subsoil moisture and evaporates soon after falling.

The remaining 68.7% of moderate to heavy rains goes as follows:

13.5% runs off or collects in low spots in the fields.

34.5% evaporates from the surface before it has a chance to soak in deep enough to be safe.

20.7% soaks into the soil and joins the permanent body of soil moisture. Of this portion 2.7% is used by tillage and 18.0% by growing plants.

With only about one fifth of the total moisture received being available for crop production and part of that wasted by weeds, there is apparently much room for improving the moisture using efficiency of the farm methods. Some justification exists for the statement that it is not more rainfall the plains region needs to insure regular crop yields but better use to be made of that received. The following discussion points out some of the possible ways this can be done and also the limitations of some of the practices advocated.

Runoff Problems

Perhpas the greatest opportunity for saving rainfall ordinarily lost lies in preventing surface runoff. The amount of water lost during flooding rains is equal to almost two thirds of the amount actually used in crop production under the present methods. It is naturally impossible to get all the runoff into the soil for crop use, but there is enough to provide a very substantial increase in moisture supply if but a portion of it is saved. The control of runoff is partly a problem of losses from the field and partly distribution in the field. Any form of level terracing or contour tillage will secure the desired results. The desirability of terracing land ordinarily termed "level" has been proved by the results of experiments on fields where the slope is less than on foot in two hundred.

Terracing for Moisture

Although terracing is not important for preventing erosion on this land profitable gains in yield have been recorded as a result of moisture saved for the crop.

Terracing Results on Heavy Soil at Goodwell, Oklahoma.

Year	Crop	Yield in Pounds Per Acre Unterraced	Terraced	Gain	Percentage of Gain
1926	Milo Grain	637	950	313	49.1
1927	Sorghum Forage	3125	4028	903	28.8
1928	Milo Grain	1343	1470	127	9.4

In 1926 the excessive rains were June 18, 1.12, and June 25-6, 2.71 inches. In 1927 they were July 23, 1.48; July 29, 1.15; Aug. 4, 1.12; and Aug. 29, 1.28 inches. The excessive rains of 1928 were May 3, 1.17; May 11, 1.60; and July 217, 1.24 inches.

As will be noted the time and size of excessive rains determined the loss suffered and the extent to which terraces save moisture. The gains of these three years vary a great deal but average 29.2%. Each year showed a more or less need for saving runoff. It is highly probable on the other hand that a season may come occasionally when no heavy rains would fall and the terraces would lie idle, but their upkeep is small and nothing is lost by their presence in the field.

Evaporation Problems

Means of reducing evaporation losses are not as successfully practiced as for controlling runoff. Perhaps the most promising opening for attacking this problem is in increasing the absorptive power of the top soil for the purpose of enabling moisture to soak in rapidly and thereby be removed from prolonged exposure to rapid evaporation conditions. Two general ways of doing this are by cultural methods and organic matter regulation.

Absorption by Culture

The preparation of a coarse mulch on the surface provdes a short period of rapid absorption during a heavy rain, but after a certain amount of rain has fallen the surface again runs together so that about the same conditions of surface penetration exists as on compacted soil. The art of using this means of saving moisture would depend on the ability of the farmer to forecast the occurrence of heavy rains. The effectiveness of moderate to light showers requires a shallow mulch. On packed ground the soil moisture reaches nearer the surface and a smaller rain is required to saturate the mulch and connect with soil water than on cultivated land. The deeper the mulch maintained the larger the rainfall is needed to saturate it. Showers of one half inch are capable of adding to the permanent body of soil moisture on uncultivated or very shallow mulched soil, but from one half to three fourths of an inch rain may not be enough to saturate a deep mulch completely and in such case would not join the soil moisture nor add any to the permanent store. Where a deep mulch has been used and rains of from one to two inches occur the mulch will be partly compacted reestablishing moisture contact with the subsurface soil and immediately reducing the mulch depth. A material advantage is gained by the more rapid absorption and consequently the saving of a larger portion of the rainfall from exposure to surface evaporation.

Long experience in plains weather observation indicates a rather low degree of accuracy is possible in guessing at the character of the next rain. However, a study of the character of the rainfall by months shows that the excessively large rains more regularly occur in May or June, and if plans are such as to enable the maintenance of a certain condition for several weeks at a time this is undoubtedly the best time of the year to use deep cultivation for moisture gathering purposes. The proportion of light showers runs so high during the other months of the wet season that no prediction is at all possible. January has proved to be consistently dry over a period of seventeen years. The chances of getting winter moisture are very low so the cultural condition of the soil does not matter so much from this standpoint.

While there is a slight chance that preparation for the reception of heavy rains will be beneficial in early summer it does not appear possible to accomplish very much in this direction.

Absorption by Manuring

The other means of promoting rapid absorption, maintaining a high vegetable matter content in the top soil, is effective regardless of the size of rain and therefore promises greater usefulnss than any possible cultural method. Experimental results under the soil and climatic conditions represented have been carried only to demonstrate the desirability of keeping up soil organic matter at a high level. Ways of doing this which will interfere least with cropping plans and prove more efficient from the operative standpoint have not yet been worked out. Returns of organic material have not only an important moisture relation but considerable significance from the fertility viewpoint, so there is a great deal of work yet to be done devising suitable and effective methods.

Two suggestions may be offered which have been indicated by experiment. Manure can be used up to twelve loads per acre without danger of disturbing the yield possibilities if it is applied just before a hay or forage crop.

When moisture conditions are such that fertilizing would stimulate the too rapid use of soil moisture which should be reserved for the latter part of the growth period of a grain producing crop it has been found that the forage crop yield is not affected.

By the second year contrary factors have been harmonized so that only beneficial effects may be expected with any crop.

Residues, manure crops, or animal manures can be profitably plowed down the fall or winter preceding summer fallow which provides ample time for rotting raw material into a beneficial condition. The main difficulty with this is that the advisability of summer fallowing cannot be told so far ahead of time, but conditions favoring cropping earlier in the year would also favor the more rapid incorporation of raw manure into the soil.

MAKING USE OF SOIL WATER

Moisture Capacity

The type of soil under discussion is capable of holding in place a permanent body of soil moisture equal to about 16% of the dry weight of soil. Numerous observations of the moisture content at times when crops cease to grow from drouth shows that the soil holds nearly 10% of moisture all the time which is not available to plants. This means about one inch of available water may therefore be held in storage per foot of soil depth after the moisture has soaked into the soil as deep as it will go following a period of wet weather and come to rest, no considerable movement of moisture in any direction may be expected until additional supplies are received. When a body of soil moisture thus reaches equilibrium it is safe from loss unless exposed either to air or to living roots of plants.

Loss From Evaporation

If soil moisture is exposed to circulating air evaporation takes place but only the first foot is usually subject to this loss. Air circulates freely in the top soil to various depths according to the fineness of the soil and the cultural condition.

The cultivation condition is the only factor capable of being changed grealy by farm operations. During periods when no moisture is being removed from the soil by plant growth and none is being added by precipitation it has been found that the losses from the soil are roughly in proportion to the depth cultivated. As well as could be determined by the study the implement used did not make much difference. It was the actual depth or cross section disturbed that affected the evaporation.

Where ordinary tillage has been done about one half inch annually has been used up by these operations. This may not seem to be very much but when it is noted that it takes from 1.50 to 2.50 inches of rainfall to produce a half inch of soil water it is worth some consideration. It is equal to about one seventh of the total amount available to crops.

Each tillage operation contemplated should be viewed with reference to moisture conservation for the current or oncoming crop. Waste from unnecessary depth or frequency of cultivation should be avoided as much as possible.

Whether the penetration of air into the soil is shallow or deep the limit of active circulation forms the actual evaporating surface. Moisture from the main body of soil water reaches this surface by dispersion but after the moisture content falls to a moderate figure the movement becomes so slow and the quantity removed so small that it is negligible from a practical standpoint. It is readily seen therefore that surface evaporation can go only so far in removing a store of soil moisture and it is really the moisture of the topsoil that is concerned.

Loss Through Growing Plants

The second and most important removal of soil moisture is by direct exposure to the roots of growing plants. The range of depth of root systems is much greater than that of tillage operations. The most shallow rooted plants such as native sod grasses penetrate to more than twice the depth of ordinary plowing. Crop plants and cultivated weeds develop root systems from 40 to 70 inches below the surface and use up available moisture as deep as they go. Crops and weeds are able to remove subsoil moisture in a few weeks which if subject only to surface evaporation would remain for many months.

It should be clearly understood that moisture does not rise from the subsoil or substratum to supply the needs of crops on the uplands of the high plains region. It is removed from the soil only so far as the roots have penetrated. Root growth continues through a normal growing season until the turning of the plant toward maturity or until the moisture is exhausted.

The control of plant growth is in the hands of the farmer to be exercised so that soil moisture is permitted to be used only by productive crops. At any time in the growing season when available moisture is on hand weed control is important. Cultivation though it does use surface moisture is much to be preferred than weeds, since the most drastic kind of tillage will waste much less water than a growth of weeds.

Behavior of Soil Moisture

The rise of water through the soil by capillary action is a natural result of a continuously replenished supply from below as where a surplus exists on the fringe of a water table. The mere absence of a shallow water table does away with the rise of subsoil moisture to the surface. In fact there is much more danger that moitsure will be lost by soaking down too deep to be reached by crop roots. Under a rainfall of 15 to 20 inches the entire six foot soil section is very rarely saturated. The moisture is usually demanded by crops or weeds faster than it can accumulate. On those exceptional occasions when the soil is flooded with water the immense half filled substratum is always reaching for more which may escape from the agricultural six foot layer and never gives any back.

The deep mulch which is popularly supposed to cut off moisture waste from below in reality lowers the evaporation surface into the soil and hastens the depletion of surface moisture. It is of benefit only as it may be the incidental result of cultivation necessary to kill weeds or provide an absorptive blanket for the rapid taking up of heavy rains, a portion of which can thus be saved from immediate evaporation. A straw mulch for adsorption purposes has the advantage of not losing its porous condition as a coarse soil mulch does during a rain and is highly recommended for trees, small fruits or certain garden crops on which their use may be practical. In any case it is the absorption that is beneficial and not the protection of soil water from evaporation.

Simple protection of moisture from weeds regardless of the condition of the surface enables a body of soil moisture to endure in the subsoil for periods of three to five months without material losses.

Character of Rainfall

There is a great difference in the effectiveness of different kinds of rainfall. Experiments have been performed to determine the most efficient size of rain for heavy soils. The slow movemenr of moisture in clay soil makes a larger rain necessary to keep all of it from being evaporated and a smaller one permissiible to keep it below the point of runoff than are found suitable for sandy soils. Thus both smaller and larger rains may be very efficient on sandy soil that are on heavy soil relatively wasteful.

A shower of less than a half inch on heavy soil does not add materially to the permanent store of soil moisture. About half of it remained in the top-soil at the end of three days but it had almost all disappeared at the end of seven days. However, if these small showers come on consecutive days they have more of the effect of a larger rain. While the small shower does not increase subsoil moisture it does play an important part during the growing season in reducing the water requirement of the crop and lessening the injury from severe atmospheric conditions.

After about one inch of water has fallen it begins to puddle on the surface or run off if it has a place to go. Rains of much more than one inch nearly always cause runoff and decrease in efficiency with their size.

Limits of Storing Moisture

One danger of inefficiency with which the farmer is threatened should he attempt to preserve a store of moisture through a prolonged rest period would be the diminishing returns from later rainfall. After the subsoil reaches a degree of saturation approaching the maximum quantity for stability the effectiveness of rainfall decreases. In other words a point of diminishing returns is reached. In practice this rarely happens even in the most unnecessary summer fallow because all other losses must be entirely stopped before over fattening of the soil could take place.

Tillage and Fertility

Plowing has much the same effect on yield that a light top dressing of manure does providing it is done far enough ahead of time to allow the soil to regain a normal firm condition. According to the weather conditions this may take from a few weeks to eight or ten months. It is never safe to assume that it will be ready for immediate planting, so deep tillage for the improvement of fertility conditions should be timed to precede a rest period. Fall is the best time of the year if top soil moisture is present so that a satisfactory job can be done, but reduced yields will result if the plowing or listing is done when the soil is dry and cloddy, unless ample rainfall is received soon after the operation. Since winter is normally the dry season some care must be exercised in fall preparation. Plowing or deep listing may still be done in the spring if summer fallow is intended, but even in this case if much manure or residues are to be turned under the fall is best.

During the summer fallow level shallow cultivation has favored the accumulation of available plant food more tthan listing and working down.

As the effects of plowing may still be observed from two to four years later the desired deep tillage need not be done on a schedule but when a favorable opportunity is presented.

The Relation of Season to Soil Moisture

All rainfall is more efficient in buildingg up soil moisture when soils are cold than when warm. Soil heat adds greatly to the evaporation rate so that spring rains of the same size are much more effective than fall rains. The possibilities of saving and making use of spring rains are good occasionally and each opportunity should be grasped.

The removals of soil water by various cultural practices are greatest in the warm season and high humidity is a very important factor. It is consequently possible to carry a store of soil moisture through the winter with less loss than it could be carried through the summer. This consideration emphasizes the importance of using soil moisture supplies immediately when they are present in the spring or early summer.

Seasonal Rainfall and Stored Moisture

When the importance of different factors which control crop yield is measured it is found that the amount of soil moisture at the beginning of the growing season for any crop exerts an influence about equal to that of the rainfall which follows. Contrary to common belief soil moisture and seasonable rainfall combined have less to do with high and low yields than certain atmospheric conditions which are highly destructive to growing crops.

An average of 15 fields of wheat grown on summer fallow used 4.03 inches of soil water in addition to the rain that fell during the growing period. When this group is thrown in with 33 others growing crops in continuous culture the average of soil water contributed to the growth of the crop falls to .91. There is a very wide variation in the amount of stored moisture used at different times. For this reason it should be closely observed when considering any planting. Planting time moisture may profitably determine the sowing or omission of spring grains and also the rate of planting for milo.

Atmospheric Conditions

Yields may be reduced all out of proportion to what might be expected from a certain soil moisture and rainfall combination by an unfavorable combination of high temperature, high winds, and low humidity. These factors operate more or less independently of rainfall and react mainly on growing vegetation. Their effects on soil moisture and the success of summer fallow is less marked.

On the other ahnd mild atmospheric conditions increase the efficiency of moisture. Going hand in hand with this is the beneficial effects of light showers during the growing season. While these showers do not add much to the soil moisture they are beneficial to the crop yields by affording frequent relief from too rapid evaporation conditions.

Little can be done artificially to control atmospheric conditions, except by the windbreaks. Wind shelters are practical for small areas of fruits and vegetables and the results are often remarkable. Experiments have shown that wind damages the plant physically in addition to causing the use of more moisture. It reduces yield and delays maturity.

SUMMARY

No forward looking and thoughtful plan of farming will fail to take into consideration the fact that the higher yields are forced from the land by tricks of increasing the moisture using efficiency the quicker will the native fertility be reduced to a low point. The fact that climatic conditions conspire to protect the native fertility from too rapid exploitation is no reason for throwing all caution to the winds and adopting the attitude that it cannot be endangered by any sort of methods. The fact is that heavy soils in cultivation only twenty-five years now contain but two-thirds of the organic matter they did when first put into cultivation. This same land has fallen far short of producing a crop every year and it is probable that if the most advanced ideas of getting the most possible from the soil under the existing rainfall conditions had been practiced the condition would be poorer still.

A fortunate relation of the fertility and moisture problem is that of the double importance of organic matter. Since the changed balance brought about by cultivation has reduced the organic matter of the top soil it has also and thereby reduceed the absorptive power of the soil and consequently the moisture using efficiency. We partly make up for this by terracing and other methods but the fine yields remembered by the old settler on new lands were due both to moisture using efficiency and fertility of the sod. It is true that a rebuilding of the native condition is incompatable with production but a practicable approach to it must be worked out.

The use of the residues of small grain and sorghum crops is bound to be inadequate though vitally necessary in spite of the transitory difficulties due to slow rotting.

It must not be thought that limited rainfall produces only difficulties without compensation. Some of the very problems it introduces are half solved by its other relationships. These advantages are usually overlooked because of the looming importance of the occasional drouthy period.

A light rainfall reduces surface erosion to a minimum and thus avoids one of the greatest losses incident to upland cultivation in humid regions. It further favors the conservation of fertility by permitting it to accumulate in the available soluble form without danger of being leached away and permanently lost in the lower soil.

Fewer wet spells in the cultivating season makes weed control easier so that both preparation and crop cultivation can be successfully done with little labor.

The harvest of both grain and forage crops is not so often interfered with and a higher grade product is produced than is commonly done in more humid areas.

Crops are generally free from such diseases and insect pests as require moist conditions for their propagation.

Taken all together the efficiencies of both fertility and moisture control contribute to each other and if each is treated with full respect to the general good only desirable results can follow.

Useful Dry Farming Practices for Heavy Soils

1. Contour tillage or level terracing saves runoff.
2. The maintenance of organic matter promotes rapid absorption of moisture into the soil.
3. Deep plowing for fertility improvement and returning vegetable matter should be done as long before planting as possible. When preparing to summer fallow is a good time.
4. The fewest cultivations necessary to control weeds conserves best the moisture already held in the soil.
5. Iron clad rotation is inefficient. Better successes and fewer failures result from planning the cropping system according to varying conditions.
6. Fallowing should be used only when the subsoil is exhausted of available moisture.
7. A store of moisture is more efficiently used during the first available crop season than saved over for a future crop.
8. The moisture using efficiency of early maturing grain sorghums is improved by late planting.
9. Highest grain yields are insured from grain sorghums by varying the stand according to the amount of soil moisture available at planting time.
10. Spring grains can best be omitted from the cropping system excepting when early spring moisture supplies are adequate.
11. In order not to let any seasonable opportunities for production go to waste equipment should be provided for small grains, row crops, and forage crops, and timely use made of them.