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Initial Soil Moisture and Crop Yield

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INITIAL SOIL MOISTURE AND CROP YIELD

Students of dry land agriculture have made many studies of the relationships between soil moisture and crop production. Usually the dependence of yield upon initial soil moisture has been found to be small or else very erratic due to the intervention of other determining factors. In many instances where a positive relationship has been established the bearing of soil moisture is not great enough to provide a dependable basis for revising farm practice. The climatic characteristics must necessarily determine the extent to which prediction results would be satisfactory. The distribution of rainfall, the dependibility of rainfall, the character of rainfall, and the temperature relationships also have much to do with the possibility of making useful such predicitons. Other very important conditions affecting the potential usefulness of preseason predictions are the types of crops adapted to the locality and the type of soil in use. Where climatic conditions and soil type have certain distinct relationships favoring prediction accuracy, it is destined to become a highly useful method.

A notable example of an instance where initial soil moisture has become a reliable index to crop possibilities has been cited by Cole and Mathews in their bulletin "Use of Water by Spring Wheat in the Great Plains," U. S. D. A. Department Bulletin, Number 1004. Under the conditions of their studies the amount of soil moisture present at seeding time has proved to be a useful indication for determining the advisibility of sowing or omitting spring grain from the crop system. Such information is applicable not only to a particular seasonal condition but as well to individual field conditions.

The observation of soil moisture is not a difficult procedure and may be successfully done by anyone familiar with his soil conditions and without elaborate equipment. For scientific purposes it is of course necessary to use more accurate methods of sampling and moisture determination in arriving at the exact facts, but for practical purposes once the basic relationships to crop production are established the simple examination of field soils is all that is necessary for the farm operator to get the needed information. A posthole digger can be used as well as a regular soil auger or tube. Many persons who have paid attention to moisture conditions in the past have probably attached more importance to surface moisture conditions than to the subsurface or subsoil. Since the subsoil moisture content is of more far reaching importance, it is advisable to provide either an auger or tube which will enable an adequate as well as a more rapid and less laborous examination to be made.

It is the purpose of this discussion to indicate what are the possibilities of using initial soil moisture information on the heavy types of soil of the southwestern high plains winter wheat region as represented by the investigations in progress at the Panhandle Agricultural Experiment Station, Goodwell, Oklahoma. The soil of the Panhandle station is typical of those areas mapped by the U. S. Department of Agriculture, Bureau of Soils in the Panhandle region of Texas as Amarillo silty clay loam. It should be clearly understood that suggestions arising from these experiments apply particularly to this one soil type as well as the climatic feature of Panhandle Oklahoma. It must not be applied to sandy types of soil nor under other climatic conditions. Three studies are reported here covering the relationships of initial soil moisture to spring grains, grain sorghum crops, and winter grains.

Oats

Spring oats are selected as a representative spring grain crop. The data assembled in Table 1 comes from four rotation experiments in which oats is a regularly planted crop following wide row kafir, wheat, wide row corn and regular spaced kafir. The moisture content at oat seeding time is represented at total quality of moisture contained in the six foot soil section in inches of water. The yields are given in pounds of threshed grain per acre. The seasonal rainfall (January to June, inclusive), is included in the table.

It is evident from a study of the relation of initial soil moisture to grain yield that there is a minimum moisture content below which it is not safe to depend upon spring grain yields. The instances of 1926 and 1927 on the other hand show that initial moisture is not a dominant factor when the moisture content of the soil is about average. During both these seasons about 13.5 inches of total water was present in the soil at sowing time.

A favorable seasonal rainfall in 1926 entirely overcame the uncertainty indicated by initial moisture conditions and resulted in high yields. In 1927 the uncertainty of initial moisture conditions was quickly turned into certain

Table 1.—Initial Moisture and Oats Yields—1924-1928.

Plot No.	Previous Crop	Initial Moisture Inches	Seasonal Rainfall	Grain Yield Lbs. Per Acre
1111R24	Fallow	16.68	6.46	630
1114R24	Fallow	16.68		710
1118R24	Fallow	16.68		730
1211R24	Fallow	16.68		620
1110R25	Kafir—Wide Spacing	12.96	4.71	Failure
1113R25	Wheat	10.76		Failure
1117R25	Corn—Wide Spacing	12.96		Failure
1210R25	Milo	10.01		Failure
1112R26	Kafir—Wide Spacing	13.27	13.17	1000
1115R26	Wheat	14.90		1590
1116R26	Corn—Wide Spacing	13.27		1090
1212R26	Kafir	12.85		1230
1111R27	Kafir—Wide Spacing	14.41	4.04	Failure
1114R27	Wheat	12.90		Failure
1119R27	Corn—Wide Spacing	14.41		Failure
1211R27	Kafir	12.40		Failure
1110R28	Kafir—Wide Spacing	14.50	12.88	1330
1113R28	Wheat	16.94		1590
1118R28	Corn—Wide Spacing	14.50		1750
1210R28	Kafir	13.07		1170

failure by continued dry weather. Only one time during the period has a high initial moisture supply entirely overcome adverse seasonal rainfall. During this season (1924) the yield was low. Distinctly favorable soil moisture conditions have occurred twice during the five years and each time resulted in yields of spring grain. Distinctly unfavorable soil moisture conditions have occurred once during the period and resulted in failure.

Favorable seasonal rainfall has occurred twice during the period and resulted in high yields. Unfavorable seasonal rainfall has occurred three times out of five years, resulting in two failures and one small yield, the small yield resulting from high initial moisture in spite of the low rainfall.

The experience of these five years tallies well with the crop history of this region since it was settled about 25 years ago. The seasonal rainfall is rather unreliable and has proved unfavorable to spring grains more often than favorable. Should spring grains be entirely omitted from the planting schedule when distinctly unfavorable soil moisture conditions prevail at seeding time, it is probable that occasionally a production opportunity would be lost when such conditions coincide with a subsequent favorable seasonal rainfall. However, the risks thus assumed are not great and appropriate cultivation would enable the operator to save a portion of the spring rainfall for the use of summer crops. The usefulness of spring grains on any particular farm in regard to livestock requirements should probably determine whether spring grains would best be sown only on highly favorable initial moisture prospects or determine either the advisibility of sowing or omitting this crop or in determining the acreage to be sown each year. Since other productive types of summer grain crops particularly the sorghums are available it seems best to follow the conservative program whereby risks of spring grain failure are almost entirely eliminated. Production opportunities which can later develop under this plan can then be used for summer crops and the temporary losses compensated. It is apparent that the passing by of uncertain production opportunities is not as wasteful as crop failures. In the case of spring grain a crop failure not only occasions the loss of seed and labor for the current crop but also destroys the opportunity for an immediately succeeding crop.

The correlation of initial moisture to yield is .42+.08 while that of seasonal rainfall to yield is more than twice as great .93+.01. Even though initial moisture is less than a fourth as important as the subsequent rainfall, it is nevertheless the most important preseason factor that can be measured ahead of time and used as a basis of planning.

Milo

Experiments with milo to study the importance of initial moisture may be considered applicable to other grain sorghums of similar growth habit and time of maturity. The possibility of using soil moisture information for the forecasting of sorghum yields is more promising than that found in a study of spring grains.

The data presented in Table 2 are from a continuous cultural experiment in which divisions of spacing and fall preparations are used. The seasonal rainfall in case of this crop includes the period from harvest to harvest. This is approximately 12 months, but varies somewhat due to the seasonal conditions at harvest time.

Four times during the five year period 3½ foot rows have outyielded the seven foot rows. One of these instances, the year of 1927, presents a result with not so much difference in the two methods of planting. However, in the other cases very significant differences show up. When an average is made of all regularly spaced plots both fall listed and unprepared the advantage is somewhat in favor of this method over the wide rows. The first instance of an almost complete failure of the regularly spaced plantings shows so great a deficiency of soil moisture at planting time it was not difficult to predict a poor crop with all methods and the probability of higher yield for wide spacing.

When a division is made on a basis of fall preparation versus planting time preparation only, there appears a significant relationship to fall moisture content of the soil and the effectiveness of fall listing. The advisability of fall listing can be easily determined by soil moisture conditions at the time the operation is contemplated. Listing or plowing may be done at once or delayed in wait for further developments or omitted entirely, dependent on soil moisture. The effectiveness of fall preparation manifests itself upon both wide and narrow spaced plantings so this decision may be made without regard to probable spacing. The benefits of fall preparation are due partly to its effect on fertility conditions and it has been supposed that the injury or benefit of fall tillage is due largely to its effect on the accumulation of soluble plant foods. When the topsoil contains sufficient moisture to permit a satisfactory job of plowing or listing to be done, the physical condition of the soil will rapidly assume a favorable attitude toward bacterial activity and such cultivation will stimulate the accumulation of usuable plant foods. On the other hand when the soil is worked in a hard cloddy condition, considerable early spring rainfall is required for the process of restoring normal topsoil conditions. Sometimes quantities of moisture are wasted in this way and the bacterial processes delayed so late that a material disadvantage is suffered by the following grain sorghum crops. The year 1925 was singularly impressive example of this. Soil moisture was reduced to an average of less than 12 inches per 6 feet of soil the fall preceding this crop and spring rains

Table 2.—Initial Moisture and Milo Yields with Various Methods.

Plot No.	Fall Soil Moisture, Inches	Topsoil Condition in Fall	Planting Time Soil Moisture	Growing Season Rainfall	Prediction Favored	Method Used		Yield, Lbs. Per Acre
						Preparation	Space	
1319M24	14.13	Moist	16.16	5.24	Fall list Close space	Listed	3½	1570
1320M24	14.13		16.48			Listed	7	1045
1321M24	14.13		16.26			None	3½	975
1322M24	14.13		17.44			None	7	795
Ave. '24	14.13		16.58					1096.2
1319M25	11.61	Dry	9.67	10.08	No Preparation Wide space	Listed	3½	61
1320M25	12.04		10.80			Listed	7	510
1321M25	11.76		10.05			None	3½	482
1322M25	15.55		12.29			None	7	867
Ave. '25	12.72		10.70					480.0
1319M26	12.15	Moist	15.26	8.34	Fall list Close space	Listed	3½	1083
1320M26	13.57		15.87			Listed	7	768
1321M26	11.87		15.54			None	3½	912
1322M26	16.66		16.12			None	7	732
Ave. '26	13.56		15.69					873.7
1319M27	12.04	Dry	12.54	13.82	No preparation Close space	Listed	3½	1535
1320M27	12.65		15.80			Listed	7	1345
1321M27	12.54		13.28			None	3½	1475
1322M27	12.94		14.62			None	7	1150
Ave. '27	12.54		14.06					1376.7
1319M28	13.17	Dry	15.28	6.83	Fall list Close space	Listed	3½	1598
1320M28	13.28		18.91			Listed	7	1393
1321M28	13.48		17.08			None	3½	752
1322M28	14.86		21.23			None	7	831
Ave. '28	13.69		18.12					1143.5

Table 3.—Average Grain Yields From All Methods—192994-1928.

No. of Trials	Method	Lbs. of Grain Per Acre	Gain Over Alternate Method
10	3½' Row Plantings	1044.3	100.7
10	7' Row Plantings	943.6	
10	Fall Listed Preparations	1090.8	193.7
10	Unprepared Plots	897.1	
10	Using Prep. Prediction alone	1143.1	298.3
10	Opposite Above	844.8	
10	Using Spacing Prediction Alone	1127.7	267.5
10	Opposite Above	860.2	
5	Using Both Predictions	1318.6	565.8
5	Opposite Both	752.8	

were so delayed before planting time. Fall moisture conditions were somewhat similar prceding the 1926 crop though not quite so low. Spring moisture conditions in this case were distinctly favorable to an early resumption of normal bacterial functions. Very slight gains in yield were measured that year due to fall prepartion. Significant gains were shown for fall preparation in 1924, 1927, and 1928. In all these cases the fall moisture content was well above the average.

Predictions of yield from fall preparation and unprepared land on this basis would have been entirely successful throughout the five year period under discussion. While the percentage of accuracy in predicting the best spacing to use at planting time has not been as good, material gains in yield would still have been made. The only season which presents a very doubtful situation was 1927 when the initial moisture seemed a trifle low for optimistic expectations. The results were slightly in favor of the narrow spacing authough satisfactory yields were obtained from both spacings. The predictions which are suggested as possible useful in determining the culture of the milo crop would be briefly as follows:

1. Fall listing or plowing should be done in preparation for the crop only whenever enough soil moisture is present to produce a good physical condition for the operation. When the soil moisture totals less than 12½ inches in six feet the fall tillage should be omitted, unless topsoil moisture is particularly favorable.

2. When more than 14 inches of total water is present in the six foot soil section at planting time, indications are favorable for the higher grain yield being produced by the ordinary rate of planting. If there is a marked deficiency of soil moisture which may go down to as low as nine or ten inches of water in the six foot soil section, the chances are distinctly favorable to wide spacing.

A full stand is usually from 20,000 to 30,000 stalks per acre. Such stands are usually obtained by using a flat plate dropping from three to five seeds in hills two to two and one-half feet apart with rows spaced 3½ feet. The stands required for best results under adverse conditions would range from about 8,000 to 15,000 stalks per acre. The thin stand may be obtained in two ways, by widening the rows or by using the regular row spacing with greatly reduced rate of drop.

An average of all methods of preparation for the five year period, 1924 to 1928, inclusive, shows that when milo was planted in the regular rate without regard to moisture conditions a gain of 100 pounds per acre was made over planting the wide rows continuously. Similarly, if fall preparation was practiced without regard to moisture conditions an average gain of 193 pounds per acre was made over no preparation at all. When the fall tillage predtiction was made use of alone a gain of 298 pounds per acre was secured. When the planting time predictions for best spacing was made use of alone, 267 pounds per acre was gained. When both fall tillage and spacing predictions were used, an average gain of 565 pounds, or 10 bushels was secured.

It is evident that if a single method is to be followed that narrow spacing with fall preparation netting a gain of 293 pounds per acre over wide spacing without preparation would be the more productive method over a period of years. However, there is no reason why initial moisture conditions should not be made the basis of variable preparation and spacing methods for the milo crop. Increased yields secured in this manner are net profits in so far as the cost of surplus production is concerned. In the case of the omission of fall preparation economy of operation is added to the increased yield secured thereby.

Winter Wheat

In a study of short season crops; namely, the spring grains and grain sorghums, it has been found that the soil is able to contain enough moisture at seeding time to materially influence the outcome of the crop. It should be pointed out that crops of low water requirements such as the sorghums are much more profoundly influenced in this way. Since winter wheat is the same type of plant as the spring grains, requiring a larger supply of water for each pound of dry matter produced, and is in addition a long season crop, it cannot be very reasonably expected that important relations would be found between seeding time moisture and final yields. A glance at Table 4 will show that fall moisture does not appear to indicate anything about grain yields on different years but may influence the size of yield when all other conditions are equal.

The correlation between seasonal rainfall and yield of winter wheat shows the same high relationship existing between them as was noted in the study of oats and seasonable rainfall. The correlation between initial moisture and yield for winter wheat is not at all significant. It is apparent that the influence of soil moisture present in the fall does not extend further than getting up a stand of wheat and supplying its needs through the winter and early spring. During the drouth of 1927 it was noted that plots beginning with high initial moisture held a month or more longer than those starting with a shortage moisture content, but were unable to reach maturity on a four inch seasonal rainfall. Winter wheat must necessarily depend upon the spring season for moisture required during the fruiting stage of the crop.

Table 4.—Initial Moisture and Wheat Yields With Various Methods.

Plot No.	Fall Moisture	Spring Moisture	Seasonal Rains	Previous Crop and Kind of Preparation	Yield Per Acre, Lbs.
1303M24	13.87	17.50	6.46	Fallow; Level	340
1304M24	13 87	18.25		Fallow; Level	780
1308M24	13.87	14.73		Fallow; Level	545
1311M24	13.04	14.56		Milo; None	280
1312M24	13.04	15.09		Milo; None	170
1316M24	13.04	13.87		Milo; None	130
1303M25	12.00	11.88	4.71	Wheat; Level	Failure
1305M25	18.16	14.10		Fallow; Level	Failure
1306M25	15.91	14.15		Fallow, Fallow; Level	Failure
1311M25	11.59	9.64		Wheat; Listed	Failure
1313M25	17.27	15.14		Fallow; Listed	Failure
1314M25	14.45	13.52		Fallow, Fallow; Listed	Failure
1303M26	13.15	11.70	13.17	Wheat Failure; Level	1137
1304M26	13.98	12.77		Fallow	1227
1307M26	15.34	14.79		Fallow, Fallow; Level	1855
1311M26	10.30	12.91		Wheat Failure; Listed	1340
1312M26	13.03	14.22		Fallow; Listed	1492
1315M26	14.11	12.56		Fallow, Fallow; Listed	2280
1303M27	11.74	10.34	4.04	Wheat; Level	Failure
1305M27	18.47	17.85		Fallow; Level	Failure
1308M27	15.51	16.91		Fallow, Fallow; Level	Failure
1311M27	12.35	12.12		Wheat; Listed	Failure
1313M27	14.65	16.84		Fallow; Listed	Failure
1316M27	14.59	15.55		Fallow, Fallow; Listed	Failure
1303M28	14.95	15.42	12.88	Abandoned Wheat; Level	1460
1304M28	17.03	13.92		Fallow, Fallow; Level	1442
1306M28	16.56	17.89		Fallow, Fallow; Level	2120
1311M28	16.65	13.96		Abandoned Wheat Listed	1562
1312M28	17.14	15.33		Fallow, Fallow; Listed	1310
1314M28	19.03	17.46		Fallow, Fallow; Listed	2200

Two factors of moisture are important during the fall. Topsoil conditions must be favorable to germination of the seed and sufficient moisture is desirable to support the crop through the dry winter season and until the spring rains begin.

During the five year period, 1924 to 1928, three wheat yields have been recorded as against two complete failures. In each of the years when the crop was successful high yields have come from plots which when planted contained much less moisture than did many plots suffering a complete failure on other years. It also is apparent that the high yields from summer fallow are to an important degree due to the fertility ocndition obtained as well as the moisture stored up. It is possible that occasionally a summer fallowed field of high moisture content will produce a low yield when other less favored fields fail, but the benefits of summer fallowing appear to be more successfully realized when highly favored seasonal conditions follow. With the limited data at hand it does not seem probable that sufficient relation between initial moisture and winter wheat yields exist to be made useful in the practical management of a wheat farm.

Summary

This report of the first year period of soil moisture studies at Goodwell, Oklahoma, does not permit definite conclusions to be drawn on many of the questions. Sufficient indications are given to show what may be expected when the initial moisture conditions are more definitely established.

Attention to soil moisture conditions can undoubtedly be made uesful on heavy soils under limited rainfall conditions for determining a variable farm practice regarding such short season crops as spring grains and grain sorghums.

The climatic conditions do not favor spring grains very consistently, but these crops can be very profitably used when early spring moisture supplies are adequate. A definite policy of omitting spring grains excepting under favorable conditions is recommended.

The influence of initial moisture on the effectiveness of fall preparation for summer crops and upon determination of the spacing of grain sorghums is sufficient to warrant dependence being placed on predictions based on it.

Fall preparation is recommended excepting when a severe lack of moisture exists at the time of the contemplated operations.

Varying the rate of planting grain sorghums according to the soil moisture present at planting time has given highly satisfactory results.

The initial moisture conditions have not been found to be of great importance to the wheat crop except for the establishment of a stand and wintering without drouth damage, and a dependable forecast of crop results cannot be projected on the present information of the subject.