For Dryland Wheat Production

Evaluation of Fallow To Increase Water Storage

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Summerfallow is included in cropping systems on North Dakota farms for agronomic reasons and to meet requirements for participation in various private and federal programs.

The reasons most frequently given are to increase water storage, improve soil fertility, especially as it pertains to available forms of nitrogen, and weed control. Fertilizers are an alternative to fallowing for fertility improvement (4, 11, 12). Herbicides are an alternative to controlling most weeds. A practical alternative to fallowing to increase moisture storage on extensive dryland acreage is lacking. But, enough water may be stored in some areas during the non-growing season (harvest to seeding) in a continuous cropping system so yields produced over a two-year period offset the larger yield usually obtained after fallow.

This report is to show when and where it is likely to pay to fallow for wheat production on dryland in North Dakota, when it is practiced to increase water storage. No attempt will be made to enumerate other factors or situations leading to decisions to utilize fallow in the cropping system.

Wheat yields are influenced by stored soil water at seending time. Thus, when fallowing increases the stored water supply, yields on fallowed soils are usually larger than on comparable soils continuously cropped. But whether the larger yields obtained on fallow will more than offset the necessary loss of a crop will depend upon production costs on fallow as compared to continuous cropping (non-fallow) and value of the product produced.

Water storage in soils depends mainly on the amount and distribution of precipitation during the time a crop is not being grown. For a continuous cropping system involving small grains, this crop-free period is about 9 months; when fallowing it is about 21 months. Studies at Mandan (5) show that on a 40-year average, about one-half of the 4.4 inches of available water stored during the 21-month fallow period was stored during the initial 9-month period. Young (12), in a study covering 4 years, showed that at seeding time fallowed soils contained an average of about 2 inches more available water than comparable non-fallowed (continuously cropped) soils. The amount of available water at seeding on non-fallowed soils varied from about 2 to 7 inches, the least being stored in soils of the western portions of the state.

Long-term precipitation records show that the average annual precipitation is greater in eastern than western portions of North Dakota.

DATA FOR ANALYSES

Data on which the analyses presented are based are published, but some details are provided here.

Data showing the effect of amount of stored water on wheat yields were obtained from 1958 through 1961 (1, 2, 3) on both fallowed and non-fallowed soils under varying fertility levels, largely on moderately-well to well drained soils.

The difference in water stored on fallowed as compared to non-fallowed soils was reported by Young (12). These data were obtained from fallowed and non-fallowed sites on the same farm. While the fallow and non-fallow sites at a given location were not repeated, enough sample numbers were taken from each to provide ample evidence of existing differences.

Monthly precipitation data from 1931 through 1967 were obtained from Weather Bureau records (9, 10). The number of weather stations represented in the average for each area was 11, 18, 20, and 22 for the Red River Valley, East Central, West Central and West, respectively.

Estimates of the proportion of non-growing season precipitation stored were made by Johns-

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gard (6) from published data from Mandan and from data obtained by Soils Department personnel.

Estimates of production costs of wheat on fallow and non-fallow were obtained from Rice and Paul (8) except that economic areas were combined in some cases to represent geographic areas[1] and adjustments were made in fertilizer costs to provide adequate fertility.

RESULTS

Average precipitation by months in the four geographic areas of North Dakota (Figure 1) are shown in Figure 2 on an accumulative basis. This shows that the average amount of precipitation is very similar among the areas from January through June, but that differences begin to occur in July and increase through October. The difference in amount through this four-month period accounts for much of the annual precipitation differences among areas.

[1]Economic areas 1 and 2A, 2B and 3A, 3B and 3C and 4 represent the West, West Central, East Central and Red River Valley Areas, respectively.

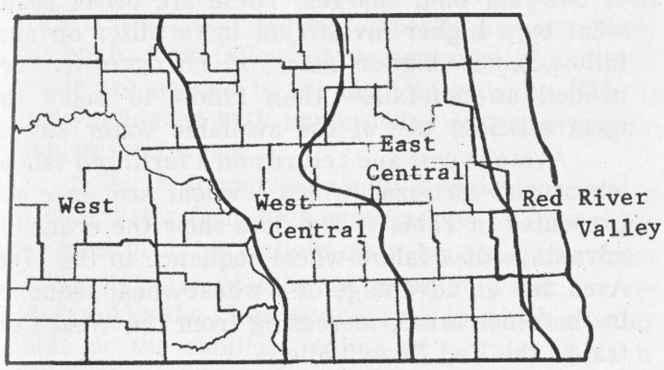

Figure 1. Geographic areas of North Dakota.

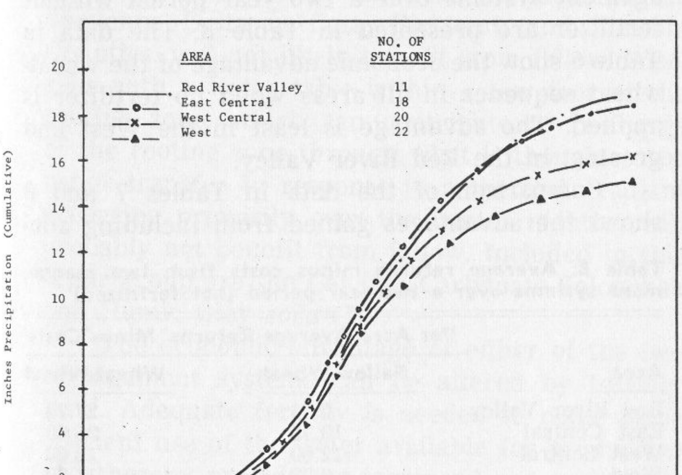

Figure 2. Cumulative average monthly precipitation of four geographic areas. (North Dakota, 1930 - 1967).

Average amounts of non-growing season precipitation in the four geographical areas and estimates of the per cent stored on nearly level soils having the needed water storage capacity are presented in Table 1. These data show that not only does average non-growing season precipitation increase from west to east, but also that the percentage stored of that received also increases. Based on these estimates, water storage during the non-growing season in the West Area can be less than one-third of that in the Red River Valley with near average precipitation.

Average wheat yields from 135 field experiments as affected by stored available soil water under two fertility levels are given in Table 2. These data show yields increased as stored available soil water at seeding increased, and that the increases were greater with adequate fertility levels.

Information relative to the average growing season rainfall at the 135 field sites referred to in Table 2 is in Table 3. This shows that the growing season rainfall at 80 of the sites did not exceed 8 inches, which is average or below for all areas of the state (Figure 2). Growing season rainfall can alter yields on soils of equal seeding time available soil water (1, 2, 3).

The average amounts of available water stored during the non-growing season in non-fallowed soils as reported by Young, and the difference in available water storage between comparable fallowed and non-fallowed soils, are presented in Table 4. The data show that average amounts of available stored water in non-fallowed soils differed greatly,

Table 1. Estimated average inches non-growing season soil moisture storage for various areas of North Dakota.[1]

Area of state	Average non-growing[2] season precipitation	Estimated percentage stored[3]	Average soil moisture storage
	inches		inches
Red River Valley	10.5	55 + 5	5.3 - 6.3
East Central	9.5	45 + 5	3.3 - 4.8
West Central	8.0	40 + 5	2.8 - 3.6
West	7.5	35 + 5	2.3 - 3.0

[1]From estimates by Johnsgard (6). The non-growing season was considered as the 9-month period from August through April.
[2]From wheat harvest to next spring seeding.
[3]On nearly level soils having the needed water storage capacity.

Table 2. Average wheat yields with and without fertilizer as affected by stored available soil water on fallowed and non-fallowed soils (1958 to 1961).

No. of Trials	Stored Water (inches)	Bushels/Per Acre No Fertilizer	Fertilized
32	Up to 2	16	19
41	2 to 4	24	29
62	More than 4	28	36

Table 3. Growing season rainfall at sites with indicated amounts of stored available soil water (1958 to 1961).

Stored Water inches	Growing Season Rainfall inches	No. Of Trials
Up to 2	up to 6	6
	6 to 8	13
	8 to 10	10
	more than 10	3
2 to 4	up to 6	17
	6 to 8	12
	8 to 10	9
	more than 10	3
More than 4	up to 6	14
	6 to 8	18
	8 to 10	15
	more than 10	15

Table 4. Average available water stored on fallowed and non-fallowed soils (1958-1961).

	Water Stored (Inches)			
Area	No. of trials	Fallow	Non-fallow	Difference
Red River Valley	10	8.7	7.4	1.3
East Central	21	6.2	4.1	2.1
West Central	14	3.1	1.1	2.0
West	24	4.0	2.0	2.0

Table 5. Average water stored, yield, returns and costs on fertilized non-fallowed soils.

	Average			
Area	Water Stored	Yield	Value[1]	Costs[2]
	inches	bu/acre	dollars	dollars
Red River Valley	5.3	38	57.00	35.95
East Central	3.8	29	43.50	26.40
West Central	2.8	22	33.00	22.40
West	2.3	19	28.50	22.25

[1]Wheat at $1.50 per bushel.
[2]From Rice and Paul (8) with adjustments in fertilizer costs.

Table 6. Average water stored, yield, returns and costs on fertilized fallowed soils.

	Average			
Area	Water Stored	Yield	Value[1]	Costs[2]
	inches[3]	bu/acre	dollars	dollars
Red River Valley	7.0	41	61.50	46.20
East Central	5.4	38	57.00	33.75
West Central	4.8	33	49.50	29.25
West	4.3	30	45.00	29.05

[1]Wheat at $1.50 per bushel.
[2]From Rice and Paul (8) with adjustments in fertilizer costs.
[3]Assumes 1.5 to 2 inches more water than on comparable non-fallowed soils as per Table 3.

Table 7. Average returns minus costs from two management systems over a two-year period (fertilized).

	Per Acre Average Returns Minus Costs	
Area	Fallow-Wheat	Wheat-Wheat
Red River Valley	15.30	42.10
East Central	23.25	34.20
West Central	20.25	21.20
West	15.95	12.50

but that the average difference in available water stored in fallow as compared to non-fallow was about two inches or less.

Average cost and returns on wheat grown on adequately fertilized non-fallowed soils supplied with average expected amounts of stored available soil moisture at seeding for each area are shown in Table 5.

Average cost and returns for wheat grown on fertilized fallowed soils under comparable growing conditions in the four areas are given in Table 6. Since water storage in fallowed soils is greater by about two inches in all areas except in the Red River Valley Area, where it is only about 1.5 inches greater (see Table 4), these amounts were added to water present in non-fallowed soils.

At $1.50 per bushel, the average value of wheat produced exceeds the cost of production in all areas. The greatest increases occur in the two Central Areas. Production costs on fallow are greater than on non-fallow, primarily because of two-year land charges. These are offset somewhat by a higher investment in fertilizer on non-fallow, since higher rates of nitrogen (N) are needed on non-fallow than fallow to make the most efficient use of the available water stored.

Average cost and returns on a fertilized fallow-wheat and fertilized wheat - wheat sequence are presented in Table 7. The data show the economic advantage of a fallow-wheat sequence in the West Area, but an advantage of a wheat-wheat sequence in the other areas, increasing from the West Central to the Red River Valley.

Average cost and returns from the two management systems over a two year period without fertilizer are presented in Table 8. The data in Table 8 show the economic advantage of the wheat-wheat sequence in all areas when no fertilizer is applied. The advantage is least in the West and greatest in the Red River Valley.

Comparison of the data in Tables 7 and 8 shows the advantages gained from including ade-

Table 8. Average returns minus costs from two mangement systems over a two-year period (not fertilized)[1]

	Per Acre Average Returns[2] Minus Costs[3]	
Area	Fallow-Wheat	Wheat-Wheat
Red River Valley	0.30	27.70
East Central	10.95	25.00
West Central	12.00	18.00
West	9.20	11.20

[1]Water stored same as in Table 6.
[2]Wheat yields without fertilizer for the water stored on non-fallow were estimated at 28, 22, 18 and 16 bushels per acre and on fallow at 29, 28, 26 and 24 bushels for the Red River Valley, East Central, West Central and West, respectively.
[3]Costs without fertilizer were estimated at $28.15, $20.50, $18.00 and $18.40 on non-fallow and $43.20, $31.05, $27.00 and $26.80 on fallow for the Red River Valley, East Central, West Central and West, respectively.

quate fertility to make more efficient use of water available to the crop. It also shows that the economic advantage of a fallow-wheat sequence between the two systems in the West Central Area occurs for the same reason.

DISCUSSION

Summerfallowing to increase the supply of available water for the succeeding crop, and thereby increase yields, is widely practiced in North Dakota. The increased yield may not be of sufficient economic advantage over a continuous cropping system in areas or on soils where about 2 to 3 inches of water can be stored during the non-growing season, on the basis of estimated costs and returns considered. A change in either cost or return (yield and/or value of the product) can alter the economic advantage of either system.

Fallowing for water storage is a questionable practice on some soil types. These include soils of very low water storage capacity and soils which are only partly re-charged by precipitation. Soils with a low water storage capacity are not likely to benefit from fallowing because small amounts of water are needed to fill them to capacity. This is easily achieved with non-growing season precipitation in most years.

Soils in topographic positions which receive run-on water from higher elevations or soils along streams or river valleys may benefit little from fallow because of other sources of water for re-charge. For the same reason, soils in which a water table or the capillary fringe of a water table is within the rooting zone of crops over much of the growing season, as is the case in much of the Sheyenne Delta in Cass, Richland, and Ransom Counties, will not likely benefit from fallow. Also, soils with a water table within a few feet of the rooting zone, which can contribute to re-charge of the rooting zone through what is thought to be vapor transfer in response to a thermal gradiant occurring primarily over the winter months, will probably not benefit from fallow. Included in this latter group are the Calcium Carbonate Solonchak and Humic Gley soils (7).

The economic advantage of either of the two management systems can be altered by fertility level. Adequate fertility is needed to make more efficient use of the water available for production and thereby provide for increased net returns on an acre basis.

SUMMARY AND CONCLUSION

Fallowing was considered from the standpoint of its practice for water storage. An economic evaluation was made from average costs and returns information, expected yields from varying amounts of stored available soil water under growing season rainfall conditions averaging slightly less than average amounts, and expected water storage associated with non-growing season precipitation for various areas of North Dakota on predominantly well to moderately-well drained soils of adequate water storage capacity. Based on these averages and information, a fallow-wheat system may be expected to be more profitable than a wheat-wheat system only in the West Area and only with adequate fertility.

In decision making with respect to including or excluding fallow in a cropping sequence, farm programs as well as agronomic reasons, in addition to water storage, must be considered by farmers. Such other factors may play a more important role in the final decision than that of water storage. In the final analysis, the cropping sequence that provides the greatest economic advantage for the individual is the one likely to be adopted.

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