WATER APPLICATION AND REQUIREMENTS FOR CROPS IN NEW MEXICO

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We have much yet to learn about the water application and requirements for crops in New Mexico. We need more precise information about: (1) the effect of different kinds of soils, (2) the significance of rainfall during the growing season, (3) the effect of fertilizer, (4) the effect of plant spacing, (5) the effect of the irrigation layout, (6) the length of growing season, (7) the call system versus rotation system. Briefly, I shall attempt to review part of the literature and try to point out certain factors that warrant further study.

One of the earliest studies in New Mexico was conducted at State College from 1922 to 1926 by Bloodgood and Curry (1). They compared different flows of water and different lengths of border for alfalfa on Gila clay adobe. Water was applied at approximately 15 day intervals. The average annual depth of water applied to 4 borders 200 feet long was 48 inches. Borders 700 feet long had an annual average annual application of 61 inches. 1400 pounds per acre more alfalfa were produced on the 700 foot long borders than on the 200 foot long borders. These early studies did not report farm ditch losses, the effect of fertilizer and plant spacing.

Blaney and Criddle (2) list consumptive use values for alfalfa at State College of 40 inches and about 37 inches at Carlsbad. They also reported consumptive use values for cotton of 27 inches at State College and 29 inches at Carlsbad. These studies as well as those in other western states were used to develop empirical consumptive use coefficients for different crops for the growing season, K. To adjust this data for a given location, the mean monthly temperature is multiplied by the monthly percent of daytime hours to give a monthly consumptive use factor, F. The sum of these factors for the growing season multiplied by the consumptive use coefficient for the crop gives the normal expected consumptive use.

To show the effect of climate on one crop, alfalfa, I have compiled the normal consumptive use predicted by Blaney, Hanson and Litz (4). The values for alfalfa vary from 28 inches in the San Juan Valley to 36 inches at State College.(table 1). These authors further reduced the consumptive use values by subtracting the average rainfall that falls during the growing season of the specific crop. Thus the normal consumptive use of water minus rainfall at Bloomfield would be 23.8 inches or a reduction of 4.5 inches. However, they point out that there may be areas where the rainfall may not be effective.

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Table 1. Estimate of normal consumptive use (4)

Location	Alfalfa inches	Corn inches	Spring grain inches	Cotton inches
Bloomfield-Shiprock	28.3	17.6	15.0	-
Albuquerque	34.2	20.9	14.2	-
Hatch-Mesilla	36.4	21.1	-	22.9
Carlsbad	40.4	-	15.8	25.8

Just how reliable is rainfall in New Mexico? First, let us include as effective precipitation, those days in which more than .50 inch precipitation occurs or adjacent days with .25 or more precipitation, table 2. Based on the daily precipitation records published by the U. S. Weather Bureau from 1930 through 1956, effective rainfall was unreliable at Bloomfield. For example in 21 out of 22 years in June there was zero effective rainfall. Even in August, the wettest month, there were only 6 times in 25 years that effective rainfall exceeded one inch. For the Bloomfield area, should not the precipitation be disregarded in calculating water requirements? Similar analyses are needed to determine those areas where effective precipitation is too unreliable to include in irrigation requirements.

Are the consumptive use values high enough for high yields under heavy fertilization and close spacing? The most complete data on alfalfa that might apply to New Mexico are from Yuma, Arizona (10). At Yuma there are normally 7 cuttings of alfalfa as compared with 5 for the Hatch-Mesilla Valley. Annual consumptive use values for alfalfa are 48.4 inches at Yuma (5) and 36.4 inches in the Hatch-Mesilla Valley (4). But the annual water application at Yuma on

Table 2. Effective rainfall* at Bloomfield, New Mexico 1930-1956

Total	April	May	June	July	August	September
Number of months	21	22	22	22	25	24
Zero effective rainfall	18	18	21	16	15	16
.5 - 1.0" " "	2	3	1	2	4	6
1.0" " "	1	1	0	4	6	2

*Effective rainfall includes days with .50 inch or more precipitation and adjacent days with .25 inch or more precipitation.

carefully controlled expreimental plots varied from 72 to 88 inches, table 3. These figures included deep percolation loss but no losses for either surface runoff or for ditch losses. On this deep sandy soil the annual yield of alfalfa increased from 8.1 tons per acre to 11.2 tons per acre by increasing the water application from 72 to 88 inches. In these plot studies, heavy applications of phosphate increased yields just as strikingly as the increased applications of water. The highest yield, 12.5 tons per acre, was obtained with 1300 pounds of P_2O_5 per acre during the 4 year period using the wet treatment - 88 inches of water. Under improved management, 48 inches annual consumptive use would appear inadequate for high yields.

How much water was used per ton of alfalfa grown at Yuma? From 1950-52 it took 8.4 acre inches to produce a ton of alfalfa under the wet treatment, 9.2 acre inches for the medium treatment and 10.2 acre inches for the dry treatment. So, if you had a limited amount of water, you would grow more tons of alfalfa by irrigating less land than by trying to spread it over a large acreage. Similar trends have been recently reported by the Agricultural Research Service for other crops at other Southwestern locations.

Table 3. Alfalfa yields and irrigation results on a deep sandy soil at Yuma, Arizona 1949-1952 (10)

	Irrigation Treatment		
	Dry	Medium	Wet
Mean time between irrigations (days)	27.2	20.1	8.6
Moisture used between irrigations (inches)	4.0	3.4	1.8
Number of irrigations (annually)	13	18	42
Annual water application (inches)	73*	76*	88*
Annual yield of alfalfa (tons/acre)	8.1 (7.1)**	9.2 (8.2)**	11.2 (10.5)**

* Plot data
**Figures in brackets calculated for 1950-1952.

Differences in climate, soil and depth to water table may affect the tonnage produced per acre inch of water. At State College, Hanson (7) conducted irrigation studies on alfalfa on a deep fine textured soil. The annual yield of alfalfa was 6 tons per acre with 28 inches of water, 7-3/4 tons for 44 inches and 8-1/4 tons for 64 inches with the yield curve still going up.

Let us consider the effect of fertilizer and spacing on another crop, sorghum. Painter and Leamer (9) found at Tucumcari on a deep sandy soil that 5 irrigations gave higher yields of sorghum than 8 irrigations when no fertilizer was applied. The opposite occurred when heavy applications of nitrogen and phosphorus were made (table 4). Yields were further increased by a row planting spacing of 4 inches as compared with 9 inches when more irrigations and more fertilizer were applied. The normal consumptive use for sorghum at Tucumcari is reported to be 24.5 inches (4). Is it enough for improved management?

What would be the expected water requirement under improved management at the farm headgate for the principal crops of New Mexico? Based on the best information available, I have presented some guestimates of water requirement in table 5 for alfalfa. Our field experience indicates that when the soil at the 6 to 12 inch depth is dry enough to make a fragile ball, you will need to irrigate

Table 4. Yields of grain sorghum for various moisture, spacing and fertilizer treatments, Tucumcari, New Mexico 1951 (9)

Irrigations	Plant Spacing	Yield, bushels per acre, for indicated lbs per acre of N-P_2O_5		
		check	120-180	240-280
8	4	34	89	102
8	9	40	65	83
5	4	40	81	79
5	9	44	68	70

in the next two or three days to maintain high yields. For deep, medium textured soils, you will need about five inches of water to refill the soil to a depth of five feet. Table 5 shows that with 75% farm irrigation efficiency that you need to apply at the farm headgate an additional 1.5 inches per irrigation for ditch loss, surface runoff, deep percolation beyond the roots and evaporation. At Bloomfield in the San Juan Valley I estimate that the annual water application under improved management on deep medium textured soils would be 45 inches for alfalfa as compared with 62 inches at State College.

Now let us consider a deep sandy soil which need a refill irrigation. At that time it can store only 3 inches of water as compared with 5 inches of water for the deep medium textured or loam soil. Soil Conservation Service irrigation guides for New Mexico indicate that we will need to irrigate alfalfa or the deep sandy soil amost twice as often as the deep textured soils if we secure high yields. So, at Bloomfield using corrugations on slope and clean water, we would expect an annual water application of 70 inches or 25 inches more than the medium textured soil. At Albuquerque, where border irrigation is used on flatter slopes and with muddy water to seal ditches, the annual water application might be only 7 inches more on the sandy soils. At State College, 18 inches more water would be required annually for alfalfa on deep sandy soils than on deep medium textured soils. Part of this higher loss would be higher ditch losses caused by the use of clear water. To what extent has the difference in refill irrigation capacity between soils been considered in annual water requirements?

Table 5. Expected water requirement under improved management for alfalfa on deep medium and deep sandy soils

Soil Texture	Effective Depth	Location	Cuttings per season Number	Irrigations per season Number	Farm Irrig. Efficiency Percent	Water Irrig. Inches	Application Annual Inches
Medium	deep	Bloomfield	3	7	75	6.5	45
"	"	Albuquerque	4	8	80	6.2	50
"	"	State College	5	10	80	6.2	62
Sandy	deep	Bloomfield	3	13	55	5.4	70
"	"	Albuquerque	4	15	80	3.8	57
"	"	State College	5	19	70	4.2	80

Let us further consider how different kinds of soil may affect losses of water past the farm headgate. For the proposed South San Juan - Shiprock project, table 6, I estimated the loss of water from farm ditches on

Table 6. Comparison of expected losses of irrigation water for deep soils South San Juan - Shiprock (3)

Slope %	Soil Texture	Refill Irrig. Inches	Loss of Water: Farm Ditches %	Loss of Water: Surface Runoff %	Loss of Water: Deep Perco. %	Loss of Water: Evap. %	Est. Farm Irrigation Efficiency %
0-1	silt loam	5	5	15	10	10	60
	loam	5	10	5	5	5	75
	loamy sand	3	20	5	25	-	50
1-3	silt loam	5	5	25	10	10	50
	loam	5	10	15	5	5	65
	loamy sand	3	20	15	25	-	40

sandy soils to be 20% of the total water requirement, 10% on loams and 5% on silt loams. If major savings are to be made of the clear water from the Navajo Dam, ditch lining on sandy soils is far more important than on the silt loam soils.

Losses from surface runoff are more important that ditch losses on the silt loam soils. The low intake rate of the silt loam soils may require sets varying from 12 to 24 hours in order to refill the root zone. In contrast, losses of surface runoff from the sandy soils on nearly flat slopes is small. The sandy soils take water rapidly and are quickly filled.

Losses from surface runoff are higher on 1 to 3% slopes for all soils than on 0-1% slopes, table 6. Note that the highest losses are on the silt loam soils.

The losses listed for deep percolation beyond the root zone are those expected under improved management, table 6. Under average farm management, deep percolation losses are much higher. Studies made in the Pecos Valley about 1940 showed average irrigation efficiencies of 53% (8). One of the major losses was due to deep percolation.

In table 7 losses of water beyond the root zone are summarized from 52 irrigation trials for which we had soil moisture data (6). Many of these trials were made when the farmer thought he needed to irrigate or to fit into the farm operation program. You can see that major losses of water by deep percolation occurred on all soils irrespective of readily available moisture capacity or intake

Table 7. Relation between intake rates and deep percolation losses by classes of readily available moisture capacity for 31 border irrigations and 21 furrow irrigations (6)

Readily Available Moisture Capacity inches	Average Percentage of Water Lost by Deep Percolation					
	Border Irrigation Intake Rates			Furrow Irrigation Intake Rates		
	.0-1.0 in/hr	1.1-2.5 in/hr	2.6+ in/hr	0-1.0 in/hr	1.1-2.5 in/hr	2.6+ in/hr
3.0-3.9	12	21	34	35	0	34
4.0-4.9	6	11	-	29	12	0
5.0-6.0	22	10	4	3	0	38

rate. Loss of water by deep percolation will exceed all the other farm losses under average irrigation management practiced today in much of New Mexico.

If deep percolation losses cannot be reduced, then the figures in table 5 are too low. These losses may be reduced under improved irrigation practices: (1) Proper irrigation layout. (2) Well made high border ridges. (3) Eliminating unessential irrigations. (4) Knowledge of the refill irrigation requirement of the different soils. (5) Estimating the amount of water needed to refill the soil prior to irrigation. (6) Measurement of the flow of water to make sure the most efficient flow of water is used. We need to make much more progress in the adoption of improved irrigation practices.

In table 5, I assumed that water is available when the farmer calls for it. There are areas, however, where a rotation system is followed instead. Suppose that water were to be delivered every 15 days during the summer months. For crops such as alfalfa, the water may come from 2 to 5 days too late for high yields on sandy soils. On deep medium textured soils the water would come a week too soon with ensuing high deep percolation losses. Some may say that less water per irrigation could be applied. Under field conditions this would require either a change in irrigation lay-out or larger flows of water. The latter usually cannot be done without overtopping the border ridges. In most border irrigation lay-outs in New Mexico you will apply 5 inches or more water per irrigation. Rotation irrigation might increase the annual farm water requirement by as much as 6 inches per acre as compared with the call system. But the call (demand) system requires that irrigation canals and supply laterals have sufficient capacity to carry the maximum demand.

The time of irrigation is important. Many studies have shown that yields of small grains, sorghum and corn are reduced if the crop is stressed during the boot and flower stage. Prior to this period, it is possible to stress these crops without reducing yields. But cotton yields may be reduced by delaying the first post planting irrigation until early July. On a deep fine textured soil at State College, Hanson obtained the highest yield of cotton with a light, early June irrigation using a total of 30 inches of water (7). But the application of 36 inches of water, depressed cotton yields on this soil which has a tight subsoil through which water and air move slowly.

Based on present information, the expected farm irrigation requirement of alfalfa in New Mexico may vary from 45 to 80 inches due to differences in soil and climate. About 3 acre feet appears to be needed for cotton. Sorghums and small grains will require about 3 acre feet of water on deep medium textured soils. This includes an additional irrigation which is often needed to sprout volunteer grain or in preparing the land. It does not include the 2 to 4 irrigations needed to establish fall planted stands of alfalfa. It does not include water for leaching salty soils. These figures indicate a beneficial annual use of between 3 and 6 acre feet of water per acre at the farm headgate with improved practices if high crop yields are to be obtained.

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(3) Blaney, H. F., and C. H. Diebold, Irrigation Water Requirements of Crops in Shiprock and South San Juan Projects, New Mexico (Provisional) Mimeo. Soil Conservation Service, Albuquerque, 1952.

(4) Blaney, H. F., and E. G. Hanson and G. M. Litz, Consumptive Use and Irrigation Water Requirements of Crops in New Mexico. Soil Conservation Service Research, 1950.

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(10) Stanberry, C. O., C. D. Converse, H. R. Haise, and O. J. Kelley, Effect of Moisture and Phosphate Variables on Alfalfa Hay Production on the Yuma Mesa. Proc. Soil Science Society 19: 303-310, 1955.