SOIL RECLAMATION AND CROPPING STUDIES IN THE GRAND VALLEY

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FOREWORD

Soil, water and crop management research in the Upper Colorado River Basin is a joint endeavor involving:

1. Colorado State University, Colorado Agricultural Experiment Station, Departments of Agronomy and Agricultural Engineering.

2. U. S. Department of Agriculture, Agricultural Research Service, Western Soil and Water Conservation Research Branch.

The cooperation and support of the following groups and agencies in planning and executing this research program are gratefully acknowledged:

1. Mesa County Research Committee.

2. Mesa County Board of Commissioners.

3. Soil Conservation Service, U. S. Department of Agriculture.

4. Grand Junction Drainage District.

5. Colorado Agricultural Extension Service.

6. Lower Grand Valley Soil Conservation District.

7. Industry:

   C. D. Smith Company
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   Holly Sugar Corporation
   Dow Chemical Company
   Geigy Agricultural Chemicals
   Caterpillar Tractor Company
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   Public Service Company of Colorado.

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SUMMARY

Of the factors that adversely affect crop yields in the Grand Valley, excess salt and sodium are major offenders, while fertility problems and poor soil physical condition are common. Poor drainage often contributes to and confounds the situation.

Results of the reclamation study indicate that leaching can be used successfully to restore productivity of lands in the valley that are too high in salt. Drainage by pumping is feasible, both economically and physically.

The experimental work included a study of crop rotation and fertility tests with numerous other aspects involving water use and weed control. The

results have shown that the combination of commercial fertilizer with a legume in the rotation will lead to greater crop yields in the area.

DRAINAGE AND GROUND WATER

Drainage Well

Since its construction in 1951, this well has been thoroughly studied to determine the feasibility of pumping for drainage in the lower valley area. Pumping is feasible (both economically and physically), and it has provided the necessary drainage in the experimental area.

The water table over an area of 200 acres is being effectively controlled by the well through operation during a six-months period each year. The annual operating cost averages $450. An economic analysis, reported in 1957, indicates an annual return of 20 percent on the original investment in the well.

Water being pumped from the well at the rate of 250 gpm contains about one percent salt. This means that about 18 tons of salt are pumped every 24 hours.

Application of Findings.--Research is valueless if the findings are not put to use. In this case, material gains can be realized for the economy of the entire valley, including the cities and towns as well as the agricultural lands, if drainage wells are established to provide water table control. However, random installation of wells is not recommended without prior consultation with engineers from the research staff. An investigation should be made to determine the likelihood of drainage success, and also to determine the best location for the well.

Ditch Seepage

Studies have been made to determine the amount of water lost into the ground water from canals and ditches. Losses from lateral ditches have been measured during the past year, and an average loss of 0.4 acre inch per day per mile of ditch was found (August measurements). For comparison, losses from main canals reported in 1957 were as follows: Grand Valley Irrigation Company--22.8 acre inches per day per mile; Grand Valley Water Users Association--42 acre inches per day per mile.

These seepage losses individually are not extreme, yet they represent a significant load on the drainage of the valley. Furthermore, this water is in addition to the considerable volume added to ground water from irrigation on the fields. It is not likely that measures can be taken which would stop all these inflows to the ground water. However, remedial steps should be taken.

Plastic Tile Drains

Agricultural engineers of the Caterpillar Tractor Company have developed a machine which can form a "mole" drain and at the same time line the tunnel with a plastic. This process has been used with success in the humid eastern states, and is now to be tested cooperatively with several interested agencies under western reclamation conditions.

Since the machine is capable of only a 30-inch placement, the utility of this type drain will probably be as a temporary drainage practice which would allow rapid water removal from a shallow soil zone. This would permit some cropping during the time that more permanent drainage measures are being established.

An experiment is being conducted with plastic tile. The plastic "tile" is about three inches in diameter and is spaced at 20 feet and 40 feet in the study. Reclamation treatment will be applied over the land (simple leaching) to find out how well it would serve the needs. . The cost of this installation is estimated to be about seven cents per toot, making it a very economical practice if it proves to be successful.

RECLAMATION AND SOIL AMENDMENTS

This experiment, started in 1952 is essentially a reclamation and soil amendment test. But it has since had other treatments imposed on it. The effects of the original reclamation treatment by leaching with two and six feet of water are still evident.

After five years of cropping (four years of alfalfa and one year of corn), soil analyses have indicated that:

1. Land initially too high in salt for plant growth can be reclaimed by putting water through the soil profile.

2. Gypsum at a rate of four tons per acre was of very little or no benefit in the reclamation process. This was due to the presence of gypsum already in the soils being studied.

3. Salts may gradually re-accumulate, so extra water should be applied periodically to keep them down to a safe level.

Based on plant yields, the results show that:

1. Leaching with six feet of water resulted in an average increase in yield of alfalfa of about three-fourths of a ton per acre per year for each of the four years compared with the yield obtained when two feet of water were used to leach. The application of excess irrigation water in the fourth year of the alfalfa had but little beneficial effect on yield, probably because of the age of the stand and well established roots.

2. After reclamation and four years of alfalfa, properly fertilized corn produced above average yields in spite of its more salt sensitive nature.

3. Corn yields were still benefitted by the higher leaching rate applied six years before and also by the application of excess irrigation water the year before (to the last alfalfa crop).

When undertaking a project of this type, a good drainage condition must be provided before much good will come from the leaching. Excess salts must be carried down through the soil profile with the water. If a poor drainage condition exists, these same salts and also others may actually be brought to the surface through evaporation and make a poor condition worse.

If the free-water table is not below four or five feet there may not be sufficient water-free soil to take these salts down and away from the rooting zone of the growing crop.

Total Yield of Alfalfa as Influenced by Reclamation Treatments, 1954 through 1957.

Leaching Rate Ac. Ft./Ac.	Alfalfa Yield - Tons (Oven-Dry) per Acre 1st Cutting	2nd Cutting	3rd Cutting	Total 4 yrs.
2	5.48	5.04	3.65	14.17
6	6.12	6.37	4.56	17.01

Corn Yield as Influenced by Reclamation Treatments, 1958.

Treatment 1/	Bushels per Acre M_1	M_2	Mean
W_1	148.1	161.2	154.7
W_2	156.3	179.5	167.9
Average Yield	152.2	170.4	161.3

1/ W_1 - Original leaching treatment two feet.
W_2 - Original leaching treatment six feet.

M_1 - Regular irrigation, during 1957 crop season.
M_2 - One and one-half times regular irrigation, 1957.

The plots are now seeded to tall wheatgrass. It is hoped that this crop may have some beneficial effect on local conditions of poor permeability within individual plots. These plots will remain in tall wheatgrass for at least two years.

FIELD SCALE LEACHING

A study was begun in 1957 and completed in 1958 to extend the information collected from the small leaching plots to a field scale. The objective was to determine if method of land preparation affects the efficiency of leaching.

Land preparation treatments studied included 20-inch furrows, 30-inch furrows and border dikes on: (1) zero slope (level) and, (2) 0.3 percent slope. Each treatment was duplicated. Extensive soil sampling for salt analysis was done before and after leaching.

Results.--It was found that the maximum leaching water that could be moved through the soil under these experimental conditions in 4½ months was 52 inches. Leaching was satisfactory to 30 inches depth on the level plots. These plots are now at a salt content which will permit limited cropping. However, the sloping plots had an extremely high initial salt content and hence did not leach to a safe salt content. The leaching rate was satisfactory, however, and there is no doubt that additional water would have more completely reclaimed these plots.

The labor cost for leaching was lowest on the level border treatment and the field operating personnel preferred that type of land preparation to the others. However, satisfactory leaching can be done under all three of the treatments on level plots. The furrow treatments in sloping plots were satisfactory but the border treatment on these plots with bare soil was difficult to manage. The water tends to form channels and it was difficult to maintain water over the entire surface area.

The following table summarizes the man-hour requirements per inch of water applied for each of the different land treatments.

Land Treatment	Furrow 30"	Furrow 20"	Border	Furrow 20" and 30" (Ave.)
Sloping plots	0.308	0.322	0.328	0.315
Level plots	0.538	0.673	0.276	0.605

ROTATION-FERTILITY TRIALS

These trials, started in 1954, are now in the sixth year. The 1959 cropping year will conclude one cycle of the six-year rotation, two cycles of the three-year rotation and six consecutive years of continuous cropping to corn and sugar beets.

The six-year rotation consists of corn, sugar beets, barley and three years of alfalfa. The three-year rotation includes corn, sugar beets and barley without alfalfa. All fertility treatments in the six-year rotation are the same as in the three-year rotation so that a comparison between the rotation systems may be made. Continuous cropping with corn and sugar beets is included in these trials in order to evaluate the merits or disadvantages of this type of management. Higher levels of fertility are maintained in the continuous cropping system than in the rotation experiment.

After five years, yield results indicate that there are decided superiorities with respect to (1) rotation system and (2) fertilizer treatment. The following summaries are presented to show some of the more pertinent findings. After five years, differences, especially between cropping systems, have gradually become greater. To better evaluate the results, all conclusions in the following discussion are based on averages from at least four years' results or in some cases they are for a five-year period (1954 through 1958).

Generally speaking, the six-year rotation system has produced yields of all crops above the other two cropping systems. Continuous cropping with corn and sugar beets, even under higher levels of fertility, has produced lower yields than the non-legume rotation. In 1958, continuous sugar beets were a complete loss and were disked up in early August after only four years of continuous cropping. Undue competition from weeds, nematodes, and plant diseases were major contributing factors.

CORN RESULTS

Average results show practically the same yield of corn was produced in the six-year rotation without fertilizer as was produced in the three-year system with 200 pounds of nitrogen per acre plus residual phosphate. Similarly, ten bushels per acre more corn were obtained from the check plot in the six-year rotation system than in the continuous corn plots which received 400 pounds of nitrogen and 75 pounds of phosphorus per acre.

Average corn yields (15.5% moisture) for all fertilizer treatments for five years were:

Six-year rotation - 122.5 bushels per acre

Three-year rotation - 96.0 bushels per acre

Continuous corn - 88.6 bushels per acre

The three highest yielding fertilizer treatments and the lowest yielding treatments for corn are as follows (four-year averages):

Six-Year Rotation

Pounds Fertilizer per Acre			
Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Bushels per Acre (15.5% Moisture)
200	75	0	139.1
100	75	K	138.3
200	Residual P	0	137.2
0	0	0	115.2

Three-Year Rotation

200	Residual (75 lbs./Ac.)	0	117.6
200	75	0	106.3
100	75	0	100.6
Manure			85.0

Continuous Corn

400	75	0	105.2
200	75	0	96.0
100	75	K	94.6
0	75	0	67.3

Examination of all results indicates that both nitrogen and phosphorus fertilizers were needed to produce the best yields of corn regardless of the cropping system. The beneficial effect of alfalfa in the rotation was demonstrated. The same results also showed a response to residual phosphate, or phosphate applied in years previous to planting.

SUGAR BEET RESULTS

With sugar beets the results were about the same as for corn. Based on an average yield of beets from all fertilizer treatments, somewhat greater tonnage was obtained in the six-year rotation than in the three-year cropping sequence, and both rotations were distinctly superior to continuous beets. Comparison of the highest yielding fertilizer treatments in the six- and three-year rotations shows that there was but little average difference due to cropping system. No combination of fertilizers applied to continuous beets resulted in a yield as great as that from either rotation system.

Average yields for all fertilizer treatments by rotation system were:

Six-year rotation - 21.1 tons per acre

Three-year rotation - 19.9 tons per acre

Continuous (3-year average) - 13.1 tons per acre

The following results are for the three highest and the lowest yielding fertilizer treatments for sugar beets by rotation system (three-year averages):

Six-Year Rotation

Pounds Fertilizer per Acre			
Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Tons per Acre
100	75	0	22.1
200	75	0	22.0
0	75	0	21.0
0	0	0	14.7

Three-Year Rotation

100	Residual (75 lbs./ac.)	0	22.5
100	75	K	21.1
100	75	0	20.4
0	0	0	11.7

Continuous Beets

100	75	0	17.9
100	75	2K	16.8
100	75	K	15.9
0	0	0	8.4

Both nitrogen and phosphorus were needed for highest yields of roots. Alfalfa in the rotation supplied part of the nitrogen requirements, but application of phosphorus was essential. Addition of both nitrogen and phosphorus for beets in the three-year rotation and in the continuous system was required for economical yields. The residual effect of phosphorus applied to previous crops also was apparent in beet yields. Use of potassium (with nitrogen and phosphorus) had no important effect on yield of roots but tended to increase sugar percentage.

BARLEY RESULTS

Barley yields by rotation system were as follows (four-year averages):

Six-year rotation - 71.5 bushels per acre

Three-year rotation - 65.5 bushels per acre

The six-year rotation barley was seeded (with alfalfa) at a rate of 65 pounds per acre while the three-year rotation was planted at the rate of 110 pounds per acre without alfalfa. Yields favored the longer rotation system which was seeded at the reduced rate.

The following four-year averages show the effects of fertilizer treatments on barley. Most of the response was from nitrogen applied the previous year for beets (residual effect).

The following results show the three highest yields and the lowest in relation to the fertilizer treatment.

Six-Year Rotation

Pounds Fertilizer per Acre			
Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Bushels per Acre*
Residual (200 lbs./ac.)	300	0	82.9
0	450	0	80.8
Residual (100 lbs./ac.)	300	0	79.4
0	0	0	46.0

Three-Year Rotation

Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Bushels per Acre*
Residual (200 lbs./ac.)	75	0	70.9
Residual (100 lbs./ac.)	Residual (75 lbs./ac.)	Residual	70.9
Residual (100 lbs./ac.)	75	0	66.9
0	0	0	48.2

* Based on a 48-pound bushel.