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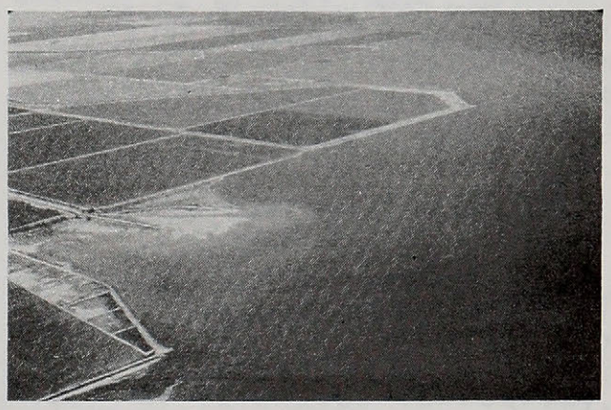
Imperial Valley: Irrigation, Drainage, and Runoff

J. D. Oster, J. L. Meyer, L. Hermsmeier, and M. Kaddah

In the Imperial Valley, almost all irrigation return flows--drainage water, canal spills, canal seepage and surface runoff--go to the Salton Sea. These flows influence the sea level. The elevation of the sea rose about four feet between 1970 and 1980 flooding some low lying fields next to the sea. One farmer has constructed earthen dikes to protect his fields as shown in the photo.



Aerial View of Salton Sea and Imperial Valley.

Are return flows from the Imperial Valley excessive due to poor irrigation practices? If so, can they be reduced? Some drainage water is essential to control salinity at acceptable levels for crop growth. Surface runoff, or tailwater, is not essential for crop growth, but runoff is difficult to prevent. It requires careful irrigation, or a system to capture tail water and return it to the head of the field, or to a holding reservoir.

How much surface runoff water reaches the Salton Sea? About 0.4 million acre feet, based on an Agriculture Research Service (ARS) and Imperial Irrigation District (IID) irrigation efficiency study conducted on nine fields for five years (1977-1981). This volume represents about 16 percent of the on-farm water deliveries in the Imperial Valley and about 29 per cent of the total inflows to the Salton Sea. The data also suggest on-farm infiltration of applied water was from 0.2 to 0.4 million acre feet less than that required to meet full crop evapotranspiration.

The ARS-IID study resulted in 595 applied water, 488 runoff, and 277 drainage measurements on nine fields. These were distributed throughout the valley and the soils were representative. The cooperator determined all the cultural practices: the distribution of the cropped area and that of the Imperial Valley during 1977-1979 were similar (Table 1). Eight fields had a separate artificial drainage system with outlets which were instrumented to measure the drainage volume. Drainage data from

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Irrigation Symposium

An irrigation symposium sponsored by Cooperative Extension will be held on February 19, 1985 at the Fresno Airport Holiday Inn. New methods and developments will be emphasized including: surge irrigation, cablegation, level basin irrigation, evaluation of irrigation systems, low pressure sprinklers, load management, and buried drip.

Please note this is a change of location. We had originally announced the meeting would be held at the Century Plaza Holiday Inn.

Programs and registration information are available at your county farm advisor's office or contact Janice Heine, LAWR--Veihmeyer Hall, UCD, (916)752-1130.

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Photo Credit:
Max Clover
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one field were unusually high, a likely result of canal seepage, and they were not used to estimate drainage for the Imperial Valley. All fields had a suitable irrigation inlet for installation of an impeller actuated flow meter and suitable sites to measure tail water with Parshall flumes. Irrigation efficiency was assumed to equal the volume of applied water, minus runoff and drainage divided by the applied water and expressed in percent.

Daily Class A pan evaporation was measured at the Irrigation Desert Research Station about two miles SW of Brawley, CA. The annual average evaporation and total variation was 9.4 ± 0.4 ft. for 1977-1981.

Fields (Table 2). Based on the drainage data set (N = 277), the irrigation efficiencies for fields 1-8 ranged from 70-78 % with a weighted average of 72 %. The corresponding weighted averages for drainage and runoff were 8% and 20%. The drainage percentage may be low. Several studies (1) (2) suggest that as much drainage water may move downward past subsurface drains as is removed by them. The uncertainty of the actual drainage percentage cannot be resolved with the data obtained by the ARS-IID project. Presumably it is greater than 8% and less than 16%.

The average runoff for the larger runoff data set (N=488) was 16%. In the section dealing with the water budget for IID, drainage and runoff percentages of 8% and 16% are used.

The influence of surface soil texture and soil type on drainage was not clear cut. Several factors were likely responsible, including small textural variations between the fields and different cropping history. Field 1, with 13% Meloland very fine sandy loam, had one of the lowest average drainage, 3%. The lowest drainage, 2%, occurred in field 7 where the only soils were Imperial silty clay or Imperial-Glenbar silty clay loam. However, for fields 6 and 8 with similar soils as field 7, the drainage percentages of 10% and 13% were somewhat greater than the overall average of 8%.

Crops (Table 3). Efficiency exceeded 70% for barley, alfalfa, wheat, cotton, and sorghum. The higher efficiencies for barley, alfalfa, wheat, and cotton were partially the result of lower drainage. The low efficiencies for lettuce and cantaloupe were partially due to high drainage percentages, 29% and 42%, respectively. Soil type may have been a factor in the drainage data obtained from lettuce: the data were obtained on Field 2 for which about 10% was mapped as Vint loamy very fine sandy. Runoff also contributed to the low efficiencies for Bermuda grass, lettuce, and cantaloupe.

Runoff for furrow irrigated crops was higher than for border strip irrigated crops. The weighted average runoff for cantaloupe, lettuce, sugarbeets, and cotton was 24% as compared to 17% for barley, wheat, sorghum, alfalfa, and Bermuda

grass. Border irrigated Bermuda grass was the exception with a runoff of 30%.

DISCUSSION

Water Budget. This section addresses two questions: 1) what are the estimated applied, evapotranspired, runoff and drainage components of the IID water budget? 2) how do these compare to projected water needs for crop evapotranspiration, ET, and leaching? We begin with a subsection entitled Field Data where the estimates of water budget components are based on the measured applied water. In the Crop Data subsection the estimates are based on crop ET requirements. For each case we assumed the same runoff (16%, runoff data set) and drainage (8%, drainage data set).

Field Data. (Tables 4 and 5). The ratio of applied water (annual average) to Class A pan evaporation ranged from 0.28 (1981) to 0.68 (1979). The average ratio for 1977-80 was 0.56 and for 1977-81 it was 0.51. The decrease was due to the low amounts of applied water in 1981: the duration and area of fallowed land were greater in 1981 than in other years. Multiplication of the ratios, 0.56 and 0.51, by the average pan evaporation, 9.4 ft/y, and irrigated area of 450,000 acres, results in the high and low (2.42 and 2.21 million acre feet per year) estimates of total applied water given in columns 2 and 3 of Table 5. Correcting for runoff and drainage, the corresponding estimates for crop ETare 1.83 and 1.68 million acre feet per year.

Crop Data. The annual depth of water required for Crop ET was estimated for each field-crop combination. The resulting average was 4.46 feet per year. The corresponding district water requirement is 2.05 million acre feet per year (Table 5, col. 5). This exceeds the ET estimates based on applied water (Table 5, col. 3 & 4) by 0.22 and 0.37 million acre feet per year. This indicates insufficient water infiltrated to meet crop ET needs. We estimate underirrigation of alfalfa in the Imperial Valley amounts to 0.33 million acre feet per year based on the data obtained in the ARS-IID study. This estimate includes the leaching requirment and the fraction of the area cropped to alfalfa. A similar analysis for cotton, sugar beets, and wheat indicates an overirrigation of 0.06 million acre feet per year for these crops. Thus the total underirrigation is about 0.27 million acre feet per year.

Water Requirements. The basic water requirements are crop ET and leaching. The leaching requirement to control soil salinity for the crop distribution in Table 1 is 12%. For a crop ET of 2.05 million acre feet per year, the drainage volume corresponding to a leaching requirement of 12% would be 0.28 million acre feet per year. Consequently, the water requirement for ET and leaching is 2.33 million acre feet per year.

Do IID farmers receive sufficient water to meet the water requirement? The annual average on-farm deliveries of 2.54 million acre feet for 1975-1979 is 0.21 million

acre feet per year greater than the water requirement. The measured drainage (8% + unknown bypass) is likely adequate in terms of a 12% leaching requirement for salinity control. This excess of 0.21 million acre feet corresponds to a surface runoff of 8%. If our estimate of runoff, 16%, is correct, the answer to the question is yes; but, runoff would have to be reduced from 16% to 8% and the saved water used on-farm to meet the crop ET requirement.

Runoff could be reduced to zero, in principle, if each field had a pumpback system. Cost estimates of pumpback systems range from $7 to $25 per acre foot of saved water. Since water costs are currently about $9.50 per acre foot, current economic incentives to install pumpback systems are small. Runoff of 8% may be achievable, without pumpback systems, with increased water delivery flexibility, improved irrigation scheduling (timing and amount of water), and improved on-site water management. Reducing runoff from 16% to 8% will require changes in IID operations and increased water costs.

The water saved by reducing runoff could be used by the farmers to reduce underirrigation of alfalfa. This also presents some problems. Alfalfa is usually irrigated twice per cutting between July and September--the period of maximum ET rates. The number of irrigations is limited by 1) a cutting schedule of once every 28 days, 2) the sensitivity of alfalfa to scalding if ponded water conditions occur during irrigation, and 3) the need for dry soil conditions for haying operations. Consequently, if underirrigation cannot be corrected by irrigating more often, or applying and infiltrating more water per irrigation, the alternative may be to over irrigate before June. This may increase the amount of stored water available for plant growth.

Implications. How much water can be saved annually by changing on-farm operations? Runoff water is the only source. Reducing it to zero, without any other change may yield 0.4 million acre feet. If alfalfa ET requirements could be met by improved irrigation practices, the water yield would be reduced to 0.2 million acre feet per year.

References

1) Chang, A.C., R. W. Skaggs, L. F. Hermsmeier, and W. R. Johnston. 1983. Evaluation of a water management model for irrigated agriculture. Trans. ASAE. 26: 412-418 and 422.

2) Robinson, F.E., and J. N. Luthin. 1968. Comparison of three commercial drain tiles in a heavy clay soil of the Imperial Valley. California Agriculture. August.

Table 1. Total cropped area, crop ET, and areal crop distribution, in percent, of the surveyed fields. The corresponding distribution for the Imperial Valley during 1977-1979 is given in column 5.

Crop	Area	ET	Areal Crop Distribution Fields	Areal Crop Distribution Valley
	ac.	in.	------%--------	
Alfalfa	2060	79	33	35
Barley	160	22	2	1
Cotton	940	41	15	18
Lettuce	460	17	7	8
Sorghum	150	21	2	2
Sugar Beets	830	46	13	9
Wheat	1200	25	19	19
Bermuda Grass	320	33	5	0
Sudan	60	21	1	0
TOTAL: ARS-IID	6,180			
TOTAL: Valley	520,400			

Table 2. Average ($\bar{x}$) runoff, drainage and irrigation efficiency, by field with corresponding standard deviation's (s).

Field	N	runoff		drainage		irrigation efficiency	
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
		----------%----------					
1	54	28	11	3	3	70	12
2	24	16	11	12	13	73	21
3	41	23	13	7	6	70	15
4	2	7	6	22	10	71	5
5	-	-	-	-	-	-	-
6	39	19	8	10	7	71	12
7	39	20	8	2	2	78	9
8	78	14	13	13	13	73	22
Weighted Average		20		8		72	

Table 3. Average runoff ($\bar{x}$), drainage, and irrigation efficiency, by crop, and corresponding standard deviations(s).

Crop	N	runoff		drainage		irrigation efficiency	
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
		----------%----------					
Barley	5	19	9	2	2	79	9
Alfalfa	109	15	9	9	8	76	20
Sugar beets	44	21	9	6	4	73	24
Wheat	45	17	9	7	9	75	15
Cotton	44	24	12	4	6	72	13
Sorghum	2	7	4	22	10	71	5
Bermuda grass	16	30	11	5	5	64	16
Lettuce	5	26	10	29	7	44	11
Cantaloupe	7	38	14	42	13	20	24

Table 4. Average water applied to all fields by year as compared to pan evaporation.

Year	Applied Water	Pan Evaporation	Applied/Pan
	-------in.	-------	
1977	61	109	0.56
1978	58	119	0.49
1979	75	110	0.68
1980	60	111	0.54
1981	32	115	0.28
overall average	57	113	0.51

Table 5. Imperial Irrigation District water budget estimates based on applied water data (Table 4) and crop water requirements (Table 1).

Budget Component	Percent of On-Farm Delivery	Water Volume Applied Water high	low	Crop ET
		million acre feet per year		
ET	76	1.83	1.68	2.05
Runoff	16	0.39	0.35	0.44
Drainage	8	0.19	0.18	0.21
Total On-Farm Delivery	100	2.41	2.21	2.70

Effects of Gypsum on a Nonsodic Clay Soil

Janet Caprile, Gary W. Hickman, and Terry L. Prichard

The application of gypsum often improves the permeability of soils that contain an excess amount of exchangeable sodium. In addition improvements have been observed in nonsodic loam and sandy loam soils with low infiltration rates. It is also a popular conception that gypsum is effective in improving the permeability of nonsodic clay soils. This concept is often cited in garden publications and on gypsum package labels. Yet a literature review reveals that little research has been conducted which would verify the claim for improving infiltration of clay soils at the commonly recommended rate of 2 ton/ac. or 10 lb/100 ft^2.

The purpose of this research trial was to examine the effectiveness of gypsum in improving the permeability of a nonsodic clay soil which we considered to be typical of clay soils in some areas of California.

Site Description

The site selected for the trial was an undeveloped portion of the Chabot Valley College campus on the northern slopes of the Livermore Valley in central California. The area was covered with an assortment of annual grasses and forbs. The only routine activity conducted on the site was an annual mowing of the vegetation in early summer. The soil was slightly acid, nonsaline, and nonsodic as reported in Table 1. The soil texture ranges from a clay loam in the surface 6 inches to clay between 6 and 12 inches in depth. When dry, the soil develops deep fissures which tend to aid in the rapid penetration of water. The surface soil was fairly well aggregated.

Materials and Methods

A bagged gypsum product (92% calcium sulfate), which is commonly available in many farm and garden supply centers, was selected as the trial material. The four treatments consisted of an untreated control, 10 (label recommended rate), 20 and 40 lb/100 ft^2 (Table 2).

A level site was divided into sixteen 10 by 10 foot plots: each treatment was replicated four times in a randomized complete block design.

Prior to the application of the gypsum, the area was rototilled to a depth of approximately four inches. The appropriate amount of gypsum for each plot was applied with a lawn-type fertilizer spreader, and tilled into the top four inches of soil. One inch of water was then applied to the experimental area.

The water application system consisted of Ein-tal micro sprinkler emitters arranged in a 5 x 2-1/2 foot triangular pattern. Tests indicated the variation in individual sprinkler discharge was less than 10 percent. The system irrigated the entire experimental area as well as 2.5 foot border around the perimeter. The spacing provided for a 100 percent overlap between sprinklers and a 200 percent overlap between laterals. Surface distribution uniformity was considered to be 100%. No lateral movement of surface water occurred.

The total applied water was measured with an American 3/4 series meter. Rainfall data was recorded at the Livermore Water Pollution Control Facility. Observations and measurements were made from the center of each plot.

Soil permeability was estimated by noting the time required for surface saturation to occur. The depth of water applied was then calculated based on the 0.6 in/hr rate of application. The average times to achieve surface saturation in the treatments were then compared statistically. Significant differences would indicate changes in soil permeability.

A commonly repeated recommendation among gardeners is to apply gypsum in the fall in order to have improved soil by the spring planting season. Two estimates of permeability were made to assess the effects of gypsum over time. The first test was performed immediately after gypsum application in the fall of 1982, and the second was conducted eight months after treatment in June 1983. Between these dates 30.09 inches of rainfall occurred.

Results and Discussion

The average water applied which resulted in initial surface saturation is reported in Table 3. There was no significant difference at the 5 percent level for the four treatments either immediately after gypsum treatment or after an eight month period of time.

Prior to the application of water for the second test, soil samples were taken in all the plots, at depths indicated in Table 4, to assess the movement of gypsum in the soil.

Soil penetrometer readings were taken after the June tests. This instrument records the force that must be applied to cause the instrument to penetrate the soil to a particular depth. The depth of penetration measured in all plots was six inches. The summary of this data is included in Table 5. Again, no significant difference was found between any of the four treatments.

CONCLUSIONS

The application of gypsum, at any of the experimental rates, did not result in measurable changes in the permeability of this particular nonsodic clay soil.

Table 1. Soil physical and chemical characteristics

Depth inches	pH	Na meq/L	Ca+Mg meq/L	EC dS/m	ESP (est)%	GR T/A	Particle Size Analysis %clay	%silt	%sand	CEC meq/100g
0-6	6.2	1.0	3.5	0.45	1	--	39	35	26	36
6-12	6.6	1.0	3.5	0.45	1	--	41	34	25	36

Table 2. Gypsum treatment rates

Treatment	Pounds/100 $ft.^2$	Tons/Acre	Relation to Recommended Rate
1	20	4	x 2
2	40	8	x 4
3	0	0	---
4	10	2	x 1

Table 3. Average water applied by treatment before surface ponding occurred.

Treatment	October 1982 (ft^3/plot)	June 1983 (ft^3/plot)
1	45.7 a	48.5 a
2	43.8 a	46.9 a
3	45.7 a	46.9 a
4	46.9 a	47.7 a

Table 4. Calcium concentrations, saturated extract

Treatment	0" - 6"	6" - 12"	12" - 18"	18" - 24"
3 (control)	2.3 a	1.1 a	1.2 a	1.2 a
4 (10#/plot)	2.0 a	1.8 a	2.5 b	2.0 ab
1 (20#/plot)	5.1 b	4.1 b	3.3 b	3.2 b
2 (40#/plot)	3.4 ab	3.7 b	3.0 b	2.1 ab

Table 5. Penetrometer Readings

Treatment	Mean Penetrometer Units
1	19.8 a
2	20.8 a
3	22.0 a
4	22.2 a

A New Report on Acid Rain

Richard L. Snyder

A new report (No. 100) on acid rain titled "Acid Precipitation in Relation to Agriculture, Forestry and Acquatic Biology" was published by the Council for Agricultural Science and Technology (CAST) in June 1984. The report summarizes much of our current knowledge on the effects of acid rain, and I recommend it highly as a reference.

The report states that "unfavorable effects of acid deposition on domestic animals, crop yields, and foliage of plants grown in the field at locations remote from local sources of large amounts of acid-forming gaseous pollutants have not been demonstrated." There can be deletereous effects in the immediate vicinity of sources of pollution which cause acid rain. The authors recognized that chemical elements in acid deposition are essential nutrients and are commonly supplied in much greater amounts as fertilizer. Because of the common practice of applying crushed limestone to neutralize soil acidity, the authors concluded that "acid deposition will not have a measureable effect upon the acidity of cropland." Direct effects on plant vegetation have been both positive and negative.

The effects of acid deposition on forests are less well known according to the report. Limestone is not applied to forest soils to neutralize acidity as in croplands, but the acid rain does provide an additional source or nutrients to forests. There might be additional nutrient leaching resulting from lower pH values over several decades, but no such effects have been documented. There are no research results that indicate acid rain has done any direct damage to forest vegetation at pH levels occurring in the United States. Seed production, seed germination, and seedling behaviour of trees might be affected but no conclusive evidence currently exists to demonstrate positive or negative effects. Aquatic systems are often sensitive to acid rain if they do not have bedrock that can neutralize the acid. The main effect of acid rain on sensitive lakes is to reduce populations of some fish species. These effects have been observed in the northeastern United States. Options that have been considered to combat the losses of fish population are to (1) genetically select fish that are resistant to acidity, (2) acclimate fish to acidity before using them to stock acid lakes, and (3) neutralize the acidity by applying limestone or some other substance to the acid water.

In California, the acid content of lakes in the Sierra Nevada has changed little since 1965. [1] Their capacity to buffer acid deposition is low because of the low total concentration of alkaline and alkaline earth metals (<5 mg/L). Data obtained in 1983 continues to support that conclusion, reported in 1981, that acid deposition in the Sierra is low and has no measureable effect on the acidity of the Sierra lakes.

Again, I recommend Report 100 as an excellent reference on the effects of acid rain. The report can be obtained by writing to:

CAST
250 Memorial Union
Ames, Iowa 50011

One copy of the report can be obtained free of charge by CAST members. There is a $2.50 charge for non-members.

(1) Bradford, G. R., A. L. Page, and I. R. Straughan. 1981. Are Sierra Lakes Becoming Acid? Ca. Agr. 35: 6-7.

Improving Low Volume Sprinkler Performance by Acid Injection

Roger Kjelgren and David Goldhamer

For growers using conventional drip (trickle) irrigation, emitter clogging can be a serious problem. Whether it's due to physical (particulates), chemical (precipitates), or biological (algae, slimes) factors, it results in reduced discharge rates and usually decreases the uniformity of water application over the field. While advances in emitter design, filtration, and drip system operation strategies have helped reduce emitter clogging, it apparently will continue to be a serious problem, due predominantly to low discharge rates, relatively small diameter internal channels and/or long water flow paths of most emitters.

Low volume sprinklers (minisprinklers, microsprinklers, misters, foggers), on the other hand, have higher discharge rates and are usually designed with much larger diameter and/or shorter water flow paths. This decreases their susceptibility to clogging. However, irregularities have been observed in spray pattern integrity in the field, usually after the first season's operation. Under conditions of adequate filtration, the magnitude and extent of these disruptions seem to be related to water quality and sprinkler head design, as the problem has appeared in various manufacturers' products. Although the uniformity of water application by low volume sprinklers inherently appears to be poor based on traditional methods of single sprinkler evaluation (Post, et al., 1984), the impact of soil water redistribution in the profile on subsurface distribution has not been addressed. This process, currently being evaluated by our laboratory, needs to be understood to accurately assess the efficiency of applied water with low volume sprinkler systems. However, it's clear that disrupted spray patterns decrease surface distribution uniformity. This can enhance deep percolation of water below the root zone and negatively affect plant performance.

We recently conducted a study to evaluate the following aspects of low volume sprinkler performance:

1) the relationship between pattern disruption and sprinkler discharge rate.

2) injection of an acidulating compound in the system to restore spray pattern integrity.

Methods

A visual survey was made of a 2.5 acre experimental block of third year walnuts equipped with a one year old Bosmith Model SP30NH Fan-Jet® [1] low volume sprinklers to identify heads with disrupted patterns. This type sprinkler, which we use in our plant-water relations field studies because of its reliability and consistency of performance, was evaluated because it represents one basic design used by the industry (no moving parts) and it was readily available. Although good quality irrigation water (EC = .24 dS/m, Ca + Mg = 1.73 meq/l, $HCO_3^- + CO_3^{-2}$ = 2.03 meq/l) was used, 53 of the 481 sprinklers surveyed had altered spray patterns of varying degrees. These heads were removed to the laboratory where their patterns and discharge rates were evaluated.

A self contained manifold con-

1. Mention of trade and/or company name does not imply an endorsement of the product by the University of California.

sisting of a tank, pump, regulator, pressure gauge, lateral tubing, and risers was designed so that solutions could be run through five heads simultaneously. Using irrigation water and an operating pressure of 20 psi, the discharge rate of each head was determined using a graduated cylinder and stopwatch. Five heads with representative spray pattern disruptions were selected for further study.

Since acidulation has been found to be effective in reclaiming emitters clogged with chemical precipitates (Bucks and Nakayama, 1980), an acid forming compound (US-10® [1,2]) was tested with the five selected heads. This material is more easily handled than concentrated sulfuric acid. A solution was prepared in the tank to a pH of 1.5 and run through the sprinklers for one hour. Discharge rates from each head were measured at 15 minute intervals and the spray patterns visually evaluated.

Results

Even though the spray patterns of all 53 heads tested were disrupted to varying degrees, this was not reflected in the discharge rate measurements. Figure 1 shows a frequency histogram of discharge rates prior to acid treatment and illustrates that most discharge rates had relatively small deviations from the 5.78 gal/hr value of new, clean heads. In fact, 77 percent of the affected heads had discharge rates that were decreased by 8 percent or less. This indicates that spray pattern disruption predominantly occurs either after the water stream has left the internal flow channel, or that material on the internal channel walls, while only mildly affecting water flow rates, markedly alters the integrity of the spray pattern. To identify the primary factor responsible, affected heads were physically cleaned by insertion of a small wire into the base of the head. This procedure returned the pattern to normal, thus supporting the theory that chemical precipitation along the wall of the internal channel was responsible, since no organic material was observed. Apparently because good pattern uniformity depends on the emerging complete column of water precisely impacting on the splash plate at the appropriate location, any deviation in the integrity or shape of the water stream will dramatically impact on the pattern.

The use of acidulated water improved both spray pattern shape and discharge rates on affected heads. Figure 2 shows that within 60 mins, the average outflow from the five heads evaluated increased from 5.23 to 5.63 gals/hr. During this time, spray pattern shape also markedly improved. Clearly, the precipitate disrupting water flow was reactive, indicating that it was probably a carbonate residue.

Conclusions and Recommendations

This study revealed that:

1) low volume sprinkler spray pattern disruptions due to precipitation of compounds within the internal flow channel may be accompanied by only slight decreases in discharge rates, and

2) both pattern disruption and decreased outflow can be effectively corrected by injecting acidulating compounds into the

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1. Mention of trade and/or company name does not imply an endorsement of the product by the University of California.

2. A product of Verdgoal Brothers, Hanford, Ca.

irrigation water.

These conclusions have practical benefits for growers using low volume sprinkler systems. Before wide variations are present in discharge rates, a potential clogging problem will manifest itself visually. With early detection, the problem can be treated much easier. Periodic injection of an acidulating agent, with the frequency depending on the severity of the precipitation problem, appears to be a viable management technique. But remember, concentrated acids are corrosive, both to most metals and human skin. Make sure all components of the irrigation system downstream from the injection port can tolerate acid conditions, and observe all precautions in handling corrosive liquids. Acidulating compounds other than concentrated sulfuric acid, such as the urea-sulfuric acid products, appear ideally suited for this work.

References

1. Bucks, D. A. and F. S. Nakayama. 1980. Injection of Fertilizers and Other Chemicals for Drip Irrigation. Proceeding of the 1980 Irrigation Association Technical Conference, pp. 166-180.

2. Post, S., D. Peck, and D. Juliano. 1984. Uniformity Evaluation of Low-Volume Sprinklers. University of California Cooperative Extension, U.C. Riverside. (Available from the author.)

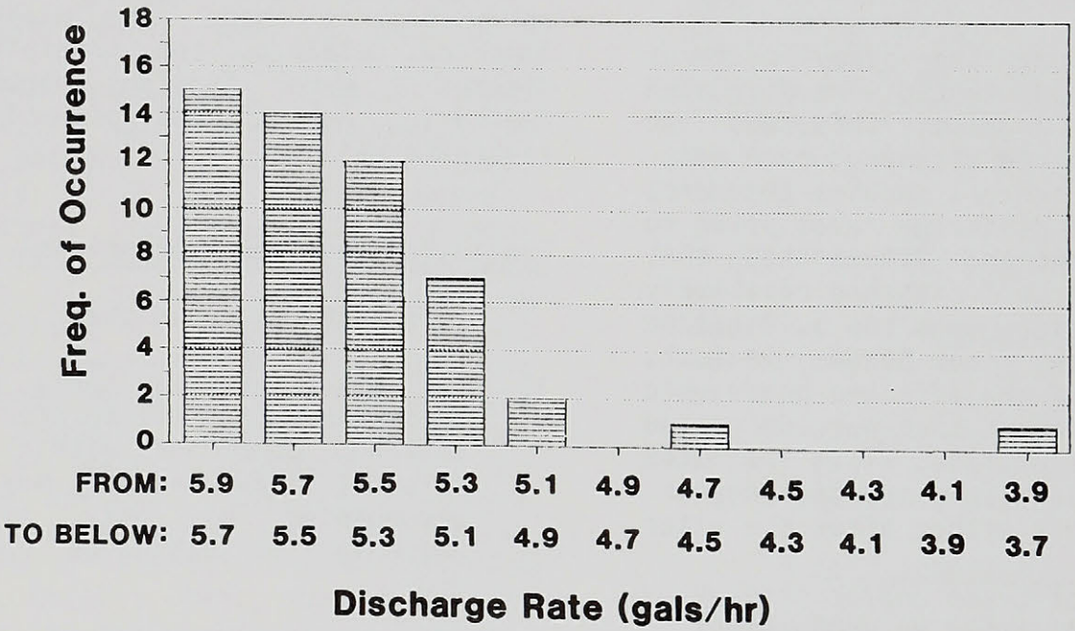

Figure 1. Frequency histogram of discharge rates from 53 heads with disrupted spray patterns. Measurements made prior to acid treatment.

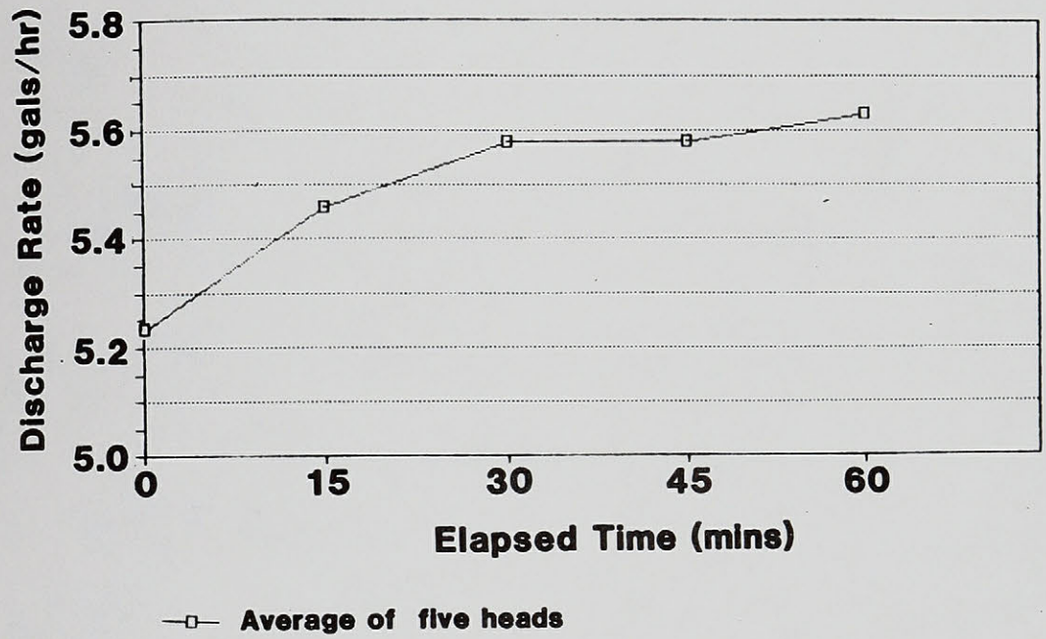

Figure 2. Time-rate change of low volume sprinkler discharge using acidulated irrigation water (pH = 1.5) on heads with disrupted spray patterns.

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