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RESPONSE OF CONTAINER GROWN BLUEBERRY PLANTS TO IRRIGATION WATER QUALITY

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INTRODUCTION

Questions have been raised relative to the effect of irrigation water quality on plant growth and yield of blueberries (*Vaccinium ashei* Reade). Field observations appeared to indicate that high pH water may increase the pH of the soil-peat mixture around the blueberry root zone below the drip irrigation emitter. A greenhouse container study was initiated in 1983 to evaluate the growth of blueberry plants irrigated with several sources of water of varying quality.

IRRIGATION WATER QUALITY

The concentration and composition of salts dissolved in a water determines its quality for irrigation. Concentration of dissolved salts is determined by measuring the electrical conductance (E.C.) of a water. A high E.C. value indicates a large concentration of salts. The lower E.C. value waters are best for irrigation, but E.C. alone is not a sufficient test for water quality.

The composition of the dissolved salts refers to the amounts of the different salts dissolved in the water. These salts are combinations of calcium, magnesium, potassium, and sodium with carbonates, bicarbonates, sulfates, and chlorides. Sodium bicarbonate and sodium chloride are the most harmful salts. A sodium hazard is a second criterion used to determine water quality.

The sodium hazard is determined by computation of a sodium adsorption ratio (SAR). A high SAR indicates a large amount of sodium compared to calcium and magnesium salts, and also indicates a poor quality water for irrigation.

The SAR and E.C. are used to determine the water's suitability for irrigation according to the chart shown in Fig. 1. In general, the lower the E.C. and SAR values the better is the water for irrigation. Good quality irrigation water would be rated C1-S1 or

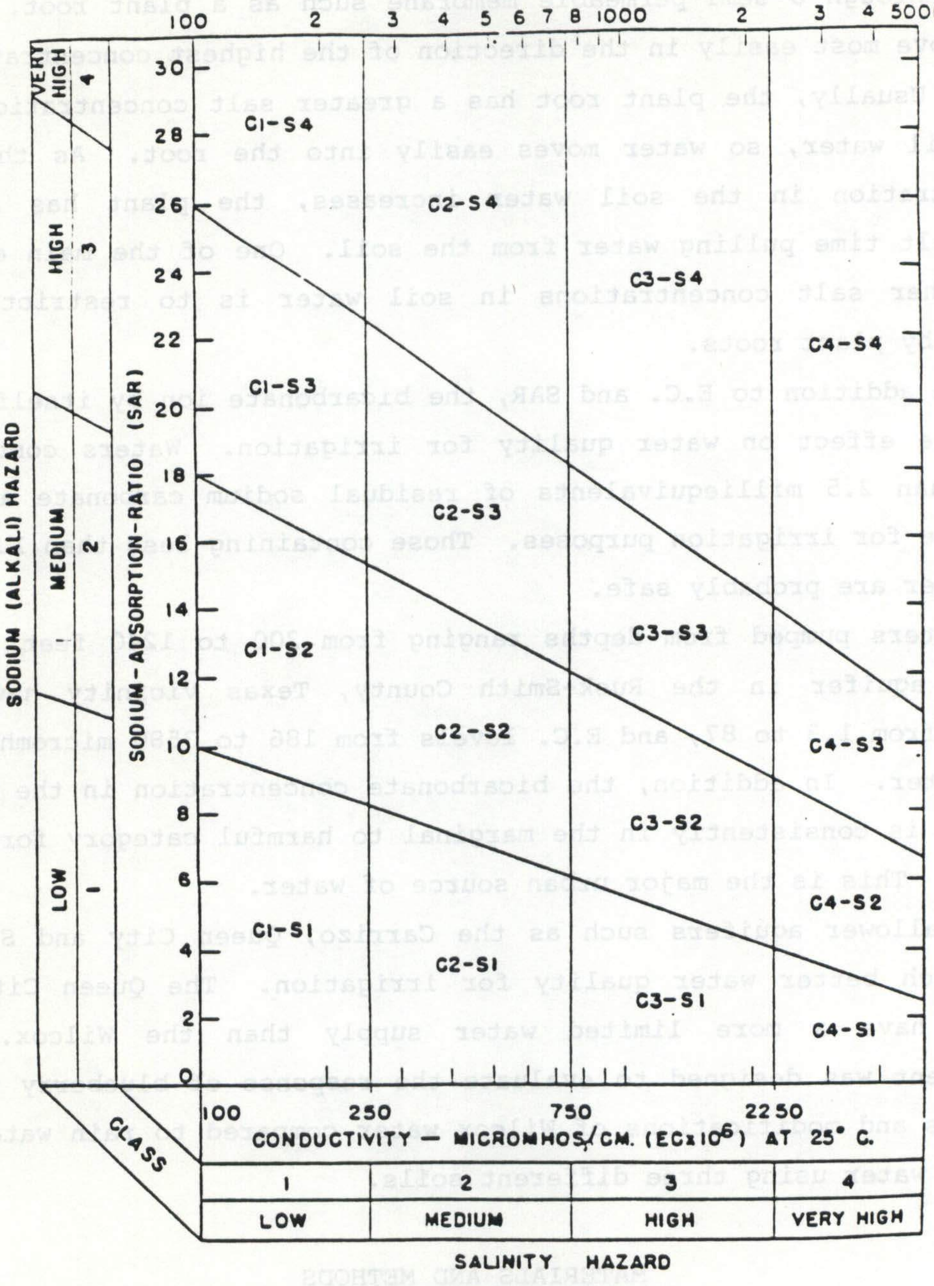

Fig. 1. Diagram for the classification of irrigation waters (From U.S.D.A. Handbook 60. Diagnosis and Improvement of Saline and Alkali Soils)

C2-S1. Poorer quality waters are rated C1-S2, C2-S2, C3-S2, and C3-S1. The poorest quality waters are in the category C4-S4.

The concentration of salt as measured by E.C. is related to plant growth by the osmotic effect. Osmosis is a process by which water moves through a semi-permeable membrane such as a plant root. Water will move most easily in the direction of the highest concentration of salt. Usually, the plant root has a greater salt concentration than the soil water, so water moves easily into the root. As the salt concentration in the soil water increases, the plant has a more difficult time pulling water from the soil. One of the main effects of higher salt concentrations in soil water is to restrict water uptake by plant roots.

In addition to E.C. and SAR, the bicarbonate ion by itself has a definite effect on water quality for irrigation. Waters containing more than 2.5 milliequivalents of residual sodium carbonate are not suitable for irrigation purposes. Those containing less than 1.25 meq per liter are probably safe.

Waters pumped from depths ranging from 200 to 1240 feet in the Wilcox aquifer in the Rusk-Smith County, Texas vicinity have SAR values from 1.3 to 87, and E.C. levels from 186 to 3580 micromhos per centimeter. In addition, the bicarbonate concentration in the Wilcox aquifer is consistently in the marginal to harmful category for plant growth. This is the major urban source of water.

Shallower aquifers such as the Carrizo, Queen City and Sparta, have much better water quality for irrigation. The Queen City and Sparta have a more limited water supply than the Wilcox. Our experiment was designed to evaluate the response of blueberry plants to rates and modifications of Wilcox water compared to rain water and surface water using three different soils.

MATERIALS AND METHODS

Soils selected for this study were loamy sand, 5.2% clay and 73.4% sand; sandy loam, 13% clay and 58% sand; and clay loam, 37.5% clay and 44% sand, having pH levels of 5.20, 5.25, and 5.29, respectively. These soils were mixed with equal volumes of peat having a pH of 3.59.

Two-year old, bare-root 'Tifblue' blueberry plants were weighed and potted February 25 and initially watered to field capacity with rain water. Water quality treatments were initiated the following week at the rate of 600 ml per pot (except at the 2x and 3x rates) as needed to maintain available water for plant growth. Soil samples for pH determination were collected 66 days into the study. The experiment was continued for 166 days after planting. Soils were sampled at this time, and root and top growth measurements were made. Soils were analyzed for pH.

Irrigation treatment waters used in this study are presented in Table 1. The source of deep well (DW) water was from the city of Overton, which pumps from three wells in the Wilcox formation. Three rates of Wilcox formation water were used. All potting media were initially irrigated to 20% moisture. Subsequent irrigations returned the soil moisture level to 20% except for treatments two and three which received two and three times the required rate, respectively.

Treatment four consisted of Wilcox water acidified (DW_a) to pH 5.0 with concentrated sulfuric acid. Acidification lowered the bicarbonate concentration to a non-hazardous level. However, the concentration of sodium remained the same while calcium was lowered slightly. This caused a 37% increase in SAR and a 4% increase in the E.C. Adding gypsum (DW_g) to the well water added calcium which lowered the calculated SAR, however, the soluble sodium decreased only slightly. Bicarbonate was decreased to 3.61 meq/L, but this level is still considered excessive for plant growth. Conductivity in the gypsum-treated well water (Treatment 5) was increased into a much more hazardous category.

Treatment six consisted of irrigation with the required amount of deep well water followed by leaching the soils with rain water (DW_r) four times during the 166-day study. Irrigation treatments seven and eight were the irrigation water requirement using rain water (RW) and surface water (SW) from a local pond, respectively.

RESULTS AND DISCUSSION

The three soils had a distinct effect on plant weight gain (roots and tops). Figure 2 illustrates the negative effect of increasing

Table 1. Irrigation water treatments, soils, and initial quality factors of each used in the greenhouse study of irrigation water quality on 'Tifblue' blueberry plants.

Water Treatment	Irrigation Water Quality Factors										
	pH	Ca	Mg	Na	K	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	E.C.	SAR
		meq/L								μmhos/cm	
Deep Well	8.7	.12	.01	7.83	.09	.41	7.89	.45	.61	695	29.7
Deep Well, Acidified	5.0	.07	.01	7.83	.26	0	.45	.42	7.24	980	40.6
Deep Well, Gypsum	8.2	27.20	.01	7.00	.07	0	3.61	.34	25.91	2445	1.9
Rain Water	6.3	.11	.02	.07	.09	0	.15	.04	0.00	15	0.3
Surface Water	6.8	.54	.60	.23	.08	0	.92	.56	0.27	155	0.3
Soil-peat, fertilized	Saturation Extracted										
Clay loam	4.62[1]	1.17	.74	.35	.69	0	.39	2.5	.22	439	0.4
Sandy loam	4.61	.58	.25	.23	.33	0	.49	3.7	.70	866	0.4
Loamy sand	4.30	2.24	1.04	.59	.80	0	0.00	2.8	1.15	973	0.5

[1] pH by 2:1 water:soil suspension with glass electrode.

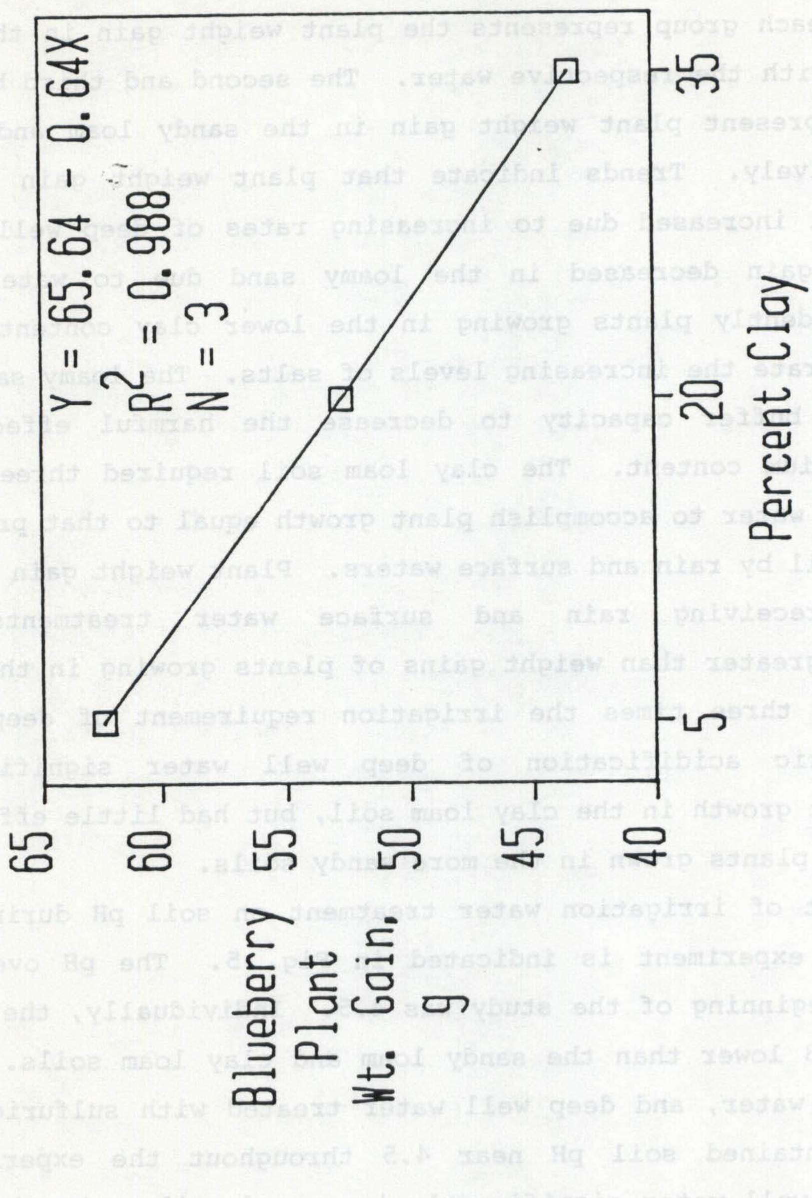

FIG. 2 SOIL CLAY VS PLANT WEIGHT GAIN

clay content on total plant weight gain, and Fig. 3 indicates the positive effect of increasing sand content of the soils on total plant weight gain.

Plant growth response to soils and water treatments are shown in Fig. 4. Each group of three bars represents a water treatment. The first bar in each group represents the plant weight gain in the clay loam treated with the respective water. The second and third bars in each group represent plant weight gain in the sandy loam and loamy sand, respectively. Trends indicate that plant weight gain in the clay loam soil increased due to increasing rates of deep well water while weight gain decreased in the loamy sand due to water rate increase. Evidently plants growing in the lower clay content soils could not tolerate the increasing levels of salts. The loamy sand did not have the buffer capacity to decrease the harmful effects of increasing sodium content. The clay loam soil required three times more deep well water to accomplish plant growth equal to that produced in the same soil by rain and surface waters. Plant weight gain in the loamy sand receiving rain and surface water treatments was significantly greater than weight gains of plants growing in the same soil receiving three times the irrigation requirement of deep well water. Sulfuric acidification of deep well water significantly increased plant growth in the clay loam soil, but had little effect on weight gain of plants grown in the more sandy soils.

The effect of irrigation water treatment on soil pH during the course of the experiment is indicated in Fig. 5. The pH over all soils at the beginning of the study was 4.5. Individually, the loamy sand pH was 0.3 lower than the sandy loam and clay loam soils. Rain water, surface water, and deep well water treated with sulfuric acid or gypsum maintained soil pH near 4.5 throughout the experiment. Untreated deep well water significantly increased soil pH by the 66th day of the study even at the lowest rate. By the end of the 166-day study, soil pH had been increased even more until the 3x rate of deep well water had raised the soil pH to 5.9.

The response of blueberry plants to irrigation waters, over all soils, is shown in Fig. 6. All deep well water treatments, including the sulfuric acid and gypsum-treated waters and that flushed with

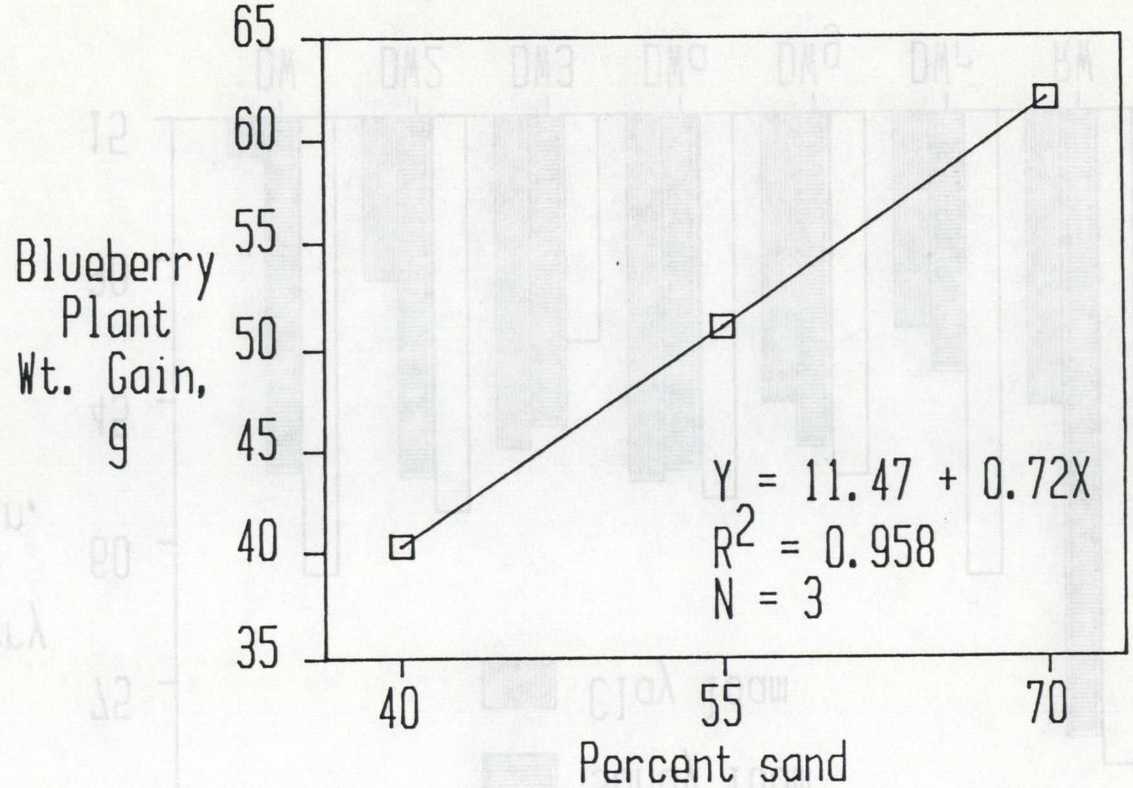

FIG. 3. SOIL SAND VS PLANT WEIGHT GAIN

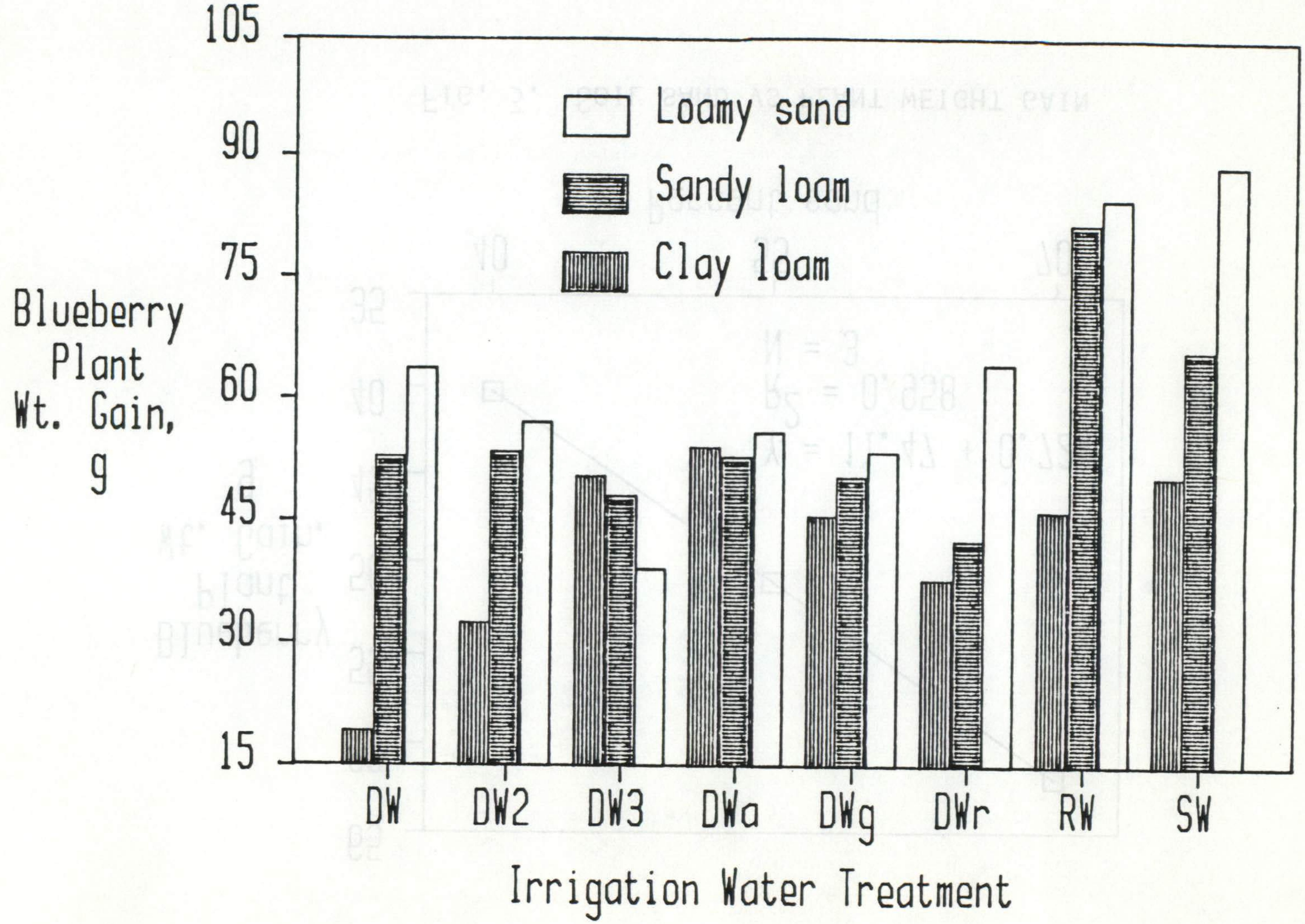

FIG. 4. EFFECT OF WATER AND SOILS ON BLUEBERRY GROWTH

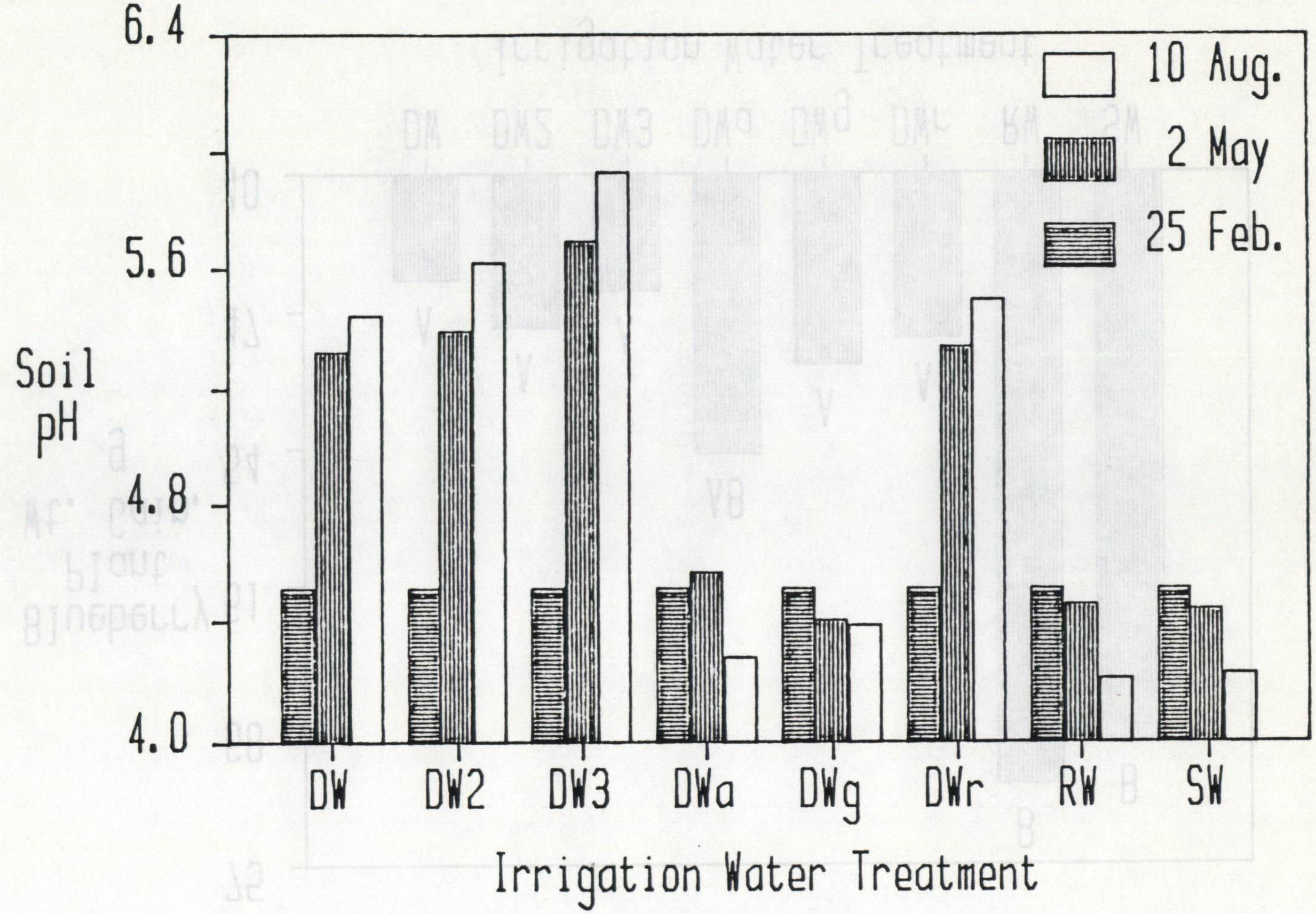

FIG. 5. EFFECT OF WATER TREATMENT ON SOIL PH, BLUEBERRIES

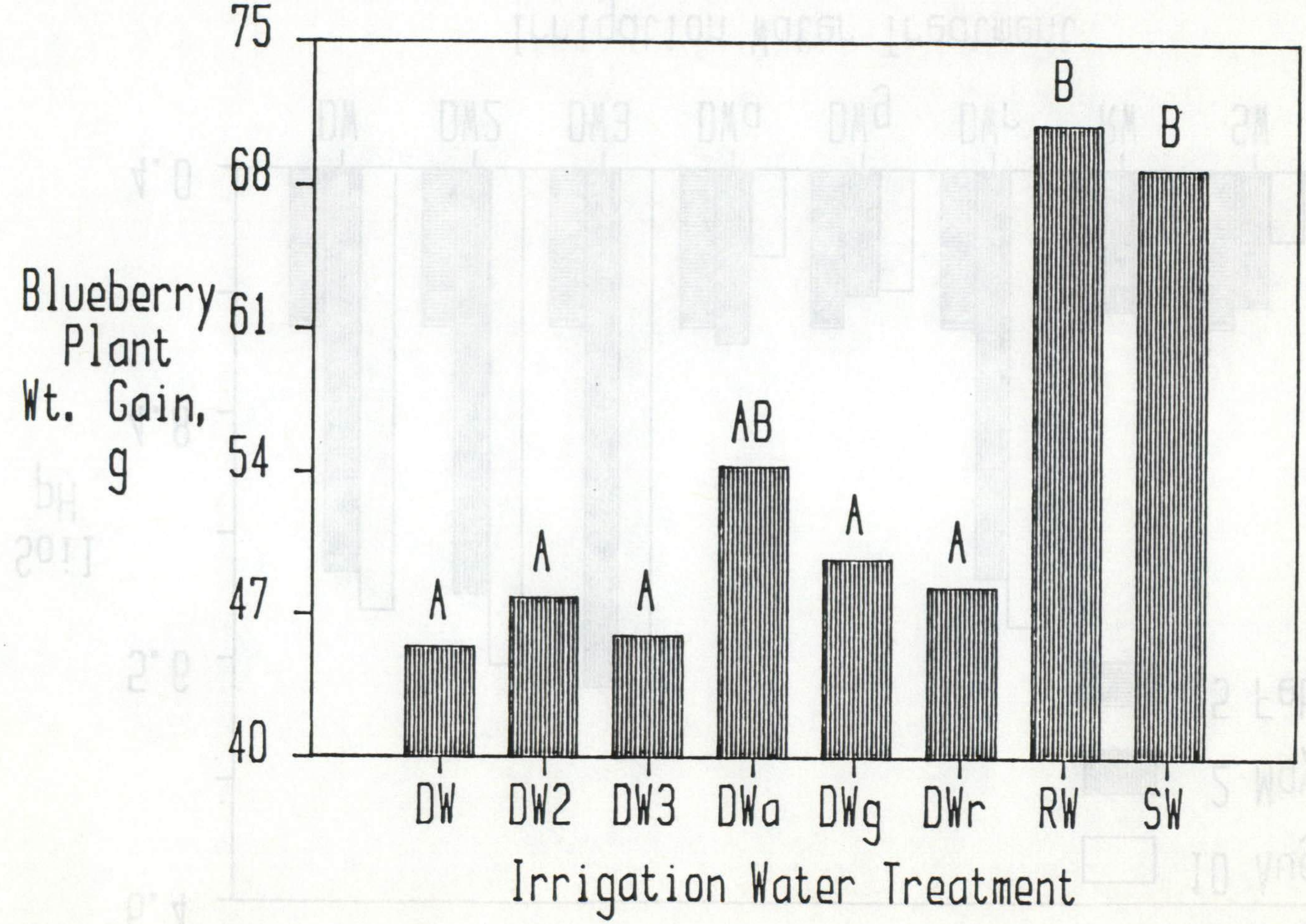

FIG. 6. WATER TREATMENT VS PLANT WEIGHT GAIN

rain water, produced statistically similar responses in plant weight gain. The rain water and surface water treatments significantly increased plant weight gain over the deep well water treatments.

Deep well water was rated as C2-S4 according to the chart in Fig. 1. This water should be considered generally unsatisfactory for irrigation purposes due to its high sodium hazard. In addition, this water contains an excess of bicarbonate ions. Waters with more than 2.5 meq per liter "residual sodium carbonate" are not suitable for irrigation use. This water contained 7.8 meq of sodium carbonate.

Acidification of deep well water to pH 5.0 with sulfuric acid produced an increase in soluble salts which changed the classification to C3-S4. Waters in this category should be considered unsatisfactory for irrigation purposes due to the high sodium and high salinity hazard, even though bicarbonates have been essentially eliminated and substituted for by sulfate from the sulfuric acid. Water pH is only an indicator of water quality and should not be considered alone as the quality determining factor in irrigation waters.

Saturation of deep well water with gypsum increased the salinity hazard, but lowered the sodium hazard. Addition of gypsum to the Wilcox well water did not significantly increase plant weight gain compared to untreated well water. Gypsum-treated water may be used occasionally to eliminate excess sodium when soils are permeable, drainage is adequate, excess water is applied to provide considerable leaching, and very salt-tolerant crops are grown.

Rain water and surface pond waters fit the C1-S1 category, indicating low salt and sodium concentrations. Waters in this category can be used for irrigation with most crops on most soils with little likelihood that harmful levels of salinity or sodium will develop. Some leaching is required at the higher level of salinity in the C1 category, but this occurs under normal irrigation practices in the more sandy soils.

With the above data showing the detrimental effects of poor quality irrigation water on blueberry plant growth, it would be advisable to test water before using it for irrigation on blueberries. The Texas A&M University Soil Testing Laboratory suggests that you collect the irrigation water in a clean plastic bottle. Rinse the container at least three times with the water you will sample. Before taking the sample run the pump for two to three hours prior to sampling the water at the pump. Analysis can be done for a cost of $8.00 by the Soil Testing Laboratory, Texas A&M University, College Station, TX 77843. See your local county extension agent to obtain an information form to complete and mail with the water sample for analysis. This form must accompany the sample to the lab. Be certain to number your samples and record the source of each sample for your use when the analyses are returned to you.

SUMMARY

These research results indicate that blueberry plants have a low tolerance for poor quality irrigation waters like those found in the Wilcox formation. Treatment of the Wilcox formation water with sulfuric acid or gypsum had little short-term effect on improving plant weight gain compared to untreated water from the same source. Periodic leaching with rainwater failed to significantly improve plant weight gains in soils irrigated with Wilcox formation water over the short term of the study. Shallower formations such as the Queen City aquifer or springs may have better quality water for irrigation. It is advisable to have samples of potential irrigation waters analyzed prior to using the water for irrigation of blueberries or other salt and sodium sensitive plants.