ALFALFA RESPONSE TO WATER AND NITROGEN VARIABLES

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INTRODUCTION

Traditionally, the main crop on the Yuma Mesa has been citrus, and the method of irrigation has been flood. The amount of water applied per acre has been in excess of 10 feet per year because of the high infiltration rates and low water holding capacity of these sandy soils. Recently many of the citrus groves have been taken out of production because of difficulties with trees on Rough Lemon rootstock and the overall poor economic return of citrus. In most cases, alfalfa has been planted in groves that have been removed, but it requires about 12 feet of water per year with flood irrigation. If alfalfa is to be grown on the Yuma Mesa, a more efficient irrigation system that will not waste water is needed. One such method is sprinkler irrigation.

Sprinkler irrigation has been used in many parts of the United States and even on the Yuma Mesa for many years. Some of the disadvantages of having to move the older sprinkler irrigation systems by hand have been overcome by the modern self-moving lateral and center pivot sprinkler systems.

New developments in self-moving irrigation systems utilizing low pressure sprinkler, spray, or drop hose techniques show possibilities for saving energy, improving efficiency of water and fertilizer use, and using more saline water to irrigate crops that are salt sensitive. These new techniques in sprinkler irrigation have enlarged the possible combinations of soil, water and crops. This experiment was designed to evaluate water and nitrogen conservation using sprinkler irrigation on various agronomic and horticultural crops grown on the sandy soils of the Yuma Mesa.

The experiment is located on the University of Arizona Yuma Mesa Experiment Station. The farm land was developed when the Yuma Mesa Division, Mesa Unit, was initiated. The experimental field used in this study has been in limited research and was in alfalfa two years prior to initiating this project. The soil is a Superstition sand series. The infiltration rate of the soil is quite high, approaching 3 inches per hour, and the water holding capacity is low, less than one inch per foot.

PROCEDURE

The sprinkler irrigation system is a self-moving lateral system. The pumping plant straddles a concrete ditch to obtain a continuous supply of water. The versatility of the system makes it especially suitable for an irrigation and nitrogen management research study. Maximum speed of the system is 7 feet per minute and it can be operated at any speed between 5% and 100% of this maximum speed. This allows a range of water application of 0.2 inches to 1.4 inches of water. The sprinkler system can operate forward or reverse, with or without water.

A central composite rotatable statistical design with 2 variables, water and nitrogen is used in this experiment. The water levels vary from 50% to 150% water applied (W.A.), and the nitrogen levels vary from 33% to 167% nitrogen (N) per acre. This statistical design can determine the crop response function (yield) for the two variables, water and nitrogen. Figure 1 shows a typical production function of 2 variables, water and nitrogen As noted in this figure, the center point (100% W.A. and 100% N) is replicated 5 times.

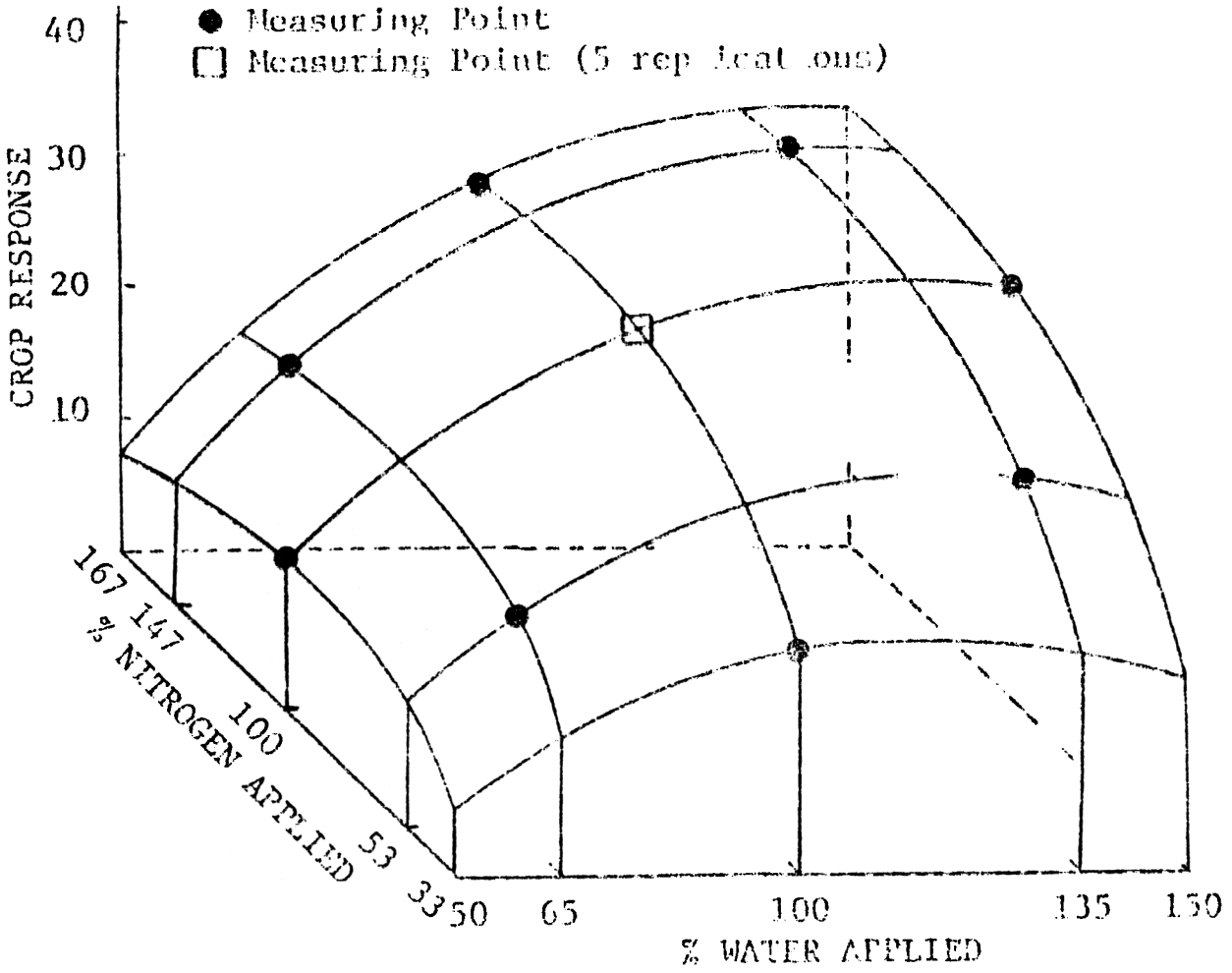

FIGURE 1. Production Function of 2 Variables Water and Nitrogen.

The water and nitroten rates specified in this design are:

TREATMENT	% W.A.	% N
	50	100
	65	53
	65	147
	100	33
	100	100
	100	100
	100	100
	100	100
	100	100
	100	167
	135	53
	135	147
	150	100

Water applied in this experiment is defined as not only the unit or amount of water used on a given area for transpiration, the building of plant tissues, and evaporation for adjacent soils, but also that amount of water necessary to keep the total soluble salts in the soil at a desirable level and maintain an adequate yield.

A total of nine different levels of water and nitrogen combinations are defined by this statistical design with the center treatment replicated 5 times. This gives a total of 13 areas where different levels of water and nitrogen are applied. Each of these 13

water and nitrogen plots are 40 feet in length. The 13 plots were randomized down the crop row.

The different amounts of water applied is accomplished by using nozzles of different orifice size. Thus, the nozzles used in the 150% W.A. plots apply 3 times the amount of water as the nozzles used in the 50% W.A. plots. The amount of water applied during each irrigation is determined by measuring the time required to travel a selected distance. The different nitrogen application rates are accomplished by using different size orifices in each plot to meter the nitrogen into the irrigation water. Water samples are collected each week when the nitrogen is injected to verify that the correct rate of nitrogen is being applied. The amount of nitrogen applied per application varies from 10 to 50 pounds per acre by changing the machine travel speed from 100% to 5%. High nitrogen applications result in high water applications since both are controlled by the machine travel speed. The nitrogen fertilizer applied in the irrigation water raises the total soluble salts about 100 ppm

Two cultivars of alfalfa were planted on March 4, 1981 at a rate of 20 pounds/acre and irrigated with the uniform spray bar to accomplish uniform germination and initial plant growth. The two cultivars of alfalfa were Mesa-Sirsa, a popular variety used by commercial growers, and Lew, a variety that has shown greater nodulation than other alfalfa cultivars. Both cultivars were planted in the same field and received the same irrigation, nitrogen, and cultural management. Because of space limitations, only one field was planted to alfalfa. Treble super phosphate was broadcast prior to planting the alfalfa at a rate of 200 pounds phosphorus per acre.

The alfalfa was cut on May 4 because of a high population of weeds. The first cutting was made June 18 when it had approximately 10% bloom. The yields from all treatments on this cutting were nearly equal because the uniform spray bar had been used since March 4. The total amount of water applied from March 4 through June 18 was 25.3 inches. Three applications of nitrogen had been applied to this first cutting of alfalfa. The total nitrogen application per acre at the 100% level for the first cutting was 64 pounds/acre. The variable spray bar was used to irrigate the alfalfa after June 18. The first alfalfa cutting made after the variable spray bar was initiated was on July 14, 26 days later. The alfalfa was cut 10 times between July 14, 1981 and July 1, 1982. After each cutting approximately 40 pounds of nitrogen per acre was applied to the 100% nitrogen treatments. The total nitrogen applied for the 10 cuttings was 346 pounds at the 100% N level and the total water applied was 112 inches at the 100% W.A. level.

Yield measurements were made by harvesting the green alfalfa and collecting the growth from a selected area. The green alfalfa was weighed as soon as it was cut. A sample was taken and dried to determine the dry weight. Yields were determined based on a 12% moisture content.

The alfalfa yields in tons/acre at 12% moisture are summarized in Table 1 for each of the harvest dates and the total yield for each of the varieties. As noted in the table, there is an increase in yield with each increment of water. At the highest levels of water there is an increase in yield with increased nitrogen application for the Mesa-Sirsa variety. Total yields are very good. The highest yields were obtained with 151 inches of water and 508 pounds of nitrogen. Yields were 24.1 and 21.5 tons of alfalfa per acre for Mesa-Sirsa and Lew, respectively.

The total yields collected for each alfalfa variety were fitted by regression to a quadratic equation. The yield contours in tons/acre for the ten cutting dates are shown in Figures 2 and 3 for the cultivars of Mesa-Sirsa and Lew, respectively. As noted in these figures, both varieties show similar contours. There appears to be little to no response to nitrogen applied at the lower water levels, less than the 100% level. At the higher water levels and higher yields, there appears to be a nitrogen response. It is also noted that the Mesa-Sirsa variety out-yielded the Lew variety by about one ton per acre for the 10 cutting dates. The equation used to predict the yield contours for the Mesa-Sirsa variety is:

$$YIELD = 16.740 + 5.901W + 1.597N - 2.183W^2 - 0.382N^2 + 0.50WN$$

R = 0.942** LOFF = 2.27ns F = 1.09** STD. ERROR = 2.4 tons/acre

TABLE 1. Summary of Alfalfa Yields in Tons/Acre.

	Inches Water	Pounds Nitrogen	Date of Cutting 7/14/81	8/11/81	10/1/81	11/18/81	1/5/82	2/23/82	4/6/82	5/11/82	6/3/82	7/11/82	
			Mesa-Sirsa										
1	56	346	0.7a*	1.2b	1.7	0.9ab	0.6b	0.3ab	0.8a	0.4a	0.1	0a	6.7a
2	73	183	0.3a	0.3a	1.7	0.6a	0.3a	0.1a	0.7a	0.5ab	0.3a	0.1a	5.0a
3	73	508	0.8a	0.7a	1.3	1.0bc	0.7bc	0.4b	1.0ab	0.9b	0.4a	0.5ab	7.7a
4	112	114	1.6ab	1.6b	1.7	1.0bc	0.6b	0.5b	1.7bc	2.5c	2.0b	1.1bc	14.2b
5	112	346	2.4bc	2.0cd	1.6	1.2bcd	0.9cd	1.0cd	1.9c	2.6c	2.2bc	1.1bc	16.8b
6	112	578	2.3bc	1.7bc	1.8	1.4de	0.9cd	1.2cd	2.3c	2.9cd	2.2bc	1.3bc	18.0b
7	151	183	3.1cd	2.4d	1.3	1.1bcd	1.0d	1.0cd	1.9c	2.7c	2.9cd	2.0d	19.4bc
8	151	508	3.9d	2.5d	2.2	1.7e	1.1d	1.3d	2.1c	3.2d	3.7d	2.4d	24.1c
9	168	346	2.2bc	2.4d	1.0	1.3d	0.9cd	0.9c	1.8c	2.8cd	3.0cd	2.0d	18.3b
		$s_{\bar{x}}$	0.126	0.126	N.S.	0.362	0.059	0.092	0.180	0.118	0.190	0.176	0.393
			Lew										
1	56	346	0.5a	1.0b	1.3	0.9	0.7	0.3a	0.7a	0.2a	0.1a	0.0a	5.7a
2	73	183	0.3a	0.3a	1.1	0.5	0.4	0.4a	0.7a	0.8ab	0.3a	0.2a	4.9a
3	73	508	0.4a	0.7ab	1.4	0.6	0.7	0.4a	1.3b	1.3b	0.4a	0.3ab	7.4a
4	112	114	1.9b	1.7c	1.7	0.6	0.8	0.9b	1.5b	2.5b	2.3c	1.1bc	15.1b
5	112	346	2.0b	1.8c	1.4	1.1	0.9	1.0b	2.0c	2.3c	2.2b	1.2bc	15.9b
6	112	578	2.1b	1.8c	2.1	1.2	0.9	1.0b	2.1c	2.7c	2.3b	1.4cd	17.6bc
7	151	183	2.3b	1.8c	1.2	1.0	0.9	1.1b	2.1c	2.7c	3.0c	2.1de	18.1bc
8	151	508	2.6b	2.3cd	1.0	1.2	1.0	1.1b	2.3c	3.0c	3.4c	2.7e	21.5c
9	168	346	2.4b	2.7d	1.6	1.1	0.9	0.9b	2.0c	2.8c	2.8bc	2.2de	19.4
		$s_{\bar{x}}$	0.326	0.627	N.S.	N.S.	N.S.	0.193	0.300	0.209	0.150	0.218	0.388

*Means followed by the same letter are not significantly different at the 5% level.

The equation used to predict the yield contours for the Lew alfalfa variety is:

$YIELD = 15.84 + 5.835W + 1.180N - 2.014W^2 - 0.114N^2 + 0.225WN$

R = 0.958** LOFF = 11.1ns F - 15.45** STD. ERROR = 2.0 tons/acre

** = 99% confidence interval LOFF = lack of fit F ns = no significance

Where: W = water applied
N = nitrogen applied

This experiment was terminated because the alfalfa production dropped drastically. The alfalfa stand reduced and a high weed and grass infestation occurred. Also, during the summer of 1982 insufficient amounts of water were applied which reduced the plant population. This research will be continued if additional funding can be obtained in the future. A neutron probe will be used to help schedule the irrigations in future plantings. The results after one year are very encouraging, however, additional data are needed to verify these results.

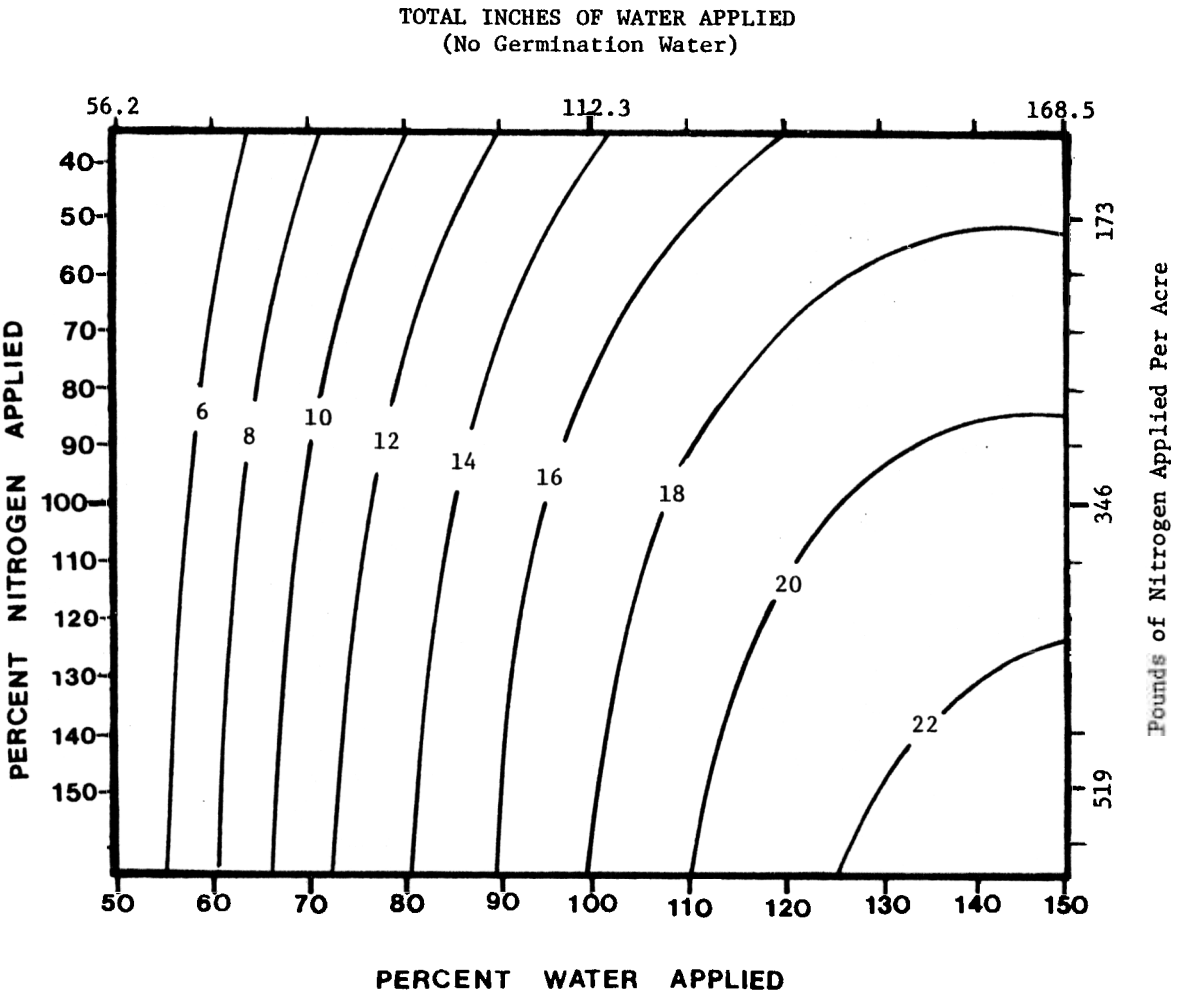

FIGURE 2. Yield Contours of 10 Mesa-Sirsa Alfalfa Cuttings in Tons/Acre for the Period of July 14, 1981 - July 1, 1982.

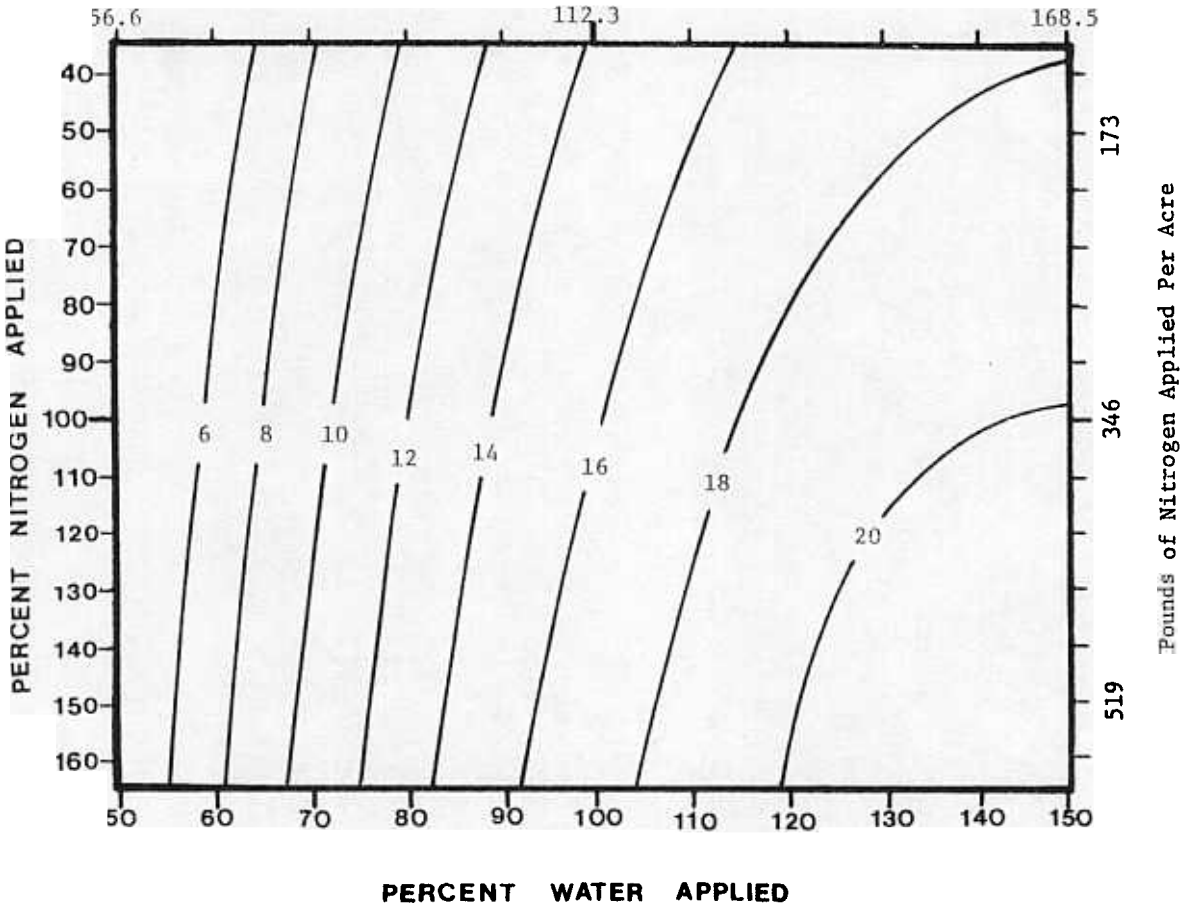

FIGURE 3. Yield Contours of 10 Lew Alfalfa Cuttings in Tons/Acre for the Period of July 14, 1981 - July 1, 1982.