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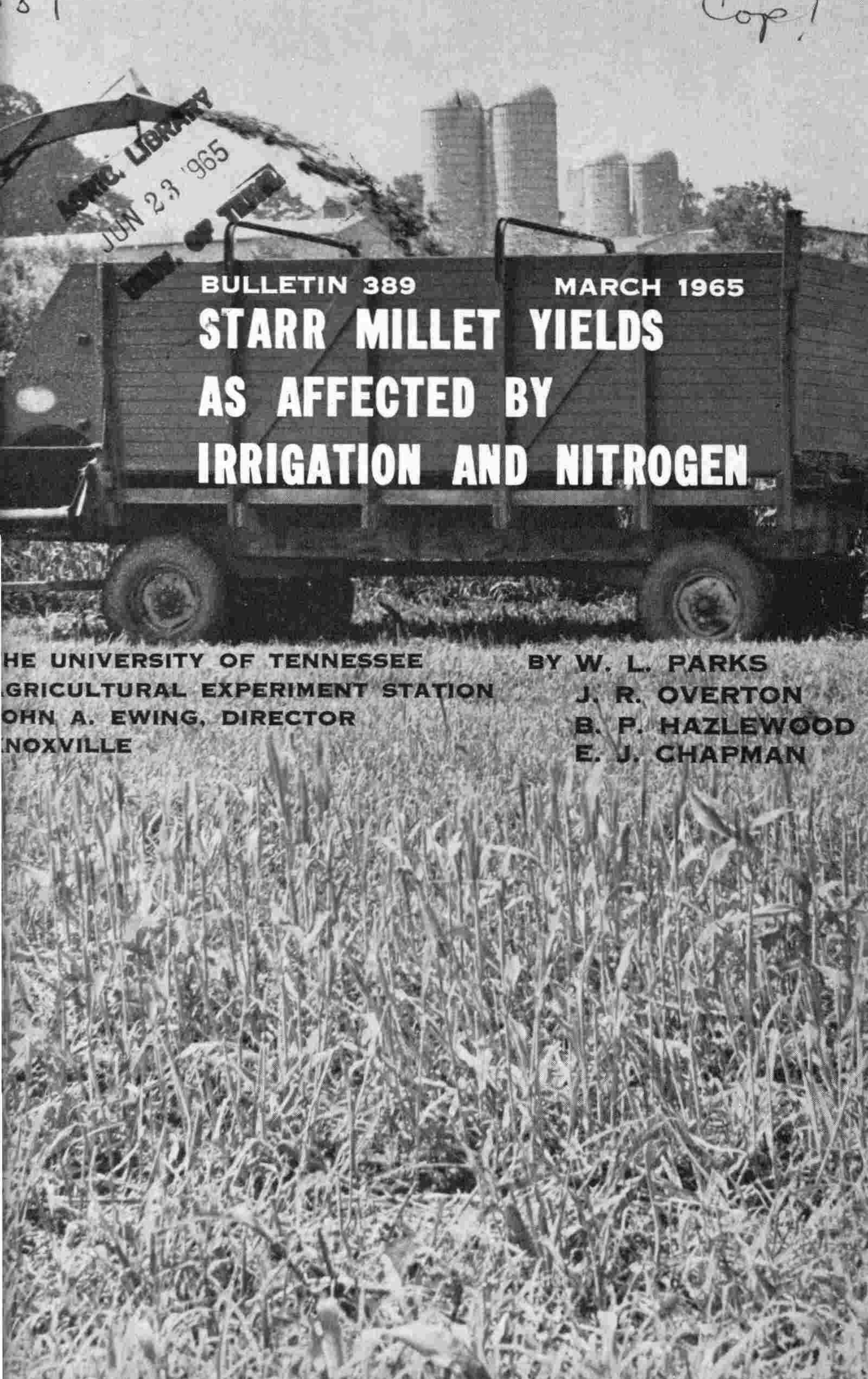

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STARR MILLET YIELDS AS AFFECTED BY IRRIGATION AND NITROGEN

HE UNIVERSITY OF TENNESSEE
GRICULTURAL EXPERIMENT STATION
OHN A. EWING, DIRECTOR
NOXVILLE

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Contents

Starr Millet Yields As Affected By Irrigation and Nitrogen[1]

by

W. L. Parks, J. R. Overton, B. P. Hazlewood, E. J. Chapman[2]

FIELD experiments involving irrigation and nitrogen fertilization of the Starr variety of pearl millet were conducted on a Maury silt loam soil at the Middle Tennessee Experiment Station, and on a Memphis silt soil at the West Tennessee Experiment Station over a 5-year period (1957-61.)

Experimental Procedures

A split plot experimental design was used with soil moisture levels as the main plots and nitrogen levels as the split plots. Four soil moisture levels, five nitrogen levels and four replicates were used on the Maury soil, while three soil moisture levels, four nitrogen levels and three replicates were used on the Memphis soil.

Soil samples were taken each week for gravimetric soil moisture determinations. Irrigation treatments were applied when soil moisture content dropped to predetermined levels. Each irrigation provided enough water to bring the surface foot of soil back to field capacity.

Cuttings were made when the highest yielding plots reached a height of 30 to 36 inches. The forage was cut to 6 to 8 inches high and the entire experiment harvested at each cutting date.

Soil Moisture Properties

The moisture holding characteristics of the two soils used in these studies are shown in Table 1. These data indicate that the

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[1] This work was conducted in cooperation with The Division of Agricultural Development, TVA.

[2] Professor, Assistant Professor, and Superintendent of West Tennessee Experiment Station, and Assistant Dean (formerly Superintendent of the Middle Tennessee Experiment Station), respectively.

Table 1. Moisture release data for Maury and Memphis soils

MAURY SILT LOAM

Soil depth	0-6"			6-12"			Total acre in. H_2O for 0-12"
Bulk density	1.38			1.47			
	Soil Moisture		Acre in. H_2O to reach F. C.	Soil Moisture		Acre in H_2O to reach F. C.	
Moisture Tension	Weight %	Volume %		Weight %	Volume %		
F. C.	26.0	35.9	0	24.9	36.6	0	0
2 Atm. Ten.	16.6	22.9	.78	15.7	23.1	.81	1.59
5 Atm. Ten.	10.7	14.8	1.27	12.7	18.7	1.07	2.34
9 Atm. Ten.	8.7	12.0	1.43	10.7	15.7	1.25	2.68
15 Atm. Ten.	7.8	10.7	1.51	9.0	13.2	1.40	2.91
MEMPHIS (LINTONIA) SILT							
Bulk density	1.33			1.38			
F. C.	24.4	32.4	0	26.1	36.0	0	0
2 Atm. Ten.	9.0	12.0	1.22	16.7	23.0	.78	2.00
5 Atm. Ten.	6.5	8.6	1.43	12.8	17.7	1.10	2.53
9 Atm. Ten.	5.5	7.3	1.50	10.9	15.0	1.26	2.76
15 Atm. Ten.	4.6	6.4	1.56	9.6	13.4	1.36	2.92

surface foot of the two soils held approximately the same amount of available water. However, in the surface 6 inches of the Memphis soil which is higher in silt content, more of the available water is held at lower tensions and was more readily available to plants for growth than was the water in the surface 6 inches of the Maury soil; it has a higher clay content and, consequently, much of the soil water was held at higher tensions.

Rainfall

The monthly rainfall over the 5-year period as well as the 30-year average for the Middle and West Tennessee Experiment Stations are shown in Tables 2 and 3. The total rainfall during the

Table 2. Rainfall for the Middle Tennessee Experiment Station, Spring Hill, Tennessee, 1957-61, and the 30-year average (1931-60)

Month	1957	1958	1959	1960	1961	30-year av.* (1931-60)
May	8.12	4.19	4.14	2.76	4.76	4.17
June	4.26	3.43	2.78	9.99	5.04	3.80
July	2.13	7.99	6.16	7.43	6.05	4.39
August	1.22	1.88	4.54	4.04	1.06	3.57
September	5.80	5.59	2.77	4.69	1.08	4.49
5-month total	21.53	23.08	20.39	28.91	17.99	20.42

* 30-year average for Ashwood Station.

Table 3. Rainfall for the West Tennessee Experiment Station, Jackson, Tennessee, 1957-61, and the 30-year average (1931-60)

Month	1957	1958	1959	1960	1961	30-year av.* (1931-60)
May	5.29	2.66	2.75	2.62	4.67	4.03
June	6.85	3.33	4.16	3.68	4.75	4.18
July	6.76	3.37	4.71	5.35	3.80	4.56
August	2.30	1.03	2.55	2.13	3.66	3.36
September	4.21	4.98	1.73	1.47	0.64	3.40
5-month total	25.41	15.37	15.90	15.25	17.52	19.53

* 30-year average for Jackson Experiment Station.

5-month, May-September period at the Middle Tennessee Experiment Station was average or above during the first 4 years of the experiment, and only in 1961 was it considerably below average. Much of the deficiency during 1961 was in August and September, or during the latter part of the growing season. At the West Tennessee Experiment Station, the rainfall was above average only in 1957 and was somewhat below average in the following 4 years.

Drouth

The number of drouth days for each season was calculated for the Middle and West Tennessee Experiment Station using the average daily evapotranspiration and a 2.50-inch moisture base at each location. This procedure assumes that the soil holds 2.50 inches of available water for the millet. The average daily evapotranspiration is subtracted each day, and rainfall or irrigation is added according to a bookkeeping procedure. The total moisture is never allowed to exceed the base or go below zero. Each day is called a "drouth day" if the moisture level is zero. These data are shown in Tables 4 and 5.

At the Middle Tennessee Station the most drouth days during the growing season occurred in 1957. It was also in 1957 that irrigation at 2 atmospheres tension brought about the greatest reduction in the number of drouth days. Most of the drouth days in 1961 occurred near or after the final harvest of that year. At the West Tennessee Experiment Station, the least number of drouth days occurred in 1957, which was the only year when the rainfall was above average. During each of the other 4 years, the number of drouth days was comparable and ranged from 54 to 68 days each year. Irrigations during these years greatly decreased the number of drouth days at this location.

Table 4. Drouth Days for the Middle Tennessee Experiment Station, Spring Hill, Tennessee, 1957-61

2.50-inch moisture base

	1957	1958	1959	1960	1961
NO IRRIGATION					
May	10	0	2	14	0
June	0	11	6	4	0
July	18	3	16	1	1
August	22	5	0	0	15
September	8	14	0	1	26
Total	58	33	24	20	42
IRRIGATED AT 9 ATMOSPHERES TENSION					
May	10	0	2	14	0
June	0	11	6	4	0
July	18	3	16	1	1
August	22	5	0	0	15
September	8	9	0	1	26
Total	58	28	24	20	42
IRRIGATED AT 5 ATMOSPHERES TENSION					
May	10	0	2	14	0
June	0	11	6	4	0
July	13	3	16	1	1
August	9	5	0	0	15
September	8	3	0	1	26
Total	40	22	24	20	42
IRRIGATED AT 2 ATMOSPHERES TENSION					
May	10	0	2	14	0
June	0	11	6	4	0
July	6	3	6	1	1
August	6	5	0	0	15
September	1	1	0	0	26
Total	23	20	14	19	42

Seeding and harvest dates

The seeding dates for the experiments at the two locations are shown in Table 6. Generally the experiments were seeded in the latter half of May with the exception of 1960 in which they were purposely seeded much later in an effort to grow the millet during a period of higher moisture stress. However, the rainfall and drouth day tables show that this did not occur during that crop year. The yields obtained during 1960 were somewhat lower than in the other years, and this was probaby due to photoperiod and temperature effects.

The cutting dates for the forage harvest at the two locations are shown in Table 7. Generally, an average of about three cut-

Table 5. Drouth days for the West Tennessee Experiment Station, Jackson, Tennessee, 1957-61

2.50-inch moisture base

	1957	1958	1959	1960	1961
NO IRRIGATION					
May	2	3	11	4	0
June	0	14	9	22	2
July	4	13	6	4	14
August	8	27	21	14	12
September	9	11	12	20	26
Total	23	68	59	64	54
IRRIGATED AT 5 ATMOSPHERES TENSION					
May	2	3	11	4	0
June	0	14	9	22	2
July	4	13	6	4	14
August	8	9	17	9	6
September	4	11	1	12	14
Total	18	50	44	51	36
IRRIGATED AT 2 ATMOSPHERES TENSION					
May	2	3	11	4	0
June	0	14	9	22	1
July	4	10	5	4	0
August	3	4	6	2	3
September	0	5	1	0	14
Total	9	36	32	32	18

Table 6. Seeding dates for Starr millet irrigation experiments at the Middle Tennessee Experiment Station and the West Tennessee Experiment Station

Station	1957	1958	1959	1960	1961
Middle Tenn. Expt. Sta.	May 29	May 16	May 30	July 1	May 26
West Tenn. Expt. Sta.	May 8	May 22	May 27	July 9	May 29

Table 7. Cutting dates for Starr millet irrigation experiments at the Middle Tennessee Experiment Station and the West Tennessee Experiment Station

Station	1957	1958	1959	1960	1961
Middle Tenn. Expt. Sta.	July 17	June 23	Aug. 3	Aug. 4	July 19
	Aug. 1	July 28	Sept. 21	Aug. 31	Aug. 30
	Sept. 11	Sept. 1			
		Oct. 13			
West Tenn. Expt. Sta.	June 12	July 1	July 8	Aug. 4	July 10
	July 5	July 15	July 28	Aug. 29	July 26
	July 25	July 25	Aug. 31	Sept. 27	Aug. 21
	Aug. 15	Aug. 15	Oct. 21	Oct. 10	Sept. 15
	Sept. 14	Sept. 18			

tings per year were taken at the Middle Tennessee Experiment Station and an average of four cuttings per year at the West Tennessee Experiment Station.

Irrigations

The number, amount, and dates of irrigation at the Middle and West Tennessee Stations are shown in Tables 8 and 9. For the 2-atmosphere treatment at the Middle Tennessee Station, no irrigations were required in 1961, one irrigation in both 1958 and 1960, two in 1959 and three in 1957. At the West Tennessee Station only one irrigation was required in 1957 and three irrigations during each of the following 4 years 1958-1961. The 2-atmosphere treatment was irrigated when 55% and 68% of the available soil moisture in the surface foot had been used on the Maury and Memphis soils, respectively.

Irrigation at 5 atmospheres tension (when about 80-87% of the available moisture had been depleted) required only 1 irrigation in 1957 and 1958 at the Middle Tennessee Station, and 1 irrigation each year during the course of the experiment at the West Tennessee Experiment Station.

Results and Discussion

Yield response to irrigations

The yields of air-dry forage produced by Starr millet at each of the locations under the different moisture and nitrogen treatments for the 5 years of the experiment are shown in Tables 10 and 11.

A significant response to irrigation was obtained in only 1 (1957) of the 5 years at the Middle Tennessee Experiment Station. During this year the rainfall for the 5-month period was about 1 inch above average. However, the rainfall during the months of July and August was about 2¼ inches below normal. These were 2 months during which the millet was growing very rapidly and moisture stress was undoubtedly encountered during this period as shown by the data in Table 4. There were 18 drouth days in July and 22 in August. Irrigation reduced this number of drouth days to 6 for each month. During the years of 1958, 1959, and 1960, rainfall was near or above normal and irrigations did result in a significant reduction in number of drouth days. However, no significant yield increase from irrigation was obtained during these years. During 1961 there was adequate rainfall through July and even in the early part of August when much of

Table 8. Number, amount, and dates of irrigation of Starr millet at the Middle Tennessee Experiment Station, Spring Hill, Tennessee, 1957-61

Irrigation treatment	1957			1958			1959			1960			1961		
	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation
Irrigated at 2 atmospheres tension (When 55% of the available water in the surface foot had been used)	3	4.8	7-12 7-29 8-27	1	1.6	9-2	2	3.2	7-7 7-16	1	1.6	8-8	—	—	—
Irrigated at 5 atmospheres tension (When 80% of the available water in the surface foot had been used)	1	2.3	7-25	1	2.3	9-4	—	—	—	—	—	—	—	—	—
Irrigated at 9 atmospheres tension (When 93% of the available water in the surface foot had been used)	—	—	—	1	2.7	9-10	—	—	—	—	—	—	—	—	—
Inches rainfall May-September	21.5			23.1			20.4			28.9			18.0		

Table 9. Number, amount and dates of irrigation of Starr millet at the West Tennessee Experiment Station, Jackson, Tennessee, 1957-61

Irrigation treatment	1957			1958			1959			1960			1961		
	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation
Irrigated at 2 atmospheres tension (When 68% of the available water in surface foot of soil had been used)	1	2.0	8-29	3	6.0	7-29 8-13 9-8	3	6.0	7-20 8-17 9-25	3	6.0	8-10 8-16 9-3	3	6.0	6-30 8-14 8-22
Irrigated at 5 atmospheres tension (When 87% of the available water in surface foot of soil had been used)	1	2.5	9-5	1	2.5	8-8	1	2.5	8-21	1	2.5	8-19	1	2.5	8-17
Inches rainfall May-September	25.4			15.4			15.9			15.3			17.5		

Table 10. Tons per acre yield of Starr millet at the Middle Tennessee Experiment Station, Spring Hill, Tennessee, 1957-61

Tmt. No.	Lb. N/A	Irrigation	1957	1958	1959	1960	1961	5-yr. av.	4-yr. av.*
			Tons	Tons	Tons	Tons	Tons	Tons	Tons
1	0	No irrigation	1.71	1.84	2.20	1.30	1.29	1.67	1.76
2	30+30	" "	2.24	2.91	3.04	2.18	2.42	2.56	2.65
3	60+60	" "	2.97	4.21	4.00	2.67	3.17	3.40	3.59
4	90+90	" "	3.03	5.09	4.30	3.19	3.52	3.83	3.99
5	120+120	" "	2.97	5.75	4.75	3.35	3.77	4.12	4.31
6	0	At 9 Atm. Ten.	1.55	1.86	2.01	1.25	1.29	1.59	1.68
7	30+30	" " " "	2.08	3.00	3.06	2.16	2.42	2.54	2.64
8	60+60	" " " "	2.91	4.06	3.87	2.65	3.17	3.33	3.50
9	90+90	" " " "	3.36	5.36	4.20	3.21	3.52	3.93	4.11
10	120+120	" " " "	3.47	5.39	4.31	3.07	3.77	4.00	4.24
11	0	At 5 Atm. Ten.	1.86	1.94	1.92	1.30	1.29	1.66	1.75
12	30+30	" " " "	3.01	3.00	3.10	2.05	2.42	2.72	2.88
13	60+60	" " " "	3.82	4.23	3.87	2.57	3.17	3.53	3.77
14	90+90	" " " "	4.22	5.03	4.19	2.79	3.52	3.95	4.24
15	120+120	" " " "	4.28	5.72	4.13	3.02	3.77	4.18	4.48
16	0	At 2 Atm. Ten.	1.90	1.94	2.01	1.45	1.29	1.72	1.79
17	30+30	" " " "	3.26	3.26	3.24	2.27	2.42	2.89	3.05
18	60+60	" " " "	3.59	4.18	3.84	2.40	3.17	3.44	3.70
19	90+90	" " " "	5.04	5.57	4.64	2.90	3.52	4.33	4.69
20	120+120	" " " "	5.42	6.00	4.44	2.96	3.77	4.52	4.91

* 1960 omitted.

RESPONSE TO IRRIGATION

	1957	1958	1959	1960	1961	5-yr. av.	4-yr. av.*
No. irrigation	2.58	3.96	3.66	2.54	2.83	3.11	3.26
At 9 Atm. Ten.	2.68	3.93	3.49	2.40	2.83	3.07	3.23
At 5 Atm. Ten.	3.44	3.98	3.44	2.35	2.83	3.21	3.42
At 2 Atm. Ten.	3.84	4.19	3.63	2.47	2.83	3.39	3.62
L. S. D. (5%)	0.62	N.S.	N.S.	N.S.	...	...	...
(1%)	0.89						

RESPONSE TO NITROGEN

Lb. N/A	1957	1958	1959	1960	1961	5-yr. av.	4-yr. av.*
0	1.76	1.90	2.03	1.32	1.29	1.66	1.75
30+30	2.65	3.04	3.11	2.17	2.42	2.68	2.81
60+60	3.32	4.17	3.89	2.57	3.17	3.42	3.64
90+90	3.91	5.26	4.33	3.02	3.52	4.01	4.26
120+120	4.03	5.72	4.41	3.10	3.77	4.21	4.48
L. S. D. (5%)	0.32	0.21	0.24	0.20	0.18	...	...
(1%)	0.42	0.29	0.32	0.27	0.24	...	...

the forage harvest of that year was produced. Consequently, no irrigations were applied during this year.

At the West Tennessee Experiment Station, a small but significant response to irrigation was obtained only in 1961. It was undoubtedly due to the irrigation water applied in late August, as the September rainfall during 1961 was about 2¾ inches below

Table 11. Tons per acre yield of Starr millet at the West Tennessee Experiment Station, Jackson, Tennessee, 1957-61

Tmt. No.	Lb. N/A	Irrigation	1957	1958	1959	1960	1961	5-yr. av.	4-yr. av.*
			Tons	Tons	Tons	Tons	Tons	Tons	Tons
1	0	No irrigation	3.33	1.37	1.43	1.07	1.63	1.77	1.94
2	30+30	" "	3.84	1.87	2.32	1.47	2.58	2.42	2.65
3	60+60	" "	4.29	2.46	3.33	1.71	2.91	2.94	3.25
4	120+120	" "	4.55	2.76	4.38	1.82	3.32	3.37	3.75
5	0	At 5 Atm. Ten.	3.91	1.60	1.41	1.13	1.83	1.98	2.19
6	30+30	" " " "	4.27	2.25	2.26	1.65	2.39	2.56	2.79
7	60+60	" " " "	4.47	2.44	2.87	1.67	3.13	2.92	3.23
8	120+120	" " " "	4.71	3.29	4.54	2.39	3.30	3.65	3.96
9	0	At 2 Atm. Ten.	3.74	1.36	1.50	.88	2.01	1.90	2.15
10	30+30	" " " "	3.80	2.26	2.21	1.49	2.89	2.53	2.79
11	60+60	" " " "	4.31	2.67	3.32	1.89	3.12	3.06	3.36
12	120+120	" " " "	5.34	3.73	5.00	2.34	3.66	4.01	4.43

* 1960 omitted.

RESPONSE TO IRRIGATION

	1957	1958	1959	1960	1961	5-yr. av.	4-yr. av.
No irrigation	4.00	2.12	2.87	1.52	2.61	2.62	2.90
Irrig. at 5 Atm.	4.30	2.40	2.77	1.71	2.66	2.77	3.03
Irrig. at 2 Atm.	4.34	2.50	3.01	1.65	2.92	2.88	3.19
L. S. D. (5%)	N.S.	N.S.	N.S.	N.S.	0.15	...	...
(1%)					0.25	...	...

RESPONSE TO NITROGEN

	1957	1958	1959	1960	1961	5-yr. av.	4-yr. av.
0	3.66	1.44	1.45	1.03	1.82	1.88	2.09
30+30	3.97	2.13	2.26	1.54	2.62	2.50	2.75
60+60	4.36	2.52	3.17	1.76	3.05	2.97	3.28
120+120	4.87	3.26	4.64	2.18	3.43	3.68	4.05
L. S. D. (5%)	N.S.	0.44	0.28	0.32	0.48	...	...
(1%)		0.60	0.38	0.44	0.66		

normal. In 1957, when rainfall was above average and only one irrigation was applied, only a small, nonsignificant yield increase resulted. During the years 1958, 1959, and 1960, rainfall was below average and three irrigations were applied each year; this caused a significant reduction in number of drouth days but no significant yield increase.

For the 10 crop years studied there was a significant response in only 2 crop years. One was at the Middle Tennessee Experiment Station and the increase was about 1 ton of forage per acre. The other was at the West Tennessee Experiment Station, and the forage increase was only about 0.30 ton of forage per acre.

Yield response to nitrogen

A significant response to nitrogen was obtained during each of the 5 years of the experiment at the Middle Tennessee Experiment Station. Generally, the 90 pounds of nitrogen at seeding and 90 pounds of nitrogen following the first or second clipping was superior to the other treatments of lower amounts of nitrogen. The higher treatment of 120 pounds of nitrogen at seeding and 120 pounds of nitrogen as a topdressing after the first or second cutting was not significantly better than the 90 + 90 treatment.

At the West Tennessee Station a significant response to nitrogen was obtained in 4 of the 5 crop years. These experiments did not include the 90 + 90 treatment and the 120 + 120 treatment was significantly better than the lower treatments.

Total yield analyses

Regression analyses on all the yield data collected indicated that at the Middle Tennessee location, 2% of the variation in yields was explained by influence of drouth and 60% by the rate of nitrogen fertilization. At the West Tennessee location 38% of the variation in yield was explained by the effect of drouth and 32% was explained by rate of nitrogen fertilization.

The yield prediction equation obtained through regression analyses—including the effect of drouth and nitrogen—indicated that when nitrogen was valued at .11¢ a pound and forage at $25 a ton, the optimum levels of nitrogen fertilization for Starr millet over all years was found to be 230 pounds of N at the West Tennessee Station and 210 pounds of N at the Middle Tennessee Station.

Summary and Conclusions

1. **Significant response of Starr millet to irrigation was obtained in only 2 of 10 crop years.**
2. **Nitrogen was the most limiting production factor for Starr millet on these soils for the years studied.**
3. **Significant yield increases from nitrogen rates of 180 pounds per acre were obtained.**
4. **Millet seeded in late May produced more forage than millet seeded in early July.**

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