RESPONSE OF TANNIN-BEARING CANAIGRE (RUMEX HYMENOSEPALUS TORR.) TO NITROGEN AND PHOSPHATE FERTILIZERS

by

John A. Lindsay

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TABLE OF CONTENTS

	Page
LIST OF TABLES AND PLATE	iii
INTRODUCTION	1
History	1
EXPERIMENTAL MATERIAL AND METHODS	4
Climatic Conditions Relating to the Experiment	4
Soil Conditions Relating to the Experiment	4
Source of Plant Material	5
Procedure	6
Sampling	6
Chemical Analysis	7
Statistical Analysis	7
PRESENTATION OF RESULTS	8
DISCUSSION	16
Effect of Fall Treatment	16
Seasonal Trend	16
Root Production As Affected By Fertilizer Treatments	17
SUMMARY	19
LITERATURE CITED	21

LIST OF TABLES

No. 1 - Tannin and Purity Analysis of Canaigre Roots As Affected By Fertilizers. Date of Sampling July 30, 1949.

No. 2 - Tons of Fresh Canaigre Roots Per Acre for Fertilizer Treatments. Date of Sampling March 24, 1949.

No. 3 - Tons of Fresh Canaigre Roots Per Acre for Fertilizer Treatments. Date of Sampling May 25, 1949.

No. 4 - Tons of Fresh Canaigre Roots Per Acre for Fertilizer Treatments. Date of Sampling July 30, 1949.

No. 5 - Increase and Decrease in Tons of Fresh Canaigre Roots for Treatments During May 25-July 30 Interval.

No. 6 - Increase in Tons of Fresh Canaigre Roots for Treatments during March 24-May 25 Interval.

No. 7 - Average Yield of Tops Per Acre. Date of Sampling March 24, 1949

LIST OF PLATES

No. 1 - Canaigre Plant

INTRODUCTION

Canaigre (Rumex hymenosepalus Torr) is an herb of high tannin content (Plate 1). It is drought resistant and grows wild in the temperate regions of North America. This plant grows during the cool months of the year. The tops die down in late spring. The tannin-bearing tubers which the plants produce remain in a dormant condition during the summer and give rise to renewed vegetative growth in the fall. New tubers are produced while the current year's tubers remain alive. Tubers remain alive for several years, then die and become mumified in the hill.

In arid regions the plant is often found growing along the banks of washes and on alluvial fans. In regions of higher rainfall canaigre is more often found growing on gravelly knolls and on foothills. The plant favors the sandy soils although it has been found growing in well drained soils of heavy texture (1).

History

The herb had been harvested for its tannin content from the wilds by the Indians and Mexicans for centuries (2). These people used the tannin for tanning hides. Roots and leaves were used for medicinal purposes.

Plate 1. Canaigre Plant

Thurber collected specimens of the plant in 1859 and sent them to Torrey who described and named it (10). In 1876 the high tannin content of the plant was discovered by Voelker (11). During the following fifteen years the plant received sporadic attention from investigators of experiment stations and the United States Commissioner of Agriculture. Cultivation of the plant started in 1890. However, the plant was never used to any extent commercially because the American Chestnut (Castana dentata Borkh) and other plants proved to be more economical source of tannin. In the last quarter century stands of the American Chestnut tree have been killed by the chestnut blight (Endothis parasitica). Prior to World War II, about 450,000 tons of 25 per cent tannin extract were used annually. The value of this amounted to about twenty million dollars.

In recent years forty per cent of the tannin extract used in this country has been imported from South America. This extract is derived from the quebracho tree (Quebrachia lorentzii) (8). Stands of these trees are now being depleted. If plantations of quebracho are not established, domestic tannin-bearing plants may again be in line for increased commercial use.

The federal government undertook to investigate plants in this country which could be used commercially. A two-fold cooperative program of research on canaigre was outlined (4). One deals with production of the plant and

the other, the processing of the roots for production of tannin extract and by-products. The field work is being done in selected locations in the Southwest, with head office in Beltsville, Maryland. The laboratory work is being done at the Eastern Regional Research Laboratory in Philadelphia, Pennsylvania.

In the fall of 1947, Mr. G. A. Russell, who was associated with the canaigre project, established plantings of canaigre on the mesa at Yuma, Arizona. (9) These plantings were used for experimental purposes by G. H. Abel and J. A. Lindsay who joined the staff in the spring of 1948.

Little is known about the response of canaigre to fertilization. Only one reference was found in the available literature, i. e., Forbes (3) demonstrated that irrigated year-old canaigre, established from crowns and fertilized with barnyard manure dug into the irrigation trenches at the time of planting, produced nearly a third more roots than those unfertilized. This was done at Tucson, Arizona, in soil that was underlaid with "caliche" limestone at about eighteen inches.

The first experiments on fertilization of canaigre on the Yuma mesa were initiated by Russell, Abel and Lindsay during 1948. Lindsay made treatment and collected data which is herein presented as a thesis problem.

EXPERIMENTAL MATERIAL AND METHODS

Climatic Conditions Relating to the Experiment

The average rainfall at Yuma is 3.44 inches and occurs at any time of the year with equal frequency. Maximum temperatures average nearly, or above, 100 degrees from May through September. The experiment was conducted on the Yuma mesa at an elevation of about 190 feet above sea level. Diurnal fluctuations vary between thirty and forty degrees. (5). Relative humidity is usually low during the day, rising at night. Relative humidity ranges from ten per cent to eighty per cent.

The frosts which have occurred in winter have not killed canaigre leaves. However, cold weather causes older leaves to acquire a reddish tinge. These leaves die down long before the end of the growing season.

Soil Conditions Relating to the Experiment

This experiment was conducted on the Yuma mesa in superstition fine sand previously cropped to alfalfa. No analysis of the soil was made. The soil of these plots was rather uniform as Roberts reports.

> "Plot E ---- This plot appears to be quite uniform as the soil texture of the layers is concerned. The crops produced should also be fairly uniform,

"although the layer below the lime region has some gravel, but not a sufficient amount of it to lower crop yields." (10)

Source of Plant Material

Seed collected from State College, New Mexico, was used to establish the canaigre plants which were used in this experiment. The planting was made on October 13-22, 1947, at the rate of two and three-quarter pounds of seed per acre. Seed was drilled on raised beds approximately 12 inches wide. The rows were 30 inches apart. A Planet Jr. hand planter was used to plant the seed approximately one inch deep. Seedlings were left unthinned.

The plants were fertilized uniformly with nitrogen and were irrigated as needed during the first season of growth (October to June). The experimental work was begun with the second season of growth.

This experiment consisted of two series of fertilizer treatments; one series in the fall of 1948 using fertilizer A (10-20-0), and another during the growing season of 1949 using fertilizer B (ammonium sulfate).

The fall treatment was intended to initiate varying degrees of stimulated vegetative growth. The growing season treatment was intended to provide a continuation of varying degrees of stimulated growth.

Each plot consisted of 6 rows each 25 feet long. Treatments occurred in all possible combinations and were replicated 6 times.

Procedure

Fall treatments were made by side dressing with a mixed 10-20-0 formula. They were applied to designated plots with a fertilizer machine attached to the tractor. Four treatments were made: (1) 400 pounds 10-20-0 per acre, (2) 200 pounds 10-20-0 per acre, (3) 50 pounds 10-20-0 per acre and (4) none. These treatments were made November 5, 1948.

The same procedure was followed for growing season treatments as above, using fertilizer B (ammonium sulfate) to give three levels of nitrogen application: (a) 80 pounds of nitrogen per acre in four side dressings, (b) 40 pounds of nitrogen per acre in two side dressings, and (c) none. These treatments were made during the interval between December 15, 1948 and March 30, 1949.

Fall and growing season treatments made a 4 x 3 or 12 treatments in all combinations. Treatments were replicated six times.

Sampling

Two one-linear foot strips of plants were dug from each plot at random. The 1948 and 1949 roots were weighed separately. This made two variates in each plot.

Three samplings were made during the growing season at two month intervals. These dates were March 25, May 26 and July 30, 1949.

On the first date of sampling the tops that came from

the root samples were weighed. These tops represented the growth that occurred from October to March.

Chemical Analysis

*The Eastern Regional Research Laboratory made tannin and purity determinations of the last sampling (7).

Roots were combined by treatments in all replications, making twelve determinations in all. Analyses by plots could not be made because such work would be too tedious and therefore expensive. None of the fertilizer treatments affected the tannin percentages or purity. (Table No. 1)

Statistical Analysis

Yield data, as tons of fresh roots per acre, for each of the three samplings were subjected to the variance method of analysis. The same method was used to compare increase and decrease from one sampling to the next (Tables 1 - 5).

* F. P. Luvisi, M. L. Happich and E. E. Leach did the analytical work.

PRESENTATION OF RESULTS

The average production of roots on the date of the first sampling (March 24) was 10.33 tons per acre. On July 30, the date of the last sampling, the yield had increased to 15.50 tons per acre. Yields shown in the tables are averages of the six replications in all possible treatment combinations.

TABLE NO. 1 - Tannin and Purity Analysis of Canalgre Roots As Affected By Fertilizers.

Date of Sampling July 30, 1949

Fert. A. lbs. of 10-20-0 per acre	Fert. B. lbs. of available nitrogen per acre							
	80		40		None		Av.	
	Tan.	Pur.	Tan.	Pur.	Tan.	Pur.	Tan.	Pur.
400	26.16	54.36	25.96	50.84	27.74	55.04	26.62	53.41
200	25.37	54.85	25.18	55.12	24.94	51.29	25.16	53.75
50	24.98	54.32	23.58	51.85	25.32	51.34	24.63	52.50
None	24.45	49.24	24.68	49.44	25.69	52.36	24.94	50.35
Av.	25.24	53.34	24.85	51.79	25.92	52.51	25.34	52.50

TABLE NO. 2 - Tons of Fresh Canaigre Roots Per Acre

For Fertilizer Treatments

Date of Sampling Mar. 24, 1949

Fert. A. lbs. of 10-20-0 per acre		Fert. B. lbs. of available nitrogen per acre 80	40	None	Av.
400	1948	7.99	7.08	6.89	7.32
	1949	5.99	6.54	5.45	5.99
	Total	13.98	13.62	12.34	13.31
200	1948	6.72	6.17	4.54	5.81
	1949	4.36	4.90	4.18	4.48
	Total	11.08	11.07	8.72	10.29
50	1948	6.17	6.72	6.17	6.35
	1949	3.82	2.73	3.27	3.27
	Total	9.99	9.45	9.44	9.62
None	1948	6.17	5.45	4.72	5.45
	1949	2.54	3.27	2.18	2.66
	Total	8.71	8.72	6.90	8.11
	Av. 1948	6.76	6.35	5.58	6.23
	Av. 1949	4.18	4.36	3.77	4.10
	Gr. Av.	10.94	10.71	9.35	10.33

Difference required for significance at 5% level:

Fertilizer A	2.81 tons
Fertilizer B	1.29 tons
Roots	0.72 tons

TABLE NO. 3 - Tons of Fresh Canaigre Roots Per Acre for Fertilizer Treatments

Date of Sampling May 25, 1949

Fert. A. lbs. of 10-20-0 per acre		Fert. B. lbs. of available nitrogen per acre 80	40	None	Av.
400	1948	12.90	9.58	10.95	11.14
	1949	10.85	10.04	10.76	10.55
	Total	23.75	19.62	21.71	21.69
200	1948	10.13	8.26	8.72	9.03
	1949	8.68	9.17	7.31	8.39
	Total	18.81	17.43	16.03	17.42
50	1948	8.67	7.09	7.68	7.81
	1949	7.99	6.63	5.27	6.63
	Total	16.66	13.72	12.95	14.44
None	1948	7.27	6.09	7.09	6.82
	1949	5.54	5.45	4.08	5.02
	Total	12.81	11.54	11.17	11.84
	Av.1948	9.74	7.75	8.61	8.70
	Av.1949	8.27	7.82	6.85	7.64
	Gr. Av.	18.01	15.57	15.46	16.34

Difference required for significance at 5% level:

Fertilizer A 3.72 tons
Fertilizer B 2.10 tons

TABLE NO. 4 - Tons of Fresh Canaigre Roots Per Acre for Fertilizer Treatments

Date of Sampling July 30, 1949

Fert. A. lbs. of 10-20-0 per acre		Fert. B. lbs. of available nitrogen per acre 80	40	None	Av.
400	1948	12.44	9.88	10.42	10.91
	1949	7.50	9.21	9.25	8.65
	Total	19.94	19.09	19.67	19.56
200	1948	10.91	8.62	7.51	9.01
	1949	7.77	6.78	6.83	7.13
	Total	18.68	15.40	14.34	16.14
50	1948	7.41	6.65	7.55	7.20
	1949	7.05	6.02	5.39	6.15
	Total	14.46	12.67	12.94	13.35
None	1948	7.99	7.00	6.42	7.14
	1949	5.93	5.52	5.97	5.81
	Total	13.92	12.52	12.39	12.95
	Av.1948	9.69	8.04	7.97	8.57
	Av.1949	7.06	6.88	6.86	6.93
	Gr. Av.	16.75	14.92	14.73	15.50

Difference required for significance at 5% level:

Fertilizer A	3.34 tons
Roots	0.99 tons

TABLE NO. 5 - Increase and Decrease in Tons of Fresh Canaigre Roots for Treatments During May 25-July 30 Interval

Fert. A. lbs. of 10-20-0 per acre		Fert. B. lbs. of available nitrogen per acre 80	40	None	Av.
400	1948	- .46	.30	- .53	- .23
	1949	-3.35	- .83	-1.51	-1.90
	Total	-3.81	- .53	-2.04	-2.13
200	1948	.78	.36	-1.22	- .03
	1949	- .91	-2.39	- .49	-1.26
	Total	- .13	-2.03	-1.71	-1.29
50	1948	-1.26	- .44	- .14	- .61
	1949	- .94	- .60	.12	- .47
	Total	-2.20	-1.04	- .02	-1.08
None	1948	.73	.92	- .67	.33
	1949	.38	.07	1.93	.79
	Total	1.11	.99	1.26	1.12
	Av.1948	- .05	.28	- .64	- .14
	Av.1949	-1.21	- .94	.01	- .71
	Gr.Total	-1.26	- .66	- .63	- .85

TABLE NO. 6 - Increase in Tons of Fresh Canaigre Roots for Treatments during March 24-May 25 Interval

Fert. A. lbs. of 10-20-0 per acre		Fert. B. lbs. of available nitrogen per acre 80	40	None	Av.
400	1948	4.91	2.50	4.05	3.82
	1949	4.86	3.50	5.31	4.56
	Total	9.77	6.00	9.36	8.38
200	1948	3.41	2.09	4.18	3.23
	1949	4.32	4.27	3.13	3.91
	Total	7.73	6.36	7.31	7.14
50	1948	2.50	.37	1.50	1.46
	1949	4.18	3.90	2.00	3.36
	Total	6.68	4.27	3.50	4.82
None	1948	1.09	.64	2.36	1.36
	1949	3.00	2.18	1.86	2.35
	Total	4.09	2.82	4.22	3.71
	Av.1948	2.98	1.40	3.03	2.47
	Av.1949	4.09	3.46	3.08	3.54
	Gr.Total	7.07	4.86	6.11	6.01

Difference required for significance at 5% level:

Fertilizer A 3.60 tons

TABLE NO. 7 - Average Yield of Tops Per Acre

Date of Sampling March 24, 1949

Fert. A. lbs. of 10-20-0 per acre	Fert. B. lbs. of available nitrogen per acre 80	40	None	Av.
400	11.98	10.35	8.17	10.16
200	7.26	6.53	3.36	5.81
50	6.17	4.18	3.63	4.66
None	4.72	3.81	1.82	3.45
Average	7.53	6.22	4.31	6.02

Difference required for significance at 5% level:

Fertilizer A 1.20 tons
Fertilizer B 1.04 tons

DISCUSSION

Effect of Fall Treatment

Greater yields of roots were associated with plants which received greater amounts of Fertilizer A (10-20-0) on all samplings. Plants which received the fertilizer at the rate of 400 pounds per acre in November produced nearly twice as many roots as those which received none. Production of roots was found to be nearly proportional to the amounts of fertilizer applied. This suggests that greater amounts of fertilizer will account for a corresponding increase in root production (See Tables 2, 3 and 4).

Seasonal Trend

All samplings showed that production of roots was a little higher from plants which received nitrogen at the rate of 80 pounds per acre in four side dressings. The differences were significant at the five per cent level of significance on the first two samplings. They were not on the last. Root production of plants which received nitrogen at the rate of 40 pounds per acre in two side dressings was nearly the same as plants which received no fertilizer (Tables 2, 3 and 4). Evidently application of

nitrogen does not materially increase yield of roots under the conditions of this experiment.

The 1948 roots accounted for the greater total weight on all samplings (Tables 5 and 6). However, the difference is not significant on the sampling of May 25. The 1949 roots showed losses in weight during the May-July interval (See Table 6). There is no known reason for this loss of weight. It may have been due to experimental error or more likely to increased respiration at higher temperatures.

Tops showed the same respective growth-response to the amounts of fertilizer applied as did the roots for the first sampling (Table 7). However, tops showed greater sensitivity to the spring application of nitrogen. This implies that although application of nitrogen at these dates during the growing season stimulates top growth, there is no corresponding increase in root production by March 25. Indications are that further experimentation is needed regarding dates of application, especially during the growing season.

Root Production As Affected By Fertilizer Treatments

During the March 24 through May 25 interval there was an increase in the yield of roots for all fall treatments (Table 6). Greater yields of fresh roots were associated

with the greater application of 10-20-0. The nitrogen side dressings applied during the growing season accounted for little difference in yield of fresh roots.

The 1949 roots showed greater increase in yield than the 1948 roots during the growing season.

The May 25 through July 30 interval showed slight losses in average yield of roots (Table 5) and greater losses were associated with greater application levels of 10-20-0. Side dressings of nitrogen during the growing season had very little effect on these losses in weight of roots.

SUMMARY

1. The average yields of fresh roots on March 24, May 25, and July 30 were 10.33, 16.34 and 15.50 tons per acre, respectively.
2. The higher yields of roots were associated with greater application of 10-20-0 applied at the beginning of the second season's growth.
3. Four hundred pounds 10-20-0 nearly doubled the yield on the March 24 and May 25 sampling, and only increased the yield by a third on the July 30 sampling as compared with the no fertilizer treatment.
4. Eighty pounds of available nitrogen applied in four side dressings yielded significantly more roots at the 5 per cent level of significance than the 40 pound application in two side dressings or the ones receiving no side dressings. There was no difference in yield between the two side dressings and the no side dressing treatments.
5. The primary root tubers (1948 roots) accounted for the greater proportion of the total weight of roots than the secondary tubers (1949) roots in all samplings.
6. Both years' roots increased in weight during March through May interval and the 1949 roots gave the

greater increases, especially from plants which received the greater amounts of fertilizer.

7. The losses in weight of fresh roots from plants which received fertilizer during May through July interval were greater for the 1949 roots. Greater losses were associated with the greater applications of fertilizer.

8. None of the fertilizer treatments affected the tannin percentages or purity.

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