THE INFLUENCE OF WEATHER ON THE RIBOFLAVIN, PANTOTHENIC ACID AND NICOTINIC ACID CONTENT OF TURNIP GREENS

by

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PREFACE

This study is one phase of a cooperative investigation undertaken to determine the effect of environmental conditions on the nutritive value of a vegetable commonly used in the South. The purpose of this particular phase was to determine the effect of soil temperature and climatic conditions on the nutritive value of turnip greens (*Brassica rapa*, *L.*). Turnip greens were selected for study because of their high vitamin and mineral content and their wide usage as a vegetable in the South.

Many investigations have been reported which demonstrated that environmental factors may be responsible for the wide variations observed in plant composition. These investigations, however, have furnished little information concerning the effects of specific factors on either chemical composition or more significantly, nutritive value. Field studies relating to the production of vegetables have been chiefly concerned with yield and marketability of the product rather than its nutritive value.

The obvious importance of detecting the specific climatic conditions responsible for these regional variations led a group of workers in the Agricultural Experiment Stations of several southern states to undertake cooperative research along such lines. As a part of the study, changes occurring in the pantothenic acid, riboflavin and nicotinic acid content of turnip greens have been determined.

TABLE OF CONTENTS

REVIEW OF THE LITERATURE

It has long been recognized that wide variations occur in the reported vitamin content of many vegetable plants grown under different conditions. Much of the variation is doubtless due to varietal differences, to inadequate sampling, and to variability in methods used in the actual determination of the constituent. Evidence has been accumulating, however, to show that when all of these variables are controlled, insofar as possible, wide differences in vitamin and mineral composition still exist, both from time to time at the same location, and from one location to another.

In carefully controlled experiments in which adequate controls on sampling and analytical techniques were maintained, the workers of the Southern Cooperative Group found unaccountable variations in nutritive value. For example, a wide variation in the ascorbic acid content of turnip greens was observed at different locations during the study by Reder, et al. (1). The spring crop of greens grown at Norfolk, Virginia, contained over four times as much ascorbic acid as those produced at Stillwater, Oklahoma. Since other variables were controlled insofar as possible, it seemed almost certain that these differences were produced by the widely differing climatic conditions at these two locations.

Careful re-examination of the data from other studies by this same group showed a relation between average daily rainfall and the ascorbic acid content of turnip greens (Reder, et al. (2)). The results indicated a highly significant and positive correlation between rainfall and ascorbic acid content. For example, at Experiment, Georgia, the total rainfall was 4.55 inches in the fall and 5.12 in the spring; the average ascorbic acid content of Seven Top greens was 100.32 mg. per 100 gm. (wet basis) in the fall and 144.51 mg. per 100 gm. in the spring. At Stillwater, Oklahoma, the total rainfall was 5.12 in the fall and 11.28 in the spring; the average content was 122.53 mg. per 100 gm. (wet basis) for the fall and 151.23 mg. per 100 gm. for the spring.

In contrast to these findings, Murphy (3) suggested that excessive rainfall may exert an unfavorable influence upon vitamin C synthesis, since the ascorbic acid content of tomatoes and cabbage was reduced during a year with high rainfall.

Experiments conducted in the spring and fall of 1943 by Reder, _et al_. (2), showed distinct seasonal variations in the ascorbic acid content of greens at Experiment, Georgia, State College, Mississippi, and Stillwater, Oklahoma. In these experiments the ascorbic acid content was consistently greater in the spring than in the fall at State College and Experiment. However, the greens which were grown in the fall at Stillwater showed a higher ascorbic acid content than those grown in the spring. Tressler, Mack and King (5) observed that spinach produced at two locations in the fall contained one-third more ascorbic acid than the same variety grown at the same location in the spring.

Spiers and Sheets (6) have reported that turnip greens grown in the fall contained less iron than those grown in the spring.

Bernstein, Hamner and Parks (7) have reported relatively great differences between the ascorbic acid and carotene in two experiments at two different seasons. Both ascorbic acid and carotene seemed to be primarily influenced by environmental variables associated with season and location. In the first experiment conducted in the early summer the average ascorbic acid values were much higher than in the second. The growth of the plants during the winter months was not as rapid as during the summer, but at the time of harvesting the plants were of about the same general appearance as those harvested in the summer. The ascorbic acid values obtained in the experiments at various seasons differed greatly. It appeared that those climatic factors which lead to low ascorbic acid values tend to result in high carotene values. The majority of the data indicate that seasonal conditions and location factors which were correlated with high ascorbic acid values were also correlated with low carotene values. These workers reported that variations such as occur between one location and another or between one harvesting date and another may be related to the light intensity prevailing just before harvesting.

It was not possible to demonstrate a correlation between the ascorbic acid content of greens and temperature, in the studies by Reder, _et al_. (2). Fairly wide variations in temperature occurred, but since these experiments were not designed to study this factor, differences due to temperature variation might not have been detected.

Reder, _et al_. (2), found the ascorbic acid content of greens with advancing maturity were not consistent. At Stillwater the Seven Top greens contained significantly more ascorbic acid in the medium stage than in the early and late stages of maturity. The variations of ascorbic acid with maturity were not significant in the fall experiments at State College, Mississippi. At Baton Rouge, Louisiana, the ascorbic acid content of greens was also slightly higher for the medium stage of growth.

Murphy (3) found that as tomato plants became more mature, the ascorbic acid increased in tomatoes but decreased in cabbage. These phenomena were related to geographical situation to the extent that maturity rate was hastened or delayed by the climatic conditions prevailing throughout the growing season in any one region.

The results of work done by Reder, Eheart and Ascham (1) showed that fertilizer treatment significantly affected the ascorbic acid content of turnip greens but the effect of location was of greater importance. Turnip greens of the Seven Top variety, grown at Norfolk, Virginia, averaged 2.41 mg. per gm. of ascorbic acid; in Blacksburg, Virginia, 1.28 mg. per gm.; Stillwater, Oklahoma, 1.58 mg. per gm.; and Experiment, Georgia, 1.90 mg. per gm.

Variations in soil type may be a factor, although analysis did not reveal marked differences in soil composition in these studies (1, 4). Perhaps more important than available soil nutrients were such factors as mechanical composition and organic matter content of the soil. These might be expected to modify the growth of the greens through their effect on the moisture-holding capacity of the soil.

The effect of moisture on plant growth has been shown to be pronounced. However, a study made by Sheets, et al. (4), showed little relationship between the total rainfall and the average calcium and phosphorus content of turnip greens. Thus greens grown in the same place but in different seasons, or in different years, failed to show any consistent correlation between rainfall and calcium and phosphorus content either between seasons or between years. Daniel and Harper (8) found phosphorus content of hay to be increased during seasons of high rainfall and calcium was decreased.

Data published by the Southern Cooperative Group (1) reveal wide differences in the ascorbic acid content of turnip greens produced at different locations. In some instances the variation could be correlated with sunshine. In one experiment the highest ascorbic acid content was observed at Experiment, Georgia, where the lowest rainfall was reported; the lowest ascorbic acid content was observed in greens grown at Norfolk, Virginia, where the highest daily rainfall was recorded. The results seem to indicate a direct relationship between the amount of sunshine and the formation of ascorbic acid. Differences in soil composition or differences in temperature did not appear directly to affect the ascorbic acid content of the plants. It was concluded that the results seem to indicate that the formation of ascorbic acid may be influenced by light intensity and rainfall.

Koham (9) has shown that there is a striking relationship between solar radiation and ascorbic acid content in the tomato plant. There was a rapid loss of ascorbic acid when the plants were kept in the experimental laboratory over-night and rapid recovery when plants were exposed to direct sunlight. The possible significance of the work done by Bernstein, Hamner and Parks (7) is discussed with the suggestion that light intensity may be an environmental factor playing the dominant role in determining the ascorbic acid content of greens. There was no correlation between the percentage of clear days during the growing season and ascorbic acid content of greens as reported by Reder, et al. (2).

Spiers, Sheets, et al. (6), found no uniform relationship between the total rainfall during the growing season and the iron content of turnip greens. The effects of rainfall at different intervals during the growing season were not investigated and the possibility remains that rainfall may have influenced iron content, in a manner not discernible in the experiment, according to the authors. The amount of moisture the plants received influenced the iron content of turnip greens at Woodward, Oklahoma, as shown in this experiment; the irrigated crop had a significantly greater iron content than the unirrigated crop. This area is characterized by soils containing low amounts of available iron.

In contrast to these findings, however, are those of Sheets, et al. (4), which showed that irrigation increased both the calcium and phosphorus content of turnip greens.

MATERIALS AND METHODS

Materials

This experiment was conducted at Stillwater, Oklahoma, in the spring of 1948. Seven Top turnip greens were used as the experimental crop, since this (Beta vulgari) variety represents a type of greens that is grown principally for the top greens rather than for the root. It is well adapted to this region and makes good growth under favorable conditions. Seed stock was obtained from the U. S. Regional Vegetable Breeding Laboratory, Charleston, South Carolina. The site selected was representative of home garden conditions. The greens were cultivated in accordance with accepted horticultural practices. This involved adequate preparation of the seed bed and subsequent cultivation to control weed growth. Seeding was comparatively heavy to insure a good stand. The plots were treated with a complete fertilizer (5-10-5) applied (broadcast) just before planting at approximately 1000 pounds per acre. During the growing season two applications of hexachlorocyclohexane ("isotex") was dusted on the greens as protection against aphids and Harlequin cabbage bugs.

The first planting of the greens was made on April 24, and a second planting on May 8. Prior to June 21, all samples were taken from the first planting and after that time weekly sampling from this planting was continued until July 6. Samples were taken from the second planting June 21 through July 10.

Sampling Techniques

Frequency of Sampling. Harvesting began when the greens reached marketable size. The leaves were collected at approximately 8 a.m. in all cases not otherwise specified. Samples were taken at weekly, daily and three-time daily intervals as follows:

Weekly: Samples were taken once a week at the same time each day and analyzed for riboflavin, nicotinic acid, pantothenic acid and dry matter. The samples were taken from the first planting from June 1 to July 6 and from the second planting from June 21 to July 10, 1948.

Daily: At three different intervals during the growing season, duplicate samples were taken on five successive days. This study included successive rainy days as well as successive dry, hot days. These samplings were taken from the first planting on June 8, June 22 and July 6, 1948.

Diurnal: At the early, middle and late stages of growth, samples were collected for analysis at 8 a.m., Noon, and 4 p.m. These samples were from the first and second plantings and were collected on June 10, June 24 and July 8, 1948.

Collection of Samples

Leaves were collected intact by cutting them or breaking them about 3/4 inch above the crown of the root. Damaged leaves or those which would be unfit for cooking were discarded. In sampling, the large, medium and small unfurled leaves were selected from average-sized plants. Each plant was sampled only once during the period.

Treatment of Samples

Immediately after the greens were harvested, they were delivered to the laboratory. A representative sample for analysis was obtained from approximately two pounds of greens. The leaves were thoroughly washed three to six times in tap water or until they were free from soil and finally washed in distilled water. The samples were dried free of excess water by placing them on cheese cloth and allowing an electric fan to blow upon them until all excess water had been evaporated. They were then stored in a refrigerator until all had been further processed.

The mid rib of each leaf was cut out and the tissue cut in small pieces as quickly as possible. After the minced tissue was well mixed, duplicate two gram samples were weighed out for each determination.

Preparation for Analysis

To assure complete extraction of the vitamins the samples of tissue were pulverized with sand in a glass mortar and extracted with several small portions of distilled water. The extracts were made to 100 ml. in a volumetric flask and a 25 ml. aliquot taken for each of the three vitamin determinations. Fifty ml. of 0.1 N HCl was added for the riboflavin determination; 25 ml. of distilled water for pantothenic acid and 8.33 ml. of 8% NaOH for nicotinic acid. These variously treated extracts were autoclaved at 15 pounds pressure for 20 minutes and stored in a dark place at room temperature until the analyses were completed.

Analytical Procedures

Moisture Content: Duplicate fresh samples for moisture determination were taken from each of the lots at the time samples were taken for the vitamin determinations. A 25 gram sample was dried at a temperature of 140°F. overnight in a large hot air oven and then transferred to a small drying oven at 104°F. to complete the drying. The samples were allowed to cool in a dessicator and weighed to .01 gram on a Torsion balance. This process was repeated until constant weights were obtained.

Methods of Assay

Riboflavin was determined by the method developed by Snell and Strong (10) using *Lactobacillus casei*. The method of Snell and Wright (11) was used for determining nicotinic acid, using *Lactobacillus arabinosis* 17-5. Pantothenic acid was determined by the procedure of Pennington, Snell and Williams (12), using *Lactobacillus casei*.

In the practice of microbiological assay it is customary to prepare a fresh inoculum for each day's work. Nevertheless, with identical media and identical conditions, identical degrees of growth are not obtained in separate experiments. This lack of reproductivity may be attributed to uncontrollable day to day variations in the compositions of the medium, to chemical changes incident to sterilization, to temperature and time differentiations during incubation or to changes in the organism itself. Inoculum for assay tubes were prepared by a transfer from stock cultures to a tube of inoculum medium. The inoculum were incubated at 37°C. for 18-36 hours before use.

In order to obtain maximum growth rate the original media described in the previously listed methods was modified slightly. The following changes were made in the amount of material present in the final dilution of the riboflavin medium: glucose was increased from 1.0 to 2.0 per cent; adenine, guanine and uracil to 10 mcg. per ml.; para-aminobenzoic acid to 0.4 mcg.; nicotinic acid 0.2 mcg.; and calcium d-pantothentate to 0.1 mcg. The pantothenic acid medium was modified in the amount of material present in the final dilution as follows: glucose was increased from 1.0 to 2.0 per cent; riboflavin increased to 0.2 mcg. per ml.; alkali-treated yeast extract discontinued; adenine, guanine, and uracil to 10.0 mcg.; nicotinic acid to 0.2 mcg.; biotin to 0.0004 mcg.; pyridoxine to 0.1 mcg.; and para-aminobenzoic acid to 0.12 mcg. The nicotinic acid medium was modified in the amount of material present in the final dilution as follows: glucose and sodium acetate increased to 2.0 per cent; cystine increased to 0.2 per cent; biotin reduced to 0.0002 mcg.; and para-aminobenzoic acid increased to 0.12 mcg. (13).

The autoclaved extracts for vitamin analysis were neutralized and made to 100 ml. in a volumetric flask. The standard vitamin solutions and solutions for analysis were placed in test tubes. Standard tubes containing 0.0, 0.05, 0.10, 0.15, 0.20, 0.30 and 1.50 mcg. of the vitamin were used to establish a standard curve for riboflavin, nicotinic acid and 0.00, 0.01, 0.02, 0.03, 0.05, 0.10 and 0.20 mcg. of pantothenic acid. Aliquots on various levels of 1, 2, 3, 4, and 5 ml. were taken from each sample for the determinations. The contents of all tubes were diluted to 5 ml. with distilled water; then 5 ml. of the basal medium was pipetted into each tube. The tubes were covered and sterilized in the autoclave at 15 pounds pressure for 20 minutes. The tubes were cooled to room temperature and inoculated.

The cells from a 24 hour cultivation of inoculum, produced as previously described, were recovered by centrifugation and resuspended in about twice the original volume of sterile 0.9 per cent saline solution. One drop of the resulting suspension was added to each assay tube. Tubes were incubated in an air incubator at 37° for about 72 hours.

The lactic acid produced at this time was titrated with approximately 0.1 N NaOH using brom-thymol blue as an indicator. The quantity of vitamin in each sample was then determined by comparison with the standard curve prepared at the same time. Only those titration values falling on the relatively linear portion of the curve were used.

Meteorological Methods

A Freiz hygrothermograph was used for recording the relative humidity and temperature changes. A Freiz soil thermograph was used for recording the changes of temperature in the soil at a two inch level.

RESULTS AND DISCUSSION

Type of day, amount of rainfall, minimum and maximum temperatures, and the temperature at the time of sampling, minimum and maximum humidity and humidity at the time of sampling are presented in Table 1. The total rainfall during the 40 day sampling period was 11.43 inches or an average of 0.29 inches daily. This rain was well scattered throughout the middle one-third of the period when 5.1 inches of moisture fell.

The average maximum temperature for the entire period was 84.6° and the average minimum temperature was 65.6°. There was considerable variation in temperature during the sampling period; the maximum temperature varied from 96.2°F. to 67°F., minimum temperatures from 78°F. to 57°F.

The maximum humidity varied from 100 per cent to 78 per cent, and the minimum humidity from 34 per cent to 73 per cent.

Data on soil temperature, presented in Table 2, include the daily maximum and minimum soil temperatures on days of sampling at the two inch level and temperatures at this level at the time of sampling.

The riboflavin, pantothenic acid and nicotinic acid content (fresh and dry bases) of greens from the first and second planting are presented in Tables 3 and 4, respectively. Individual and mean values are shown for the duplicate samples taken at each harvest.

The average vitamin content for the sampling period was riboflavin 27.24 mg. per gm.; pantothenic acid 19.03 mg. per gm. and nicotinic acid 139.26 mg. per gm.

TABLE 1

Meteorological Data for Period June 1 to July 10, 1948.

Date	Weather	Rainfall	Temperatures °F					Relative Humidity %				
		Inches	Maximum	Minimum	8 am	Noon	4 pm	Maximum	Minimum	8 am	Noon	4 pm
June 1	Partly cloudy		67	60	63			100	65	86		
June 2	Clear		80.4	57	74			100	55	58		
June 3	Partly cloudy		81.2	59	72			100	46	72		
June 4	Clear		83.1	65.8	75.3			100	--	51		
June 5	Clear		---	---	---			100	--	73		
June 6	Clear		---	---	---			---	--	--		
June 7	Partly cloudy	.04	---	---	---			100	--	100		
June 8	Partly cloudy	.02	80.3	66.4	76			100	66	100		
June 9	Partly cloudy		80.2	57	74			100	50	96		
June 10	Partly cloudy		80.5	59.2	72	74	59	100	50	75	100	100
June 11	Clear		86	65.7	75			92	47	60		
June 12	Clear		92.8	74	85			100	49	80		
June 13	Partly cloudy		89	70.4	77			100	61	85		
June 14	Cloudy		94	78	80			100	43	73		
June 15	Partly cloudy	.18	93.8	75	88			84	48	60		
June 16	Partly cloudy	.03	89	70	70.3			100	55	91		
June 17	Partly cloudy	.03	96.2	70	80			100	47	--		
June 18	Cloudy		---	---	---			---	--	--		
June 19	Rainy		---	---	---			---	--	--		
June 20	Partly cloudy		---	---	---			---	--	--		
June 21	Cloudy	1.73	94	78	82			78	45	74		
June 22	Cloudy	1.04	88.4	68	70			100	51	100		
June 23	Partly cloudy	1.85	88.3	70	74.1			100	55	100		
June 24	Partly cloudy	.05	96	70	80	91	95.8	100	47	78	55	47
June 25	Cloudy		---	---	---			---	--	--		
June 26	Cloudy	.46	79.8	60.6	64			100	73	100		
June 27	Partly cloudy	.21	81	61	62.3			100	--	100		
June 28	Partly cloudy	1.43	83	62	66			100	58	--		
June 29	Partly cloudy	.06	88	63.8	80			100	68	88		
June 30	Clear		84	63	72			100	36	72		
July 1	Partly cloudy		85	64	74			100	34	74		
July 2	Partly cloudy		78	65	70			100	48	63		
July 3	Partly cloudy		81	66	71			100	59	90		

TABLE 1 (Continued)

Meteorological data for period June 1 to July 10, 1948.

Date	Weather	Rainfall	Temperatures °F					Relative Humidity %				
		Inches	Maximum	Minimum	8 am	Noon	4 pm	Maximum	Minimum	8 am	Noon	4 pm
July 4	Partly cloudy		82	64.4	72			100	63	86		
July 5	Partly cloudy		82	68	73			100	—	—		
July 6	Partly cloudy	.06	82	59	70			100	42	80		
July 7	Cloudy		84	62	72			100	38	70		
July 8	Clear	1.15	84	64	74	82.7	82.3	100	34	70	42	39
July 9	Cloudy		78	65	70			100	49	63		
July 10	Fog	1.12	80.2	64.1	71.6			100	59	99		

TABLE 2

Minimum and Maximum Soil Temperatures on

Days of Sampling for Period June 1 to July 10, 1948.

Temperature at 2 inch level					
			Sampling time		
Date	Minimum	Maximum	8 am	Noon	4 pm
	°F	°F	°F	°F	°F
June 1	68	75			
June 9	69.6	79	71		
June 10	79.6	81	71	80	81
June 11	70	82	71		
June 15	75	82	76		
June 21	68	74	68		
June 22	70	78	72		
June 23	69	72	69		
June 24	69	79	71	78	79
June 25	74	81	75		
July 7	66	77	67		
July 8	69	80	71	76	77
July 9	68	78	68		
July 10	68	78	72		

The Riboflavin, Pantothenic Acid and Nicotinic Acid Content (Fresh and Dry Bases) of Seven Top Turnip Greens Taken From the First Planting in the Period From June 1 to July 6, 1948

Date		Vitamin Content (micrograms per gram)								
		Riboflavin			Pantothenic Acid			Nicotinic Acid		
		Fresh	Dry	Average Dry	Fresh	Dry	Average Dry	Fresh	Dry	Average Dry
June 1	1	4.2	38	37.5	4.3	36.1	36.1	19.5	165	160
	2	4.4	37					17.2	156	
June 7	1	4.5	32.1	32.6	3.8	28.9	29.6	26.9	184	184
	2	4.8	33.1		3.9	30.3				
June 8	1	4.9	32.2	30.2	3.3	24.9	26.0	23.2	152	150
	2	4.3	28.3		4.2	27.1		22.4	147	
June 9	1	5.9	33	31	2.9	18.0	19.4	28.8	181	182
	2	5.2	29.1		3.3	20.7		29.2	184	
June 10	1	5.4	29.5	29.9	3.0	16.4	16.1	30.7	182	182
8 am	2	5.1	30.3		2.7	15.9				
Noon	1	5.2	29.1	28.6	2.8	15.8	16.3	30.5	171	168
	2	5.0	28.1		3.0	16.9		29.3	165.6	
4 pm	1	4.5	22.9	23.9	3.2	16.0	15.1	29.5	149	149
	2	4.9	24.9		2.8	14.2		29.4	150	
June 11	1	4.5	26.2	26.7	2.4	14.0	14.3	25.7	150	142
	2	4.5	27.1		2.5	14.6		22.3	135	
June 15	1	4.7	21.6	20.8	2.6	11.7	11.3	22.8	105	108
	2	4.3	20.0		2.4	10.9		21.6	100	
June 22	1	4.9	30.7	29.6	2.8	17.7	18.0	22.5	141	142
	2	4.4	28.1		2.9	18.2		22.5	144	
July 6	1	2.9	18.9	19.2	2.6	16.9	16.2	21.1	138	141
	2	2.7	19.4		2.2	15.5		20.1	145	

The Riboflavin, Pantothenic Acid and Nicotinic Acid Content (Fresh and Dry Bases) of Seven Top Turnip Greens Taken From the First Planting in the Period From June 21 to July 10, 1948.

Date		Vitamin Content (micrograms per gram)								
		Riboflavin			Pantothenic Acid			Nicotinic Acid		
		Fresh	Dry	Average Dry	Fresh	Dry	Average Dry	Fresh	Dry	Average Dry
June 21	1	5.5	33.5	32.7	3.8	22.8	22.7	23.9	146	147
	2	5.5	31.8		3.9	22.5		25.6	148	
June 23	1	4.5	39.5	38.3	2.6	22.4	22.4	15.5	136	136
	2	4.3	37.1		2.6	22.4		15.5	136	
June 24	1	3.3	26.9	28.9	2.9	23.3	24.1	16.1	131	133
8 am	2	3.6	30.0		3.0	25.0		16.1	134	
Noon	1	3.4	26.6	28.9	2.9	20.8	21.7	16.9	132	135
	2	4.1	31.1		2.7	22.7		18.2	139	
4 pm	1	4.0	30.3	31.1	2.9	21.9	20.8	17.3	127	127
	2	4.5	32.0		2.8	20.0		17.9		
June 25	1	4.2	27.2	24.6	2.6	17.8	17.9	19.4	131	132
	2	3.1	22.0		2.5	18.0		18.8	133	
July 7	1	2.8	17.1	16.8	1.9	11.7	12.3	19.1	117	117
	2	2.7	16.5		2.1	12.9		18.3		
July 8	1	3.2	23.4	23.4	2.0	15.0	15.0	14.4	105	105
8 am	2									
Noon	1	3.0	21.3	21.3	2.0	14.2	13.8	16.1	115	117
	2				1.8	13.2		16.8	119	
4 pm	1	2.9	20.0	21.9	2.4	16.0	16.0	18.9	129	128
	2	3.5	23.7							
July 9	1	3.2	25.3	24.6	2.5	19.3	18.3	15.9	126	123
	2	2.9	23.8		2.1	17.1		14.8	121	
July 10	1	3.1	24.6	24.5	1.7	13.5	14.4	13.7	108	105
	2	3.1	24.4		1.9	14.9		12.9	102	

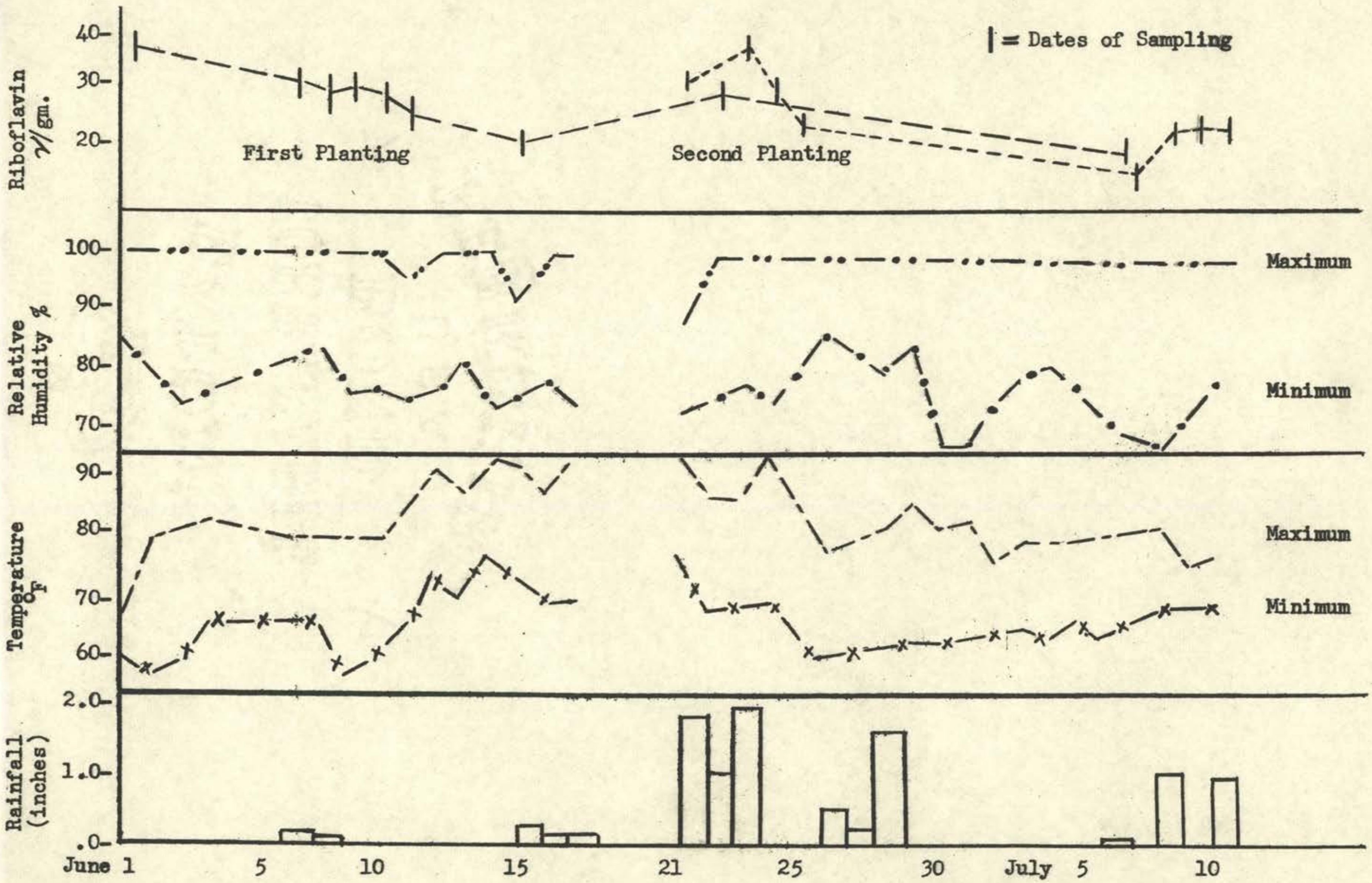
The riboflavin, pantothenic acid and nicotinic acid content together with the principal meteorological observations of rainfall, humidity and temperature are shown graphically in Figures 1, 2 and 3.

An examination of the data presented in Figures 1, 2 and 3 indicates that there is a definite climatic effect on the vitamin content of turnip greens. During the early portion of the growing season of the first planting there was a period of continued dry weather during which time only .06 inches of rain fell. It might be expected, during this time, that the plants declined in moisture content from June 1 to June 15. This decline doubtless was due both to the decreased soil moisture and to the advancing maturity of the plants. That the former was more important is indicated by the relatively small change in moisture content which occurred during the development of the second planting at which time adequate soil moisture was available throughout the growing period.

Figure 1 shows that during the first two weeks of sampling from the first planting there was a definite downward trend in the riboflavin content of the greens. In this period the riboflavin content decreased from 37.5 to 20.8 mg. per gm., dry basis. As was pointed out previously, it is thought that this general decline was due to the reduction in growth rate due to the dry weather. After 1.97 inches of rain fell, the riboflavin content increased to 29.6 mg. per gm. Changes in riboflavin content of the greens throughout this sampling period was gradual.

In the second planting samples were taken during a time of adequate rainfall. It will be noted that although the vitamin content tended to decrease, the trend was less during this period of adequate precipitation than in the preceding dry period. This was particularly true for

Figure 1 — Riboflavin Content of Turnip Greens Grown at Stillwater, Oklahoma, and Maximum and Minimum Daily Temperatures, Relative Humidity and Rainfall During Period from June 1 to July 10, 1948.



riboflavin in which the changes throughout this entire sampling period were relatively small.

As shown in Figure 2, the change in pantothenic acid was likewise quite consistent during the first sampling period. During the first two weeks of sampling from the first planting the vitamin content decreased from 36.1 mg. per gm. to 11.3 mg. per gm. The pantothenic acid content increased to 18.0 mg. per gm. after the 1.97 inches of rain fell. The amounts of pantothenic acid and nicotinic acid in the greens from the second planting also decreased as the plants grew older, but the changes were not as striking as those observed in the first planting. Near the end of the sampling period after an interval of approximately ten days with essentially no precipitation, rain again fell. In every instance the vitamin content of the plants again increased although the changes were of much smaller magnitude than had been observed in the first planting.

The nicotinic acid content of the greens varied somewhat more eratically as shown in Figure 3. The vitamin content fell on the middle of the second week, then rose the third week after rainfall, after which it remained fairly constant.

During the first week of sampling of the second planting there was a decline in the nicotinic acid content of greens which continued until the last three days of this sampling, when rain again fell. In general during subsequent five-day sampling periods uniformity was observed for riboflavin and pantothenic acid, but in one of the two periods nicotinic acid again showed a marked increase after rainfall.

The general pattern of change for the three B-complex vitamins investigated is essentially similar. During the first week very moderate

Figure 2 — Pantothenic Acid Content of Turnip Greens Grown in Stillwater, Oklahoma, and Maximum and Minimum Daily Temperatures, Relative Humidity and Rainfall During Period from June 1 to July 10, 1948.

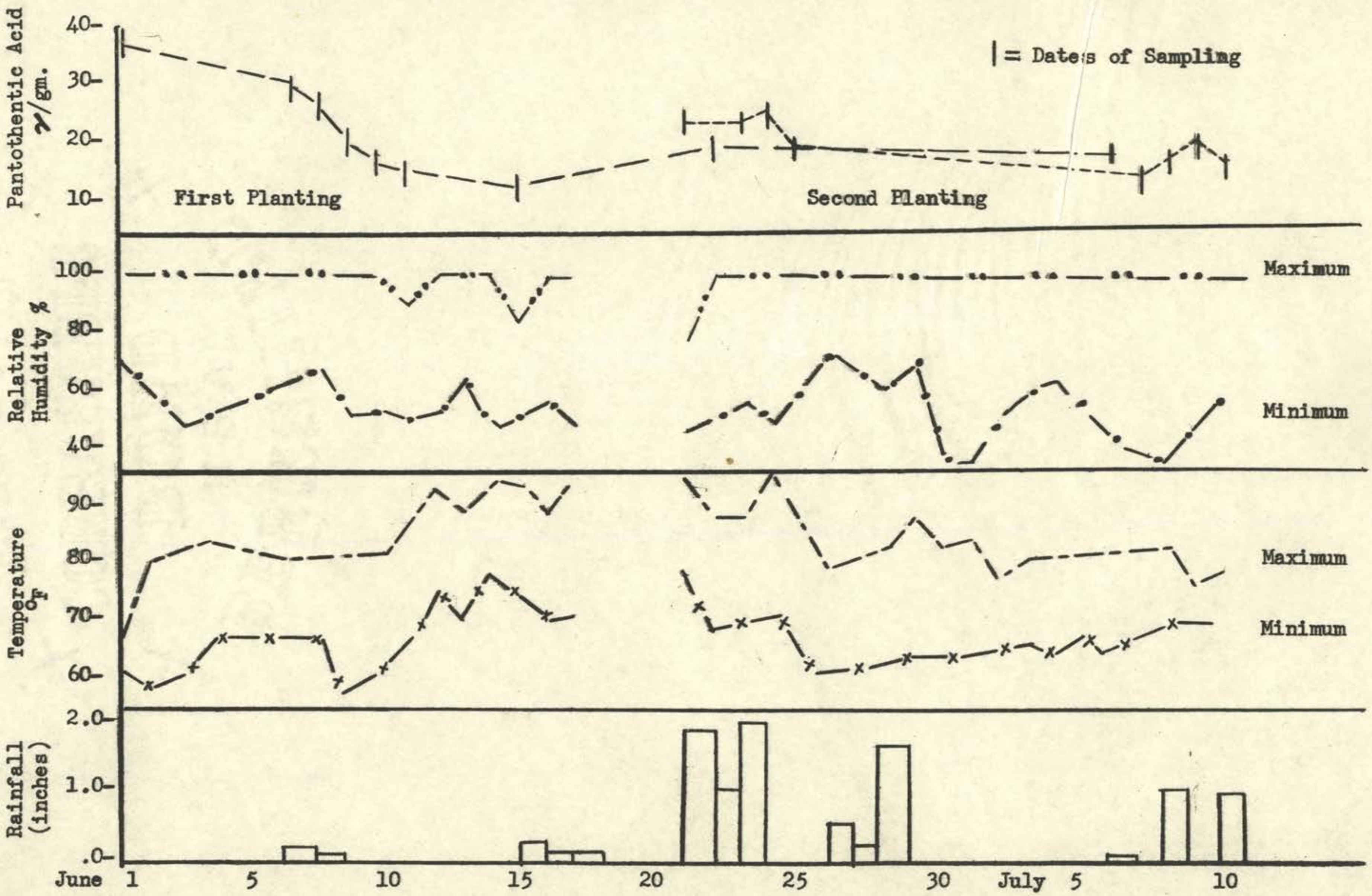
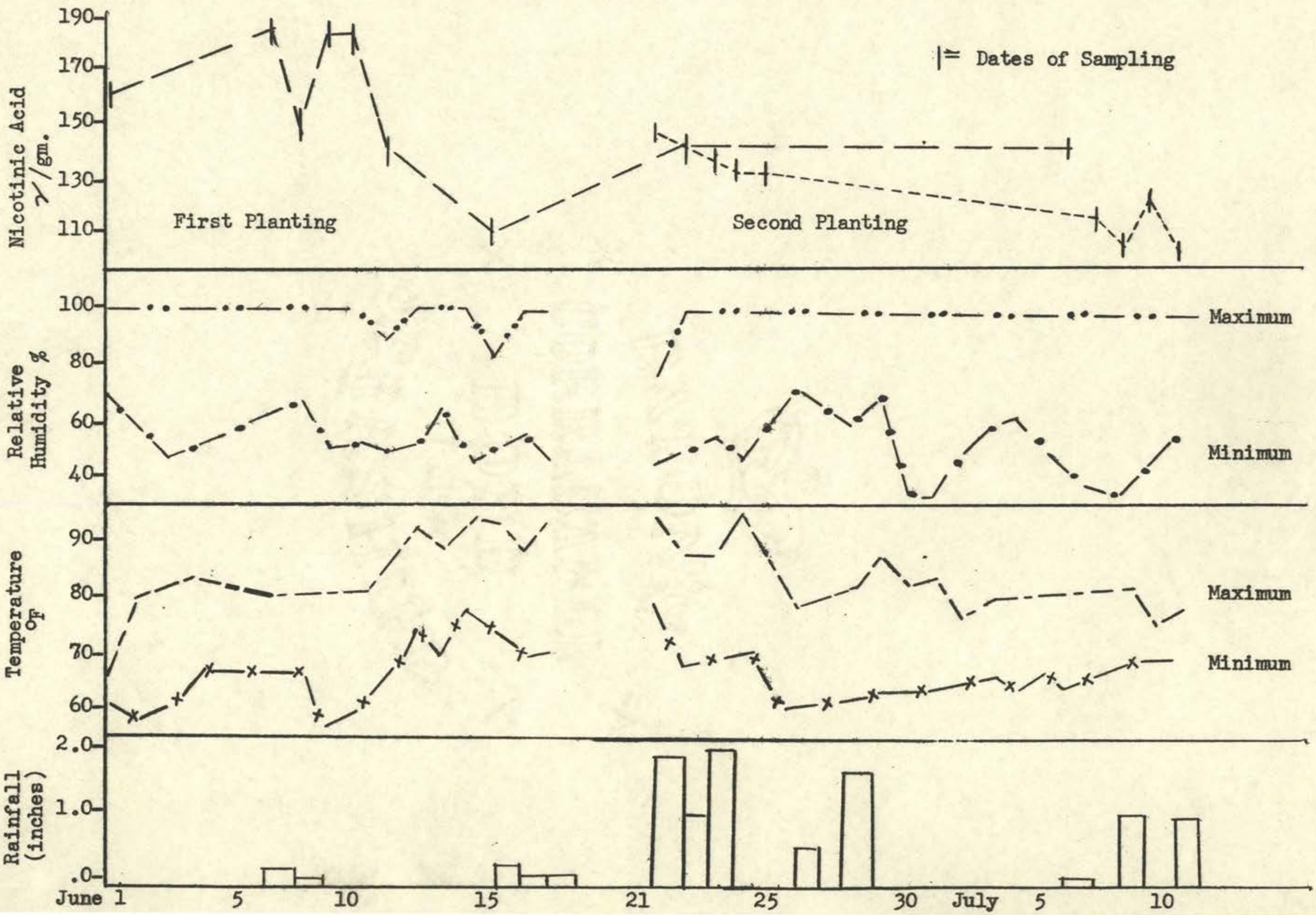


Figure 3 — Nicotinic Acid Content of Turnip Greens Grown at Stillwater, Oklahoma, and Maximum and Minimum Daily Temperatures, Relative Humidity and Rainfall During Period from June 1 to July 10, 1948.



declines were observed followed by a more decided decline the second week of dry weather. Several days before the collection of the samples on the 22nd day, 3.03 inches of rain fell. In every instance the vitamin content increased significantly and did not subsequently decrease to the previous low level. During this later growing period adequate soil moisture was available at all times. It is believed likely that this increase in vitamin content following the period of rainfall was due to renewed growth of plants with the development of more embryonic tissues.

Examination of the temperature curves and vitamin content gives little evidence of any relationship between this climatic factor and vitamin content. Although the temperature curve rose gradually throughout the period of decline during the first planting, it remained relatively high during the increased vitamin content following the rains. Changes during the entire period of the second planting were not very great, and it is not possible to note any obvious correlation between temperature and vitamin content.

The entire period of sampling was characterized by relatively high humidity. Generally, the periods of highest humidity were associated with intermittent rainfall, and it is not believed that the influence on transpiration rate of this factor influences the vitamin content directly.

Examination of soil temperature data shows a correlation between this factor and rainfall. Any correlation between vitamin content and soil temperature is believed to be secondary to soil moisture.

The Table of Food Composition prepared by Chatfield and Adams (14), and used extensively as a reference, gives a value of 58.9 mg. per gm. for riboflavin and a value of 84.6 mg. per gm. for nicotinic acid in turnip greens. These values differ somewhat from those reported in this study. However the values for riboflavin varied widely depending upon the season. This is shown by Reder (18) who found a wide variation between riboflavin content of the Seven Top turnip greens produced in the spring and fall at Stillwater, Oklahoma, 1949. The mean riboflavin content for the spring planting 1949 was 14.1 mg. per gm. and in the fall planting the vitamin content rose to 29 mg. per gm. This wide discrepancy in reported and observed riboflavin and nicotinic acid in turnip greens may be partly accounted for due to the climate and other environmental factors. Values obtained in this study for riboflavin by microbiological assay generally compared well with those obtained by Reder (18 unpublished data) by chemical means at the same location during the same year.

No references giving the values for pantothenic acid in turnip greens were found.

SUMMARY

The effect of climatic conditions and soil temperature on the riboflavin, pantothenic acid and nicotinic acid content of turnip greens was investigated.

The mean riboflavin, pantothenic acid and nicotinic acid contents of 41 samples of Seven Top turnip greens taken during a period of rapid growth in June and early July were 27.24, 19.03 and 139.26 mg. per gm., dry basis, respectively.

Greens harvested in the later stages of maturity contained less of each of these vitamins than those harvested in an early stage. In two instances the vitamin content declined during a period of drouth and the values increased again after moisture. Whether this particular correlation between rainfall and vitamin content is due to increased growth under the more favorable conditions or to some other factor associated with a period of rainy weather will require further study. There was little evidence of any correlation between air temperature and vitamin content.

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THESIS TITLE: THE INFLUENCE OF WEATHER ON THE RIBOFLAVIN, PANTOTHENIC ACID AND NICOTINIC ACID CONTENT OF TURNIP GREENS

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