A STUDY OF FACTORS AFFECTING CRACKING OF THE STORAGE ROOTS OF THE SWEET POTATO, *IPOMEA BATATAS* POIR.

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INTRODUCTION

The phenomenon of "cracking" which occurs in many vegetable and fruit crops is characterized by breaking of the skin, rupture of the outer tissues and exposure of the internal tissue. Although cracking may not impair the quality of the product, it does lend a displeasing appearance and may make it more susceptible to disease.

The economic loss arising from cracking has long been recognized as an important problem in the production of many fruit and vegetable crops. Cracking of the storage roots of sweet potato, (*Ipomea batatas* Poir.), has caused tremendous losses in certain years. For example, it was estimated that between 30 and 50 per cent of the 1949 crop in Maryland was made unmarketable by cracking.

Cracking in sweet potatoes is characterized prodominantly by longitudinal fissures which vary in length from a few millimeters to several centimeters and may extend the entire length of the root. Occasionally, roots are found which exhibit radial cracking.

The fact that cracking is more prevalent in certain years has led many writers to report, or at least imply, that certain soil moisture relationships are responsible for the trouble. The most popular assumption is that cracking is due primarily to an interruption of growth during a prolonged drought, followed by an acceleration of growth at the end of the dry period. Sweet potatoes are generally produced without irrigation or constant moisture supply. Since no two years have identical amounts and distribution of rainfall, it is most logical to hypothesize that this is the causal agent of cracking.

Despite the popular association of soil moisture conditions with the problem of cracking of the sweet potato, to the writer's knowledge, no controlled experiments have been conducted to support the contention. The present study was initiated in an effort to isolate certain of the causal factors involved in cracking and thereby arrive at a practical solution to the problem. In 1950 and 1951 a series of experiments were carried out in an attempt to establish the relationship of soil moisture with cracking. Nitrogen and fumigation studies were also included because certain recently reported experiments have indicated an association of these factors with this disorder.

Since the problem of cracking is similar in many horticultural crops, a review of cracking studies in other crops is pertinent to this problem. Therefore, a review of cracking studies with sweet potatoes and certain other crops will be made.

REVIEW OF LITERATURE

Cracking in Sweet Potatoes: Research dealing directly with the sweet potato cracking problem has been very limited. In 1929 Harter and Weimer (14) proposed that cracking may be associated in some way with weather conditions. These workers found that cracking was prevalent during a year when precipitation was heavy for the entire season. In the following year when precipitation was much less, cracking was not prevalent, which led them to believe that soil moisture may be a factor involved in cracking. They further noted that cracking was more prevalent in better drained soils.

In 1929 Poole and Schmidt (30) observed that cracked roots were often severely infected with nematodes. In recent studies, Mullins (26,27) working with soils infested with nematodes, reported that percentage of cracking was reduced significantly by fumigation with dichloropropene-dichloropropane. According to Scott (33), less cracking was obtained in plots receiving soil sterilization in Mississippi in 1947.

Smoot (35) in Maryland, has reported that cracking may be associated with pox, (*Streptomyces ipomea*). In a greenhouse experiment where sweet potato plants were innoculated with Streptomyces isolates from pox lesions of sweet potatoes, 42 per cent cracking was observed in storage roots, while no cracking was found in untreated checks. He suggested that cracks are a symptom of pox which is expressed under certain environmental conditions which promote abnormal growth of internal tissues and periderm. Moore (25), also working in Maryland, showed that varieties which are more susceptible to pox are likewise more susceptible to cracking.

El-Kattan (11) in 1949, observed that date of planting influenced cracking, but that cracking was not always reduced as date of planting was delayed. In later work (11), he suggests that growth cracking results from internal pressure generated by the expansion of the vascular cylinder when the outer tissues are inactive. He further suggests that moisture deficits and low temperatures may be the limiting factor in outer tissue activity.

There have been several reports relative to the effect of mineral nutrition on cracking. Willis (47) found that boron applications were beneficial in reducing cracking of sweet potatoes in North Carolina. Other investigators (22,33) have been unable to demonstrate this effect, while Nusbaum (28,29), in South Carolina, has shown that in one experiment boron increased cracking. Lutz, et al. (22), reported that high nitrogen fertilization was associated with cracking. Increasing the rate of fertilization from 200 to 1000 pounds per acre, however, had no effect on percentage cracking or on total yield. Nusbaum (29), also reported that high nitrogen fertilization increased cracking.

Variety trials have indicated that sweet potatoes show wide varietal differences in susceptibility to cracking. Harter and Weimer (14) in 1929, reported that Porto Rico was one of the most susceptible varieties while Nancy Hall exhibited no cracking. In later work, Scott (33,34) reported that Jersey Orange was less affected by cracking than Maryland Golden. He suggested that this may be related to the smaller root size of the former. Variety studies by Matthews and Stark in 1951 (24) are in accord with this report.

Cracking in Other Horticultural Crops: Late crops of Irish potatoes are often subject to cracking. MacMillan (23) in California, reported an instance where 50 per cent cracking was incurred as a result of increased turgor pressure when a light rain was followed by a heavy frost two days prior to harvest. The turgor pressure was of such great magnitude that piercing the tubers resulted in cracks often two inches in length. According to Jones and Moore (18) this increase in turgor results from excessive uptake of water by the roots such as that following a dry period or from a normal uptake of water that is not counterbalanced by the usual loss by transpiration. In one test, they found an increased incidence of cracking when a drought was followed by heavy rainfall. In other experiments, these workers demonstrated that spraying the vines with dilute solutions of sulfuric acid increased the tendency to crack. Similar observations were reported by Bonde (4) from Maine. During the first part of one growing season growth was retarded severely by an extended dry period. Following heavy rains, the plants resumed growth and continued to grow much later in the season than normally. Cracking was unusually high for that year.

Werner (45), in a study of tuber development in Irish potatoes, found that cracking occurred when hot dry periods were followed by cool moist conditions. He states that growth cracks result when the development of relatively immature tubers are retarded and then very suddenly accelerated.

Several investigators (31,45,46) have reported that severing the vines at the soil level decreased the tendency of the tubers to crack. They thought that this was due to a reduction of turgor pressure in the tubers.

Cracking in tomatoes, according to Frazier (12), is associated with moisture relationships. He found that heavy irrigation throughout the season induced more cracking than occurred in plots left continually dry. However, dry treatment followed by continued heavy irrigation produced significantly more cracked fruits than heavy irrigation throughout the season. This increase in cracking was noted three to six days after applying water. Cracking following rain often occurred within a few hours. He suggested that water is absorbed through the corky area of the stem and results in cracking.

In later work, Frazier and Bowers (13) found that cracking often occurs at night when the rate of evaporation is low. They suggested that water deficits may indirectly cause cracking by inducing a hardening of the peripheral tissues. When the tissues enlarge, cracking results.

Cracking is noticeably more severe in sweet cherries than in sour cherries. This has led several investigators (15,20,44) to study the effect of osmotic pressure of the juice in association with cracking. Verner and Blodgett (44), in 1931 showed that as cherries ripened there was a rapid increase in the osmotic pressure of the juice which was directly proportional to the degree of cracking. Kertesz and Nebel (20), in 1935 reported that cracking was caused by swelling of colloids in the flesh rather than by osmotic forces. They believe that the increase in osmotic pressure as cherries ripen is coincidental rather than the real cause of cracking.

According to Verner and Blodgett (44), cracking in cherries is not related to soil moisture. It is significant, however, that cracking was reduced by protecting certain branches from rainfall which indicated that the cherry absorbs water directly through the skin. By physiological studies, they were able to show that permeability of the cherry skin was related to cracking. In later work, Verner (43) found that sprays of Bordeaux mixture greatly reduced the susceptibility to cracking. He further showed that the effective constitutent in this spray was calcium. He thought the reduction in cracking was due either to decreased permeability of the skin or increased elasticity of the peripheral tissues. Bullock (10) has reported that sprays of 1 ppm of napthalene acetic acid was beneficial in decreasing cracking.

Tucker (38), working with several different varieties of sweet cherries, found that large varieties tend to crack more readily than small fruited varieties. Surprisingly, the concentration of soluble solids in the juice, as far as varietal differences were concerned, seemed to have no direct effect on cracking.

Verner (41), in a physiological study with cracking in Stayman Winesap apples, reported that drought followed by high soil moisture did not increase cracking. He found, however, that cracking, which generally occurred in regions characterized by abnormalities, was increased by high humidity. It is perhaps significant that osmotic values for tissue from regions beneath the abnormal areas had higher osmotic values than tissue from other regions of the same fruit. In later studies Verner (42) proposed that cracking is due chiefly to premature cessation of growth in the hypodermal layer. Upon unusual acceleration of growth, expansion of the tissues beneath leads to cracking.

GENERAL METHODS

The field work for the study reported herein was conducted on a Norfolk sandy loam at the University of Maryland Vegetable Research Farm near Salisbury during the summers of 1950 and 1951. The main experiment was designed to test the effect of soil moisture, soil fumigation, and nitrogen level in relation to cracking in sweet potatoes. Separate tests with varieties, nematode test crops, nitrogen source, and growth regulators were employed to supplement the studies. The Maryland Golden variety was used in all experiments with the exception of variety trials.

In addition to these studies, a greenhouse sand culture experiment was conducted in the spring of 1951. This study was designed primarily to test widely varying moisture conditions relative to cracking in sweet potatoes. The data obtained from these experiments were subjected to statistical analysis (36) when applicable.

Soil Moisture Determinations: Soil moisture content was determined by an electrical resistance method described fully elsewhere (1,2,6,7,8). Plaster of paris resistance blocks were buried at 6- and 12-inch depths. Three blocks at each of the two depths were buried in each plot of the soil moisture - fumigation - nitrogen experiments. Resistance determinations were made three times weekly with an alternating current impedance meter described by Bouyoucos (5). The blocks were later calibrated in the laboratory according to a method proposed by Kelley (19) and the resistance values were converted to percentage soil moisture by weight. The moisture data reported are averages of three blocks. Permanent wilting percentage was determined by a method suggested by Briggs and Shantz (9) as modified by Veihmeyer and Hendrickson (40). Field capacity was determined 24 hours after a heavy rain, as suggested by Veihmeyer and Hendrickson (39), by weighed samples.

Sampling Technique: Ten-hill samples were taken from each plot in the soil moisture - soil fumigation - nitrogen level experiments at two-week intervals for cracking observations, growth studies and subsequent chemical analyses. The periodic sampling of roots, vines, and leaves was started when a majority of the storage roots had attained a diameter of about one-half inch. Sampling was accomplished by removing the vines carefully from ten plants in each plot. The vines were chopped into 2-inch lengths and a composite sample of 200 grams was dried and preserved for subsequent nitrogen determinations. The sweet potatoes were dug by hand and carefully inspected for cracking. Yield and percentage cracking records were obtained, but no attempt was made to grade the roots at this time. Yield was based on total weight of all roots and percentage of cracking was calculated from the number of cracked roots.

A ten-root sample of all sized roots was selected from each plot. Longitudinal slices from each of the ten roots were chopped into small sections and mixed. 100 grams of the chopped material was placed in a Waring Blendor with 200 ml. of water and blended for five minutes. From this blend, a sample was weighed out for moisture determinations. A second sample was dried and preserved for subsequent nitrogen determinations, and a third sample of 30 grams was placed in No. 1 cans with approximately 100 ml. of boiling 95 per cent ethyl alcohol for carbohydrate analysis.

Leaf samples, which were composed of 30 young, fully expanded leaves, were taken from each plot at each sampling for nitrogen determinations. Prior to actual analysis, the root, leaf, and vine samples were ground separately in a Wiley mill through a 40 mesh screen.

Total Nitrogen: Determinations for total nitrogen were made in 1950 by a colorimetric method described by Lindner (21). In 1951, nitrogen was determined by the Ranker salicylic-thiosulphate method (32).

Sugar Analyses: Both total and reducing sugars were determined from the soluble extract of the canned root samples using the Heinze and Murneek adaptation of the Shaffer-Somogyi method (16).

Alcohol Insoluble Solids: Determination of alcohol insoluble solids content was determined from the canned samples according to the method of the Association of Official Agricultural Chemists (3).

Final Harvest Data: In addition to the six periodic samplings a final harvest was made on October 7, 1950 and

October 19, 1951. The roots were separated into cracked and sound roots and further divided into grades according to diameter. The grades employed were as follows: Jumbo, 3.75 inches or larger; No. 1, 1.75-3.75 inches; No. 2, 1.25-1.75 inches; and No. 3, .75-1.25 inches.

1950 FIELD EXPERIMENTS

Nitrogen - Soil Moisture - Fumigation Studies

Methods

Preliminary trials were conducted in 1950 to test the effect of soil fumigation, nitrogen level, and different soil moisture conditions on cracking in sweet potatoes. Figure 1 presents the plot design used in this test. Due to the fact that it was impractical to withhold rainfall from many small plots, the alternating soil moisture plots were not replicated. It was also not deemed feasible to replicate the high soil moisture plots and the fumigated plots.

Three weeks prior to planting, the field used in this experiment was split lengthwise into two equal parts, one half of which was treated uniformly with dichloropropene-dichloropropane (DD) mixture at the rate of 400 pounds per acre. The other half was left untreated.

Unreplicated soil moisture treatments were superimposed over the fumigation experiment. In an effort to simulate actual drought conditions, two 5-row plots, selected from the standpoint of good drainage, were subjected to two cycles of alternating dry and wet periods. Each cycle comprised a 3-week dry and a 3-week wet period. The dry periods were accomplished by withholding rainfall from the plots with protective covers in the advent of rain. The covers used in this test were constructed by covering 6 x 12 foot wooden frames with celloglass. Figure 2 shows how these were used

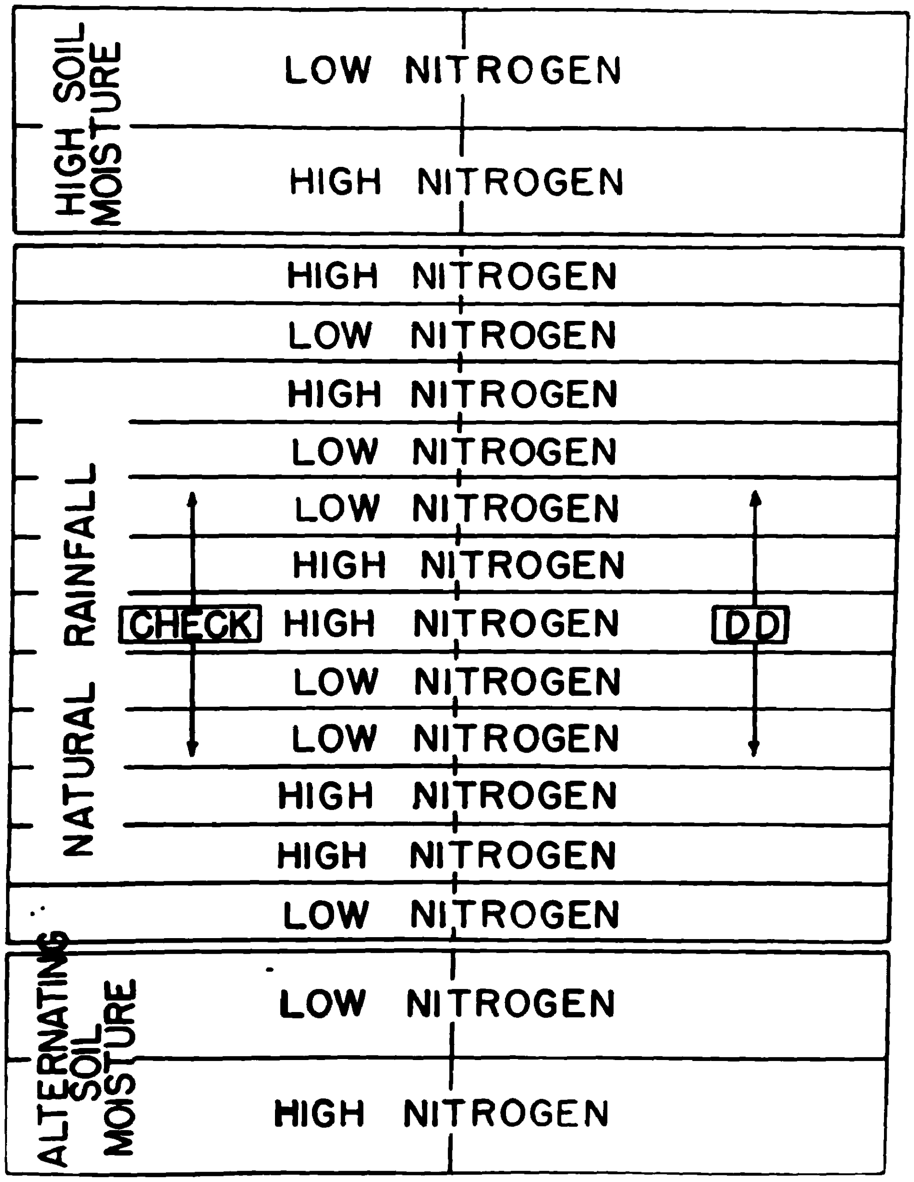

Figure 1. Field plot design employed in the soil moisture - soil fumigation - nitrogen studies. 1950.

Figure 2. Field view showing how the protective covers were used to protect certain plots from rainfall.

in the field. The protective covers did not remain on the plots for the entire dry period but were put in place just before and removed after each rain. At the end of the 3-week dry period the plots were irrigated with two inches of water and an available soil moisture content of 60 per cent or higher was maintained for three weeks. At the end of this period, the entire cycle was repeated. The first dry period was started July 14 and was terminated on August 6. The second dry period was begun August 28 and terminated September 17.

Two additional 5-row plots were selected for high soil moisture studies. The available soil moisture content in these plots was maintained by means of irrigation at a level of 60 per cent or higher throughout the growing season. Irrigation of the high soil moisture plots and the alternating soil moisture plots was accomplished by means of a portable, spray-type irrigation system equipped with No. 25, part circle, Rain Bird sprinklers[1].

The remainder of the field was divided into 3-row plots for nitrogen studies. A 3-9-12 commercial fertilizer was applied to the low nitrogen plots as a split application at the rate of 1500 pounds per acre. The first application was applied June 23 followed by a later application July 11. The high nitrogen plots were treated in exactly the same manner, except that additional nitrogen was applied at each application

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[1]Manufactured by L. R. Nelson Manufacturing Co., Peoria, Ill.

as a side dressing to give a final analysis comparable to a 6-9-12 fertilizer. The treatments were randomized throughout and replicated six times. One plot from both the alternating soil moisture treatment and the high soil moisture treatment likewise received the additional nitrogen application. In this manner, all possible combinations of three soil moisture conditions, two levels of nitrogen and two levels of fumigation were employed. However, only the nitrogen treatments were replicated and randomized.

Plants of the Maryland Golden variety were set May 30 in rows 100 feet long and 32 inches apart with the plants spaced 15 inches apart in the row. Beginning July 15, ten-hill samples were dug by hand from one plot of each of the twelve treatments at approximately 2-week intervals, giving six periodic samplings. The sweet potatoes were first graded into cracked and sound roots then weighed and counted. A final harvest of one 50-foot row from all plots was made on October 7, at which time the roots were separated into cracked and sound roots and further divided into Jumbo, No. 1 and No. 2 sizes.

Growth curves were plotted from both periodic samplings and the final harvest. However, it should be pointed out that the final harvest data represents a much larger sample and is probably a much more precise measurement of growth. Percentage cracking was very low in all plots, therefore, these data are for only the final harvest.

Results

Soil Moisture Studies: Soil moisture determinations indicated that the field capacity for this Norfolk sandy loam was 10.3 per cent moisture at the 4- to 10-inch depths and 9.3 per cent at the 12- to 18-inch depth. The permanent wilting percentage was 2.6 at the 4- to 10-inch depth and 2.3 at the 12- to 18-inch depth. Thus, the available soil moisture for plant growth is calculated as 7.7 and 7.0 per cent for the two depths respectively.

Figure 3 presents the 1950 seasonal trends in soil moisture at 6- and 12-inch depths for three different soil moisture conditions. Excepting the occasions when a light rain increased the moisture level in the upper level only, the soil moisture percentages at the two depths were not greatly different. Thus, soil moisture at the 12-inch depth reached the permanent wilting percentage at approximately the same time that permanent wilting percentage was reached at the 6-inch level. This is not surprising since periodic sampling showed that the fibrous roots were well distributed in the upper 12 inches of soil.

It is apparent that under conditions of natural rainfall, soil moisture was low at two times during the growing season. The permanent wilting percentage was approached on August 2, but a heavy rain August 3 was sufficient to bring the moisture content up to field capacity. Soil moisture again neared the permanent wilting percentage August 26. Light rains September

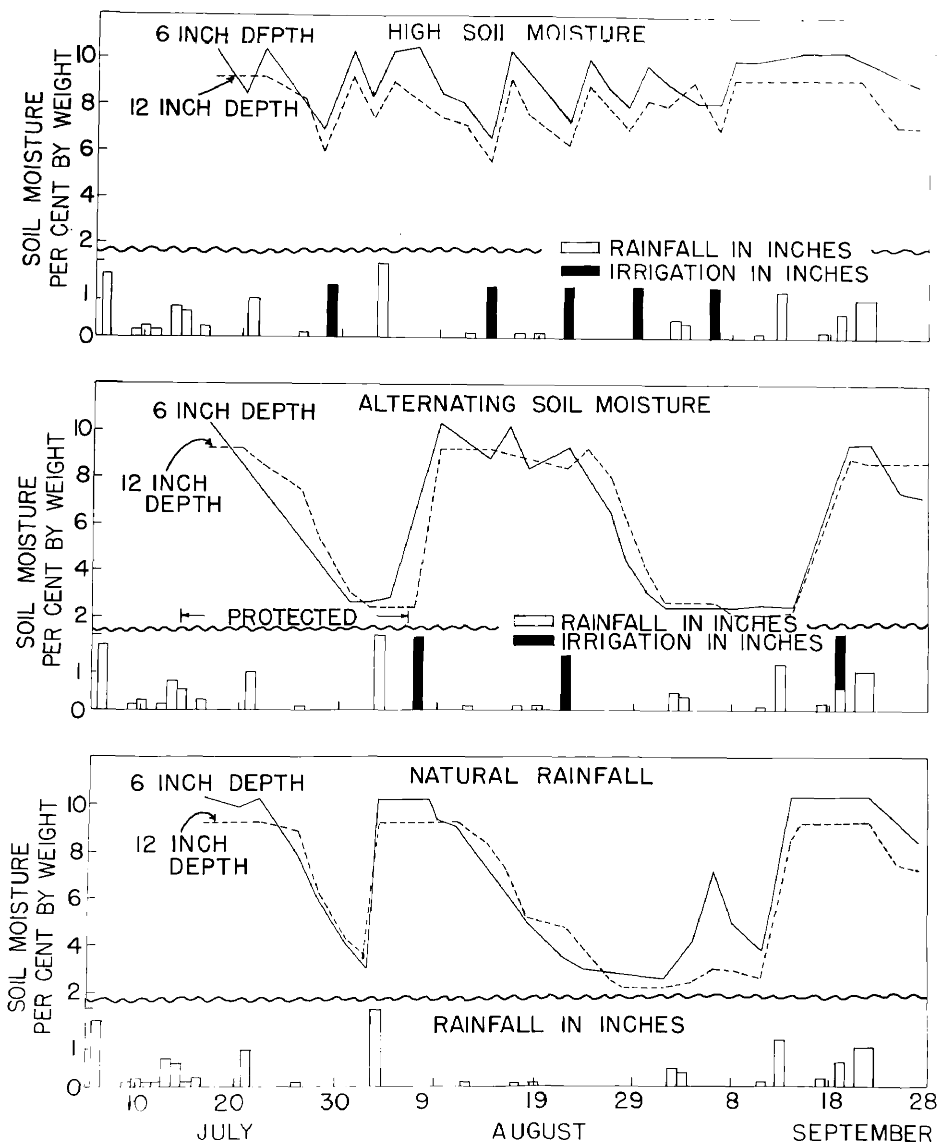

Figure 3. Seasonal trends in soil moisture as influenced by three soil moisture conditions at 6- and 12-inch depths. 1950.

2 and 3 raised the soil moisture level at the 6-inch depth to 6.8 per cent, but soil moisture at the 12-inch depth remained unaffected. During this period of drought, soil moisture was reduced to the permanent wilting percentage for 14 days at the 12-inch depth and for 6 days at the 6-inch depth.

Data on the growth rate of sweet potato storage roots grown under conditions of natural rainfall are presented graphically in Figure 4. Examination of the growth rate reveals that the brief dry period in the latter part of July had little or no effect on growth since the growth rate of roots from the natural rainfall plots roughly paralleled that of roots grown under conditions of high soil moisture. This indicates that although soil moisture approached the wilting percentage for a brief period it was not a limiting factor for growth at that time.

The more extended dry period in August did influence the growth rate to a considerable extent. During the period of August 17 to September 14, when the soil moisture was lowest for the season, growth of roots under conditions of natural rainfall was much less than that of comparable roots under conditions of high soil moisture. This is evidenced by the departure of the growth curve from that produced by conditions of high soil moisture in the latter part of August.

The dry period in August was followed by heavy rains beginning September 13. As a result, soil moisture was

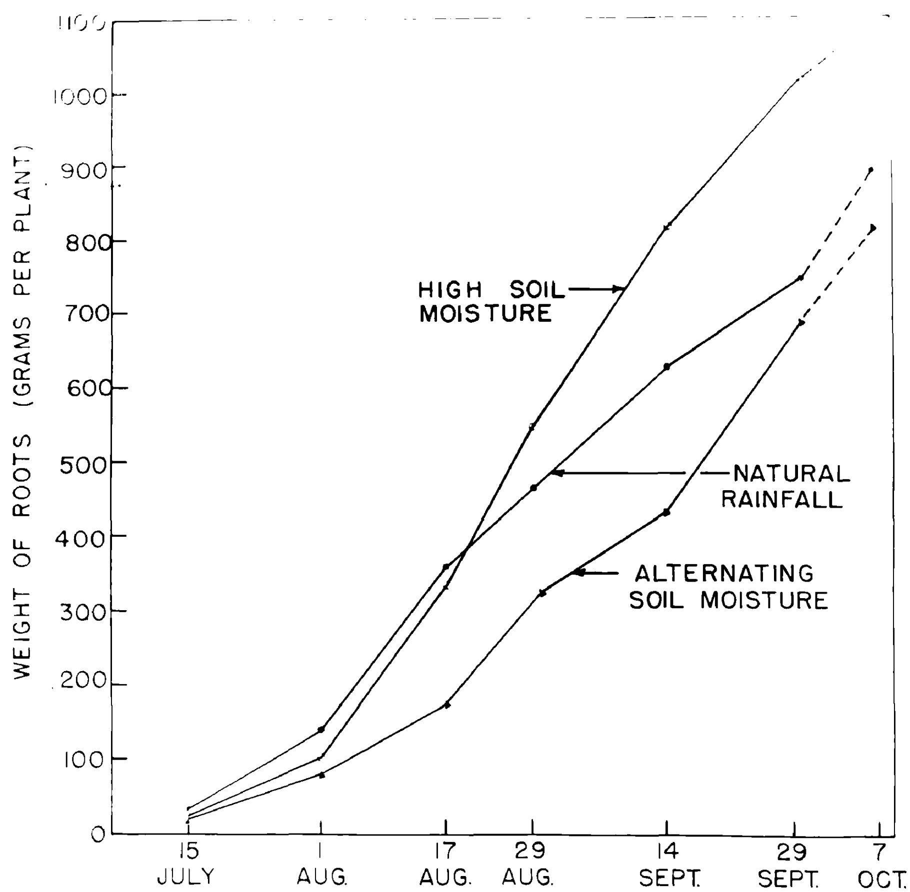

Figure 4. Storage root production curves of Maryland Golden sweet potatoes as influenced by three soil moisture conditions. 1950.

maintained at a high level for the remainder of the growing season. During this latter period of growth, growth rate did not increase but continued to decline.

In plots receiving supplemental irrigation, moisture was never limiting, as shown in Figure 3. Soil moisture dropped below the 6 per cent level at only one time during the entire study. Growth of storage roots from these plots followed a smooth curve, as shown in Figure 4.

Attempts to alter the growth rate by withholding rainfall during certain periods were successful. During the period July 17 to August 7, when the alternating soil moisture plots were protected from rainfall, soil moisture decreased steadily at both the 6- and 12-inch depths until the permanent wilting percentage was reached on July 31 at the 6-inch depth and on August 2 at the 12-inch depth (Figure 3).

The 3-week dry period had a pronounced effect on growth rate as shown in Figure 4. The growth of storage roots from the protected plots roughly paralleled that of roots from the high soil moisture plots until August 1 when soil moisture became limiting. At this time, growth rate decreased sharply until August 17. During the period August 17 to August 29 when soil moisture was maintained at a high level, growth rate of storage roots from the alternating soil moisture plots again equalled that of roots from the high soil moisture plots.

As previously mentioned, the plots were again protected from August 28 to September 19. Soil moisture content decreased rapidly during this period until the permanent wilting percentage was reached by September 1 at both the 6- and 12-inch depths. The plots were held at this low moisture level until September 17. Growth rate of the roots decreased sharply during the protected time, as shown in Figure 4, for the period August 29 to September 14. The effect is undoubtedly more pronounced than is apparent on the graph, since the date of sampling was September 14, while the protected period was not terminated until September 17. After irrigation of the alternating soil moisture plots, growth rate again rose rapidly.

Final yield results (Table 1) are in close agreement with the trends obtained in the periodic samplings. The

Table 1. Effect of different soil moisture conditions, nitrogen level, and soil fumigation on yield and percentage cracking of Maryland Golden sweet potatoes. 1950.

Treatment	Yield (bu./acre) Jumbo	1	2	Total	Cracking[1] (per cent of total)
Soil moisture					
Natural rainfall	31.5	256.5	50.4	333.4	2.2
Alternating soil moisture	10.8	239.1	65.7	315.6	1.5
High soil moisture	33.3	315.0	68.4	416.7	2.6
Nitrogen level					
Low	21.0	246.6	64.8	332.4	2.4
High	29.4	293.8	58.2	381.4	2.0
Fumigation (lbs. DD/acre)					
None	20.4	256.8	61.8	339.0	3.4
400	30.0	283.2	61.2	374.4	1.0

[1]Based on number of roots.

alternating soil moisture plots yielded considerably less than natural rainfall plots, while plots of relatively high soil moisture content produced significantly more bushels per acre than the check with natural rainfall. It appears that high soil moisture increased the yield of the larger roots as compared to the natural rainfall plots, while alternating soil moisture decreased the yield of the larger sized roots.

Percentage cracking, as seen in Table 1, was very low in all plots in the 1950 season. It is perhaps significant that although the growth rate of the roots was altered sharply by manipulation of soil moisture levels, cracking was not influenced. In fact, cracking was actually less in the alternating soil moisture plots, although little significance can be attached to this slight decrease. Similarly, there was little difference between natural rainfall plots, where the growth rate had been slightly altered, as compared to plots of high soil moisture.

Nitrogen Studies: From Table 2 it is seen that the yield from the high nitrogen plots was higher than that of the low nitrogen plots throughout the entire season. The difference was accentuated at the last two harvests, indicating that nitrogen was most effective in increasing the yield toward the latter part of the season. The additional nitrogen was more effective in increasing yield under high soil moisture conditions than under either alternating soil moisture or natural rainfall conditions (Table 3).

Table 2. Effect of three soil moisture conditions, nitrogen level and soil fumigation on yield of Maryland Golden sweet potatoes at seven dates of harvest. 1950.

Treatment	July 15	Aug. 1	Aug. 17	Aug. 29	Sept. 14	Sept. 29	Oct. 7[1]
	Yield (gms./plant) when harvested:						
Soil moisture							
Natural rainfall	34	139	356	464	629	732	889
Alternating soil moisture	18	78	173	324	431	693	824
High soil moisture	26	101	339	546	815	1024	1091
Nitrogen level							
Low	25	88	276	439	605	724	873
High	27	124	302	450	645	909	996
Fumigation (lbs.DD/acre)							
None	32	115	327	468	585	752	914
400	20	96	252	422	665	881	958

[1]Calculated from final harvest yield.

Table 3. Yield of Maryland Golden sweet potatoes as influenced by nitrogen fertilization and three soil moisture conditions at seven dates of harvest. 1950.

Soil Moisture Condition	Nitrogen level	July 15	Aug. 1	Aug. 17	Aug. 27	Sept. 14	Sept. 29	Oct. 7[1]
		Yield (gms./plant) when harvested:						
Natural rainfall	Low	30	99	336	509	623	706	854
	High	39	179	377	420	636	758	923
High soil moisture	Low	23	97	321	555	781	828	957
	High	29	105	357	537	848	1219	1225
Alternating soil moisture	Low	23	67	173	254	410	638	808
	High	22	88	174	395	452	750	840

[1]Calculated from final harvest data.

The final yield is in close agreement with the growth studies (Table 1). Plots receiving 90 pounds of nitrogen per acre showed an increase in yield of nearly 50 bushels over plots receiving 45 pounds of nitrogen per acre. The increased yield was in the larger sized roots.

The final yield data (Table 4) also show the effectiveness of the additional nitrogen in increasing yield when used in conjunction with high soil moisture. Under high soil

Table 4. Percentage cracking and yield of Maryland Golden sweet potatoes as influenced by nitrogen level and soil moisture conditions. 1950.

Soil Moisture	Nitrogen level	Yield (bu./acre) Jumbo	No.1	No.2	Total	Cracking[1] (per cent of total)
Natural rainfall	Low	27.0	259.8	53.4	340.2	2.1
	High	39.6	277.8	46.2	363.0	3.9
L.S.D. 5% level		N.S.	N.S.	N.S.	N.S.	N.S.
F value		1.31	.68	.98	2.20	2.38
Alternating soil moisture	Low	8.4	240.0	61.8	310.2	2.1
	High	13.2	238.2	69.6	321.0	1.0
High soil moisture	Low	27.6	247.8	78.6	354.0	3.0
	High	39.0	382.2	58.2	479.4	2.1

[1]Calculated from number of roots.

moisture conditions the additional nitrogen increased the yield by 125 bushels per acre as compared to an increase of only 11 and 23 bushels per acre, respectively, under the natural rainfall and alternating soil moisture conditions.

Although the growth of the sweet potato storage roots was altered to some extent by increased nitrogen applications, percentage cracking remained unaffected as shown by Tables 4 and 5.

Table 5. Effect of nitrogen level and soil fumigation on yield and percentage cracking of Maryland Golden sweet potatoes. 1950

	Yield (bu./acre)				Cracking[1]
	Jumbo	No. 1	No. 2	Total	(per cent of total)
Nitrogen level					
Low	27.0	259.8	53.4	340.2	2.1
High	39.6	277.8	46.2	363.0	3.9
L.S.D. 5% level	N.S.	N.S.	N.S.	N.S.	N.S.
F value	1.31	.68	.98	2.20	2.88
Fumigation (lbs.DD/acre)					
None	24.6	247.8	51.6	324.0	4.8
400	42.0	290.4	48.0	379.2	1.1
L.S.D. 5% level	N.S.	N.S.	N.S.	33.1	.7
F value	2.51	3.74	.31	12.98*	12.96*

*Significant 5% level.

[1]Calculated from number of roots.

<u>Fumigation Studies:</u> Growth studies with sweet potato storage roots from plants grown in plots fumigated with 400 pounds of DD fumigant, as compared to untreated plots, are presented in Table 2. The yield per plant for fumigated plots was less than that for untreated plots from the first through the fourth date of harvest. This indicates that DD had a depressing effect in the early part of the season. At the fifth and sixth and final harvests yield was higher in fumigated plots indicating that the growth rate was faster in the fumigated plots. Final yield data presented in Tables 1 and

5 show significantly higher yields for the treated plots.

Although both storage roots and fibrous roots were inspected repeatedly during the growing season, no nematodes were found in either fumigated or control plots. However, wireworm injury was present in the untreated plots. Results from observation data, taken at the time of final harvest, are presented in tabular form in Table 6. Fifty sweet

Table 6. Effect of soil fumigation on percentage of infected plants and degree of injury by wireworms in Maryland Golden sweet potatoes. 1950.

Fumigation	Degree of Injury[1] (no. of roots) 0	1	2	3	4	5	Per cent injured
None	95	84	79	29	9	4	63.3
400 lbs. DD	280	15	3	2	0	0	6.6

[1]0 indicates that the roots were free from injury while 5 indicates severe injury.

potatoes from each of six fumigated and control plots were selected at random and scored on the basis of wireworm injury. Only 6.6 per cent of the storage roots were injured in the fumigated plots as compared to 66.3 per cent in the untreated plots, showing that fumigation decreased wireworm injury markedly.

Percentage cracking was also affected by fumigation as shown in Tables 1 and 5. Although percentage cracking was very low in all plots, fumigation slightly decreased cracking.

Variety Studies

Methods

In another experiment, an unreplicated sweet potato variety trial was conducted in combination with a fumigation test. The field used in this test was split lengthwise into two equal parts and one-half of the field was treated uniformly with 400 pounds of DD approximately four weeks before planting. The varieties Jersey Orange, Maryland Golden, B-5999, L-241, Porto Rico, Australian Canner, Oklahoma Allgold, and Vineland Bush were planted across the fumigation test. All varieties were planted June 9 with a transplanter in 3-row plots but only the center row was used for final harvest data. All varieties were fertilized uniformly with a 3-9-12 commercial fertilizer as a split application in bands at the rate of 1500 pounds per acre. The first application of fertilizer was made June 27 followed by a later application July 19.

In addition to the sweet potato variety trials, test crops of Topcrop snap beans, Rutgers tomatoes, and Hale's Jumbo cantaloupes were likewise planted across the fumigation test to check for the presence of nematodes and to study the effect of fumigation on performance of other vegetable crops. The various crops were planted in 6-row plots and replicated four times. On August 9, one row from each plot was dug with a shovel and the roots were examined for root knots.

Results

The sweet potato variety trials in 1950 supported earlier evidence that there is a varietal difference in respect to cracking. Total yield and percentage cracking for eight varieties are presented in Table 7. Maryland

Table 7. Effect of soil fumigation on yield and cracking of eight varieties of sweet potatoes. 1950.

Variety	Total yield (bu./acre) 400 lbs.DD	Check	Per cent cracked[1] 400 lbs.DD	Check
Jersey Orange	180	200	.3	8.3
Maryland Golden	156	136	.8	14.3
L-241	285	301	.0	.3
B-5999	328	275	.7	2.9
Australian Canner	321	335	.0	.0
Porto Rico	125	148	5.5	5.5
Vineland Bush	262	217	.0	2.6
Allgold	382	411	.0	.0
Average	-	-	.9	4.2

[1]Calculated from weight of roots.

Golden, Jersey Orange, and Porto Rico, respectively, were the most susceptible to cracking. All other varieties showed very little cracking. The percentage of cracking was less in the DD treated plots in all varieties which exhibited cracking, with the exception of Porto Rico.

Examination of the other crops showed that root knot nematodes were present in the field (Table 8). Fumigation with DD gave excellent control in all crops, as shown by the decrease in percentage of infected plants in treated plots. Aside from control of nematodes, DD has other effects.

Table 8. Percentage of infected plants and degree of infection by nematodes in snap beans, tomatoes and cantaloupes as influenced by soil fumigation. 1950.

	Degree of infection[1] (no. of plants) 0	1	2	3	4	5	Per cent infected
Snap beans							
Check	143	14	17	9	8	9	28.5
400 lbs. DD	188	6	4	2	0	0	6.0
Tomatoes							
Check	32	32	8	4	4	0	60.0
400 lbs. DD	80	0	0	0	0	0	0
Cantaloupes							
Check	12	20	28	12	4	8	85.0
400 lbs. DD	72	8	0	0	0	0	10.0

[1] 0 indicates that the plants were free from injury, while 5 indicates severe injury.

Table 9. Effect of soil fumigation on total yield and weed control in cantaloupes, snap beans and tomatoes. 1950.

Test Crop	Total yield (lbs./100-ft. row) Check	400 lbs.DD	Weight of weeds (gms./4 sq. ft.) Check	400 lbs.DD
Cantaloupes	66.4	143.6	228	38
Snap beans	36.4	26.2	257	32
Tomatoes	354.7	408.0	302	73

Table 9 shows that it was a rather effective weed control agent. Crab grass, in particular, was controlled by this chemical. It was also noticed in 1951 that very few weeds were present in plots which were treated with DD in 1950.

Table 9 shows that the effect on yield varied with the crop grown. Fumigation decreased the yield of snap beans, but increased the yield of tomatoes and cantaloupes. It is interesting that the latter two crops were much more severely infected with nematodes.

Nitrogen Source Studies

Methods

A third experiment was designed to determine the effect of different sources of nitrogen on cracking. This test was conducted in plots adjacent to the variety trial and as in that test was superimposed over the fumigation treatments. Sprouts of the Maryland Golden variety were transplanted June 21 in rows 32 inches apart and spaced 15 inches in the row. Three-row plots, 50 feet in length were employed in this experiment. However, only the center row was used for total yield and percentage cracking data.

Fertilizers used in this test included an organic nitrogen and an inorganic nitrogen fertilizer of a 3-12-10 analysis from a Salisbury fertilizer company. Two additional fertilizers of a 3-9-12 analysis were prepared as follows: In one, sodium nitrate was used as the source of nitrogen while super phosphate and potassium chloride were employed as sources of potassium and phosphorus. Sand was used as a filler. The other fertilizer was prepared in the same manner, except that ammonium sulfate was used as the source of nitrogen.

Each of the four treatments was replicated three times and randomized throughout. The fertilizer was placed in bands as a split application at the rate of 1500 pounds per acre. The first application was made July 1 followed by the final application July 19. Total yield and percentage data were analyzed statistically. However, it should be pointed out that the fumigation treatments were not randomized.

Results

Tests with different nitrogen sources revealed no differences between nitrate, ammonium and organic nitrogen on either yield or percentage cracking. However, the fumigation test used in combination with source of nitrogen is noteworthy (Table 10). The effect on percentage of cracking

Table 10. Effect of nitrogen source and soil fumigation on yield and percentage cracking of Maryland Golden sweet potatoes. 1950.

	Total yield (bu./acre)	Cracking (per cent of total)
Nitrogen source		
3-12-10		
Organic	282.6	3.5
Inorganic	286.8	2.8
3-9-12		
Ammonium sulfate	255.6	2.3
Sodium nitrate	285.0	3.2
L.S.D. 5% level	N.S.	N.S.
F value	.45	.17
Fumigation		
None	307.8	4.2
400 lbs. DD	247.2	1.7
L.S.D. 5% level	46.3	N.S.
F value	7.52*	4.06

*Significant 5% level.

appears to be consistent with other tests. The decrease in percentage cracking in fumigated plots just failed being significant at the 5 per cent level.

1951 GREENHOUSE EXPERIMENT

Since cracking had not been induced experimentally by manipulating soil moisture conditions in the field in 1950, it was decided to attempt more extreme methods in the greenhouse. For this purpose an experiment was designed to test the effect of widely varying moisture conditions on cracking in sweet potatoes. In an effort to remove variables, other than moisture, it was decided that a sand culture experiment would most closely fit the purpose.

Methods

Plants of the Maryland Golden variety, which had been carefully selected for uniformity, were started March 6 in glazed crocks filled with 18-mesh, white quartz sand. The plants were watered every other day with 250 ml. of nutrient solution. The nutrient solution used was as follows:

Element	Source	Concentration ppm
Nitrogen	NH_4NO_3	400
Potassium	KH_2PO_4 + KCl	800
Phosphorus	KH_2PO_4	200
Magnesium	$MgSO_4 \cdot 7H_2O$	50
Calcium	$CaCl_2$	50

Hoaglands A to Z solution was employed to furnish minor elements.

A simple design with completely randomized blocks was employed to test the effect of seven different moisture treatments on cracking in sweet potatoes. All treatments were replicated four times giving a total of 28 plots and 84 crocks. Each plot consisted of three plants.

Experimental treatments were as follows:

Treatment 1. The plants were subjected to an early dry period of three weeks beginning April 15. The plants were watered only when necessary to keep the plants alive. During the dry period, nutrient solution was added only once after the plants were watered. The dry period was terminated May 4 and the plants were treated like those in Treatment 2 for the remainder of the experiment.

Treatment 2. Plants in this treatment were watered daily and nutrient solution was added regularly at 2-day intervals.

Treatment 3. Beginning May 20, water was added at the rate of 150 ml. at 2-day intervals for five weeks. Nutrient solution was not added during this period. The dry period was terminated June 28 and the plants were treated as in Treatment 2 for the remainder of the experiment.

Treatment 4. Plants in this treatment were subjected to a 3-week dry period beginning May 20. Water was added only when necessary to keep the plants alive. The dry period was terminated June 13 and for the remainder of the experiment the plants were watered daily.

Treatment 5. In this treatment, plants were subjected to a 5-week dry period. During this period water was added only when necessary to keep the plants alive. The treatment was started May 20 and terminated June 28.

Treatment 6. Plants in this treatment were treated exactly as plants in Treatment 5 except that the plants were sprayed with liquid wax to reduce transpiration at the end of the 5-week dry period.

Treatment 7. Plants in this treatment were treated exactly as those in Treatment 5 except that the plants were placed in a humidity chamber at the end of the 5-week dry period and held at a relative humidity of 100 per cent for the remainder of the experiment.

The sweet potatoes were harvested, weighed and counted on August 1. Vine weights were also recorded for all treatments.

Results

The crop in the greenhouse was greatly inferior to that grown in the field as shown by the low yield data of roots in Table 11. The data show that the dry periods had a marked effect on yield of roots but the weight of vines was affected to much lesser extent. The severity of the dry periods is illustrated in Figure 5. Plants subjected to long dry periods were practically defoliated but not killed. Figure 6 shows the remarkable recuperative power of the sweet potato plant. Thirty-two days after revival, the plant showed no marked effect from the 5-week dry period. A comparison of Treatments 1 and 2 (Table 11) reveals that the

Figure 5. Typical injury of Maryland Golden sweet potato plants caused by 5-week dry periods. Check (upper). Treated (lower).

Figure 6. Effect of a 5-week dry period on plants of the Maryland Golden variety 32 days after treatment was terminated. Check (upper). Treated (lower).

yield of roots was decreased markedly by the first dry period of three weeks even though final vine growth was unaffected. Similarly, vine growth was unaffected by a 3-week dry period later in the season as shown in Treatment 4, but root growth was further reduced.

Table 11. Effect of different moisture conditions on yield of vines and storage roots of Maryland Golden sweet potatoes. 1951.

Treatment	Yield (gms./plant) Vines	Roots
1	669	161
2	675	220
3	399	92
4	689	126
5	478	71
6	539	72
7	477	65
L.S.D. 5% level	208	32
F value	3.05	29.43

The 5-week dry period reduced both final vine growth and root growth as compared to the 3-week dry period. Placing the plants in humidity chambers and spraying with wax to reduce transpiration had no effect on final yield of roots and vines.

Despite the fact that widely varying moisture conditions were used and the growth rate of roots was altered markedly, as evidenced by the final yield data, absolutely no cracking was found in this experiment.

1951 FIELD EXPERIMENT

Soil Moisture - Nitrogen - Fumigation Studies

Methods

In 1951, studies with soil moisture, nitrogen level and fumigation were continued and expanded. Sprouts of the Maryland Golden variety were set May 23 with a transplanter in a field which had been in cantaloupes the preceding year. The plants were set in rows 100 feet long and 32 inches apart and spaced 15 inches apart in the row.

In 1950, it was found impractical to replicate alternating soil moisture treatments. However, it was noted that irrigation and fumigation treatments could be replicated in small plots. Therefore, in 1951 these treatments were replicated with the alternating soil moisture plots handled as in the previous year.

For the alternating soil moisture treatments four 5-row plots 100 feet in length, were selected from the standpoint of good drainage. Three weeks prior to planting, one half of each plot was treated uniformly with dichloropropene-dichloropropane (DD) mixture at the rate of 200 pounds per acre. The remaining half of each plot served as a check.

Beginning July 5, one plot was protected (as in the previous year) from rainfall, by means of the protective covers, for four weeks while an adjacent plot was protected for six weeks. One plot on either side of the protected treatments served as a check. The 4-week dry period was terminated August 3 and the 6-week dry period was terminated August 14. Immediately after the dry period was ended the plot was irrigated with two inches of water and a high moisture level was maintained for the remainder of the season.

Only the center row of each plot was used for final harvest data, while the two adjacent rows were used for periodic samplings. The remaining two rows served as guards.

A 2 x 2 x 2 factorial experiment with completely randomized blocks was designed to test the effect of irrigation, nitrogen level, and soil fumigation on cracking. Each plot consisted of six rows 50 feet in length of which two were used for final yield data. The two outside rows served as guard rows while the remaining two rows were used for periodic samplings.

All fumigated plots received DD mixture at the rate of 200 pounds per acre two weeks prior to planting. Untreated plots were left as checks. The nitrogen treatments were carried out exactly as in the previous year. The first application of fertilizer was made June 6 followed by a final application July 3. High soil moisture plots were irrigated when necessary to maintain an available soil moisture content of 60 per cent or higher throughout the growing season.

Sampling was carried out in the same manner as in the previous year. Due to the fact that development of storage roots was somewhat later in 1951, the first sample was not dug until July 23. Samples were taken from all plots. The final harvest was made October 19 at which time the roots were divided into Jumbo, No. 1, 2 and 3 sizes.

Results

Soil Moisture Studies: Soil moisture determinations indicated that the field capacity for the block used in 1951 was 10.0 per cent at the 4- to 10-inch depth and 8.8 per cent at the 12- to 18-inch depth. The permanent wilting percentage was 3.0 at the 4- to 10-inch depth and 2.2 at the 12- to 18-inch depth, giving an available moisture percentage of 7.0 and 6.6 for the two levels. These values are slightly less than those obtained for the block used in 1950. In the natural rainfall plots, used as controls for the protected plots, soil moisture reached the permanent wilting percentage August 31 and again September 14. At the 12-inch level soil moisture remained at the permanent wilting percentage from September 7 to September 14 (Figure 7). This is reflected sharply in growth rate as seen in Figure 8 and Table 12. The growth rate increased during the period September 17 to September 29 when soil moisture was relatively high. The earlier short dry period in August apparently had no deleterious effect on growth.

In protected plots, it was apparent that the treatments were very severe. Vine growth was severely retarded and leaf size was decreased markedly. Toward the end of the 4-week protected period severe wilting was noted as early as

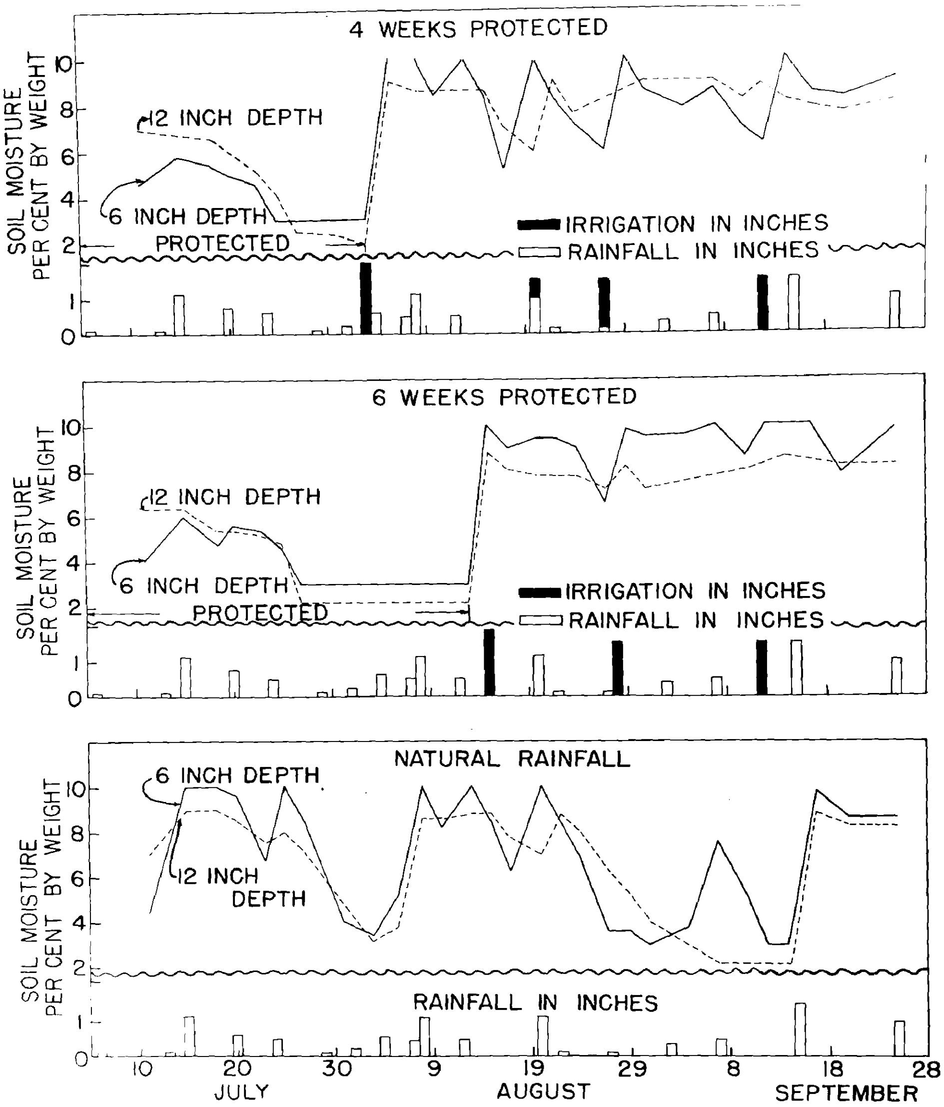

Figure 7. Seasonal trends in soil moisture as influenced by three soil moisture conditions at 6- and 12-inch depths. 1951.

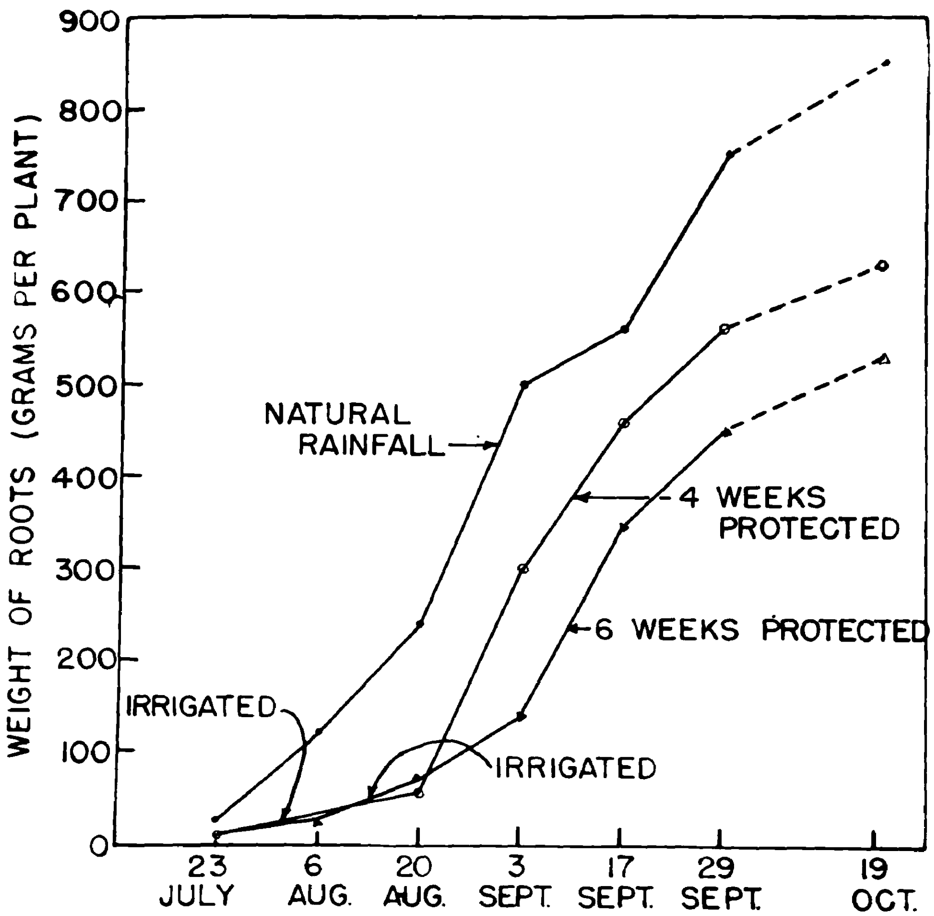

Figure 8. Storage root production curves of the Maryland Golden sweet potato as influenced by three soil moisture conditions. 1951

10:00 A.M. In plots protected for six weeks this was even more pronounced before the treatment was terminated.

Table 12. Effect of soil fumigation and three soil moisture conditions on yield of Maryland Golden sweet potatoes at seven dates of harvest. 1951.

Soil Moisture	Fumigation (lbs.DD/ acre)	Yield (gms./plant) when harvested:[1] July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29	Oct. 19
Natural rainfall	None	30	131	250	522	629	763	815
	200	14	104	225	481	488	742	885
Average	-	22	118	238	502	559	753	851
4 weeks protected	None	9	50	68	299	540	577	627
	200	15	45	63	295	408	544	594
Average	-	12	47	65	297	474	560	610
6 weeks protected	None	27	18	72	149	368	458	561
	200	24	22	68	135	347	467	522
Average	-	26	20	70	142	358	462	541
Average (all moisture conditions)	None	22	63	130	323	512	599	668
	200	18	57	119	304	414	584	667

[1]Calculated from final yield data.

In plots protected from rainfall for four weeks, the permanent wilting percentage was reached July 25 at the 6-inch depth and July 27 at the 12-inch depth. Figure 8 shows that the growth rate of the storage roots in these plots was retarded for the 4-week period, July 23 to August 20. During the first two weeks of this period, soil moisture was obviously limiting growth. After August 20 the growth of storage roots was very rapid for the remainder of the season.

In plots protected for six weeks, soil moisture decreased until the permanent wilting percentage was reached July 31 at both the 6- and 12-inch depths. Figure 8 shows that the growth rate of the roots in these plots was severely retarded until September 3. As in the plots protected for the shorter period, rapid growth did not begin until about two weeks after the plants were irrigated and then proceeded at a rapid rate for the remainder of the season.

Final yield data presented in Table 13 are in accord with the trends indicated in the periodic samplings. The

Table 13. Effect of three soil moisture conditions and soil fumigation on yield in Maryland Golden sweet potatoes. 1951.

Moisture Condition	Fumigation (lbs. DD/acre)	Jumbo	Yield (bu./acre) 1	2	3	Total
Natural rainfall	None	94.2	184.2	108.0	18.6	405.0
	200	106.2	181.2	129.6	25.2	442.2
Average	-	100.2	182.7	118.8	21.9	423.6
4 weeks protected	None	60.0	143.4	66.0	19.8	289.2
	200	19.8	154.2	84.0	24.0	282.0
Average	-	39.9	148.8	75.0	21.9	285.6
6 weeks protected	None	42.2	160.6	64.4	19.2	286.4
	200	48.6	138.2	54.4	19.2	260.4
Average	-	45.4	149.4	59.4	19.2	273.4
Average (all moisture conditions)	None	65.5	162.7	79.4	19.2	326.8
	200	58.2	157.9	89.3	22.8	328.2

4-week protected period decreased total yield considerably as compared to conditions of natural rainfall. Similarly, plots which were protected for six weeks produced less total yield than plots under natural rainfall and slightly less than plots which were protected for four weeks. The decrease in yield was found in the grades of larger sized roots.

The percentage cracking data obtained in the periodic harvest presented in Table 14, indicate that conditions of drought increased cracking. In plots protected for four

Table 14. Effect of soil fumigation and three different soil moisture conditions on percentage of cracking in Maryland Golden sweet potatoes at seven dates of harvest. 1951.

Soil Moisture Condition	Fumigation (lbs.DD/acre)	Percentage cracking when harvested:[1] July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29	Oct.[2] 19
Natural rainfall	None	0	0	1.1	6.0	0	6.2	6.7
	200	0	0	0	1.0	9.8	7.5	6.7
Average	-	0	0	.5	3.5	4.9	6.8	6.7
4 weeks protected	None	0	2.4	0	3.8	15.8	15.6	24.6
	200	0	13.8	3.0	0	8.5	17.1	18.8
Average	-	0	8.1	1.5	1.9	12.1	16.3	21.7
6 weeks protected	None	0	0	0	7.4	17.5	25.8	28.6
	200	0	0	0	60.9	22.9	10.5	24.3
Average	-	0	0	0	34.1	20.2	18.1	26.4
Average (all moisture conditions)	None	0	.8	.4	5.7	11.1	15.9	20.0
	200	0	0	1.0	20.6	13.7	11.7	16.6

[1]Percentage cracking based on number of roots.

[2]Based on final harvest data.

weeks, cracking was observed shortly after the plots were irrigated, although the storage roots were in a retarded state of growth. In plots protected for six weeks, cracking of storage roots was not found until two weeks after irrigation was applied, but as before, the storage roots were still in a retarded state of growth. The data further show that cracking was more severe in plots subjected to prolonged periods of low soil moisture, than in plots of natural rainfall. The cracking data for the final harvest are presented in Table 15.

Table 15. Effect of three soil moisture conditions and fumigation on percentage of cracking in Maryland Golden sweet potatoes. 1951.

Moisture condition	Fumigation (lbs. DD/ acre)	Percentage Cracking[1] Jumbo	1	2	3	Total
Natural rainfall	None	26.2	9.2	3.5	2.0	6.7
	200	26.9	14.6	2.5	1.3	6.7
Average	-	26.5	11.9	3.0	1.6	6.7
4 weeks protected	None	75.0	39.1	7.8	18.1	24.6
	200	0	36.4	13.2	14.3	18.8
Average	-	37.5	37.7	10.5	16.2	21.7
6 weeks protected	None	83.3	50.0	19.3	5.3	28.6
	200	83.3	37.2	22.0	4.0	24.3
Average	-	83.3	43.6	20.6	4.6	26.4
Average (all moisture conditions)	None	61.5	32.8	15.3	8.5	20.0
	200	36.6	29.5	16.0	6.5	16.6
Average (all treatments)		49.0	31.1	15.6	7.5	18.3

[1]Percentage cracking data based on number of roots.

The soil moisture data from the replicated irrigation and natural rainfall test are presented graphically in Figure 9. In natural rainfall plots, moisture content was low in the upper 12 inches during the early part of August and again in the early part of September. The slight drought of August was of short duration and the moisture content did not drop to the permanent wilting percentage. The drought of September was of longer duration. Soil moisture at the 12-inch depth fell steadily from August 22nd until the permanent wilting percentage was attained on September 7. At the 6-inch depth, moisture content approached the permanent wilting percentage August 31, but was increased by light rains on September 2 and 7. However, by September 12 the permanent wilting percentage was again reached. Heavy rains following this dry period held soil moisture at a high level until the experiment was terminated. In irrigated plots, the moisture content was held at a high level by means of irrigation throughout the growing season (Figure 9).

There was a very noticeable foliar difference between irrigated and natural rainfall plots. The vine growth in irrigated plots was more succulent and appeared thicker than that of the natural rainfall plots. Leaf size was decidedly larger and the leaf petioles were much longer in the irrigated plots.

From Table 16 it is seen that the yield at the periodic samplings was not affected by irrigation. However, at the final harvest, the yield was slightly higher in irrigated

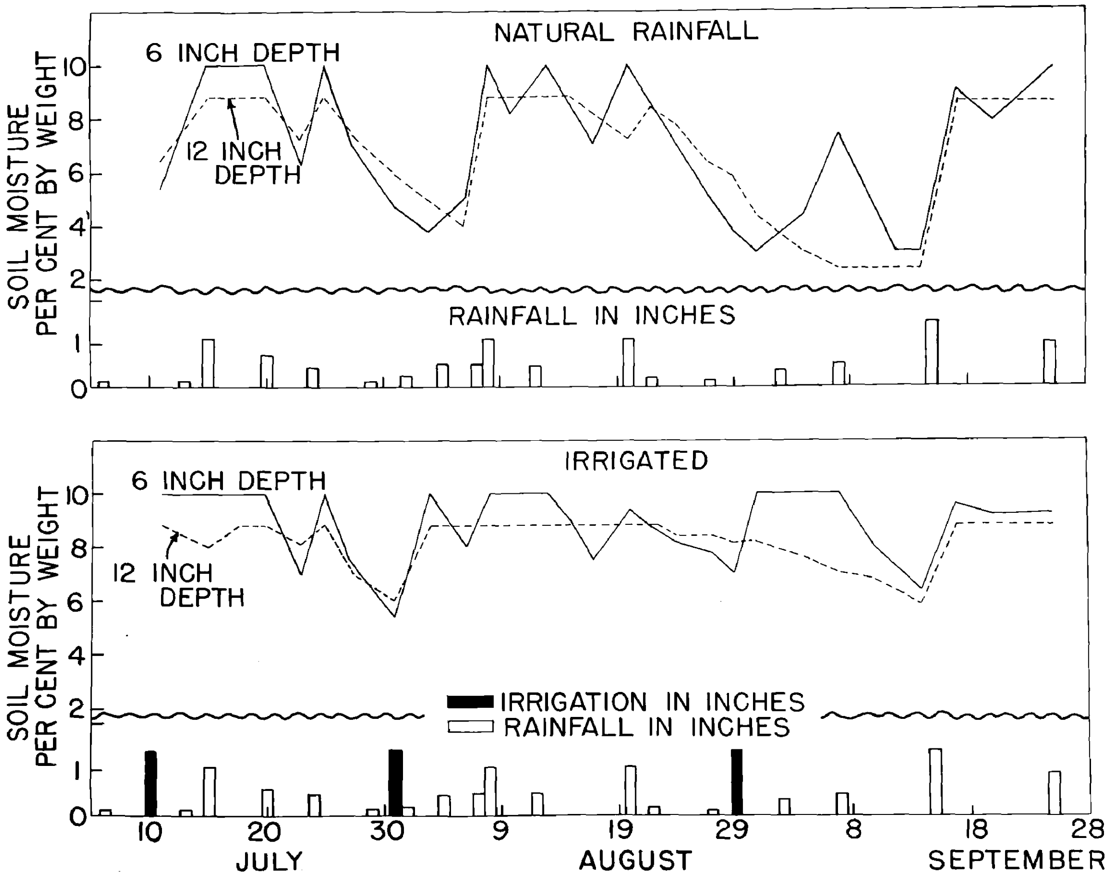

Figure 9. Seasonal trends in soil moisture in irrigated and natural rainfall plots at 6- and 12-inch depths, 1951

Table 16. Effect of fumigation, nitrogen level, and soil moisture on yield at seven dates of harvest. 1951.

Treatment	Yield (gms./plant) when harvested: July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29	Oct. 19[1]
Fumigation (lbs.DD/acre)							
None	29	122	252	472	575	745	904
200	29	107	190	434	613	758	848
L.S.D. 5% level							34.6
F value							10.62*
Nitrogen level							
Low	28	124	234	478	590	740	851
High	30	105	209	429	599	762	902
L.S.D. 5% level							34.6
F value							10.43*
Soil moisture							
Natural rainfall	23	106	204	450	589	756	855
High soil moisture	35	122	238	455	601	747	898
L.S.D. 5% level							34.6
F value							5.56*

*Significant 5% level.

[1]October 19 harvest calculated from final harvest data.

plots, indicating that this increase came during the latter part of the season. Percentage cracking was consistently less in the irrigated treatment for the six samplings (Table 17). At the final harvest, however, percentage cracking was higher in the irrigated plots (Table 18). There was also a sharp increase in cracking at the final harvest.

Close examination of the data obtained in the periodic sampling indicate that cracking under conditions of natural

Table 17. Effect of irrigation, nitrogen level, and fumigation on percentage of cracking in Maryland Golden sweet potatoes. 1951.

Treatment	Per cent cracking when harvested: July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29	Average	Oct.[1] 19
Irrigation								
Natural rainfall	.9	3.7	2.6	8.9	8.4	12.0	6.1	16.3
Irrigated	.2	.6	.5	3.6	4.6	9.0	3.1	20.8
L.S.D. 5% level							1.0	N.S.
F value							28.84*	5.22
Nitrogen level								
Low	.5	1.4	.5	3.1	4.8	9.4	3.3	16.2
High	.6	2.8	2.6	9.3	8.2	11.9	5.9	21.0
L.S.D. 5% level							1.0	3.0
F value							22.50*	5.42
Fumigation (lbs.DD/acre)								
None	0	2.5	1.0	6.4	6.8	10.1	4.5	16.8
200	1.1	1.7	2.1	6.0	6.2	10.2	4.7	20.3
L.S.D. 5% level							N.S.	N.S.
F value							.41	3.09

[1]October 19 harvest calculated from final harvest data.
*Significant at 5% level.

rainfall increased sharply during the periods July 23 to August 6, August 20 to September 2, and September 17 to September 29. Examination of the data in Figure 9 reveals that soil moisture on August 6 and September 3 was practically down to the wilting point in the upper 12 inches.

Nitrogen Studies: Yield data obtained by periodic samplings of the storage roots indicate little or no effect of the increased nitrogen application (Table 16). However, the final yield data, which is based on larger plots, show significantly higher yields of the high nitrogen treatment

(Table 16). Apparently the nitrogen effect was exerted only near the end of the growing season.

The influence of nitrogen level on cracking is shown in the higher percentages of cracked roots consistently found in the high nitrogen plots at the periodic harvests (Table 17). The cracking percentages calculated from final harvest data are in accord with the results of periodic harvests.

The effect of additional nitrogen on growth toward the end of the season was more pronounced in irrigated plots than natural rain fall plots as shown in Table 19. Apparently,

Table 19. Effect of nitrogen level on yield of Maryland Golden sweet potatoes under irrigation and natural rainfall at seven dates of harvest. 1951.

Treatment	Yield (gms./plant) when harvested: July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29	Oct.[1] 19	Cracking (per cent) Oct.[1] 19
Natural rain-fall								
Low N	21	100	222	494	585	746	849	14.6
High N	26	112	187	409	590	767	860	18.1
Irrigated								
Low N	36	147	246	461	596	735	853	18.0
High N	33	97	230	448	607	758	943	23.6
L.S.D. 5% level							48.2	N.S.
F value (inter-action)							4.92*	.22

*Significant 5% level.

[1]Calculated from final harvest data.

increased nitrogen had little effect on growth in the absence of irrigation. Percentage cracking, however, was increased by additional nitrogen in natural rainfall plots as well as in irrigated plots.

Fumigation: The yield data from periodic harvest of storage roots grown in fumigated and in control plots show no marked effect of the fumigation treatment (Table 16). However, the final harvest data indicate that the yield was actually decreased by fumigation.

Percentage cracking data for the periodic harvests revealed no consistent trends in fumigated and untreated plots, (Table 17). Final harvest data presented in Table 18 show lower percentages of cracking in the fumigated plots but the difference was significant only with the No. 3 grade when calculated by number of roots. Similarly, in the protected plots, the amount of cracking was not affected definitely by fumigation (Table 14).

In order that information might be obtained concerning the role of nematodes with respect to cracking, fibrous root samples were collected at the final harvest from both fumigated and control plots. The roots were examined by J. N. Sasser, Assistant Nematologist, Division of Nematology, U.S.D.A. According to Sasser, the plants from control plots were slightly infected with nematodes (Meloidogyne incognito var. acrita), while treated plots were practically free of nematodes.

Root Size and Cracking: An average of all treatments in Table 18 suggests an association with size and cracking. The data show, without exception, that as the size of roots increased, cracking likewise increased. Similar results are shown in Table 19. From Table 20 it is noted that without exception, treatments producing highest yields likewise show the highest degree of cracking. This suggests that irrigation,

Table 20. Effect of irrigation, fumigation, and nitrogen level on total yield and percentage of cracking in Maryland Golden sweet potatoes. 1951.

Treatment	Total yield (bu./acre)	Cracking (per cent of total)
Fumigation (lbs.DD/acre)		
200	428.4	16.8
None	457.2	20.3
L.S.D. 5% level	18.3	N.S.
F value	10.62*	3.09
Nitrogen level		
Low	428.4	16.2
High	457.2	21.0
L.S.D. 5% level	18.3	3.0
F value	10.43*	5.42*
Irrigation		
Natural rainfall	432.6	16.3
Irrigated	453.3	20.8
L.S.D. 5% level	18.3	3.0
F value	5.56*	5.22*

*Significant 5% level.

nitrogen level, and fumigation may have affected cracking only indirectly by increasing or decreasing the size of the potatoes. However, this apparently is not the case. If the increase in cracking were due to size alone, it would logically follow that differences in cracking would be magnified if calculated on a weight basis as compared to that of cracking calculated on a number basis since the greatest amount of cracking would occur at the large size range for each grade. This is not the case. Percentage cracking was remarkably constant, as shown in Table 18, whether computed as a number of roots or weight of roots, thus refuting the argument of the indirect treatment effect on cracking.

Data presented in Table 21 indicate that, in general, cracking increased as the season progressed. It is also

Table 21. Effect of date of harvest on yield per hill and percentage of cracking in Maryland Golden sweet potatoes. 1951.

Date of Harvest	Yield (gms./plant)	Cracking (per cent)
July 23	29	.6
August 6	114	2.1
August 20	222	1.6
September 3	453	6.2
September 17	594	6.5
September 29	752	10.7
October 19	926	18.6

seen that sharp increases of cracking were not always accompanied by large increases in root weight.

Growth Regulator Studies

In 1951 an experiment was designed to test the effect of foliar sprays of napthalene acetic acid (NAA) upon the incidence of cracking in sweet potatoes.

Methods

A 3 x 4 factorial design with completely randomized blocks was employed to test four concentrations applied at three dates. Each treatment consisted of one application only. The concentrations used were 0, 10, 100 and 1000 ppm applied July 15, August 1 and August 15. All treatments were replicated four times giving a total of 48 plots. Each plot consisted of three rows, 25 feet in length. Only the center row was used for final harvest data.

The napthalene acetic acid (NAA) was applied with a hand sprayer and a detergent was used as a spreader. All applications were made late in the afternoon to allow time for the material to be absorbed before the foliage dried.

Results

Table 22 presents the results obtained from foliar sprays of NAA on the percentage of cracking in sweet potatoes.

Table 22. Effect of foliar sprays of napthalene acetic acid on percentage of cracking in Maryland Golden sweet potatoes. 1951.

Concentration ppm	Percentage of cracking when applied: July 15	August 1	August 15	Average
0	8.2	11.3	10.0	9.8
10	5.6	9.6	10.2	8.5
100	9.0	3.3	5.5	6.0
1000	5.2	3.4	2.2	3.4
Average	7.0	6.9	6.8	

L.S.D at 5 per cent level between concentrations: 3.7
Differences between dates of application not significant.

The data indicate that the 1000 ppm of NAA was very effective in reducing cracking. The concentration of 100 ppm also decreased cracking, but to a lesser degree than the 1000 ppm application. Apparently, 10 ppm was entirely ineffective in decreasing cracking. An average of all concentrations indicates that there is no difference between the three dates of application. However, there is trend toward decreased cracking at 1000 ppm as the date of application is delayed.

Statistical analysis revealed no differences in yield of storage roots due to the foliar treatments with NAA. Although measurements were not taken for vine growth, there was no noticeable difference between treatments other than a slight twisting of the petioles at the 1000 ppm concentration. This effect was not noted at the lower concentrations.

RESULTS OF CHEMICAL ANALYSES

Moisture Content: In an effort to ascertain the possible effect of soil moisture, fumigation, and nitrogen fertilization on moisture content of the roots as related to cracking, the moisture content was determined for roots from all plots in the soil moisture - nitrogen - soil fumigation experiments for the 1950 and 1951 seasons. Since cracking was not prevalent in the 1950 season the results for that year are presented in Appendix Tables 5, 6, 7 and 8.

Table 23 presents the results of moisture content of roots from protected plots for six periodic samplings. It

Table 23. Effect of three soil moisture conditions on percentage cracking and moisture content of Maryland Golden sweet potatoes at six dates of harvest. 1951.

	Harvested on:					
	July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29
Natural rainfall						
Cracking (per cent)	0	0	.6	3.5	4.9	6.9
Moisture (per cent)	76.5	76.0	73.9	73.9	74.5	73.5
4 weeks protected						
Cracking (per cent)	0	8.1	1.5	1.9	12.2	16.4
Moisture (per cent)	72.2	76.7	75.0	75.2	75.4	73.1
6 weeks protected						
Cracking (per cent)	0	0	0	34.2	20.2	18.2
Moisture (per cent)	73.5	70.4	74.1	75.9	76.2	75.7

is noted that in plots protected for four weeks, the moisture content of the roots was much less than that of roots from natural rainfall plots on July 23. After irrigation of the plots on August 3, moisture content of the roots from the plots protected for four weeks was equal to that of roots from natural rainfall plots. Similar results are noted in plots protected for six weeks. During the period when the plots were protected the moisture percentage of roots decreased markedly through the second date of harvest. After irrigation prior to the third periodic sampling, moisture content of the roots from plots protected for six weeks was equal to that of roots from natural rainfall plots for the remainder of the season.

In 4-week protected plots, the rise in moisture content was accompanied by the first observed cracking for these plots. It is noted, however, that the rise in moisture content was not accompanied by an increase in cracking in the 6-week protected plots. Further, there is no clear evidence that the moisture content in subsequent harvests was related to cracking.

Table 24 presents the main effects obtained from moisture determination for roots from the irrigation - soil fumigation - nitrogen experiment at six samplings. It is seen that moisture content actually decreased as the season progressed while percentage cracking increased.

Moisture determinations for roots from irrigated and natural rainfall plots for six harvest dates are presented

Table 24. Effect of date of harvest, soil fumigation, nitrogen level, and irrigation on moisture, alcohol insoluble solids, reducing sugars, total sugars, and percentage cracking of Maryland Golden sweet potatoes. 1951.

Variable factor	Moisture (per cent)	A.I.S. (per cent)	Reducing sugar (mgm./gm.)	Total sugar (mgm./gm.)	Cracking (per cent)
1. Date of harvest					
July 23	76.8	1[illegible].7	5.2	33.5	.6
August 6	76.5	18.7	2.6	26.1	2.1
August 20	73.5	22.5	3.3	32.3	1.6
September 3	73.[illegible]	21.9	2.5	34.4	6.2
September 17	73.[illegible]	21.5	[illegible].6	34.2	6.5
September 29	74.0	21.1	3.8	45.8	10.7
L.S.D. 5% level	.6	.4	.5	1.9	3.7
F value	33.1	64.34	117.37	94.02	33.11
2. Fumigation (lbs. D/acre)					
None	74.8	20.7	3.3	34.6	4.5
200	74.5	20.8	3.3	34.3	4.7
L.S.D. 5% level	.3	n.s.	n.s.	n.s.	n.s.
F value	2.16				.41
3. Nitrogen level					
Low	74.4	21.1	3.8	35.5	3.3
High	74.9	20.4	2.9	33.3	5.9
L.S.D. 5% level	.3	.4	.3	1.1	1.0
F value	12.17	29.71	40.44	16.07	22.55
4. Irrigation					
Non-irrigated	74.6	20.7	3.1	34.6	6.1
Irrigated	74.7	20.8	3.5	34.5	3.1
L.S.D. 5% level	n.s.	n.s.	.3	n.s.	1.0
F value	.07		[illegible].40		28.8

in Table 25. The data show that moisture content of the roots was not affected by irrigation. The data further show that percentage cracking was not related to the moisture content of the roots. Similar results are noted in Tables 26 and 27. Additional nitrogen and fumigation had no effect on moisture content of the roots.

Carbohydrate Analyses: Since cracking in cherries (44) has been associated with an increased sugar content the total sugar, reducing sugar, and alcohol insoluble solids were determined for roots from all plots in the soil moisture - nitrogen - soil fumigation experiment.

Table 24 presents the main affects obtained from carbohydrate determinations of roots from the irrigation - soil fumigation - nitrogen experiments. Total sugar content for the first five dates of harvest was rather constant with a sharp increase at the sixth date of harvest, while percentage cracking increased steadily throughout the season. High nitrogen decreased total sugar slightly while fumigation and irrigation had no effect, indicating that percentage of cracking was not associated with sugar content. In protected plots, there is likewise little to suggest that cracking was associated with the total sugar content of the roots (Table 28).

Total Nitrogen: Determinations for nitrogen in the roots, vines, and leaves revealed no consistent relationship between nitrogen content of these parts and percentage of cracking. Therefore, the results for these determinations are presented in the appendix.

[redacted]

Table 25. Effect of date of harvest and irrigation on moisture content, alcohol insoluble solids, reducing sugars, total sugars, and percentage cracking of Maryland Golden sweet potatoes. 1951.

Date of Harvest	Soil moisture condition	Moisture (per cent)	A.I.S. (per cent)	Reducing sugar (mgm./gm.)	Total sugar (mgm./gm.)	Cracking (per cent)
July 23	Natural rainfall	76.5	16.8	5.1	34.2	.9
	Irrigated	77.1	15.5	5.3	32.8	.2
August 6	Natural rainfall	75.4	16.9	2.3	26.2	3.7
	Irrigated	76.3	18.8	2.8	26.1	.6
August 20	Natural rainfall	74.1	21.9	3.1	32.4	2.6
	Irrigated	72.8	23.1	3.5	32.3	.5
September 3	Natural rainfall	73.2	21.9	2.0	33.9	8.9
	Irrigated	74.0	21.3	2.9	34.0	3.6
September 17	Natural rainfall	73.2	21.8	2.6	35.8	8.4
	Irrigated	73.8	21.3	2.6	32.7	4.6
September 29	Natural rainfall	74.0	21.1	3.7	45.2	12.0
	Irrigated	74.1	21.2	3.9	46.4	9.0
L.S.D. 5% level		1.1	.9	N.S.	N.S.	N.S.
F value (Interaction)		3.41	3.45	.79	1.45	1.43

[redacted]

Table 26. Effect of date of harvest and nitrogen level on moisture content, alcohol insoluble solids, reducing sugars, total sugars, and percentage of cracking of Maryland Golden sweet potatoes. 1951.

Date of Harvest	Nitrogen level	Moisture (per cent)	A.I.S. (per cent)	Reducing sugar (mgm./gm.)	Total sugar (mgm./gm.)	Cracking (per cent)
July 23	Low	76.9	16.5	[illegible]	35.5	.5
	High	76.7	[illegible]	4.1	31.5	.6
August 6	Low	75.5	[illegible]	3.0	26.7	1.4
	High	77.2	17.8	2.1	25.6	2.8
August 20	Low	73.1	23.0	[illegible]	33.6	.5
	High	73.8	22.0	[illegible]	31.1	2.6
September 3	Low	73.3	21.2	2.5	34.9	3.1
	High	73.9	21.6	2.4	33.6	9.3
September 17	Low	73.2	22.0	2.7	35.0	4.8
	High	73.8	21.0	2.5	33.5	8.2
September 29	Low	74.1	21.1	[illegible]	47.5	9.4
	High	73.9	21.2	[illegible]	44.1	11.4
L.S.D. 5% level		1.1	.9	.9	N.S.	N.S.
F value (interaction)		3.41	[illegible]	[illegible]	1.25	1.37

[redacted]

Table 27. Effect of date of harvest and soil fumigation on the moisture content, alcohol insoluble solids, reducing sugars, total sugars and percentage cracking of Maryland Golden sweet potatoes. 1951.

Date of harvest	Fumigation (lbs. D/acre)	Moisture (per cent)	A.I.S. (per cent)	Reducing sugar (mgm./gm.)	Total sugar (mgm./gm.)	Cracking (per cent)
July 23	None	76.[illegible]7	1[illegible].71	[illegible].06	33.3	.9
	200	76.06	1[illegible].53	[illegible].29	33.7	1.1
August 6	None	76.61	1[illegible].43	2.64	26.6	2.5
	200	76.11	18.96	2.49	25.7	1.7
August 20	None	7[illegible].47	22.51	3.33	32.5	1.0
	200	73.47	22.46	3.25	32.2	2.1
September 3	None	73.59	21.85	[illegible].21	34.0	6.4
	200	73.64	21.92	[illegible].42	33.9	6.0
September 17	None	73.43	21.53	[illegible].67	35.2	6.8
	200	73.[illegible]1	21.52	[illegible].55	33.2	6.2
September 29	None	74.[illegible]	21.01	3.[illegible]	45.5	10.1
	200	73.66	21.30	3.72	46.1	11.2
L.S.D. .05 level		N.S.	N.S.	N.S.	N.S.	N.S.
F value (interaction)		1.05	.83	1.79	.43	.46

[redacted]

Table 28. Effect of soil moisture conditions on total sugar content and percentage of cracking in Maryland Golden sweet potatoes at six dates of harvest. 1951.

	Harvested on: July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29
Natural rainfall						
Total sugar (mgm./gm.)	35.5	34.4	35.4	34.6	40.1	51.2
Cracking (per cent)	0	0	.6	3.5	4.9	6.9
4 weeks protected						
Total sugar (mgm./gm.)	36.9	31.7	32.0	31.1	32.5	49.4
Cracking (per cent)	0	8.1	1.5	1.9	12.2	16.4
6 weeks protected						
Total sugar (mgm./gm.)	30.6	29.7	30.5	32.6	39.2	50.7
Cracking (per cent)	0	0	0	34.2	20.2	18.2

DISCUSSION

Soil Moisture and Cracking: Harter and Weimer (14) have reported that in a 2-year study with sweet potatoes, cracking was more prevalent during the first season when precipitation was very high than the following year when precipitation was much less. Frazier (12), working with irrigation on tomatoes, found that heavy irrigation throughout the season induced more cracking in tomato fruits than occurred in plots left continually dry. Results obtained in irrigation experiments with sweet potatoes in the 1951 season are in accord with the results of these workers. At the final harvest, a significantly higher percentage of cracked storage roots were found in irrigated plots than natural rainfall plots.

Verner and Blodgett (44) have suggested that sweet cherries often cracked as a result of the absorption of water through the skin of the fruit during rainy weather. This apparently was not the case in sweet potatoes. Results obtained by moisture determinations of roots from irrigated and natural rainfall plots revealed no differences in moisture content. This indicates that the increased cracking in high moisture plots was not associated with increased moisture uptake by the storage roots.

A possible explanation for the differences in absorption of water by the cherry fruit and the sweet potato storage root, aside from anatomical aspects, lies with the difference in development of the two. According to Verner and Blodgett (44), as the sweet cherry fruit matures there is a rapid increase in sugar content up to a certain stage of maturity. During this same time, susceptibility to cracking increases. This is due to an increase in the osmotic pressure of the juice. In the sweet potato, however, sugar content did not increase steadily during the season as it did in the cherry (Table 24).

Data presented in Table 16 indicate that an increase in yield in high soil moisture plots occurred near the end of the season. It would appear that the higher incidence of cracking found in these plots may be associated in some way with this increase in yield. El-Kattan (11) has suggested that growth cracking results from internal pressure generated by the expansion of the vascular cylinder when the outer tissues are inactive. He further suggests that low temperatures and moisture deficits may be limiting factors in outer tissue activity. It is possible that the low temperatures in October resulted in an inactivation of the outer tissues of the roots, while the plants in the high soil moisture plots were still in an active state of growth. This may have resulted in an increased amount of cracking in these plots.

Werner (45) has proposed that growth cracks in Irish potatoes result when the development of relatively immature tubers was retarded and then very suddenly accelerated. The conditions which produced this retardation and acceleration were a prolonged drought followed by heavy precipitation. Results obtained in the 1951 season in the present study with sweet potatoes are in agreement with Werner's report. Plants subjected to prolonged periods of drought followed by heavy and continued irrigation produced a markedly greater amount of cracked roots than plants grown under conditions of natural rainfall. Further, the amount of cracking seemed to depend on the extent of the dry period.

Growth studies with plants subjected to prolonged periods of drought followed by heavy irrigation indicated that the growth of storage roots decreased sharply during the dry periods. After irrigation there was a rapid increase in growth accompanied by increased cracking. This is in agreement with El-Kattan's theory that moisture deficits may cause inactivation of the outer tissue which would result in cracking when growth was resumed.

Jones and Moore (18) attribute cracking in Irish potatoes to increased turgidity resulting from an excessive uptake of water following a dry period. MacMillan (23) has reported an instance where tubers had absorbed excess moisture in quantities as large as 6 per cent of the tubers' "normal" weight. As a result, heavy cracking losses were incurred due to the increased turgidity.

Studies with moisture content of sweet potato storage roots indicate that moisture content of the roots was not associated with cracking. During the dry period, moisture content did decrease slightly and after irrigation, moisture content was slightly higher than controls with natural rainfall. However, an increase in moisture content was not always accompanied by an increase in cracking. Further, there was no apparent association between moisture content and percentage of cracking at subsequent samplings.

<u>Nitrogen Level and Cracking:</u> Lutz and co-workers (22), have reported that high nitrogen fertilization increased the amount of cracking in Porto Rico sweet potatoes. Nusbaum (29) has reported similar results. Results obtained in the 1951 season are in accord with these findings. High nitrogen fertilization did increase cracking. It was also found, from periodic samplings, that the percentages of cracking in high nitrogen plots were higher throughout the season. No explanation can be offered for this effect. However, it does not seem to be related to soil moisture conditions. Table 19 shows that additional nitrogen was just as effective in increasing the amount of cracking under natural rainfall as under conditions of high soil moisture. This suggests that a number of environmental factors may combine to give the high incidence of cracking that has occurred in years such as 1949.

<u>Soil Fumigation and Cracking:</u> Results obtained from fumigation tests in 1950 and 1951 indicate that the application of dichloropropene-dichloropropane decreased cracking slightly in most tests. In 1951 fewer nematodes were found in roots from fumigated than from untreated plots. This is in accord with the results of Mullins (26) who has reported

that fumigation was very effective in reducing cracking losses. He believes that this reduction in cracking is associated with nematode control.

The presence of other soil organisms has also been associated with cracking in sweet potatoes. Smoot (35) and Moore (25) have reported that the incidence of pox is associated with the amount of cracking in sweet potatoes. It is perhaps significant that in the 1951 season when crack-was prevalent, the plants were only slightly infected with nematodes and no pox was found. This would indicate that factors other than soil organisms are also involved in the cracking of sweet potatoes.

Growth studies with storage roots from fumigated and untreated plots showed that fumigation often has a suppressing effect on growth (Table 16). It is possible that this effect may be associated in some way with cracking.

Size of Roots and Cracking: Results obtained in the 1951 season indicate that larger sized roots have a greater tendency to crack than smaller sized roots. This could explain in part the difference in susceptibility to cracking between Maryland Golden and Jersey Orange sweet potatoes. This could also partially explain the increased percentages of cracking as the season progressed. It would seem logical that this could explain the increased cracking found in the high nitrogen and in the high soil moisture plots. Evidence presented in the "Results" section for the 1951 season, however, do not bear this out, indicating that factors other than size of the roots are responsible for the increased cracking here.

Growth Regulators and Cracking: Results obtained in the 1951 season with foliar sprays of napthalene acetic acid (NAA) indicate that 1000 ppm of this growth regulator reduced cracking in sweet potatoes significantly. Similar results have been obtained by Bullock (10) with sweet cherries using much lower concentrations.

Thimann (37), working with pea plants, found that one of the primary functions of growth regulators is the inhibition of growth. He further showed that higher concentrations are required to inhibit growth of vines than roots. This suggests that NAA may have had an inhibiting or regulating effect on rapid growth of roots and thus decreased the percentage of cracking.

An alternate theory would be that NAA increased the plasticity of cell walls. This effect would allow for further expansion of the roots. This theory would be in agreement with reports by Heyn (17) who has reported that a "growth hormone" increased the plasticity of the oat coleoptile cell wall.

Summary: Results obtained from these studies suggest that cracking in storage roots of the sweet potato results from an unbalanced growth rate rather than an osmotic force. This would imply that any factor which contributes to this unbalance is a factor to be considered in this problem. Soil moisture relationships, nitrogen fertilization and

injury by soil organisms are all important contributing factors. However, control of one or all of these will not necessarily prevent cracking since other factors may be just as important.

Results from the soil moisture studies indicate that production of sweet potatoes under conditions of constant moisture supply during seasons of pronounced drought will decrease cracking. However, the economic feasibility of this for partial control of cracking is doubtful.

Investigation of the use of dichloropropene-dichloropane mixture should not be abandoned entirely. Further research may prove the value of this chemical in soils badly infested with nematodes.

The slight increase in the amount of cracking resulting from high nitrogen fertilizer does not justify decreased nitrogen applications since yield was also increased by the additional nitrogen.

The use of napthalene acetic acid is one of the most promising approaches to the problem of cracking in the sweet potato. It may later prove practical to make applications of NAA to reduce cracking in the Maryland Golden sweet potato.

SUMMARY

Field and greenhouse studies were conducted with factors associated with cracking in sweet potatoes. The main factors under consideration were soil moisture relationships, injury by soil organisms, and nitrogen fertilization. Additional studies were made on varietal susceptibility and the effect of foliar applications of napthalene acetic acid in relation to cracking. The results may be summarized as follows:

1. It was found that cracking in Maryland Golden sweet potatoes was more pronounced in plots subjected to prolonged dry periods, followed by heavy irrigation, than control plots with natural rainfall. Percentage of cracking was directly related to the extent of the dry period.

2. Conditions of heavy and continued irrigation throughout the growing season slightly increased the amount of cracking as compared to conditions of natural rainfall in a season when cracking was prevalent.

3. Soil fumigation tests with dichloropropene-dichloropropane mixture (DD) indicated that cracking was slightly reduced by this chemical.

4. Nematode test crops of tomatoes, cantaloupes, and snap beans indicated that root knot nematodes were present in the soil. Sweet potatoes, however, were found to be only slightly infected with nematodes. Fumigation with DD markedly decreased the injury by nematodes in all crops.

5. In a year when cracking was prevalent, percentage cracking was increased by additional application of nitrogen. This effect was not observed in the previous year when the amount of cracking was much less.

6. No correlation was found between the amount of cracking and moisture content of the roots. Similarly there was no apparent relationship between percentage of cracking and the carbohydrate composition of the storage root.

7. Determinations for total nitrogen revealed no consistent relationships between percentage cracking and nitrogen content of roots, vines, and leaves.

8. Final root size was found to be related to the amount of cracking. Larger roots show a much greater tendency to crack than smaller roots.

9. Foliar sprays of napthalene acetic acid (NAA) at 1000 ppm were very effective in reducing the amount of cracking.

LITERATURE CITED

1. Anderson, A. B. C. and Edfelson, N. E. Laboratory study of response of 2- and 4-electrode plaster of paris blocks as soil-moisture content indicators. Soil Sci. 53:413-428. 1942.

2. ____________ and ___________. The electrical capacity of the 2-electrode plaster of paris blocks as an indicator of soil moisture content. Soil Sci. 54:35-46. 1942.

3. Association of Official Agricultural Chemists. Official and Tentative Methods of Analysis. Washington, D.C. 6th Edition. 1945.

4. Bonde, R. Tuber cracking in Green Mountains. Maine Agr. Exp. Sta. Bul. 380. 1935.

5. Bouyoucos, G. J. A practical soil moisture meter as a guide to irrigation practices. Jour. Amer. Soc. Agron. 42:104-107. 1950.

6. ______________ and Crabb, G. A. Measurement of soil moisture by the electrical resistance method. Jour. Amer. Soc. Agr. Engin. 30:581-588. 1949.

7. ______________ and Mick, A. H. An electrical method for the continuous measurement of soil moisture under field conditions. Michigan Agr. Exp. Sta. Tech. Bul. 172. 1940.

8. ______________ and ___________. Improvements on the plaster of paris absorption block electrical resistance method for measuring soil moisture under field conditions. Soil Sc. 63:455-465. 1946.

9. Briggs, L. J. and Shantz, H. L. The wilting coefficient for different plants and its indirect determination. U. S. Dept. Agr., Bur. Plant Ind. Bul. 1912.

10. Bullock, R. M. Hormone research at the tree fruit experiment station. Proc. Washington State Hort. Assoc. 46:119-122. 1950.

11. El-Kattan, A. A. Personal communication.

12. Frazier, W. A. A study of some factors associated with the occurrence of cracks in the tomato fruits. Proc. Amer. Soc. Hort. Sci. 32:519-523. 1934.

13. Frazier, W. A. and Bowers, John L. A final report on studies of tomato fruit cracking in Maryland. Proc. Amer. Soc. Hort. Sci. 49:241-255. 1947.

14. Harter, L. L. and Weimer, J. L. A monographic study of sweet potato diseases and their control. U. S. Dept. of Agr. Tech. Bul. 99. 1929.

15. Hartman, H. and Bullis, D. E. Investigations relating to handling of sweet cherries with special reference to chemical and physiological activities during ripening. Oregon Agr. Exp. Sta. Bul. 247. 1929.

16. Heinze, P. H. and Murneek, A. E. Comparative accuracy and efficiency in determination of carbohydrates in plant material. Missouri Agr. Exp. Sta. Bul. 314. 1940.

17. Heyn, A. N. The physiology of cell elongation. Botanical Review 6:515-574. 1940.

18. Jones, A. P. and Moore, H. I. Cracking of potato tubers. Gardeners' Chronicle 98:445-446. 1935.

19. Kelley, O. J. A rapid method of calibrating various instruments for measuring soil moisture in situ. Soil Sci. 58:433-440. 1944.

20. Kertesz, Z. I. and Nebel, B. R. Observations on the cracking of cherries. Plant Physiol. 10:763-771. 1935.

21. Lindner, R. C. Rapid analytical methods for some of the more common inorganic constituents of plant tissues. Plant Physiol. 19:76-89. 1944.

22. Lutz, J. M., Deonier, M. T. and Walters, B. Cracking and keeping quality of Porto Rico sweet potatoes as influenced by rate of fertilizer, nitrogen ratio, lime and borax. Proc. Amer. Soc. Hort. Sci. 54:407-412. 1949.

23. MacMillan, H. G. Turgescence and rupture of the potato tuber. Phytopath. 21:701-703. 1931.

24. Matthews, . A. and Stark, F. C. Performance of sweet potato varieties on the peninsula. Trans. Peninsula Hort. Soc. (Bul. Delaware St. Bd. Agr.) 41 (5): 31-33. 1951.

25. Moore, J. . Comparative susceptibility of three varieties of sweet potatoes and their high carotene mutants to pox, scurf, stem rot and cracking.

M.S. Thesis. Univ. of Maryland. 1951.

26. Mullins, R. S. Control of cracking in sweet potatoes by soil fumigation. Phytopath. 42:15. 1951.

27. ____________. Sweet potato cracking. Vegetable Growers News. Vol. 5, No. 8, Feb. 1, 1951. Virginia Truck Exp. Sta., Norfolk, Va.

28. Nusbaum, C. J. Studies of boron deficiency of sweet potatoes. Phytopath. 37:435. 1947.

29. ____________. Nitrogen affects sweet potato response to boron. Victory Farm Forum. No. 35, June, 1949. Chilean Nitrate Educational Bureau, Inc., New York, N. Y.

30. Poole, R. F. and Schmidt, R. The nematode disease of sweet potatoes. North Carolina Agr. Exp. Sta. Bul. 265. 1929.

31. Pumphrey, F. V. and Harris, L. Cracking of Triumph potatoes. Amer. Pot. Jour. 26:355-361. 1949.

32. Ranker, E. R. A modification of the salicylic-thiosulphate method suitable for the determination of total nitrogen in plant, plant solutions and soil extracts. Jour. Assoc. Official Agr. Chem. 10:230-251. 1927.

33. Scott, L. E. Factors associated with cracking of sweet potatoes. Trans. Peninsula Hort. Soc. (Bul. Delaware St. Bd. Agr.) 39 (5):37-40. 1949.

34. ____________, Stark, F. C., Matthews, R. A., El-Kattan, A. A., Ogle, W. L., and Duncan, A. A. Progress report on sweet potato cracking experiments. Report Maryland Agr. Soc. 35:215-220. 1950.

35. Smoot, J. J. Pathogenicity and cultural characteristics of Streptomyces isolates associated with sweet potato pox in Maryland. PhD Thesis. Univ. of Maryland. 1951.

36. Snedecor, G. W. Statistical Methods. The Iowa State College Press, Ames, Iowa. 4th Edition. 1946.

37. Thimann, K. V. On the nature of inhibitions caused by auxin. Amer. Jour. Bot. 24:407-412. 1937.

38. Tucker, L. R. A varietal study of susceptibility of sweet cherries to cracking. Idaho Agr. Exp. Sta. Bul. 211. 1934.

39. Veihmeyer, F. J. and Hendrickson, A. H. The moisture equivalent as a measure of the field capacity of soils. Soil Sci. 32:181-193. 1931.

40. ______________ and ________________. Permanent wilting percentages of soils obtained from field and laboratory trials. Plant Physiol. 20:517-539. 1945.

41. Verner, L. A physiological study of cracking in Stayman Winesap apples. Jour. Agr. Res. 51:191-222. 1935.

42. __________. Histology of apple fruit tissue in relation to cracking. Jour. Agr. Res. 57:813-824. 1938.

43. __________. Reduction of cracking in sweet cherries following the use of calcium sprays. Proc. Amer. Soc. Hort. Sci. 36:271-274. 1938.

44. __________ and Blodgett, E. C. Physiological studies of the cracking of sweet cherries. Idaho Agr. Exp. Sta. Bul. 184. 1931.

45. Werner, H. O. Tuber development in Triumph potatoes as influenced by time of planting on dry land in northwestern Nebraska. Nebraska Agr. Exp. St. Res. Bul. 61. 1932.

46. Werner, H. O. and Dutt, J. O. Reduction of cracking of late crop potatoes at harvest time by root cutting or vine killing. Amer. Pot. Jour. 18:189-208. 1941.

47. Willis, L. C. Apply borax to improve quality of sweet potatoes. North Carolina Spec. Circ. No. 1. 1943.

Appendix Table 1. Nitrogen content of roots, vines, and leaves of Maryland Golden sweet potatoes as influenced by date of harvest, soil moisture conditions, nitrogen level, and soil fumigation. 1950.

Variable Factor	Nitrogen content (mgm./gm. dry wt.) Roots	Vines	Leaves
Harvest date			
July 15	13.1	35.3	---*
August 1	15.1	30.0	58.7
August 17	12.2	27.8	47.9
August 27	12.2	29.3	44.3
September 14	11.2	23.5	42.2
September 29	10.1	15.7	33.3
Soil moisture condition			
High soil moisture	11.3	25.6	36.5
Alternating soil moisture	13.2	28.8	37.1
Natural rainfall	12.5	26.5	37.8
Nitrogen level			
Low	11.5	25.0	36.2
High	13.8	28.9	39.3
Fumigation (lbs.DD/acre)			
None	12.1	26.6	37.2
400	12.2	27.3	38.3

*Leaf samples for first harvest were lost.

Appendix Table 2. Nitrogen content of roots, vines, and leaves of Maryland Golden sweet potatoes as influenced by soil moisture conditions and date of harvest. 1950.

Harvest date	Soil moisture condition	Nitrogen content (mgm./gm. dry wt.) Roots	Vines	Leaves
July 15	High soil moisture	13.0	34.2	---[1]
	Alternating soil moisture	14.2	36.4	---
	Natural rainfall	12.0	35.6	---
August 1	High soil moisture	15.2	27.8	60.4
	Alternating soil moisture	15.4	36.4	55.7
	Natural rainfall	14.7	26.1	59.9
August 17	High soil moisture	11.7	27.0	41.8
	Alternating soil moisture	14.1	34.7	53.1
	Natural rainfall	10.8	21.9	48.8
August 27	High soil moisture	9.6	27.8	42.7
	Alternating soil moisture	12.0	27.9	44.8
	Natural rainfall	14.9	32.3	43.5
September 14	High soil moisture	9.7	21.6	42.8
	Alternating soil moisture	13.2	22.9	43.6
	Natural rainfall	10.7	26.0	40.3
September 29	High soil moisture	8.5	15.0	29.0
	Alternating soil moisture	10.2	14.8	37.2
	Natural rainfall	11.5	17.2	34.4

[1] Leaf samples for first harvest were lost.

Appendix Table 3. Nitrogen content of roots, vines, and leaves of Maryland Golden sweet potatoes as influenced by nitrogen level and date of harvest. 1950.

Harvest date	Nitrogen level	Nitrogen content (mgm./gm. dry wt.) Roots	Vines	Leaves
July 15	Low	11.6	32.4	---[1]
	High	14.5	38.3	---
August 1	Low	14.1	26.6	56.4
	High	16.0	33.5	60.9
August 17	Low	10.2	26.1	45.6
	High	14.1	29.6	50.1
August 27	Low	11.6	28.4	43.7
	High	12.7	30.2	44.8
September 14	Low	11.1	22.0	41.7
	High	11.2	25.0	42.7
September 29	Low	9.7	14.6	29.9
	High	10.4	16.6	37.2

[1]Leaf samples for first date of harvest were lost.

Appendix Table 4. Nitrogen content of roots, vines, and leaves of Maryland Golden sweet potatoes as influenced by soil fumigation and date of harvest. 1950.

Harvest date	Fumigation (lbs.DD/ acre)	Nitrogen content (mgm./gm. dry wt.) Roots	Vines	Leaves
July 15	None	13.2	34.5	---[1]
	400	13.0	36.2	---
August 1	None	15.1	28.6	58.3
	400	15.0	31.5	47.6
August 17	None	12.0	28.6	47.6
	400	12.4	27.1	48.1
August 27	None	12.2	28.9	44.2
	400	12.2	29.7	44.3
September 14	None	11.2	23.2	44.0
	400	11.2	23.8	40.4
September 29	None	10.0	15.7	35.7
	400	10.0	15.6	31.4

[1] Leaf samples for first harvest were lost.

Appendix Table 5. Effect of date of harvest, soil fumigation, nitrogen level, and soil moisture conditions on moisture content, alcohol insoluble solids, reducing sugars, and total sugars of Maryland Golden sweet potatoes. 1950.

Variable factor	Moisture (per cent)	A.I.S. (per cent)	Reducing Sugar (mgm./gm.)	Total sugar (mgm./gm.)
Date of harvest				
July 15	74.6	19.6	11.7	36.3
August 1	76.7	17.3	7.1	28.5
August 17	77.9	15.9	10.0	39.8
August 27	77.4	17.8	12.4	34.6
September 14	74.0	20.9	10.3	34.7
September 29	78.0	18.9	4.7	22.7
Fumigation (lbs.DD/acre)				
None	76.4	18.2	10.2	32.2
400	76.5	18.6	11.3	33.4
Nitrogen level				
Low	76.5	18.5	10.5	32.6
High	73.3	18.3	10.1	38.8
Soil moisture condition				
Natural rainfall	76.5	18.6	8.7	31.8
Alternating soil moisture	76.7	18.8	9.9	33.1
High soil moisture	76.0	18.0	12.3	33.6

[redacted]

Appendix Table 6. Effect of soil moisture conditions and date of harvest on moisture content, alcohol insoluble solids, reducing sugars and total sugars. 1950.

Harvest date	Soil moisture condition	Moisture (per cent)	A.I.S. (per cent)	Reducing sugar (mgm./gm.)	Total sugar (mgm./gm.)
July 1[illegible]	Natural rainfall	75.9	19.6	13.6	38.1
	Alternating soil moisture	72.8	22.3	10.5	35.5
	High soil moisture	75.0	1[illegible].8	11.2	35.6
August 1	Natural rainfall	75.5	17.9	7.0	28.8
	Alternating soil moisture	75.0	17.9	6.5	28.9
	High soil moisture	78.4	16.2	9.6	28.0
August 1[illegible]	Natural rainfall	77.2	17.2	10.7	36.5
	Alternating soil moisture	77.5	14.9	15.7	45.9
	High soil moisture	79.0	15.7	16.3	37.1
August 27	Natural rainfall	76.9	1[illegible].3	5.5	33.2
	Alternating soil moisture	78.3	16.9	14.0	34.5
	High soil moisture	76.9	16.1	19.7	36.1
September 14	Natural rainfall	73.3	20.9	11.1	34.0
	Alternating soil moisture	74.8	20.8	7.7	32.0
	High soil moisture	73.7	21.3	12.3	36.2
September 29	Natural rainfall	80.0	17.8	4.1	20.1
	Alternating soil moisture	76.7	19.9	5.2	21.7
	High soil moisture	77.3	18.9	4.7	26.3

[redacted]

Appendix Table 7. Effect of nitrogen level and date of harvest on moisture content, alcohol insoluble solids, reducing sugars and total sugars of Maryland Golden sweet potatoes. 1950.

Harvest date	Nitrogen level	Moisture (per cent)	A.I.S. (per cent)	Reducing sugar (mgm./gm.)	Total sugar (mgm./gm.)
July 15	Low	74.3	20.1	13.1	38.9
	High	74.9	19.0	10.4	33.1
August 1	Low	76.3	17.6	5.8	26.9
	High	77.1	17.0	9.6	29.8
August 17	Low	78.4	16.0	15.3	38.5
	High	77.4	15.7	13.2	41.2
August 27	Low	77.0	17.9	14.6	35.3
	High	77.1	17.7	11.5	33.9
September 14	Low	73.9	20.5	9.2	33.2
	High	74.0	21.3	11.1	36.3
September 29	Low	79.2	18.8	4.8	22.9
	High	76.7	18.9	4.6	22.5

Appendix Table 8. Effect of soil fumigation and date of harvest on moisture content, alcohol insoluble solids, reducing sugars and total sugars of Maryland Golden sweet potatoes. 1950.

Harvest date	Fumigation (lbs.DD/ acre)	Moisture (per cent)	A.I.S. (per cent)	Reducing sugar (mgm./gm.)	Total sugar (mgm./gm.)
July 15	None	74.7	19.1	11.9	35.5
	400	74.5	20.0	11.6	37.4
August 1	None	76.9	17.0	7.3	28.2
	400	76.4	17.1	8.2	29.0
August 17	None	78.0	16.0	15.3	38.0
	400	77.8	15.7	13.3	41.7
August 27	None	77.3	17.7	12.8	34.8
	400	77.5	17.9	13.4	34.4
September 14	None	74.2	20.3	10.0	33.5
	400	73.6	21.5	10.7	36.0
September 29	None	77.6	19.1	5.1	23.3
	400	78.3	18.6	4.3	22.1

Appendix Table 9. Nitrogen content of Maryland Golden sweet potatoes as influenced by date of harvest, fumigation, nitrogen level, and irrigation. 1951.

Variable factor	Nitrogen content (mgms./gm. dry wt.) Roots	Vines	Leaves
Harvest date			
July 23	12.5	38.0	51.1
August 6	11.6	36.1	53.9
August 20	9.0	28.0	49.9
September 3	9.5	20.8	46.1
September 17	9.7	17.0	41.3
September 29	8.4	16.6	37.8
L.S.D. 5% level	.6	.7	1.6
F value	53.63	1567.13	119.90
Fumigation (lbs.DD/acre)			
None	10.0	26.1	47.0
200	10.1	26.1	46.4
L.S.D.5% level	N.S.	N.S.	N.S.
F value	.10	.05	1.57
Nitrogen level			
Low	8.6	23.9	44.4
High	11.6	28.3	49.0
L.S.D. 5% level	.4	.4	.9
F value	265.15	502.63	98.72
Soil moisture conditions			
Natural rainfall	10.6	27.1	46.4
Irrigated	9.6	25.0	46.9
L.S.D. 5% level	.4	.4	N.S.
F value	3.91	12.01	.94

Appendix Table 10. Nitrogen content of Maryland Golden sweet potatoes as influenced by date of harvest and irrigation. 1951.

		Nitrogen content (mgm./gm. dry wt.)		
Harvest date	Soil moisture	Roots	Vines	Leaves
July 23	Natural rainfall	12.9	39.9	50.4
	Irrigated	12.1	36.1	51.8
August 6	Natural rainfall	12.2	37.1	55.6
	Irrigated	11.1	35.1	52.1
August 20	Natural rainfall	9.6	30.1	50.4
	Irrigated	8.4	26.0	49.4
September 3	Natural rainfall	10.7	22.0	45.5
	Irrigated	8.3	19.5	46.7
September 17	Natural rainfall	9.7	17.3	40.9
	Irrigated	9.6	16.8	41.6
September 29	Natural rainfall	8.7	16.5	35.7
	Irrigated	8.0	16.7	39.7
L.S.D. 5% level		1.2	1.3	3.1
F value (interaction)		2.92	12.88	4.75

Appendix Table 11. Nitrogen content of Maryland Golden sweet potatoes as influenced by nitrogen level and date of harvest. 1951.

Harvest date	Nitrogen level	Nitrogen content (mgm./gm. dry wt.) Roots	Vines	Leaves
July 23	Low	11.4	36.3	49.0
	High	13.7	39.7	53.3
August 6	Low	10.3	33.6	50.6
	High	13.0	38.5	57.1
August 20	Low	6.8	25.2	47.2
	High	11.2	30.8	52.6
September 3	Low	8.0	19.1	44.6
	High	10.9	22.4	47.6
September 29	Low	7.3	14.7	35.8
	High	9.4	18.5	39.8
L.S.D. 5% level		1.2	1.3	N.S.
F value (interaction)		3.43*	4.37*	1.14

*Significant at 5% level.

Appendix Table 12. Nitrogen content of roots, vines and leaves of Maryland Golden sweet potatoes as influenced by date of harvest and soil fumigation. 1951.

Harvest date	Fumigation (lbs.DD/ acre)	Nitrogen content (mgm./gm. dry wt.) Roots	Vines	Leaves
July 23	None	12.7	38.8	51.2
	200	12.4	37.1	51.0
August 6	None	11.7	35.1	53.9
	200	11.5	37.1	53.9
August 20	None	8.6	28.4	50.7
	200	9.4	27.7	49.1
September 3	None	9.9	20.8	46.4
	200	9.1	20.7	45.8
September 17	None	9.4	16.7	41.5
	200	9.9	17.4	41.0
September 29	None	8.3	16.6	38.0
	200	8.4	16.5	37.6
L.S.D. 5% level		N.S.	1.3	N.S.
F value (interaction)		1.62	6.89	.25

Appendix Table 13. Nitrogen content of roots of Maryland Golden sweet potatoes as influenced by soil moisture conditions and soil fumigation at date of harvest. 1951.

Soil Moisture Condition	Fumigation (lbs.DD/acre)	Nitrogen content (mgms./gm.) when harvested: July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29
Natural rainfall	None	10.8	13.1	11.4	8.1	7.2	7.9
	200	11.7	11.0	8.8	8.5	8.2	8.4
Average		11.3	12.0	10.1	8.3	7.7	8.1
4 weeks protected[1]	None	14.7	10.0	10.9	7.3	6.0	5.9
	200	12.8	12.8	7.5	7.5	6.0	6.3
Average		13.7	11.4	9.2	7.4	6.0	6.1
6 weeks protected[1]	None	11.9	13.0	14.6	6.1	7.1	5.4
	200	18.7	12.2	10.1	7.0	8.2	6.6
Average		15.3	12.6	12.3	6.5	7.6	6.0
Average (all moisture conditions)	None	12.5	12.0	12.3	7.2	6.8	6.2
	200	14.4	12.0	8.8	7.7	7.5	7.1

[1] Plots were protected from rainfall for the period indicated.

Appendix Table 14. Nitrogen content of vines of Maryland Golden sweet potatoes as influenced by soil moisture conditions and soil fumigation at date of harvest. 1951.

Soil Moisture Condition	Fumigation (lbs.DD/acre)	Nitrogen content (mgms./gm.) when harvested: July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29
Natural rainfall	None	41.8	32.4	27.0	19.0	13.2	15.8
	200	37.9	37.1	30.7	19.7	14.7	16.0
Average		39.8	34.7	28.8	19.3	14.0	15.9
4 weeks protected[1]	None	38.5	42.1	29.9	21.6	12.8	14.6
	200	42.4	40.8	21.0	21.7	13.0	17.3
Average		40.4	41.4	25.4	21.6	12.9	15.9
6 weeks protected[1]	None	43.9	38.7	26.1	19.1	13.0	14.0
	200	36.7	38.3	23.2	18.5	15.5	15.3
Average		40.3	38.5	24.6	18.8	14.2	14.6
Average (all moisture conditions)	None	41.4	37.7	27.7	19.9	13.0	14.8
	200	39.0	38.7	25.0	20.0	14.4	16.2

[1]Plots were protected from rainfall for the period indicated.

Appendix Table 15. Nitrogen content of leaves of Maryland Golden sweet potatoes as influenced by soil moisture conditions and soil fumigation at date of harvest. 1951.

Soil Moisture Condition	Fumigation (lbs. DD/acre)	Nitrogen content (mgms./gm.) when harvested: July 23	Aug. 6	Aug. 20	Sept. 3	Sept. 17	Sept. 29
Natural rainfall	None	49.5	49.8	44.8	43.1	35.0	32.7
	200	48.9	49.8	46.4	45.4	35.5	33.7
Average		49.2	49.8	45.6	44.2	35.2	33.2
4 weeks protected[1]	None	49.9	48.7	47.1	46.6	36.2	32.5
	200	44.5	50.9	43.0	44.6	35.4	36.0
Average		47.2	49.8	45.5	45.6	35.8	34.2
6 weeks protected[1]	None	42.2	50.9	44.1	39.0	34.9	32.8
	200	50.5	55.3	46.9	45.0	36.4	35.0
Average		46.3	53.1	45.5	42.0	35.6	33.9
Average (all moisture conditions)	None	47.2	49.8	45.3	42.9	35.4	32.7
	200	48.0	52.0	45.4	45.0	35.8	34.9

[1]Plots were protected from rainfall for the period indicated.

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Scott, L. E., Stark, F. C., Matthews, S. A., El-Kattan, A.A., Ogle, W. L. and Duncan, A. A. Progress report on sweet potato cracking experiments. Report Maryland Agr. Soc. 35:215-220. 1950.