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TRANSLUCENT END OF POTATOES IN SOUTHWESTERN IDAHO

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Translucent End of Potatoes In Southwestern Idaho

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This study investigated effects of moisture and nitrogen fertilizer on quality factors related to Translucent End, a physiological problem of tubers that is particularly serious in processing areas of southwestern Idaho. Though no clear evidence was shown that this problem can be eliminated, results show that growers can improve yield and quality of tubers by maintaining available soil moisture above 65 percent during the growing season and limiting nitrogen rates to levels suggested in Idaho Current Information Series No. 261, "Idaho Fertilizer Guide: Potatoes." Moisture stress applied to potato plants either early season or midseason reduced yield and quality of tubers. A combination of both early and midseason stress reduced yield and quality the greatest. Applications of nitrogen higher than Fertilizer Guide recommendations also reduced both total yield and quality.

Translucent End, a serious physiological deterioration of the potato tuber, has occurred in most potato growing areas of Idaho. The problem appears as tubers with translucent ends — high in reducing sugars and low in starch at one end — and tubers with pointed ends or dumbbell-shape associated with low solids content. The translucent end potatoes produce french fries that are dark on one end, an unsatisfactory product.

Translucent End is particularly severe in the 10 southwestern Idaho counties where potatoes are grown exclusively for processing. Before the processing boom, these counties produced 15,000 acres of potatoes or less. In 1972, potatoes were grown on 27,000 acres in these 10 counties, producing 9,045,000 cwt valued at $19,265,850. This was a reduction of 6,000 acres from 1971 when poor quality, primarily low solids content and translucent end, resulted in a loss of 2 million cwt of potatoes valued at more than $4 million.

A College of Agriculture research team cooperated with industry to make an initial study in 1972. This showed that both moisture and fertilizer were related to potato quality factors involved. In 1973, a more extensive experiment was established. The objectives were:

1. To evaluate the effects of moisture and nitrogen fertilizer on total yield and No. 1 tubers.
2. To evaluate the effects of moisture and nitrogen fertilizer on tuber quality. Quality indicators include percent solids, total and reducing sugars, french fry color, malformed tubers, translucent end tubers, and rot and weight loss in storage.
3. To relate soil nitrogen to nitrogen needed from commercial fertilizers to produce top yield and quality of tubers.
4. To relate nutrients in potato petioles during growing season to the effects of moisture and fertilizer on plant growth, tuber yield and quality.
5. To evaluate soil temperature relationships with soil, moisture and nitrogen fertilizer and yield and quality of tubers.

Literature Review

Research has demonstrated that nitrogen fertilization and moisture affect both tuber yield and quality. The effect appears to vary between localities probably due to climatic differences which affect growing season, temperatures, light intensity and light quality.

For example, increased nitrogen caused a decrease in specific gravity in some studies (1, 3, 7, 8). Other reports (3, 10) indicated no effect from nitrogen on specific gravity from late-harvested potatoes. Most research data showed total yield increased with increased nitrogen rates (1, 2, 3, 7, 8, 9) but in some cases a higher percent of malformed tubers were produced (6, 7, 8). Nitrogen fertilizer did not affect chip or french fry color (2, 8) but did show more light-skinned tubers (8).

Banded or side-dressed nitrogen was more efficient than broadcast nitrogen plowed down before planting (10) but nitrogen banded in spring as ammonium nitrate and calcium nitrate produced lower yields of No. 1 tubers than that broadcast in fall and plowed under. This effect was not noted from application of ammonium sulfate (11).

Moisture stress early in the growing season resulted in more malformed tubers (4, 5).

Table 1. Locations, type of irrigation, soil texture and available moisture of study plots.

Location	Type of Irrigation	Soil Texture	Available Moisture (inch/ft)
No. 1	Furrow	Fine sandy loam	1.46
No. 2	Sprinkler	Loamy sand	0.81
No. 3	Furrow	Silt loam	2.66
No. 4	Sprinkler	Loam	2.00

Procedure

Locations for this study (Table 1) were selected to represent the main soil textures under both sprinkler and furrow type irrigations. A split-plot design within locations was used to investigate the influence of 4 main plot levels of moisture and 4 sub-plot levels of nitrogen with 3 replications at 4 locations on components of potato quality and yield.

Moisture Treatments

The 4 moisture levels, arranged in 2 x 2 factorial arrangements, were:

M1 — Applying moisture stress to plants from early tuber set through 3-ounce tuber size by depleting available moisture to 25 percent before irrigation.

M2 — Applying moisture stress to plants during the period July 15 to August 15, when temperatures are at a high level, by depleting available moisture to 25 percent before irrigation.

M3 — Applying moisture stress to plants at both periods M1 and M2.

M4 — Control: depleting available moisture to 65 percent before irrigation during the growing season up to about 14 days before harvest.

The number of irrigations applied and dates of stress varied between locations depending on soil texture and date of planting.

Early stress occurred about May 29 on early plantings and June 13 on the later plantings and ended about June 30. The number of times potatoes came under early moisture stress ranged from 2 on the medium-textured soils to 3 on the sandy soils. Late moisture stress occurred about July 15 and ended on August 10. The number of times potatoes came under late moisture stress varied from 2 on the silt loam soil to 5 on the loamy sand. Total number of irrigations applied to the control treatment varied from 13 on the silt loam to 28 on the loamy sand. The amount of water and time of irrigations were determined by soil sampling and oven drying for available moisture and by consumptive use determined by the evapo-transpiration rate, a method developed by Wright and Jensen (12).

Nitrogen rates

The 4 nitrogen rates applied in this study were:

N1 — Fertilizer guide rate less 60 lb. N per acre.

N2 — Fertilizer guide rate as determined by soil analysis (13).

N3 — Fertilizer guide rate plus 120 lb. N per acre.

N4 — Fertilizer guide rate plus 240 lb. N per acre.

All nitrogen fertilizer was in the form of uran banded in potato beds just before or after planting. Bands were placed about 8 inches deep and 8 inches to the side of each potato row. Actual rates of N applied are listed in Table 2. Other needed nutrients, determined by soil analysis, were applied at the recommended rates to the entire experimental area.

The potatoes were planted on April 11 at location No. 3, April 13 at location 1, April 23 at location 2 and April 24 at location 4.

To collect temperature data, temperature recorders were placed 6 inches deep in center of beds after the last cultivation. These were placed in the M3 and M4 moisture treatments and the N4 nitrogen treatment.

Petioles, usually the fourth from the top of the terminal branches, were collected at 4 sampling dates, starting at early tuber set about 55 days after planting and continuing at 2 week intervals. These were oven-dried, ground and analyzed for nitrate-nitrogen by the electrode method. Samples at the first sampling date were analyzed for phosphate-phosphorus, total potassium, zinc and manganese.

On the second and third petiole sampling dates, tuber samples were collected and graded for size and malformations. When tubers reached 2 to 4 ounces in size, samples were collected from each plot and analyzed by J. R. Simplot Co. for sugars, raw fry color, dark and discolored fries, dark end and percent solids. Sampling and quality evaluation were continued at weekly intervals through harvest.

Readings on verticillium wilt were taken at 3 locations on 2 sampling dates in August.

Potatoes for the detailed study were harvested during the first two weeks in September. Samples from each plot were harvested and checked for yield and grade and sent to the Aberdeen Experiment Station for storage.

Table 2. Locations and rates of nitrogen fertilizer applied.

Nitrogen treatment	Location No. 1	2	3	4
	(Pounds N/acre)			
N1	80	120	0	140
N2	140	180	60	200
N3	260	300	180	320
N4	380	420	300	440

Weight loss was measured on March 3 and May 16, 1974. Fry color and texture readings were made on June 6, 1974, at end of storage period.

At harvest, bulk samples were taken from plots and evaluated by J. R. Simplot Co. in processing for french fries at one-week intervals during storage.

Soil samples were collected from the M3 and M4 moisture treatments after harvest to determine the amount of nitrate-nitrogen in the top 3 feet of soil as affected by nitrogen and moisture treatments.

Results and Discussion

Problems occurred at most locations some time during the growing season. At location No. 1, slow subbing of moisture into the center of beds made it difficult to maintain a desirable moisture level. Plant growth and color varied between nitrogen rates early in the growing season but, by harvest, these variations were not marked and all vines were green and growing actively.

At location No. 2, moisture control and water application presented no problem. Vine growth and color varied greatly between nitrogen rates. By the end of August very little vine growth was shown at the two low rates. Good vine color and growth were shown at the two high nitrogen rates.

At location No. 3, poor subbing of moisture into beds was also a problem. Some plots missed several water applications because of gopher holes in ditch and furrows. Variation in plant growth and color from nitrogen rates was slight. Vine color and growth were good at harvest.

At location No. 4, low water infiltration rates and high rates of application caused areas to be either too wet or too dry during the growing season. Water rot was a severe problem. A severe weed problem also existed. Some variation in plant color and growth was observed between nitrogen rates.

Moisture

The effects of moisture stress on total yield and percent No. 1 tubers (Tables 3, 4) varied between locations. Treatment M1, early moisture stress, reduced total yield and percent No. 1 tubers at 3 of the 4 locations. These locations, 1, 2 and 4, were the coarser textured soils. These locations had more malformed tubers such as pointed stem ends, bottlenecks and dumbbells. Treatment M2, late moisture stress, reduced total yield on sandy soil, locations 1 and 2, and had no great effect on percent No. 1 tubers.

Both M1 and M2 moisture treatments reduced percent total solids in tubers during the growing season (Fig. 1).

Percent reducing sugars in tubers during the growing season was increased by treatment M1 but not by M2 (Fig. 2). The higher reducing sugars caused more dark-colored french fries which is not desirable in processed potatoes.

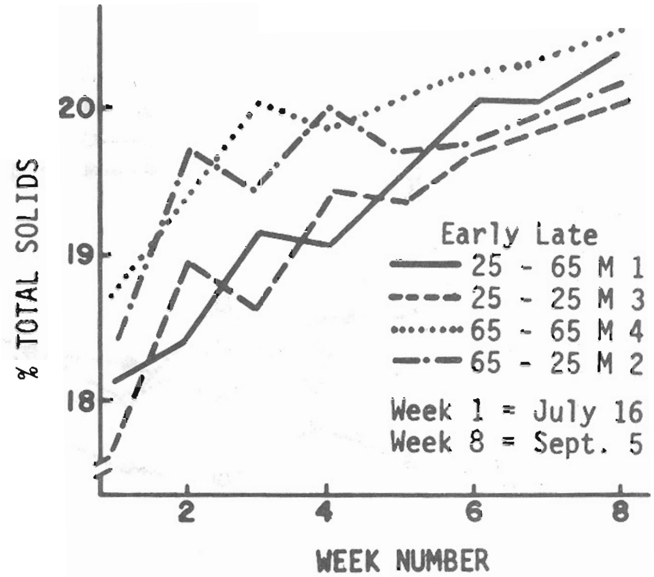

Figure 1. Total solids preharvest for 4 different moisture levels

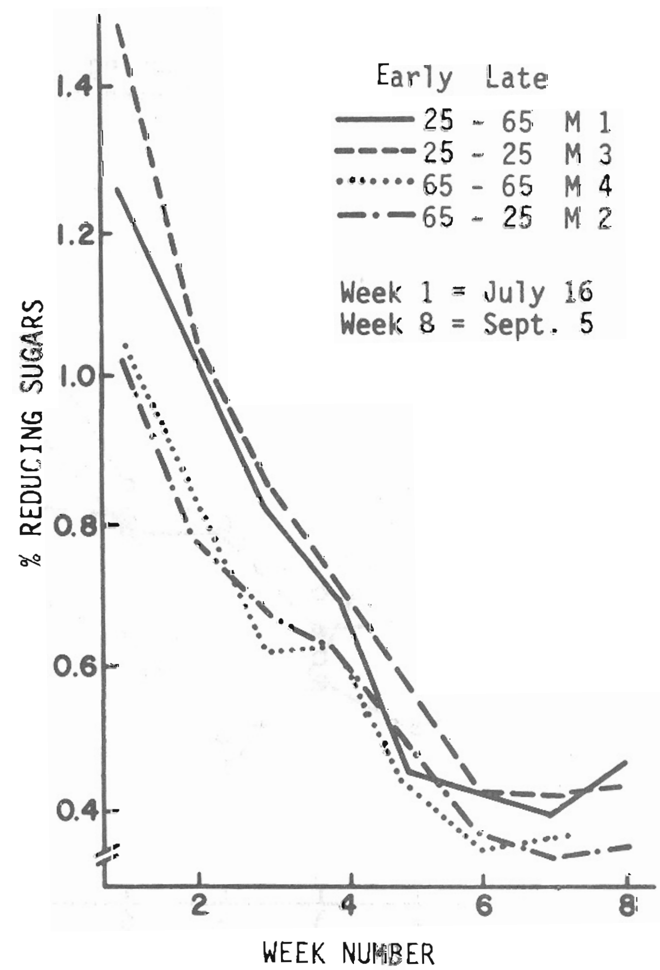

Figure 2. Reducing sugars preharvest for 4 different moisture levels

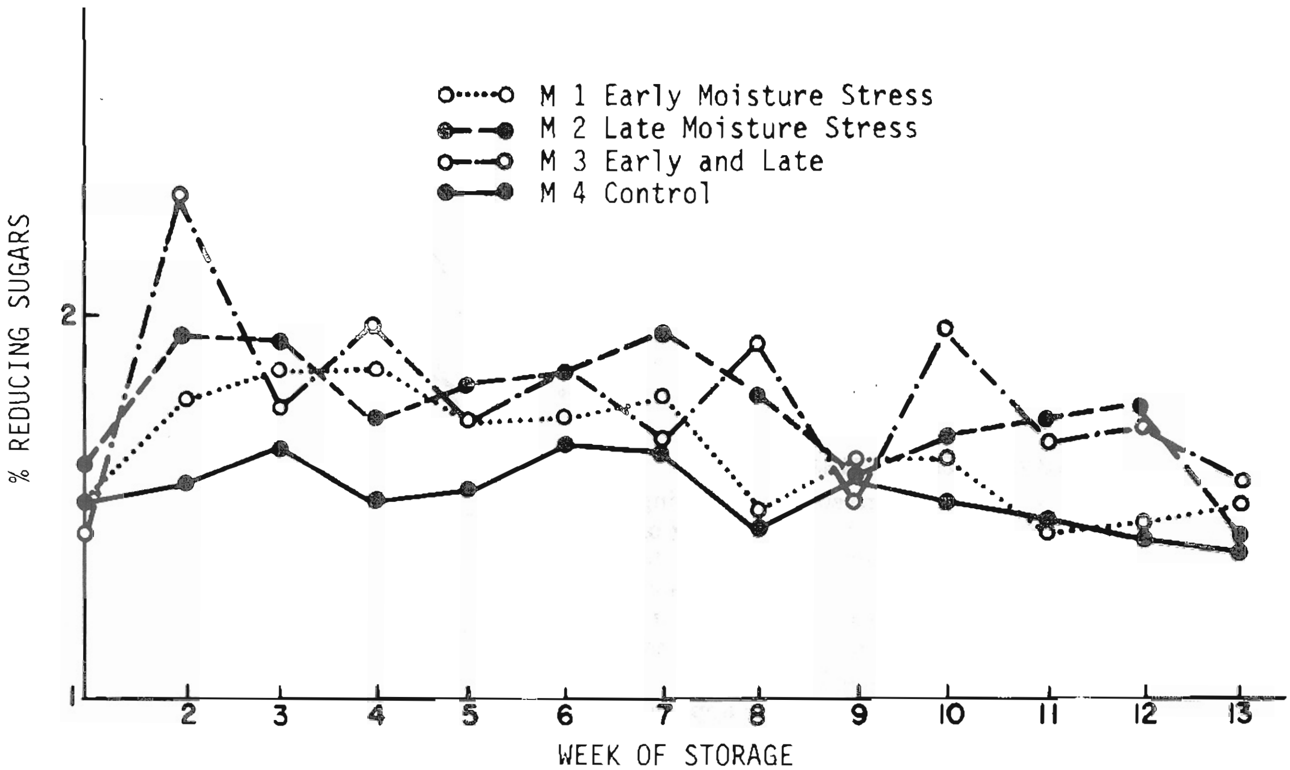

Figure 3. Percent reducing sugars in tubers during storage as affected by moisture during growing season.

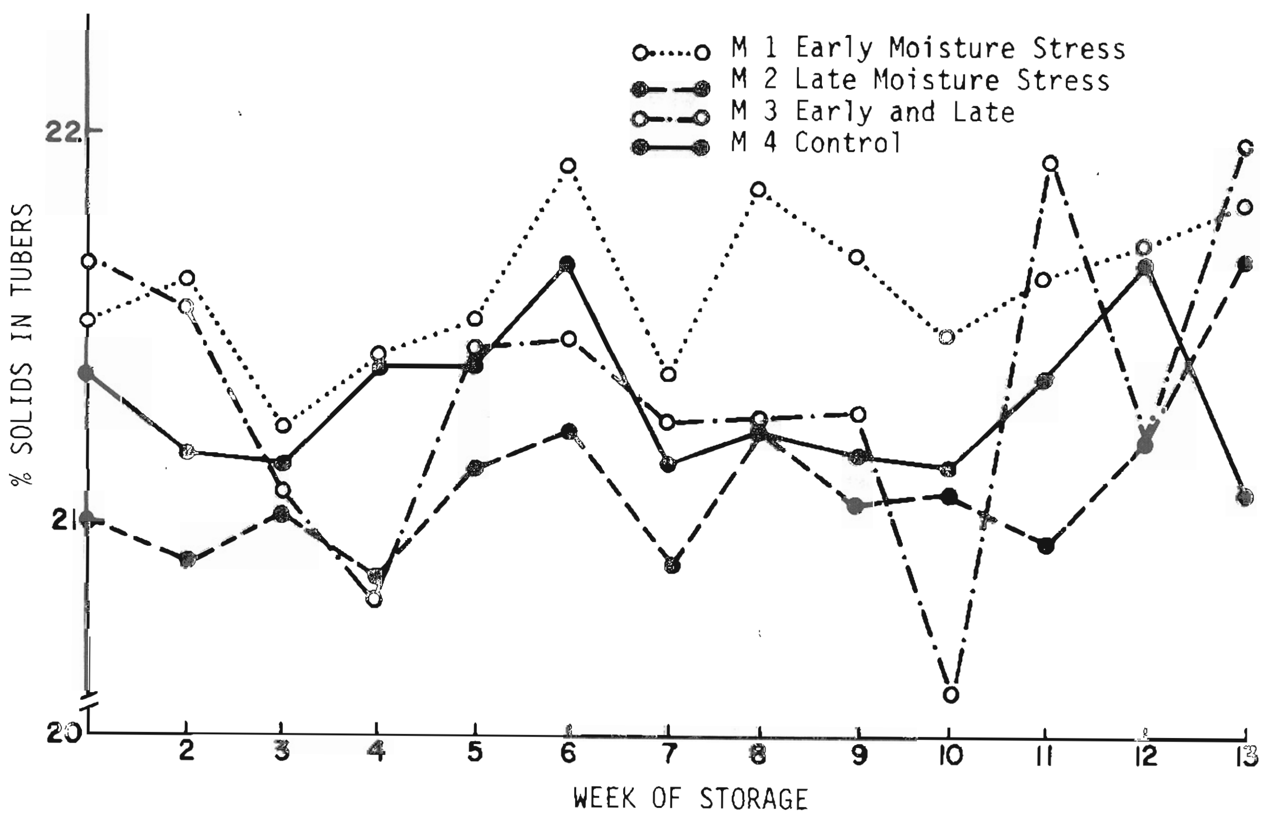

Figure 4. Percent solids in tubers during storage as affected by moisture during the growing season.

Maintaining available moisture at a high level, treatment M4, produced tubers that had consistently lower reducing sugars. The percent reducing sugars in these tubers remained relatively constant throughout the 13 week storage period (Fig. 3). Percent reducing sugars in the potatoes grown under moisture stress showed a slight downward trend during storage. After 13 weeks in storage, the effect of moisture treatment on reducing sugars was insignificant.

No differences except random effects seemed to influence the total solids for moisture levels (Fig. 4).

Moisture treatments M1 and M2 both reduced the french fry texture score after storage at Aberdeen. Fries were less mealy from potatoes grown under moisture stress. Fry color and tuber weight loss during storage were not significantly affected by moisture treatment. Fry texture varied between farms after storage, with tubers from the sandy soils showing less mealiness.

Moisture stress did not affect the incidence of verticillium wilt or early dying of vines.

Nitrogen

The highest total yield and percent No. 1 tubers were obtained with nitrogen treatment N1, 60 pounds below the recommended rate (Tables 3, 5). Total yield and percent No. 1 tubers decreased with increased nitrogen rates. Percent malformed tubers at harvest increased with increased nitrogen rates. The malformations included pointed stem ends, bottlenecks and dumbbell tubers. During the growing season, percent solids in tubers was decreased and percent reducing sugars increased with increased nitrogen rates (Figs. 5, 6). Higher nitrogen rates produced darker french fries early in season, but by harvest this effect was not a major factor.

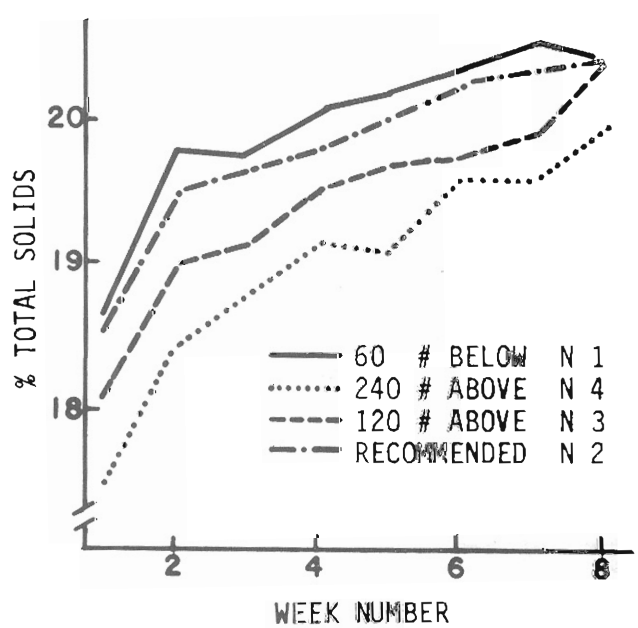

Figure 5. Preharvest % total solids for 4 nitrogen levels

Table 3. Main effects of nitrogen and moisture on yield and percent No. 1 potatoes, average for four locations, 1973.

Moisture treatment	Total yield (cwt/A)	% No. 1	Nitrogen treatment	Total yield (cwt/A)	% No. 1
M1	347	43	N1	367	52
M2	346	50	N2	343	51
M3	324	41	N3	344	46
M4	363	53	N4	318	40
Avg	345	47	Avg	343	47
LSD*	22.1	4.3	LSD*	20.7	2.7

*5% significance

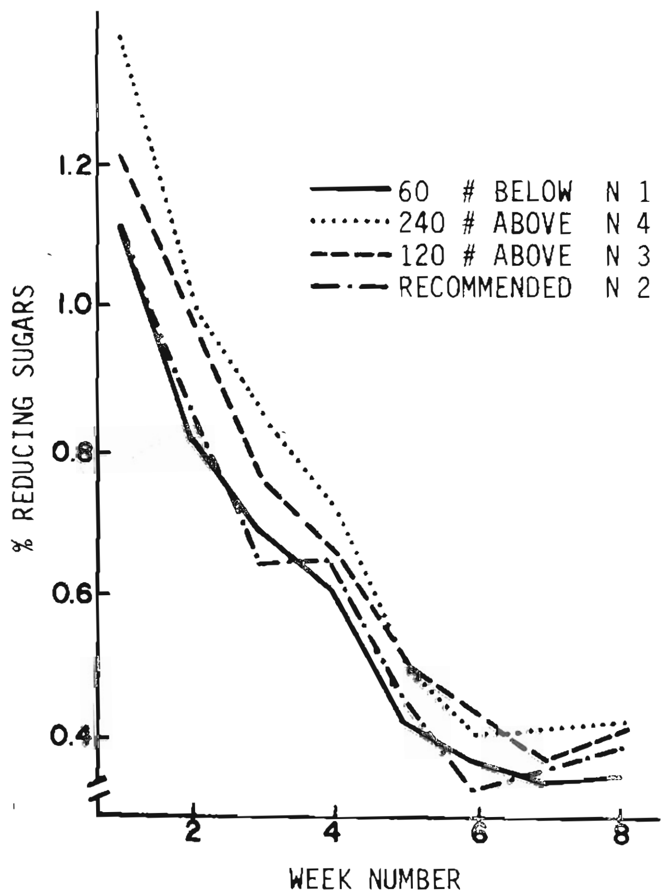

Figure 6. Preharvest % reducing sugars for 4 nitrogen levels

Table 4. Effect of moisture treatments on total yield and percent No. 1. Potatoes, 1973.

Location and variable	Moisture treatments*			
	M1	M2	M3	M4
No. 1				
Cwt/acre	454	453	427	518
% 1's	28	34	32	34
No. 2				
Cwt/acre	362	377	347	383
% 1's	63	72	67	74
No. 3				
Cwt/acre	301	266	280	272
% 1's	50	47	41	50
No. 4				
Cwt/acre	270	289	244	278
% 1's	31	45	23	53

*Moisture x Location LSD, 5% significance: Total yield, 44.3 cwt
No. 1's, 8.5%.

Although percent reducing sugars was higher with increased nitrogen rates (Fig. 7), these differences were non-significant after 13 weeks in storage at J. R. Simplot Co. The higher reducing sugar shown with high nitrogen rates declined during the storage period, while the reducing sugar content of tubers grown under low nitrogen levels was more stable. This suggests that processors should store tubers having high reducing sugars for late processing, assuming there is no difference in percent spoilage between tubers having low and high percent reducing sugars.

Percent solids were higher in tubers grown under the lower nitrogen rates (Fig. 8) and this effect was apparent throughout the 13 weeks of storage.

In the Aberdeen storage study, weight loss during storage varied between farms on both March 25 and May 16. Location 4 showed the largest weight loss (4.53 and 6.06 percent) followed by location 2 (4.31 and 5.41 percent), location 1 (3.87 and 5.13), and location 3 (3.35 and 4.29 percent).

Nitrogen fertilizer increased weight loss during storage at some locations but variation between rates and locations was not consistent so general conclusions are not possible.

The incidence of verticillium wilt or early dying of vines decreased with increased nitrogen rates.

High accumulations of nitrate-nitrogen were present in soils in the 3-foot soil depth of N3 and N4 treatments

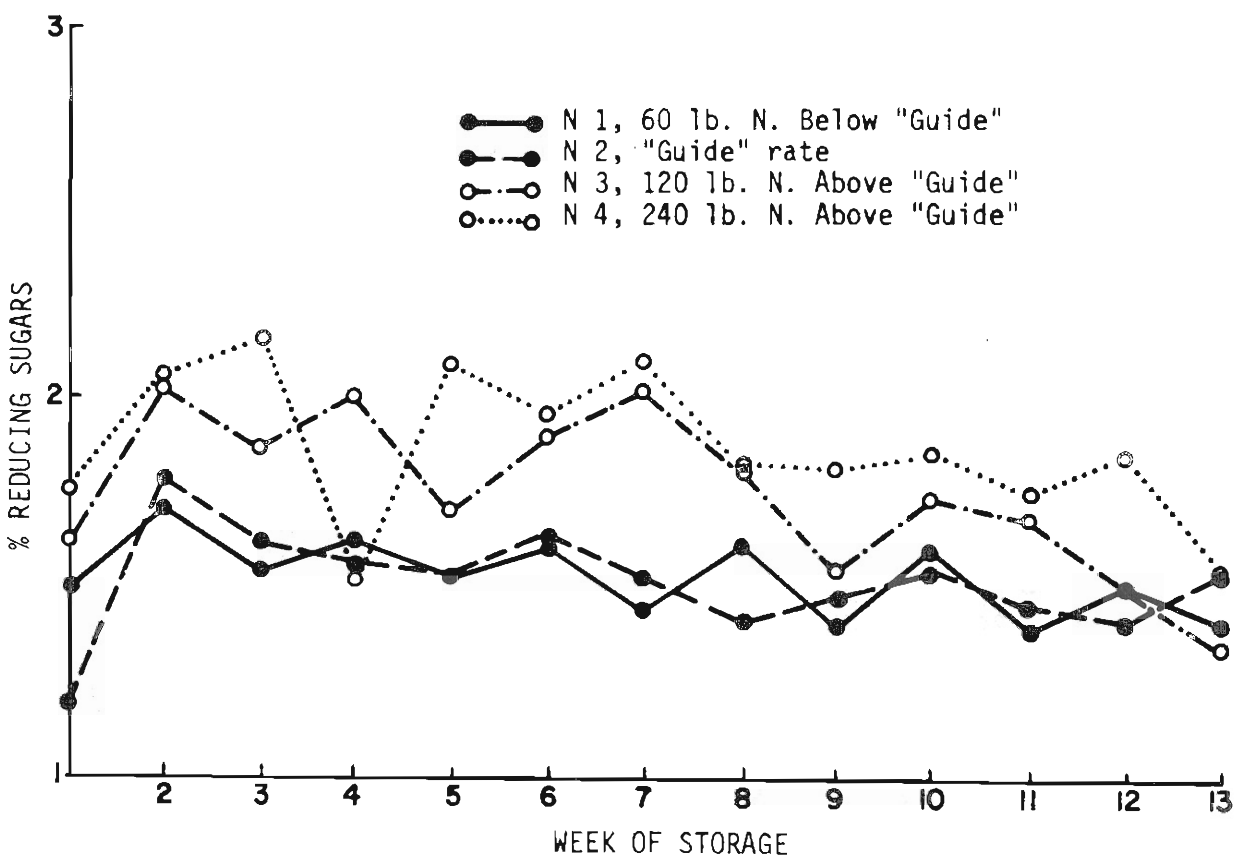

Figure 7. Percent reducing sugars in tubers during storage as affected by nitrogen rates applied at planting

following harvest. This was more evident on the medium-textured soils where N levels were high before fertilization (Table 5). High soil nitrate-nitrogen together with high fertilizer rate is conducive to high reducing sugar, low solids and reduced grade-out of No. 1 potatoes.

Nitrate-nitrogen in potato petioles increased with increased nitrogen rates (Fig. 9). Petiole levels shown in the N1 treatment were sufficient to grow the optimum yield and quality of potatoes under 1973 growing season conditions.

Soil Temperatures

Soil temperatures at 6-inch soil depth taken at Parma location during the past 5 years show that mid-July through August temperatures were highest in 1971 and 1973 (Fig. 10). These were the seasons when dark-end french fry problem was most severe.

Data from this experiment showed that moisture treatment M4 appeared to lower the soil temperature slightly during the growing season (Fig. 11). The sandier soils showed higher soil temperatures from early season through August 10 (Fig. 12).

Table 5. Effects of nitrogen rates on yield and grade of potatoes and nitrate-nitrogen in soil after harvest, 1973.

Location and soil type	Fertilizer rate (lb.N/A)	Nitrate-nitrogen, ppm at three soil depths (inches) 12	24	36	Total yield*** (cwt/A)	Percent No. 1***
1. Fine sandy loam soil	80	25	9	7	492	39
	140*	23	9	5	485	38
	260	21	19	13	440	27
	380	35	16	15	403	24
Soil test**		9	17	-	-	-
2. Loamy sand soil	120	4	3	4	386	73
	180*	4	5	14	368	74
	300	5	13	10	372	67
	420	6	36	31	344	62
Soil test**		8	7	-	-	-
3. Silt loam soil	0	32	24	30	293	50
	60*	64	44	35	249	49
	180	62	46	40	292	48
	300	196	97	65	282	40
Soil test**		40	60	-	-	-
4. Loam soil	140	8	5	2	293	44
	200*	4	7	3	270	42
	320	11	11	7	272	43
	440	33	39	12	245	33
Soil test**		9	11	-	-	-

*Fertilizer guide rate, from soil analysis.
**Nitrate-nitrogen (ppm) in soil test before fertilization.
***Nitrogen x location LSD, 5% significance: total yield, 41.4 cwt; No. 1's, 5.4%.

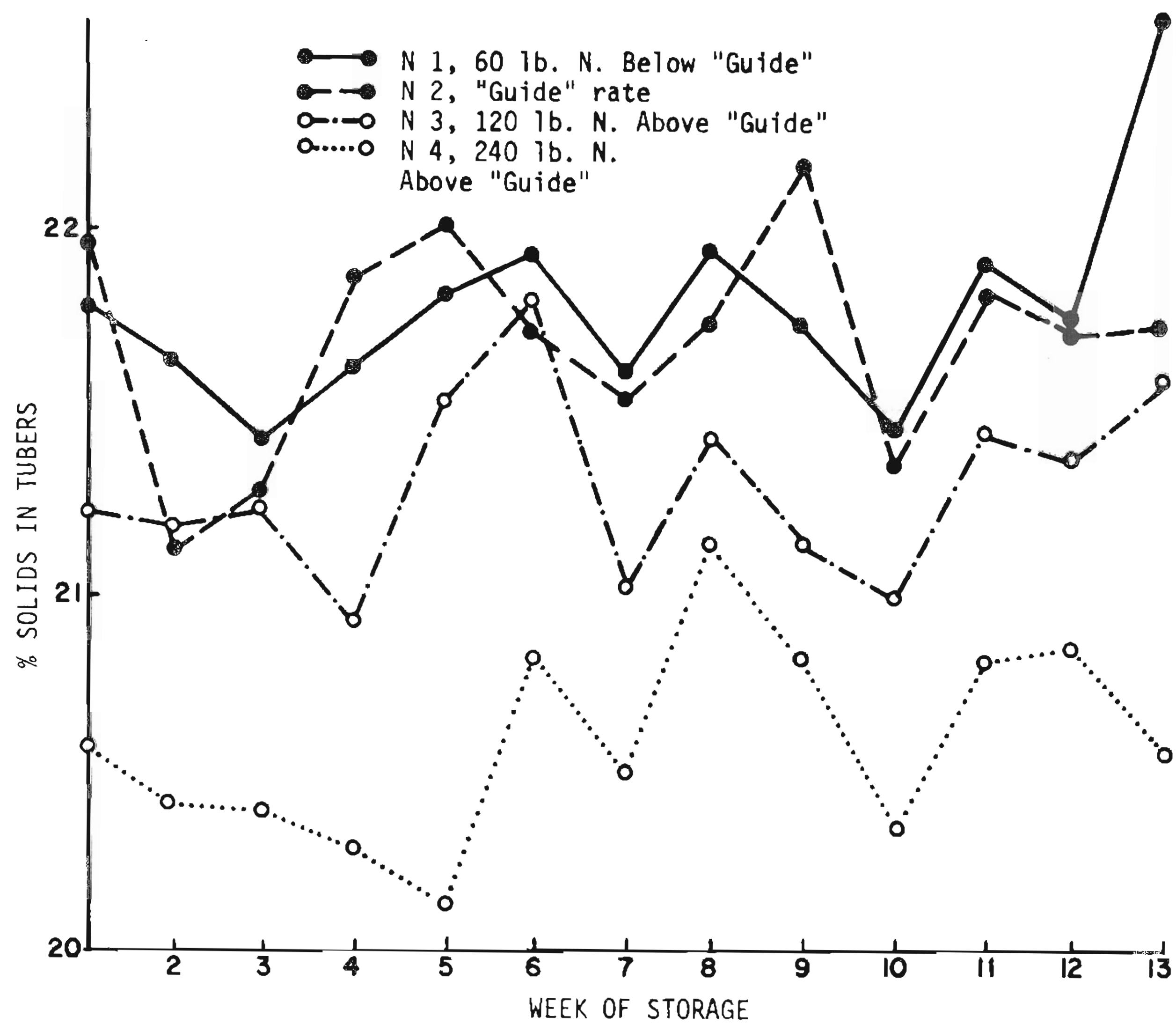

Figure 8. Percent solids in tubers during storage as affected by nitrogen rates applied at planting

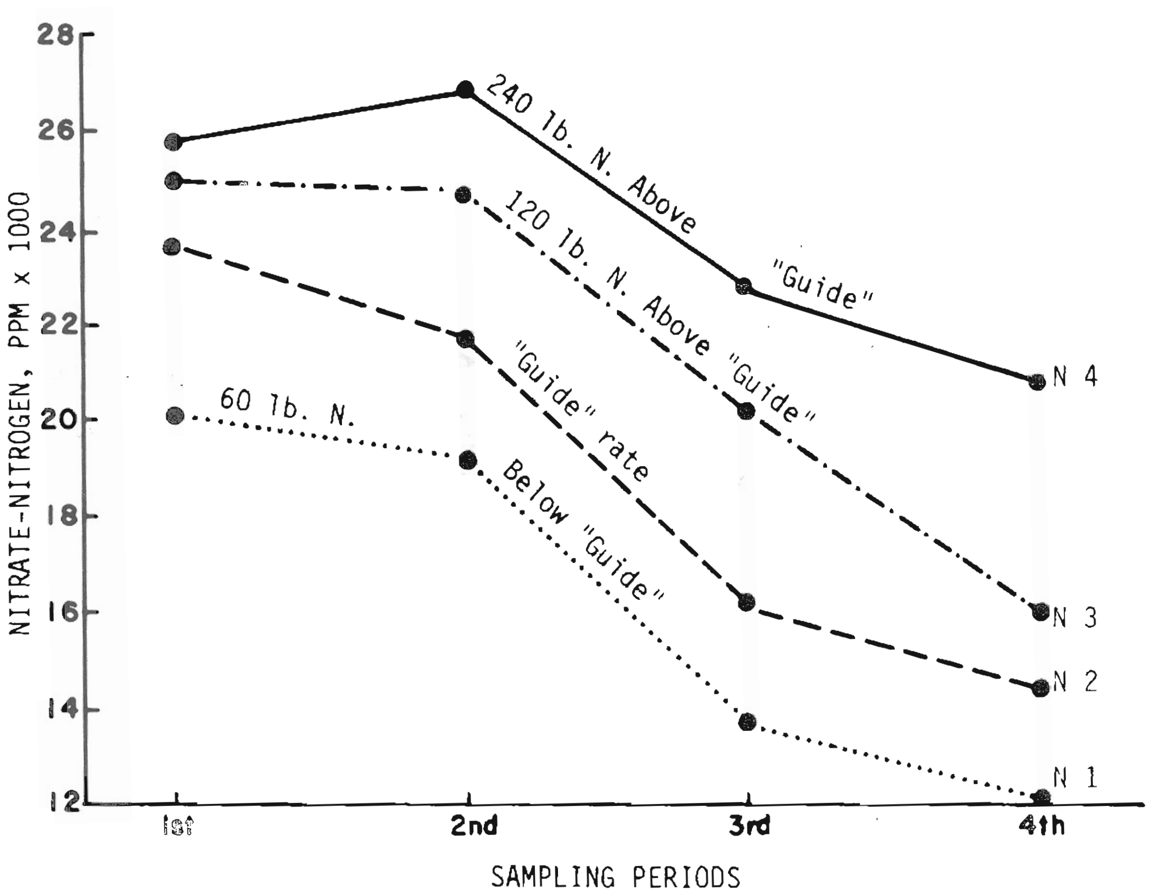

Figure 9. Nitrate-nitrogen in potato petioles as affected by Nitrogen rates and time of sampling. Average of four locations.

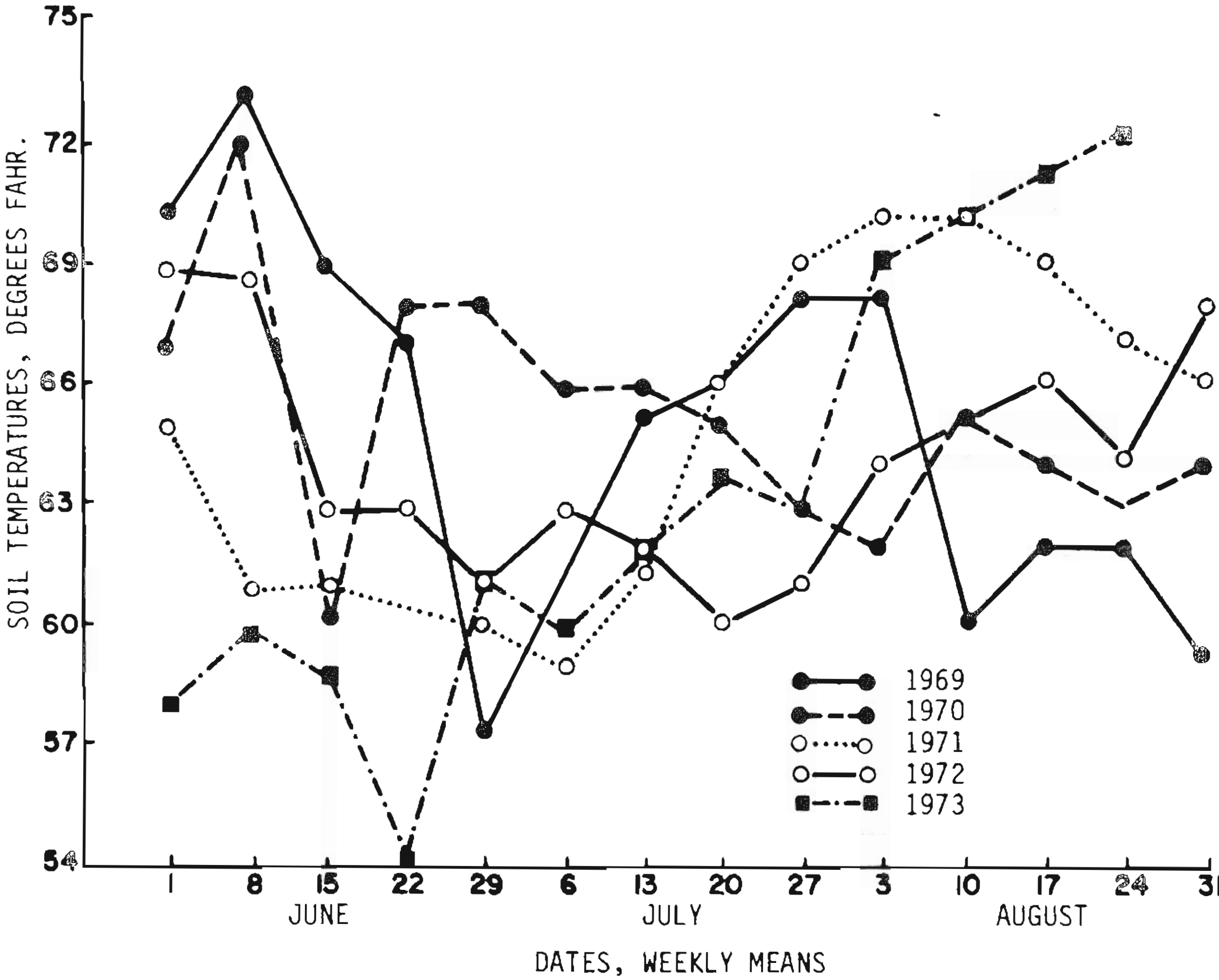

Figure 10. Comparing soil temperatures at six inch soil depth during growing season for period 1969-73. Silt loam soil.

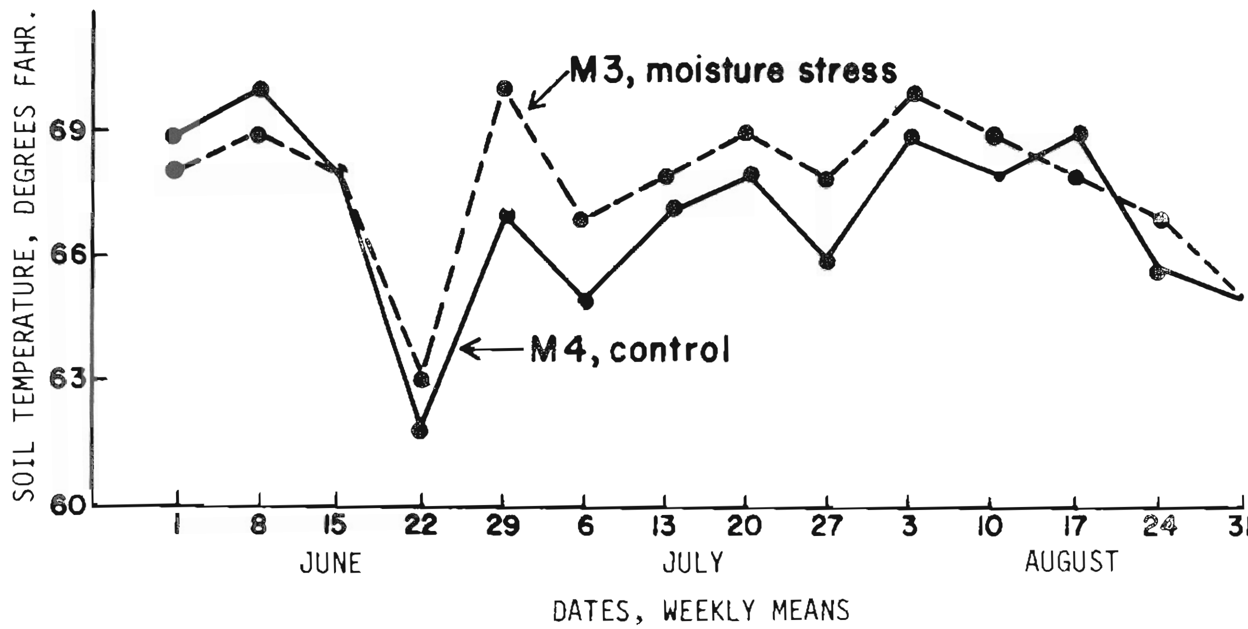

Figure 11. Soil temperatures at six inch soil depth as affected by moisture during the growing season. Average of four locations.

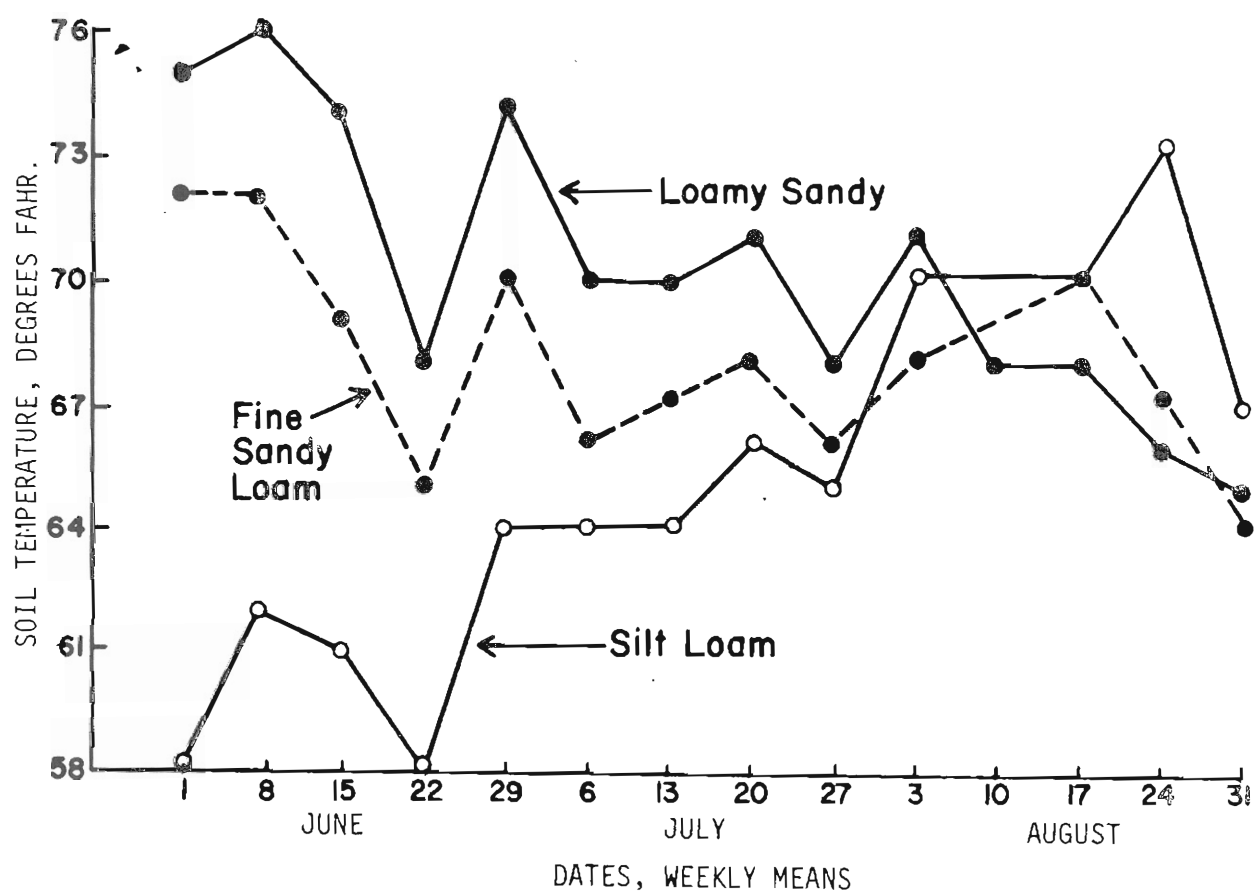

Figure 12. Soil temperatures at six inch soil depth as affected by soil texture during the growing season.

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