Management practices & sugar end potatoes

Introduction

French fries processed from sugar end potatoes become undesirably dark on one end while remaining light on the other (fig. 1). The darkening is usually caused by a higher concentration of reducing sugars in the darkened end of the fry strip. Sugar ends are associated with tubers that are pointed on the stem end but also occur in ideally shaped tubers.

"Translucent end," "jelly end," and "sugar end" describe the same physiological tuber problem. Translucent end tubers with high levels of sugars develop jelly end rot after progressive tissue breakdown occurs. The Russet Burbank variety is particularly susceptible to sugar end formation when subjected to water and heat stress.

Heat and water stress

Cultural or management practices that increase the potato plant's susceptibility to heat or moisture stress during tuber initiation and bulking can cause sugar end development. Tubers are particularly sensitive to stress during the early bulking phase (fig. 2A). Sugars can also develop in tubers weeks or even months after the environmental stress occurred.

Irrigation practices

Irrigation system

The irrigation system and its management have a major influence on the incidence of sugar end tubers. Potatoes grown under sprinkler irrigation usually have a higher proportion of U.S. No. 1 tubers and a lower incidence of sugar end tubers than potatoes grown under furrow irrigation. Properly designed sprinkler systems make adequate, uniform water applications that cool the potato plants and soil and reach the roots concentrated in the upper 18 inches of the beds.

Under furrow irrigation, water must sub-up to wet the bed above the furrow bottom. Straw mulching in irrigated furrows after layby can help water sub-up, particularly on steeply sloping fields.

Reservoir tillage should be used under sprinklers if runoff is a problem. Sprinkler flow-control nozzles also may be helpful where water distribution is poor.

Irrigation management

Potato plants use the most water during tuber initiation and bulking (fig. 2A), and this is when potatoes are most susceptible to stress-related sugar end problems. (Tuber initiation starts when swelling is visible on the ends of the stolons.) Failure to maintain adequate soil moisture can cause sugar ends, especially when coupled with high temperatures.

Management checklist

1. Choose fields with the potential to grow a quality crop. Avoid fields having saline, steep, shallow, or high-bulk-density soils.
2. Plant potatoes after small grains, corn, or other crops that leave significant residues after harvest.
3. Rotate crops to reduce buildup of potato diseases and insects.
4. Bed soil in the fall when weather and soil conditions permit and when wind erosion is not a factor.
5. Reduce bed widths from 36 to 34 inches, particularly under furrow irrigation.
6. Avoid overfertilization, especially with nitrogen.
7. Use sprinkler irrigation systems on fields with variable soil types and slopes.
8. Apply straw mulch in steeply sloping furrows; use basin tillage under sprinklers where runoff is expected.
9. Delay the first irrigation until after plants emerge when soil moisture permits.
10. Minimize plant water stress by monitoring and maintaining an adequate level of plant-available soil water in the crop's active rooting zone. This is especially critical between tuber initiation and the end of tuber bulking.
11. Harvest and process stressed crops early when possible.

Irrigations may be scheduled by one of two strategies: (1) soil moisture monitoring or (2) replacement of water lost by crop evapotranspiration. With either strategy, check fields daily to ensure adequate soil moisture.

Irrigation scheduling using a calendar technique usually increases the risk of developing sugar end tubers. Overirrigating does not reduce the level of sugar ends below that found in ideally irrigated fields nor does it increase tuber yields. Excess water early or late in the season can aggravate early plant death and water rot problems, respectively.

The plant-available soil water should decrease to 50 percent by vine kill to promote skin maturation and tuber lenticel closure.

Soil moisture monitoring method — Irrigating according to soil moisture status depends on knowing (1) when the soil water supply needs to be replenished, (2) how much water the crop's root zone can hold, and (3) the capabilities of the particular irrigation system. Several methods are available to determine soil moisture status (tensiometer, Watermark sensor, gravimetric, and hand feel). Contact your local potato specialist, Extension agricultural agent, or industry specialist for information on their correct use.

In general, the lowest incidence of sugar ends in silt loam soils occurs when soils are irrigated before soil moisture sensors (placed at the seed-piece depth) reach a soil water potential of -60 kPa (100 kPa = 100 centibars). Suggested potentials for other soil textures are -35 kPa for sandy soils, -50 kPa for sandy loam soils, and -70 kPa for silty clay loam soils. A greater soil moisture deficit (more negative potential) that coincides with high temperatures is always associated with an increased incidence of sugar ends. An example of irrigation management using soil water potential is given in figure 2B.

Each irrigation should replenish only the soil water in the crop's active rooting zone. Any additional water will be lost from the root zone by deep leaching.

Base application amounts on the allowable depletion for each soil texture. Typical allowable depletion amounts for light-, medium-, and heavy-textured soils are 0.6, 1.0, and 1.5 inches of water per foot of soil depth, respectively. Between 0.8 and 1.2 acre-inches are sufficient to replenish the rooting zone of medium-textured soils.

Evapotranspiration method — Use the evapotranspiration method to irrigate fields with variable soil areas. This method uses meteorological data to estimate crop water use during plant development and growth. This estimate is combined with information on soil type, potato variety, and irrigation system to schedule irrigations.

The first irrigation should replenish the soil moisture in the upper root zone (18 inches) to the soil's field capacity. Base the allowable depletion between following irrigations on a water budget computed from the plant-available soil water held between field capacity and some allowable depletion level (usually 40 percent of the amount between field capacity and the permanent wilting point) and the crop's water use since the last irrigation. Base the allowable depletion on the soil type with the lowest water-holding capacity. Apply sufficient water with each irrigation to completely replenish the soil water in the crop's rooting zone to the soil's field capacity. This irrigation schedule should be very similar to that based on the soil moisture method (fig. 2B) for uniform soil conditions.

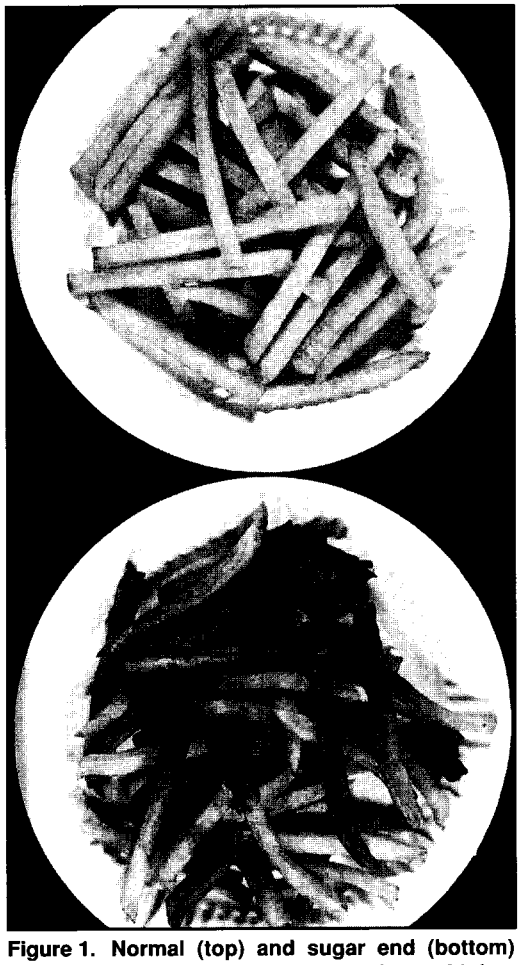


Figure 1. Normal (top) and sugar end (bottom) french fries from potato tubers with low and high levels of reducing sugars.

Cultural practices

Crop rotation

Plant potatoes after small grains, corn, or other crops that leave large amounts of residue. Shallow incorporation of residue promotes soil aeration, water infiltration, and lower soil bulk density. Do not plant potatoes after sugarbeets or onions because they leave low levels of crop residue and harvesting them can compact soil. Frequent cropping of a field in potatoes increases soilborne potato diseases, which interfere with root development and water uptake.

Field choice

Fields intended for potato production must have an adequate water supply and an irrigation system capable of meeting peak crop water demands. They should also be relatively free of soilborne potato diseases. Nema-

todes, Verticillium wilt, and other diseases interfere with root health and increase the susceptibility of the plant to water and heat stress. Fumigate soils with high levels of nematodes and diseases before planting.

Avoid saline and high-sodium soils and soils with high levels of residual nitrogen. Sprinkler irrigate exposed calcareous subsoils (white soil areas) and fields with variable soil textures; manage them separately. Fields with extremely variable soils may be unsuitable for potato production. Infiltration rates on heavy-textured soils may be too low for potato production. Light-textured soils (e.g., sand) require frequent irrigations because of their low water-holding capacities.

Tillage

Avoid any tillage practice that compacts the soil and forms clods. Consider fall bedding where soil conditions are usually wet at spring planting and where wind erosion is not a problem. Slightly moist to dry soils are preferred before fall tillage and bedding.

Shallow incorporate crop residues to improve water infiltration. Do not use deep tillage to break hardpan or tillage layers in furrow-irrigated fields because leaching losses may increase. Excessive tillage before planting may cause soil compaction problems.

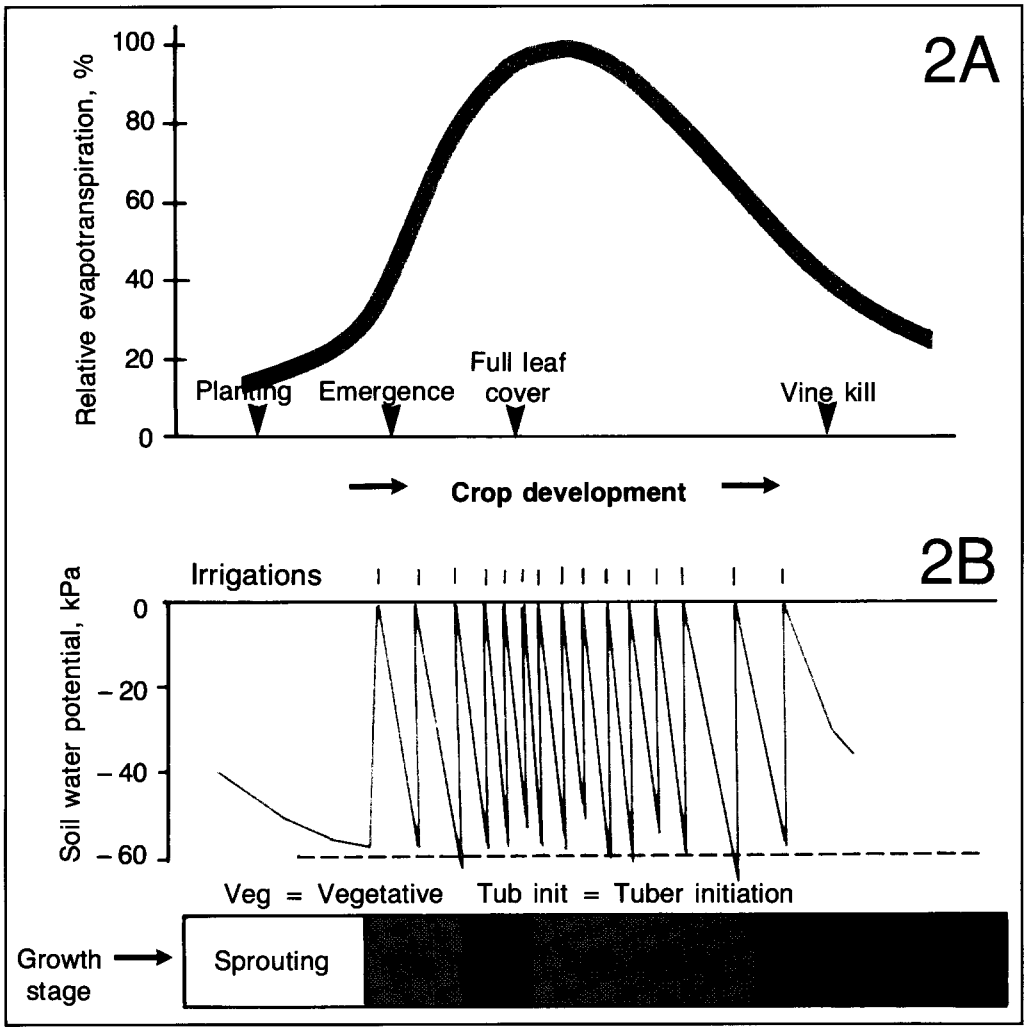
Make the last cultivation before plant emergence and preferably before the first irrigation. Cultivation after emergence may prune roots and accelerate soil moisture loss, hastening the onset of plant moisture stress.

Fertilization

Start the production year with a good soil sampling and testing program and then follow fertilizer recommendations developed for your production area. Soil testing identifies fields with high residual nitrogen carryover (nitrate plus ammonium) from previous crops, with salt problems, and with a need for additional fertilizer. (The residual nitrogen left after alfalfa is generally not an accurate indicator of the nitrogen available because it fails to account for nitrogen yet to to be mineralized from the plant's residues.) Variable soil areas within a field should be sampled and fertilized separately.

The high rates of preplant fertilizer nitrogen may stimulate growth of excessive vegetation and delay the start of tuber bulking. They also increase the plant's susceptibility to stress. Apply one-half to one-third of the total nitrogen requirement preplant if you intend to apply nitrogen in the irrigation water during tuber bulking. Nitrogen applied in the irrigation water during crop growth can be effective, provided it doesn't wash off the field or leach below the root zone.

Always base nitrogen applications during growth on soil and petiole nitrate-nitrogen concentrations. Petiole nitrate concentrations higher than recommended sensitize the plant to



Figures 2. The relationship between relative evapotranspiration (water use) by a well-watered potato crop and plant growth stage (2A), and the scheduling of irrigations according to soil water potential on a silt loam soil (2B).

environmental stresses and can lead to sugar end development, tuber shape problems, or both. Nitrogen applications within 30 days of vine death are not recommended. Monitor other petiole nutrient concentrations and take corrective measures when needed.

Planting

Planting healthy seed (about 2 ounce) when soil temperatures are higher than 45°F at the seed piece depth accelerates plant emergence and development. Early emerged plants and uniformly spaced plants shade a larger percentage of the total soil surface during early tuber development and help reduce soil temperatures.

The incidence of sugar end tubers is greater with 36-inch beds than 34-inch beds, particularly under furrow irrigation. The narrower bed spacing promotes earlier shading of the soil surface, helping to reduce soil temperatures at critical times and promoting faster water movement to the seed piece. Placing the seed piece deeper than 3 to 4 inches below the original soil surface delays emergence and row closure.

Harvest timing

Stressed potatoes develop sugar end symptoms as maturity increases. Test fields suspected of being stressed during tuber bulking. To minimize losses, consider early harvest and processing of tubers with high levels of reducing sugars.

Production problem or condition	*Management method for correction*
1. Compacted, cloddy soils.	1. Delay tillage until soil dries; incorporate high-residue crop; plant another crop.
2. Poor water infiltration.	2. Avoid compaction; incorporate crop residues; use properly designed sprinkler irrigation system.
3. Variable soil areas; white and dark soils in the same field.	3. Test soil and fertilize separately; use crop evapotranspiration water management method and sprinkler irrigation.
4. Steep slopes.	4. Use sprinklers with flow controllers; use reservoir tillage; add straw in irrigated furrows.
Irrigation	
5. Plants appear water stressed, plants are dark, and soil moisture potential is high.	5. Irrigate as soon as possible; keep soil moisture potential in desirable range.
6. Poor water distribution with sprinklers.	6. Check nozzle size, wear, pressure, and coverage pattern; use flow controllers.
Climate	
7. High temperatures during tuber initiation and bulking.	7. Irrigate frequently; plants need more water than normal amount.
Nutrition	
8. Excess residual nitrogen before planting.	8. Plant another crop.
9. Petiole nitrate-nitrogen becomes low within 30 days of harvest.	9. Do not apply nitrogen after August 15 or within 30 days of harvesting an early crop.
10. Petiole concentrations of other nutrients become low.	10. Apply the necessary fertilizers if not within 30 days of vine kill.
Other	
11. Hilling, last cultivation.	11. Best done before plant emergence; do not cultivate after plants are 5 to 6 inches tall.
12. Sugar end potatoes at harvest.	12. Avoid long-term storage if possible.

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