

SOIL MOISTURE BASED IRRIGATION SCHEDULING TO IMPROVE CROPS AND THE ENVIRONMENT

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Summary

In an attempt to improve crop production and protect water quality, some growers have started using irrigation scheduling based on soil moisture. In this trial, soil moisture was monitored using Watermark Soil Moisture Sensors and Hansen units. Six Watermarks and a temperature gauge were attached to each Hansen unit. Seven Hansen units were placed in different crop fields to aid in irrigation scheduling. Water was applied to the crop when the soil reached a certain moisture criterion, according to the sensors. The criteria varied depending on the crop.

Introduction

Groundwater contamination from agricultural pesticides and nutrient contamination is a major environmental issue in the part of Malheur County, Oregon, under intensively irrigated agricultural production. Excess water from irrigations can leach nutrients from the soil and can carry these nutrients and pesticides to ground water through percolation. Additionally, surface water receives sediment and nutrient runoff from agricultural irrigation. Erosion is increased by excess water or unneeded irrigations. Irrigation management by soil moisture measurement reduces the amount of water applied to a crop and reduces excess water, while maintaining a soil moisture that is ideal for crop production.

Compared to sprinkler and drip irrigation, furrow irrigation causes more erosion and deep percolation. Sprinkler and subsurface drip irrigation permit more precise control of the timing and amount of water applied than furrow irrigation, facilitating the accurate management of crop root-zone soil moisture. Excessive use of water with any type of irrigation can cause leaching of nutrients, which can reduce crop productivity and increase water loss to the ground and surface water systems.

Crop yields and quality in Malheur County are directly related to the quality of irrigation management. Watermark Soil Moisture Sensors (Irrrometer Co., Inc., Riverside, CA) have been used for managing soil water in potatoes and irrigation scheduling by growers in Malheur County since the late 1980's and that use has expanded to onions and other crops. We have shown that onion yield and grade and the growth of poplar

trees are closely related to irrigation scheduling and maintenance of soil water potential (SWP) within narrow limits.

Growers need easy and convenient ways to monitor soil moisture status to improve their irrigation scheduling. In the past we have developed irrigation criteria based on soil water potential for onions, potatoes, and poplar trees grown in silt loam soils of the Treasure Valley. The soil water potential has been read daily using Watermarks and a manual meter. The daily readings have been logged and graphed, showing the drying trends of the soil. We examined the AM400 Soil Moisture Data Logger with Graphic Display ("Hansen unit") (M.K. Hansen Co., East Wenatchee, WA) to see if it would aid in providing the information that growers need in a convenient form. The Hansen unit reads the sensors every 8 hours and the data are immediately available in graphical form to the grower by pressing a read button on the front of the unit.

Materials and Methods

Setup in 2002

Hansen units were placed in fields at the Malheur Experiment Station and nearby farms. The crops included onion, potato, alfalfa, mint, and sugar beet. The Hansen units were mounted on 4- by 6-inch posts, and were set facing north. The posts themselves were placed in an area that was judged to be representative of the entire field.

Six granular matrix sensors (GMS, Watermark Soil Moisture Sensor model 200SS) were installed at 10-inch depth (depth to the bottom of the sensor) in the crop rows in seven fields (Table 1). The GMS were checked for operation by measuring the sensor dry and saturated before installation. The presoaked GMS were installed directly in the center of the crop rows for furrow-irrigated and drip-irrigated onions and sugar beets. For potatoes, the sensors were located at 10-inch depth, and between two plants, 4 inches off of the center of the hill. Sensors were installed with the aid of a 7/8-inch-diameter soil probe. The sensor was pressed to the bottom of the soil probe hole with an insertion rod, 2 oz of water were poured into the hole, soil was gently packed above the sensor, and the hole was filled with dry soil, leaving the soil level with little trace of installation except the wires coming out of the soil.

An additional 50-125 ft of wire was added to each of the GMS before installation and attachment to the Hansen units. This extra wire allowed the grower to spread the sensors over a wider area of the field. Insulation was stripped off of the GMS wire and the GMS was connected to an 18-gauge copper wire using a butt connector adapter (4*260-5, 3M Highland) and shrink tubing, (3KH56-7, W.W. Grainger). The other end of the wire was connected to the Hansen unit. Six GMS and one temperature probe were connected to the Hansen unit starting at the double portal no. 1 and ending with the temperature probe connected to portal no. 7.

Irrigations could follow specified SWP criteria during the season. Water was to be applied to the crop when the soil reached a certain crop-specific SWP. The SWP is

allowed to oscillate through the season, from saturated soil to the given criterion for the specific crop. The irrigation decisions were made by the grower or the experiment station personnel responsible for a specific field.

Results and Discussion

Drip-irrigated Mint

Although no irrigation criterion has been established for mint, it appears that this crop was allowed to get too dry twice during the season, around days 166 and 195 (Fig. 1). The rapid drying on day 195, as seen on the graph as a sharp spike, may have been partially the result of the extremely high temperatures. The drop in SWP at the end of the season, beginning on day 225, reflects the end of the irrigation for the season.

Sprinkler-irrigated Alfalfa

The irrigation criteria for alfalfa at this site was thought to be approximately -70 kPa. The SWP irrigation criterion was generally followed (Fig. 2), but the crop became too dry near day 205 and near days 233-234. The dry conditions on day 205 coincided with a planned harvest. Irrigation depended on the growth stage of the alfalfa. The alfalfa was harvested on days 148, 176, 205, and 252. The SWP was allowed to fall at these times. Following harvest, irrigation water was applied.

Sprinkler-irrigated Potato

The SWP irrigation criterion for sprinkler-irrigated potatoes is known to be -60 kPa for silt loam soils in the Treasure Valley (Eldredge et al. 1992, 1996). The irrigations of this crop were scheduled relatively close to this criterion (Fig. 3). Two partial irrigations at the end of the season are shown in the graph. The field contained both early and late maturing potato varieties. Water was applied using partial irrigations at the end of the season to avoid soil saturation and prevent rot of the early potato varieties while still providing water for the late potato varieties in these trials.

Drip-irrigated Onion, First Commercial Field

The SWP irrigation criterion for drip-irrigated onions on silt loam is known to be -20 kPa (Shock et al. 2000). By looking at the frequent irrigations, this crop appears to have been carefully managed close to the irrigation criterion determined (Fig. 4). The crop was allowed to get too dry on days 175-176. The SWP reached -54.6 kPa mid-day on day 176.

Drip-irrigated Onion, Second Commercial Field

Again, in this field, the SWP irrigation criterion for drip-irrigated onions is -20 kPa. The soil became too dry on days 174-176 and 187-188 reaching -45 and -46.8 kPa respectively (Fig. 5). During 163-170, 178-184, and 190-226 the SWP was maintained too wet. The soil was kept too wet for a large part of the season, which risks onion decomposition in storage. Denitrification and leaching losses of N fertilizer and N available in the soil often occurs when soil remains very wet for a prolonged period. The drop in SWP, beginning on day 226, indicated the end of the irrigation season.

Furrow-irrigated Onion

The SWP irrigation criterion for furrow-irrigated onions on silt loam is known to be -20 kPa (Shock et al. 1998). This criterion was maintained for most of the season (Fig. 6). On July 3 (day 184) and July 9 (day 190) the crop was allowed to become too dry, -40 and -68 kPa, respectively. Just before and through day 190 the field was weeded and the weeds were allowed to dry in an attempt to reduce weed pressure. At that time, temperatures were high. Consequently, evaporation and evapotranspiration occurred at much quicker rates. The drying trend that began on day 234 represents the end of irrigation before harvest.

Furrow-irrigated Sugar Beet

The ideal criterion for sugar beets is estimated to be between -40 and -50 kPa. This crop had a regular pattern of irrigation (Fig. 7). The crop was irrigated at a criterion of near -70 kPa through mid-July and at a criterion of -30 kPa later in the season.

Conclusions

The Hansen units were a very effective irrigation scheduling aid where used. In two of the seven fields it appears that the information generated by the Hansen units was not consulted by the irrigator.

References

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- Eldredge, E.P., C.C. Shock, and T.D. Stieber. 1992. Plot sprinklers for irrigation research. *Agron. J.* 84:1081-1084.
- Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 1998. Onion yield and quality affected by soil water potential as irrigation threshold. *HortSci.* 33:1188-1191.
- Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2000. Irrigation criteria for drip-irrigated onions. *HortSci.* 35:63-66.

Table 1. Hansen units were installed in 7 crop fields during the 2002 crop season. Malheur Experiment Station, Oregon State University, Ontario, OR.

Crop	Irrigation system	Location	Depth to the bottom of the 5 or 6 shallow sensors
			inches
1. Mint	Drip	Cooperating	10
2. Alfalfa	Sprinkler	MES Field A2	10
3. Potato	Sprinkler	MES field D1b	10
4. Onion	Drip	Cooperating	10
5. Onion	Drip	Cooperating	10
6. Onion	Furrow	MES Field D1c	10
7. Sugar beet	Furrow	MES Field B6a	10

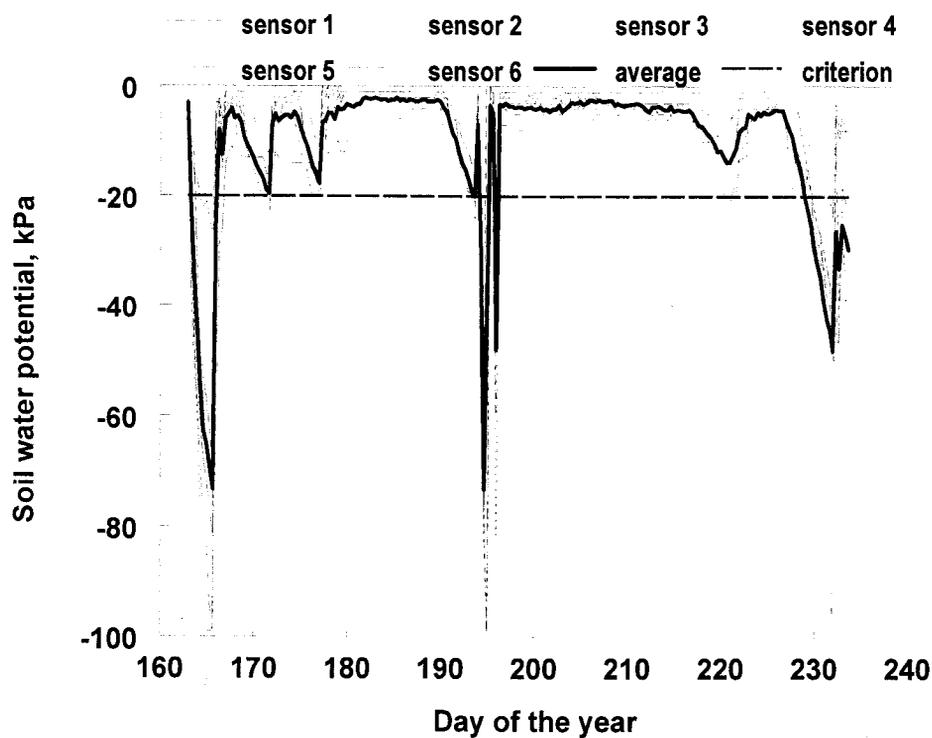


Figure 1. Soil water potential at 10-inch depth in drip-irrigated mint as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

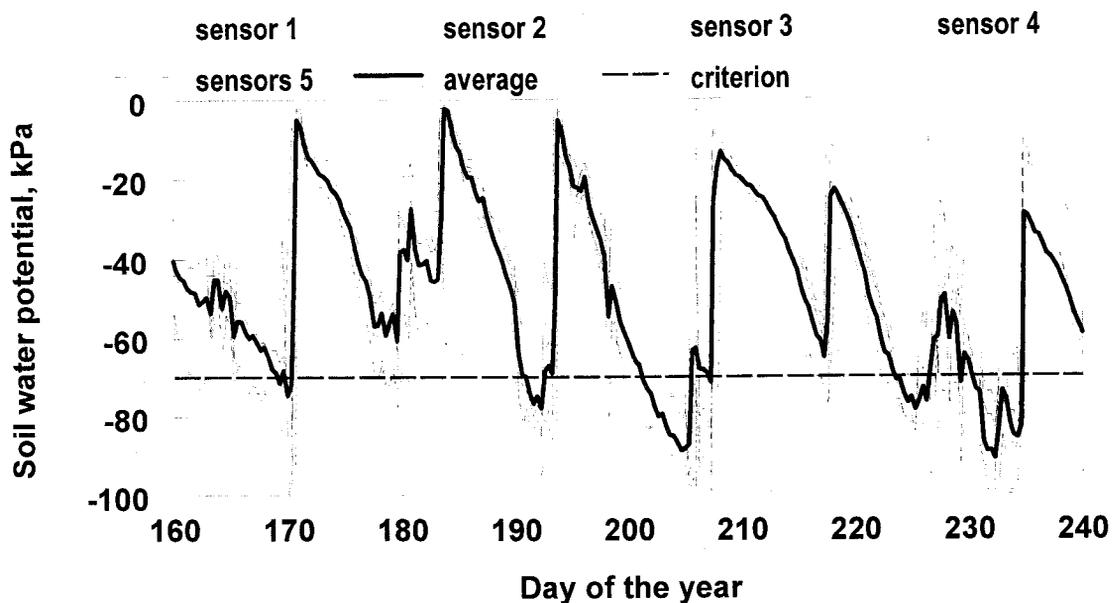


Figure 2. Soil water potential at 10-inch depth in sprinkler-irrigated alfalfa as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

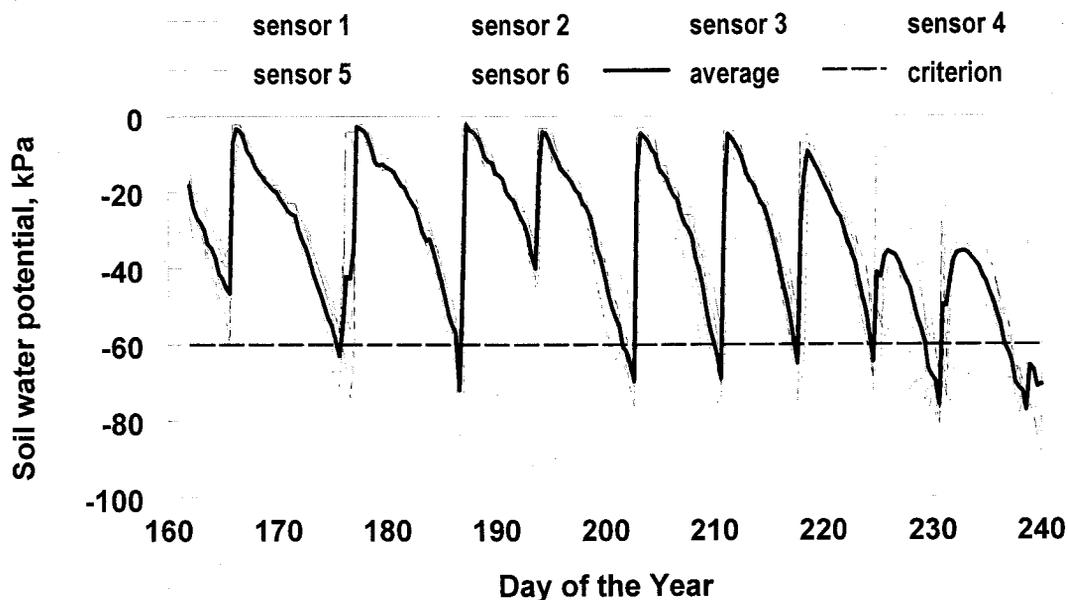


Figure 3. Soil water potential at 10-inch depth in sprinkler-irrigated potatoes as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

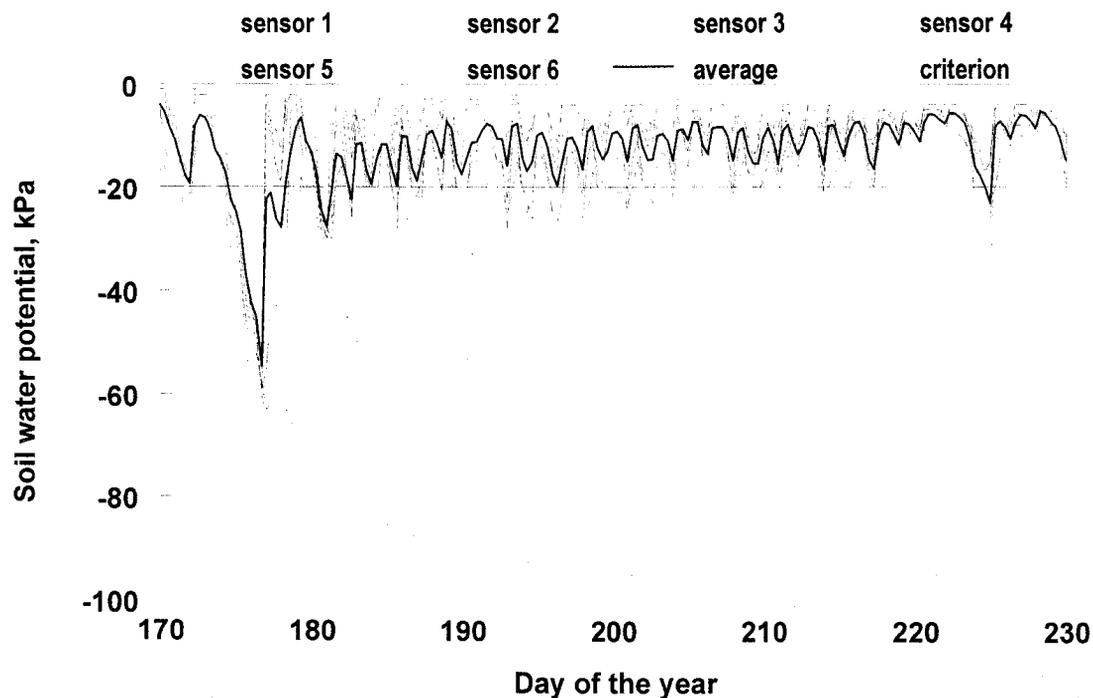


Figure 4. Soil water potential at 10-inch depth in commercial drip-irrigated onions as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

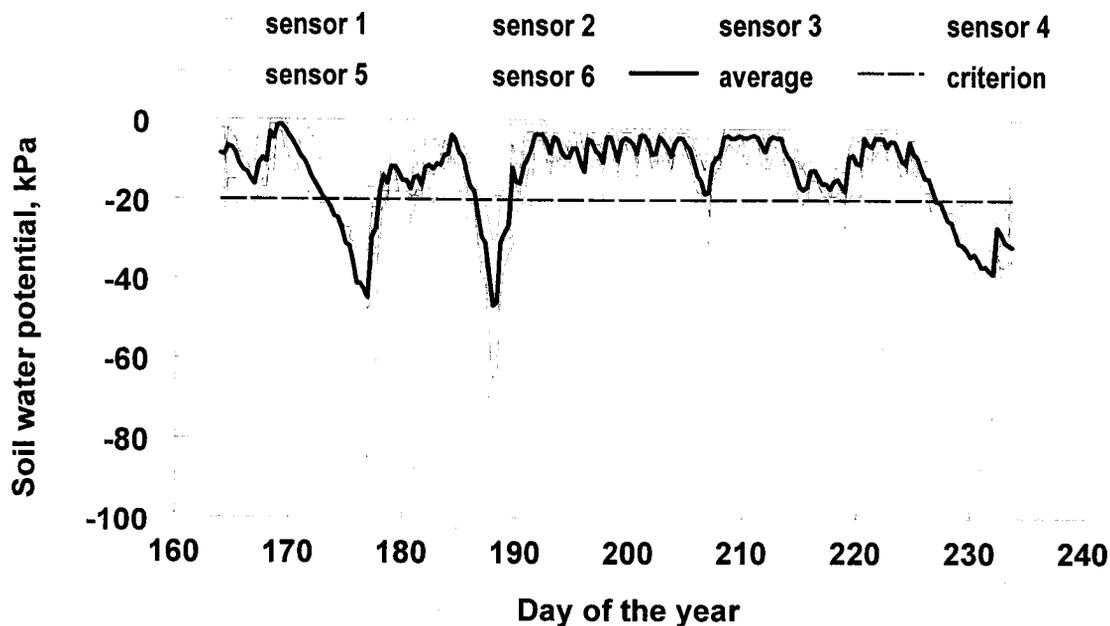


Figure 5. Soil water potential at 10-inch depth in commercial drip-irrigated onions as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

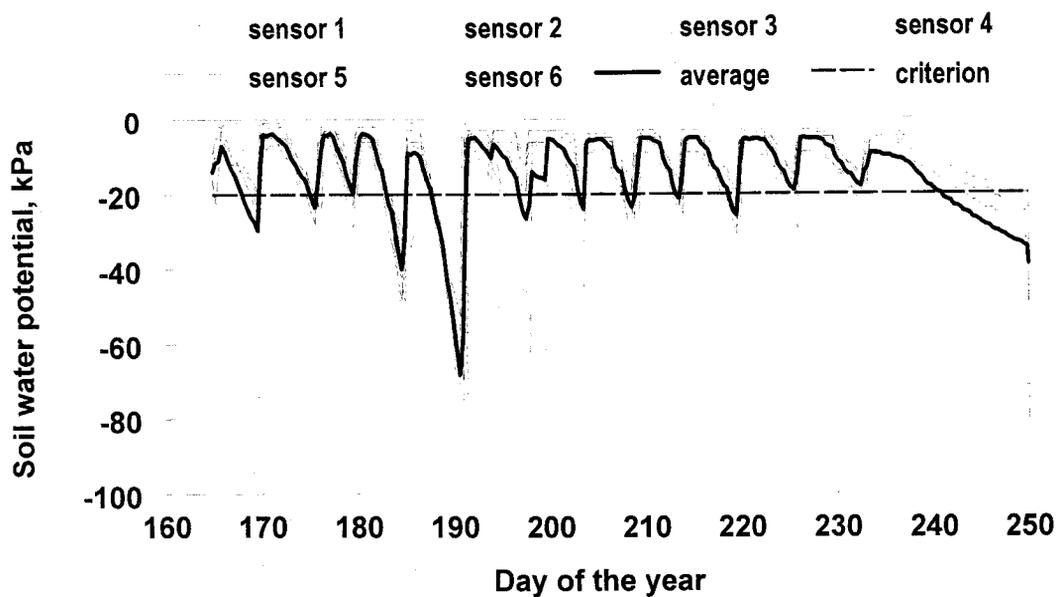


Figure 6. Soil water potential at 10-inch depth in furrow-irrigated onions as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

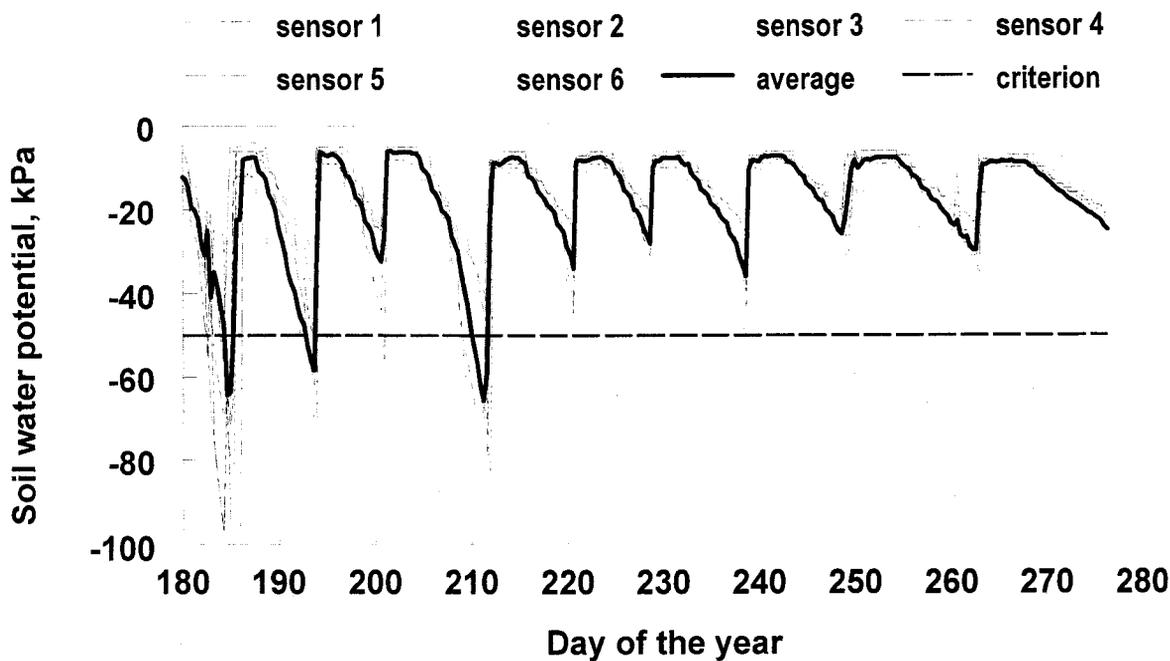


Figure 7. Soil water potential at 10-inch depth in furrow-irrigated sugar beets as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.