MICRO-IRRIGATION ALTERNATIVES FOR HYBRID POPLAR PRODUCTION 2003 TRIAL

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Summary

Hybrid poplar (cultivar OP-367), planted for sawlog production in April 1997 at the Malheur Experiment Station, received five irrigation treatments in 2000-2003. Irrigation treatments consisted of three water application rates using microsprinklers and two water application rates using drip tape. Irrigation scheduling was by soil water potential at 8-inch depth with a threshold for initiating irrigations at -50 kPa in 2000-2002, and at -25 kPa in 2003. Reducing the water application rate reduced the annual growth in diameter at breast height (DBH) and stem volume for the microsprinkler-irrigated treatments. There was no significant difference between the microsprinkler-irrigated treatment irrigated at the highest rate and the drip-irrigated treatments in terms of height, DBH, or stem volume growth in 2000 and 2001. In 2002 and 2003, drip irrigation with two tapes per tree row resulted in higher tree growth than microsprinkler irrigation.

Introduction

With timber supplies from Pacific Northwest public lands becoming less available, sawmills and timber products companies are searching for alternatives. Hybrid poplar wood has proven to have desirable characteristics for many nonstructural timber products. Growers in Malheur County have made experimental plantings of hybrid poplars for saw logs and peeler logs. Clone trials in Malheur County have demonstrated that the clone OP-367 (hybrid of *Populus deltoides* x *P. nigra*) performs well on alkaline soils for at least 7 years. Other clones have higher productivity on soils with nearly neutral pH.

Hybrid poplars are known to have high growth rates (Larcher 1969) and transpiration rates (Zelawski 1973), suggesting that irrigation management is a critical cultural practice. Research at the Malheur Experiment Station during 1997-1999 determined optimum microsprinkler irrigation criteria and water application rates for the first 3 years (Shock et al. 2002). The results showed that tree growth was not reduced by scheduling irrigations when the soil water potential reached -50 kPa. Irrigating at -25 kPa necessitated 38 irrigations for 3-year-old trees, compared to 26 irrigations when trees were irrigated at -50 kPa. Based on these results it was decided to use an irrigation criterion of -50 kPa for the wettest treatments starting in 1998. In 2000 we noticed that the rate of increase in annual tree growth started to decline in the wettest treatment. It was decided that one of the causes probably was the use of an irrigation criterion of -50 kPa. Starting in 2003 the irrigation criterion was changed to -25 kPa for the wettest treatment. The objectives of this study were to evaluate poplar water requirements in the seventh year and to compare microsprinkler irrigation to drip irrigation.

Materials and Methods

Establishment

The trial was conducted on a Nyssa-Malheur silt loam (bench soil) with 6 percent slope at the Malheur Experiment Station. The soil had a pH of 8.1 and 0.8 percent organic matter. The field had been planted to wheat for the 2 years prior to 1997 and to alfalfa before 1995. The field was marked using a tractor, and a solid-set sprinkler system was installed prior to planting. Hybrid poplar sticks, cultivar OP-367, were planted on April 25, 1997 on a 14-ft by 14-ft spacing. The sprinkler system applied 1.4 inches on the first irrigation immediately after planting. Thereafter the field was irrigated twice weekly at 0.6 inches per irrigation until May 26. A total of 6.3 inches of water was applied in nine irrigations from April 25 to May 26, 1997.

In late May, 1997, a microsprinkler system (R-5, Nelson Irrigation, Walla Walla, WA) was installed with the risers placed between trees along the tree row at 14-ft spacing. The sprinklers delivered water at the rate of 0.14 inches/hour at 25 psi and a radius of 14 ft. The poplar field was used for irrigation management research (Shock et al. 2002) and groundcover research (Feibert et al. 2000) from 1997 through 1999.

Procedures Common to all Treatments

In March 2000 the field was divided into 20 plots, each of which was 6 tree rows wide and 7 trees long. The plots each were assigned one of five treatments arranged in a randomized complete block design and replicated four times (Table 1). The microsprinkler irrigation treatments used the existing irrigation system. For the drip-irrigation treatments, either one or two drip tapes (Nelson Pathfinder, Nelson Irrigation Corp., Walla Walla, WA) were laid along the tree row in early May 2000. The plots with two drip tapes per tree row had the drip tapes spread 2 ft apart, centered on the tree row. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft at 8 psi. Each plot had a pressure regulator (set to 25 psi for the microsprinkler plots and 8 psi for the drip plots) and ball valve allowing independent irrigation. Water application amounts were monitored daily by water meters in each plot.

Soil water potential (SWP) was measured in each plot by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors model 200SS, Irrometer Co., Riverside, CA); two at 8-inch depth, two at 20-inch depth, and two at 32-inch depth. The GMS were installed along the middle row in each plot and between the riser and the third tree. The GMS were previously calibrated (Shock et al. 1998) and were read at 8:00 a.m. daily starting on May 2 with a 30 KTCD-NL meter (Irrometer Co.). The daily GMS readings were averaged separately at each depth within each plot and over all plots in a treatment. Irrigation treatments were started on May 2.

The five irrigation treatments consisted of three water application rates for the microsprinkler-irrigated plots and two water application rates for the drip-irrigated plots (Table 2). From 2000 through 2002, all plots in the three microsprinkler-irrigated treatments were irrigated whenever the SWP at 8-inch depth for treatment one reached -50 kPa. The plots in each drip-irrigated treatment were irrigated whenever the SWP at 8-inch depth for the respective treatment reached -50 kPa. Irrigation treatments were terminated on September 30 each year.

Soil water content was measured with a neutron probe. Two access tubes were installed in each plot along the middle tree row on each side of the fourth tree between the sprinklers and the tree. Soil water content readings were made twice weekly at the same depths as the GMS. The neutron probe was calibrated by taking soil samples and probe readings at 8-, 20-, and 32-inch depth during installation of the access tubes. The soil water content was determined gravimetrically from the soil samples and regressed against the neutron probe readings, separately for each soil depth. The regression equations were then used to transform the neutron probe readings during the season into volumetric soil water content. Coefficients of determination (r^2) for the regression equations were 0.89, 0.88, and 0.81 at $P = 0.001$ for the 8-, 20-, and 32-inch depths, respectively.

2000 Procedures

The side branches on the bottom 6 ft of the tree trunk were pruned from all trees in February, 1999. In March of 2000, another 3 ft of trunk were pruned, resulting in 9 ft of pruned trunk. The pruned branches were flailed on the ground and the ground between the tree rows was lightly disked on April 12. On April 24, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.7 inch of water to incorporate the Prowl. To control the alfalfa and weeds remaining from the previous years' groundcover trial in the top half of the field, Stinger at 0.19 lb ai/acre was broadcast between the tree rows on May 19, and Poast at 0.23 lb ai/acre was broadcast between the tree rows on June 1. On June 14, Stinger at 0.19 lb ai/acre and Roundup at 3 lb ai/acre were broadcast between the tree rows on the whole field.

On May 19 the trees received 50 lb N/acre as urea-ammonium nitrate solution injected through the microsprinkler system. Due to deficient levels of leaf nutrients in early July, the field had the following nutrients in pounds per acre injected in the irrigation systems: 0.4 lb boron, 0.6 lb copper, 0.4 lb iron, 5 lb magnesium, 0.25 lb zinc, and 3 lb phosphorus. The field was sprayed aerially for leafhopper control with Diazinon AG500 at 1 lb ai/ac on May 27 and with Warrior at 0.03 lb ai/acre on July 10.

2001 Procedures

In March of 2001, another 3 ft of trunk were pruned, resulting in 12 ft of pruned trunk. The pruned branches were flailed on the ground on April 2. On April 4, Roundup at 1 lb ai/acre was broadcast for weed control. On April 10, 200 lb N/acre, 140 lb P/acre, 490 lb S/acre, and 14 lb Zn/acre (urea, monoammonium phosphate, zinc sulfate and elemental sulfur) were broadcast. The ground between the tree rows was lightly disked on April 12. On April 13, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.8 inch of water to incorporate the Prowl.

A leafhopper, willow sharpshooter (Graphocephala confluens, Uhler), was monitored by three yellow sticky traps attached to the lower trunk of selected trees. Traps were checked weekly. From mid-April to early June only adults were observed in the traps. A willow sharpshooter hatch was observed on June 6, as large numbers of nymphs were noted in the traps and on the lower trunk sprouts. The field was sprayed aerially with Warrior at 0.03 lb ai/acre on June 11 for leafhopper control.

2002 Procedures

In March of 2002, another 3 ft of trunk were pruned, resulting in 15 ft of pruned trunk. The pruned branches were flailed on the ground on April 12. On April 23, 80 lb N(urea)/acre, 40 lb K(potassium sulfate)/acre, 150 lb S(elemental sulfur)/acre, 20 lb Mg(magnesium sulfate)/acre, 6 lb Zn(zinc sulfate)/acre, 1 lb Cu(copper sulfate)/acre, and 1 lb B(boric acid)/acre were broadcast and the field was disked. On April 24, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.7 inch of water to incorporate the Prowl.

The willow sharpshooter was monitored by three yellow sticky traps attached to the lower trunk of selected trees. Traps were checked weekly. The field was sprayed aerially with Warrior at 0.03 lb ai/acre on June 10 for leafhopper control.

2003 Procedures

In March of 2003, another 3 ft of trunk were pruned, resulting in 18 ft of pruned trunk. The pruned branches were flailed on the ground on March 31. On April 23, 80 lb N/acre as urea and 167 lb S/acre as elemental sulfur were broadcast and the field was disked. On April 16, Prowl at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.4 inch of water to incorporate the Prowl.

Starting in 2003 the irrigation criterion was changed to -25 kPa and the water applied at each irrigation was reduced accordingly (Table 2). All plots in the three microsprinkler-irrigated treatments were irrigated whenever the SWP at 8-inch depth for treatment one reached -25 kPa. The plots in each drip-irrigated treatment were irrigated whenever the SWP at 8-inch depth for the respective treatment reached -25 kPa. Irrigation treatments were terminated on September 30.

The drip tape needed to be replaced because iron sulfide plugged the emitters. The drip tape was replaced with another brand (T-tape, T-systems International, San Diego, CA) in mid-April because Nelson Irrigation discontinued production of drip tape. The drip tape specifications were the same.

The willow sharpshooter was monitored by three yellow sticky traps attached to the lower trunk of selected trees. Traps were checked weekly. The field was sprayed aerially with Warrior at 0.03 lb ai/acre on June 5 for leafhopper control.

The heights and diameter at breast height (DBH, 4.5 ft from ground) of the central three trees in the two middle rows in each plot were measured monthly from May through September. Tree heights were measured with a clinometer (model PM-5, Suunto, Espoo, Finland) and DBH was measured with a diameter tape. Stem volumes (excluding bark and including stump and top) were calculated for each of the central six trees in each plot using an equation developed for poplars that uses tree height and DBH (Browne 1962). Growth increments for height, DBH, and stem volume for 2003 were calculated as the difference in the respective parameter between October 2003 and October 2002.

Results and Discussion

The microsprinkler-irrigated treatment with 1 inch of water applied at each irrigation consumed 47 acre-inch/acre of water in 47 irrigations (Table 1). The drip treatment with 1 inch of water applied with 2 tapes consumed 52 acre-inch/acre applied in 35 irrigations. The drip treatment with 0.5 inch of water applied with 1 tape consumed 29 acre-inch/acre in 35 irrigations.

In November 2003 (seventh year), trees in the wettest sprinkler-irrigated treatment averaged 57 ft in height, 8.3-inch DBH, and 1,697 ft^3/acre of stem volume (Table 2). In November 2003, trees in the treatment drip-irrigated with 2 drip tapes per tree row averaged 64 ft in height, 8.5-inch DBH, and 2,090 ft^3/acre of stem volume.

Comparing all treatments, drip irrigation with two tapes per tree row (water application rate of 1 inch) resulted in the highest DBH growth, height growth, and stem volume growth in 2003 (Table 2). Using one drip tape instead of two per tree row resulted in a reduction in DBH growth, height growth, and stem volume growth. For the microsprinkler-irrigated treatments, the highest growth in DBH and stem volume was achieved with a water application rate of 1 inch.

There were positive linear relationships, with similar slopes, between total water applied and stem volume growth for both the drip and microsprinkler systems (Fig. 1). However, the line for the drip system was above the line for the microsprinkler system, reflecting the higher water use efficiency of the drip system (Table 1).

The SWP at 8-inch depth was reduced, as expected, with the reductions in water application rate in the sprinkler treatments (Fig. 2, Table 3). There was no significant difference in 8-inch average SWP among the two drip treatments and the sprinkler treatment with 1 inch of water application rate. The SWP at 8-inch depth in the drip treatments oscillated with a higher amplitude (became wetter) than in the sprinkler plots, as expected, since the wetted area was smaller with drip irrigation. The SWP at 32-inch depth in the wettest sprinkler treatment remained drier than in the first foot during the season, suggesting that applied irrigation water was not lost to deep percolation.

The rate of increase in annual stem volume growth increased (growth approximately doubled every year) up to 2000, when the stem volume growth for the microsprinkler irrigated trees started to decline (Table 4). In 2002 the stem volume growth for the drip-irrigated trees started to decline. The decline in annual growth would not be expected until later when the trees are approaching harvest size. The reduction of the SWP for irrigation scheduling from -25 to -50 kPa in 2000 might be associated with the decline in annual stem volume growth. Tree growth was substantially higher in 2003 and was approximately double the growth in 2002. The higher tree growth in 2003 could have been due to the change to a wetter irrigation threshold from -50 to -25 kPa. Season-long average soil water potential at 8-inch depth for the wettest microsprinkler treatment and for the treatment drip irrigated with two drip tapes was substantially higher (wetter) in 2003 than in the last 3 years (Table 4).

References

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Table 1. Irrigation rates, amounts, and water use efficiency for hybrid poplar submitted to five irrigation regimes, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Irrigation threshold	Water application	Irrigation system	Total number of irrigations	Total water applied†	Water use efficiency
	kPa*	inch			acre-inch/ acre	ft³ of wood/acre-inch of water
1	-25	1	Microsprinkler	47	47.1	12.9
2	coincide with trt #1	0.77	Microsprinkler	47	35.8	8.2
3	coincide with trt #1	0.39	Microsprinkler	47	21.6	4.3
4	-25	1	Drip, 2 tubes	35	54.8	17.1
5	-25	0.5	Drip, 1 tube	35	29.8	14.8
LSD (0.05)				1	0.8	6.4

*Soil water potential at eight-inch depth.
†Includes 2.39 inches of precipitation from May through September.

Table 2. Height, diameter at breast height (DBH), and stem volume in early November 2003 and 2003 growth for hybrid poplar submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

	November 2003 measurements			2003 growth increment		
Treatment	Height	DBH	Stem volume	Height	DBH	Stem volume
	ft	inch	ft³/acre	ft	inch	ft³/acre
1	56.5	8.27	1,697.0	7.7	1.50	605.9
2	47.0	6.96	1,020.0	5.6	0.98	293.7
3	32.5	5.00	351.0	2.5	0.71	91.4
4	63.6	8.45	2,090.0	14.0	1.89	937.9
5	51.7	7.73	1,370.0	7.1	1.27	438.2
LSD (0.05)	16.7	0.76	507.2	5.7	0.26	221

Table 3. Average soil water potential and volumetric soil water content for hybrid poplar submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Average soil water potential		
Treatment	1st ft	2nd ft	3rd ft
	------------------ kPa ------------------		
1	26.9	36.9	36.1
2	65.3	83.2	62.9
3	92.8	84.9	90.8
4	21.8	25.5	27.4
5	28.3	25.2	35.7
LSD (0.05)	20.8	25.8	26.0

Table 4. Annual stem volume growth and seasonal average soil water potential at 8-inch depth for hybrid poplar under drip and microsprinkler irrigation at highest irrigation intensities, Malheur Experiment Station, Oregon State University, Ontario, OR.

	Stem volume growth		Seasonal average soil water potential at 8-inch depth	
Year	Drip	Microsprinkler	Drip	Microsprinkler
	---- ft^3/acre ----		---- kPa ----	
1997		1.3		-21.4
1998		78.5		-20.0
1999		177.7		-22.2
2000	361.9	401.5	-24.2	-37.9
2001	448.7	354.7	-26.4	-33.9
2002	413.1	256.8	-31.3	-35.8
2003	937.9	605.9	-21.8	-26.9

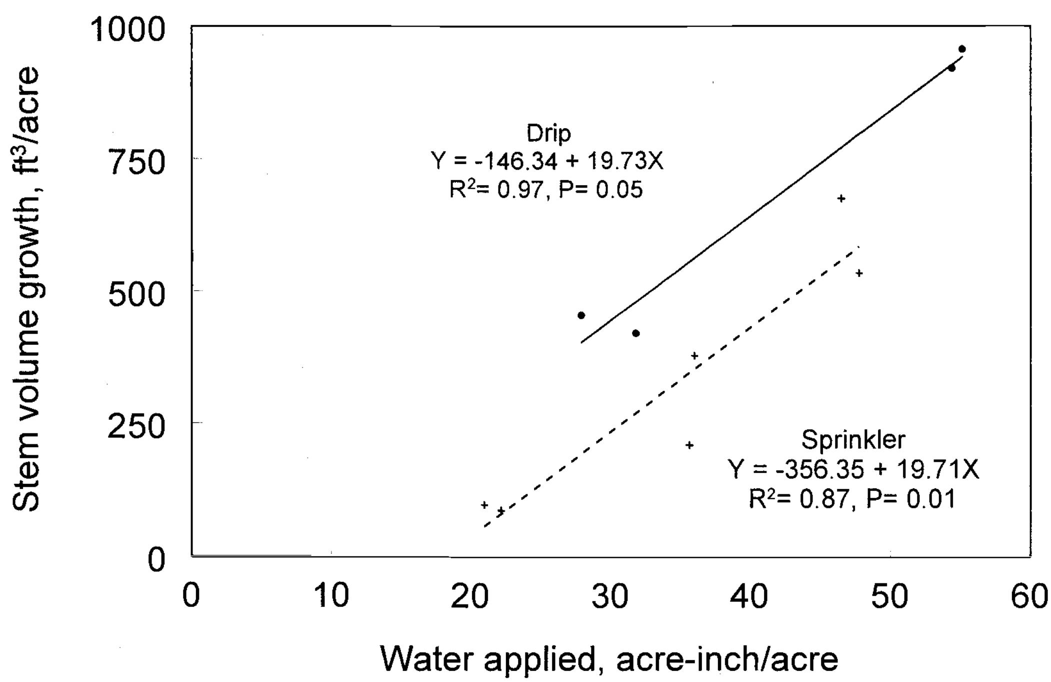

Figure 1. Response of stem volume growth to water applied in 2003 for hybrid poplar using microsprinkler and drip irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR.

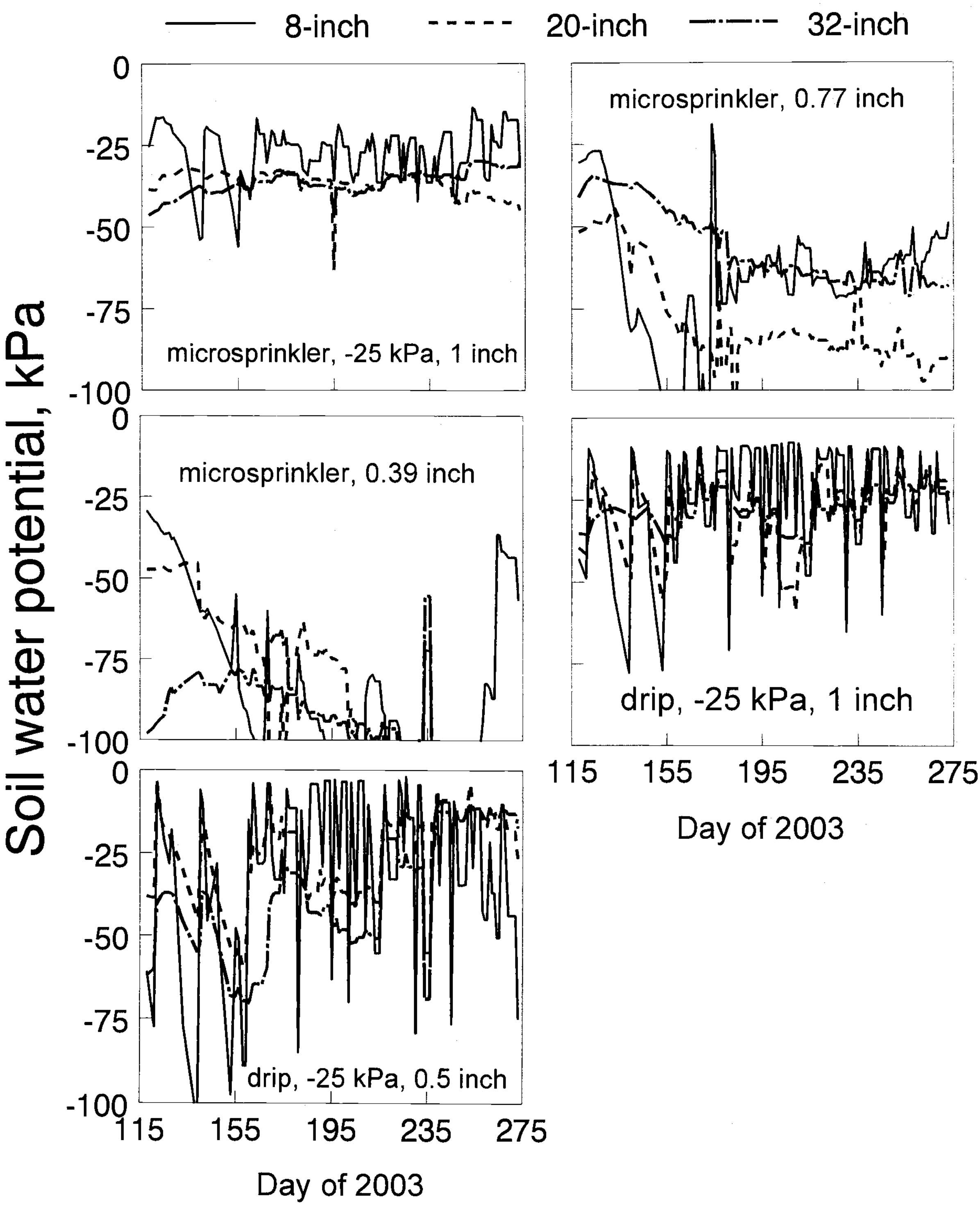

Figure 2. Soil water potential at three depths using granular matrix sensors in a poplar stand submitted to five irrigation regimes, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.