IRRIGATION MANAGEMENT FOR DRIP-IRRIGATED ONIONS

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Summary

Onions (cv. Vision) were submitted to 8 soil water potential (SWP) treatments using subsurface drip irrigation in 1997 and 1998. Onions were grown on two double rows spaced 22 in apart on 44-in beds with a drip tape buried 6 in deep in the bed center. Soil water potential was maintained nearly constant at five levels by automated, high frequency irrigations based on SWP measurements at 8-in depth. In 1997, the highest total and colossal yields were achieved with the wettest SWP tested, -10 kPa. The highest marketable yield was achieved with a SWP of -21 kPa because of an increase in storage decomposition with increasing SWP. In 1998, the highest total, marketable, and colossal onion yields were achieved with the wettest SWP tested, -10 kPa. Storage decomposition was not responsive to SWP in 1998. Onion profits were maximized in 1997 by a SWP of -17 kPa, and in 1998 profits were highest with the highest SWP tested of -10 kPa. Maintenance of SWP at -10 and -20 kPa required 36 and 27 acre-in/acre in 1997 and in 1998 required 37 and 23 acre-in/acre of applied water. Onion evapotranspiration from emergence to the last irrigation was estimated in 1997 to be 27 acre-in/acre and in 1998 to be 28 acre-in/acre. Reducing the soil moisture after July 15 below -20 kPa did not have any significant or consistent effect on storage decomposition, but tended to reduce colossal onion yield in 1997 and marketable and total yield in 1998

Introduction

Previous research with furrow-irrigated onions at the Malheur Experiment Station has demonstrated the sensitivity of onions to small water deficits and the need to maintain high SWP for optimum yield and economic return (Shock et al., 1998a). The superior water application efficiency with subsurface drip irrigation allows for more precise irrigation management than with furrow irrigation. With subsurface drip irrigation, onions can be irrigated so that SWP can be maintained nearly constant, avoiding the oscillations in soil water common with furrow or sprinkler irrigation. The objective of this trial was to evaluate the effects of different and stable SWP with subsurface drip irrigation on onion yield and quality.

Methods

Trials were conducted at the Malheur Experiment Station on fields of Owyhee silt loam previously planted to wheat. Spring soil samples from the top foot of soil in 1997 and 1998 respectively, showed a pH of 7 and 7.5, 1.5 and 2.3 percent organic matter, and 110 and 36 lb N/acre available.

Onions (cv. Vision, Petoseed, Payette, ID) were planted in 2 double rows, spaced 22 in apart in 44-inch beds on April 16, 1997 and on April 14, 1998. Onions were planted at 140,000 seeds/acre (4.1 in/seed). Drip tape (Nelson Irrigation Corp., Walla Walla, WA) was laid simultaneously with planting at 6-in depth between the two double onion rows. The drip tape had emitters spaced 12 in apart and a flow rate of 0.24 gal/minute/100 ft. Immediately after planting the onion rows received 3.7 oz of 'Lorsban 15G' per 1000 ft of row (0.82 lb ai/acre), and the soil surface was rolled. The trials were irrigated three times in 1997 and twice in 1998 with a microsprinkler system (R10 Turbo Rotator, Nelson Irrigation Corp., Walla Walla, WA) before onion emergence. Risers were spaced 25 ft apart along the flexible polyethylene hose laterals which were spaced 30 ft apart. Onions started emerging on May 1, 1997 and on April 29, 1998.

Irrigation treatments consisted of five SWP levels (-10, -20, -30, -50, and -70 kPa), maintained nearly constant at 8-in depth during the entire season. In addition, there were three treatments where the SWP was maintained nearly constant at -20 kPa until July 15 and then decreased to -30, -50, or -70 kPa for the remainder of the season. The SWP (8-in depth) was maintained constant by 0.06 acre-in/acre of water applied up to eight times a day based on SWP readings every 3 hours. The irrigation treatments were started in early June. The 8 irrigation treatments were replicated five times and arranged in a randomized complete block design. Plots were 2-beds wide and 50-ft long.

Soil water potential was measured with four granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) at 8-inch depth, below one onion row in each plot. Sensors were calibrated to SWP (Shock et al. 1998b). The GMS were connected to a datalogger (CR 10 datalogger, Campbell Scientific, Logan, UT) via five multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger was programmed to read the GMS in each plot every 3 hours and, if necessary, irrigate the plots individually, according to the plot's irrigation criteria. The irrigations were controlled by the datalogger using a controller (SDM CD16AC controller, Campbell Scientific, Logan, Utah) connected to solenoid valves in each plot. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each plot. The amount of water applied to each plot was recorded daily at 8:00 a.m. from a water meter installed between the solenoid valve and the drip tape. Irrigations were terminated on August 29, 1997 and on September 10, 1998.

Onion evapotranspiration (Et_c) was calculated with a modified Penman equation (Wright, 1982) using data collected at the Malheur Experiment Station by an AgriMet weather station. Onion Et_c was estimated and recorded from crop emergence until the final irrigation.

Fertilizer solutions were applied through the drip lines via a venturi injector (Mazzei injector Model 1087). Uran at 20 lb N/acre was applied weekly from early June through early July totaling 100 lb N/acre in 1997. An additional two applications of 25 lb N/acre following the hail storm on July 4, 1998 resulted in a total of 150 lb N/acre being applied in 1998.

Postemergence weed control was achieved with one herbicide application in 1997, two herbicide applications in 1998, one hand weeding in 1997, and two hand weedings in 1998. Thrips control and disease control (including downy mildew) was achieved with two insecticide and fungicide applications in 1997 and four insecticide and fungicide applications in 1998.

Onions were lifted on September 23 each year. In late September, the onions in the central 40 ft of the middle two double rows in each plot were topped by hand and placed into storage. Onions were graded out of storage on December 15, 1997 and on December 2, 1998. Rotten and split bulbs were separated before grading. Bulbs were graded according to diameter: small (< 2¼ in), medium (2¼ to 3-in), jumbo (3 to 4-in), and colossal (4-in and larger). Marketable onions were mediums, jumbos, and colossals. Total yield included rotten and split bulbs.

All bulbs from each plot were counted during grading to estimate the plant population.

Gross economic returns were calculated by crediting each marketable onion class with the average price of onions paid to the grower from the beginning of the marketing season in early August through January for each year. Average onion prices for each year were calculated from data prepared by the USDA Agricultural Marketing Service, Idaho Falls, ID. Average onion prices per hundred weight were: $2.90 in 1997 and $3.52 in 1998 for mediums, $4.42 in 1997 and $9.96 in 1998 for jumbos, and $6.20 in 1997 and $13.74 in 1998 for colossals. Production costs were based on data prepared by Malheur County Extension (Oregon State University, Ontario, OR). Fertilization costs were calculated by assuming 150 lb N/acre applied to the -10, -20, -30, kPa treatments and 75 lb N/acre applied to the -50 and -70 kPa treatments. Irrigation costs were the same for all treatments except for the diesel fuel for the pump. Onion loading, hauling, and storage costs were calculated based on the yield for each treatment. All other production costs were considered the same for all treatments.

Data were analyzed by regression (NCSS 6.0, Number Cruncher Statistical Systems, Kaysville, UT). The SWP for maximum yield and profit responses in 1997 was calculated using the first derivative of the regression equation using the formula $x = -b/(2 \cdot c)$ where x is the SWP and *b* and *c* are the regression equation coefficients for the first and second order terms, respectively of the quadratic equation

$Y = a + bx + cx^2$.

Results and Discussion

The microsprinkler system used to germinate the onions resulted in uniform emergence. There was no significant difference between treatments in plant population. The average plant population based on bulbs packed out of storage was 103,841 plants/acre in 1997 and 94,159 plants/acre in 1998.

The onion crop suffered from suboptimal growing conditions in 1998. The growing season started out cooler and wetter than normal. The month of May had 4.55 in of precipitation compared to the 50-year mean of 1.02 in. A severe hail storm on July 4 resulted in close to 100 percent onion leaf loss. Plants were reduced to 2-in high, injured stubs. The months of July and August were hotter than normal. Weather station data recorded 11 days with maximum air temperatures of 100 °F or higher compared to the 50-year mean of 5 days. There were far more degree-days in the above optimal range (86 to 104 °F) in 1998 compared to the previous 8-year mean; 70 percent more in July and 29 percent more in August. The hot weather in July and August resulted in higher total Et_c in 1998 than in 1997, despite the cool and wet weather in May and June (Table 1). The hot weather in July and August was suboptimal for onions especially for the regrowth of hail-damaged onions where most of the soil surface was uncovered.

The automated drip irrigation system maintained the SWP at 8-in depth relatively constant for the -10 kPa and -20 kPa treatments (Fig. 1). The SWP at 8-in depth for the -30 kPa, -50 kPa, and -70 kPa treatments oscillated more and the oscillations increased with decreasing SWP. The SWP at 20-in depth generally was close to the SWP at 8-in depth. The SWP decreased rapidly with the termination of irrigations each year.

The total amount of water applied to the -10 kPa treatment was substantially higher than the estimated Et_c indicating the possibility of deep percolation and nitrate leaching (Table 1). The total amount of water applied to the -20 kPa treatment was close to Et_c. Water applications over time were higher than Et_c for the -10 kPa treatment and were close to Et_c for the -20 kPa treatment (Fig. 2).

In 1997, the highest total and colossal yields were achieved with the wettest SWP tested, -10 kPa (Fig. 3). The highest marketable yield in 1997 was achieved with a SWP of -21.1 kPa because of an increase in storage decomposition with increasing SWP.

In 1998, the highest total, marketable, and colossal onion yields were achieved with the wettest SWP tested, -10 kPa (Fig. 4). Storage decomposition was not responsive to SWP in 1998. Onion profits were maximized in 1997 by a SWP of -17 kPa. The lower optimum SWP for profits than for marketable yield (-21 kPa) is a reflection of the higher monetary value placed on large bulbs. In 1998 profits were highest with the highest SWP tested of -10 kPa.

Reducing the SWP level after July 15 below -20 kPa did not have any significant or consistent effect on storage decomposition, but tended to reduce colossal onion yield in 1997 and marketable and total yields in 1998 (Table 2). Storage decomposition was low in this trial, averaging 1.6 percent in 1997 and 2.9 percent in 1998. Based on these results, the idea of cutting back irrigation in the later part of the season to reduce bulb decomposition in storage was not valid at Ontario.

References

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Shock, C.C.; J. Barnum; and M. Seddigh. 1998b. Calibration of Watermark soil moisture sensors for irrigation management. p. 139-146. Proceedings of the International Irrigation Show, Irrigation Association, San Diego, CA.

Wright, J.L. 1982. New evapotranspiration crop coefficients. J. Irrig. Drain. Div., ASCE 108:57-74.

Table 1. Total water applied to drip-irrigated onions to maintain soil water potential at different levels at 8-in depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 1997-1998. Precipitation and Et_c were measured from emergence to the final irrigation.

Year	Total irrigation water -10 kPa	-20 kPa	-30 kPa	-50 kPa	-70 kPa	Precipitation	Estimated Et_c
	acre-in/acre						
1997	35.9	27.2	21.4	17.5	14	3.2	26.8
1998	36.8	23.2	20.6	13.6	11.9	6.4	28.2

Table 2. Effect of reducing subsurface drip irrigation and the soil water potential late in the season. Malheur Experiment Station, Oregon State University, Ontario, OR, 1997-1998.

Soil water potential (kPa)		Percent decomposition		Decomposition		Colossal		Marketable		Total yield	
		1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Early	After July 15	----- % -----		------------------- cwt/acre -------------------							
-20	-20	1.7	2.0	15.9	8.7	386.2	5.0	882.3	473.5	933.3	497.2
-20	-30	1.4	2.2	13.1	10.1	314.1	3.8	830.9	461.6	934.8	486.0
-20	-50	2.1	5.2	20.1	19.6	267.3	0.7	895.3	343.9	958.1	382.3
-20	-70	1.0	3.0	9.0	8.9	184.7	1.7	744.1	282.1	799.9	319.2
LSD (0.05)		NS[†]	2.3	NS	NS	105.3	NS	NS	91.2	NS	86.6

[†]NS: not significant

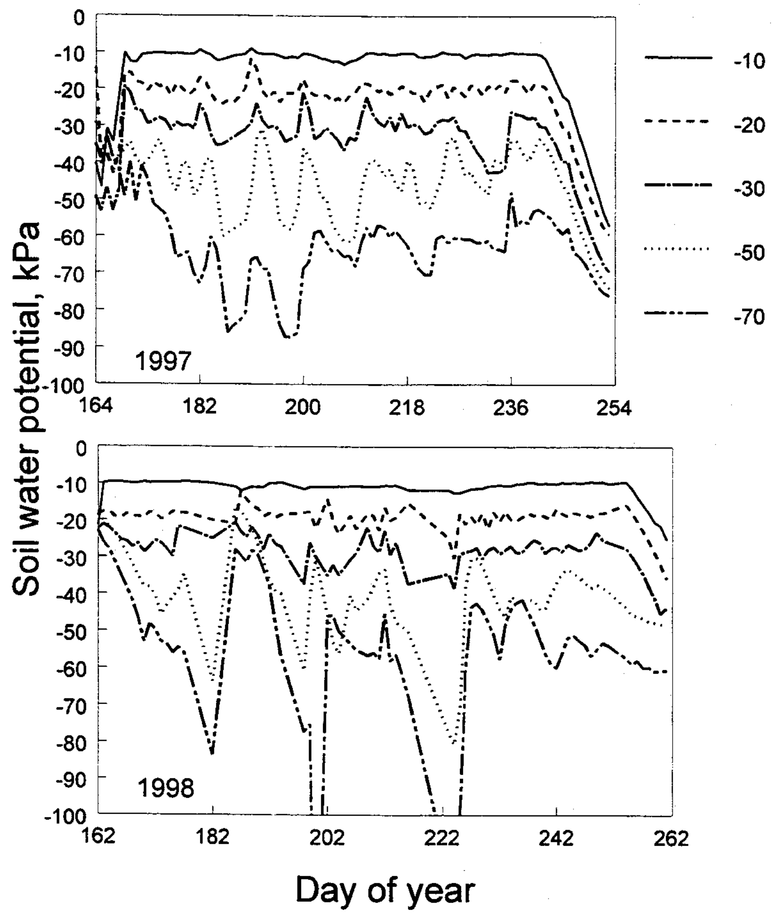

Figure 1. Soil water potential at 8-in depth for drip irrigated onions, Malheur Experiment Station, Oregon State University, Ontario, OR, 1997-1998.

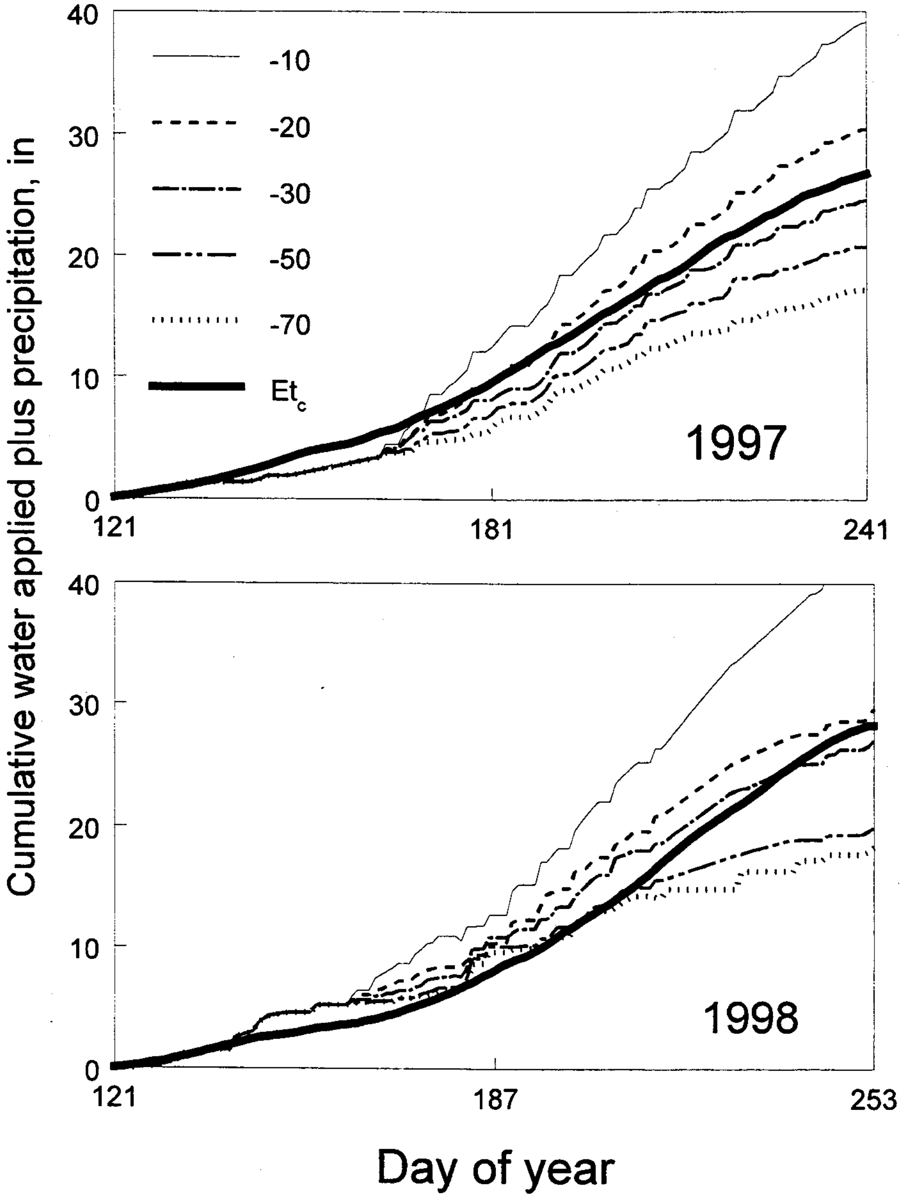

Figure 2. Cumulative water applied to drip-irrigated onions, Malheur Experiment Station, Oregon State University, Ontario, OR, 1997-1998.

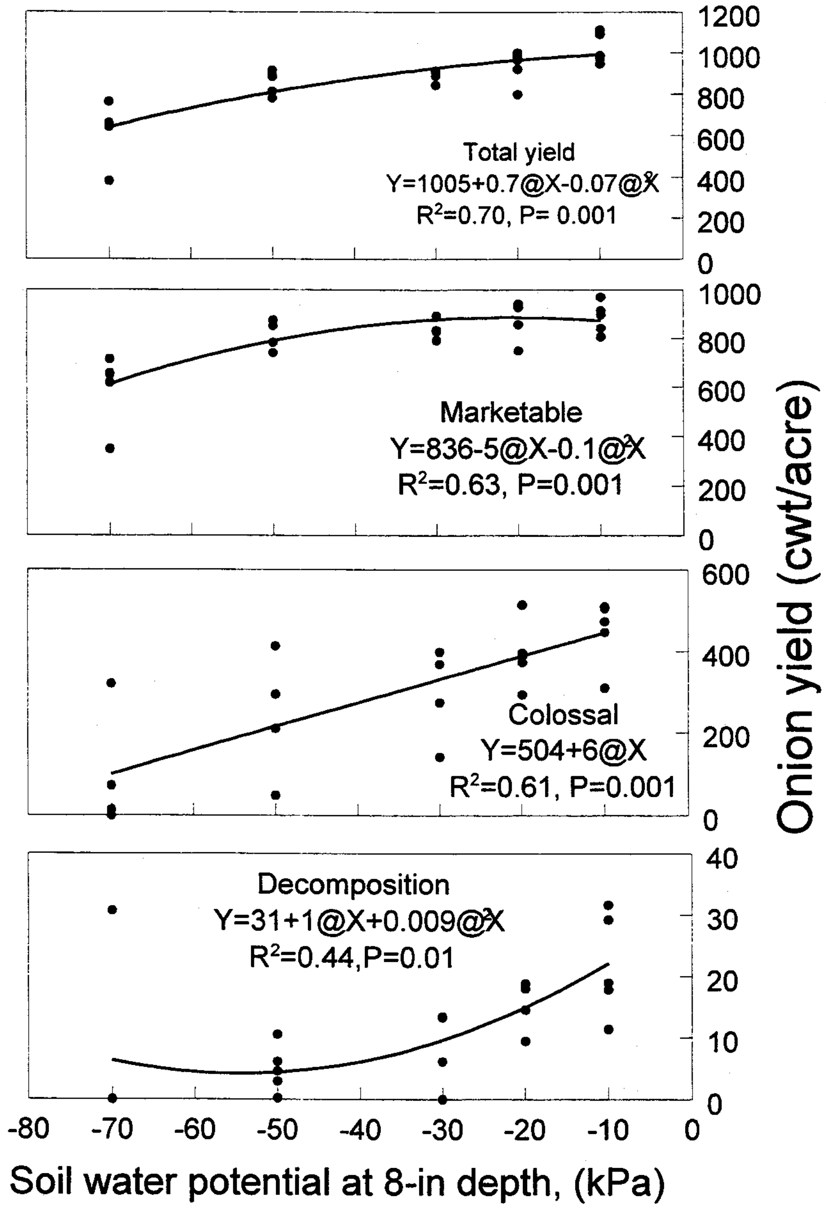

Figure 3. Onion yield response to soil water potential at 8-in depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 1997.

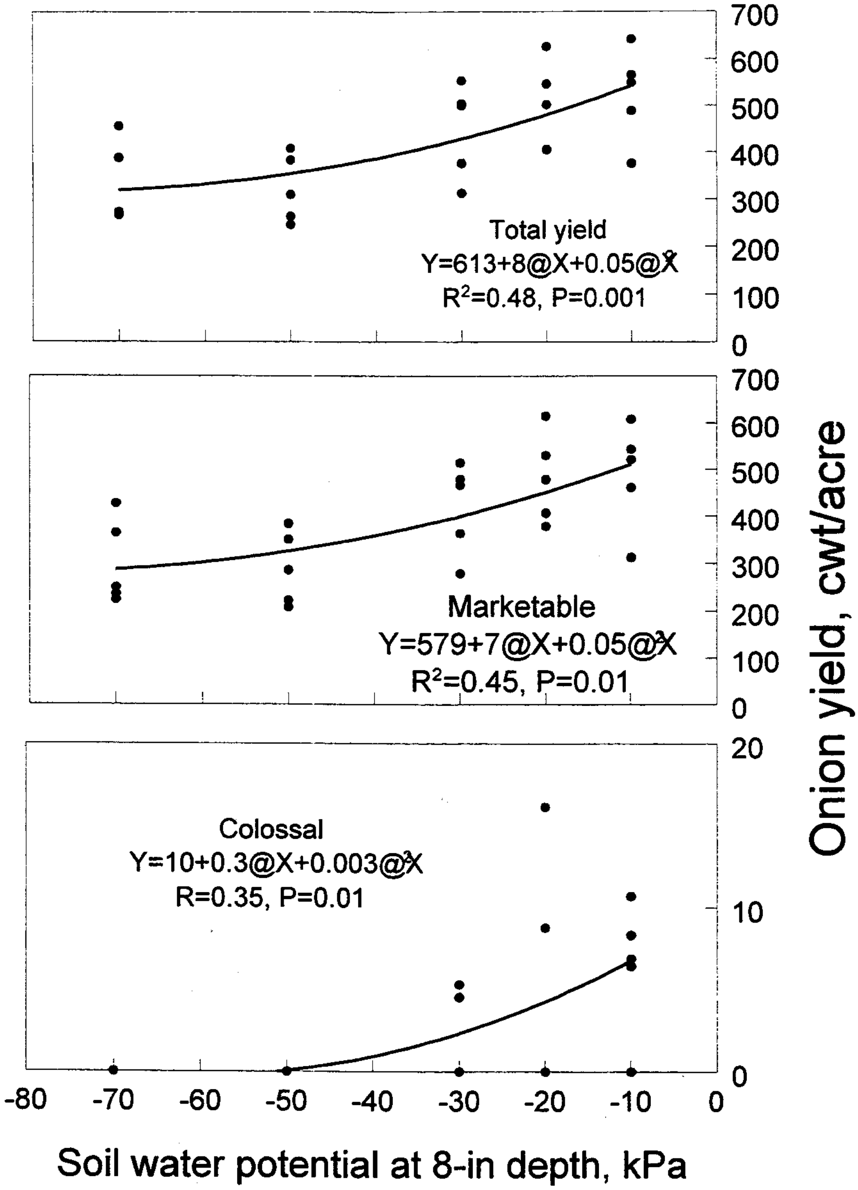

Figure 4. Onion yield response to soil water potential at 8-in depth. Malheur Experiment Station, Oregon State University, Ontario, OR, 1998. Onion yields and grade were reduced by hail for all treatments in 1998.

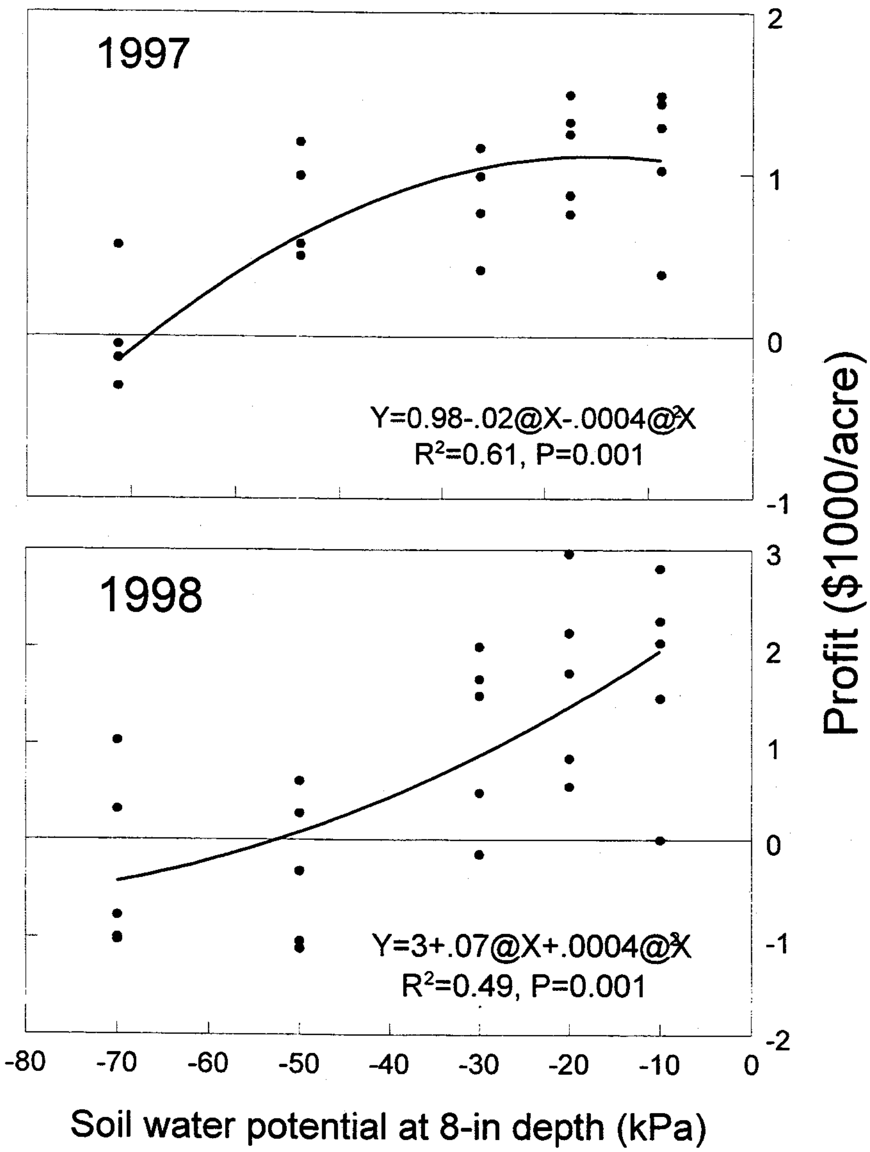

Figure 5. Effect of soil water potential on onion profits, Malheur Experiment Station, Oregon State University, Ontario, OR, 1997-1998.