YELLOW NUTSEDGE GROWTH IN RESPONSE TO ENVIRONMENT

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Introduction

Yellow nutsedge is a perennial weed common in irrigated row crop production in the Treasure Valley of eastern Oregon and southwestern Idaho. It is particularly problematic in onion production. Onions are relatively short statured plants with vertical leaves producing an incomplete canopy with limited potential to effectively suppress weeds. Yellow nutsedge has a C_4 photosynthetic pathway and therefore responds well to conditions of high light intensity that exist in onion production. Management practices including frequent irrigation and high nitrogen fertilization required to maximize onion yield also serve to stimulate yellow nutsedge growth (Keeling et al. 1990).

Yellow nutsedge reproduces and is dispersed primarily by tubers that are formed at the apical ends of underground rhizomes. Tubers are produced in the upper 18 inches of the soil profile with the greatest concentration located in the upper 6 inches (Stoller and Sweet 1987, Tumbleson and Kommedahl 1961). After a period of dormancy, tubers germinate and produce shoots in subsequent growing seasons. Tubers may remain viable for 1-3 years providing an effective means of survival. Asexual reproduction by yellow nutsedge tubers can be quite prolific. Tumbleson and Kommedahl (1961) reported that a single tuber produced 6,900 tubers the first fall after planting, and 1,900 plants the following spring in an area of approximately 34 ft^2. Yellow nutsedge grows best where soil moisture is high (Bendixin and Nandihalli 1987). Garg et al. (1967) reported that nitrogen promotes vegetative growth over reproductive growth in yellow nutsedge, leading to increased basal bulb formation (and subsequent shoot production) as opposed to tuber formation.

Two trials were conducted in 2003 at the Malheur Experiment Station to evaluate yellow nutsedge growth with various environmental factors.

Methods

Yellow Nutsedge Emergence and Growth as Influenced by Depth of Germination
The objectives of this experiment were to 1) determine the depth from which a yellow nutsedge tuber can emerge in the field, 2) determine the date of emergence based on depth of burial, and 3) determine the growth (i.e., shoot and tuber production) potential based on burial depth.

Yellow nutsedge tubers were harvested from the bank of an irrigation canal on March 19, 2003. The tubers were then washed from the soil, rinsed with deionized water, and placed in a refrigerator at 38.5°F for approximately 21 days. Both washing and chilling have been shown to effectively break tuber dormancy (Tumbleson and Kommedahl 1961, Bell et al. 1962). This was necessary to ensure that the tubers would readily germinate when buried and that any differences in emergence would be based on depth of burial and/or soil temperature and not differences in dormancy. Ten tubers were buried in a single container at a depth of 2, 4, 6, 8, 10, 12, 14, 16, or 18 inches on April 17. Each depth was replicated four times. Containers consisted of 10-inch-diameter pvc pipe for depths below 12 inches. Large pots were used for depths from 2 to 12 inches. Temperature sensors were placed at 6 and 12 inches in the pots and 6, 12, and 18 inches in the pvc pipe. Watermark sensors were buried at depths of 6 and 12 inches in 4 of the pots and at depths of 6, 12, and 18 inches in 4 of the pvc pipes to monitor soil moisture. Each container was irrigated by a single drip emitter with an output of 0.5 gal per hour. Soil water potential was measured every morning and irrigations were initiated each time the average of the Watermark sensors (Irrometer Company Inc., Riverside, CA) at the 6-inch depth was greater than or equal to -20 kPa.

Shoots were counted up to the point where every container had at least 10 shoots present and again prior to tuber harvest on July 21. Shoot biomass was taken at harvest. Tubers were harvested on July 22 and their lengths were quantified in 6-inch increments of 0-6, 6-12, 12-18, and 18-24 inches.

Yellow Nutsedge Growth in Response to Irrigation and Nitrogen Fertilization
The objectives of this experiment were to 1) monitor patch expansion from a single yellow nutsedge tuber in the absence of crop competition over the course of one growing season, 2) evaluate the effects of selected irrigation regimes on yellow nutsedge growth, and 3) evaluate the effect of nitrogen fertilization on yellow nutsedge growth.

Tubers were harvested from a ditch bank on March 19, 2003. The tubers were then washed from the soil, rinsed with deionized water, and stored in a refrigerator at 38.5°F for approximately 40 days. Tubers weighing from 0.18 to 0.2 g and measuring between 6 and 7 mm were selected and planted in flats in the greenhouse on May 28. Tubers of similar size and weight were selected because research has shown that tuber size can affect early plant vigor, with plants from smaller tubers being less vigorous. On June 2, germinated tubers with a shoot of at least 1 inch in length were transplanted into the center of a circular plot with a 6-ft diameter. Transplanted yellow nutsedge plants were used to ensure a more uniform date of establishment among the 18 individual plots. The circular plots consisted of 14-inch-wide galvanized valley flashing cut to a length of 19 ft with the ends riveted together to produce a circle with a diameter of 6 ft. The flashing was then buried approximately 10 inches deep in the soil. Ten days before transplanting, each plot was irrigated to a soil moisture potential of -20 kPa to incorporate fertilizer applications and to provide similar moisture conditions for early yellow nutsedge establishment.

The trial consisted of 18 circular plots, 6 each for the 3 irrigation regimes and 3 each for the 2 fertilization levels split over the irrigation regimes. Irrigation water was applied to the plots through six drip emitters evenly spaced in a circular pattern where each emitter was located 1.5 ft from the center of the plot. The six emitters had a combined output of 3.0 gal/hour. The values for irrigation criteria were -20, -50, and -80 kPa and were selected to represent soil moisture conditions similar to those in wheat, sugar beet, and dry bulb onion production systems, respectively. The two fertilization levels consisted of plots receiving nitrogen (46 percent urea) at rates of either 90 or 268 lbs/acre. All plots were fertilized before transplanting with 90 lb/acre P, 90 lb/acre S, 1 lb/acre Cu, 1 lb/acre B, and 9 lb/acre Mg. Soil water potential was measured in each plot with a single Watermark soil moisture sensor installed at a 6-inch depth equidistant from the yellow nutsedge plant at the center of the plot and the drip line. Irrigation water was applied independently for each regime when the average 6-inch soil water potential from the six sensors reached -20, -50, or -80 kPa. The sensors were read by a datalogger every 12 hours and when the soil water potential exceeded the treatment criteria irrigation was initiated using a solenoid valve. Water meters were installed between the solenoid valves and the water line for each individual irrigation regime to record the amount of water applied daily.

Yellow nutsedge growth was measured initially by counting shoot numbers within each plot. At a point where shoots became too numerous to efficiently count, nutsedge growth was evaluated by taking overhead digital images of each plot. These images were used to quantify the plot area that was covered by yellow nutsedge shoots using a software program produced at Oregon State University. Shoots and tubers were harvested from subsamples within each plot on September 3 and 4. Thirteen subsamples were collected across the 6-ft diameter of the plots. The subsamples consisted of 4.25-inch-diameter circles from which shoots were counted to estimate the total shoot number per plot. The shoots were then clipped at ground level and placed in bags to be dried. The dry weights were used to estimate the total above-ground biomass. Once the shoots were removed a soil core measuring 4.25 inches in diameter by 8 inches in depth was taken from the same area as the shoots were removed. The individual core samples were bagged and recorded as to their location within the plot. The core samples were then emptied into a bucket with multiple 11/64-inch holes in the bottom and sides. Water was sprayed into the bucket to remove the soil from the tubers. The tubers were then counted and those numbers were used to estimate the total tuber population for each of the plots.

Results and Discussion

Yellow Nutsedge Emergence and Growth as Influenced by Depth of Germination

The first shoots to emerge from the 2-, 4-, 6-, and 8-inch burial depths were observed 36 days after planting (Table 1). Thirty-nine days were required for the first observed shoot to emerge from the 10- and 12-inch depths. The 14-inch depth required 42 days and the 16- and 18-inch depths each took 46 days from the planting date for the first shoot to emerge. Despite similar dates for first-shoot emergence, it took 7 days longer to produce an average of 10 shoots per container in the 4-, 6-, and 8-inch depths compared to the 2-inch planting depth. An additional 11 days were required for the 10-, 12-, and 14-inch depths to produce an average of 10 shoots per container and the 16-inch and 18-inch depths took 21 and 25 days longer, respectively, than the 2-inch burial depth. The average daily soil temperatures for planting depths of 4, 8, 12, and 16 inches from time of planting to the point where each container had at least 10 shoots are illustrated in Figure 1. Figure 2 shows the increase by depth of emergence of yellow nutsedge shoots across a 35-day period from the first shoot observation on May 23 through June 27, at which time each container had at least 10 shoots. Shoot numbers were significantly greater for burial depths of 2, 4, 6, and 8 inches than those associated with 12-, 14-, 16-, and 18-inch depths on all observation dates from June 4 through June 27. The final shoot counts were taken on July 21, 59 days after the first shoot emergence. Shoot numbers ranged from a low of 121 with the 18-inch burial depth to 212 with the 10-inch burial depth (Table 2).

Yellow nutsedge shoot biomass (total g/container) was similar among the 2- through 10-inch burial depths and were significantly greater than all other depths (Table 2). The 12-inch depth produced greater total shoot biomass than the depths of 14, 16, and 18 inches. The average weight per shoot (average g/shoot) at the 2-inch depth was 0.49 g, which was similar to the 4-inch depth and greater than all other burial depths (Table 2). In general, both the total shoot biomass per container and the average weight per shoot decreased as the depth of tuber burial increased. This pattern is likely the result of both the time delay involved between shoot emergence based on burial depth as well as reduced shoot vigor following emergence due to depletion of tuber resources with deeper planted tubers. For example, while the total number of shoots produced was similar for both the 6-inch and 12-inch depths, the total shoot biomass and average weight per shoot were significantly less for the 12-inch depth (Table 2). The 6-inch depth produced an average of 1 shoot per container 3 days earlier and an average of 10 shoots per container 4 days earlier than the 12-inch depth. These data suggest that yellow nutsedge shoots lose vigor as the depth of their tubers increases.

Tuber numbers ranged form a high of 1,384 per container in the 4-inch burial to a low of 328 from the 18-inch burial (Table 3). There were no differences in tuber production among burial depths of 2 to 10 inches. Parent tubers buried at 12 inches produced tuber numbers similar to the 10-, 14-, and 16-inch depths. More tubers were produced from parent tubers buried at 4 and 8 inches than from those buried at depths between 12 and 18 inches. No attempt was made to differentiate between initial parent tubers and daughter tubers during the recovery process. Therefore, as many as 10 tubers harvested from the same zone as they were buried in may be parent tubers. This will probably have a greater influence on tuber counts from 12- to 18- and 18- to 24-inch incremental depths. For example, the only tubers recovered from the 18- to 24-inch depth zone were associated with the 18-inch burial depth and were most likely parent tubers since no other burial depth resulted in daughter tubers produced in that zone. However, it is interesting to note that tubers were found in the 12- to 18-inch zone for burial depths of 2-10 inches; these are almost certainly daughter tubers. More than 10 tubers were found between 12 and 18 inches for burial depths of 14, 16, and 18 inches. The depth of burial of the parent tubers did not influence the depth at which the daughter tubers were produced. When averaged across all burial depths, approximately 85 percent of all tubers were produced in the 0- to 6-inch zone and 13 percent were produced in the 6- to 12-inch zone (data not shown).

These data suggest that there are no differences in yellow nutsedge shoot biomass or tuber production from parent tubers distributed from 2 to 10 inches deep in the soil profile maintained at a soil water potential of -20 kPa. Yellow nutsedge growth appears to be less vigorous as the depth of germination increases in the soil profile. Although we did not address it in this trial, we could reasonably assume that less vigorous nutsedge plants would be less competitive. Both the duration of competition due to delayed emergence and the intensity of competition from fewer and smaller shoots may be less from nutsedge plants that germinate deeper in the soil profile.

Table 1. Yellow nutsedge shoot emergence as influenced by depth of germination, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Yellow nutsedge shoot production			
Depth of burial	1st shoot emergence*	Average ≥1 shoot/container†	Average ≥10 shoots/container‡	Average ≥10 shoots/container§
	Days after planting			Days after 1st emergence
2 inch	36	39	46	10
4 inch	36	36	53	17
6 inch	36	36	53	17
8 inch	36	39	53	17
10 inch	39	39	57	21
12 inch	39	39	57	21
14 inch	42	42	57	21
16 inch	46	48	67	31
18 inch	46	53	71	35

*Days after planting in which the first shoot appeared in any of the four replicates for the given depth of burial.
†Days after planting in which the average of the four replicates for the given depth of burial was greater than or equal to 1.
‡Days after planting in which the average of the four replicates for the given depth of burial was greater than or equal to 10.
§Days after 1st shoot emergence in which the average of the four replicates for the given depth of burial was greater than or equal to 10.

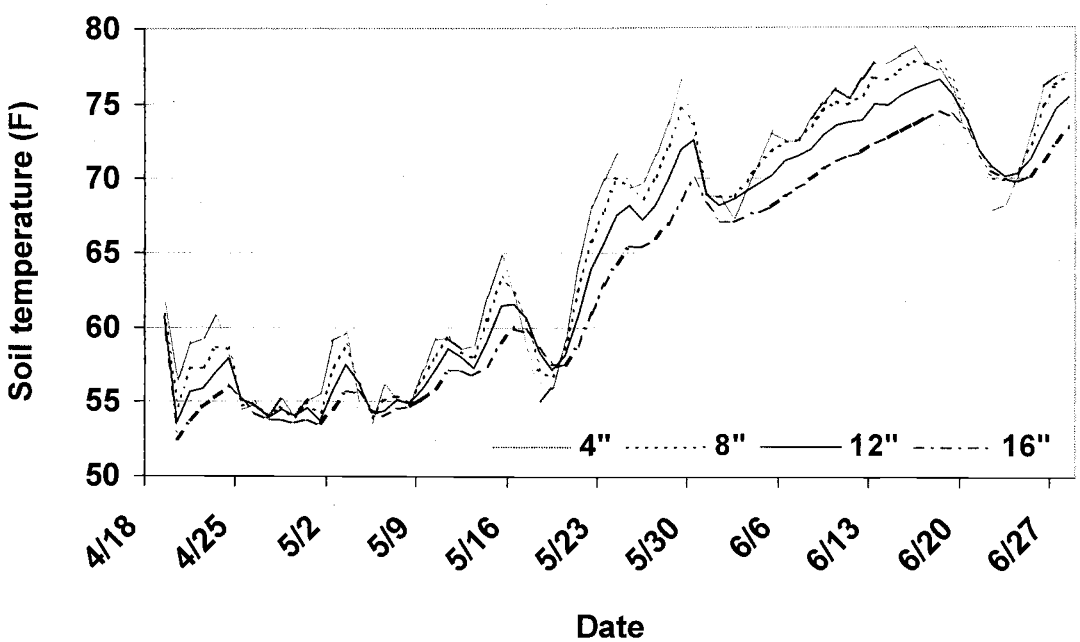

Figure 1. Average daily soil temperature at 4-, 8-, 12-, and 16-inch planting depths from date of planting up to the time when each container had at least 10 yellow nutsedge shoots, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

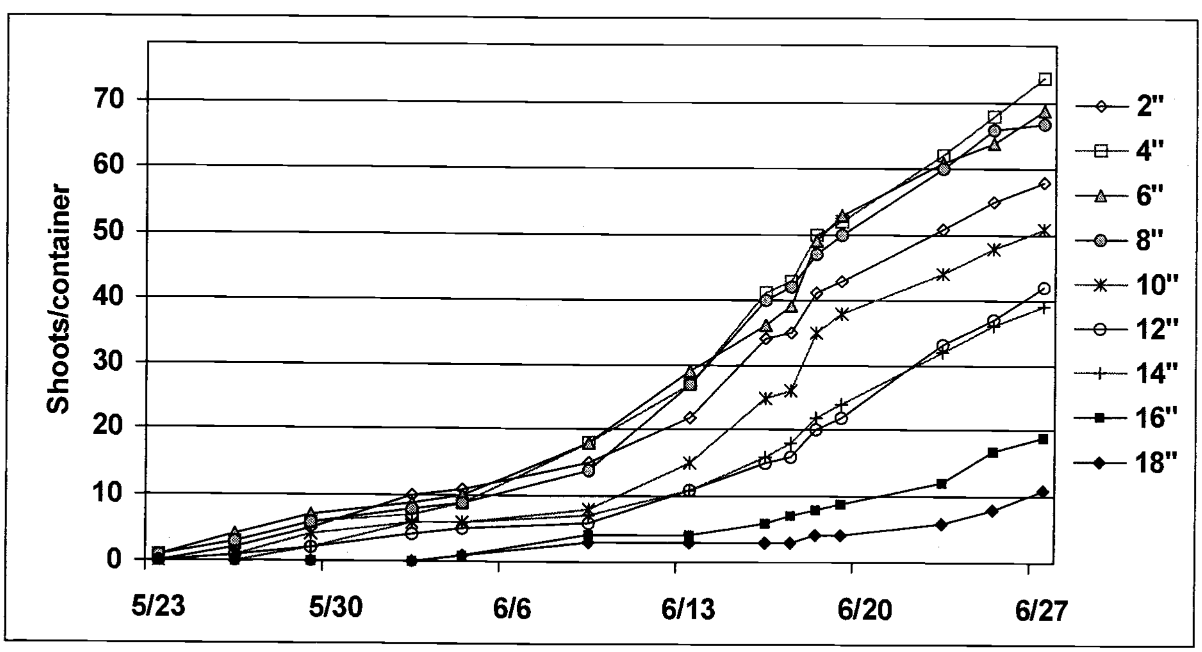

Figure 2. Yellow nutsedge shoot emergence over time as influenced by depth of tuber burial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 2. Yellow nutsedge total shoot number, weight, and weight per shoot at harvest, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Depth of burial*	Yellow nutsedge shoots† No/plot	Wt/plot	Wt/shoot
		---------- grams ----------	
2 inch	164 bc	77 a	0.49 a
4 inch	196 ab	84 a	0.43 ab
6 inch	209 a	80 a	0.38 b
8 inch	210 a	85 a	0.41 b
10 inch	212 a	77 a	0.37 bc
12 inch	209 a	63 b	0.31 cd
14 inch	153 c	43 c	0.28 d
16 inch	158 bc	45 c	0.3 cd
18 inch	121 c	33 c	0.27 d

*Yellow nutsedge tubers were buried on April 17, 2003.
†Yellow nutsedge shoots were harvested on July 22, 2003.

Table 3. Yellow nutsedge tuber production as influenced by depth of germination, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

	Yellow nutsedge tubers†				
	Recovery depth				
Depth of burial*	0-6 inches	6-12 inches	12-18 inches	18-24 inches	Total
	----------	----------	number/depth	----------	----------
2 inch	930 abc	146 ab	2 d	0 b	1,078 abc
4 inch	1174 a	207 a	4 cd	0 b	1,384 a
6inch	1096 ab	94 bc	3 cd	0 b	1,193 abc
8 inch	1154 a	150 ab	5 cd	0 b	1,308 a
10 inch	1098 ab	154 ab	17 ab	0 b	1,268 ab
12 inch	818 bc	120 abc	6 cd	0 b	944 bcd
14 inch	695 cd	173 ab	23 a	0 b	891 cd
16 inch	521 de	108 abc	16 ab	0 b	644 de
18 inch	282 e	34 c	11 bc	1 a	328 e

*Yellow nutsedge tubers were buried on April 17, 2003.
†Yellow nutsedge tubers were harvested on July 22, 2003.

Yellow Nutsedge Growth in Response to Irrigation and Nitrogen Fertilization

Nitrogen fertilization had no significant (P = 0.05) influence on yellow nutsedge shoot or tuber number, total weight per plot, or individual shoot or tuber weight (data not shown). Since both shoot and tuber variables were not affected by nitrogen fertilization, data were averaged over fertilization variables to evaluate irrigation effects on yellow nutsedge. Irrigation events and total water applied are shown in Table 4. Soil moisture potential over time by irrigation regime is illustrated in Figure 3. Irrigation had a significant effect on both yellow nutsedge shoot number and total weight (Table 5). The -20 kPa irrigation treatment produced an average of 2,968 shoots per plot. This was significantly greater than the -50 kPa and -80 kPa irrigation treatments, which produced 1,512 and 974 shoots per plot, respectively. The -50 kPa treatment produced a greater number of shoots per plot than did the -80 kPa treatment. In terms of total pounds of shoot biomass per plot, the -20 kPa treatment produced an average of 3.9 lb per plot, 2.4 times more than the -50 kPa treatment and 2.7 times more than the -80 kPa treatment produced (Table 5). While more shoots were produced in the -50 kPa treatment than the -80 kPa treatment, they both had similar total weights of 1.6 and 1.4 lb, respectively. The average weight per shoot was not different among irrigation treatments. Based on the digital images, the percent of the plot area covered by yellow nutsedge shoots grew more rapidly with the -20 kPa treatment than with either the -50 or -80 kPa treatments (Fig. 4). The percent of the plot area covered was fairly small from June 2 to July 15. Over a 20-day period from July 15 to August 4 the percent of the plot area covered by yellow nutsedge increased by 70, 22, and 15 percent with the -20, -50, and -80 kPa treatments, respectively. At harvest the -20 kPa treatment gave 95 percent coverage with an average of 105 shoots/ft^2 , the -50 kPa treatment produced 43 percent coverage with 53 shoots /ft^2, and the -80 kPa treatment gave 23 percent coverage with an average of 34 shoots /ft^2.

Yellow nutsedge tuber production increased with increasing soil water potential (Table 6). An average of 18,789 tubers per plot were produced from a single plant with the -20 kPa treatment. This was 4,217 and 7,462 tubers per plot greater than the -50 and -80 kPa treatments, respectively. There was a twofold increase in tubers produced between the -50 and -80 kPa treatments. Tuber production increased 1.3 times with a soil moisture potential of -20 kPa compared to -50 kPa. An increase of 1.4 lb of tubers per plot was produced between -80 kPa and -50 kPa and between -50 kPa and -20 kPa (Table 6).

These results that indicate the ability of yellow nutsedge to increase both shoot and tuber production with increasing soil water potential are not surprising. However, the total shoot and tuber production from a single yellow nutsedge tuber is greater than previously reported in the literature; tuber production from a single parent tuber in this trial was significantly greater than that reported by Tumbleson and Kommedahl (1961), where tuber production was evaluated under dryland production.

Table 4. Number of irrigations, amount applied per irrigation, and total water applied, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Irrigation	Irrigations		Total applied*
kPa	number/plot	inches/event	inches/plot
-20	74	0.32	24.3
-50	15	1.0	17.5
-80	4	1.38	8.0

*Total includes 0.6 inch of rainfall. The -50 and -80 kPa treatments received 1.9 inches of irrigation water between August 28 and September 1 to bring all plots to a soil moisture potential of -20 kPa at harvest to facilitate core sampling.

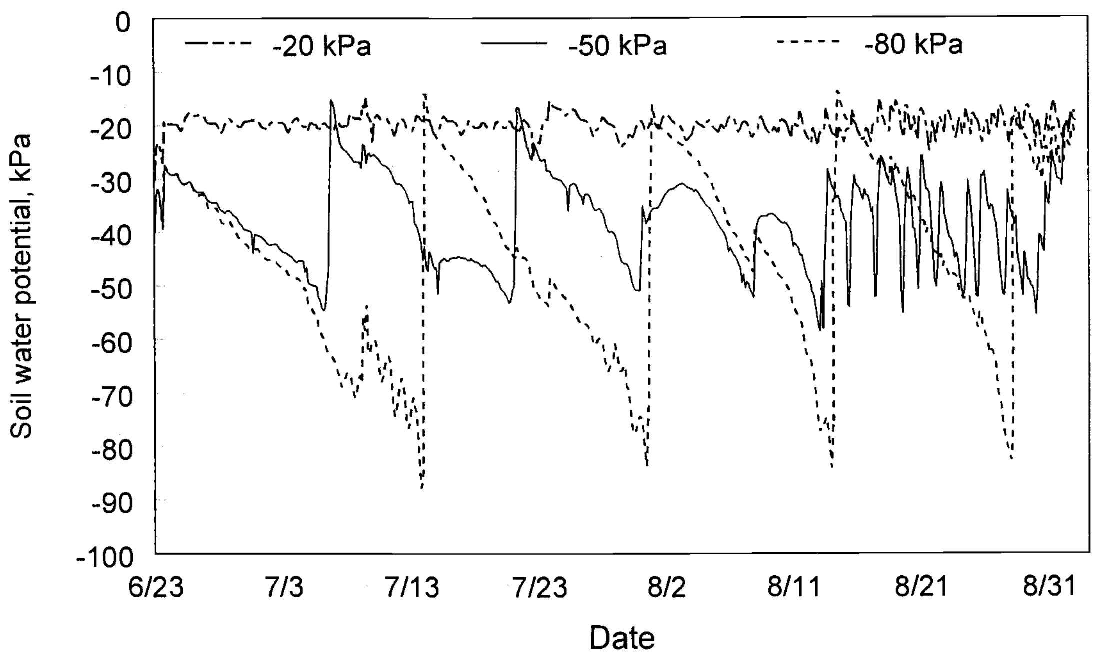

Figure 3. Soil moisture potential over time by irrigation regime, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 5. Yellow nutsedge shoot production as influenced by irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Irrigation	Yellow nutsedge shoots*				
kPa	no/plot	no/ft^2	lb/plot	lb/ft^2	g/shoot
-20	2,968 a	105 a	3.9 a	0.14 a	0.61 a
-50	1,512 b	53 b	1.6 b	0.05 b	0.56 a
-80	974 c	34 c	1.4 b	0.04 b	0.61 a

*Values followed by the same letter designation are not statistically different (P = 0.05).

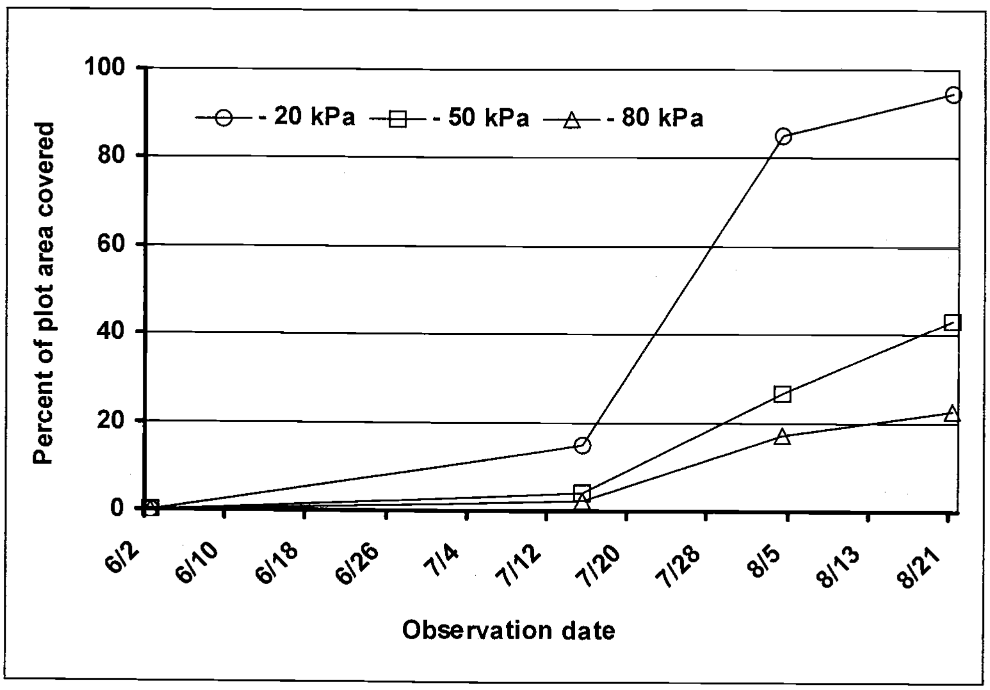

Figure 4. Yellow nutsedge patch expansion over time based on percent ground coverage between transplanting and harvest, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 6. Yellow nutsedge tuber production as influenced by irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Irrigation	Yellow nutsedge tubers				
kPa	no/plot	no/ft^2	lb/plot	lb/ft^2	g/tuber
-20	18,789 a	665 a	4.8 a	0.17 a	0.12 a
-50	14,572 b	515 b	3.4 b	0.12 b	0.11 a
-80	7,110 c	251 c	2.0 c	0.07 c	0.13 a

*Values followed by the same letter designation are not statistically different (P = 0.05).

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