Reprinted from: Perspectives on new crops and new uses. 1999.
J. Janick (ed.), ASHS Press, Alexandria, VA.

Growth Analysis of Lesquerella in Response to Moisture Stress

Naveen Puppala and James L. Fowler

Lesquerella fendleri (Gray S. Wats.) native to the arid south-western United States has been cited as prime candidate for domestication as a new source of hydroxy fatty acids. Lesquerella oil can replace castor oil and produces a seed containing gum and unique oil, which can be used in a variety of industrial applications and cosmetics. The manner in which plants partition products of photosynthesis into various plant parts is important in determining growth rate and yield. The adaptation of a crop to a particular environment depends upon its efficiency in using resources to produce biomass and its ability to partition the biomass into seed yield. Adequate soil moisture is essential for maximum crop production, but different stages of plant development possess varying sensitivity to moisture stress. Therefore, with limited irrigation, it is essential to distribute the water according to a specific development stage. The objective of this study was to study the effect of moisture stress at different phenological stages on photosynthetic rate, leaf water potential, and growth analysis.

METHODOLOGY

Two field experiments were conducted at the New Mexico State University, Plant Science Center during 1994–95 and 1995–96 growing seasons. The experimental design was a randomized complete block with six replications. Treatments consisted of (1) continuous favorable soil moisture [irrigated at 50% available water content (AWC)], (2) moisture stress (irrigated at 25% AWC) from establishment to final harvest, (3) moisture stress (irrigated at 25% AWC) from establishment to flowering with no stress afterwards (50% AWC), and (4) no stress imposed from establishment to flowering (50% AWC) followed by stress (25% AWC). Lesquerella seeds obtained from Dr. D.A. Dierig, ARS, US Water Conservation Laboratory, Phoenix, AZ, were sown using brillion planter at the rate of 8 kg/ha. The data presented is the mean of two years.

The mean Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) were calculated as suggested by Buttery (1970) and Enyi (1962). A random sample was taken from the leaf fraction for leaf area measurements with a LI-3000 automatic leaf area meter (LI-COR, Inc., Lincoln, NE). The growth analysis were conducted in each plot on plants harvested from a ground area of 0.25 m^2 at 15 days intervals from the onset of stress treatments. These components were oven-dried at 65°C for 48 h.

Top most fully expanded leaf of the marked plants was selected from each plot to measure photosynthetic rate (PN) using LICOR 6100 (LICOR, USA). The xylem water potential was measured during mid-day between 12 noon to 1:00 p.m. using a model 3005-1422 Plant Water Status Console (Soil Moisture Corp., Santa Barbara, CA) from one stem of each plant. To evaluate leaf water potential leaf samples were collected during the afternoon in 10 cc syringes and stored in the freezer. The samples were thawed and analyzed using a Model 5130C vapor pressure osmometer (Wescor, Inc., Logan, UT).

EXPERIMENTAL RESULTS

Mean pod yield of two seasons is presented in Table 1. The consumptive use of water (CUW) for the 50% AWC treatment was 662 mm. The seed yield was 925 kg/ha. The water use efficiency was 1.13. Stress prior to and after 50% flowering resulted in 12% and 21% reduction in pod yield compared to the control. The WUE efficiency was 4% percent higher than the control treatment because of saving in one irrigation. Stress after 50% flowering resulted in 5% reduction in WUE compared to control. Irrigating the crop at 25% AWC drastically reduced the yield by 45%. Thus irrigating the crop at 50% after flowering is most beneficial resulting in maximum growth and yield and was similar to that reported by Hunsaker et al. (1998).

Data for the growth analysis during the maximum vegetative stage is presented in Table 2. The maximum CGR occurred when leaf cover was complete and it represented the maximum potential dry matter production (219 DAS) and solar energy conversion rate. The lower CGR rate for treatment 25:50% was due to the release of stress during this period. The RGR decreases with the age of the crop and this decrease are due to the fact that an increasing part of the plant is structural rather than metabolically active tissue and as such does not contribute to growth. The decrease is also due to shading and increase in age of lower leaves (Brown

Table 1. Seed yield, consumptive use of water (CUW) and water use efficiency (WUE) of *Lesquerella fendleri*.

Available water content	Seed yield (kg/ha)	CUW (mm)	WUE
50%	925	662	1.13
25:50%	825	588	1.17
50:25%	725	550	1.09
25%	525	519	1.00

Table 2. Mean growth analysis as influenced by irrigation treatments (207–219 DAS).

Available water content	Ps (mmol CO_2 m^{-2} s^{-1})	CGR (g m^{-2} d^{-1})	RGR (g g^{-1} d^{-1})	NAR (g m^{-2} d^{-1})
50%	27.2	8.47	0.026	0.011
25:50%	28.5	5.57	0.021	0.001
50:25%	20.4	8.80	0.032	0.012
25%	17.5	6.04	0.022	0.005

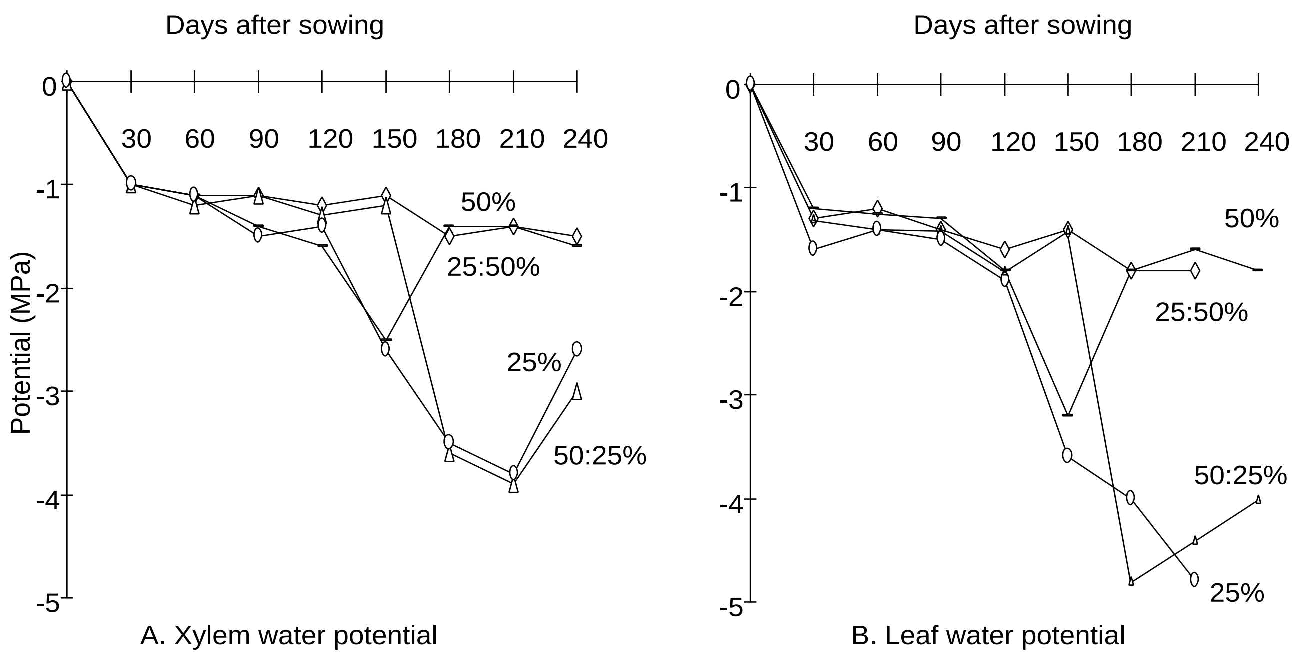

Fig. 1. Effect of water deficit on xylem and leaf water potential of lesquerella.

1984). The NAR is a measure of the average efficiency of leaves on a plant. The high efficiency of NAR in treatments 50% and 50:25% was due to high CGR rates during this period. A disadvantage of using leaf area as a basis for growth expression is that only the average efficiency of leaves in producing dry matter is known.

The effect of stress on leaf water potential was more drastic than xylem water potential (Fig. 1). Stress after 50% flowering and irrigating the crop at 25% resulted in a leaf water potential of 0.5 MPa. The low leaf water potential had a severe impact on the net photosynthetic rate (PN) resulting in lowering the oil synthesis due to lack of photosynthates as most of the fats are synthesized from phosphates by gluconeogensis pathway. The effect of water deficit on oil yield and returns are presented in Fig. 2. Irrigating the crop at 25% AWC resulted in almost 50% reduction in returns compared to control.

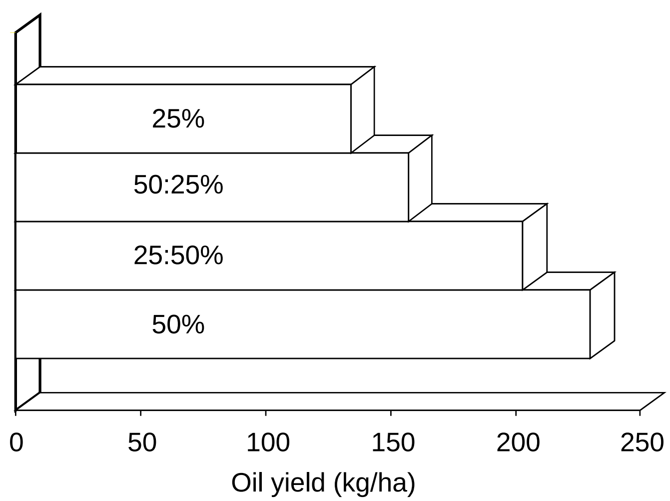

Fig. 2. Effect of water deficit on oil yield of lesquerella.

CONCLUSIONS

This study confirms that lesquerella can withstand mild water stress prior to flowering. Lesquerella should not be water-stressed from flowering to early pod formation and is considered to be the most critical stage for irrigation. Irrigating the crop at 75% depletion of the available soil water prior to flowering and 50% depletion after flowering can result in maximum growth and yield.

REFERENCES

Brown, R.H. 1984. Growth of the green plants. p. 153–174. In: M.B. Tesar (ed.), Physiological basis of crop growth and development. Am. Soc. Agron. Madison, WI.

Buttery, B.R. 1970. Effect of variation on leaf area index on maize and soybean. Crop Sci. 10:9–13.

Enyi, B.A.C. 1962. Comparative growth rates of upland and swamp rice varieties. Ann. Bot. 26:467–487.

Hunsaker, D.J., F.S. Nakayama, D.A. Dierig, and W.L. Alexander. 1998. Lesquerella seed production: Water requirements and management. Ind. Crops Prod. 8:167–182.