The Response of Lesquerella to Nitrogen Fertilizer Rate and Time of Application

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Abstract

Lesquerella is a plant that grows in the wild in southwestern U.S. and produces seeds containing hydroxy fatty acids similar to those in castor beans. Research has indicated that lesquerella has potential as a crop plant for Arizona. An important step in the commercialization of this plant for Arizona farms is the development of an efficient agronomic production system. Research to determine the effect of nitrogen (N) rates and timing of N applications on lesquerella production was conducted at the Maricopa Agricultural Center in the 1993-94 and 1995-96 seasons. Nitrogen application rates of 0 to 108 and 0 to 162 lbs. N/acre were evaluated in 1993-94 and 1995-96 tests, respectively. Seed yields as high as 1780 lbs./acre were obtained in the 1995-96 test using a conventional combine for harvest. In both tests, lesquerella biomass production and seed yields increased as the N rate was increased. In 1995-96, a split application of N in March and April resulted in higher seed yields than a single application in March. Seed oil content decreased in both tests as the N rate was increased. In 1995-96, seed oil content decreased 12% as the N rate was increased from 0 to 162 lbs. N/acre. The N application rate had no effect on 1000-seed weight.

Introduction

Lesquerella [Lesquerella fendleri (Gray) Wats.], a member of the Brassicaceae, has the potential to provide U.S. industry with a domestic source of hydroxy fatty acids. Presently, imported castor oil and its derivatives are the only commercial source of these fatty acids. Lesquerella seed oil is high in lesquerolic acid which is similar to ricinoleic (seed) acid, the dominant fatty acid in castor oil. Lesquerella oil and its derivatives can be used in a wide range of products including resins, waxes, nylons, plastics, lubricants, cosmetics, and coatings (Dierig et al., 1993; Kleiman, 1990; Roetheli et al., 1991).

The native species currently being domesticated as a crop plant for Arizona farms grows in the wild from Arizona to Texas as a perennial at elevations from 2000 to 6000 ft. with precipitation ranging from 10 to 16 inches (Gentry and Barclay, 1962). Research indicates that lesquerella can be grown as a winter annual in Arizona with a growing season of October through May or June (Nelson and Hart, 1995) and a water requirement of about 25 inches (Dierig et al., 1992).

Agronomic research has been in progress since the mid-1980's. In 1991, a USDA-led task force evaluated the status of lesquerella research and development and reported that no insurmountable barriers to commercialization existed (Roetheli et al., 1991). Studies have provided information on seed-bed preparation, plant population, planting dates, water requirement, irrigation timing, weed control and harvesting (Coates, 1994; Coates, 1996; Dierig et al., 1993; Nelson and Hart, 1995; Roetheli et al., 1991; Thompson et al., 1989). Preliminary research indicates that lesquerella responds to nitrogen (N) fertilizer (Nelson and Hart, 1995). The objective of this research was to obtain additional information on the effects of N application rate and timing of N application on growth and yield characteristics of lesquerella grown in central Arizona.

Materials and Methods

Tests were conducted in 1993-94 and 1995-96 at the University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona. The soil at this location is a variable Mohall sandy loam. Field preparation included disking and land leveling. Each year, in mid-September before fertilizer was applied, the N mineral content of the soil was determined to a depth of four feet in 12 inch increments at five locations within the test site. In 1993 and 1995, the total soil NO_3-N in the top four feet of soil was 27 and 20 lbs./acre, respectively.

In the 1993-94 test, 200 lbs./acre of ON-20P-OK fertilizer was applied and incorporated before planting. In the 1995-96 test, 170 lbs./acre of 16N-9P-OK fertilizer was applied preplant to all plots except plots receiving no N fertilizer. Th O-N plots received 75 lbs./acre of ON-20P-OK fertilizer preplant.

Lesquerella seed was planted on level land with a Brillion planter at rates of 8 and 10 lbs./acre on 30 September 1993 and 19 October 1995, respectively. In each test, the plantings were flood irrigated two or three times to obtain stands. Final plant populations were 600,000 and 1,020,000 plants/acre in the 1993-94 and 1995-96 tests, respectively.

In both tests, after stands were established, the plot area was flood irrigated one time in December and one time in February and then every 2-3 weeks beginning in March. Irrigation water was not measured in the 1993-94 test, but the 1995-96 test received 8 irrigations for a total of 28 inches of water in addition to water applied for stand establishment.

In the 1993-94 test, no nitrogen fertilizer was applied until 18 March 1994. At that time, N treatments were established using application rates of 0,54 and 108 lbs. N/acre (Table 1) . One additional treatment received 54 lbs. N/acre on 18 March and 54 lbs. N/acre on 25 April. The experimental design was a randomized complete block with four replications. Plots were 10 ft. wide by 20 ft. long. On 17 June 1994 a 10.5 sq. ft. area was hand-harvested from each plot. The harvested plant material was dried at 150°F and weighed to determine above-ground biomass production and then threshed to determine seed yield.

In the 1995-96 test, eleven N treatments were compared as shown in Table 2. The source of N for preplant applications was 16N-9P-OK fertilizer except where noted and for March and April applications was urea (46%N). Experimental design was a randomized complete block with four replications. Nitrogen fertility plots were 20 ft. wide by 50 ft. long. On 20 June 1996 a 10.5 sq. ft. area was hand-harvested from selected treatments to estimate above-ground biomass production. These samples were dried at 150°F and weighed. On 24 June 1996 a 13 by 43 ft. strip was harvested from each plot using a conventional combine. The seed was dried, cleaned and weighed to determine seed yield. Seed oil content for seed from both tests was determined by pulsed nuclear magnetic resonance (NMR).

Results and Discussion

1993-94 Test

As in preliminary tests, lesquerella responded to N fertilizer in terms of dry matter production and seed yield (Table 3). Above-ground dry matter production generally increased as the N rate was increased resulting in a significant linear relationship ($r^2 = 0.78$, $P<0.01$) between N rate and dry matter production.

Seed yields as high as 1550 lbs./acre were obtained in this test (Table 3). Yields were increased as the N rate increased from 0 to 108 lbs. N/acre. Similar to dry matter production, there was a significant linear relationship ($r^2 = 0.80$, $P<0.01$) between N rate and seed yield. A split application of N in March and April (treatment 4) did not significantly influence seed yield compared to a single application of N in March (treatment 3).

Seed oil content was reduced as the N rate was increased resulting in a negative correlation ($r^2 = 0.54$, $P<0.01$)

between N rate and seed oil content (Table 3). There was a 7 percent reduction in seed oil content at the 108 lbs./acre N rate. The N rate had no significant effect on 1000-seed weight.

1995-96 Test

The relationship between N rate and dry matter production was similar to that obtained in the 1993-94 test. As the N rate was increased from 0 to 162 lbs. N/acre (treatments 1,4,6 and 8) there was a significant linear increase in dry matter ($r^2 = 0.86$, $P<0.01$) (Table 4).

In this test, seed yields as high as 1780 lbs./acre were obtained using a conventional combine for harvest (Table 4). The combine harvested seed contained an average of 22 percent trash. Seed yield increased as the N rate was increased. There was a significant linear relationship ($r^2 = 0.89$, $P<0.01$) between N rate and seed yield. Splitting N applications to provide N fertilizer in March and April (treatments 9,10 and 11) resulted in higher seed yields and 1000-seed weights than the same N rates applied only in March (treatments 5,6 and 7).

Seed oil content was reduced as the N rate was increased resulting in a negative correlation ($r^2=0.49$, $P<0.001$). There was a 12 percent reduction in seed oil content when the N rate was increased from 0 to 162 lbs. N/acre. The N rate had no significant effect on 1000-seed weight.

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Table 1. Nitrogen fertilizer treatments in 1993-94 test with N applied shown as lbs./acre.

	Time N applied			
Treatment	Preplant	18 March	25 April	Total
1	0	0	0	0
2	0	54	0	54
3	0	108	0	108
4	0	54	54	108

Table 2. Nitrogen fertilizer treatments in 1995-96 test with N applied shown as lbs./acre.

	Time N applied			
Treatment	Preplant	4 March	23 April	Total
1	0	0	0	0
2	27	0	0	27
3	54*	0	0	54
4	27	27	0	54
5	27	54	0	81
6	27	81	0	108
7	27	108	0	135
8	27	135	0	162
9	27	27	27	81
10	27	54	27	108
11	27	54	54	135

* Treatment No. 3 received preplant applications of 170 lbs./acre of 16N-9P-OK fertilizer and 59 lbs./acre of urea (46%N)

Table 3. Effect of N treatment on dry matter production, seed yield, seed oil content, and 1000-seed weight of lesquerella, 1993-94 test.

N treatment		Dry	Seed		1000-seed
No.	Total N	matter	yield	Oil	weight
	(lbs./A)	(lbs./A)	(lbs./A)	(%)	(g)
1	0	4,190	590	27.5	0.583
2	54	7,710	1,220	26.4	0.583
3	108	9,210	1,550	25.6	0.578
4	108*	10,230	1,520	25.3	0.599
LSD (.05)		1,580	240	1.3	NS**

* 54 lbs. N/acre applied on 18 March and 54 lbs. N/acre applied on 25 April.
**NS=Not statistically significant.

Table 4. Effect of N treatment on dry matter production, seed yield, seed oil content and 1000-seed weight of lesquerella, 1995-96 test.

N treatment		Dry	Seed		1000-seed
No.	Total N	matter	yield	Oil	weight
	(lbs./A)	(lbs./A)	(lbs./A)	(%)	(g)
1	0	3,520	590	26.7	.609
2	27	-----	700	26.4	.599
3	54	-----	850	26.7	.596
4	54*	5,800	990	26.3	.607
5	81*	-----	1,190	25.7	.586
6	108*	8,610	1,500	25.0	.597
7	135*	-----	1,490	25.7	.587
8	162*	9,590	1,670	23.4	.583
9	81**	-----	1,460	25.1	.621
10	108**	-----	1,610	24.2	.623
11	135**	-----	1,780	23.5	.628
LSD (.05)		1,590	190	1.3	.039

* Received applications of N in March.
** Received applications of N in March and April.