Field Production of Texas Native Evening Primrose (*Oenothera* spp.) as a Source of Gamma Linolenic Acid

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Abstract

Gamma linolenic acid (GLA) has been recognized as a beneficial treatment for a variety of human ailments including high blood pressure, cardiovascular disease, skin disorders, and diabetic neuropathy. *Oenothera biennis* has been the most widely used species of evening primrose to produce GLA. Over a period of two years, native accessions of *O. elata, O. jamesii* and *O. rhombipetala* were produced as transplants in a greenhouse and mechanically transplanted to the field using three different plant spacings. Plots were harvested and analyzed to determine seed yield, oil content and GLA level. In the two years of this study, seed yield, oil content and GLA level were significantly impacted by plant spacing treatments. Generally, the higher plant populations gave the best results.

INTRODUCTION

Historically, evening primrose (*Oenothera* spp.) has been grown both as an attractive wildflower and as an herbal supplement. Increasingly, evening primrose oil has been recognized by the medical community as a legitimate health care product. Researchers have found that the high levels of gamma linolenic acid (GLA) (C18:3 Δ6, 9, 12) found in evening primrose oil can be used to treat many of the pathological conditions in humans caused by GLA deficiencies. Recent research has indicated that GLA may reduce the symptoms of diabetes mellitus and atherosclerosis (Hathaway, 1999; Keen et al., 1993). Supplementation of the diet with the GLA derived from the oil of plants such as evening primrose is thought to reduce the severity of many diseases (Mengeaud, Nano, Fournel and Rampal, 1992).

Commercially, *Oenothera biennis* is used for GLA production; however, the best production with this crop occurs in cool moist climates. Previous research has identified the Texas natives *Oenothera jamesii*, *Oenothera elata* and *Oenothera rhombipetala* for their high levels of GLA and their ability to thrive in demanding climates while producing economic quantities of GLA (Balch, McKenney and Auld, 1998 and 2002). Published information on the current production of evening primrose oil involves transplanting young plants of *Oenothera biennis* from the greenhouse to the field in what can be an expensive and labor intensive task (Brandle, et al., 1993; Nightingale and Baker, 1995). Very little published information as to the specifics of this process are available. Plug transplanting by mechanical means is a common method for many flower and vegetable crops and appears to be a viable solution. The purposes of this study were to determine the optimal cultural management for field production of evening primrose in a semiarid climate and to attempt to reduce the seed dormancy present in these species.

MATERIALS AND METHODS

Accessions of *O. rhombipetala* (R-36 and R-46), *O. elata* (R-50) and *O. jamesii* (T-60) were seeded in the greenhouse using a peat-lite media. Water and fertility were maintained consistently throughout the process as necessary. At 11 weeks after seeding, the transplants were mechanically transplanted in the field using a Rotary One (Holland Transplanters, Holland, MI) in one meter spaced rows. Plant spacing was 30, 60, or 90 cm. Irrigation was supplied as necessary throughout the growing season. Flea beetles were a significant problem and were managed using applications of a carbaryl insecticide at the recommended rate. At maturity, adjacent plants within a 3.5 m sampling unit of the

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9.14 m blocks were harvested by hand, threshed and the seed screened with 12.7 cm perforated plate soil sieves (Humboldt Mfg., Norridge, Il). Seed samples were then cleaned and final seed weight determined. The experiment was evaluated as a randomized complete block design with four replications. Each of the four accessions was evaluated in separate experiments. Data were analyzed by analysis of variance (SAS, Version 7 1998) and means separated with a Fisher's Protected Least Significant Difference Test at the 0.05 probability level. Oil content was determined by nuclear magnetic resonance (NMR) using a canola seed sample as a standard.

RESULTS AND DISCUSSION

A uniform stand of the three species was successfully established using the mechanical transplanter and appears to be a viable alternative for commercial production. Development in the field for each of the four accessions (R-50, T-60, R-36, R-46) varied due to species differences, but were consistent in maturity from weeks after seeding (WAS) between the two years. R-36 and R-46 varied the least developmentally being the same species.

The three different plant spacings of evening primrose were evaluated for seed yield. The seed of each accession was hand harvested when the seedpods began to shatter. Even though individual plant yields varied and often improved with increased distance between the plants, the improvement was not enough to offset the greater numbers of seed obtained with decreased spacing and increased plant populations per hectare. All spacings were sufficient to allow for normal growth.

Yield data for all of the species is presented in Fig. 1. The two *O. rhombipetala* accessions R-36 and R-46 were harvested at 28 WAS (the beginning of September) and exhibited flower abortion along the stem, possibly due to a response to heat. The smaller number of ripened capsules resulted in a consistently smaller yield throughout the *O. rhombipetala* samples. *O. jamesii* (T-60) was harvested at 35 WAS when the pods began to shatter. This entire plant was much larger and woodier than any of the other evening primrose in the study. All of the evening primrose are indeterminate; however, the *O. jamesii* had much more leafy growth at the time of harvest making the determination of time of harvest more difficult. The more moderate seed yield may be due to the pods shattering and loosing seed while this indeterminate plant kept flowering. *O. elata* (R-50) took place 37 WAS (the last week of November). In 1999, *O. elata* had the highest yields; however; during 2000 excessively cold weather began early and caused a loss in seed yield for R-50. The slightly smaller capsules did not split early and were more easily threshed.

Approximate weights per 100 seeds for each of the accessions were determined. *O. elata* (R-50) weighed 0.03 g, *O. jamesii* (T-60) weighed 0.06 g and *O. rhombipetala* (R-36) and (R-46) weighed 0.02 g each. The plant populations of 10.8 thousand plants ha^{-1} (90 cm. spacing) gave significantly poorer seed yields with *O. elata* than 16.1 (60 cm.) and 32.3 thousand (30 cm.) plants ha^{-1} for both years. *O. jamesii* (T-60) showed higher seed yields with 32.3 thousand plants ha^{-1} than 16.1 thousand plants ha^{-1} and 10.8 thousand plants ha^{-1}. Seed yields for both species greatly decreased in the 2000 season. *O. rhombipetala* (R-46) showed no significant differences between any of the spacing treatments while *O. rhombipetala* (R-36) showed significant improvement when planted with the narrowest spacing but showed very little difference between the other two and over the two years (Fig. 1).

The percent oil content was determined from the four highest seed yielding individual samples of each 3.5 m replication in both years. The results of the percent oil are presented in Fig. 2. Oil yield for *O. elata* was much higher in 1999 than 2000 while spacing appeared to have no significant affect on a percent basis (Fig. 2). Because *O. rhombipetala* matures much earlier in the season, the percent oil did not appear affected over both years.

NMR determined the percent GLA from the four highest seed yielding individual samples in a 3.5 m harvest area. The results of this analysis are presented in Fig. 3. *O.*

elata was the highest GLA yielding species in both 1999 and 2000 with 8.2, 8.4 and 8.3 % in the first year and 11.1, 11.1 and 10.9 % in 2000 on the 30, 60 and 90 cm. spacing respectively. Comparing the different accessions at the 0.05 level of probability, significant differences existed for GLA levels with *O. elata* (R-50) being the most superior with *O. jamesii* (T-60) next. *O. rhombipetala* was the lowest GLA yielding species in both years. R-36 held levels of 3.7, 3.5, and 3.3 % in 1999 and 3.4, 3.5 and 3.2 % in 2000. R-46 gave 3.8, 4.7, and 4.3 % in 1999 and 3.0, 3.1 and 3.1 % in 2000 for the 30, 60 and 90 cm. spacings. *O. jamesii* had GLA yields of 7.7, 8.1 and 7.8 % in 1999 and 9.1, 8.6 and 9.2 % in 2000 on 30, 60 and 90 cm. respectively. It may be seen from this analysis and the weather data provided in Figs. 4 and 5 that GLA is affected by the environmental conditions occurring during seed development. Earlier work in other evening primrose reports cooler temperatures during seed maturation to increase levels of GLA (Yaniv et al. 1989).

CONCLUSION

Many features appear to impact the yield and quality of oil produced by *Oenothera* spp. Because of the climatic differences between the two years, interactions developed in the major components such as seed and oil yield. For production, *O. elata* (R-50) proved the highest yielding and easiest to manage of the identified Texas native evening primrose. Where there is no significant difference in yields between spacing, a producer would choose the lesser plant population unless the per unit cost of transplants were offset by the increase in oil yield. This study showed that native Texas *Oenothera* spp. could be produced using commercial transplanting methods and that generally, the larger plant populations gave the highest seed yield on a per hectare basis. Percent oil and GLA did not appear affected by different spacings, but the environment affects the quality of the oil. This study showed that both environment and cultural management have important roles on the overall production of evening primrose oil.

ACKNOWLEDGEMENTS

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Figures

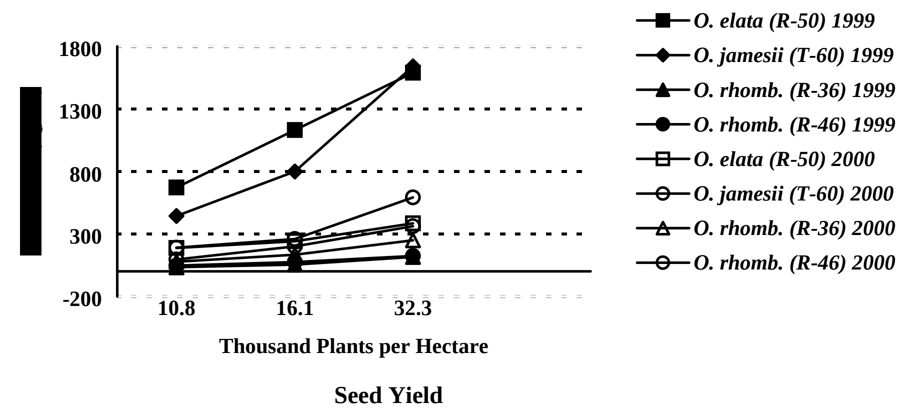

Fig. 1. Seed yield per hectare of the four highest yielding samples submitted for each of the three accessions of Evening Primrose.

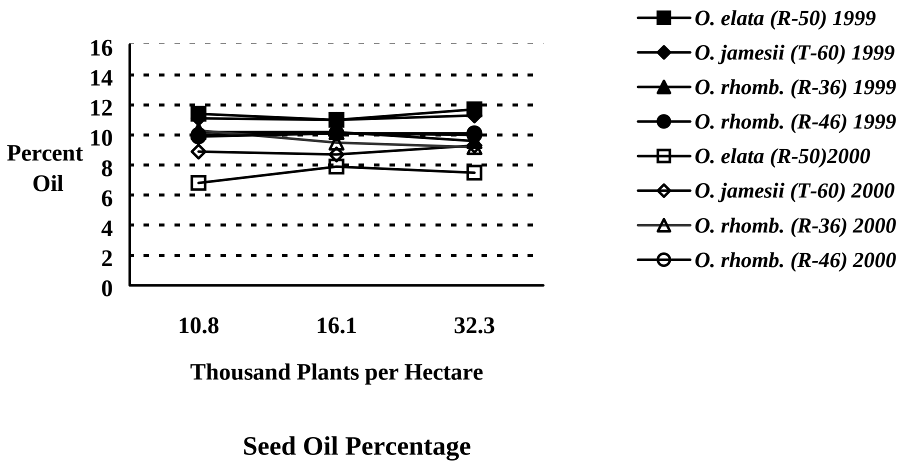

Fig. 2. Percent seed oil of four Evening Primrose accessions over three plant populations. Analysis provided through nuclear magnetic resonance by the University of Idaho, Moscow, Idaho.

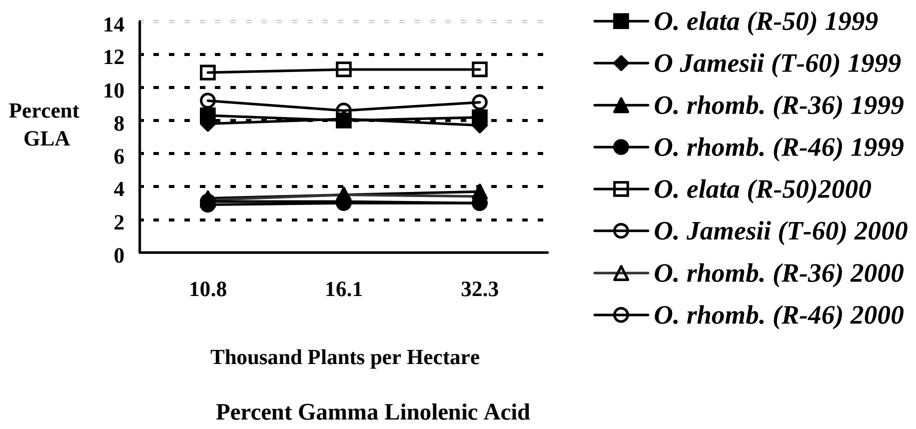

Fig. 3. Levels of GLA illustrated graphically for all accessions over the two-year period.

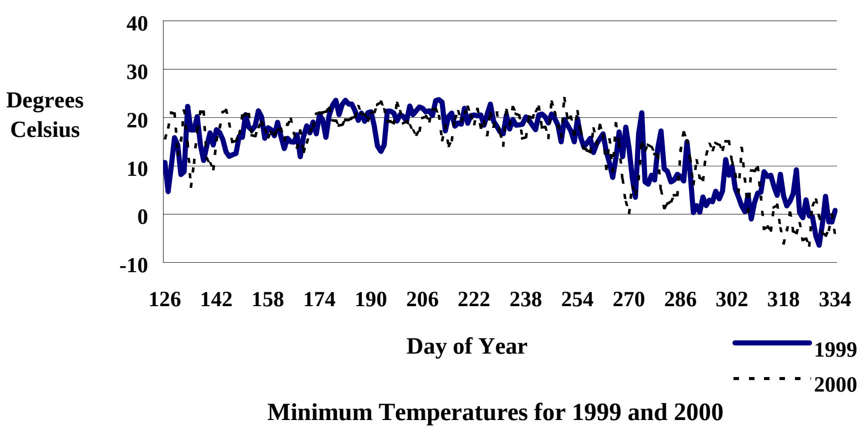

Fig. 4. Combined minimum temperatures or the 1999 and 2000 growing seasons showing an extended period of low temperatures in early November for 2000.

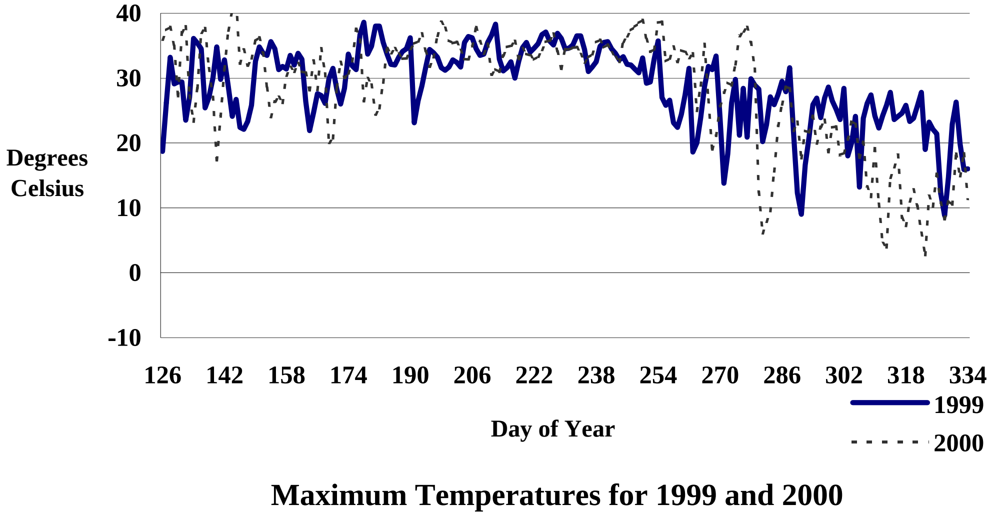

Fig. 5. Combined maximum temperatures for the 1999 and 2000 growing seasons.