Borage Culture on the Black Soil Zone of Alberta, Canada

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Recently, borage (Borago officinalis L. Boraginaceae) has been the subject of increasing agricultural interest because of the potential market for gamma linolenic acid (GLA), an unusual fatty acid extracted from the oil seed. GLA is an omega-6 essential fatty acid which has been identified as having several beneficial properties. Increased interest in production of the crop in western Canada has brought about a need for adequate agronomic management practices since very little local research information was available.

Field studies were conducted in central Alberta in 1998 and 1999 on a black Malmo silt loam soil to evaluate the effects of planting date and nitrogen fertility level on borage seed yield, harvest index, and seed oil GLA content.

Plots from all possible combinations of two planting dates (early vs late) and four nitrogen fertility rates (0, 20, 40, and 80 kg N/ha) were established and arranged in a factorial randomized complete block design. Plots were harvested twice during each growing season.

In general, early planting resulted in significantly higher seed yield, and harvest index. Nitrogen fertility level had no significant effect on seed yield; while increasing nitrogen fertility rate tended to decrease the harvest index. The no-response to nitrogen could be the result of a high initial soil nitrogen content.

Results indicate that, under the conditions of the experiment, early seeding is recommended. Although 20 to 40 kg N/ha proved to produce higher yields, further studies are needed to clarify the effect of nitrogen fertilization on the performance of borage crop before any recommendation is to be made.

OVERVIEW ON BORAGE SEED CROP IN WESTERN CANADA

In Canada, crop diversification has intensified in the last 20 to 30 years as a result of the need for improved sustainability and in response to declining economic returns on most of our traditional main crop commodities. For various reasons, Canada has been considered as the “Sleeping Giant” of the medicinal plant industry. A pristine environment, vast resources for crop production, relatively cheap land, well educated producers, adequate infrastructure, as well as motivated research and extension teams could all contribute to the development of the medicinal plant industry. Besides, Canada has access to an important herbal products market in the US.

Up to the year 2000, borage seed was an important seed crop in western Canada. However, borage crop area was estimated to have dropped dramatically this past spring 2000 in response to a sharp drop in the price to $ 5.5 /kg ($2.50/lb.) in 1999 to about $2.20/kg ($1.00/lb.) spot price in 2000. Excess borage seed production in western Canada reduced prices because some producers were growing borage seed without a production contract. In addition, there was over-production in other countries (England and New Zealand). Evening primrose (Oenothera lamarckiana) from China, another source of GLA, was also flooding into the North American market last year at a lower price. In parallel the demand for GLA had softened in both North America and in Asia. The poor economic performance in Japan has slowed demand for health products in general, including GLA-containing items. It is expected that the market for borage seed will recover, in a year or two, after the world glut is used up (Ward 2000). Furthermore, evening primrose hybrid Oenothera, of commercial interest to the health food market and principal competitor to borage in the production of GLA, is a biannual or winter annual that does not over-winter well in western Canada. Evening primrose can be started in a greenhouse and transplanted, but this results in high cost of production. Thus, until there are evening primrose varieties that can over-winter under the harsh environment of western Canada, borage remains a better option.

BORAGE: Plant Description and Uses

Known as the bee-plant, borage (Borago officinalis L.) is a hardy annual well suited to cultivation in western Canada. It is a traditional medicinal and culinary herb native to the Mediterranean (Janick et al. 1989). It is self-incompatible and thus, pollinating insects are required to transfer pollen between different plants. A minimum of two honey bee hives per hectare is recommended. Recently, borage has been the
subject of increasing agricultural interest because of the potential market for gamma linolenic acid (GLA), an unusual fatty acid extracted from the oil seed. It is widely recognized that borage, together with evening primrose is one of the main arable sources of GLA. Of the two, borage is the preferred source of GLA. The oil content of the seed is 30%–40% by weight; of which 23%–24% is GLA, which is about twice the level found in evening primrose (Beaubaire and Simon 1987; Simpson 1993a; Piquette and Laflamme 2000). Furthermore, borage oil is more stable and easier to process than evening primrose oil. However, the major competitor to borage as a source of GLA remains evening primrose. It makes up about 90% of all the GLA oil sold. As a medicine, GLA is commonly used as nutritional supplement and prescription pharmaceutical to combat heart diseases, diabetes, atopic eczema, arthritis, multiple sclerosis, and cyclical mastalgia (Horrobin 1990, 1997; Fan 1999; Piquette and Laflamme 2000).

As a culinary plant, borage leaves may be used as spinach, in pickles and salads, and in claret cup and iced drinks, and the flowers as an edible decoration for salads. In many Mediterranean countries, the edible part of the plant is the basal leaf petioles. This part was found to have a high nutritive value (Medrano et al. 1992).

Borage is relatively new to Alberta. Therefore, information on optimal cultural practices for borage production is lacking. Therefore, determining the optimal seeding date and harvesting date would contribute to optimizing borage seed yield and quality, as measured by the GLA level in the seed. To our knowledge, there has been no research investigating borage response to nitrogen fertilization in western Canada or elsewhere.

The objectives of the study were to determine optimum seeding date and nitrogen fertility levels for growing borage in central Alberta.

MATERIAL AND METHODS
Field studies were conducted in 1998 and 1999 at the Crop Diversification Centre North, Edmonton, Alberta, Canada on a black Malmo silt loam soil. Plots from all possible combinations of two planting dates (early vs late) and four nitrogen fertility rates (0, 20, 40, and 80 kg N/ha) were established and arranged in a factorial randomized complete block design, with four replications. Early planting dates were June 3 and May 29 in 1998 and 1999, respectively. Late planting dates were June 22 and June 8 in 1998 and 1999, respectively. Borage crop was seeded at a rate of 17 kg/ha. Phosphate was applied with the seed at a rate of 33.6 kg P/ha. Nitrogen (46–0–0) was surface broadcast approximately 3 weeks after seeding. Plots were frequently hand-weeded, as needed.

Because of the indeterminate growth habit of borage crop, plots were harvested twice during each growing season. Early-seeded plots were harvested on Aug. 20 and Sept. 2 in 1998; and on Aug. 20 and Aug. 30 in 1999. Late-seeded plots were harvested on Sept. 2 and Oct. 19 in 1998; and on Aug. 30 and Sept. 24 in 1999. Grain yield and TDW were assessed by harvesting an area of approximately 0.91 m² within each plot. Harvest index was calculated as the ratio of grain yield and TDW. Seed oil GLA content was determined using gas chromatography.

Treatment effects were analyzed using the PROC ANOVA procedure of SAS (SAS Inst. 1988). Treatment means were compared, when appropriate, using Fisher’s protected LSD (0.05).

RESULTS

Planting Date Effect
Delaying planting consistently resulted in a significant reduction in seed yield at both harvests (Fig. 1). Averaged over the two years of the experiments, this translates into a potential loss of 18 kg/ha in TDW and 11 kg/ha in grain yield for each day delay in seeding. Relatively similar trend was observed for the harvest index, which was significantly higher under early planting (Fig. 2).

Delaying planting increased seed oil GLA content (Fig. 3). Our results suggest that there is a trade off between seed yield and seed oil GLA content.
Nitrogen Effect

The highest seed yield were generally obtained by applying 20 or 40 kg N/ha (Fig. 1). Harvest index tended to decrease with increasing nitrogen application rate (Fig. 2). Nitrogen rate did not seem to affect seed oil GLA content (Fig. 3). Our results suggest that it is important to provide the crop with the optimum quantity of nitrogen. Too much or too little nitrogen could be detrimental to the crop.

Harvest Date Effect

Seed yield and harvest index were in general higher at the first harvest (Fig. 1, 2). This could be the result of seed shattering due to delayed harvest. It is widely recognized that one of the most serious production problem in producing borage seed is the indeterminate flowering habit and seed shattering (Simpson 1993a; Slinkard and Kulow 1996). Seed oil GLA content tended to increase as harvesting is delayed (Fig. 3).

Fig. 1. Borage seed yield at early (A) and late (B) harvests as affected by seeding date and nitrogen fertilization.

Fig. 2. Borage harvest index at early (A) and late (B) harvests as affected by seeding date and nitrogen fertilization.

Fig. 3. Seed oil GLA content at early (A) and late (B) harvests as affected by seeding date and nitrogen fertilization.
CONCLUSION
For optimum borage seed yield and total biomass, early seeding (i.e. last week of May–first week of June) is recommended under central Alberta conditions. Nitrogen application rate of 20 or 40 kg/ha produced the highest yields. However, further studies are needed to investigate nitrogen fertilization effects before any recommendation is to be made.

REFERENCES