Crambe: Research and Development Effort in North Dakota

ABSTRACT

Crambe (Crambe abyssinica Hochst.) has been evaluated as a potential industrial oilseed crop in the United States since the mid-1900's. Renewed interest in alternative crops and a diversified agriculture has stimulated the research effort of crambe in North Dakota. A multidisciplinary team of university researchers, industry professionals, and farmers has been assembled to evaluate the potential of commercial crambe production in the Northern Great Plains. Researchers in crop production have identified suitable production practices and possible management problems for crambe grown in North Dakota. This integrated effort has resulted in the first successful field-scale production, processing, and marketing of crambe oil.

INTRODUCTION

Crambe (Crambe abyssinica Hochst.) is a member of the mustard (Cruciferae) family, which includes crops such as rapeseed and tame mustard. Crambe, native to the Mediterranean region, was first introduced into the United States during the 1940's and has been under development by various state and federal agencies since that time.

Crambe is an erect annual with large pinnately lobed leaves similar to mustard. The crop exhibits an indeterminate flowering habit and may continue to set seed late in the season. The plant produces numerous white flowers that result in small round seeds borne singly on panicled racemes. Each seed is enclosed in a hull or pod which usually remains on the seed after harvest.

Crambe seed yields an industrial oil (~ 30%), which contains a high level of erucic acid (~ 57%), a valuable, renewable raw material for industrial products. Erucic acid is a 22-carbon unsaturated fatty acid containing one double bond. High erucic acid oils and derivatives of erucic acid have current and potential use as a raw material for erucamide, plastics and nylon, paints and coatings, and high temperature lubricants (Van Dyne et al. 1990).

The USDA's Office of Agricultural Industrial Materials identified crambe's potential and leads a commercialization project by organizing and coordinating a team research effort involving the High Erucic Acid Development Consortium of universities and government (HEADE), private organizations, and farmers.

As a member of HEADE, North Dakota State University initiated a multidisciplined integrated research and development effort towards commercializing crambe in 1989. The project aims to coordinate a diverse set of crambe research projects to accomplish the goal of establishing and maintaining a significant production and processing base for crambe in the Northern Plains.

SOIL FERTILITY MANAGEMENT FOR CRAMBE PRODUCTION

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The data on which to base fertility recommendations for crambe production in the Northern Plains states is limited. An Oregon experiment showed nitrogen applications of 0 to 134 kg ha^{-1} resulted in no differences in seed yield (White and Higgins 1966). Fertility trials in western Kentucky indicate a decrease in oil percentage as nitrogen rates increased (Palmer 1983). The knowledge of proper nitrogen and phosphorous nutrition for the production of an efficient seed yield with good oil quality will be required as crambe is commercialized. Trials were conducted for three years at three locations in North Dakota to evaluate the influence of different rates of phosphorous and nitrogen fertilizer on crambe yield and oil quality.

Significant nitrogen responses were not observed in 1989 and 1991. The lack of response could be attributed to moisture stress in 1989 and relatively high residual nitrogen levels in 1991. A significant response to nitrogen was observed at two locations in 1990. The addition of 34 kg ha^{-1} of phosphorous resulted in a yield increase two years out of three at the location having the lowest level of residual phosphorous. An analysis of the effect that soil fertility may have on oil quality is not complete at this time. Although these studies have not been conclusive concerning the fertilizer needs of crambe, the data does begin to serve as a basis to provide soil fertility recommendations to growers.

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ADDITIONAL CROP PRODUCTION AND MANAGEMENT TRIALS

Statewide Crambe Variety Trials

A.A. Schneiter, Principle Investigator

Uniform variety trials representing most registered crambe cultivars are planted annually at seven locations across North Dakota. Data related to crop development, quality, and yield are collected to assess crambe's adaptation across the state. Current results have shown crambe to be widely adapted, however yields did range from 407 to 2809 kg ha^{-1} across the state in 1991.

Determination of Optimum Seeding Rates in Crambe

S.F. Zwinger, Principle Investigator

The current production practice in North Dakota is to plant crambe at a seeding rate of 17 to 22 kg ha^{-1}. This rate is based on information provided in a report by White and Higgins (1966). With objectives of optimizing seed production and gaining knowledge on crambe's compensatory capabilities, seeding rate trials were initiated at four locations in 1991. Treatments included seven rates of planting ranging from 9 to 36 kg ha^{-1}. Preliminary results show extreme elasticity of the crambe plant in yield compensation at low plant densities.

Influence of Environment on Quality of Oil and Meal from Different Oilseeds

N. Riveland, Principle Investigator

The quality characteristics of oil and meal from crambe and other minor oilseeds when grown under differing environments in North Dakota are not well understood. Additional technical information is needed on these alternative oilseed crops to clearly establish their product value. Commercial varieties of crambe, rapeseed (canola), and safflower are being planted in field trials at six diverse environments in North Dakota. Sufficient data on oil contents and fatty acid profiles are not yet available to make conclusive comments.

Evaluation of Crambe Genotypes for Agronomic Improvement

B.G. Schatz, J.C. Gardner, and S.F. Zwinger

Crambe cultivars for commercial production are limited. Currently, the only registered cultivar available in sufficient quantity for field production is 'Meyer'. The commercialization of crambe will hasten the need for an expanded effort in varietal improvement. A thorough evaluation of know crambe cultivars and experimental lines has been initiated to identify genotypes with improved agronomic traits, yield potential, and oil quality. A crambe nursery consisting of advance materials from Koert Lessman, a crambe geneticist at New Mexico State University, was evaluated at Carrington, ND in 1989-91.

Genotypes evaluated in the nursery generally appear similar. However, variability in maturity, plant height, and yield potential are evident. The two oil factors of most importance, total oil content and percent erucic acid, were found to vary significantly among lines in 1990. Data accumulated from more environments will be required to better assess the potential improvement in agronomic traits and oil characteristics among the existing set of experimental lines.

Chemical Conversion of Erucic Acid to Cleavage Products

P.Boudjouk, and M. Sibi

Products that could be derived from the cleavage products of erucic acid may hold the greatest potential for market expansion for high erucic acid oils. Cleavage of erucic acid at its double bond results in the coproducts of brassylic acid; a 13-carbon acid, and pelargonic acid, a 9-carbon product. Pelargonic acid, has established uses in industry, while brassylic acid has been identified as a precursor for numerous products desired by industry (Van Dyne et al. 1990). Current methods for the conversion of erucic acid to brassylic and pelargonic acids are essentially limited to ozonolysis, an expensive and somewhat hazardous technology.

Laboratory trials were initiated to evaluate alternative procedures by which the desired coproducts could be derived from the cleavage of the double bond in erucic acid. Success of these efforts has led to the conversion of erucic acid from crambe into brassylic and pelargonic acids by a new catalytic process. The catalyst is safe, has given high yields, and can be recycled. This process could position crambe oil derivatives at a very competitive price in industry.

FIELD-SCALE EVALUATION AND COMMERCIALIZATION

J.C. Gardner

Prior to 1990, the only confirmed attempt to produce crambe on a commercial scale occurred in western Kentucky and resulted in failure due to weather related production problems and a warehouse fire. (Princen 1983). Gaining additional experience with field scale production and processing of the crop was identified as a major step towards commercialization of crambe.

In the spring of 1990, a project was established to attempt commercial scale crop production and seed processing of crambe in North Dakota. A partnership of responsibility and risk was organized among HEADE, thirty-eight North Dakota farmers, and National Sun Industries (NSI). NSI is a major oilseed processor with a 1,360 tonne per day facility near Enderlin, ND. HEADE, working through individuals at NDSU, was responsible for soliciting farmers to grow crambe, providing seed and production information, and serving as a link between the farmers and the processor. Crambe was planted on 970 ha in early May and 88% of the crop was harvested resulting in an average yield of 145 kg ha^{-1}. Processing of the crambe took place in September through NSI's pre-press/solvent facility where 1360 tonne of crambe seed was processed into 454 tonne of oil and 906 tonne of meal. NSI then marketed the oil and meal through company outlets.

Results from surveys of the individual crambe growers revealed that stand establishment, weed management, and harvest methods were the most critical problems in crambe production. Additional research will be necessary to improve recommendations in these areas of crop management. Operators of the processing plant were pleased with the performance of crambe seed in their modern facility. With only minor adjustments, NSI found their equipment readily adaptable to efficient processing of crambe.

In summary, for the first time crambe was successfully grown, processed, and marketed on a commercial scale in 1990. The success was due to a sharing of risk among a partnership of farmers, private industry, and government. In 1991, NSI contracted 2025 ha of crambe production in North Dakota and has plans for continued production and processing in the years ahead.

INFLUENCE OF PLANTING DATE ON CRAMBE PRODUCTION

K. McKay, A.A. Schneiter, B.L. Johnson, B.K. Hanson, and B.G. Schatz

Earlier experience with crambe grown during North Dakota's relatively short growing season suggested that crambe will mature when planted over a wide range of planting dates. This experience did not provide information on comparisons among planting dates as they may affect yield and oil content. Seed and oil yield of oilseed sunflower were found to be influenced by differing dates of planting in North Dakota (Gardner et al. 1986). The effect of planting date on crambe yield, oil quality, and agronomic traits were objectives of studies conducted at three locations. Plantings of crambe were made in early spring (late April) and then at three additional times at two week intervals.

Crambe seed yields were not significantly influenced by planting date, although a general decrease in yield was observed as plantings were delayed beyond May 15. Days to first anthesis, days to physiological maturity, and plant height significantly decreased as planting date was delayed. Planting date did not significantly influence oil content. However, the trend indicates a general decrease in oil content as planting was delayed beyond late May.

The data show that crambe may be successfully grown over a wide range of planting dates in North Dakota. However, the trends identifying higher oil yields and observations of soil moisture conditions more favorable toward stand establishment, suggest some advantage associated with early planting dates.

DETERMINATION OF CRAMBE TOLERANCE TO FEEDING BY FLEA BEETLE

M.J. Weiss, M.D. Anderson, and C. Peng

Flea beetles, mainly Phyllotreta Cruciferae (Goeze), are the major insect pest of cruciferous crops in North Dakota (Weiss et al. 1991). In many instances, rapeseed and mustard can not be economically grown without use of granular insecticides at planting. Severe feeding damage to crambe plants by flea beetles had been indicated in earlier reports (White and Higgins 1966). If crambe were susceptible to damage by flea beetle, the subsequent loss in yield could prove a significant loss in yield could prove a significant deterrent towards production as no insecticides are approved for use in crambe.

A field choice test was initiated to determine differences in susceptibility to feeding by flea beetle among four cruciferous crops including crambe. Damage was evaluated by estimating the area of feeding pits on cotyledons or leaves and separating pit damage into either deep or shallow feeding patterns. Results indicate that P. Cruciferae does not significantly feed on crambe when given a choice between other Cruciferae and crambe. Further tests showed that extracts of crambe will cause a cessation of feeding on rapeseed indicating a gustatory inhibition (Anderson et al. In press).

Interpretation of this work indicates that flea beetles, P. Cruciferae are not a serious insect pest and will not affect crambe production in the Northern Plains. Future work will attempt to isolate the feeding deterrent(s) of crambe and upon successful identification, use the deterrents to protect susceptible crucifer crops.

SUMMARY

Crambe, a crop which yields an oil high in erucic acid, was identified as having potential for commercialization. A multidisciplinary team of researchers at North Dakota State University identified problem areas in crambe production or utilization and initiated studies to begin addressing these areas of concern. Results to date have assisted in updating the knowledge base of information that can be used to implement an efficient crop production program for crambe in the Northern Plains. Utilization research has aided the effort to expand the markets for high erucic acid oils. This effort has also helped identify future research needs in the area of crop production. The integration of these efforts along with those of other HEADE members, industry, and growers has resulted in the successful commercialization of crambe.

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