Research and Development of Seabuckthorn in Canada - A Success Story

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Abstract: Seabuckthorn (*Hippophae rhamnoides* L.) has been used to a limited extent in North America for conservation plantings and shelterbelts. Recently, the use of food and non-food products from seabuckthorn, with great potential markets, has been pursued. This multipurpose and valuable plant is currently being domesticated in various parts of the world including Canada. Seabuckthorn is easily propagated and production is reliable under cultivation. Most seabuckthorn research has been conducted in Eurasia in the past and Canada has intensified its research recently. Unique plant products, especially those with proven nutraceutical quality, are gaining popularity in North America. Development of a North American seabuckthorn industry presents a unique opportunity for agricultural production of a value-added crop on marginal land.
Key Words: Seabuckthorn, new cultivar, crop management, value-added

1. Introduction

Seabuckthorn (*Hippophae rhamnoides* L.) is a unique and valuable plant currently being cultivated in various parts of the world, including Canada (Li and Schroeder 1996). It is an ideal plant for soil erosion control, land reclamation, wildlife habitat enhancement, and farm stand protection (Schroeder et al. 1996). It can withstand temperatures from -43°C to +40°C and is considered to be drought resistant (Lu 1992, Yao and Tigerstedt 1995). However, irrigation is needed in regions receiving less than 400 mm of rainfall per year (Li and Schroeder 1999). Seabuckthorn can be easily propagated either by seeds, cuttings or suckers (Li and Wardle 1999, Schroeder and Walker 1996).

Seabuckthorn berries have been used and exploited for centuries in Eurasia for their nutritional and medicinal values (Li and Wang 1998). However, it has been largely unknown in North America until recently (Li and Schroeder 1996). In Canada, besides shelterbelt planting, orchard-type plantation, under proper crop management, was recommended (Li and Schroeder 1999). By 1999, more than 120 kilometres of seabuckthorn tree rows were planted in farmstead shelterbelts (Schroeder and Walker 1996) and over 600 acres of orchard-type cultivation were established in British Columbia and prairie provinces (unpublished data).

2. Seabuckthorn Cultivation

Seabuckthorn is a new cultivated crop in Canada. There are many important characteristics which need improvement such as yield, thornlessness, fruit size, quality and early maturity, mechanical harvesting, nitrogen-fixing ability, and crop management techniques including soil fertility, cultivation techniques, pruning, and insect, disease, and weed controls.

Recommended plant spacing for seabuckthorn is one metre within the row and four metres between rows to allow equipment access, with rows oriented in a north-south direction to provide maximum light. The ratio of male to female plants is important for maximizing the number of fruit-bearing trees. Recommendations for male:female ratios vary with plant density and region. In British Columbia, with an orchard planting of 4000 trees per hectare, a 1:6 to 1:8 male:female ratio is considered adequate. Moderate pruning of seabuckthorn will increase the yield and reduce fluctuation of fruiting from year to year. The crown should be pruned annually to remove overlapping branches, and long branches should be headed to encourage development of lateral shoots. Weed control is very important in seabuckthorn plantings, especially for promoting growth of newly planted seedlings.

3. New Cultivar Development Programme

In Europe and Asia, seabuckthorn is valued for its nutraceutical and pharmaceutical properties. The goal of this programme is to develop hardy, functional cultivars with high yield, nutraceutical and pharmaceutical values suitable for cultivation in Canada. Cultivar “Indian-Summer” was released in 1997 by Shelterbelt Centre at Indian Head, Saskatchewan and Pacific Agri-Food Research Centre, at Summerland, British Columbia (Schroeder and Walker 1994, Schroeder et al. 1996).

Indian-Summer is well adapted to growing conditions in Canada. In the last twenty years, it was tested at 12 sites in Manitoba, Saskatchewan and British Columbia, and performed well on a variety of soils including moderately saline sites. This new cultivar also shows above average drought tolerance and is fully hardy to Zone 1a. Fruit production ranged from 4 to 6 kilograms per shrub from shelterbelt plantation. Analysis of fruit samples showed average ascorbic acid and total carotenoid contents of 165 and 16.9 mg/100g fruit, respectively. Seed oil content averaged 14.2% and contained 31.2% protein, 88.3% to 89.1% unsaturated fatty acids, particularity linolenic (32.3%), linoleic acid (40.8%), and oleic acid (15%). Other constituents of the seed oil included rich gamma and alpha tocopherols, vitamin E content reached an average of 200 mg/100 g fruit and 93.6% of antioxidant activity (unpublished data). The seed oils have properties such as low viscosity, high transmittance and unique thermal characteristics that make them attractive for potential functional food uses and provide opportunities for non-food applications in cosmetics.

4. Research and Development

Pacific Agri-Food Research Centre of Agriculture and Agri-Food Canada at Summerland, British Columbia began seabuckthorn research in 1992. The objectives are to develop the technology for commercial seabuckthorn production and value-added products in North America.

There are a few major research and development projects for seabuckthorn in Canada. Major problems of seabuckthorn cultivation include thorniness, harvest difficulties as berries remain firmly attached to the branches, tree size control, establishment of a pruning system, diseases, insects and pest control, and development of mechanical harvesting.

A. Tree size control - The objectives of tree size control include:

i. produce and maintain the proper plant size, shape and architecture,
ii. improve branching habit and strength,
iii. produce and maintain the optimum amount of new and young fruiting branches,
iv. remove old and weak fruit bearing branches with marginal productivity and poor fruit quality,
v. maintain or increase plant vigour by removing broken, diseased, or insect-infested branches,
vi. increase light penetration thus equalizing the fruiting potential throughout the tree canopy, induce and maintain an annual bearing habit and maintain high and predictable yield,
vii. renew structural units of declining fruitfulness,
viii. improve insect and disease control by ensuring effective penetration of pesticide sprays (Li and Schroeder 1999).

Shrubs of most of the *Hippophae* species can reach 2-4 m in height in a nature habitat (Schroeder and Walker 1994). For orchard-type cultivation, a proper pruning system is needed to control shrubs’ growth into a manageable height and shape, which will effectively stabilize the yield and improve the efficiency of harvesting. It is important to realize that all portions of the tree canopy must receive adequate sunlight for the initiation of flowers, for fruit set, and for large fruit size with good coloration.

Vegetative growth is necessary for any plant to maintain its vigour, provide leaf area, and develop berry-bearing branches. However, vegetative growth of any fruiting tree is competing directly with fruiting for the nutrients within the tree, and the development and maintenance of excessive unproductive branches are unnecessary. Therefore, the objective of pruning of seabuckthorn is the manipulation of the ratio of vegetative growth and fruiting by minimizing unproductive shoot growth and optimizing fruiting. To achieve this objective, the development and understanding of the principles and practices of pruning are important. Proper pruning will expose evenly more leaf area to sunlight, which is one of the most influential factors for a good growth and higher yield. A plant that is pruned on an annual basis appears to have increased vigour because it creates new and better shoots where the pruning cuts are made.

B. Diseases, insects, and pests control - At the present time, there are few pests and diseases that have been reported. These include verticillium wilt, fusarium wilt, damping off, brown rot and scab. The most damaging insects are green aphids, rose leaf roller, gypsy moth, gall tick, comma-shaped scale, fruit fly and caterpillars. There are a few pests, including birds, mice, and rats that are causing damage to seabuckthorn. Since seabuckthorn is a new cultivated crop, there are no registered pesticides or fungicides available to control the problems. Research is underway in Canada to find the best chemical and organic control measures.

C. Development of mechanical harvester - Researchers at the Pacific Agri-Food Research Centre are searching for the best mechanical harvester for seabuckthorn. There are a few attempts in Europe indicated in the literature, however, there are disadvantages such as reduced yield, loss of vitamins, and tree shape changes. Our objectives in developing a mechanical harvester are to maximize the yield without compromising fruit quality and, most important of all, to reduce labour cost for production. A shaker was developed in 1998 with very promising results. Time needed for harvesting a mature tree is only 1-2 minutes, without any damage to the fruits. More experiments are underway to confirm and improve the results.

D. Thorniness - In general, almost all the *Hippophae* species start to develop thorns on the two or three-year-old plants, ranging in length from 1-2" (Li and Schroeder 1996, Lu 1992). This characteristic is a handicap especially during harvesting. Testing for new selections without thorns is underway in combination with other characteristics such as fruit size, yield, neutraceutical values, and oil contents.

5. Scientific Challenges for Seabuckthorn Value-added Aspects

5.1 Post-Harvest problems and control

The berries carry with them an odour, which ranges from unusual to offensive depending upon unknown factors. The odour does not seem to accompany the juice or washed seed, but is certainly part of the processing "scene" and as such may influence perceptions. Certainly the post-harvest treatment influences the perceived odour. Ethylene may be the active agent, certainly the berries react to ethylene during storage. In the short term we will circumvent this problem by freezing the berries immediately after harvest and during storage and transport (Beveridge et al. 1999).

5.2 Production of raw products or ingredients

5.2.1 Juice

The basic problem here is how to make a juice that can be marketed as "Seabuckthorn" juice, taking advantage of its health perceptions while presenting an attractive, acceptable product. This is going to require knowledge of the composition of the juice combined with some careful product development for testing prototypes. Recently, two projects were conducted which can be summarized as follows: Juice obtained from seabuckthorn fruits was subjected to dynamic rheological measurements in a controlled stress rheometer. Seabuckthorn juice exhibited wide variations in flow behaviour from pseudoplastic to dilatant with increasing temperature. Seabuckthorn juice was found to be thermostable within the temperature range from 25 to 75 ^{o}C, although critical changes occurred in juice components above 70 ^{o}C (Beveridge et al. 1999).

Seabuckthorn juice contains glucose and fructose as the major sugar component with further contributions from an unknown carbohydrate. Four organic acids were definitely identified as contributing to the total acid of seabuckthorn juice. Unexpectedly, quinic acid was quantitatively the most important. While quinic acid is not unknown in fruit, its presence at these levels is unusual. The acids present were quinic (23.0 mg/ml), malic (13.9 mg/ml), citric (1.99 mg/ml) and oxalic (0.29 mg/ml) acids (Beveridge et al. 1999).

5.2.2 Seed and pulp oil

Seed contains 12-15% oil by Soxhlet extraction. Separation of the seed from the press cake requires knowledge of the finishing and washing characteristics of the seed. The oil extraction method of preference is likely to be supercritical carbon dioxide. Carbon dioxide is inexpensive, environmentally friendly, leaves minimal or no residue, and it is food safe and non-combustible. The oil obtained by this method probably needs little or no further refining. It is currently used commercially for low volume, high value flavour/odour extracts where it is known to produce a superior product relative to solvent extraction.

As detailed above, the adaptation of technology to the specific case of seabuckthorn is a necessary pre-requisite to the utilization of the crop. Collaboration with local industry increases the chances of adoption of the technology. Three researchers at Pacific Agri-Food Research Centre are actively developing an expertise in seabuckthorn technology complete from the farm to the table.

5.2.3 Understanding seabuckthorn biochemistry and establishing product standards

Seabuckthorn is a unique and valuable plant species currently being domesticated in various parts of the world. The plant has been used to a limited extent in North America for conservation plantings, but its use for food and non-food application is only now beginning to be pursued.

There is an urgent need for a better understanding of the genetics, physiology, and biochemistry of seabuckthorn, especially the biosynthetic pathways leading to the formation of bioactive compounds. The physio-chemical properties, such as stability, reactivity, toxicity and mode of action both *in vitro* and *in vivo* of secondary metabolites used in the pharmaceutical industry, need to be understood. Proven methods of analysis for quality control of products also need to be developed and transferred to the industry. Products need to be standardized with respect to composition of active ingredients. More information on shelf life, dosage and pharmacological effects is needed, as available information is incomplete and often contradictory.

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