Essential oils and natural plant chemicals

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Tasmania is located within the latitudes 40-43?S with a temperate climate, isolation, good water resources, reliable labour force and an atmosphere relatively free from pollution. Currently some 37% of the state's total area is used for agricultural purposes and of this agricultural land only 3.5% is applied to the growing of crops. Cropping accounts for approximately 28% of total employment and 30% of the gross value of agricultural and agriculturally based products. If cropping activities could be expanded these values suggest that a more efficient use of agricultural land would be possible with increased economic and social gains.

The fragrance and flavour industry currently has a sales volume of around $1.7 billion and has been growing at an average rate of about 10% over the last 10 years. The outlook is for high rates of growth to be maintained probably of the order of 5-6% per annum by volume and 10-15% per annum by value over the next 10 years. Comparing these rates of growth with world G.D.P. it is clear that the fragrance and flavour industry is a growth industry. Of the $1.7 billion world sales volume, raw materials account for 40-50% and of this about half is natural essential oils. This puts the value of essential oils in the world flavour and fragrance industry at approximately $300-400 million.

The forecast growth in the fragrance and flavour industry and the belief that the current ratio of natural to synthetic has evened out, will mean that increased demand for fragrance and flavour compounds will generate an equal increase in demand for natural essential oils along with synthetics. This together with the failure of supplying countries to guarantee quantity, quality and price stability gives Tasmania an excellent opportunity to extend its agricultural commodities into this area of production. Furthermore, isolation and freight problems are essentially overcome in products of low volume and high value.

The approach to research and development on essential oils and other natural chemicals is unique. The University, together with the Marketing Croup of the Tasmanian Development Authority have ascertained which products of temperate origin have some future demand on international markets. The survey identified products like peppermint, spearmint, parsley, fennel and extracts such as boronia, blackcurrant and pyrethrum. The market required high quality natural products free from adulteration with reliability of supply at competitive prices. It was clear that there would be no easy way into production and that new technologies would need to be applied to production, extraction and marketing to provide Tasmania with a competitive advantage.

There have been three distinct phases in the development of new crops. Phase 1 has involved the collection of germplasm, fingerprinting chemical constituents of products, physiological studies associated with oil accumulation and preliminary work on extraction. Phase 2 involved the application of Phase 1 technology to small semi-commercial field plots in order to generate sufficient product for preliminary marketing tests. At this stage growers commenced their familiarisation and experimental programme. Phase 3 involved commercial implementation of Phase 2 followed by full commercial production. During Phase 3 funding was the major factor controlling the rate of implementation at the commercial level. To quote de Kantzow (1984), "the capital used in development of the enterprise must be provided on very understanding terms". We have been fortunate to be associated with the Tasmanian Development Authority which has not only understood the development problems but has also appreciated the lag time between initial assessment trials and full scale—production. During the last five years approximately $1 million has been received in research funds from private industry, Rural Credits Development Fund, University and State Government. Approximately one—third of the funds have been received from the State Government but because of the obvious application to the state at this stage the level of State Government support has increased considerably this year. This also coincides with rapid expansion to full commercial production of crops such as peppermint, fennel and Boronia.

In the last five years of the research and development programme some major advances have been made. These include; the development and release of new cultivars; micro propagation techniques for rapid multiplication of clones; use of sophisticated chemical techniques to fingerprint oils and extracts and identify flavour and fragrance constituents; perfecting mechanical harvesting and field distillation; commissioning pilot extraction plant to produce new products; the development of production techniques to optimise yield and quality of oils. These points will be emphasised with examples from peppermint, Boronia and pyrethrum.

The peppermint cultivar Black Mitcham is well established throughout the world as an outstanding producer of high quality peppermint oil. It was developed by the Todd Company in the United States. The industry has accepted this cultivar as the standard oil of commerce from which all oils are judged. Our approach was to investigate ways of producing high yields of high quality oil. The work commenced as a Ph.D. study by Dr. R.J. Clark who investigated environmental factors affecting the quality of peppermint oil grown under Tasmanian conditions. It was revealed that day length, light intensity and day and night temperatures were important factors determining the biosynthetic pathway from pulegone to menthol, the latter being the major constituent required by commerce. An alternative pathway to menthofuran, an undesirable component of the oil, was induced through low light, short days and high night temperatures (Clark and Menary, 1981). This work gave a physiological basis for the selection of growing areas. A further extension of the work introduced the concept of double harvesting which involved an early harvest of slightly immature oil and a late harvest of very mature oil. The blend gives oil of optimum quality and the yield is approximately doubled. In order to optimise quality, GC techniques have been used to monitor oil quality leading up to harvest. This technique has enabled high standards to be maintained and good reproducibility from year to year.

One of the largest on—farm capital investments for essential oil production is the steam distillation facility. A mobile unit has just been designed by the University and funded by the Tasmanian Development Authority to demonstrate that mobile facilities will give high utilization time for equipment and maintain high quality. This unit is now in operation and consists basically of a steam source, condenser and separator on one mobile unit and a vat or distillation vessel on the other. The latter is taken to the field to collect herb and then returned to the steam source for distillation. The unit is capable of distilling 3 tonnes of herb per hour, which represents a production rate of 15 litres of oil per hour.

Boronia megastigma is a native of the south-western part of Western Australia and a small perfume industry is based on the collection of wildflowers from this source. The species is drought resistant, grown on poor acid soils, flowers in late winter or early spring when soil conditions are very wet, is extremely susceptible to root pathogens, difficult to propagate, intolerant of nitrate fertilizer, pollinated by an insect indigenous to Western Australia and does not generally fulfil the requirements for intensive cropping. However, its application in flavour and fragrances, coupled with a price of $3 million per tonne for refined product, gives some incentive for commercial development. In fact, it does fulfil all of Dr. Bruce Davidson's criteria for establishment, that is, there is an export market potential, it is easily transported, has low labour inputs and uses cheap land.

There is great genotypic diversity in the seedling population of Boronia megastigma. A selection programme has been conducted over the past six years to obtain high flower and oil yields, an oil quality suitable for specific end-use and a plant architecture suitable for mechanical harvesting. Oil yields greater than 1% have been obtained and oils having a high volatile fraction and a high top note of specific fragrances have been identified. The monoterpene hydrocarbons appear to have little favourable effect. Of the compounds identified, the most important would seem to be the ionones and related epoxides and dihydro compounds; the esters including fatty acid methyl and ethyl esters and acetates of decyl, dodecyl and tetradecyl alcohols; dihydroactinidiolide; methyl jasmonate isomers; and sesquicineole. The petal waxes clearly contribute to the bulk of the weight of the concrete from Boronia flowers and the C17 to C33 saturated branched and linear hydrocarbons represent the proportion of these waxes amenable to CC analysis. The major involatile compounds of the concrete have not been studied but their role in the stability of the product is of considerable importance (Davies and Menary, 1984).

Boronia megastigma is known to be pollinated by a single species of night flying moth in Western Australia. In our study of the chemical composition of concretes dodecyl and tetradecyl acetates were found in the stigma of the flower and since these compounds are components in several dozen moth pheromones it is tempting to suggest that in this instance the Boronia is producing a specific sex attractant for pollinating insects and this would account for the lack of pollination under Tasmanian conditions.

Having defined some of the important chemical characteristics of Boronia concrete and made corresponding organoleptic assessment by sniffing the eluant from GC columns it has been possible to study extraction techniques which give the highest recovery of favourable constituents. These products have now been made on a commercial scale and are being sold to the flavour and fragrance industry.

Pyrethrum germplasm was taken from a source in Kashmir which included material from Kenya, United Kingdom, Yugoslavia and Japan (Bhat, Menary and Pandita, 1985). This material is described as the base population (BP) and is held at the Regional Research Laboratory, Srinagar.

Selections were made in this population on the basis of plants having greater than 1.5% pyrethrins. This population is described as the selected population (SP) and seed from this population was grown in Tasmania in 1980. Plants were selected which had pyrethrins contents greater than 1.5% but some of these did not have erect habit. After selection for erectness the remaining plants had pyrethrins content in the range 2.0-2.4%. These plants were crossed in all possible combinations and the progeny defined as the recurrent selection (RS) population. The selection pressure towards increased pyrethrins content has lead to a progressive increase in the frequency of the population having a higher pyrethrins content than the preceding generations. The SP population had approximately 8% of individuals having higher pyrethrins content than the BP population and the RS population had 12% of its progeny with pyrethrins content higher than the SP generation. As well, the maximum pyrethrins content of the DP generation was 1.9%, the SP generation 2.3% and the RS generation 2.8% pyrethrins. A clone was selected from the SP population with high pyrethrins content erect habit, synchronous flowering and good storage stability of pyrethrins in mature flowers. This clone has been named Hypy and is registered with the Crop Science Society of America (Bhat and Menary, 1984). An Australian patent has been filed for this same cultivar.

An important aspect of the total programme has been the close association with producers and end-users via production and marketing research groups. To facilitate interchange between these groups, the growers have just elected an interim Board to consider the formation of a Natural Plant Chemicals Cooperative and becoming a partner in an established market and research company, Essential Oils of Tasmania. These structures will provide the necessary links and safeguards for two-way communication between production and marketing and a forum for debate on future research objectives.

The introduction of new crops to an agricultural system, via the application of technology, is not an end in itself but only a means to an end. Only after careful integration of economic, social, political, marketing, management and technical aspects will problems be revealed and solutions found. This often means cutting across artificial barriers which have been set up around small, large and even warlike territories. When such barriers are breached, trained minds are let free to conquer common goals. The status of the essential oils programme in Tasmania is proof of the outcome of this approach.

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