CULTIVATION OF SOLANUM IN CANTERBURY

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INTRODUCTION

New Zealand could produce raw material for the manufacture of hormone drugs, which after vitamins and anti-biotics are reputed to be the third most important group of chemicals manufactured. These drugs, with sales exceeding $1 billion, are used as anti-inflammatory agents, metabolic stimulants, general stress reaction protectives, cancer palliatives, and in a very wide range of sex complaints. The production of cortisone from plant material nearly 20 years ago, led to this major breakthrough.

The synthetic manufacture of these drugs is expensive and complicated, and as yet, unsuitable for commercial exploitation. World supplies therefore, largely depend on basic steroid raw material available from certain plants. Seventy-nine percent of the raw material used today, is supplied as diosgenin, an extract of a wild yam *Dioschorea* grown in Mexico, and from this material, many thousands of pharmaceutical compounds have been synthesised.

It appears that demand for diosgenin may outstrip available supplies and the position may worsen because of the increasing cost of labour, and urban drift of population in Mexico.

This has aroused interest in our native solanums, *Solanum laciniatum*, and *Solanum aviculare*, which can supply a replacement basic steroid raw material for diosgenin, in the form of solasodine. These two species of solanum have been under investigation on a large scale in Russia, Hungary and India for some years. If solanum can be taken to these countries and grown successfully, it appears reasonable to presume that it should be possible to grow it even more successfully in New Zealand. Even if this proves to be the case it does not necessarily mean that solasodine will replace diosgenin right away - the investment in the latter, involving millions of dollars will ensure its continued production. Rather it is the future expansion of the industry that will require solasodine, provided that it can be supplied to the world market at a price competitive to that paid for diosgenin.

Research into the commercial cultivation of solanum in New Zealand is being carried out by Ivon Watkins-Dow Ltd in Taranaki, and Crop Research Division of Department of Scientific and Industrial Research in Canterbury.

In the main, this paper concerns the work carried out by Crop Research Division.

INVESTIGATIONS

The first thing to establish was a method to successfully grow the crop as cheaply as possible on a commercial scale, under Canterbury conditions. The decision to evaluate its potential as an annual crop grown from seed, was made because of the advantages this method appeared to have. They are:-.

1. Although both solanums are perennials, they are frost tender, and growing them from seed each year would obviate the risks of over-wintering.

2. Solanum is subject to various virus diseases, especially cucumber mosaic virus in the second and subsequent years. Annual sowings would probably obviate this problem.

3. The crop may be grown annually from transplants planted out in the spring, as is done with many tomato crops, but this is expensive, involving glasshouses, a lot of labour, and specialised equipment.

4. Canterbury is renowned for its excellent cropping capabilities because of its advantages in climate, large areas of flat land, know-how, mechanisation and the availability of irrigation.

Although Ivon Watkins-Dow Ltd had been growing solanum in Taranaki, for some time, nothing was known concerning its establishment from seed in Canterbury, and it was necessary to start from scratch, and find out what the difficulties were involved.

The cultivation of solanum is discussed in terms of:

Species, Establishment, Management and Harvest.

SPECIES

At the beginning of the project, it was thought that Solanum laciniatum would be the best choice for Canterbury, because of its greater hardiness and growth rate. Solanum aviculare, on the other hand produces less material and is more susceptible to cold, but it has two advantages **viz.** a high solasodine content - over 2% on the average as compared with about 1.5% for Solanum laciniatum and it is more resistant to virus diseases.

Trials indicate that the advantages of Solanum aviculare may offset its disadvantages, especially after drying, and processing costs have been taken into account.

ESTABLISHMENT

Seed Bed:

Solanum thrives but on free draining friable loam, and as customary for seeds of this size, the seed bed should be fine and firm, e.g., as for white clover. Just before sowing, treflan should be incorporated into the soil to a depth of 10 cm, at the rate of 2.3 - 2.9 litres/ha, for weed control.

Seeding Rate:

This depends on germination capacity of seed, population density desired and species sown.

Germination:

Germination of solanum seed is slow and uneven, taking about six weeks before the first seedlings emerge. Various seed treatments such as application of heat, cold, chemicals, as well as prolonged washing in cold water, were tried with varying success under glasshouse conditions, but under field conditions, they have proved of doubtful value, probably because of the long period the seed was in the soil under indifferent conditions. Germination is possibly inhibited by solasodine itself, as well as other genetic factors. It is anticipated that use of a suitable seed treatment will eventually improve germination. Meanwhile it is recommended that in order to attain a particular population in the field, the number of viable seeds sown should be based on the following formulae:

Solanum laciniatum (1000 seed wt 1.5 g),
Population x 4

Solanum aviculare (1000 seed wt 0.5 g),
Population x 8.

These recommendations are made because it is easy to thin the crop if the resultant population is too dense.

Population Density:

Limited trials last year (1971) with Solanum laciniatum showed that at higher populations dry matter yields and solasodine percentages tended to be higher.

TABLE 1 : DRY MATTER YIELDS AND SOLASODINE PERCENTAGE AT TWO POPULATIONS.

Plants/ha	Dry Matter	Solasodine % D.M.
10,000	1,800	1.8
25,000	2,900	2.0

It was considered important that a major trial be carried to investigate this aspect further, particularly as it seems that ground cover could be increased to advantage.

In 1971 a replicated and randomised trial was put in at Lincoln to study the effect of various populations on the solasodine return per given area, for both species. The populations aimed at were 25,000, 37,500, 50,000, 75,000, 100,000, 150,000 and 300,000 plants/ha. Seed sown was at a rate of four times the population desired. Unpelleted seed was sown through a Stanhay precision drill in rows at 60 cm and 30 cm centres according to population desired.

With Solanum laciniatum the desired populations were obtained following some thinning in most plots, but with Solanum aviculare, populations achieved were well below the populations desired. Dry Matter yields and leaf stem ratios are given in Table 2.

TABLE 2 : YIELDS DRY MATTER kg AND LEAF/STEM RATIOS.

	Population	Dry Matter	Leaf/Stem Ratios	
			Fresh	Dry
Solanum laciniatum	25,000	3,900	38/62	46/54
	37,500	4,200	41/59	47/53
	50,000	5,700	34/66	45/55
	75,000	5,800	32/68	41/59
	100,000	6,700	29/71	43/57
	150,000	5,900	28/72	41/59
	300,000	9,100	28/74	39/61
Solanum aviculare	25,000	1,100	66/34	55/45
	37,500	1,300	58/42	57/43
	50,000	1,800	64/36	58/42
	75,000	2,400	60/40	57/43
	100,000	2,500	50/50	57/43
	150,000			
	300,000			

For optimum dry matter yields row spacing of 30 cm gave best results, but this may interfere with inter-row cultivation.

Solanum laciniatum showed that it is capable of very high dry matter yields in a very short time (9,100 kg in five months).

A population density of between 50,000 plants/ha and 100,000 plants/ha would appear optimal for Solanum laciniatum, but solasodine, analyses are essential to finally establish this.

In the case of Solanum aviculare the various seeding rates did not result in populations greater than half of the desired populations, in spite of a seeding rate equivalent to four times that considered necessary.

As dry matter yield increased, beyond a certain population, the leaf/stem ratio dropped.

Time of Sowing:

It is necessary to obtain seedling emergence after the risk of heavy frosts has passed, so a lapse of six weeks between seeding and emergence - late August or early September seeding - is recommended. 1970 sowings were made in early September, and at that time, slow germination was believed to be due to the cold wet soil conditions, and for this reason in 1971 sowings, were delayed until early October. This did not cause an improvement and emergence date was delayed a week or so. It is now considered that earlier sowings:

1. Probably assist germination with the damp soil conditions acting as a seed treatment.

and

2. Allow the earlier germination seedlings to take advantage of favourable conditions, as soon as they occur.

Method of Sowing:

It was considered that in order to make the most economical use of expensive seed, (seed collection and extraction is laborious) that single seeds should be sown. However, germination problems preclude this at present. Satisfactory results obtained by either sowing the seed in clumps with a Stanhay precision drill, or in a spreader and sowing it through the fertiliser box of a coulter drill. Broadcasting would be feasible, but the resultant distribution of plants would prevent inter-row cultivation.

CROP MANAGEMENT

Management problems associated with the crop includes weed control, use of fertilisers, irrigation, pest control and control of diseases.

Weed Control:

Control of weeds is essential for a period of several months after sowing, because of the long period which elapses before rapid growth commences.

Recommendations are:

(a) Treflan 2.3 - 2.4 litres/ha incorporated into the soil to a depth of 10 cm (rotary hoe, harrows, discs, etc.,) before sowing. This will control most weeds except brassicas (shepherds' purse), storksbill, twitches, etc.

(b) Paraquat at 1.4 - 2.3 litres/ha applied no later than 4 weeks after the sowing will control all seedlings present. It is risky to apply paraquat later because solanum seeds may have germinated but not emerged.

(c) Inter-row cultivation as often as necessary, but it is necessary to ensure that the implement tracks accurately.

Fertiliser:

A fertiliser trial with *Solanum laciniatum* and *Solanum aviculare* was conducted.

The treatments were:

1. Control
2. P20 kg/ha at seeding
3. P20 kg/ha at seeding + P20 kg/ha after establishment.
4. P20 kg/ha at seeding + P40 kg/ha after establishment.
5. P20 kg/ha at seeding + N40 kg/ha after establishment.

6. P20 kg/ha at seeding + N80 kg/ha after establishment.

7. P20 kg/ha at seeding + K48 kg/ha after establishment.

8. P20 kg/ha at seeding + K96 kg/ha after establishment.

9. P20 kg/ha at seeding + N40 kg + P20 kg + K48 kg/ha after establishment.

10. P20 kg/ha at seeding + N80 kg + P80 kg + K96 kg/ha after establishment.

The trial was sown with a coulter drill with the seed mixed with lime 200 kg/ha for the control treatment and with super phosphate 200 kg/ha for the other treatments. After the plants had established the balance of the treatments were applied as side bands, through a Stanhay drill fitted with a fertiliser attachment.

Irrigation was applied as required.

Germination was uneven and the numbers of plants per plot ranged from 45 down to 20 in the case of Solanum laciniatum and from 28 down to 8 in the case of Solanum aviculare.

The trial was further complicated by primary and secondary germinations of seed due to inhibiting factors. These germinations were separated by 3-4 weeks, and the resulting populations showed their effect as a growth difference throughout the trial.

The trial crop was cut at the end of April and the total yields of fresh material in each plot obtained. The total numbers of both 1st and 2nd germination plants in each plot were counted. Two average plants of each germination from every plot were weighed.

It was found that with Solanum laciniatum the average weight of 2nd germination plants over all treatments was 0.32 of that of the weight of 1st germination plants. The formula used to calculate yields was:-

$$\text{Average weight/plant} = \frac{\text{Fresh weight/plot}}{(\text{Number 1st germination plants} + 0.32 \text{ number 2nd germination plants})}$$

Corrected fresh weights of solanum plants are given in Table 3.

TABLE 3 : CORRECTED MEAN PLANT FRESH WEIGHTS g/PLOT

Treatment	Solanum laciniatum	Solanum aviculare	Solanum laciniatum	Solanum aviculare
Control	830	670	100	100
P20	898	700	108	105
P20 - P20	1500	1140	180	170
P20 + P40	1630	956	196	146
P20 - K48	1710	1460	207	218
P20 + K96	1630	1030	196	154
P20 + N40	1820	1230	220	184
P20 + N80	1310	1150	158	172
P20 + N40 + P20 + K48	1780	1540	215	230
P20 + N80 + P40 + K97	1490	1220	179	182

There was a high correlation between 1° germination and fresh weights/plot.

The application of P20 kg/ha at sowing appeared to have little effect and so a spreading **material only** is apparently necessary with this method of sowing.

In the case of Solanum laciniatum there was no particular significance between individual side dressings at the lower rates, but there was a significant difference in comparison with no side dressing. Where the application rate of the side dressings was doubled, there was a depression in yield in all cases, statistically significant in the case of N.

In the case of Solanum aviculare application of K was significantly important but the higher rate had a significant depressing effect. Applications of N did not appear to be as effective as with Solanum laciniatum.

Suitable recommendations for Lincoln are therefore: no superphosphate at sowing and an application of a side dressing of N40 kg + P20 kg + K48 kg/ha. If a spreader is required for sowing the seed super phosphate 125 kg/ha should prove adequate.

Irrigation:

As germination is better under damp soil conditions, pre-emergence spray irrigation should be applied, if rainfall is inadequate. Although solanum does reasonably well under dry conditions, later irrigations ensure optimum growth, particularly in the dry summers, experienced in Canterbury. By the time plant growth makes irrigation difficult, adequate growth, both above and below ground, will lessen the need for it.

Pests:

The main pest of Solanum spp in Canterbury is the tomato stem borer. Attacks are likely in areas where tomatoes or potatoes are grown, and also in those districts where Solanum spp grow naturally. Where present, tomato stem borer appears about the time of 1st flowering towards the end of December, and the damage resulting from caterpillars boring into the stems can be heavy. A 20% lindane emulsion spray, at 2.9 litres/ha is an effective control. Damage caused by later attacks is not enough to warrant the cost of later spraying, unless the berries are required for seed. Where there are ripe berries, tomato stem borer attacks are concentrated on these, and the caterpillars penetrate the fruit and ingest the seed.

Aphids may be a problem, and should be sprayed as for tomato stem borer, if necessary.

Disease:

Virus disease, principally cucumber mosaic virus but also spotted and verticillium wilts, and potato X and Y virus to a lesser extent, are the main diseases attacking Solanum spp.

In Taranaki, it has been found that the incidence of virus is particularly severe in the second season, particularly if the plants have been harvested previously on a perennial system. *Solanum aviculare* is much more resistant than *Solanum laciniatum*.

In Canterbury the dry climate, together with the practice of growing solanum as an annual crop, reduces the problem of virus disease. Aphids may be responsible for virus build-up in the future. To date, no control measures have been required.

HARVESTING

The whole solanum plant, apart from the thick woody basal stem is used for solasodine extraction. Although solasodine content is highest in the leaves, fruit and vigorously growing shoots, there appears to be enough in the stems, to warrant processing these too. Economics will probably demand a one cut harvest crop, even though total solasodine production may be higher from a multi-harvested crop.

Periodic sampling of leaves throughout the growing season, has shown that solasodine percentage tends to increase as the crop matures and to be higher in regrowth material.

TABLE 4 : SOLASODINE CONTENTS OF LEAF SAMPLES.

Line	Species	Date	Solasodine %
SL8	*Solanum laciniatum*	13.1.72	1.4
SL8	*Solanum laciniatum*	21.1.72	1.6
SL8 (regrowth)	*Solanum laciniatum*	21.1.72	1.9
NA9	*Solanum aviculare*	13.1.72	2.0
NA9	*Solanum aviculare*	21.1.72	2.8
NA9 (regrowth)	*Solanum aviculare*	21.1.72	3.8

The above results indicate that multi-cuts may well prove economic, particularly in the case of *Solanum aviculare*. Most lines follow this pattern.

If there is to be only one harvest, it would be advantageous to defer this as long as possible.

The easiest way to harvest solanum, is with a forage harvester either direct or from a windrow formed by cutting with a tractor mounted mower. If the latter method is feasible the crop could be partially dried in the windrow and large economies in drying costs could be made. Also this would result in lower losses of juice. A forage harvester of a chopper type is preferred because the size of chopped material can be regulated. The loss of material through unsea unseasonable weather may be heavy.

The green or partially dried material is transported to a commercial drier where after drying it is ground. The ground material can be stored without deterioration until it can be processed.

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