SIRATRO SEED PRODUCTION

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ABSTRACT

Siratro (Macroptilium atropurpureum) *seed production is reviewed in terms of the history of harvesting and the choice of locality for the seed crop in Queensland.*

Progress in harvesting has proceeded from original hand picking, through multiple header harvests with low-capacity headers, to a single annual harvest of multiple flushes of seed, produced under irrigation by alternate wet and dry cycles, and recovered by high-capacity headers followed by suction harvesters.

The critical requirements in choice of locality are seen as being climatic, notably relative freedom from both frost and low winter temperatures, and reliability of both the summer wet season and winter dry season. A physiological rationalization of the climatic requirements is attempted, particularly in connection with the apparent stimulation of reproductive activity through water stress.

INTRODUCTION

The success of Siratro seed production in Australia has hinged on the solution of two dominant problems—of where best to grow the seed crop, and how best to harvest it. I propose to review the subject in terms of these two topics, reversing their logical order for the convenience of using the topic of harvesting as a framework upon which to reconstruct the history of the crop. This is appropriate because, once the correct choice of locality had been made, the history of Siratro seed production became very much an account of the evolution of harvesting methods.

HARVESTING AND HISTORY

Siratro was released in 1960, but neither the mechanism nor the experience then existed in Queensland to ensure smooth seed multiplication, and it was five years before seed production equalled demand. Seed was originally hand harvested by farmers for their own pasture sowing, by opportunists, and by early seed producers. N. H. Adams (personal communication) estimates that one person could harvest one kg of seed in two hours in ideal conditions. In the Cooktown district, into which Sir K. J. Morris had introduced Siratro in about 1962, the black people of Hopevale Mission provided labour for field-scale hand picking.

Hand harvesting was an inadequate long-term solution, however. Its slowness restricted the areas that could be harvested to very small ones, and labour was either unobtainable or unpredictable. Consequently farmers began to search for mechanical harvesting methods. Promise of success led a few farmers at Walkamin on the lower Atherton Tableland, notably C. P. Vicary, to plant crops of Siratro in pure stands specifically for mechanized seed production. These were header harvested in 1965, and for the first time an abundance of seed came on to the market. The off-farm price fell from \$4.40 to \$1.80 per kg, and hand harvesting, which by then cost \$2.20 per kg of seed in pod for picking alone (J. W. Wright, personal communication), became uneconomic.

The success of header harvesting was relative rather than absolute, and the operation still held many problems. Headers were not designed to handle thick, green, tough, tangled vegetation. Moreover, the machines then available were, by present standards, of low capacity. Tractor-drawn machines proved inadequate, but International A83, Case 600, and John Deere 55 autoheaders came to be widely used.

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Low harvesting capacity dominated crop management, especially with the northern farmers who grew Siratro in pure stands as a specialist seed crop. These growers aimed to produce a crop with the seed held high in the canopy so that they could harvest it with the minimum intake of green vegetation. The first crop grew on wet season rainfall and developed as a seed crop when the soil dried out. Subsequent crops were induced by successive cycles of irrigation and drought for as long as the dry season lasted. C. P. Vicary, writing in North Queensland Seed Producers' Notes in 1967, advocated four crops annually. He aimed to produce 200-300 kg per annum, but not without great effort and expense (Vicary 1970).

So long as this management system operated, the costs of specialised seed production and of casual harvesting of pastures (the latter analysed by L. Hannah and D. S. Loch in an unpublished submission to Q.H.P.L.C. in 1973) remained similar. The comparatively high yields of the specialists were balanced by the absence of tangible pre-harvest costs to the casual operators, and between about 1965 and 1973 quite substantial quantities of seed were header harvested from pastures in south-east Queensland (Table 1).

TABLE 1

Annual recorded production and use of Siratro seed in Queensland (Anon. 1968-1976). *Production is separated into northern (mainly Shires of Mareeba and Cook), central (mainly Sarina Shire) and south-eastern (mainly Shires of Burrum, Isis, and Miriam Vale). Figures are not available for the years before* 1967-68.

Year	Total recorded state production (tonnes per annum)	Percent contribution of each region N	C	S-E	Total recorded state plantings (tonnes per annum)
1967–68	46·0	42	0	58	28·5
1968–69	53·6	81	0	19	12·9
1969–70	43·1	87	0	13	15·3
1970–71	57·2	89	0	11	26·6
1971–72	62·8	72	0	28	21·1
1972–73	133·8	76	9	15	37·3
1973–74	121·9	83	11	6	21·7
1974–75	35·8	97	3	0	15·0

The next change followed realization of the accumulation of a very large reservoir of good seed on the ground beneath the crop (Hopkinson and Loch 1973), a proportion of which could be recovered by the use of suction harvesters (Hopkinson and Vicary 1974). It became customary to manage the crop as before (though two crops rather than four per annum had become the aim), but to complete the season with a suction harvest.

This roughly doubled the potential seed yield, but it also introduced a number of problems. The greatest was that of separating soil particles from seed during cleaning. It was solved by the use of a heavy solvent (perchlorethylene, S.G. = 1.6), the separation performed by simple flotation. The method had been used experimentally on tropical pasture legume (Loch and Butler 1976) and other seeds for some years, and was adapted to commercial cleaning with the design and construction of a continuous-flow flotation cleaner (Grevis-James and Fusae 1974).

Meanwhile, with the development of a lucrative export market in the early seventies, the demand for Siratro seed grew, production rose (Table 1), and the growers prospered. The specialists were able to afford, and justify the expense of, much larger headers than before. They still retained a narrow width of cut (less than 5 m), however, and by this and other means greatly increased their capacity to handle thick vegetation. At the same time, with rising costs and labour problems, the attractions of the multiple harvest system of management were declining.

These circumstances led a Walkamin farmer, T. J. Gilmore, to propose a system in which, by successive wet and dry cycles, he would still induce multiple crops, but instead of harvesting each crop as it ripened he would irrigate, submerge the ripening crop in new growth, and proceed to the next flush of flower. He put the system to the test in 1973, with very promising results. A single October harvest, made with the cutter bar close to the ground, recovered not only the current ripe crop but also a great quantity of older seed lodged in the lower layers of the canopy and in the litter of dead leaf.

This system had several advantages over the former one. It involved far less total harvesting time; it shortened the interval between flower flushes, since the vegetative framework did not have to recover from harvest damage between crops; and it still left time for the suction harvester to come in and clean up what the header had missed. Other growers followed, with modifications to suit their own circumstances, and the system became standard on irrigated farms. It has generally yielded a total of 500-800 kg per ha of seed per annum, though its potential is rather higher than this. Difficult seasons and diminished markets have, since 1973, reduced both the prospects for and the incentive to achieve maximum yields.

CHOICE OF LOCALITY

The "gold rush" of the early years after release led people in many parts of northern Australia to attempt to produce Siratro seed, and thus served as an effective regional screening operation. It resulted in a fairly complete knowledge of what were, and what were not, suitable growing districts by about 1965. The recent expansion in the use of Siratro overseas has brought the topic of choice of locality to the fore again, however, and it is still important to try to define the conditions that combine to produce a suitable environment for seed production.

The starting point is the knowledge of the environment of the districts of proved suitability. In Queensland these districts have fallen into two categories:— those where seed production is a specialised enterprise, and those where it has been merely an adjunct to grazing. The latter, which are mainly in the Bundaberg-Maryborough area, produced yields between 1968 and 1974 that averaged only about 35 kg per ha per annum. Although their production was valuable in a certain economic climate, it reflects the popularity of Siratro as a pasture plant there rather than the suitability of the region for seed production.

By contrast, the northern farmers found Siratro a poor pasture legume but a vigorous seed crop. Grown in pure stands and under intensive management, it yielded an average of about 150 kg per ha per annum between 1968 and 1972, in spite of massive losses through inefficient recovery. Annual production potential has been crudely estimated as being of the order of 3000 kg per ha under ideal conditions (Hopkinson and Loch 1973). It is therefore to the environment of the northern districts to which we must look for an indication of suitable conditions for seed production.

The relevant districts extend discontinuously from Walkamin (the coolest and most elevated locality) through Lakeland Downs to the Endeavour and McIvor Rivers north of Cooktown. Choice of soil type in this region has been, within broad limits, of minor importance. Most arable soils of good drainage have grown Siratro adequately, provided their various nutritional disorders have been rectified.

Climate, on the other hand, has been critical. The marked climatic changes over short distances that are so much a characteristic of the region have emphasized this fact sharply. The weather records of Cooktown and Walkamin (Table 2) represent almost the extremes of climatic variation within the appropriate districts, the former being at the warm wet end of the range and the latter the cool dry.

All districts have a number of essential points in common. They are almost, though not entirely, frost free; the duration of the period over which temperature

TABLE 2

Temperature and rainfall records of Siratro seed producing districts in Queensland. T = average daily ((max. + min.)/2) temperature in °C. R = average monthly total rainfall in mm.

Station	Cooktown		Walkamin		Bundaberg	
Lat. and Long.	15°S 145°E		17°3 145°E		25°S 152°E	
Elevation (m)	5		580		15	
	T	R	T	R	T	R
January	27·7	369	25·0	247	25·4	219
February	27·5	355	24·3	237	25·3	179
March	26·8	376	23·6	265	24·2	138
April	25·9	208	22·2	44	21·9	82
May	24·4	72	20·4	20	18·8	65
June	23·1	49	18·6	23	16·6	69
July	22·3	26	17·8	7	15·7	54
August	22·9	30	19·3	9	16·4	33
September	24·4	15	20·6	6	18·8	38
October	26·0	23	22·6	20	21·3	61
November	27·2	59	24·5	75	23·3	81
December	27·8	156	24·7	119	24·9	132
Total		1738		1072		1151

severely limits vegetative growth is brief; the wet season is reasonably reliable and confined to about four months (mid December to mid April, very roughly); and the dry season is reliably dry, with only minor occurrence of winter rainfall. These factors are recognized by growers as essential for successful seed production of pasture legumes in general, and Siratro in particular. Consider the evidence that helps rationalize this experience in terms of physiological processes.

Frost is readily disposed of. The aerial parts of Siratro are sensitive to the least ground frost. Leaf and shoot death occur, the effective framework and photosynthetic surfaces of the crop are destroyed, and considerable time must elapse before a new canopy can arise from the protected vegetative axillary buds of the lower, older vine.

The low temperatures that accompany periods of frost risk are also unfavourable to the development of a seed crop. They are inevitably within the range of mean daily temperatures that depress vegetative growth severely (cf. Whiteman 1968, Sweeney and Hopkinson 1975), and thus retard recovery from frost. Moreover, in order for a vigorous flush of flower to develop, the rate of emergence of axillary buds from the terminal shoots must be high. In the absence of water stress, node emergence rates are more closely correlated with mean daily temperature than with other routine meteorological records. They decline by about 13% of the maximum with each degree fall below about 23°C, and in conditions that approach frost are too low to produce the necessary bud population (own unpublished data).

It is not possible to define an adequate wet season precisely, or to state the extent to which irrigation will supplement failure of the rain. Experience suggests that a growing season of at least three months is necessary to produce the closed vegetative canopy required for maximum production, and that irrigation would be an adequate substitute for rainfall at any time if costs were no consideration.

The extension of the wet season *beyond* about four months causes problems, however, not merely through shortening the season available for seeding (for reasons that will be made clear later) but also because it gives rein to the ever-present fungus disease *Rhizoctonia*. The useful distribution of Siratro in north Queensland is very strongly influenced by the incidence of this disease. A subtle balance between host and pathogen vigour makes definition of high-risk districts in terms of meteorological records very difficult, though their geographical boundaries are known locally with great accuracy. In general, the protraction of the wet season beyond the minimum necessary, the occurrence of damp, overcast weather either during or outside it, or the excessive retention of soil moisture, all favour the disease.

In order to judge the importance of the last climatic factor—the occurrence of a reliably dry dry-season—it is necessary to consider the subject of the control of flowering as a whole.

Imrie (1973) and Whiteman (1974) both recorded partial or total failure of Siratro to flower in a 16-hour photoperiod, and some hastening of flowering with reduction of photoperiod below 12 hours. Whiteman also recorded long delays in flowering of plants exposed to a night light break, and concluded that Siratro is a facultative short day plant, verifying a long held but previously undocumented belief (e.g. Hutton 1962).

Whiteman's interpretation is not in dispute. Nevertheless, the relevance of the short-day response to the seed crop is questionable. Seed growers believe that soil moisture dominates flowering, and that a measure of water stress is necessary to promote it. Their belief is based on the observations that:—

(1) the earlier the wet season ends, the earlier the first flower flush appears;

(2) crops growing on the most freely drained soils flower first;

(3) strong mid-summer flower flushes may occur over the full latitudinal range of the seed crop if unseasonally dry conditions prevail;

(4) heavy rain or exceptionally heavy irrigation will arrest flowering at any time of year.

These observations suggest that if the short-day response operates in the field, it does so only weakly, and may be overridden by the soil moisture effect.

There are indications that it is not specifically the imposition of a water stress so much as the general retardation of vegetative growth that stimulates reproductive activity. This implies a kind of mutual antagonism between vegetative and reproductive vigour, which indeed seems to operate. Such an antagonism is reflected in the marked geographical separation of Siratro in its two roles of pasture plant and seed crop. Hutton (1970) recognized it, observing "abundant flowering and seeding when growth is checked" and Imrie (1973) possibly witnessed it in the early flowering of plants grown at a low level of nitrogen. Edey and Byth (1970) recorded the effect in another situation when they induced flushes of flowering through application of a growth retardant, TIBA, to the crop. The prevailing conditions of their experiment favoured vegetative growth, probably through abundance of soil moisture, but TIBA apparently broke the strong apical dominance that accompanies such conditions, removing the restraints on development of both vegetative and floral axillary buds.

The effect has many parallels in other crops, and was recognized some sixty years ago by Klebs in his theories on the control of flowering through nutrition (Chailakhyan 1968). Even so, there seems as yet to be no widely accepted physiological explanation for it. In Siratro we are still some way from recording even the stages at which it operates (floral induction, inflorescence bud suppression and abortion, seed set, etc.), let alone explaining it. But even though the reasons are still not understood, there is no doubt that a manipulable constraint on vegetative growth is necessary to achieve maximum reproductive vigour; that the most practicable means of control is the water supply; and that access to irrigation in a predictably dry locality is the only situation that allows such control.

From the foregoing it may be argued that temperature and rainfall records could be used to characterize the suitability of a climate for Siratro seed production, and within limits this is a realistic prospect. The duration and reliability of wet and dry season and the temperatures of the dry season are the critical criteria. To take the stations recorded in Table 2 as an example, we can see that Walkamin's mid winter temperatures must restrict total potential production; or that Cooktown's wet season is marginally too long (the seed growing districts are actually some 400-500 mm drier than the recording station (K. G. Morris, personal communication)). Bundaberg is far too cool in the dry months, and not reliably dry in the warm. Its best prospects would come in spring and autumn in years of aberrant rainfall, which is hardly a sound basis for a seed industry and a strong reason why seed has remained a catch crop in the region.

PROSPECTS

In August 1974 the Brazilian Ministry of Agriculture forbade the further importation of Siratro seed from Australia. In the same year the Australian export beef market collapsed. The two events led to a sudden fall in the demand for Siratro seed, and much of the 1974 crop remained unsold. Production diminished accordingly in 1975, but stocks were still carried over into 1976 and further depressed production.

One assumes that the market will recover eventually, since it has always done so before for seeds of cultivars of known usefulness. When this happens, it is likely that production will rest with a small group of specialist growers who have the knowledge and equipment to produce seed so efficiently that the small grower or catch cropper is unlikely to be able to compete.

There is no immediate prospect of a change in the general system of management now practised by the specialists. Its further sophistication ought to continue, but with yields potentially so high the incentive for radical change has gone. In addition to improved management methods, acceptance of the necessity for crop rotation and greater expertise in weed and pest control have increased the reliability of production.

The corollary to this picture, technically if not economically optimistic, is that agronomic research on Siratro seed production in Australia is no longer a priority. On the other hand there is conspicuous ignorance of the physiological processes that govern the behaviour of the Siratro seed crop. Also, there is an obvious need for agronomic research in the other countries attempting to grow their own seed and currently making all the mistakes that we made in the early sixties. A message that I have tried to emphasize in this review is that the highest priority should be given to the correct selection of the locality in which to grow the crop when such research programs are undertaken.

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