Foreword

I attended the last Australian Soybean Industry Conference that was held in Barooga, in March 2005. I remember large fields, flood irrigation and dairy cattle, quite different to the small fields, travelling irrigators and sugarcane that typifies the Bundaberg district.

Research, by a project called the Sugar Yield Decline Joint Venture has shown that soybeans are a very good rotation crop for sugarcane, as they change the monoculture and improve soil health. Consequently, a soybean rotation can improve cane yields by 10 to 20% in comparison to a cane replant. Fortuitously, the canelands are a very good place to grow soybeans. With a good water supply and good advice, high yielding crops of edible grade soybeans can be grown by farmers not accustomed to growing grain crops. Therefore, there is considerable economic sense in growing soybeans as a cane rotation: for the profit from the grain, the increase in cane yield, and the fixed nitrogen, enough for at least one year of cane. Reflecting this, the area of soybeans in the Queensland cane districts has increased rapidly over recent years, especially in the south east where the proximity to markets makes grain production more profitable. For these reasons it was decided that the 14th Australian Soybean Industry Conference should be held in Bundaberg, a centre for the south east Queensland sugarcane industry.

The soybean industry is flourishing in Bundaberg, so it is appropriate that the theme of the conference should be ‘Success with Soybeans’ covering research, production, processing, and marketing. In view of this theme, we hope that the conference tour, presentations, reports, and discussion amongst delegates, will focus on how to succeed with soybeans and how to overcome barriers to success.

This conference could not have been a held without the generous contributions by our sponsors. We appreciate their investment in the industry, and in return, we have strived to organise the best conference possible. We would also like to extend our gratitude to those who have contributed papers for these proceedings, and to those who will make presentations or chair sessions. This sharing of knowledge is what conferences are all about, and is the means by which the industry can advance. Finally I would like to thank my colleagues on the organising committee, particularly Veronica Timm whose experience in organising large events has been a fantastic asset to the committee.

It is possible that this will be the last Australian Soybean Industry Conference, with future plans to merge it into a ‘Summer Crops Conference’. So make the most of it! Share in the success with soybeans!

Andrew Dougall
Chairman, Conference Organising Committee
Industry support for Soybeans

Soybean growers across Australia are set to receive a boost in much-needed support through two industry funded projects.

For over a year, Ms Felicity Pritchard has been managing a project under the auspices of the Irrigated Cropping Forum involving both soybean and canola in southern NSW and Victoria based in Horsham, Victoria. The project is funded by the Grains Research and Development Corporation and the Australian Oilseed Federation. For soybeans the project focuses on undertaking a review of extension materials available to farmers and advisors and developing new extension materials. It also aims to encourage the uptake of a benchmarking system for continuous improvement of the soybean industry, with the ultimate aim of increased production in the regions.

Dr Steve Marcroft and Dr Sue Knights have been appointed to a National Program Coordination role to increase the value of the Australian oilseeds industry through enhancing productivity and value of key oilseeds. The project is for 3 years, jointly funded by the Grains Research and Development Corporation and the Australian Oilseed Federation and will focus on canola, soybeans and sunflowers. It will support the oilseed industry to improve its position as a leading supplier of premium oil, meal and food products and also place it in the position to expand market share in key markets. The project started in July 2006 and will address an urgent and critical need to lift the productivity of oilseed crops to ensure the critical mass and consistency of production and to improve the quality of grain produced.

There are 3 key areas of focus for this project: identifying and providing the best management practices that improve profitability and quality of the crops, providing grower support through demonstration sites and communication activities and ensuring industry feedback and ownership of the project. It is an exciting new project that includes activities to create increased awareness about the potential and value of oilseeds; to encourage the adoption of best practices and to provide motivation for growers and extension providers to put oilseeds as a crop of choice.

This season demonstration sites for soybeans have been established in the Wide Bay region of Queensland and are being coordinated by Judy Plath, BSES and on the North Coast of NSW being coordinated by Bob Aitken, BSES and Natalie Moore, NSW DPI, Grafton. The main aim of the Wide Bay demonstration site being to develop a low cost minimum tillage practice for planting soybeans that retains trash in the system, can be readily adopted by most growers with minor modifications to existing equipment and that actually works!! The North Coast NSW sites look at fertilizer, plant density and row spacing of soybeans.

A major task for the project is to create a web site for agronomic resources for all 3 oilseeds. This will be established on the AOF website and act as a hub for agronomic information.

Oilseed production has suffered in recent years due to drought conditions but it has equally suffered from lack of agronomic support and it is this aspect that will be addressed in these projects.

For further information contact Sue Knights
(03) 53 840 370, e-mail: sknights@netconnect.com.au
or
Felicity Pritchard (03) 53 622 111, e-mail: oilseed@icf.org.au
Contents

The efficiency coagulation of soy protein induced by commercial proteases .................................................... 4
V. Blazek & R. A. Caldwell

IPM in Coastal Soybeans and Beyond ..................................................................................................................... 12
H. Brier, A. McLennan & A. Dougall

Weed management – a major challenge to the success of NT soybean production .............................................. 19
R.J. Eastick & M.N. Hearnden

Irrigated soybean agronomy and variety improvements in southern NSW and northern Victoria ...................... 23
Luke Gaynor, Felicity Pritchard & Dale Grey

Soybean Biotechnology, Functional Genomics and End-User Benefits ............................................................... 31
Peter M. Gresshoff

Soya foods – Global Trends ....................................................................................................................................... 32
V. Lakshminarayana

Soybean for crop diversification, cash income and poverty alleviation in Cambodia ............................................ 37
Robert J Martin, Stephanie Belfield, Chan Phaloeun, Ung Sopheap, Pol Chanthy, Sieng Lay Heng, Pao Sinath, Pin Tara, Nin Charya & Fiona Scott

Why Bother with IPM .............................................................................................................................................. 44
Geoffrey and Maureen McCarthy

The Role of Independent Associations in the Australian Soybean Industry ........................................................... 47
Greg Mills

Improving soybean varieties for coastal farming systems ....................................................................................... 48
Moore, N.Y., Rose, I.A. & James, A.T.

Soybeans in the Northern Territory ........................................................................................................................ 56
Vernon C.E Nicolle

Building IPM capacity for Soybean Break Crops in the Bundaberg/Isis Regions of Coastal Queensland .......... 60
Jenny Rule, Dianne Bush, Coral Zunker, Sandra Webb & Angela Williams

Soybean Industry Development in North Queensland: ......................................................................................... 65
S. Sinclair, A. Lashmar & A. Soesanto

The potential for nematode problems in Australia’s developing soybean industry .............................................. 82
Graham R. Stirling
The efficiency coagulation of soy protein induced by commercial proteases

V. Blazek\(^1\) and R. A. Caldwell\(^1\)

\(^1\) The University of Sydney, Faculty of Agriculture, Food and Natural Resources, NSW 2006, Sydney, Australia

Abstract

Soy protein is a popular food ingredient used throughout the world for its nutritional and functional properties. Coagulation of soymilk is the most important step in the tofu making process and it depends on the complex interrelationship of many variables. Proteases have been found to coagulate soy protein. The paper investigates the ability of various kinds of commercially available proteases originating from microorganisms, plants and animals to induce the gelation of soymilk protein. The coagulum produced by the action of enzyme was separated into soymilk-curd and whey by centrifugation. The coagulating ability of eighteen proteases from different sources was studied and the results showed that some of the proteases did not coagulate the protein at any of the studied temperature or concentration. The optimum temperature for soymilk-clotting activity varied widely with the enzyme origin. The effect of the addition of calcium on the coagulation of soymilk and protein recovery is discussed.

Introduction

Soy proteins are used in the food industry for their ability to form heat-induced gels. This gelation involves the formation of aggregates, which subsequently form a more or less continuous network. The properties of heat-induced gels depend on the conditions during aggregate formation (Kuipers et al., 2005). Gels can also be prepared at ambient temperature, as reviewed by Bryant and McClements (1998). In the cold gelation process two stages can be distinguished: firstly, the preparation of a heat-denatured globular protein solution and secondly, the induction of gelation at ambient rather than elevated temperature (Kuipers et al., 2005). Using heat-denatured soy proteins, gelation can be induced by gradual acidification (Blazek & Caldwell, 2006).

Besides heating and acidification, enzymatic hydrolysis can be used to improve the functional properties of soy proteins. In general, hydrolysis is assumed to be unfavorable for the gelling properties of proteins, because it increases the amount of charged groups and reduces the molecular weight, which impede gelation. On the other hand, the structure of the protein is modified during hydrolysis, and hidden hydrophobic groups become involved, which could result in aggregate formation (Kuipers et al., 2005). Under certain conditions these aggregates can form gel networks, and in certain cases, hydrolysis has been observed to enhance the gelling properties of the protein (Doucet et al., 2001).

It was shown that bromelain could induce the gelation of soy proteins (Fuke et al., 1985). It has also been found that different proteases of microbial origin can induce coagulation of proteins in soy milk (Murata et al., 1987a). It might be expected that under certain conditions these aggregates would form a gel network upon hydrolysis. To be able to alter and control the texture of soy protein products, the aggregation behaviour of the protein hydrolysates and the parameters that influence this behaviour, should be understood.
Several studies (Zhong et al., 2007) evaluated the ability of selected microbial proteases to coagulate the soy protein dispersions. Only very few studies (Murata et al., 1987a; Murata et al., 1987b; Fuke and Matsuoka, 1980) have paid more attention to the importance of the differences in the protease efficiency to coagulate soymilk. The objective of this study was to survey the gelation ability of most common commercially available proteases to coagulate non-defatted soymilk. Thermal stabilities of selected protease systems were compared.

Materials and Methods

Soybeans

Soybeans (variety Djakal grown in northern NSW in 2005) were provided by Unigreen Food Pty. Ltd. Protein content was determined by Kjeldahl method (N x 5.7) and was 32.4% as is (35.2% mfb - assumes 8% moisture in samples). The harvested seed samples were cleaned and stored in plastic containers in dark at 4 °C until they were processed for soymilk.

Proteases

The commercial proteases originating from microorganisms, plants and animals are listed in Table 1, and were used during this experiment without any purification. They were purchased from Sigma (St. Louis, MO, USA), Fluka (Switzerland) and MP Biomedicals (NSW, Australia).

<table>
<thead>
<tr>
<th>No.</th>
<th>Enzyme</th>
<th>Activity</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protease from <em>Bacillus sp.</em></td>
<td>17.1 U/g</td>
<td>Sigma</td>
</tr>
<tr>
<td>2</td>
<td>Protease from <em>Streptomyces griseus</em></td>
<td>5.2 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>3</td>
<td>Thermolysin from <em>Bacillus thermoproteolyticus rokko</em></td>
<td>36.5 U/mg solid</td>
<td>Fluka</td>
</tr>
<tr>
<td>4</td>
<td>Protease from <em>Aspergillus sojae</em></td>
<td>0.43 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>5</td>
<td>Protease from <em>Aspergillus oryzae</em></td>
<td>554 U/g</td>
<td>Sigma</td>
</tr>
<tr>
<td>6</td>
<td>Proteinase N from <em>Bacillus subtilis</em></td>
<td>8.66 U/mg solid</td>
<td>Fluka</td>
</tr>
<tr>
<td>7</td>
<td>Protease from <em>Bacillus amyloliquefaciens</em></td>
<td>0.86 U/g</td>
<td>Sigma</td>
</tr>
<tr>
<td>8</td>
<td>Protease from <em>Rhizopus sp.</em></td>
<td>0.51 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>9</td>
<td>Bromelain from pineapple stem</td>
<td>3.0 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>10</td>
<td>Ficin from fig tree latex</td>
<td>0.1 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>11</td>
<td>Papain from Carica papaya</td>
<td>4.0 U/mg solid</td>
<td>Fluka</td>
</tr>
<tr>
<td>12</td>
<td>Papain from Papaya latex (Papainase)</td>
<td>1.0 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>13</td>
<td>Protease from <em>Bacillus polymyxa</em></td>
<td>0.8 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>14</td>
<td>Protease from bovine pancreas</td>
<td>6.9 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>15</td>
<td>Proteinase from <em>Aspergillus melleus</em></td>
<td>4.0 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>16</td>
<td>Protease from <em>Bacillus licheniformis</em></td>
<td>12.9 U/mg protein</td>
<td>Sigma</td>
</tr>
<tr>
<td></td>
<td>(Subtilisin Carlsberg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Rennin from calf stomach (Chymosin)</td>
<td>24 U/mg solid</td>
<td>Sigma</td>
</tr>
<tr>
<td>18</td>
<td>Protease from <em>Streptomyces caesipitosus</em></td>
<td>107 U/mg</td>
<td>MP Biochem.</td>
</tr>
</tbody>
</table>

Table 1. Enzymes used in this study

1 One unit will hydrolyze casein to produce color equivalent to 1.0 μmole (181 μg) of tyrosine per min at pH 7.5 at 37 °C (color by Folin-Ciocalteu reagent).
2 One unit will coagulate 10 mL of milk per min at 30 °C.
3 One unit will hydrolyze 1.0 μmole of N-benzoyl-L-arginine ethyl ester (BAEE) per min at pH 6.2 at 25°C.
4 One unit will release 1.0 μmole of p-nitrophenol from Nα-Z-L-lysine p-nitrophenyl
ester per min at pH 4.6 at 25 °C.
5 One unit is will hydrolyze 1 μmol of L-leucine-p-nitroanilide per minute.

Chemical reagents
All chemical reagents were of analytical grade.

Preparation of soymilk

One hundred grams of soybeans were first rinsed and soaked in 500 mL of distilled water for 16 h at 5 °C. Hydrated soybeans were drained, rinsed and ground in a Waring commercial blender for 2 min on high speed with 400 mL water. The slurry was run through a centrifugal fruit juice extractor, which had been lined with a layer of Miracloth (pore size 22 - 25 µm; Calbiochem, USA) to remove the coarse material (okara) from the soymilk slurry. The volume of the final raw soymilk was set to 500 mL. In each experiment, the raw soymilk was freshly prepared daily.

Coagulability of soymilk with proteases

Freshly prepared soymilk was preheated in a waterbath at 96 °C for 30 minutes and then allowed to cool. The pH and protein content of the preheated soymilk were 6.4 and 2.0% (w/w), respectively. In order to compare the coagulation ability of different proteases on soy proteins, eighteen different proteases at concentrations providing the same activity (0.083 U/mL soymilk) were used individually to coagulate the soymilk. Three different temperatures (37, 50 and 70 °C) were used to evaluate the coagulation efficiency of proteases. Soymilk (30 mL) was preincubated in a waterbath at the indicated temperature. A 0.1 mL sample of the enzyme solution was added to the soymilk and mixed for a few seconds. After 10 minutes of incubation, the contents of the tube were quickly cooled by submersion of the tube in ice water. The resulting coagulum was centrifuged at 3,000 g for 10 min in a Beckman ultracentrifuge. The volume and the protein content of whey was determined.

Assay for soymilk-clotting activity of proteases

Portions of freshly prepared soymilk (500 mL) were heated in a waterbath (96°C) for 30 minutes. After the heat treatment, the soymilk was cooled in an ice bath to about 10°C. Two mL of an enzyme solution containing respectively 10, 20, 50 and 100 mg of papain (equivalent of 1, 2, 5, resp 10 U/mL soymilk), was placed in four screw-cap tubes. Soymilk (35 mL) preheated to a temperature of 40 °C was added to the tubes and the mixture was incubated in a waterbath for 10 min. The resulting coagulum was centrifuged at 3,000 g for 10 min in a Beckman ultracentrifuge. The experiment was repeated with soymilk preheated to either 50, 60, 70 or 80 °C. In this experiment, soymilk curd refers to the precipitate made by centrifugation of the coagulum. The protein recovery of soymilk-curd was calculated by subtracting the protein content in whey measured by the Bradford method from the total protein content in the soymilk.

Effect of calcium ions on coagulation of soymilk protein

The enzyme showing high soymilk-clotting efficiency was used. Soymilk (30 mL, 50 °C) containing enzyme (0.083 U/mL) was supplemented with 30, 60 or 90 mM of CaCl₂, and the soymilk-clotting activity determined as described earlier.
Determination of soymilk and whey protein content

After the lipids had been removed by n-hexane, the protein content of soymilk and whey samples was determined by the Bradford method (Bradford, 1976) using bovine serum albumin as a standard.

Results and Discussion

The ability of various proteases to coagulate soymilk

Table 2 shows the soymilk-clotting efficiency of various proteases. Figure 1 compares the protein recovery in the curd based on the protein in soymilk. The results are mean values from two measurements unless stated otherwise. Out of eighteen enzymes used in this study, only six were able to coagulate the soymilk at all three tested temperatures. The amount of protein that was retained in the curd after the centrifugation of the coagulum (i.e. protein recovery) ranged from 94.4 to 99.3 %. The volume of separated whey ranged from 5.1 to 12.0 mL. Proteases 10, 7 and 1 all displayed high soymilk-clotting activity in a broad range of temperatures even when relatively small amounts of enzyme were used.

<table>
<thead>
<tr>
<th>No.</th>
<th>Enzyme</th>
<th>Volume of separated whey (mL)</th>
<th>Protein recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>37°C</td>
<td>50°C</td>
</tr>
<tr>
<td>1</td>
<td>Bacillus sp.</td>
<td>8.8</td>
<td>8.4</td>
</tr>
<tr>
<td>2</td>
<td>Streptomyces griseus</td>
<td>-</td>
<td>7.5</td>
</tr>
<tr>
<td>3</td>
<td>B. thermoproteolyticus</td>
<td>-</td>
<td>9.6</td>
</tr>
<tr>
<td>4</td>
<td>Aspergillus sojae</td>
<td>-</td>
<td>6.7</td>
</tr>
<tr>
<td>5</td>
<td>Aspergillus oryzae</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Bacillus subtillis</td>
<td>7.3</td>
<td>10.2</td>
</tr>
<tr>
<td>7</td>
<td>Bacillus amyloliqufaciens</td>
<td>9.9</td>
<td>8.5</td>
</tr>
<tr>
<td>8</td>
<td>Rhizopus sp.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>Bromelain</td>
<td>5.7</td>
<td>10.3</td>
</tr>
<tr>
<td>10</td>
<td>Ficin</td>
<td>9.4</td>
<td>9.5</td>
</tr>
<tr>
<td>11</td>
<td>Papain (Carica papaya)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>Papain (Papaya latex)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>Bacillus polymyxa</td>
<td>5.1</td>
<td>7.3</td>
</tr>
<tr>
<td>14</td>
<td>Bovine pancreas</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>Aspergillus mellesus</td>
<td>-</td>
<td>12.0</td>
</tr>
<tr>
<td>16</td>
<td>Bacillus licheniformis</td>
<td>-</td>
<td>11.2</td>
</tr>
<tr>
<td>17</td>
<td>Rennin</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>18</td>
<td>Streptomyces caespitosus</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

N.C. = not coagulated (i.e. the curd and whey didn’t separate after centrifugation)

Table 2. Properties of coagulum

1 The amount of preheated soymilk was 30 mL. The concentration of each enzyme was 0.083 U/mL.

2 The results are mean values from two measurements.

In a previous paper (Blazek & Caldwell, 2006) we reported that significant correlation was found between tofu hardness and volume of separated whey. It could therefore be assumed that enzymes that resulted in a greater volume of separated whey could be suitable for tofu making where hardness is an important attribute affecting the quality of a product.
Proteases originating from *Aspergillus oryzae*, *Rhizopus sp.*, *Streptomyces caespitosus*, papain from Carica papaya, protease from bovine pancreas and rennin didn’t coagulate the soymilk when using the enzyme concentration 0.083 U/mL. We decided to test these six enzymes at higher concentrations of enzyme (0.417 U/mL, i.e. five times higher compared to the original concentration). Proteases originating from *Aspergillus oryzae*, *Rhizopus sp.* and papain from Carica papaya were able to induce the coagulation of soymilk at this concentration. The values characterizing the coagulum reached similar values compared to the results in Table 2 with protein recovery ranging from 95.0 to 97.1 % and the volume of separated whey ranging from 8.0 to 10.4 mL.

![Figure 1. The comparison of the protein recovery in the curd based on the protein in soymilk. In case that the high of a column is null it means the whey and curd didn’t separate after the centrifugation.](image)

Three enzymes (protease from bovine pancreas, rennin from calf stomach and protease from *Streptomyces caespitosus*) didn’t demonstrate any coagulating activity at any of the tested temperatures and enzyme concentrations. While in the case of rennin and protease from bovine pancreas, the results are consistent with the data found in the literature (Kim et al., 1990), Murata et al. (1987a) reported that protease from *Streptomyces caespitosus* showed coagulating activity comparable to that of other microbial proteases. It is possible that the concentration of this enzyme was higher than we used in this study and able to induce the coagulation of soymilk.

The results also indicate the differences between the temperatures where the enzymes display highest soymilk-clotting activity. That indicates that the temperature for the formation of coagulum can be set by the selection of enzyme used.

**Influence of enzyme concentrations and coagulating temperature on the gelation properties of soymilk**

Papain was chosen to further examine the coagulating properties of soymilk. Five different temperatures and four concentrations of papain were applied. The results are shown in Figure 2. The incubation at 40 °C resulted in the highest protein recovery in the curd. However, there wasn’t a significant difference among the protein recovery values within the temperature range with the exception of a case when the mixture was incubated at 80 °C. In this case, the protein recovery values reached only about 90% of those obtained for lower temperatures. We observed that the volume of separated whey increased both with increasing temperature and amount of papain.
Figure 2. Graphs showing the effect of temperature and proteolytic activity on protein recovery, volume of whey, and pH of whey.

These results show that papain has its maximum activity at temperatures higher than 80 °C. Our results are in agreement with the findings of Murata et al. (1987b) who reported that the optimal temperature for papain was about 95 °C. On the other hand Zhong et al. (2007) found that papain’s activity decreased to about 60% level after 6 min at 90 °C indicating that optimal temperature for papain was between 60 and 70 °C.

We assume that using relatively high levels of papain in conjunction with temperatures where papain demonstrated its peak activity could lead to reaching high degree of hydrolysis (DH) within the range of the experiment which would explain why pH of whey and protein recovery in curd rapidly decreased. It is expected that higher papain usage levels would lead to hydrolysis of protein beyond optimum amount and would not form stronger gels compared to lower papain concentrations. However, to our knowledge the relationship between the hardness of soy protein curd and DH is not reliably known.
Effect of CaCl$_2$ and protease on the coagulation of soymilk

Figure 3 shows the effect of simultaneous addition of calcium ions and protease on the coagulation of soymilk-protein. Soymilk treated with enzyme and various levels of calcium in form of CaCl$_2$ was incubated at 50 °C followed by centrifugation of the coagulum. Ficin was used during this experiment because it showed high soymilk-clotting efficiency. The levels of CaCl$_2$ were sufficient enough to induce the coagulation of soymilk without the addition of an enzyme solution. The results show that for all tested concentrations of CaCl$_2$ the presence of ficin increased the protein recovery in the curd as well as increased the volume of separated whey.

References

It is known that almost all proteolytic enzymes are able to hydrolyze soymilk which could lead to the coagulation. The difference in the temperature where the enzyme shows its highest activity seems to be the most significant indicator when choosing a suitable enzyme for a certain industrial application. Among the eighteen tested commercial proteases, ficin, protease from Bacillus amyloliquefaciens and Bacillus sp. were the most effective and versatile soymilk coagulants. Papain was shown to be effective even at temperatures higher than 80 °C. The presence of small amounts of ficin in the system increased the protein recovery when calcium chloride was used as a coagulant.

Further studies would be desirable to elucidate the relationship between the hardness of soy protein curd and the degree of hydrolysis.

Acknowledgements

V. B. was supported by a postgraduate research scholarship from the Faculty of Agriculture, Food and Natural Resources. The soybeans were kindly provided by Unigreen Food Pty. Ltd. (NSW, Australia).
References


IPM in Coastal Soybeans and Beyond

Hugh Brier¹, Austin McLennan² and Andrew Dougall³

¹ DPI&F, PO Box 23, Kingaroy Q4610. Hugh.Brier@dpi.qld.gov.au
² DPI&F, 60 Short St., Pittsworth, Q4356. Austin.McLennan@dpi.qld.gov.au
³ DPI&F, 49 Ashfield Road Kalkie (Bundaberg) Q4670. Andrew.Dougall@dpi.qld.gov.au

Abstract

The adoption of the ‘go soft early’ Integrated Pest Management (IPM) strategy in coastal soybeans is paying dividends, with reduced silverleaf whitefly and soybean aphid activity in recent seasons. The switch to biopesticides early season has boosted beneficial insect populations in soybeans, and has undoubtedly maximised the effectiveness of the recently introduced whitefly parasite, Eretmocerus hayati. While the lack of soft options for podsucking bugs remains an IPM challenge, delaying bug sprays till early podfill reduces the risk of flaring whitefly. Indeed, the adoption of the ‘go soft early’ IPM strategy has been hastened by the risk of whitefly attack. Networking between researching and industry groups has been a pivotal factor in the uptake of IPM.

Introduction

The spread of soybeans as a break and cash crop into coastal Queensland sugarcane areas has presented the industry and researchers with a number of significant pest management challenges. These include the threat of flaring silverleaf whitefly (SLW), for which there are no viable pesticide options in soybeans, and managing high densities of podsucking bugs, which severely reduce seed quality, and which can only be managed at present with non-selective pesticides. Other challenges include a lack of IPM skills and knowledge in new production areas, an abundance of leaf eating caterpillars which inflict visually noticeable but frequently not yield threatening damage, and the ever present soybean aphid, the naturally enemies of which can be confused with a leaf eating caterpillar. Furthermore, the move by the soybean industry towards edible soybeans, which have a far lower tolerance of bug damage in particular, has increased the pressure to develop effective pest management strategies for coastal production areas.

However, the challenges outlined above have brought dual benefits: First, they have provided the impetus for RD&E that benefits for the entire industry, and, secondly, they have provided a focus on the need for IPM, i.e. an integrated approach to insect pest management that does not rely soley on insecticides to reduce insect damage. For example, the advent of SLW, and the dire predictions made for soybeans in Queensland, increased the need for soft options and validated thresholds for all pests.

Materials and Methods

A multi-pronged approach has been taken to address the above challenge of developing IPM strategies for coastal soybeans, and promoting their adoption:

The key feature of the industry’s approach was to:

- Decide on an overall IPM strategy based on our current knowledge.
- Promote the most effective IPM tools currently available.
- Identify gaps in our collective IPM capacity/and knowledge
- Address IPM management gaps by targeted research and extension
- Back up (validate) these IPM guidelines with ‘hard’ data from past and current trials.
- Link with industry to secure ‘in-kind’ collaboration and additional funding.

**Results/Discussion**

**Overall IPM strategy/message**

The IPM strategy being widely promoted is to “go soft early”. The strategy recommends only using biopesticides during the vegetative stages (against caterpillars) and to avoid non-selective or ‘hard’ pesticides for as long as possible. In essence, the strategy promotes a multi-pest approach, with silverleaf whitefly regarded as the over-riding ‘IPM enforcer’.

The aim is to foster a build up of predators and parasites to keep early pests in check and to buffer the crop against pest attack during later crop stages. The assumption is that if damaging populations of ‘flareable’ pests such as whitefly and aphids are not present by early podfill, or are suppressed until then, there will be insufficient time in soybeans for these pests to flare to damaging numbers. This assumption is backed by data and observations showing that, as soybeans progress through podfill, they become increasingly unattractive to whitefly and soybean aphids. (Note: flaring occurs when pest populations dramatically increase after ‘hard’ pesticides remove the beneficial insects keeping them in check.)

However, intervention may be required during podding, especially against podsucking bugs, populations of which peak during late podding. Podsucking bugs cannot be ignored as they can drastically reduce seed quality, as well as yield. In the early years of coastal soybean production, uncontrolled high podsucking bug populations resulted in many crops not even meeting crushing standards, let alone edible standards (2% seed damage MAX).

**Effective IPM tools**

**Biopesticides for caterpillars**

The ‘go soft early’ approach has been made possible by the registration in soybeans of two caterpillar biopesticides, namely VivusGold (a helicoverpa virus) against helicoverpa, and Dipel (Bt) against loopers and helicoverpa. Both are highly specific to caterpillars (though the virus only kills helicoverpa) and have no impact on beneficials. While biopesticides don’t always give a 100% kill, DPI&F data (Rogers pers. com.) shows that up to 10 helicoverpa larvae can be tolerated in vegetative soybeans with no yield loss, indicating that near 100% control is not always necessary.

**New generation softer caterpillar pesticides**

Two new generation caterpillar pesticides, Steward (indoxacarb) and Tracer (spinosad) with moderate selectivity are now registered in soybeans. The recommended strategy is to reserve these pesticides until the more critical podding stages, as biopesticides traditionally give a lower and slower kill. Both are far more selective than the older carbamate products such as methomyl (e.g. Marlin) and thiodicarb (Larvin) and are far less toxic to humans (an important factor in closely settled coastal regions).

Because these products and the biopesticides must be ingested by the caterpillars to work, thorough spray coverage is essential for best results. Spray volumes used on the coast are
typically high, being in the range of 200-300L/ha, which has contributed to the excellent control achieved to date in most crops. It must be acknowledged that registrations for these products and the biopesticides have been secured with data and support from past and current GRDC-funded grains and pulse IPM projects.

**Beneficial insects**

Very high beneficial insect populations have been observed in coastal soybeans. Major predators include ladybirds, hoverfly larvae and predatory bugs, and have undoubtedly been a key factor in the stabilising of soybean aphid populations on the coast. Key parasites include *Trichogramma* sp. wasps (caterpillar egg parasites), including the highly effective *T. pretiosum*, and the recently introduced (by Paul deBarro, CSIRO) silverleaf whitefly (SLW) parasite *Eretmocerus hayati*. The latter is now well established in the Bundaberg and other regions. High levels of whitely parasitism by *Eretmocerus* sp. have been observed to the point where potentially damaging SLW populations have been checked or reduced in soybeans. Low SLW activity has been reported from other coastal regions.

**Selective option for Monolepta beetles**

A submission is currently before the APVMA to extend the label for indoxacarb (Steward) to cover this pest at the rate registered for soybean looper (200mL/ha). This submission is based on data generated showing that this rate, or even lower, gives effective Monolepta control, and greatly reduces the risk of subsequent helicoverpa attack compared with non-selective option such as trichlorfon (Lepidex). Another IPM option for Monolepta is to only treat the parts of a crop that are heavily infested, as infestations are often confined to only one edge or corner of a block.

**IPM gaps:**

**Soft options for podsucking bugs**

Unfortunately, trials have shown that there are no highly selective bug pesticides, either registered or unregistered. Registration has been completely withdrawn for endosulfan which was moderately selective, having relatively little impact on parasitic wasps, but a marked impact on predatory bugs.

Of the currently registered products, the only really effective option against (most) podsucking bugs is deltamethrin (Decis) which, being a synthetic pyrethroid, is extremely hard (non-selective) on most beneficials. The only option therefore is to delay spraying as long as possible without jeopardising seed quality. This means holding off until early podfill, a recommendation which is supported by DPI&F data showing that early bug damage does not affect harvested seed quality.

**No effective options (hard or soft) for redbanded shield bug**

DPI&F trials last season confirmed that none of the pesticides currently registered for green vegetable bug, including deltamethrin, give control of redbanded shield bug (*Piezodorus oceanicus*). However, control can be moderately improved to 40% by the addition of 0.5% salt to spray tank mixes (Figure 1). Further trials are planned this season to determine if this level of control can be improved with higher salt rates.
The damage potential of mirids in soybeans

Because of their reputation in other pulse crops (especially mungbeans), mirids are greatly ‘feared’ in some soybean growing regions such as the Darling Downs, with populations as low as 1/m² being sprayed. However, this fear would appear to be unfounded. DPI&F trials over the past two seasons show that mirid (Creontiades sp.) populations up to 3/m² have no impact on podding in cultivars A6785 and Bunya. This would seem to justify the current threshold set of 4/m² for determinate soybean cultivars as grown in northern Australia, and will be further verified when current trials are assessed for yield.

Avoiding unnecessary mirid sprays is an important IPM strategy as spraying at flowering increases the risk of whitefly attack. Because of their determinacy, northern cultivars are inherently at lesser risk from mirid damage than indeterminate cultivars that are grown in southern Australia. For this reason, mirid thresholds for soybeans in southern Australia need to be based on trial data from southern soybean cultivars.

Figure 1: Relationship between mirid activity and podset in A6785 soybeans infested with mirids (Creontiades sp.) at densities averaging 2.5/m² and as high as 4/m² in individual plots.

<table>
<thead>
<tr>
<th>Mirid management trial soybeans E3F3 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total pods per plant</strong></td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td><strong>Cumulative mirids/m² for 29 days</strong></td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>90</td>
</tr>
</tbody>
</table>

\[ y = 0.0653x + 52.975 \]

\[ R^2 = 0.0122 \]

\[ P = 0.643 \]

Soybean IPM extension:

**IPM training workshops**

Two very successful workshops were held in the summer of 2006 in the Bundaberg and Isis regions of south east Queensland, in conjunction with a SRDC-funded initiative by Women in Sugar. These workshops have been comprehensively reported on by Women in Sugar elsewhere in these proceedings.

However, it should be noted that the aim of these courses was to improve participants’ confidence in IPM, to take the fear out of pest management, and to build significant IPM capacity and networks in a new soybean production region. A key message for researchers from the participants is that the information provided in such courses needs to be as digestible as possible, while not compromising on content. Post course uptake and continued IPM interest suggests the basic format has been successful. Similar IPM courses are planned for soybean and other pulse growers in southern Australia (when it rains). These workshops are part of GRDC funded
National Invertebrate Pest Initiative (NIPI), and will network with Australian Oilseeds Federation (AOF) and Pulse Australia representatives in southern Australia.

**Pulse Break Crop IPM reference manual**

A major output from the IPM workshops has been the publication of a comprehensive Pulse Break Crop IPM reference Manual. While this manual has a focus on coastal soybeans, it can easily be adapted to other regions with different pest spectrums.

*Podsucking bug threshold models*

Determining the true damage potential of podsucking bug complexes of different ages and species is a major problem for consultants and growers, particularly as the potential damage and the thresholds themselves are influenced by the size of the crop (seeds per unit area) and the crop’s proximity to harvest. In essence, the closer the crop to harvest, the less time bugs have to cause a given amount of damage, and so the higher the threshold. In addition, the closer it is to harvest, the less time young bugs (early instars) have to reach a more damaging size, and so the damage potential of late infestations with a large proportion of small nymphs is lower still. Such scenarios are not uncommon as current pesticides don’t always give total control of egg rafts under leaves in the lower crop canopy.

Finally, because bug thresholds in edible soybeans are based on % damage, the more seeds in a crop, the lower the % seed damage for a given bug population. With the added complication of at least moderate mortality for young bug nymphs, ‘on the spot’ threshold calculations are impossible in the field armed with merely a pen and paper.

However, a sophisticated threshold model has been developed that factors in all the above variables. All the user has to do is punch in the number of nymphs (each instar) and adults of each bug species, plus their crop’s row spacing, plants per row metre, pods per plant, and seeds per pod. The model then calculates and graphs the damage potential of your bugs in green vegetable bug adult equivalents (GVBAEQ), and also the threshold for your crop, at periods ranging from 42 days to 7 days from harvest (Figure 2). The model is user-friendly for researchers but needs some refinements before commercial release.

**Figure 2:** Bug damage potentials and thresholds for a crop with three (3) 2nd instar, one (1) 3rd instar and 0.2 adult green vegetable bugs per square metre, and with 3,000 seeds per square metre. Note how the bug thresholds and damage potentials are inversely influenced by time to harvest.
**Soybean insect identification including ‘new pests’ in coastal soybeans**

The increased use of biopesticides heightens the need for correct caterpillar identification, as VivusGold only acts against *Helicoverpa*, and Dipel (Bt) is the only biopesticide option for other caterpillars such as loopers. In addition in coastal regions, there are many ‘new’ caterpillars such as *Mocis* sp. and *Pantydia* sp., which are brown caterpillars and which can be confused with helicoverpa larvae (by non-entomologists).

One of the objectives of the IPM courses has been to provide scouts with simple identification guidelines, which don’t rely solely on colour (which can be extremely variable). These and many more soybean pests are described and illustrated in detail in the ‘Summer Pulse Pest’ chapter (written by Hugh Brier) in the forthcoming CSIRO publication ‘Insect and Allied forms in Australian Field Crop and Pastures’ (in press). Correct insect identification remains an ongoing IPM issue as surveys in other regions show that 75% of consultant agronomists can’t immediately identify 50% of the common pest and beneficial insects in the crops they are scouting.

**Conclusions**

Evidence of the IPM strategy’s success in soybeans to date is the low incidence of SLW and soybean aphids in the majority of crops in recent seasons. This switch to biopesticides against caterpillars early in the life of the crop has resulted in the build up of massive beneficial insect populations. The reduction in early ‘hard sprays’ has also undoubtedly maximised the effectiveness of the newly released SLW parasite (*Eretmocerus hayati*). While soybeans are well armed with IPM options for caterpillars, they still lack genuinely soft but effective options for pod-sucking bugs. Having soft options equivalent in IPM fit to a biopesticide, or even a low rate of indoxacarb, would preserve the large populations of beneficial insects present in many crops by podding, and allow them to move onto other less advanced crops, or to overwinter.

It is emphasised that any future soft bug options must also be effective to meet the more stringent quality requirements for edible grade soybeans. However, the bug damage threshold model above (Fig. 2) gives IPM practitioners some leeway, at least for late infestations. The challenge will be to match the recent high standards in grain quality achieved as a result of greatly improved bug management (particularly in coastal regions). For example, over 70% of crops in the Bundaberg/Isis regions made the edible grade in the 2005/06 season, a massive improvement from the early soybean years when many crops failed to meet even crushing standards, largely as a result of inadequate insect pest management.

Finally, the widespread adoption of IPM in coastal soybeans is a tribute to the many growers, industry and scientific personnel networking with project DAQ00086 throughout eastern Australia. While this paper focuses on coastal soybeans, the IPM threat posed by SLW on the coast has proved a boon for IPM, and there are messages for other regions with different IPM threats such as mites.

**Acknowledgements**

The authors would like to acknowledge GRDC funding for projects generating threshold and registration data for softer IPM options in soybeans, and SRDC for funding the recent Pulse Break Crop IPM courses in the Bundaberg/Isis regions. We would also like to acknowledge the invaluable in-kind assistance from industry organisations and groups, consultants and growers.
Special local mention should be given to Angela Williams (Sugar Executive Officer, Wide Bay Burnett Area Consultative Committee, Bundaberg), Women in Sugar (Isis and Bundaberg), Judy Plath and Matt Leighton (CANEGROWERS Isis and Bundaberg). Broader recognition is due to the Northern Australian Soybean Industry Association (NAISA) and the Australian Oilseeds Federation (AOF). Finally, a special thanks to all our collaborator growers who have given so selflessly of their time to assist with IPM trials.
Weed management – a major challenge to the success of NT soybean production.

R.J.Eastick1 and M.N.Hearnden2

1 Rowena Eastick. NT Department of Primary Industry, Fisheries and Mines, PO Box 3000, NT 0801 (corresponding author).
2 Mark Hearnden. NT Department of Primary Industry, Fisheries and Mines, PO Box 3000, NT 0801.

Abstract

There is renewed interest in soybean production in the NT for biodiesel. Weed control is a major challenge to the success of such an enterprise, and weed management strategies will need to be developed specifically for soybeans and NT conditions. Legume weeds, specifically sicklepod and cavalcade, are difficult to selectively control in soybean crops. An experiment was conducted at Katherine Research Station to evaluate a number of herbicides on weed control in soybean. Preliminary results are presented. Imazethapyr and metolachlor applied pre-emergent produced the best broadleaf and grass weed control. Future work will need to examine the efficacy of a range of herbicides, potentially including chemicals not currently available in Australia, to provide alternate options for control of sicklepod. An integrated weed management strategy with minimal impact on the environment is required for sustainable soybean production.

Introduction

Soybeans are not grown commercially in the Northern Territory (NT), although there is interest in soybean production for biodiesel. Energy Crops Australia (ECA) has embarked on a project to assess the commercial viability of soybeans for oil, with the intention to supplement the recently commissioned Darwin Biodiesel plant. There are a number of technical and agronomic challenges to the ‘success’ of NT soybean production, confounded by weather extremes in the wet season. Effective weed management is one such challenge.

Weed management systems need to be developed specifically for soybean production under NT conditions. Sparkes and Charleston (2003) examined weed control in far north Queensland, concluding that pre-emergent herbicides such as trifluralin and pendimethalin, and inter-row cultivation, are options for control of broadleaf weeds. Farming systems in the NT are based on minimum tillage practices, reducing the opportunity for inter-row cultivation, and the use of herbicides requiring mechanical incorporation. Pre-plant mulch management and in-crop chemical control will need to form the basis of weed management in soybeans in the NT.

Previous weed control experiments (Garside and Buchanan @1985) examined effects of trifluralin and bentazon, and concluded that there was no effective chemical control for native or introduced legumes in soybean crops. Sicklepod (Senna obtusifolia), a major legume weed in the southern United States (Wilcut et al. 1995), will also be a threat to soybean production in the NT. Cavalcade (Centrosema pascuorum cv.cavalcade), an introduced legume pasture also has the potential to be a major weed in soybean crops. Herbicide efficacy, and interaction with mulch, needs to be evaluated for a range of weed species, with specific attention to legume weeds such as sicklepod and cavalcade.

Two soybean varieties (cvs.Leichhardt and Stuart), and sunflowers, will be evaluated for yield at Katherine Research Station (KRS) over the 2006-07 wet season. A number of herbicides will be assessed in conjunction with this experiment to assess their efficacy on weed control, particularly
of sicklepod, in soybeans. Herbicides currently registered for broadleaf weed control in soybean (QDPI 2005) include: Imazethapyr (Spinnaker®), flumetsulam (Broadstrike®), metolachlor (Dual Gold®), trifluralin (Treflan®) and pendimethalin (Stomp®) applied pre-emergence; imazamox (Raptor®, imazethapyr, acifluorfen (Blazer®), and bentazone (Basagran®) applied post-emergence. Imazethapyr is currently the recommended herbicide for broadleaf and grass weed control in soybeans in the NT. However, this has no efficacy against sicklepod, so alternative herbicides need to be considered. According to USA experience (Rankins et al. 1995; Prostko 2006), herbicides effective on senna include: acifluorfen post-emergence (at 2 leaf stage only), flumetsulam pre-emergence, metribuzin (Sencor®) pre-emergence, although this has several soil type constraints, imazaquin (Scepter®) either pre- or post-emergence, and chlorimuron (Classic®) post-emergence. The latter two herbicides are not available in Australia.

This paper presents the early results of this experiment, and discusses future directions for weed management strategies in NT soybean production.

Materials and Methods

The experiment was conducted at the Katherine Research Station (S14°28’ E132°18’), NT. Soil was a Fenton Red Earth. The site was retained as a sabi grass fallow, (Urochloa mosambicensis cv. Nixon) for the previous two years, with a history of broadleaf weeds. The area was mulched on 20th December 2006 to reduce sabi biomass (3-6 t/ha over the area), then irrigated to refresh up vegetation prior to an application of 3L/ha glyphosate (450 g/kg) on the 29th January 2007. The area was re-mulched on the 2-3rd January due to large amounts of remaining biomass. Soybean was sown in 25cm rows on the 11th January using a John Shearer trash-culti drill planter; intended plant population was 350-450,000 plants/ha.

The pre-emergent herbicide treatments were applied on the 12th January with 100L/ha water volume, applied with 18m boomspray. Main weeds present were regenerating sabi and emerging pigweed (Trianthema portulacastrum). Approximately 30mm of rain fell two days after herbicide application.

Experimental design was a randomised complete block (4 blocks) of six herbicide treatments (Table 1) within each of the 2 cultivars; Leichhardt and Stuart. Plot size was 18m by 18m.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Active (g/kg or /L)</th>
<th>When applied</th>
<th>Rate / ha</th>
<th>Amount ai / ha (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Gold &amp; Spinnaker WDG</td>
<td>Metolachlor (960) &amp; Imazethapyr (700)</td>
<td>Pre</td>
<td>2L</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post</td>
<td>140g</td>
<td>98</td>
</tr>
<tr>
<td>Spinnaker WDG</td>
<td>Imazethapyr (700)</td>
<td>Pre</td>
<td>140g</td>
<td>98</td>
</tr>
<tr>
<td>Spinnaker WDG</td>
<td>Imazethapyr (700)</td>
<td>Post</td>
<td>140g</td>
<td>98</td>
</tr>
<tr>
<td>Sencor 480SC</td>
<td>Metribuzin (480)</td>
<td>Pre</td>
<td>750ml</td>
<td>360</td>
</tr>
<tr>
<td>Broadstrike</td>
<td>Flumetsulam (800)</td>
<td>Pre</td>
<td>50g</td>
<td>40</td>
</tr>
<tr>
<td>Control</td>
<td>No herbicide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Soybean emergence counts and biomass samples (2 by 1x0.5m quadrat per plot) were on the 25th January to assess phytotoxicity. Weed ratings were also conducted to determine efficacy of herbicide treatments on grass and broadleaf weed control. Ratings were given as: 0 = no weed; 1 = very low (<5% coverage, isolated emerging plants); 2 = low infestation (5-25% coverage, weeds less than 5cm diameter or height); 3 = medium infestation (25-50% coverage, weeds between 5-10cm diameter or height; 4 = high infestation (>50% coverage, weeds greater than
10cm diameter or height). There was no difference between Stuart and Leichhardt on the parameters assessed, so variety was pooled for the Analysis of Variance (ANOVA). Post-hoc comparisons were conducted using Dunnett’s test versus the no herbicide treatment.

Haloxyfop (Verdict 520) at 400ml/ha was applied on the 26th January (2 weeks after pre-emergent treatments applied) over all plots except the control, for control of regenerating perennial sabi, plus emerging sabi and barnyard grass (*Echinochloa* spp.). The post-emergent treatments (Spinnaker) were applied on the 31st January. Crop, grass and broadleaf weed biomass will be assessed on the 14th February (2 weeks after post-emergent treatments applied) to evaluate early weed control. Final crop, grass, and broadleaf weed biomass will also be assessed at crop maturity. Other soybean physiological parameters, such as plant height, number of pods, total grain weight / plant and 100 seed weight, will be assessed at final harvest as part of the soybean versus sunflower yield comparison.

**Results and Discussion**

There were no treatment effects on number of soybeans / plot, or soybean weight / plant. Grass species, mainly barnyard grass, were the dominant weeds. Pigweeds were the dominant broadleaf weed. Unfortunately, no senna, and only isolated cavalcade, emerged in any treatments, including the control. The Dual Gold, Spinnaker pre-emergent, and Sencor treatments (no post-emergent treatment results were collected by time of writing) provided significantly better grass weed control than no herbicide. All herbicide treatments, with the exception of Spinnaker post emergent, which was effectively another control at the time of first ratings, resulted in less broadleaf weeds than no herbicide (Figure 1).

![Weed rating graph](image)

**Conclusions**

Imazethapyr is currently the basis of weed control in wet season minimum tillage soybeans in the NT. It is likely to be the most effective option for broad spectrum weed control. Initial results from this experiment confirm this. The next series of measurements will indicate the relative weed control of Spinnaker applied either pre-emergent, post-emergent only, or post-emergent following a pre-emergent herbicide treatment. Generally, the use of alternate pre-emergent herbicides requiring incorporation by cultivation or irrigation is not feasible, and reliance on rainfall for incorporation is unpredictable.
Further work is required to assess available herbicides on a wider weed spectrum, including legume weeds such as sicklepod, cavalcade, *Crotalaria* spp, phasey bean (*Phaseolus macroptilium*) and buffalo clover (*Alysicarpus vaginalis*). Ideally, inclusion of the herbicides imazaquin and chlorimuron available in the USA, offers the potential for more effective weed control options in the NT. Chlorimuron is considered the best choice for control of sicklepod in soybean, based on environmental behaviour, as well as cost-effectiveness (Franklin et al 1994). The scope to include these herbicides is uncertain.

Future work should include herbicide assessment in wet season and in dry season irrigated crops, where incorporation by irrigation provides greater pre-emergent herbicide options. Shielded sprayers may also be more suited to dry season than wet season production, due to better access and trafficability.

Identifying suitable in-crop herbicides is one of the major strategies for soybean weed management. However, other weed control options, including grass or cereal rotations, mulch management and minimal tillage, need to be considered. Future commercial soybean production in the NT may also provide impetus for adoption of varieties genetically modified for herbicide resistance. Weed control is one of the many challenges to the potential success of soybeans in the NT. Developing effective integrated weed control strategies with minimal impact on the environment will contribute to addressing this challenge.

References


Irrigated soybean agronomy and variety improvements in southern NSW and northern Victoria

Luke Gaynor1, Felicity Pritchard2 and Dale Grey3

1 NSW Department of Primary Industries, Technical Officer
2 Irrigated Cropping Forum, Oilseeds Industry Development Officer
3 Vic. Department of Primary Industries Senior Agronomist

Abstract

Irrigated soybean trials were conducted in southern NSW (Leeton & Coleambally) and Northern Victoria (Katandra) in 2005-06 as part of the GRDC-funded National Soybean Improvement Project. Trial results in 2005–06 and averages over the last five years show Djakal to be the top-performing soybean variety in the southern region. The new soybean variety Snowy, released in 2005, also performed well. These varieties are proving to be higher yielding and have better end-use quality than older varieties. Furthermore, their quicker maturity means they potentially use less water.

Agronomy trials were also conducted in both regions examining the effect of variety, plant population, row spacing and, at Leeton, sowing time on grain yields. These trials are continuing at Leeton in 2006-07 to further the study.

Introduction

The area planted to soybeans in southern NSW more than doubled from 1570 ha in 2004-05 to 3650 ha in 2005-06, with grain yields averaging an estimated 3.3 t/ha, and top yields of 4.6 t/ha. Due to extreme drought conditions, approximately 250 ha was planted (Figure 1) in 2006-07. General irrigation allocations were reduced to a low 15%, with much of the water used to finish winter crops in spring 2006. This left very little water for summer crops.

The main varieties grown in this region are Djakal and Snowy, which are higher yielding and of a better end-use quality than older varieties due to their larger seed size, higher protein and tofu-
making quality. They are also faster-maturing, making them more suitable to double-cropping programs. In addition, many growers have found that they generally require one less watering, and are therefore more water-use efficient. Snowy is considered premium quality for export markets, in particular the tofu market.

The following information summarises some of the results from the research into soybean breeding and agronomy.

I. Soybean breeding and evaluation trials

Advanced breeding lines of soybeans were evaluated in four trials across southern NSW and northern Victoria in the 2005–06 season. Trials were conducted at Leeton, and Coleambally by NSW DPI, and one was conducted in Katandra (Victoria) by Vic. DPI. Leeton is approximately 580 km WSW of Sydney and Coleambally is a further 90km SW of Leeton. These regions are known as the Murrumbidgee Irrigation Area and Coleambally Irrigation Area. Katandra, near Shepparton, is about 170 km north of Melbourne in the Murray Valley.

The trials at Leeton were sown at two sowing times: late November (optimum sowing time), and late December (later than ideal). These trials were conducted to evaluate the advanced breeding lines in fully replicated regional trials with commercially available varieties.

At Leeton, a further 28 lines and 104 lines were tested in the F7 and F6 trials, respectively. The F7 trial is the first replicated trial of the newly crossed lines and is the first trial to statistically test yield potential. The F6 trial is a non-replicated natural seed increase of selected F5 lines which are screened for Phytophthora root rot and maturity suitability. Approximately 450 lines were screened in the F5 trial at Leeton for suitability to this growing region and for visual suitability (yield, seed size, seed quality etc). Early generation trials were also conducted in Victoria to screen lines.

Method

In southern NSW at Leeton and Coleambally, the advanced lines were replicated four times in fully randomised complete block designs. Advanced lines were also tested across a range of sowing dates, from ideal (mid November) to a late planting date (late December). In northern Victoria, advanced lines were replicated three times in randomised complete blocks at Katandra.

Table 1: 2005–06 trial site details

<table>
<thead>
<tr>
<th>Site</th>
<th>Coleambally</th>
<th>Leeton</th>
<th>Katandra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinator</td>
<td>Luke Gaynor, NSW DPI</td>
<td>Dale Grey Vic DPI</td>
<td>Tige Gardner</td>
</tr>
<tr>
<td>Co-operator</td>
<td>David Bellato</td>
<td>NSW DPI</td>
<td></td>
</tr>
<tr>
<td>Sowing date</td>
<td>14 Nov</td>
<td>25 Nov</td>
<td>23 Dec</td>
</tr>
<tr>
<td>Soil type</td>
<td>Grey self-mulching clay</td>
<td>Grey self-mulching clay</td>
<td>Red loam</td>
</tr>
<tr>
<td>In-crop rainfall (mm)</td>
<td>na</td>
<td>42 mm</td>
<td>118 mm</td>
</tr>
<tr>
<td>Irrigation (ML)</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Method</td>
<td>Raised Beds (1.83 m)</td>
<td>Raised Beds (1.83 m)</td>
<td>Border check</td>
</tr>
<tr>
<td>No. irrigations</td>
<td>10</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Harvest</td>
<td>27 Mar</td>
<td>12 Apr</td>
<td>12 Apr</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>250 kg legume starter</td>
<td>40 kg P/ha as super</td>
<td></td>
</tr>
<tr>
<td>Previous winter crop</td>
<td>Fallow</td>
<td>Fallow</td>
<td>Oaten-vetch hay</td>
</tr>
<tr>
<td>Previous summer crop</td>
<td>Soybeans</td>
<td>Fallow</td>
<td>Maize</td>
</tr>
</tbody>
</table>
In the southern NSW, long-term data were derived from 12 trials at Leeton (two sowing dates) and Coleambally from 2003–04 to 2005–06. Long-term data were taken yearly from the northern Victorian sites from five trials from 2001–02 until 2005–06 at Congupna and Katamatite.

**Results**

2005–06 yields

**Table 2:** Fully-graded grain yields for southern NSW and off-header grain yields for Victoria of advanced soybean varieties and selected advanced breeding lines for 2005–06 harvest. All varieties/lines are culinary types, except Stephens, which is a black-hilum crushing variety. Results are expressed as tonnes per hectare (t/ha).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Leeton early sowing</th>
<th>Leeton late sowing</th>
<th>Coleambally</th>
<th>Katandra</th>
<th>Overall mean (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Djakal</td>
<td>4.10</td>
<td>3.93</td>
<td>3.40</td>
<td>4.99</td>
<td>4.11</td>
</tr>
<tr>
<td>F148-4</td>
<td>3.30</td>
<td>3.84</td>
<td>2.68</td>
<td>4.77</td>
<td>3.65</td>
</tr>
<tr>
<td>F190-6</td>
<td>3.88</td>
<td>3.69</td>
<td>2.77</td>
<td>4.21</td>
<td>3.64</td>
</tr>
<tr>
<td>99091A-4</td>
<td>3.32</td>
<td>3.31</td>
<td>2.99</td>
<td>4.66</td>
<td>3.57</td>
</tr>
<tr>
<td>Snowy</td>
<td>3.40</td>
<td>3.67</td>
<td>2.50</td>
<td>4.57</td>
<td>3.53</td>
</tr>
<tr>
<td>Empyle</td>
<td>3.39</td>
<td>3.84</td>
<td>2.94</td>
<td>3.90</td>
<td>3.52</td>
</tr>
<tr>
<td>99091A-7</td>
<td>3.52</td>
<td>3.92</td>
<td>2.99</td>
<td>nt</td>
<td>3.48</td>
</tr>
<tr>
<td>99091A-18</td>
<td>3.55</td>
<td>3.85</td>
<td>2.97</td>
<td>nt</td>
<td>3.46</td>
</tr>
<tr>
<td>99024-76</td>
<td>3.33</td>
<td>3.36</td>
<td>2.65</td>
<td>4.38</td>
<td>3.43</td>
</tr>
<tr>
<td>F148-3</td>
<td>3.45</td>
<td>3.63</td>
<td>3.04</td>
<td>nt</td>
<td>3.37</td>
</tr>
<tr>
<td>F147-5</td>
<td>3.43</td>
<td>3.76</td>
<td>2.93</td>
<td>nt</td>
<td>3.37</td>
</tr>
<tr>
<td>F190-4</td>
<td>3.40</td>
<td>3.57</td>
<td>2.97</td>
<td>nt</td>
<td>3.32</td>
</tr>
<tr>
<td>Curringa</td>
<td>3.12</td>
<td>3.54</td>
<td>2.29</td>
<td>4.09</td>
<td>3.26</td>
</tr>
<tr>
<td>F191B-4</td>
<td>3.12</td>
<td>3.45</td>
<td>2.64</td>
<td>3.73</td>
<td>3.23</td>
</tr>
<tr>
<td>99024-15</td>
<td>3.12</td>
<td>3.80</td>
<td>2.77</td>
<td>nt</td>
<td>3.23</td>
</tr>
<tr>
<td>F215-5</td>
<td>3.21</td>
<td>3.43</td>
<td>2.38</td>
<td>3.89</td>
<td>3.23</td>
</tr>
<tr>
<td>99091A-6</td>
<td>3.22</td>
<td>3.53</td>
<td>2.91</td>
<td>nt</td>
<td>3.22</td>
</tr>
<tr>
<td>F215-3</td>
<td>2.85</td>
<td>3.55</td>
<td>2.83</td>
<td>3.63</td>
<td>3.22</td>
</tr>
<tr>
<td>F191A-4</td>
<td>3.17</td>
<td>3.48</td>
<td>2.52</td>
<td>3.69</td>
<td>3.21</td>
</tr>
<tr>
<td>99027-10</td>
<td>3.11</td>
<td>3.78</td>
<td>2.71</td>
<td>nt</td>
<td>3.20</td>
</tr>
<tr>
<td>99027-4</td>
<td>3.31</td>
<td>3.61</td>
<td>2.61</td>
<td>nt</td>
<td>3.18</td>
</tr>
<tr>
<td>96248-23</td>
<td>2.94</td>
<td>3.18</td>
<td>2.34</td>
<td>4.22</td>
<td>3.17</td>
</tr>
<tr>
<td>99024-10</td>
<td>3.04</td>
<td>3.75</td>
<td>2.68</td>
<td>nt</td>
<td>3.16</td>
</tr>
<tr>
<td>F145-8</td>
<td>2.98</td>
<td>3.22</td>
<td>2.65</td>
<td>3.71</td>
<td>3.14</td>
</tr>
<tr>
<td>Bowyer</td>
<td>3.01</td>
<td>3.77</td>
<td>2.29</td>
<td>nt</td>
<td>3.02</td>
</tr>
<tr>
<td>99024-30</td>
<td>3.02</td>
<td>3.60</td>
<td>2.32</td>
<td>nt</td>
<td>2.98</td>
</tr>
<tr>
<td>F124-1</td>
<td>2.94</td>
<td>3.16</td>
<td>2.14</td>
<td>3.40</td>
<td>2.91</td>
</tr>
<tr>
<td>F148-2</td>
<td>2.91</td>
<td>2.79</td>
<td>2.88</td>
<td>nt</td>
<td>2.86</td>
</tr>
<tr>
<td>F190-7</td>
<td>2.97</td>
<td>3.00</td>
<td>2.48</td>
<td>nt</td>
<td>2.82</td>
</tr>
<tr>
<td>F191-1</td>
<td>2.92</td>
<td>2.81</td>
<td>2.56</td>
<td>nt</td>
<td>2.76</td>
</tr>
<tr>
<td>F215-9</td>
<td>2.80</td>
<td>3.15</td>
<td>2.29</td>
<td>nt</td>
<td>2.75</td>
</tr>
<tr>
<td>Stephens</td>
<td>nt</td>
<td>nt</td>
<td>nt</td>
<td>5.12</td>
<td></td>
</tr>
</tbody>
</table>

| mean      | 3.220               | 3.516              | 2.680       | 3.971    |
| lsd       | 0.394               | 0.291              | 0.418       | 0.568    |
| cv%       | 8.83%               | 5.89%              | 9.32%       | 7.82%    |

**Table 3:** Days from sowing to physiological maturity (P95) at Leeton (two sowing dates), Coleambally and Katandra in 2005–06 of commercial varieties and potential release genotypes.
<table>
<thead>
<tr>
<th>Variety</th>
<th>Leeton Nov sown</th>
<th>Leeton Dec sown</th>
<th>Coleambally</th>
<th>Katandra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowyer</td>
<td>127</td>
<td>121</td>
<td>128</td>
<td>nt</td>
</tr>
<tr>
<td>Curringa</td>
<td>126</td>
<td>118</td>
<td>127</td>
<td>134</td>
</tr>
<tr>
<td>Snowy</td>
<td>123</td>
<td>103</td>
<td>120</td>
<td>134</td>
</tr>
<tr>
<td>Empyle</td>
<td>121</td>
<td>103</td>
<td>118</td>
<td>132</td>
</tr>
<tr>
<td>99091A-4</td>
<td>117</td>
<td>99</td>
<td>117</td>
<td>130</td>
</tr>
<tr>
<td>F148-4</td>
<td>119</td>
<td>100</td>
<td>116</td>
<td>129</td>
</tr>
<tr>
<td>F190-6</td>
<td>114</td>
<td>97</td>
<td>114</td>
<td>123</td>
</tr>
<tr>
<td>99091A-18</td>
<td>121</td>
<td>106</td>
<td>118</td>
<td>nt</td>
</tr>
<tr>
<td>99091A-7</td>
<td>123</td>
<td>106</td>
<td>122</td>
<td>nt</td>
</tr>
<tr>
<td>96248-23</td>
<td>118</td>
<td>99</td>
<td>114</td>
<td>128</td>
</tr>
<tr>
<td>Djakal</td>
<td>117</td>
<td>99</td>
<td>112</td>
<td>129</td>
</tr>
</tbody>
</table>

**Mean** | 120 | 105 | 119 | 130

Long-term yields

The long-term data show that Djakal is the highest yielding variety, followed by a number of lines, Snowy (4), Empyle (7), Curringa (10) and Bowyer (13) (Table 4).

The newer varieties Snowy and Djakal, which are faster maturing (Table 3), have consistently and significantly out-yielded the older varieties such as Stephens, Curringa and Bowyer, especially in the Riverina.

**Table 4: Long-term mean yields of soybean varieties and advanced breeding lines for Victoria from 2001–02 to 2005–06 (off-header yields), and Riverina from 2003–04 to 2005–06 (seed-graded yields).**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Year of release</th>
<th>Northern Victoria</th>
<th>Riverina</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Djakal</td>
<td>2001</td>
<td>4.06</td>
<td>3.97</td>
<td>4.02</td>
<td>1</td>
</tr>
<tr>
<td>Snowy</td>
<td>2005</td>
<td>3.69</td>
<td>3.59</td>
<td>3.64</td>
<td>4</td>
</tr>
<tr>
<td>Empyle</td>
<td>2001</td>
<td>3.63</td>
<td>3.52</td>
<td>3.58</td>
<td>7</td>
</tr>
<tr>
<td>96248-23</td>
<td>Unreleased</td>
<td>3.14</td>
<td>3.21</td>
<td>3.17</td>
<td>12</td>
</tr>
<tr>
<td>Stephens</td>
<td>-</td>
<td>3.34</td>
<td>3.63</td>
<td>3.49</td>
<td>9</td>
</tr>
<tr>
<td>Curringa</td>
<td>1999</td>
<td>3.23</td>
<td>3.32</td>
<td>3.28</td>
<td>10</td>
</tr>
<tr>
<td>Bowyer</td>
<td>-</td>
<td>2.99</td>
<td>3.06</td>
<td>3.03</td>
<td>13</td>
</tr>
<tr>
<td>99091A-18</td>
<td>Unreleased</td>
<td>3.69</td>
<td>3.75</td>
<td>3.72</td>
<td>2</td>
</tr>
<tr>
<td>99091A-7</td>
<td>Unreleased</td>
<td>3.64</td>
<td>3.72</td>
<td>3.68</td>
<td>3</td>
</tr>
<tr>
<td>99091A-4</td>
<td>Unreleased</td>
<td>3.64</td>
<td>3.57</td>
<td>3.61</td>
<td>5</td>
</tr>
<tr>
<td>F148-4</td>
<td>Unreleased</td>
<td>3.48</td>
<td>3.57</td>
<td>3.53</td>
<td>8</td>
</tr>
<tr>
<td>F191A-4</td>
<td>Unreleased</td>
<td>3.13</td>
<td>3.23</td>
<td>3.18</td>
<td>11</td>
</tr>
<tr>
<td>F190-6</td>
<td>Unreleased</td>
<td>3.61</td>
<td>3.57</td>
<td>3.59</td>
<td>6</td>
</tr>
</tbody>
</table>

**Mean** | 3.49 | 3.52 | 3.50

**No. trials** | 4 | 12

What do the long-term data mean?

Djakal continues to be the top-performing variety, with very robust yields across all conditions and a range of sowing dates over a number of years (Table 2). It is very well suited to double-cropping because of its fast maturity, high yields and very quick dry-down finish.

Snowy performed well and recorded high yields. Snowy has improved quality attributes with excellent tofu-making characteristics, larger seed size and higher protein than Djakal. Snowy is the only clear hilum soybean commercially available in southern NSW and northern Victoria. Djakal has a buff (light brown) hilum.
Overall, Djakal is an outstanding variety in the Coleambally and Murrumbidgee Irrigation Areas, with best commercial yields of 4.6 t/ha and a number of crops exceeding 3.8 t/ha last season (2005-06). Snowy achieved in excess of 4.0 t/ha commercially last season, but due to continued drought conditions, adoption has slowed. Djakal matured on average 10-11 days ahead of Curringa and 14-15 days ahead of Bowyer (depending upon sowing date).

Snowy and Djakal both performed well and are proving to be higher yielding with better end-use quality than the older varieties. They have been readily accepted by domestic end-users and the export market.

The recent releases of Djakal and Snowy have lifted the yield potential of the culinary-type soybeans. Further, they are more water-use efficient as they produce higher yields and may require one less watering than the older, later maturing varieties. The industry is set to capitalise on recent variety developments, expanded marketing opportunities and will expand once normal water allocations return.

Snowy and Djakal have the potential to fit into both the premium culinary and the crushing markets. Snowy is the first clear hilum variety, and is highly desirable for export markets.

The two new varieties have different genetic backgrounds for resistance to the disease Phytophthora root rot. In situations where two soybean crops are grown in succession and there is a history of Phytophthora present in the area, Snowy and Djakal can be rotated as a disease management strategy to reduce disease build up.

II. Current agronomic research

In southern NSW, soybeans are commonly sown in wide rows, with two rows per 1.8 m raised bed. In northern Victoria, soybeans are usually sown more narrowly in 17-20 cm rows on a flat border check layout. Border check layouts allow growers in each district to use conventional winter cropping equipment for sowing. Precision planters are commonly used for wide row applications to achieve even plant stands.

Wider rows are used in southern NSW to allow for row-cropping techniques and the use of existing row-crop machinery. This includes precision planters (which help guarantee correct plant densities), and the use of inter-row cultivators and sprayers for weed control, which have been used for other crops such as cotton and maize. Soybean growers in southern NSW should seriously consider the benefits and disadvantages of both systems before changing their sowing methods. Narrower row spacing can be used as a part of an integrated weed management strategy. Best management strategies developed by NSW DPI suggest raised beds are the optimum choice for maximising soybeans yields (given soil-type suitability).

Past research in Australia and overseas soybean growing areas has found that row spacing can have a significant impact on grains yields of irrigated soybeans. Further investigation into the effects of plant density will be studied closely in 2006-07.

In southern NSW, the effects of soybean variety and maturity type, row spacing, plant density and sowing time have been researched. This work is currently in its second year with positive results been achieved in the first.
Method

Three soybean varieties, Bowyer, Djakal and F148-7, were sown at three row spacings (2, 4 or 6 rows per 1.83 m bed) with three plant populations (30, 45 & 60 plants per square metre) and two sowing dates, 24 November and 20 December 2005 at Leeton Field Station, southern NSW. The aim was to determine the effect of these factors on grain yields. Data on biomass accumulation, light interception, leaf area (LA), leaf area index (LAI), harvest index (HI), grain yields and plant characteristics (height, lodging, protein etc) on each treatment was measured and, but only yield data are presented in this paper.

Preliminary trial results

To date, no data have been published as the trial is currently in its second year. Preliminary results from the 2005-06 season suggest that significant yield gains can be achieved through the use of narrow rows for both November and December sowing times, for short season soybean varieties, like F148-7 (Figure 2). F148-7 is approximately 5-6 days earlier than Djakal whilst Bowyer is approximately 10-12 days later than Djakal.

The results also indicate that high yields can be achieved with late sowing of both early and late maturing varieties (Fig. 2).

Figure 2: Effect of soybean variety (Bowyer, Djakal, F148-7), row spacing (2, 4 or 6 rows per 1.83m bed) and sowing date on grain yields (t/ha). Preliminary data from first year’s research. Sowing date 1 (sd1) was 24 Nov. 2005 and sowing date 2 (sd2) was 20 Dec. 2005.

Discussion

According to the most recently available extension literature, the recommended optimal sowing time for irrigated soybeans in the Murrumbidgee Valley is from mid-November until the end of the first week of December (Colton et al., 1995). This places a limitation on growers who wish to double-crop in order to maximise profitability from the paddock and optimise water-use efficiency. The winter cereal crop would benefit from the residual moisture from the irrigated soybean crop and likewise, the soybean crop from the winter cereal crop.
Many possibilities for double-cropping rotations exist. Later sowing of the soybean crop provides the grower with more winter crop choices when double cropping. Preliminary results from this research suggest that the current recommendations may be outdated, as yields of late December sown soybeans were similar or greater than those of late November. Further research is underway in 2006-07 which will assist in updating current recommendations.

Row spacing can have a considerable effect on yields because it is related to the crop’s ability to capture sunlight, accumulate leaf area (LAI) and produce crop biomass, which in turn, leads to grain production (when other factors like water are not limiting).

In the early growth stages of a soybean crop, light interception is related to the proportion of ground covered by the crop’s leaf canopy (Charles-Edwards and Lawn, 1984). Closer row spacing improves the crop’s light interception (Leach and Beech, 1988). The first year’s results of this two-year study are consistent with past research in Queensland, which showed that narrower spacing of soybeans lead to faster development of leaf area/biomass, but higher water use in dryland situations. However in more favourable conditions or in irrigated situations, this can lead to higher yields as full moisture is utilised (Lawn, 1983).

The effects of plant density are also yet to be fully understood. Research has shown that although higher plant densities of grain legumes increases crop growth rates and water use, it does not result in better yields. This is probably due to competition between plants within a row for nutrients and light, and, possibly water (Lawn, 1983). However, it appears more local research is needed on this issue, as other work in the USA has found that soybean yields could be lifted by increasing plant populations when sowing in narrow rows in both irrigated and rain-fed crops (except where lodging occurs) (Ball et al., 2000).

Further research is currently being undertaken to study the effect of the spatial arrangement of soybeans on biomass and yields, using a range of sowing dates from mid-November until late January. This may help us understand and develop strategies to overcome the current yield penalties associated with late sowing. At this stage until this study is completed, it is advised to sow soybeans on time in the ideal window for your region to achieve maximum yields. However, if late sowing of early-maturing varieties leads to optimum yields, it may become an important management tool in a double-cropping situation. Results from the second year of the trial (2006-07) are still been measured and recorded, and hence are unavailable at time of writing.

Future directions

The soybean breeding program is funded until June 2007. Trials in the southern NSW through the NSW DPI were planted as normal in 2006, and variety demonstrations will also be undertaken in northern Victoria. The trial to evaluate the effects of variety, plant density, row spacing, sowing date, and their interactions will also continue this season at Leeton Field Station, in collaboration with CSIRO and James Cook University.

References


Acknowledgements

We acknowledge the assistance of Chris Lisle, NSW DPI, Wagga Wagga, for biometrical analyses, Don McCaffery for reviewing the article and the GRDC for project funding.

Contacts

Luke Gaynor NSW DPI (02) 6938 1657 or 0428 260 156 luke.gaynor @ dpi.nsw.gov.au
Felicity Pritchard ICF (03) 5382 4396 or 0427 600 227 oilseed @ icf.org.au
Soybean Biotechnology, Functional Genomics and End-User Benefits

Peter M. Gresshoff

Australian Research Council Centre of Excellence for Integrative Legume Research, The University of Queensland, St. Lucia, Brisbane QLD 4072, Australia, www.cilr.uq.edu.au

Biotechnology and functional genomics work hand-in-hand with plant physiology, biology and breeding to advance the ability of the soybean plant to produce more seed, better seed, and all with less input. We now have available an up-to-date toolbox of genomic tools. Many quantitative trait loci (QTLs as they are called) controlling properties such as disease resistance, root structure, oil, isoflavone and protein content have been linked to codominant molecular markers allowing ‘Smart Breeding’. A molecular map of soybean has been established covering every ‘corner’ of its 1,110 megabase genome. A commercially available ‘Affymetrix genechip’ analysing over 37,000 soybean genes concurrently is employed in our Centre (at about $1,500 a chip!) to determine the pattern of gene expression in different plant organs during different developmental and environmental situations. Our Centre achieved the first positional cloning of any soybean gene, when we determined that the supernodulation mutation in Bragg was caused by changes in a leucine rich repeat (LRR) receptor kinase (Searle et al, 2003). We now know that this gene exists in all legumes and that it regulates nodulation control signals through a function in the vascular system of the leaf (see Kinkema et al, 2006). Its function may be derived from ancestral mechanisms relating to defence-related signalling. We have the ability to transfer genes into the genome of soybean and also to silence genes. As yet it is not possible to replace genes, however both chemical and radiation mutagenesis are feasible allowing the elimination of gene function without the use of recombinant DNA technology (Men et al, 2002). A fascinating recent advance is the development of TILLING as a method to detect targeted local lesion in genomes. We have been first to demonstrate the utility of this approach in soybean showing that the ‘orphan’ gene CLAVATA 1A, related to the soybean supernodulation gene GmNARK, is responsible for suppressing basal node branching in soybean.

The near future will see many opportunities for soybean biotechnology. Clearly environmental stresses impact productivity and we are discovering mechanisms by which the plant handles such conditions. We also need to move towards increased sustainability through improved nitrogen, phosphorus and carbon inputs. Faster, deeper roots are needed to ‘explore’ water. At the same time issues relating to seed content and especially relating to biofuel production become essential. Soybean as a protein and oil crop has its place in the biofuel cycle. Perhaps ‘designer beans’ are needed. Our capability to achieve end-user benefits will depend in a large part on political factors here and abroad surrounding the acceptance of products from genetically engineered organisms. I suggest that once the lights start flickering, the dam is drying, and petrol is at $3 per litre, political and social attitudes so quickly will adjust. As scientists we need to be vigilant to have the technology and knowledge ready for their implementation for the soybean industry. Failure not to do so seems more irresponsible and unethical, than dealing with the limited risks conceived at present.

Soya foods – Global Trends
Vish Lakshminarayana, So Natural Foods NSW 2229

Abstract

Soybeans provide a balanced nutritional profile that can supplement the requirements of protein globally. Worldwide soybean production is increasing at 5% per year, however it is not reflected in Soya foods growth as it is challenged by health benefits, reduction in consumer appeal, saturation of market, reduction in shelf space etc.

New products continue to emerge in the marketplace filling in the space of “healthy eating”. Recent trends include: organic foods, functional proteins, innovative products, use as basic ingredients source (protein and fibre), better tasting alternatives, etc. Research is targeting on heart health, cancer, bone health, obesity, and weight management and educating consumer and health professionals.

Soya Foods

Soy foods form the base of a new food platform for the 21st century. Soybeans have a wide range of functional properties and high nutritive value which makes it a perfect ingredient for an array of food and nutritional products. Excluding the meal and oil, soy foods sales is estimated to be worth 100 billion. Soybean production has increased by 500% during the past 40 years making it the world’s largest protein and oil crop and increasing at an average rate of 5% per year in the past five years. There are enough soybeans to give every man, women and child on the planet 30 kilos per year equivalent to 30 g of protein and 15 g of oil per day (Peter Golbitz, 2006).

Soymilk beverages have moved to number 1 position at 21.5% of the total sales, followed by energy bars with 18.1% of the total.

Soya foods, once a leading micro food trend within the greater macro trend of “healthy eating” has been displaced by new consumer interests and trends. Macro trends such as healthy eating are supported by an array of micro trends that change the position often as it happened with low Carb foods.

Only 10% of the soybeans produced are used for human consumption. On a worldwide basis, the average per capita consumption of soy proteins was 2.2 g per day in 1995 and projected to be at 3.3 g per person by 2010. Due to high cost of production of animal proteins in the developing world it is likely that vegetable protein source becomes increasingly important.

The pattern of consumption of soy foods vary across the globe from tofu to speciality foods and used for protein substitution. The FDA approval of soy proteins as a “heart healthy” ingredient boosted the nutritional profile and acceptance by the consumers (FDA 1999).

As America's favorite "health food," it promises to make us skinny and lower our cholesterol, prevent cancer and reduce menopausal symptoms, put us in a better mood, give us energy. It's the cheap and guilt-free source of protein for millions of vegetarians, the "heart smart" option for meat-eaters, and the infant formula ideal for eco-minded mums. Soy has become one of the America's biggest industries.
Role of Soy in Maintaining Good Health

Reduces cancer risk, menopausal symptoms and cholesterol levels, improves osteoporosis, kidney diseases, diabetes and high blood pressure (Messina and others 1994)

People who consume soy over long periods of time have lower cancer rates, most likely related to either isoflavones, phytate, saponins, phytosterols, protease inhibitors and possibly displacing intake of more cancer promoting foods

In 1995 with the publication of a meta-analysis that found soy protein lowered serum low density lipoprotein cholesterol (LDLC) approximately by 13%. Four years later, the U.S. Food and Drug Administration approved a health claim for soy protein and coronary heart disease. More recent research suggests that the cholesterol-lowering effects of soy protein is much less pronounced than initially thought but there is also evidence that soy protein, as well as the soybean isoflavones, exert multiple coronary benefits independent of effects on LDLC. For example, soy protein may modestly raise HDL-cholesterol and lower triglycerides, whereas isoflavones may improve endothelial function. Thus, although the effects of soy on any individual CHD risk factor may be modest, collectively, these effects may be quite clinically relevant.

Controversies and concerns

After more than 20 years of steady growth in the US market, many soy food categories have levelled off or shrunk. Reasons for this include saturation of markets, reduction in shelf space, competing foods, questioning of Soya health benefits and loss of consumer appeal etc and resulted in overall drop by 2% in 2005.

The limiting factors in soy food acceptability are its Sensory characteristics which include Colour, Flavour, Aroma, Texture, aftertaste and Anti-nutritional factors.

Though lots of research has been carried out, still results are inconsistent leading to confusion among consumers and some breast cancer patients avoid altogether. Many take isolated isoflavones and it is also considered as one of the top 8 allergy causing foods, especially in 3 year olds.

Soya proteins and heart health

American Heart Association, reports that large amount of soy proteins reduced LDL by 3% and no effect on HDL.

Soy and Cancer

The American Cancer Society suggests that those who are at the risk of breast cancer should not take soy. However, epidemiologically, soy intake is associated with lower breast, prostate and colon cancers

The French Centre for Cancer Research has stated that soy products in no amount should be eaten by children under 3 years of age or women with or at risk of breast cancer. The Israeli Health Ministry issued a public warning on soy, claiming that consumption of soy be limited in young children and avoided, if possible, in infants. The American Heart Association has backtracked on its endorsement of soy.
**Isoflavones and Bone Health**

Increase in bone density for post menopausal women, not likely to reverse the osteoporosis. Some soy foods are rich in Calcium through fortification.

**Obesity Epidemic**

Two thirds of US Adults are overweight (BMI >25) and 30% are obese (BMI >30), more calories, dinning out more, just dieting won’t work. It is well known that over weight and obesity are risk factors leading to major physiological break downs; diabetes, heart disease, stroke, hyper tension, high blood cholesterol, pregnancy complications etc.

Israeli Advisory body reported that Soy’s proven risk out weigh its possible benefits. Evidence points to the phytoestrogens in SOY as increasing risk of breast cancer and reducing male fertility.

**Future**

Within the new products category, organic products continue to dominate and some of the examples include frozen and ethnic entrees of ready to eat, meat alternatives, yoghurt drinks, non dairy frozen desserts, snacks, soy based functional beverages etc. Obesity / weight loss management is the latest and greatest health crisis now. Organic foods are being embraced as a broad category by supermarkets.

**Obesity Complex**

Over weight and obesity is particularly prevalent among the young. Between 1985 and 2000, the proportion of over weight and obese youth in China is estimated to have increased by more than 400% and 2800 % respectively (Suku Bhaskaran 2006). The influencing factors are; people are eating more calories, food everywhere, more dinning out, more people dieting and tendency to regain weight after five years etc.

**Weight Management**

There is an opportunity to move soy foods from being medicine to a food source. Weight Loss management could be achieved through reduction in calorie intake and increase in calorie expenditure or the combination.

**Action items**

Creation of healthy soy foods for consumers, non restaurant (schools, hospitals, military) and commercial restaurants. Educate the consumers and health professionals regarding food labelling, inclusion of soy as part of balanced diet, status of organic and genetic modification. Achieving satiety in meals and snacks through good quality proteins, healthy fat and fibre fillings would assist in managing the obesity epidemic.

World Initiative for Soy in Human Health (WISSH) program (Jim Hershey 2006) reported that the world population is growing at 80 million per year and 16% of the world is mal nourished.
Substitution of soy protein in place of dairy protein is economical and WISSH program is promoting the incorporation of Soya proteins in local diets.

**Case Study**

A research project (Alicia Thorp et al, 2006) was undertaken in collaboration of So Natural Foods with University of South Australia, University of Western Australia and University of Wollongong to study the importance of soy protein and isoflavone intake for protection against heart disease. Current health claims indicate that daily intake of 25 g of soy protein (SP) may reduce the risk of heart disease by lowering cholesterol, particularly low-density lipoprotein cholesterol (LDL-C).

Whether the isoflavones (ISO) associated with the SP contribute to this benefit is still unclear. However, they may offer additional protection against heart disease by improving arterial dilatation and arterial compliance as a result of their ability to bind to endothelial oestrogen receptors and stimulate vasorelaxation.

**Objective**

To investigate differential effects of SP and ISO on total cholesterol (TC), LDL-C and other risk factors for heart disease.

**Methodology**

91 subjects underwent a 18 week dietary intervention studies subjects consumed foods containing 24 g of SP with 80 mg of ISO per day and rotated to Soy – Dairy and Dairy foods on its own. At the end of each six week diet phase, the physiological changes were measured.

**Conclusions**

In contrast to the approved health claim, we found that 24 g/day of SP did not reduce LDL-C and resulted in only a small reduction in TC. Significant reductions in Tri Glycerides with both 12g and 24g of soy protein/day, suggested that the effect is mediated by isoflavones. Arterial dilatation was significantly improved to an equal extent by the soy/diary and soy diets – suggesting that the beneficial effect is mediated by isoflavones. No significant changes were detected in arterial compliance.

Do we really need the recommended 25g of soy protein a day to protect against heart Disease if we also have isoflavones in our diet?

**Acknowledgement**

1,2 A Thorp, 1 J Buckley, 1 A Coates, 3 T Mori, 3 J Hodgson, 3 J Mansour, 1,2 P Howe and 4 B Meyer. 1 Nutritional Physiology Research Centre, University of South Australia, SA, 2 School of Molecular and Biomedical Sciences, University of Adelaide, SA, 3 School of Medicine and Pharmacology, University of Western Australia, WA, 4 School of Health Sciences, University of Wollongong, NSW

References

Alicia Thorp, Peter Howe, Alison Coates, Jon Buckley, Trevor Mori, Jonathon Hodgson, & Barbara Meyer (2006); Research communication “Importance of soy protein and isoflavone intake for protection against heart disease”.

American Heart Association, Journal Report, Jan (2006); “Soy protein shows little effect on "bad" cholesterol”.


Food and Drug Administration (1999); Food Labelling: Health Claims; Soy Protein and Coronary Heart Disease.


Soybean for crop diversification, cash income and poverty alleviation in Cambodia

Robert J Martin¹, Stephanie Belfield², Chan Phaloeun³, Ung Sopheap³, Pol Chanthy³, Sieng Lay Heng³, Pao Sinath³, Pin Tara³, Nin Charya³, and Fiona Scott¹

¹ NSW Department Of Primary Industries, 4 Marsden Park Road, Tamworth NSW 2340
² NSW Department Of Primary Industries, PO Box 209, Moree NSW 2400
³ Cambodian Agricultural Research & Development Institute, PO Box 01, Phnom Penh Cambodia

Abstract

Around 85,000 ha of soybeans are grown in rainfed upland areas of Cambodia with this crop being an important source of cash income and potential for crop diversification for farm families. Average on-farm soybean yields are 1 - 1.5 t/ha which is less than half the estimated potential yield of 3 t/ha under local conditions. Soybeans are popular with farmers because of ease of production, yield potential and access to markets in Vietnam and Thailand. Through a four year ACIAR funded project, the agronomy and economics of soybean production in the provinces of Battambang in the north west and Kampong Cham in the east are being studied through farmer surveys, workshops, on-farm trials and field days. On-farm trials and demonstrations are educating farmers and advisors on the response of legumes to inoculation; reduced tillage and mulching techniques; intercropping maize with soybean; insect resistance and varietal evaluation.

Introduction

The aim of this project is to help reduce poverty and contribute to food security at household and national levels in Cambodia through the development of technologies and opportunities for the production of non-rice upland crops. The research process involves discussion with farmers, validation of local knowledge, documentation of case studies and identifying priorities for field experimentation. Problems and research questions have been identified in partnership with farmer and community groups with support from the provincial extension agencies.

Upland areas may be defined as non-rice growing areas without irrigation and generally possessing soils with superior structure and fertility compared to rice paddy soils. The two upland crops with greatest potential to satisfy the overall project objectives are maize and soybean. Hybrid maize and soybean production has been expanding in north-west Cambodia in response to market demand in Thailand and soybean production in eastern Cambodia is also increasing due to market demand in Vietnam. John Spriggs (pers. comm.) has suggested that the main priorities for moving the country out of poverty are: improved marketing opportunities for farmers; better regional transport infrastructure; and better technical training for farmers to increase productivity.

In upland areas, Cambodian farmers generally attempt to grow two upland crops during the rainy season Martin et al. (in press). The first crop is planted in March-April and the second in July-August. Farmers respond readily to market demand and high price. Ease of production and low cost of seed are also important considerations in crop choice. Short duration was an important consideration for early wet season crops. The most commonly given reason for not growing a crop was damage from insect pests followed by risk of crop failure, drought or natural disaster and high cost of inputs.
Farmer workshops conducted in the villages have provided researchers with a better understanding of traditional practices and problems associated with the growing and marketing upland crops in Cambodia (Martin et al. in press). Farming systems research priorities for upland crops have been based on this information. On-farm experiments were conducted between 2004 and 2006 to evaluate improved varieties, fertiliser, rhizobium inoculation, reduced tillage, mulching and crop protection. This paper reports the results for soybeans from farmer surveys, experiments and demonstrations carried out in Cambodia between 2004 and 2006.

The potential for soybeans in Cambodia

The area and production of soybean in Cambodia almost trebled between 2002-03 and 2004-05 from under 30,000 ha to almost 85,000 ha (Table 1).

Table 1. Area, production and yield of rainfed soybean in Cambodia (Anon. 2003, 2004, 2005)

<table>
<thead>
<tr>
<th>Year</th>
<th>Harvested area (ha)</th>
<th>Production (t)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002-03</td>
<td>28,760</td>
<td>38,661</td>
<td>1.344</td>
</tr>
<tr>
<td>2003-04</td>
<td>51,699</td>
<td>62,918</td>
<td>1.217</td>
</tr>
<tr>
<td>2004-05</td>
<td>84,154</td>
<td>109,704</td>
<td>1.314</td>
</tr>
</tbody>
</table>

In 2003, Jeff Milne (pers. comm.) estimated that the potential area for soybean expansion in the province of Kampong Cham in eastern Cambodia was almost 200,000 ha. However, soybean production has rapidly increased recently in other parts of Cambodia, particularly in the northwest (Figure 1, 2).
Figure 1. The main production areas of soybean in Cambodia (base map from: http://www.cambodia-airports.com/userImages/cambodia-map.jpg)

Figure 2. Soybean production in Cambodia (total) and in the province of Kampong Cham between 2002-03 and 2004-05.

The average farm yield of soybean appears to be stable around 1.3 t/ha. It is estimated that the potential yield of soybean under rainfed conditions in Cambodia is 3 t/ha (Farquharson et al (in press) and yields of up to 3.32 t/ha have been obtained under experimental conditions (Richard Bell pers. comm.).

Farmers’ observations on soybean production in Cambodia

Annual rainfall in cropped upland areas of Cambodia is in the range 1300-1600 mm. Crops such as sesame, mungbean, maize and peanut are planted as early as March in the early wet season and harvested in June. A second or main wet season crop (soybean, mungbean, peanut, maize) can be planted in mid July. Soybean is grown in the main wet season only. Drought and short periods without rain during the main wet season are a major concern to farmers with regard to soybean production.

The main variety of soybean grown by Cambodian farmers is B-3039 (locally known as Hungary). This is a late maturing variety that produces a lot of biomass but has a yield ceiling of around 2.5 t/ha (Stephane Boulakia pers. comm.). B-3039 also has a small seed size that is not favoured by Vietnamese buyers. Although Cambodian farmers are reluctant to purchase seed for sowing, they are beginning to grow earlier maturing varieties such as DT-84 (Vietnam) and Nakornsawan-1 (Thailand) in response to market demand. Farmer response to the new varieties has varied but generally, farmers in more progressive areas consider DT-84 to be better than B-3039 because of the quicker maturity, higher yield potential and better seed quality.

Farmers rated insect damage as an important problem for soybean and at workshops identified bean aphids, brown bean bug (Riptortus spp.), green stink bug (Nezara viridula) and limabean pod borer (Etiella zinckenella) as occurring on soybean. Farmers are generally unaware of the existence of beneficial insects in upland crops and apply organophosphate insecticides 4-6 times during the crop growth cycle. Sometimes pesticide sprays are prophylactic, other times because
the neighbour is spraying, or when they see an insect whether beneficial or pest as they are unable to determine the difference.

**Varietal testing and resistance to major pests and diseases**

Soybean varietal testing in the project was limited to four experiments in 2004. Varieties were also evaluated for resistance to major pests and diseases in 2004 and 2005. The early maturing Thai variety Nakornsawan-1 had the highest relative yield and B-3039 also performed well (Table 2).

**Table 2. Relative yield and response of soybean varieties to a range of insect pests and diseases in Cambodia.**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Relative yield</th>
<th>Bean Mosaic Virus&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Downy Mildew&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Pod borer damage (%)</th>
<th>Aphids (%)&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nakornsawan-1 (Thailand)</td>
<td>100</td>
<td>MS</td>
<td>HS</td>
<td>12</td>
<td>89</td>
</tr>
<tr>
<td>AGS-2 (Taiwan)</td>
<td>88</td>
<td>MS-MR</td>
<td>R</td>
<td>23</td>
<td>62</td>
</tr>
<tr>
<td>B-3039 (Local)</td>
<td>86</td>
<td>MS</td>
<td>R</td>
<td>32</td>
<td>74</td>
</tr>
<tr>
<td>Chiang Mai-60 (Thailand)</td>
<td>83</td>
<td>MS-MR</td>
<td>R</td>
<td>30</td>
<td>97</td>
</tr>
<tr>
<td>KKU-35 (Thailand)</td>
<td>82</td>
<td>S-MS</td>
<td>S</td>
<td>68</td>
<td>63</td>
</tr>
<tr>
<td>AGS-314 (Taiwan)</td>
<td>66</td>
<td>MS-MR</td>
<td>R</td>
<td>13</td>
<td>61</td>
</tr>
<tr>
<td>DT-84 (Vietnam)</td>
<td>65</td>
<td>S</td>
<td>HS</td>
<td>9</td>
<td>84</td>
</tr>
<tr>
<td>AGS-372 (Taiwan)</td>
<td>56</td>
<td>MS</td>
<td>MR</td>
<td>19</td>
<td>62</td>
</tr>
<tr>
<td>Sukhothai-2 (Thailand)</td>
<td>44</td>
<td>S-MS</td>
<td>HR</td>
<td>7</td>
<td>70</td>
</tr>
<tr>
<td>AGS-371 (Taiwan)</td>
<td>43</td>
<td>S-MS</td>
<td>HR</td>
<td>21</td>
<td>62</td>
</tr>
<tr>
<td>KKU-74 (Thailand)</td>
<td>30</td>
<td>HS-S</td>
<td>S</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>AGS-129 (Taiwan)</td>
<td>27</td>
<td>HS-S</td>
<td>HR</td>
<td>23</td>
<td>24</td>
</tr>
</tbody>
</table>

<sup>1</sup>HS = highly susceptible, S = susceptible, MS = moderately susceptible, MR = moderately resistant, R = resistant, HR = highly resistant

<sup>2</sup>Aphids per hill expressed as a % of the worst variety – mean of two sites.

The average yield for the variety experiments was 0.5 t/ha and there was not a good relationship between relative yield and resistance to pests and diseases. Therefore the results should be treated with some caution. There is also a wider range of soybean varieties that are potentially adapted to Cambodian conditions (Andrew James pers. comm.) and further testing is warranted under better agronomic conditions.

**Response to rhizobium inoculation**

Cambodian farmers seldom use fertilisers on rainfed upland crops and inoculation of legumes with rhizobium is not practiced. Soybean crops with effective nodules do occur but are not commonly found. Between 2004 and 2006, six experiments were conducted to determine the response by soybean to rhizobium inoculation and nitrogen fertilisation.

The experimental design was a split-plot factorial with 2 rhizobium (+/-), 3 nitrogen treatments and 4 replications. Rhizobium strain CB 1809 (Group H), imported from Australia, was applied to the seed and the nitrogen treatments were 0, 40 and 80 kgN/ha applied as urea. The plot size was 5m by 2.5m. Planting was by hand with 40 cm between rows, 30 cm between plants and a total of 96 hills/plot.
Without nitrogen fertiliser, inoculation increased soybean yield by an average of 20% (Figure 2a). Soybeans also responded to fertiliser at 40 KgN/ha with a 30% increase. Inoculation increased the gross margin by $28US (Figure 2b). With improved agronomy and higher yields it is expected that responses to rhizobium could be even greater.

**Effect of reduced tillage and application of rice straw mulch on yield of soybean**

Farmers in upland areas of Cambodia usually chop, burn or remove crop and weed residues from their fields before ploughing. The field is ploughed twice or three times and left over residues are incorporated into the soil. Reduced tillage could increase soil water retention and reduce the risk of crop failure due to short-term drought.

**Effect of tillage**

Four experiments were conducted in 2004 and 2005 to identify the optimum tillage practice for the establishment of upland crops and to determine the effects of stubble retention and reduced tillage on crop yield. Crops involved were mungbean, soybean, maize, sesame and cowpea. The experimental design was a split-plot with three replications. The main plots were tillage (disc plough, chisel plough, and no-tillage). However, because of farmer practice, very little stubble was present in the field at the start of the experiments. Sub-plots were the method of weed control (hand weeding with hoe, or in-crop herbicide application).
Table 3. Effect of tillage on the grain yield and gross margin for soybean

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (t/ha)</th>
<th>Gross margin ($US/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-tillage</td>
<td>1.467</td>
<td>$138</td>
</tr>
<tr>
<td>Chisel plough</td>
<td>1.536</td>
<td>$128</td>
</tr>
<tr>
<td>Disc plough</td>
<td>1.465</td>
<td>$74</td>
</tr>
</tbody>
</table>

There was good establishment for all crop species in all tillage treatments, which proved that even with very little ground cover no tillage could establish as good a plant population as tillage minus the expenses of ploughing ($US27-38/ha). However, there was generally more weed growth in the no-till treatments. Tillage, in the absence of crop residues, had no significant effect on soybean grain yield but the gross margin for no-tillage ($138US) was almost double that for the traditional disc plough method ($74US/ha) (Table 3).

Effect of rice-straw mulching

An experiment was carried out in 2005 to determine the effect of applying rice straw to reduce evaporation, increase rainfall infiltration and to reduce soil surface temperature. In other areas of South-East Asia, farmers spread crop residues in the field so as to conserve soil moisture, prevent weed growth and to reduce soil erosion.

A randomized complete block 6*2 factorial design with three replications was used with 6 crops (maize, soybean, mungbean, peanut, sesame and cowpea) and two mulch treatments (+/- 3 t/ha of chopped rice straw). Soybean variety DT-84 was sown at 60 kg/ha in 40 cm rows with hills spaced at 30 cm and 5 seeds per hill.

Table 4. Effect of rice straw mulch on the biomass and yield of soybean

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Biomass (t/ha)</th>
<th>Grain yield (t/ha)</th>
<th>Gross margin ($US/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil mulch</td>
<td>7.07</td>
<td>0.59</td>
<td>-$98</td>
</tr>
<tr>
<td>Plus mulch</td>
<td>7.79</td>
<td>1.39</td>
<td>$11</td>
</tr>
<tr>
<td>Significance</td>
<td>ns</td>
<td>P&gt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

The application of rice straw mulch did not significantly affect biomass production of soybean but the grain yield was increased by 136% (Table 4) and the gross margin was increased by $105/ha. Considerable effort is warranted to encourage Cambodian farmers to preserve crop residues and to reduce tillage. The retention of crop residues or application of straw mulch could result in reduced crop failures due to drought, increased yields and cash income.

Conclusions

Although the area of soybean cultivation is rapidly expanding in Cambodia, average grain yield is around 1.3 t/ha and does not appear to be increasing. It is estimated that the yield potential of soybeans under rainfed upland conditions in Cambodia is around 3 t/ha.

The main factors contributing to low yields are: lack of suitable photoperiod-insensitive early varieties; impact of insect pests, diseases and weed competition; poor nutrition; and lack of effective rhizobial strains.

Excessive tillage and removal of crop residues increase evaporation, reduce rainfall infiltration and increase the impact of drought and risk of yield loss and crop failure of soybeans in...
Cambodia. The cost of cultivation also reduces the gross margin. Through on farm trials and demonstrations ACIAR project ASEM2000/109 has proven that Cambodian farmers could implement a few simple key changes to their farming practices which would in turn significantly increase their sustainability and profitability, such as the implementation of no tillage, mulching and retaining crop residues. The next phase of this project is focused on extending these key results to a wider group of upland Cambodian farmers through on farm demonstrations of improved technology packages.

Acknowledgements

We are thankful for the financial support provided by the Australian Centre for International Agricultural Research (ACIAR), the Royal Government of Cambodia and the New South Wales Department of Primary Industries.

References


Why Bother with IPM?

Geoffrey and Maureen McCarthy1

1 Cane and grain growers, 14 McCarthy’s Road, Childers. maureenmc_1@hotmail.com

Abstract

This paper tracks the personal experiences of cane growers, Geoff & Maureen McCarthy from a sugarcane monoculture to a legume break crop rotation with cane and their experience in using IPM for insect management in soybeans.

Introduction

Five years ago we realized our farming enterprise was losing money and unless we acted quickly we would possibly go broke. Plant cane crops were unimpressive and ratoons failed to thrive requiring early replanting: a vicious cycle. Sugar prices were dreadful and costs continued to rise. After reading through all the old BSES Quarterly Bulletin articles on yield decline we decided to give soys a go on 12 hectares. We had heard about green vegie bugs (GVB) and some other pests but the odd look amongst the soys while changing irrigators didn’t seem to find any and anyhow you could send them off for oil, couldn’t you?

Methods and Materials

We did spray once late in our first crop when my neighbour alerted me that his block was a crawling mass of GVB – they were all over his irrigator and hose etc and he was getting a crop duster in - but the damage was already done. We managed full fat quality for most but there were some I was ashamed to send to market.

We resolved that next year we had to do a lot better! We enlisted the help of DPI&F entomologist, Hugh Brier and agronomist Matt Leighton. Meantime we purchased a run down cane farm next door which had to be spelled due to ratoon stunting disease (RSD) which we did not want to spread to our existing property. Our area of soys grew from 12ha to 40 ha. We needed income from the new farm to finance repayments and costs of replanting to cane. Our eyes were on the edible market and minimizing our spray costs.

To achieve this, IPM is the only way to go. You must know what pest is in your crop before you select a pesticide to target it anyway so monitoring is essential. By monitoring systematically and recording findings it is relatively easy to decide when a threshold is approaching, when to spray and with what.

Sowing to flowering we watch for heliothis and loopers – hint: crows don’t stand around in groups in young crops for no good reason – go and look at why they are there!

We work as a team. Maureen does two bug checks a week from just prior to flowering; one check of every 3 hectare paddock. About five shakes of a beat cloth in each site – minimum one location/3ha. The second weekly check is less intensive but she goes to different areas of the block each time so a broadly sampled area is covered and a good picture can emerge of what
pests are where and if numbers are increasing. You will encounter wide variability in numbers in any one paddock.

Don’t ever underestimate the heliothis grub! He is very destructive and will happily eat young growing tips, flowers, chew through young pods and eat all your developing seeds if left unchecked – ultimately eating your profits! We have had remarkably good results using the heliothis virus (Gemstar or Vivus Gold) by targeting small larvae in soys.

Flowering and pod fill we watch mainly for heliothis, GVB and cluster caterpillar, red banded shield bug and especially brown bean bugs (BBB) which are difficult to detect. Large BBB adults are very mobile and show a reddish flash as they fly away and small nymphs look similar to ants but have no mouth pincers. We monitor good bugs also as their interaction is an important part of IPM.

NOTE: White fly have not been a problem on our property since the first crop.

Maureen records her findings and when hot spots of nymphs are discovered these areas are marked and revisited next time to monitor numbers as predator beneficiaries will often wipe out a lot of these.

I calculate the numbers of pod suckers in GVB adult equivalents and when thresholds are exceeded, spray accordingly with registered chemicals only and at recommended rates with good spray gear and record everything in a spray record book.

This ensures I only use the minimal amount of chemical to achieve good results. Costs are minimized and returns maximized – environmental impact also is minimal.

Early in 2006 Maureen signed up for the Women in Sugar Bug checking Workshop funded by SRDC in Childers. Experts from DPI&F and BSES took participants through various aspects of IPM, they learnt about good and bad bugs; how to identify and monitor; control them if necessary or just let nature take its course.

DPI & F entomologist, Hugh Brier just loves sharing his knowledge and love of bugs with others and his enthusiasm is catching! Getting their hands dirty in the paddock on Day 2 was a great way to test how much they’d absorbed the day before. They used beat sheets to find what was lurking in the bushes, recorded what they found and went home a lot more confident to scout effectively in their own paddocks. Bug checking really does get to be quite an interesting and fascinating pastime, yes it does take time but if you want to do it well it is very rewarding and satisfying. There’s another world out there just waiting to be discovered!

A couple of years ago Maureen took the scissors to the DPI publication ‘Insects – What Soybean insect is that?’ Although it is a very handy reference with lots of useful information it was difficult to use in the paddock so she cut out most of the pictures and rearranged them into their lifecycle stages with good and bad bugs in their own section. With funding from Landcare and help from CANEGROWERS ISIS staff this was later developed into ‘The Bug Book’, a laminated field guide which was distributed to participants at both the Bundaberg and Childers Bug checking Workshops.
Results and Achievements

All of our beans achieved edible quality the last two seasons and some were even exported to Japan. IPM really does work!

Added to this the new farm is now our highest producing block with no nitrogen fertilizer top dress applied to plant crops – a reduction of 150kg/ha N or 325kg/ha urea fertilizer thus reduced costs! In fact this farm topped productivity figures for our region of the Isis mill area last season.

I attribute this to the reduction in lesion nematode numbers by growing soys and breaking the life cycle of these and other cane pathogens eg pachemetra fungi – still more IPM benefits!

Conclusions

- Legume break crops have increased overall cane production on our property
- Soys managed well under IPM can yield over 4t/ha of edible quality beans
- IPM done properly minimizes chemical costs and maximizes profit
- Reduced costs for plant cane production – free nitrogen!
- Reduced bare fallow costs – mostly converted to production costs of soys
- Better weed control in fallows and following cane crops
- Farm viability/profitability greatly increased under new system
- New soy varieties should be evaluated for their susceptibility to pests
- New chemicals need to be independently evaluated (eg by DPI&F) to ensure reliable pest control and to assess their impact on our beneficial insects and their IPM fit.
- Need for continued IPM research into the biological control of soy pests.

Crops now work for us instead of us working for them!
The Role of Independent Associations in the Australian Soybean Industry

Greg Mills, Qld DPI&F Kingaroy

The Australian soybean industry is relatively small and extremely diverse, ranging across a wide range of production systems and end uses. Soybean production is a very important component of local farming systems providing an important rotational crop and diversity of cropping options in both dryland and irrigated farming systems. At the same time soybeans are important in a range of domestic and export markets underpinned by local oilseed production for the domestic crushers, high quality feeds for the livestock and poultry industries, and high quality culinary quality markets serving bakeries, soymilk and Asian food production. The Australian industry also remains free of genetically modified varieties and has an important organic production component.

The current industry size, diversity and end uses create inherent problems that are not easily addressed by individuals or agribusiness entities associated with local production regions. Nor are they easily addressed by the limited overall research and development investment that occurs via the private and public sectors. The industry also encounters problems with the limitations imposed by access to germplasm and the largely public availability of the current commercial varieties. There is a relatively large array of varieties available which are difficult to maintain and supply to the industry. Constraints on variety development and adoption can be hindered by a lack of private investment.

The Australian soybean industry is fortunate to have three important regional associations and the over-arching Australian Oilseeds Federation to help reduce the impacts of these barriers to industry development and investment. Regional associations are reaping the increasing benefits of improved communication, prioritisation of issues, assisting with investment in problem solving, crop protection, agronomic development, quality control, and variety development and adoption. Industry support associations have an increasingly important role and can do even more to help the outcomes for producers and end users as well as drive further industry growth. This is strongly reflected in areas of agronomic improvement and market performance where local activities reflect strong industry participation, support from agribusiness and state primary industries departments and wide producer representation working through the alliance provided by industry associations. This paper explores the current status and role of industry associations and their potential to help sustain and improve outcomes for producers, processors and end users of soybeans.
Improving soybean varieties for coastal farming systems

Moore, N.Y.1, Rose, I.A.2 and James, A.T.3

1 NSW Department of Primary Industries, Trenayr Rd, Grafton NSW 2460
2 NSW Department of Primary Industries, Wee Waa Rd, Narrabri NSW 2390
3 CSIRO Division of Plant Industries, 306 Carmody Rd, St Lucia Qld 4072

Abstract

This paper describes research into breeding and evaluation of new varieties of soybean to suit the environment and farming systems of coastal northern New South Wales. Data will be presented to show developments in new material for maturity, yield, seed size, grain quality, protein, oil, and weathering tolerance.

Soybean is an integral component of a diverse range of organic and conventional coastal farming systems in northern NSW. Some of the particular needs of the soybean phase in beef, dairy, sugar cane, and winter cereal production systems will be covered.

Introduction

The New South Wales Department of Primary Industries (NSW DPI) research station at Grafton in northern NSW has been an important centre for coastal evaluation of breeding lines and new varieties of soybean since the late 1980’s. Varieties that have been released from Grafton based on desirable production qualities and adaptation to the coastal environment of NSW include Manta (1991), Zeus and Poseidon (1999), Cowrie (2002) (all bred by Dr Ian Rose, NSW DPI Narrabri and evaluated by Mr Peter Desborough, NSW DPI Grafton), and Surf (2004) (P. Desborough).

Over the past decade the market for Australian soybeans has expanded from mostly crushing grade beans for oil and animal feed to also include culinary grade soybeans suitable for human consumption. Accordingly soybean breeding efforts in Australia have concentrated on producing varieties with desirable traits that will enable growers to expand into higher-value human consumption markets whilst also supplying the crushing and feed markets (see paper by James in these proceedings).

Germplasm from the Australian soybean breeding programs based at NSW Department of Primary Industries at Narrabri, NSW and CSIRO at Brisbane, Queensland (Qld) is evaluated at Grafton as part of the ‘National Soybean Improvement Program’. This program is funded by grower levies, the Grains Research and Development Corporation (GRDC), CSIRO, NSW DPI and Qld DPI.

The primary aim of the National Soybean Improvement Program is to provide soybean growers with improved varieties of soybean to enable wider market access and to enable more reliable and robust soybean production across a range of production environments.

Soybean breeding material is assessed for its ability to satisfy the requirements of new and existing markets and for improved agronomic traits. Grain quality characteristics desired by human consumption markets include a colourless hilum (in order to produce soy products with a clean pale colour), high total protein content, large pale-coloured seed, and other functional traits for suitability to soymilk, tofu and flour production.
Critical agronomic traits include yield potential, height, resistance to lodging, disease resistance and weathering tolerance (the ability for ripe pods to withstand rain at harvest time). Maturity is also critical in the selection of varieties for this region where the optimum planting window for soybean extends from late November to the end of January. Different varieties are needed to suit this range of planting times. Tolerance to acid soils and manganese toxicity are also important for many of the production areas of coastal NSW.

**Coastal farming systems**

Due to relatively reliable rainfall and increasing numbers of soybean growers, the North Coast region of NSW has become the largest single soybean producing region in Australia. As prolonged drought conditions in much of NSW and Qld continue, more buyers from other regions are seeking grain from the North Coast to maintain supply.

In this region soybean is produced in a diverse range of coastal farming systems including sugar cane, winter and summer grain production, and beef and dairy grazing systems. Varieties assessed at Grafton are evaluated with the needs of coastal farming systems as well as the coastal environment in mind.

New varieties must fit the wide range of planting windows in this region (end of November to early February). As most of the coastal farming systems are rain-fed, many growers wait for rainfall to plant the summer crop and may, therefore, only require early season varieties in some but not all seasons. In other seasons rainfall occurs at or after the end of December and in some areas not until late January.

**Sugar cane**

The range of benefits to sugar cane from a soybean rotation is well known and around 75% of cane growers in this region have adopted a soybean phase as a regular part of their cane operation. The three mill areas on the North Coast of NSW (Condong, Broadwater and Harwood) have a total Productive Area Entitlement of around 36 500 ha, which is managed by about 645 growers (R. Aitken, pers. comm.).

Sugar cane harvesting is carried out according to a schedule whereby individual fields of cane on each farm are harvested at different times throughout the season, with the schedule changing completely in the following season. Due to harvesting operations, wet weather and land preparation, many cane growers are not able to plant early season varieties and require varieties suited to later planting times (mid to late January up to early February).

Some sugar cane growers in the North Coast region are converting cane fields to a minimum tillage, raised bed system where dual row cane is rotated with 3 or 4 rows of soybean. In some cases GPS-guidance and permanently formed beds are also being incorporated to reduce soil compaction. Soybean is an important component of this farming system (refer to paper by A. Garside in these proceedings).

**Winter cereal**

The soybean – winter cereal rotation is a popular minimum tillage system in this region. Winter cereals such as barley, triticale, wheat and oats are planted into soybean stubble to conserve soil moisture and make immediate use of nitrogen residues from the soybean crop. Growers who produce soybeans in this double cropping system need a choice of varieties to enable early, mid
or late season planting of soybean depending on the completion of the winter crop. Recent barley and triticale variety development work is aiming for early maturing varieties for the NSW North Coast to enable harvest of the winter crop in sufficient time for planting soybean into the cereal stubble.

**Beef, dairy and sheep production**

The benefits of a soybean phase to improve beef and dairy grazing pastures is well known eg. the ‘Beef n Beans’ program promoted by NSW DPI. The soybean phase may not be taken through to grain harvest. Robust varieties with good vegetative growth are preferred. At the end of the soybean phase seed of pasture species or forage crops is often flown into the senescing soybean crop to conserve soil moisture, make immediate use of nitrogen residues and to ensure that the pasture is developed as soon as possible to maximise winter and spring feed.

Soybean is popular for silage production in this region and varieties with smaller stems and petioles (eg. A6785) are preferred for this use. Large woody stems are not as palatable to cattle.

Soybean hay is also popular, particularly for use in sheep production on the nearby tableland areas. Varieties with good vegetative growth and finer petioles and stems are also preferred, particularly where round-bales are covered with plastic wrapping.

**Materials and Methods**

**Field evaluation trials conducted at Grafton**

Each season small amounts of seed of new lines are received from NSW DPI and CSIRO soybean breeders for evaluation in the ‘Line Trial’. Some lines are potential new varieties and others are used in breeding program for the introduction of new traits. The ‘Line Trial’ is planted in mid December. Lines that have performed well in previous seasons are advanced to larger scale replicated field trials known as the ‘Variety Trials’. The Variety Trials are planted at an early sowing date (first week of December) and a late sowing date (second week of January) each year with four field replicates of each.

**Field assessment sites and production regime**

The field trials at the Grafton research station are conducted on secure, hare-proofed field sites with a known history of management. The trials are maintained according to industry best practice management guidelines for inoculation, sowing, nutrition, insect pest and weed management. Minimum tillage practices and a direct-drill seeder are used. Care is taken in harvesting the trials at the optimum maturity and to obtain good quality grain. Grain samples are cleaned and stored in a de-humidified cold room until analyses are complete. The soybean field trial areas are in rotation with winter cereals every year and with grazing pasture every four years. Irrigation is used as required to minimise drought stress on the trials and to reduce seasonal variation as much as possible between seasons. A plant population of 363 000 plants/hectare is targeted.

**Industry standard varieties for comparison**

The following table (Table 1) describes the current commercial varieties that are included in the trials as industry standards and the reasons for their inclusion. Note the particular deficiencies or risk factors inherent in each of the current commercial varieties.
Table 1. Industry standard soybean varieties included in field evaluation trials for comparison with breeding lines and potential new varieties at NSW DPI, Grafton.

<table>
<thead>
<tr>
<th>Early season varieties</th>
<th>Reason for inclusion in trials and varietal characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowrie</td>
<td>Cowrie is adapted to the coastal rain-grown and northern inland production areas of NSW and is amongst the earliest sown varieties in the region. It has a clear (colourless) hilum, large pale-coloured seed and good protein levels. Cowrie requires good management to reach its yield potential, which is below that of Manta and Poseidon. It does not have as high weathering tolerance as Zeus, but as the first clear hilum variety released for the North Coast, it has enabled growers to access new human consumption markets.</td>
</tr>
<tr>
<td>Soya 791</td>
<td>Soya 791 has been grown in the region for many years. It has a buff (tan/brown) coloured hilum and is therefore not a ‘white-eye’ variety. It has smaller seed size than Cowrie but yields well if planted at the optimum sowing time. It is susceptible to <em>Sclerotinia</em> fungus and manganese toxicity and has similar weathering tolerance to Cowrie.</td>
</tr>
<tr>
<td>Zeus</td>
<td>Zeus has the highest weathering tolerance of any of the current commercially available varieties in this region and is included in all trials as a benchmark for that trait. It has a dark (black) coloured hilum, which makes it suitable only for crushing markets. It has good levels of tolerance to <em>Sclerotinia</em> but not downy mildew.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mid-Late season varieties</th>
<th>Reason for inclusion in trials and varietal characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manta</td>
<td>Manta is a well known variety in coastal NSW. It yields well, is suited to mid season planting dates (mid-late December) and has tolerance to manganese and <em>Sclerotinia</em>. It has a dark hilum, which makes it suitable only for crushing markets, and reasonably high weathering tolerance.</td>
</tr>
<tr>
<td>Poseidon</td>
<td>Poseidon has similar traits to Manta but was released as a higher yielding replacement for Manta.</td>
</tr>
<tr>
<td>Surf</td>
<td>Surf was the second clear hilum variety released for this region and is suited to a later planting date (mid December-mid January). It has large pale-coloured seed and good protein levels but weathering tolerance is not as high as Zeus.</td>
</tr>
<tr>
<td>A6785</td>
<td>This variety is well known in coastal NSW and is suited to a mid to late season planting date (end December to mid January). It has the smallest seed of all the currently available varieties in the region and has a dark brown coloured hilum, which makes it suitable only for crushing markets although it is occasionally used by the human consumption market when preferred varieties are not available. It is popular for the production of silage as it has finer stems and petioles than current varieties, particularly when the planting density is increased. If planted too early or at too high a plant density lodging can be a problem with A6785.</td>
</tr>
<tr>
<td>Warrigal</td>
<td>Warrigal has very poor weathering tolerance which makes it a high risk choice for coastal environments where rain at harvest is likely. It is also highly susceptible to manganese toxicity and <em>Sclerotinia</em>. However, it can yield well at a late planting date in this region and is included in late planted evaluation trials for this reason. It has large pale coloured seed with a clear hilum.</td>
</tr>
</tbody>
</table>
Data collected

Field assessments

Assessments are made to ensure good germination of the seed in each plot. Many measurements are made on the plants in the field throughout the growing season including: plant population counts (10 data points per plot), plant height (10 data points per plot), flowering time (days to reach 50% flowering), maturity (days to reach P95 stage where 95% of the pods are mature), lodging ratings (two per season) and downy mildew rating. Assessments of tolerance Phytophthora are made by Dr Malcolm Ryley at the Qld DPI&F laboratories in Toowoomba.

Grain assessments

Grain is harvested from the central rows of each plot over a measured length in order to calculate yield. As the grain from each plot is weighed a moisture reading is taken (in order to express yield at 12% moisture) and seed size is assessed (grams per 100 seed at 12% moisture). Samples of grain are sent to a NATA accredited laboratory for oil, protein and moisture analysis. Protein and oil content is assessed using NIR with Dumas combustion method for protein and Soxlet digestion method for oil.

Samples from the best performing lines are also sent to the CSIRO soybean breeding program in Brisbane for soymilk and tofu gelling assessments.

Weathering tolerance assessment

Twenty whole plants are cut by hand at the P95 stage of maturity from each plot of three field replicates. These plants are carefully placed in a dry, rodent-proof room until they are used in the weathering facility located at the research station. The weathering facility simulates constant rainfall conditions with temperatures maintained between 19 and 24°C. In each run three replicates of Zeus (upper benchmark) and Warriga (lower benchmark) are included. Each field replicate of each variety is replicated three times in the weathering facility (i.e. in three different, randomised locations on the benches in each run), increasing the three paddock replicates of each variety to a total of nine replicates of each variety in the weathering room.

The timing of each run is determined by the level of grain damage in Zeus. Most runs take around 5 days and 2 hours in order for the weathering tolerance of Zeus to begin to break down. The plants are then removed, dried and threshed with the grain from each replicate assessed separately. A 50g sample of grain is taken and the amount of weather-damaged and undamaged grain is assessed by hand. This is very labour intensive but has proven to be the most reliable method for assessing weathering tolerance.

Statistical analysis

All data is analysed by Mr Stephen Morris, the biometrician at NSW DPI Wollongbar. Spatial analysis is used to account for variations along and between rows. The planting design is also determined by the biometrician to ensure a randomised planting design that does not disadvantage or advantage any variety over another based on its position in the trial. The data for new varieties is assessed in relation to the performance of known industry standard varieties. In the case of weathering tolerance data, the performance of each new variety is expressed in relation to the performance of Zeus in each weathering run, as Zeus is the current benchmark for weathering tolerance.
Pre-release assessments by growers and manufacturers

Prior to the release of a potential new variety, seed is provided to a number of growers for feedback on its performance in their production system, in particular any weaknesses or shortcomings that are observed. Also, grain of potential new varieties is made available to soymilk and flour manufacturers for feedback on the performance in relation to currently available varieties.

Results and Discussion

2005-2006 Data summary

The following is a summary of results from recent variety evaluation trials conducted at Grafton.

Breeding Line Trial

Eighty four new lines (43 NSW DPI + 41 CSIRO) were assessed against the early season industry standard varieties Cowrie, Soya 791 and Zeus (96 plots x 2 replicates) in 2005-2006. Assessments were made on lodging, downy mildew, maturity (P95), yield, seed size, protein, oil, and weathering tolerance. On the basis of performance across these traits, 15 of these new breeding lines were advanced to the Early and Late planted Variety Trials currently underway at Grafton (planted on the 6th of December 2006 and the 10th of January 2007).

This season (2006-2007) a further 122 new lines from the NSW DPI and CSIRO breeding programs were included in the breeding line trial at Grafton (planted on the 13th of January 2007).

Early Variety Trial

The Early Variety Trial (planted 7th December 2005) included nine industry standards and 15 potential new varieties advanced from trials in previous seasons. Of the 15 potential new varieties tested, seven were within acceptable ranges for early planting for maturity (120-130 days); seed size (20-23g/100 seed at 12% moisture); plant height (80-100cm) and protein level (greater than 40%).

Five of these varieties produced acceptable yields that were greater than Cowrie (3.9 t/ha) and between that of Soya 791 (4.4 t/ha) and Poseidon (4.8 t/ha).

Of these five lines, only three (98053-3, WAM 214 and NF246-64) showed levels of weathering tolerance superior to that of Cowrie and Soya 791. None showed weathering tolerance as high as that of Zeus, but the clear hilum lines that are being developed in the breeding programs are closing that gap. Until the data from current trials is assessed, 98053-3, WAM 214 and NF246-64 lead the early season evaluation trials with their combination of traits and improvements over the current varieties.

Late Variety Trial

The Late Variety Trial (planted 12th January 2006) included seven industry standards and 17 potential new varieties. Of the 17 potential new varieties tested, seven were within acceptable ranges for late planting for maturity (107-113 days); plant height (70-90cm), and protein level (greater than 40%). These seven lines also produced yields in the range of 3.5 to 4.0 t/ha at 12%
moisture compared with Warrigal (3.8 t/ha), Poseidon and Surf (4.0 t/ha) and A6785 (4.1 t/ha). Line PR443 exceeded this range to top the yields with 4.3 t/ha.

Of these seven potential new varieties, six maintained seed size in the targeted range of 20-23g/100 seed at 12% moisture.

Of these, four lines (PR443, 99028-12, NF245-12, and 99069-23) showed levels of weathering tolerance superior to that of Surf and nearing that of Zeus. This is encouraging evidence that the clear hilum lines being advanced through the breeding programs are improving this trait in clear hilum varieties compared with the first clear hilum material. Until data from the current trials is assessed, PR443, 99028-12, NF245-12, and 99069-23 lead the late season evaluation trials based on their combination of traits and improvements over the current varieties.

It is interesting to note the performance of the variety Bunya that was recently released for the Darling Downs region. Bunya was included in the Late Variety Trials at Grafton for the first time in 2005-2006. It yielded very well (4.2 t/ha at 12% moisture) and produced good plant height (73cm) and large seed (24g/100 seed at 12% moisture). However, it only just achieved the 40% protein level compared to Surf (42%). Weathering tolerance was acceptable and higher than that of Surf but not as high as Zeus. Bunya has been included in the 2006-2007 Late Variety Trial for further evaluation.

Conclusions

Early season varieties

The CSIRO bred line 98053-3 and the NSW DPI bred line WAM 214 have consistently been the best performers in early planted variety trials over a number of seasons and possess a good combination of traits. 98053-3 has been advanced to seed increase at Grafton pending potential release. It was also planted on two properties on the North Coast this season for feedback from growers. 98053-3 has attractive looking round seed with a shiny seed coat.

WAM 214 is currently in Dr Andrew James’ backcrossing program to produce a clear hilum (WAM 214 has a buff coloured hilum) and will be returned to the evaluation trials and seed increase next season.

NF246-64 has been included in both the late and early planted variety trials at Grafton this season. This is only the second season in which this variety has been assessed in large scale trials and more data is needed to thoroughly evaluate its performance.

Late season varieties

Better clear hilum varieties for late planting dates are needed for this region. Potential new varieties that have performed well in recent late planted variety trials include PR443, 99028-13 and NF245-12. These lines are included in the variety trials currently underway at Grafton along with material that has been advanced from other trials.

Seed of five potential new varieties has been sent to Dr Ian Rose for evaluation at inland NSW sites (Narrabri and Breeza). This material does not necessarily have high weathering tolerance but was considered acceptable or superior in other traits.
Advances are being made by the National Soybean Improvement Program to develop and deliver improved soybean varieties for coastal production areas.

Acknowledgements

The authors gratefully acknowledge Mr Graeme Doust and Mr Bernard Makings (NSW DPI Grafton) for technical assistance in field work and grain quality assessments, Mr Stephen Morris (NSW DPI Wollongbar) for statistical analysis of data, and Dr Malcolm Ryley (QDPI&F Toowoomba) for plant pathology assessments. Funding for this work is provided through the National Soybean Improvement Program, a GRDC and industry funded collaborative program between CSIRO, NSW Department of Primary Industries, and the Queensland Department of Primary Industries and Fisheries.
Soybeans in the Northern Territory

Vernon C.E Nicolle

Energy Crops Australia, P.O Box 1655, Margaret River WA 6285

Introduction

My name is Vernon Nicolle, and I am an ex Zimbabwean. I was born in 1944, and am from farming stock. My father moved to the north of the country in the 1930’s, settling in the then small farming community near the town of Banket. In the early 1960’s as a young man I grew up with Soybeans, and remember well the problems encountered trying to master the growing of the crop. In those early days one looked at the beans, and wondered what we were trying to achieve. It was not long before they were named ‘SORRY BEANS’. The pods were close to the ground, and when the beans matured, you looked at them and they shattered.

The research department of the Seed Company developed some improved varieties over the years, and I was lucky to be part of it. We have progressed a long way since then, and I have been involved in the industry ever since. My farm was under irrigation, and I cropped 2000 Hectares in summer – wet – and 1600 Hectares in winter under irrigation. Crops grown were maize, soybean, wheat and seed crops.

I was awarded the Soybean Oscar and grower of the year in 1988. My wife and I came to Australia in July 2003, and on the 21st of February 2007 we became Australian Citizens.

The Northern Territory

As you are all aware there was no Soybean industry in the top end. In fact there is little to no information on Soybeans full stop.

Thanks to a friend, I met the promoters and owners of the Biodiesel facility in Darwin. The Company is Natural Fuel Australia Limited, and the plant is the first in Australia to produce Biodiesel to Army Specs. We talked Soybean and in May last year we came and had our first look at the Territory. To say I was impressed is an understatement. To this day I still can’t believe there are places like this left undeveloped here in Australia.

Two weeks were spent meeting people, and numerous meetings were held with Government Officials. We collected as much information as we could find and returned to Western Australia. On our return we met with the directors of Natural Fuels. Our answer was quite simple, YES, We can grow Soybeans in the top end. Having opened my mouth I returned to the N. T. and grew some Soybeans in the dry under irrigation. I only planted the beans in August, but the results achieved were encouraging.

Energy Crops Australia Pty Ltd

The company was formed in July 2006. The company is Agro based, Stand alone, and contracted to Natural Fuel Australia to grow OIL, OIL, and OIL. The Biodiesel plant in Darwin uses mainly Palm Oil from the north. It would seem logical to produce our own feed stock of oil here in Australia.
We were told that we could not grow Soybean in the WET here in the N.T. Just look around at all the failures. I listed to all the advice given. When I said I was planning to grow Soy in the wet everyone thought I was MAD!! Some still think it will never work. Challenges I love, so here we are. We still have a long way to go, and as all farmers know only too well, it is only a success when the crop is in the bag, and the money is in the bank.

No Industry, No Seed, No Research and Development Etc

So what are our goals and what do we do? Our goal is to produce sufficient oil to feed the Biodiesel plant in Darwin, and should there be any excess, supply their other plants internationally.

To grow Soybeans economically, and at world prices, based on The Chicago Board of Trade.

1. To grow any crop successfully the farmer needs to make a profit.
2. The Biodiesel plant requires its own strategic stock of oil at competitive prices to stabilise production. Furthermore it needs guaranteed regular supplies that cannot be affected by political change and upheaval abroad.
3. By producing oil locally ECA would stabilise the oil supply, and not be subjected dramatically by the vagaries of the world market.

ECA would like to own the crop, and have the farmer produce Soybeans under contract. However there are some farmers who would prefer to produce their own, and sell at world prices on the day. Contracts will be put in place to meet the individual farmer’s needs and aspirations. Some of the many problems facing farmers in the top end in the past have been.

1. Find a market,
2. Distance to the market,
3. Price for their product.

THE FARMER NOW HAS A MARKET FOR THE PRODUCT LOCALLY

Let’s examine what has been achieved so far, and what is achievable. It rains in the N.T. only in the summer months, known as the “wet” and temperatures are HOT and humid. In winter known as the “dry”, conditions are good for growing crops, but we need irrigation. There is an abundance of water that runs out to sea, and good aquifers.

I AM NOT HERE TO DEBATE WATER ISSUES, JUST TO STATE THE OBVIOUS

Soybeans grow well here in the N.T. in the Dry. Trials grown in the Tortilla and Douglas Daly were encouraging. Only two varieties were grown namely Leichhardt and Stuart. Leichhardt being a non determinant variety grew well but would not die off. When it came to harvest we had to kill it off, and sacrifice yield potential. The crop was still encouraging. Stuart did not germinate well, and at Tortilla the wallabies ate it. We did get sufficient data from the Douglas Daly to be satisfied and continue. Weeds were a problem where we were not able to pre irrigate, and kill off the weeds before crop emergence. Hand cleaning was undertaken, but would not be an option once in commercial production. We would expect to grow determinant varieties in the dry, and develop suitable new ones as we progress. Pests were not a major problem, and can be controlled in the dry. To sum up the dry irrigated Soybeans – The crop grew well with good vegetation, good flowering and pod set. From a research point of view I could not have asked for more.
From this cautious start we have now stepped out and planted approximately 500 Hectares in the wet.

*CAUTION IS THE KEY, AND ONLY AS WE PROGRESS WILL WE EXPAND*

It is too early to say how the wet season crop will perform, but you can see some of the pictures on the screen, it looks promising. The crop grows well, and loves the humidity and water. Provided we do not get washed away there is no reason why Soybeans cannot be grown successfully in the wet. We have had the best and the worst weather wise this year, but so far the crop has survived. We had prolonged dry spells in the Douglas Daly, and lost beans on the sandy/gravely soil. The Adelaide River flooded, and the beans on Tortilla went under water, but they survived and are flourishing. Farming is full of challenges, these are some of them.

A Vibrant Soy Industry is achievable, because Soybeans do grow in the Northern Territory. Look at Brazil and Zambia which are on the same latitude and grow excellent Soybeans. My experience tells me no two farms are the same, and likewise all farmers like to farm their way. However there are fundamental principals to growing good Soybeans and the N.T. will be no different. The industry will grow faster than even I think is possible, provided we can crank up and get suitable varieties for the N.T. Once we get to grips with local issues farmers will produce excellent crops. My information tells me farmers are getting good crops here in the East.

*Agronomic problems*

There were pests during the dry, and the only major ones were pod suckers. We sprayed the crop once and controlled them. Multiple spraying might become necessary as the industry develops.

Weeds are a problem on paddocks that have been in production for some time. Here farming is built around the cattle industry, and legumes are grown. So far the weed that gave me the biggest problem was SENNA – sickelpod. However as we progress we will find ways around difficult weeds. Shielded spraying is an option in the short term, and if one is able to pre irrigate Glyphosate does an excellent job. Furthermore, rotations will be needed as one cannot grow mono culture Soybeans for ever.

Farming in the wet will have many additional challenges, but so far they are similar to the dry. The caterpillars died from the air born virus, but the pod suckers will need to be sprayed. We will also need to spray the crop out before harvesting, as there are many little weeds lurking under the canopy and waiting for the crop to mature and dry off. No doubt there will be many more hidden problems as we progress.

*Logistical Problems*

It is not hard to believe that the N.T. is a long way from nowhere. Everything costs a lot more, and this is why there is no real Agro Industry. Thus in the top end everything costs more, and takes time. Once we crank up, prices and service will become more competitive. The infrastructure of roads, telecommunication etc., while being satisfactory will need to be upgraded as development takes place. Out in the bush you need a sat phone, but you can get one and it works. We do live in a first world country, but with many third world short comings. Consequently we can get everything we need, but it all takes time, planning and costs more than
Electricity which is fundamental to development is seldom available. Diesel generators are the order of the day. There is no fertiliser industry as we know it.

ECA will encourage development and improvement in all sectors, and should the need arise we will get involved to make it happen, and become more efficient. If we are to produce and be competitive on the world market, there is no reason for the farmer to have to pay more just because we are farming in the N.T.

Challenges and problems

We all see challenges and problems differently and there will always be those who don’t believe growing Soybeans in the top end is possible. I am continuously reminded of all the failures, and that crops cannot be grown in the wet. I have heard it all before, but keep saying to myself how come Brazil exports in excess of 20 Million tonnes? There is a lot of pressure on farmers to move north, but I am not sure how it will work.

- I do not see any Northern Territory Government Agricultural policy.
- Land there is plenty, to get it, and then be allowed to farm it on a broad acre basis is a challenge.
- Water there is plenty, to be able to harness it and use it is a challenge.
- Electricity is another challenge.
- Communications are good for main roads, but get off them, and they go from adequate to none, another challenge.
- Telephones are adequate on station, but get out in the paddocks, there is no mobile coverage, unless you have a sat phone.
- Weeds, there are plenty
- Pests are for ever present
- The N.T. Ag department is well staffed and helpful, but lacks information, and indeed access to suitable Soybean varieties. – There has not been the demand.
- Without being controversial, some of the laws governing the use of chemicals in the N.T. are very different to what we are accustomed to in the rest of Australia.

These problems and many more are only CHALLENGES. There is nothing that cannot be solved given good will and time. The farmers challenge is to be able to adapt to the different growing conditions of the N.T. and then to be able to grow the crop and get the yield. There is only a very short window of opportunity to get in and plant ones crop in the wet, and timing is critical. The fact is everything grows well in the N.T.

Oil Extraction and Protein

Once we get to our minimum critical mass, an oil extraction plant will be built which will be in modular form. It will have the design to add on additional units as we grow. The Soybean industry will compliment the cattle industry with it’s by products. The high quality protein cake will benefit the cattle industry, because Australia is a net importer of protein. There is no reason why all this cannot be achieved in the Northern Territory.
Building IPM capacity for Soybean Break Crops in the Bundaberg/Isis Regions of Coastal Queensland

Jenny Rule¹, Dianne Bush¹, Coral Zunker¹, Sandra Webb² and Angela Williams³

¹ Women in Sugar Bundaberg, C/- CANEGROWERS, PO Box 953, Bundaberg Q4670.
³ Sugar Executive Officer, Wide Bay Burnett Area Consultative Committee, PO Box 1000, Bundaberg Q4670.

Abstract

In early 2006, Women in Sugar organised two IPM workshops at Bundaberg and Childers. We took this IPM initiative to improve the profitability and sustainability of our cane farming system, by maximising the productivity of our soybean break crops. IPM training was identified as a priority as insect damage and poor pest management were seen as threats to break crop productivity. The group recognised that it needed to upgrade its insect management skills, and saw IPM training as an opportunity to address another major IPM problem, namely ‘a shortage of local labour to implement IPM’. In essence we wanted to differentiate between the good and the bad bugs and to better manage the latter in our soybeans with a minimum of pesticides. The IPM workshops have greatly boosted our confidence in all aspects of farm management in general, and in pest management in particular. A measure of the course’s success has been the greatly improved soybean seed quality in the 2005/06 crop, with the majority of crops meeting ‘edible’ standards. The workshops would not have be possible without project funding secured from SRDC by Angela Williams (Sugar Executive Officer, Wide Bay Consultative Committee), the provision of workshop venues by Cane Growers, and the technical expertise of DPI&F and BSES scientists, as well as the enthusiastic participation of our members.

Introduction – Coral/Jenny

Women in Sugar took this Integrated Pest Management (IPM) initiative to improve the profitability and sustainability of our sugar farming system, by maximising the productivity of our soybean break crops. We wanted to maximise not only soybean’s rotational benefits, but also to maximise the cash returns from their harvested grain, in order to make all our extra effort worth while. Our interest in IPM was heightened by a SRDC-funded IPM study trip to the Cotton Cooperative Research Centre at Narrabri, NSW.

Many farmers in our vicinity were growing soybeans but simply “flying by the seat of their pants”, spraying when they believed it necessary but not really basing this practice on any solid evidence. IPM training was therefore identified as a priority as insect damage and poor pest management were seen as threats to break crop productivity. We recognised we needed to upgrade our insect management skills

We also saw IPM training as an opportunity to address another major farm management problem, namely the shortage of local labour to implement and champion IPM. As farming enterprises lose employees, the workload on family members becomes more intense and therefore more and more women are taking up the challenge of taking on farm work and filling the void created by workers moving into these other industries.

In essence our IPM objectives were to better understand the crop, to differentiate between the good bugs and the bad bugs and between cosmetic and serious damage, and to manage our pests
with a minimum of toxic pesticides, and (importantly), with a minimum of cost, while at the same time maximising crop returns.

**Strategy/Methods – Coral/Jenny**

Women in Sugar determined that the best method of gaining practical knowledge of IPM practices was to run two workshops in both the Bundaberg and Isis districts using soybean break crops as a case study. The aim of these courses was to build the IPM skills of 50 industry personnel (with at least 25 women) in our region. The knowledge gained would be extended to other canegrowers through productivity groups and communication opportunities.

After planning meetings with DPI&F scientists Hugh Brier, Austin McLennan and Andrew Dougall, the course format agreed on followed that used for the successful ‘Accredited Mungbean Agronomist’ courses developed by DPI&F. Each course was broken up into two sections. The one-day theory component addressed such topics as basic soybean agronomy, common pests in coastal break crops, insect identification, monitoring and thresholds, plus chemical intervention options. The second component consisted of two half-day field courses, the first immediately after the theory, the 2nd field course one month later. To ensure a broad farming systems perspective, the courses discussed pests common to soybeans and horticultural pests (input from Ian Kay, DPI&F), and cane grub management in break crops (Keith Chandler, BSES). Hugh Brier, Austin McLennan and Andrew Dougall,

Funding for the workshops (course preparation, course materials, catering, transport etc) was secured from SRDC, with invaluable assistance from Angela Williams (Sugar Executive Officer, Bundaberg) who wrote the workshop project proposal. Course venues and insurance were provided by CANEGROWERS at Bundaberg and Isis.

**The Courses – from a Participant’s Perspective - Jenny**

The theory component of the course was intense with a huge amount of information being presented to a group with varying amounts of prior knowledge. While extremely informative, the course material was heavy to absorb in such a short time. However the course ‘heaviness’ was offset by the light-hearted and extensively illustrated delivery by the DPI&F presenters (the bug busters). Participants were provided with a comprehensive (85-page) ‘Pulse Break Crop IPM Reference Manual’, and the lectures were broken up with exercises and group discussions. The practical component, which followed later, was extremely beneficial and allowed us to put the theory into practice, including sampling with a beat sheet, and identifying key pest and beneficial insects. Everything fell into place so to speak.

Specific aspects and messages of the course that ‘stood out’ included the differences between immature and adult insects, similarities between many pest and beneficial insects, soybean’s tolerance to pest attack during the earlier stages of crop development, the importance of thorough insect sampling with beat sheets, the risk of creating pest problems with ‘hard’ non-selective pesticides, and the value of pest thresholds in rationalising pesticide use and costs. In the field we were able to match the insects we saw under our magnifying glasses, with the images in our manual, and felt more confident in making management decisions based on our bug counts, the crop stage, and the risk of damage or lack thereof.
Pre and Post Course Evaluation Results - Angela

Pre and post course evaluation surveys were used to measure a change in knowledge of workshop participants in IPM practices and determine if the workshop program delivered the projected outcomes of the project. Specialist presenters were also surveyed post course to determine the effectiveness of the project.

Forty-five people, predominately growers, participated in the workshop program (59% from Isis, 41% from Bundaberg). Pre-evaluation surveys indicate that 46% viewed themselves as unprepared to manage insects, 32% with average or moderate preparedness and only 22% were well prepared. This indicated a training need or gap, which this short course attempted to fill. Post survey results showed 94% of respondents indicating a moderate to large improvement in managing insects since the pre-course assessment.

The post evaluation showed that 75% of respondents thought that the IPM course helped them a great deal and a further 19% indicating a moderate improvement in managing insects in their break crop. All respondents indicated they had referenced their IPM manuals, the most referenced sections being insect identification and biology (75%) and pest thresholds (56%).

Specific areas where ongoing assistance is required (as indicated by >50% of respondents) include; insecticides (types and timing of – 69%), pest and beneficial insect identification (63%), and pulse break crop agronomy (53%).

Post Course Outcomes and Observations - Sandra

It has become widely recognised in the Isis and Bundaberg districts that women are now much more actively involved in farming enterprises. Many of the participants from the IPM workshops have gone on to utilise and incorporate their newly acquired knowledge of pest management into their farming practices. Many who have not, or do not currently grow soybeans, are transferring their knowledge of pest management to other break crops such as industrial hemp and peanuts, and also into general small crop production. Some are practicing their skills by bug checking on other people’s farms. Others, whilst not growing soybeans at the time of the IPM course, have subsequently entered the soybean market for the first time this year, undoubtedly encouraged by their newly acquired knowledge.

We are all now more aware that pests such as whitefly that can be transferred from one crop to another. This is a major concern with the much higher incidence of small crops in the district since the diversification push. We are also better able to differentiate between major damage, e.g. by heliothis, and cosmetic damage, e.g. by legume webspinner, which in most crops, has little impact on the actual bean crop yields.

Even busy farmers, who previously did not closely monitor their soybean crops in the past, are recognising the importance of monitoring and are incorporating “a quick look at the soys” into their irrigation schedules. Overall, participants who were involved in the IPM course have embraced the importance of effective and responsible farming practices in relation to the successful production of rotational break crops.

And to demonstrate the acceptance of this practice, some of the participants from the course have been approached by industry bodies to be a part of a consultancy service for growers who do not have the time to monitor their own crops. This has been a great step forward, as in previous years many farmers expressed concern that they did not know when or how often they needed to
spray to maintain a healthy crop. Often crops were sprayed two or three times simply because “the bloke next door was spraying”.

With trained people in the district the occurrence of such pests as heliothis, and GVB are being monitored and dealt with before they become a serious threat to soybean crops. As well, the widespread use of biopesticides in pre-podding crops against caterpillar pests, and the use of softer pesticides at podding, are conserving our beneficial insects, and have undoubtedly helped stabilise silverleaf whitefly, mites and soybean aphids in our region. This in turn is contributing to an increase in yield and higher quality crop coming from the district, thus increasing our profitability. In 2006, over 70% of soybeans in our region made culinary/edible soybean grade, a vast improvement from previous years.

Overall our district has now built a network of regional expertise that continues to grow as knowledge of IPM spreads throughout the Bundaberg / Isis community.

Conclusions and Future Directions - Dianne

Environmental issues are impacting on all farming practices. Outside political pressure and changing demographics in our region have encouraged farmers to embrace changes, including the adoption of legume (pulse) break crops, and softer more sustainable pest management practices for these crops. We believe that the IPM skills we have acquired as a result of the IPM courses are helping with this change.

Today we farmers are increasingly accountable for our micro environment and for sprays and water runoff that impacts negatively on the macro environment, e.g. the reef. It is important that one farmer’s practices do not interfere with neighbouring farming systems or with lifestyle dwellers. IPM is a way on ensuring that harmful effects are minimised.

A major measure of IPM’s adoption in our region has been the increased use of biopesticides which are safe for humans and only target the pests. Biopesticides don’t upset the delicate balance of nature, and while sometimes they only kill 60 to 70 percent of pests (we often have much higher kills), they leave the many predators in our crops to kill the pest survivors.

As mentioned previously, we now realize that through frequent monitoring and the correct identification of pests, excessive spraying can be reduced, thus cutting costs and boosting profits. Bug monitoring teams have been established in the Isis district to service local growers and raise awareness of importance of good bug management practices. We are anticipating that similar schemes will follow in the Bundaberg area. Lastly, improved pest management has resulted in greatly improved soybean seed quality in the 2005/06 crop, with the majority of crops meeting ‘edible’ standards.

Soy beans has been the major focus of this conference, but with farming women monitoring our crops, we believe successful IPM monitoring is being extended to other legumes including navy beans and peanuts plus industrial hemp and the numerous small and tree crops in this region. This is important, for as we have learnt at the courses, many pests attack a range of crops and successful IPM requires a multi-crop area wide approach.

Finally, it is important the IPM and break crop initiatives taken in our region are ongoing, to help ensure that future generations can inherit farms with healthy soils and crops that are protected from pests by natural enemies. It is hoped that updated IPM courses will be held in the future.
The IPM workshops have generally boosted women’s confidence in aspects of farm management and in pest management in particular.

So look out for women in the field beating those beat sheets and with magnifying glasses in hand. Women can challenge the economic thresholds and decide if it is necessary to spray as a result of hot spots or ascertain that the ladybirds will counteract the baddies. Bugs Rule!

Acknowledgements

Women in Sugar acknowledges the invaluable work by Angela Williams (Sugar Executive Officer, WBBACC Bundaberg) in securing SRDC funding, SRDC for providing that funding, Cane Growers at Bundaberg and Isis for providing venues, insurance cover, and funding administration, and lastly to the following scientists who wrote the IPM reference manual and who presented so enthusiastically at the IPM courses; Hugh Brier, Austin McLennan, Andrew Dougall and Iain Kay (DPI&F), and Keith Chandler (BSES). We would also like to thank Judy Plath (CANEgrowers Isis) and Matt Leighton (CANEGROWERS Bundaberg) for their assistance at the IPM workshops, and for their invaluable post-course IPM support. Lastly, special mention is due to Geoff and Maureen McCarthy for their IPM enthusiasm and initiative, particularly in the reformatting of extension material to better suit growers’ needs.
Soybean Industry Development in North Queensland: Export Value Chain Initiatives to SE Asia

S. Sinclair 1, A. Lashmar 2 and A. Soesanto 3

1 Senior Trade and Business Officer (FutureCane), Queensland Dept. of Primary Industries and Fisheries, Mackay QLD 4740
2 Lashmar Nominees Pty Ltd, Giru QLD 4809
3 Auspac Investments Pty Ltd., Melbourne VIC 3065

Abstract

Growers in the northern Queensland coastal cane regions are currently developing a soybean industry based on both sound agronomic and environmental principles within new integrated farming systems for the sugar cane industry, but also using grain production as an income diversification stream for their farm business in addition to sugar cane revenue. Current challenges with cost competitiveness in the domestic market has led growers and the Queensland Government to investigate export market options from northern Queensland to SE Asia. A trial export shipment of soybean grain from the Burdekin region to Indonesia has revealed both export market opportunities and challenges, but has also enabled, via a detailed value chain analysis, identification of the export chain cost competitiveness and future potential market strategies. Challenges for the soybean industry in northern Queensland to address in the near future are grain supply tonnages of export market volume to enable consistency of supply to customers, grain quality and grain management systems improvement, and a commitment by growers and other chain sectors to build on initial export supply chain relationships.

Keywords: Soybeans, sugar cane growers, export value chain, Burdekin, Indonesia

Introduction

In addressing recent sugar industry challenges, research results from the Sugar Yield Decline Joint Venture (SYDJV; Garside 2002) have elucidated integrated farming system practices that improve both cane farming system productivity and profitability. In particular, breaking monoculture systems with rotational legume crops, such as soybeans, has resulted in both a contribution of fixed nitrogen to the soil, and improvements in soil health (Garside and Bell 2001). The Queensland Department of Primary Industries and Fisheries (DPI&F) FutureCane initiative (in association with BSES Ltd) seeks to assist and promote the implementation of both profitable and sustainable cane farming systems based (in part) on SYDJV results, including viable rotational crop options for each sugar cane region in Queensland. In this context, the use of fallow soybean cropping in the Mackay/Burdekin sugar cane growing regions of North Queensland are supported based on two key components;

1. improved agronomic and soil attributes with a legume fallow crop within an integrated farming system, and
2. farm income diversification with legume grain crops.

The ability to provide profitability, and hence true on-farm income diversification, from the legume cropping regime depends on the ability for northern growers (defined in this paper as growers within the Queensland coastal zone of Mackay-north) to secure markets (i.e. customers) for the product, and receive margins derived from sales revenue over an above the cost of production (COP), including marketing costs. The major soybean varieties grown within the north Queensland coastal zone (commercial soybean fallow crops essentially defined within the
central sugar region based around Mackay, and the Burdekin sugar region) and associated domestic (Australian) market segment identification are provided in Table 1.

Table 1 Soybean varieties and market options for northern growers

<table>
<thead>
<tr>
<th>Variety</th>
<th>Type</th>
<th>Market products</th>
<th>Market segment identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leichhardt</td>
<td>Dark hilum</td>
<td>Soy meal, oil</td>
<td>Crushing (Oil)</td>
</tr>
<tr>
<td>YY</td>
<td>Dark hilum</td>
<td>Soy meal, oil</td>
<td>Crushing (Oil)</td>
</tr>
<tr>
<td>AG 6785</td>
<td>Light/buff hilum</td>
<td>Food grade and higher grade edible culinary markets, eg. soy flour, soy milk, tofu, miso and edible grade oil</td>
<td>Edible manufacturing (milling) and culinary markets</td>
</tr>
<tr>
<td>Stuart</td>
<td>Light hilum</td>
<td>Food grade edible market, predominantly soy flour and edible grade oil</td>
<td>Edible milling market</td>
</tr>
</tbody>
</table>

* A This soybean variety generally suitable to the Burdekin region only

* B Stuart variety (developed by CSIRO) was commercially released for planting in late 2005, with commercial crop harvests in 2006. This soybean variety is considered suitable for coastal and tropical Queensland with key agronomic and market advantages (A. James pers comm., CSIRO Plant Industry Information Sheet).

**Domestic market perspective and background**

Prior to 2006, the major soybean varieties available for marketing from northern Queensland comprised black-brown coloured hilum types (cf. dark hilum varieties cv. Leichhardt and YY; Table 1) usually contracted to either oilseed crushers or full fat soybean meal processors, with lesser options (particularly due to limited agronomic suitability) for edible grade varieties (cf. light hilum cv. AG 6785; Table 1). The domestic soybean market segments, products, dynamics and market analysis have been described previously by Anon. (2001), Willis (2003) and Tucker *et al.* (2005). As a précis, three broad market category segments exist, namely:

1. Stockfeed and oilseed crushing. Soybean meal is both a preferred and principal feed vegetable protein source used predominantly in the poultry and pig industries, and to a lesser extent intensive cattle, pet food and aquaculture industries. The market utilises both solvent extracted soybean meal (provides vegetable oil for food manufacture) and extruded full fat soybean meal (animal feed protein and energy source). Domestic stockfeed and industry usage demand exceeds domestic supply, however extensive product importing occurs to meet shortfalls, and this market segment is competitively priced based on world commodity factors. The segment is considered the benchmark for domestic soybean pricing (farm gate), and while able to absorb domestic production expansion, is characterised as low value, highly price competitive commodity trading with basic grain quality specifications (*refer* AOF Commodity quality standards reference CSO-9; AOF 2004a). The full fat soybean meal segment will generally attract some premium over the base oil/crushing price.

2. Milling (flour) and edible manufacturing. Soybean usage in the baking and milling industry as enzyme active, full fat flour and whole seed and kibble additives, is priced at a premium to the oilseed/crushing market. However this market segment is considered mature, with a requirement for light hilum varieties and more stringent grain quality specifications (*refer* AOF Commodity quality standards reference CSO-11.1; AOF 2004a). Domestic production (supply competitive) usually meets demand with excess crop absorbed by the crushing market. There is also select and cost-competitive soybean protein product imports into this market category.

3. Higher value whole bean ‘premium edible’ market for soy milk, tofu, tempeh, and miso products. Domestic market demand suggests a small and competitive market segment,
with the highest grain quality specifications (select light hilum varieties only; also refer AOF Commodity quality standards reference CSO-11.2; AOF 2004a). This market segment is showing some measured domestic growth as human consumption increases with human health and socio-economic trends.

The northern Queensland coastal soybean industry has potential for production expansion, with the introduction of tropically adapted light hilum cultivars such as ‘Stuart’ offering further potential for market segmentation into the edible manufacturing and milling segments (A. James, CSIRO pers. comm.). However, it is also recognised that the cost competitiveness of northern growers is compromised by the ‘costs to market’, primarily freight and grading costs for delivery to southern Queensland grain merchants and processors. Current feasible domestic market segments for northern growers, as defined above, are primarily market category 1, and to a limited extent market category 2 (subject to variety and grower crop and grain management ability). Clearly northern growers are then restrained to access to low and medium value domestic revenue streams, albeit with potential to improve market category 2 access.

In respect to the market categories, stockfeed and oil crushing (1) consumes all market downgrades with resultant products consumed and utilised domestically. As a general rule, the human consumption (2 and 3) and full fat soybean meal market segments are satisfied by domestic production prior to domestic grain allocation to the base oil/crushing market (Cargill pers. comm., P. McKey pers. comm.). Such market grain allocations are further complicated for northern growers given the seasonal production capacity, storage and marketing advantages applicable to southern Queensland and Northern NSW producers. Currently northern growers produce, on a tonnage basis, around 3% of the total domestic soybean production in Australia (refer Tucket et. al. 2005).

Comparative marketing costs (supply chain costs ex farm gate1) for selected Queensland regional cane growing areas are shown in Figure 1. The information is based on financial analysis undertaken within the DPI&F FutureCane program, and uses the full fat soybean meal market as delivered to southern Queensland as the appropriate market segment benchmark.

![Figure 1](https://example.com/f1.png)

**Figure 1** Comparative Domestic Soybean Grain Marketing Costs for 2005 delivery to ‘full fat’ stockfeed market delivered Dalby Qld. from selected Queensland regional sugar cane growing areas

---

1 'Costs _ Freight' refers to road transport costs ex farm to grain merchant, inclusive of ex-drying freight where applicable. 'Costs _ Other' refer to crop levies, pre-cleaning, drying, packaging and handling, and grading costs where applicable.
What is illustrated in Figure 1 is the higher ‘costs to market’, and hence by inference reduced
grower margins (potentially ameliorated to a degree by COP manipulation and logistics
consolidation), available to northern growers compared to their southern Queensland grower
compatriots (competitors?), when targeting the same market segment. The major factor in higher
northern marketing costs is freight cost. This marketing constraint or disadvantage has prompted
investigation into developing new differentiated or ‘niche’ market segments that offer either an
improved revenue stream, lower marketing costs or a combination thereof. In this regard, export
market development initiatives have been appraised.

Export market overview: challenges and opportunities

Access to export markets for northern Queensland soybean growers offers both challenges and
opportunities dependent on the country of origin for grain and identified market segmentation
within that country. Notwithstanding attention to product attributes, effective supply chains and
marketing relationships, growers will have variable risk exposure to trade market access barriers
(incl. tariffs, duties, quota arrangements, non-tariff barriers), foreign exchange rate fluctuation,
and socio-political challenges. Marketing risk exposure increases as the product point-of-sale
progresses from FOB (Free on Board) at Queensland port, to CIF (Cost, Insurance and Freight)
and possibly DDP (delivered duty paid to store) at country of destination.

The SE Asian and Pacific Rim countries are viewed positively for trade and market development
given an existing Australian agri-industry trade presence in the region, logistical sea and air-
freight proximity to northern Australia, and evidence of growing demand for edible soybean and
soy related products, plus regional intensive livestock stockfeed requirements (Anon. 2001; J.

Indonesia

Indonesia offers genuine trade and market development opportunities, with a population of 224
million, proximity to northern Australia, increasing GDP per capita growth and improved
microeconomic reforms. As a cautionary note however, recent Indonesian business risk
assessment (EFIC 2005) has noted continuing moderate to high risks in regard to trade finance
payment and currency, corporate governance. Use of local import agents linked to competent
export broker/agent intermediaries is considered most advantageous to the trading relationship.
In regard to soybeans, Indonesian local production is approximately 600,000 tonnes p.a. of
variable quality, with a human edible domestic consumption requirement shortfall met by
imports in excess of 1.1 million tonnes p.a. sourced predominantly from the United States and
South America (Argentina, Brazil). With regard to imported soybean to Indonesia,
approximately 80% is for tempeh and tofu processing, with remaining 20% for higher value
soymilk and soy product market segments. Currently Australia is the sixth major trade import
source for Indonesia, predominantly based on cereal grain, cotton and industrial resource exports
from Australia (Anon. 2006). Soybean exports from Australia to Indonesia, either as whole
beans or to a lesser extent soybean meal, have to date been both minimal (generally less than 120
tonnes p.a.) and intermittent (Anon. 2005). A recent trade and study tour to Indonesia of
Queensland Government, northern soybean grower and private industry merchant/broker
representatives (Sinclair and Lashmar 2006), has elucidated trade and market development
information and opportunities as provided in Table 2.
Table 2  A preliminary and succinct appraisal of the Indonesian edible soybean market with regard to trade development opportunities and issues

<table>
<thead>
<tr>
<th>Product type and import specifications</th>
<th>Market development information</th>
</tr>
</thead>
</table>
| **Tempeh**                             | • Tempeh (a fermented soybean based cake) and Kripik Tempeh (a fried tempeh snack) generally considered low value food commodities sold at ‘wet’ markets and vendors. A basic food staple.  
• Imported Australian soybean will need to be price competitive with US and South American soybean (CBOT\(^1\) benchmark), and of equivalent quality and food manufacture properties  
• Dark hilum varieties are acceptable (eg. Leichhardt)  
• Generally no price premiums, and non-GMO\(^2\) grain not a market issue  
• Market generally high volume trading relationships (> 20,000 t per client) with consistent annual supply. Supply opportunity for ‘fresh’ Australian harvested soybean May to August |
| **Tofu and soymilk**                   | • Higher value consumer market (supermarket and shop retail) desiring a light hilum variety (eg. Stuart)  
• Must be price competitive and quality comparable to US and possibly Canadian soybean (depends on importer)  
• Lower trade volumes acceptable (< 10,000 t) however consistent supply, preferably on a monthly basis  
• Possibility for price premiums and a non-GMO grain market advantage (depends on importer) |

\(^1\) Chicago Board of Trade  
\(^2\) Genetically Modified Organism

**Other SE Asian and Pacific Rim markets**

Australia currently exports both whole soybeans and soybean flour and soybean meal to SE Asian and Pacific Rim countries. In regard to human edible soybean, exports of quality light hilum soybean to higher value markets in Japan (major market), Taiwan and Malaysia, but also Papua New Guinea, New Caledonia and New Zealand (Anon. 2005). A total of approximately 7500 tonnes were exported in the 2004 calendar year, of which 4800 tonnes were to Japan and Taiwan (Anon. 2005).

South East Asian edible soybean market characteristics (refer Brodie 2003) are linked to specific country food uses (such as tofu, natto and miso in Japan, tofu and soymilk in Thailand) that require quality specific light hilum varieties (generally equivalent to quality standard CSO 11.1; AOF 2004a). These markets are high value but demand consistency in supply and quality. Australian soybean is attractive given fresh seasonal supply ability and non-GMO status considered market advantages. Soybean exports to countries in the region are invariably benchmarked with Northern Hemisphere suppliers, particularly Canadian soybean, and are price competitive.
In lieu of the low value human edible market segments (eg. tempeh in Indonesia) in SE Asia being generally characterised as volume driven, commodity based markets with limited product differentiation, it is considered that identified ‘niche’ markets for higher value human edible soybeans (eg. soy milk, tofu and miso) probably offer the most attractive export market development options (Anon 2001; Brodie 2003) for northern growers. It is also worth noting that recent grain composition analysis (viz. 2006 season crop) for both dark hilum (cv. Leichhardt) and light hilum (cv. Stuart) varieties grown in the Mackay/Burdekin regions are in compliance to protein, oil and dry matter quality specifications as specified for the CSO-9 and CSO11.1 AOF quality standards respectively (AOF 2004a).

**Case study: Trial shipment of whole soybean grain from Townsville, North Queensland (ex Burdekin region) to Indonesia for the purpose of tempeh manufacture and distribution to Indonesian customers**

This case study refers to the ‘trial shipment’ of 22.5 tonne of whole soybean grain (cv. Leichhardt) to Indonesia that occurred in October 2005. The purpose of the case study presentation is to provide some preliminary export value chain information that will assist in future export market and associated value chain management initiatives.

**Farm-gate baseline: Soybean production in the Burdekin region 2005**

It has been generally estimated (based on initial plant seed sales and regional agronomist observations) that 600 ha of fallow land within cane farming systems in the Burdekin region were planted to soybean varieties late 2004, with 150 ha (25% of planted area) completing the crop cycle to grain harvest in May/June 2005. Assuming a conservative average crop yield of 2.8 t/ha from irrigated crops, the 2005 grain harvest (measured ex harvester-farm gate) would have provided potentially 420 tonne of soybean for market use. Reduced grain harvest area compared to area planted is not unexpected given individual grower management decisions in regard to green manure crop objectives only, and farmer assessment on the cost: benefit of green manure crop to grain crop based on whole farm priorities, prevailing grain market price trends, projected variable crop costs etc. Ideally from a grain marketing and market development perspective, higher proportions of grain crops would be encouraged.

The grain harvest in 2005 was marketed domestically to either local intensive livestock industries (primarily as feedstock for poultry mash and meal requirements, a small volume market), or directly sold to grain merchants and specialist stockfeed processors in central and southern Queensland for direction to the oil/crushing and full fat soybean meal markets. A small proportion would have been used on-farm for select cane grower beef cattle enterprises (as a whole bean supplement with molasses generally), with the notable allotment of tonnage for the trial export shipment completing the marketing mix.
Grain management systems

With respect to grain management systems, the convention generally implies grain harvester operations and efficiencies (t/hr flow rate and grain pre-cleaning, quality control), more generic grain handling and storage facilities and logistics (including cleaning, drying and grading as applicable; refer Tucker et al. 2005), and the grain transport ‘chain’ ex farm to customer. Current basic grain management systems in the Burdekin for soybean (in the absence of regional infrastructure) generally involve grain harvester transfer direct to road transport (bulk semi-trailer and B-double configurations) for immediate transit to grain merchants/agents and end-users where additional grain management occurs as applicable, and costs borne within the ‘chain’, including marketing costs ex-farm gate. In regard to the export trial shipment, the following grain management system occurred to point of product transfer (sale) as FOB, Port of Townsville:

- Paddock/block grain harvest (incl. harvester pre-cleaner) and loading into 1 tonne bulk bags (export approved). On-site AQIS² inspection.
- Temporary storage on-farm
- Road transfer to port facilities container logistics area
- AQIS inspection, grain fumigation and Phytosanitary certification
- Export documentation, container logistics (incl. Bulk bag loading into 20’GP TEU)³ container, stevedoring and shipping agent transaction conclusion
- Container loading on ship (FOB)

Supply chain management

In its basic tenet, a supply chain encompasses the physical flow of materials (in this instance a legume grain commodity) between the various sectors of the agri-industry from farm sector to consumer. The output of one sector becomes the input for the next sector in the chain. One definition of supply chain management is ‘the planned continuous improvement of processes and relationships that exist to support the movement of goods and services through the value chain’. Hence the implication for information flow and relationship building, in essence operationalising “trust” (O’Keefe 1998).

---

² Australian Quarantine and Inspection Service
³ General Purpose Twenty Foot Equivalent Unit
The trial shipment export supply chain applicable to this case study is illustrated in Figure 2.

**Figure 2** Structure of the export supply chain for soybean from Australia to Indonesia for tempeh manufacture, based on trial export shipment in October 2005

In regard to product and information flow within the supply chain, the following points refer, as detailed by Sinclair and Lashmar (2006).

- Bulk grain delivery at Port in Indonesia is visually appraised, cleaned (if applicable to market use) and re-bagged into 50 kg bags. In trial shipment, 1 Tonne bulk bags were unloaded from container and re-bagged.
- Bagged soybean grain is transported to Co-op member warehouses. Due to logistical and physical constraints, bulk grain delivery in Jakarta and surrounding regional centres is limited. Warehouses tend to be small capacity (< 200 Tonne) with regular grain delivery turnover.
- Warehouses re-sort grain prior to arranging ‘lot’ bagged delivery (customer volume and bag size requirements vary) to the numerous family owned and operated tempeh processing plants in that particular warehouses’ distribution zone. The processing/manufacturing sites tend to be rudimentary, and generally process only 1 to 3 tonne per day of soybean grain.
- Wholesale and retail distribution appears to be either Co-op or third party agent operated. Retail packaging generally comprised 200 g packs distributed to ‘wet’ markets and street vendor, food outlets.
As an indication of scale for the soybean tempeh (and tofu) processing and distribution, a leading Indonesian importing and processing cooperative was quoted as collectively consuming up to 80,000 t of soybean per month (domestic and import), representing some 148 secondary cooperative ventures (mainly Java Island based) in turn representative of distribution to numerous small manufacturing/processing facilities for tempeh and tofu production (Sinclair and Lashmar 2006).

The tempeh production and retail distribution supply chain appears reliant on extensive internal chain communication for daily soybean and processed product delivery and coordination, particularly as most transport and freight components are small volume based, using basic cartage and distribution road networks. Price determination largely set by ‘agents’ and sector margins based on domestic supply/demand parameters and internalised costs. Overall the supply chain is characterised by intensive labour input and basic operational activities, indicative of maintaining a low cost chain in a rudimentary socio-economic demand environment.

**Value chain definition and analysis**

The value chain concentrates on the flow of revenue and amount of value added along sectors of the chain. The “value chain” has been described as the sequence of activities from farm gate to the consumer where costs and margins are quantified with each sector link (DPI 1998). Conceptually, the consumer includes retail, wholesale and manufacturing sectors. It is noteworthy that the concept of customer ‘value’ may vary with market segments, however intrinsic value components to product delivery will include product quality, customer services, consistency of supply and cost competitiveness (Gattorna and Walters 1996).

Value chain analysis provides an overview of the value added at each step or sector in the process from raw product to processed product and sale to consumer. However; realistically data compilation and value interpretation becomes more difficult as one moves ‘up’ the chain, due to less transparent cost disclosure and product flow information. In this case study, information on costs ex. Port in Indonesia, particularly wholesale and retail value chain values and margins, are based on possibly equivocal data, with price discovery assumptions made from information interpretation arising from personal industry contacts and disclosure in Indonesia (refer Sinclair and Lashmar 2006).

The value chain for tempeh manufacture and sale in Indonesia using soybean grain from Australia, *as per* the trial shipment export chain relationship in late 2005, is presented in both Figures 3 and 4. In this particular case, the food manufacture of tempeh was as a low value staple food product at retail. The biggest cost components in the value chain for tempeh in Indonesia were the ex-farm gate price in Australia (22%); and ex-Port Indonesia being food processing, wholesaler and retailer components with a combined 41% (Figure 3). What is noteworthy is the seemingly sizeable proportional cost component (or share) of the value chain attributed to the grower/farmer (i.e. ex-farm gate). This contrasts with value chain observations for other export commodities value chains, such as sugar (DPI 1998), where farmer value components are frequently less that 15% of the total chain value. This may be attributed to the more basic commodity transformation from whole soybean to tempeh, where processing costs and retail value are lower than say more higher value product processing and retail value chains in more developed countries.
Figure 3 Value chain cost component analysis for tempeh production in Indonesia using Australian soybean

Progressive costs from ex farm gate to Port in Townsville, to ex Port in Indonesia (including import duties, taxes etc.) accounted for 20% of the value share in the chain.

A development on the value chain analysis is presented in Figure 4, where price transformation that occurs as the product moves through the value chain is specified. While total value chain components in Figure 4 are costed in Australian dollars (AUD$), the following cost and currency conversions have been calculated, namely:

- Costs to FOB Townsville Port are costed in AUD$
- Sea freight charges and marine insurance are based on a USD$ quote, with conversion to AUD$ equivalent at time of transaction
- Import duties, taxes, tariff and costs ex-Port Indonesia are based on an Indonesian rupiah (IDR) basis, with conversion to AUD$ on exchange rate assumptions prevailing in late 2005

The farmer/grower transferred ownership of goods at FOB, Port of Townsville (2nd tier exporter), to an export broker/agent (1st tier exporter; consignor). Delivery to port in Jakarta, Indonesia completed ownership transfer to a processing cooperative (consignee) and resultant product flow and transformation through the value chain to wholesale to retail sectors.

---

4 OANDA.com FX quoted foreign exchange rates at bank rate +3%.
5 Austrade definition
Figure 4  Value chain analysis for tempeh manufacture and sale in Indonesia using soybean grain from Australia, October 2005. Value is specified in AUD$.

For definitions, assumptions and currency conversion statements refer to text.

The built-up wholesale and retail prices shown in Figure 4 contain cost components including processing, packaging, distribution and marketing costs. In addition, a wholesale and retail margin would also be included, possibly accounting for some cost components already identified. The gross section values are assumed based on observed retail pricing, however itemised actual cost component values are either not known or are commercial-in-confidence.
In regard to the calculated on farm price ($232 per tonne, Figure 4), i.e. the value chain price allocation for grain ex-farm gate, an estimated 9% gross margin (GM) return over crop management variable costs was calculated. Alternative domestic market segmentation use for the grain to the ‘full fat’ stockfeed industry in Southern Queensland would have measured an estimated 17% GM return. With respect to comparative marketing costs (real time ex farm gate to FOB, Port of Townsville or delivered in-store to stockfeed manufacturer, Southern Queensland), an indicative 12% increase in marketing costs would have occurred in targeting the domestic stockfeed market in this instance. It is important to note that with initial market development initiatives such as this ‘trial shipment’, it is not uncommon that chain partners, particularly wholesale and retail customers, consider some variance in price determination (essentially market risk management) to compensate for evaluation of a new supplier and product source with untried quality attributes and consumer acceptance. To this extent, the GM returns analysis may well be biased to the domestic market in this case study. Nevertheless, selection of the export market alternative provided genuine marketing cost savings for the grower.

Clearly, the value chain analysis for Indonesian tempeh in Figure 4 demonstrates the significant costs and margins post farm gate. There is often misunderstanding in the apparent price discrepancies and profit-taking implied by differences in retail and farm gate prices for agricultural products. However, as illustrated in Figure 4, there are multiple cost components in progressing from a raw commodity ex farm gate to a processed and consumer-ready product available at retail. While food processing costs and wholesale/retail margins are quantitatively sizeable in the context of the whole value chain ($425 per tonne), the inherent costs to export, as compared to domestic marketing, amounted to an additional $190 per tonne from FOB Port of Townsville to ex-Port Indonesia. The built-up retail price (based on the Jakarta retail vendor market) is believed to be broadly representative for main island Java markets as current in late 2005.

Discussion

The desire to initiate an export value chain for soybean from northern Queensland arose through the recognition that current domestic market cost competitiveness is constrained by freight costs and an absence of cost effective grain tonnages. In assessing region specific issues for the soybean industry in northern Queensland, A. James (CSIRO pers. comm.) has suggested that a potential 25,000 ha of allocated fallow land is available for soybean production within existing cane farming systems, to produce up to 62,000 tonnes p.a. Current soybean grain tonnages for the Mackay and Burdekin sugar cane regions combined are estimated to be within the range of 450 to 1000 tonnes p.a. (based on actual estimates and projections for the period 2005 to 2007). While it is appreciated that recent regional constraints in water availability, late cane harvesting affecting fallow planting, domestic market pricing and variable climatic conditions have impacted on potential plantings and annual yields for soybean grain crops; grower participation rates and grain tonnages are still in the initial stages in regard to attaining regional marketing tonnages generally attractive to export markets (viz. > 3000 tonne p.a.). It is probable that the decision by sugar cane farmers to diversify into grain soybean crops is complex, driven by socio-economic characteristics that combine commercial and social rewards or limitations, with added perceptions in management risk and effort (Windle and Rolfe 2005). In respect to northern region growers, results by Windle and Rolfe (2005) indicate that current diversification options most preferred by sugar cane farmers are those that complement sugar cane, such as annual field crops. Gross margins are also influential, hence the impetus for northern soybean industry development to be both complementary within regional sugar cane farming systems and also profitable.
It is proposed that through market driven demand, northern growers will develop cash cropping opportunities for fallow legume grains within a sustainable and integrated sugar cane farming system, notably via successful market development initiatives creating a ‘demand pull’ for soybean grain. Assuming successful soybean industry development in this regard, the following potential outcomes for the Mackay and Burdekin sugar regions can be identified as:

- Market driven adoption of fallow legume cropping for income diversification amongst northern sugar cane growers, providing farm business management risk minimisation and contributing cash flow.
- Impetus for establishment of regional grain storage and handling infrastructure (refer Tucker et al. 2005).
- Environmental sustainability. The promotion of integrated farming systems with legume cash crops will contribute to environmental objectives for the sugar cane industry. Implementation of soybean grain cropping, concomitant with initiatives in controlled traffic and minimum tillage, result in lower external nitrogen application rates, less soil erosion potential and improved water holding capacity, targeted and lower level herbicide usage.
- Reliability in sugar cane production and supply. Soybean grain production in fallow land rotations with sugar cane promotes robust and integrated farming systems that provide organic matter and nitrogen to following cane crops, improve cane yields with similar to less input costs, enhance soil health, and break monoculture disease cycles (Garside and Bell 2001).
- Enhancement of human capacity and partnerships through active participation in an export supply chain, and associated requirements for industry networking and formal co-operation and relationship building to achieve desired outcomes.

In order for the ‘market pull’ demand to occur with realistic outcome of profitable soybean crops, the issues of trade and market development and value chain competitiveness must be addressed.

Export trade and market development issues

It is evident that the low value, commodity based soybean markets in SE Asia are highly price competitive and volume sensitive. In view of the current marketing grain supply constraints, it seems evident that with an emergent industry, lower trade volume ‘niche’ markets may be a more attractive option in the short term. There are clear advantages with northern Queensland soybean being non-GMO, the potential to promote identity preservation standards for product, and new regional tropically-adapted light hilum soybean varieties that offer market access to defined edible human consumption markets (eg Stuart; A. James CSIRO pers. comm.), particularly the soymilk and tofu markets of Malaysia and Thailand. A niche market has been referred to as ‘selling a normal product into a specialised market or a specialised product into a normal market’ (G. Conaster as quoted by Thatcher 2004). In the context of soybean exports from northern Queensland, the former niche market approach may be evident for light hilum varieties into small volume SE Asia; while the latter more evident as trade volumes increase to enable dark hilum varieties into selected Indonesian supply chains where cost competitiveness, seasonal supply are the attached value or specialised product attributes.

The ability to have variable export market segments would improve market risk management within the export value chain (Gattorna and Walters 1996), and there is evidence that the soybean markets in Indonesia and SE Asia are expanding and providing marketing opportunities (Anon. 2001; Sinclair and Lashmar 2006). Northern soybean growers are also in a position where existing known products (i.e. soybean) are being grown in new environments or regions
for existing markets; viewed as an appropriate risk management strategy to minimise exposure to undue productivity or market risk (NOO framework, Hanlon 2004).

In respect to targeting niche high value markets in SE Asia, the ability to be cost and product competitive with Canadian soybean is evident. The Canadian product to SE Asia is professionally marketed with a defined identity preservation standard based on varieties, effective grain quality through grain management systems, and assurance auditing (Morrison 2003). Current grain tonnages in northern Queensland have not obtained the critical mass required for investment into grain storage and handling infrastructure. The current inability to cost-effectively store, clean, dry and grade soybean in northern regions constrains cost-effectiveness in the value chain. Placement of suitable grain storage and handling infrastructure will promote improved transport and marketing logistics, reduce market risk, maintain grain quality and underpin product identity preservation (refer Tucker et. al. 2005). Such infrastructure should be based on accepted industry standards and quality assurance (QA) principles and codes of practice (AOF 2004a, 2004b).

Note that while adoption of identity preservation, QA principles, and effective grain management systems are important to maintain or gain market access and competitor advantage, in themselves these innovations are not substitutes for market goals of profitability and viability. This requires a more ‘whole system’ view of the value chain and its cost competitiveness. Finally, successful marketing strategies for northern Queensland soybean growers remain reliant on successful supply chain relationships and transparent customer specifications for product quality and quantity, and pricing signals. This requires commitment to communication with chain partners, and maintaining a focus on the market requirements (Hanlon 2004, Thatcher 2004) and the realistic abilities of the growers and regional support base to meet these.

Export value chain competitiveness

It is recognised that a critical success factor for export commodity based industries and businesses is a lean value chain managed for minimising costs of production and marketing chain costs reduction (Gattorna and Walters 1996; Laitt 2004). In lieu of the preceding discussion on the export (and indeed domestic) market segments available to northern soybean growers for whole grain, it appears generally evident that customers in the supply chain are not prepared to pay for differentiated product per se, and as a result growers will continue to produce to a specification with negligible control over price. In this trading environment for soybeans generally interpreted as a commodity market, profitability and a sustainable marketing position are reliant on being a low-cost producer (Laitt 2004) within a value chain managed to protect margins. It is noteworthy that Laitt (2004) also clarifies that based on a platform of low-cost production, and time to develop supply chain relationships and product attributes, product differentiation and branding may emerge and be sustainable. This may be a long term goal for the northern soybean industry, particularly if value-adding ventures into stockfeed manufacture, bio-diesel and other technology add-ons using soybean grain as a feedstock indeed eventuate. In the short to medium term however, commodity trading and cost-competitiveness remain the business realities.

In view of current and near future grain supply capabilities for northern Queensland growers, market export entry is probably preferable at the indirect exporter level, i.e. 2nd tier exporter using export agents/brokers with payment at Australian Port FOB basis. While this limits grower revenue stream to a low end of the chain, exposure to CIF or indeed country of destination supply chain product ownership commitments and costs would not be warranted with low trading volumes and hence poor economies of scale (Gattorna and Walters 1996). In addition, growers would not be directly exposed, at an emergent industry phase as currently
exists with soybean production and marketing in northern Queensland, with market risks such as terms of trade, international trade barriers, exchange rates and country of destination customer payment defaults etc. In effect FOB payment pricing is seen as a low-risk strategy.

Preliminary evidence from market planning and relationship building in SE Asia suggests that the current cost structure of the value chain outlined in Figure 4, (primarily ex-farm gate to CIF equivalent) would not be cost competitive with Northern Hemisphere soybean exporters in the same market segments identified as having potential for Queensland growers. Interpretation of the value chain analysis in Figure 4 also suggests that minimising cost structures on farm, and ex farm gate to Port (FOB) or longer term CIF at country of destination, offers opportunities to improve the value chain margins to the grower. Specific value chain sector cost minimisation would be:

- **On-farm cost reduction.** Reducing soybean COP through improved crop management and technologies, adoption of best practice farming systems to improve crop yield (t/ha) over marginal cost.
- **Bulk grain handling ex farm to Port.** Establishment of regional grain storage and handling infrastructure has potential to improve transport logistics, reduce freight costs, maintain grain quality and improve marketing attributes. This cost component rationalisation would achieve regional marketing cost savings. Further economies of scale in grain cleaning, drying and grading would also bring cost efficiencies, assuming determined critical volume of grain delivery via a cost: benefit infrastructure analysis was achieved.
- **In the short term,** use of 1 tonne bulk bags, while involving extra handling costs and inefficiencies compared to paddock harvester transfer to bulk grain road transport, is an alternative short term on-farm storage option in the absence of significant regional grain storage infrastructure. The 2005 est. cost for bulk 1 T bags plus grain handling comprising total FORM costs (machinery incl. labour, depreciation and interest) was in the order of $20/t grain. This could broadly be the price differential compared to bulk grain transport negating bag use. Longer term, as farm and regional tonnages increase, a trend to broader bulk handling, transport and storage would be considered cost effective.
- **Longer term,** sea freight charges could be rationalised on a per tonne basis with larger trading volumes and continuity of shipping company use (regular customer status).

**Conclusions**

Whilst still an emergent industry in northern coastal Queensland, the soybean industry, whose complementary production systems are encouraged within sugar cane farming systems, is being supported in its expansion to meet more holistic environmental sustainability and longer term sugar cane productivity outcomes for the Queensland coastal cane regions. However, adoption and continuing production for grain soybean crops to allow grower profitability goals and broader sugar industry economic diversification on-farm, requires the development and establishment of suitable market segment options. The export value chain analysis for the trial soybean shipment from the Burdekin to Indonesia has revealed the possibility of establishing an export market for soybean from northern Queensland to SE Asian customers. The supply chain relationships being established and the value chain knowledge being acquired by northern growers allow the opportunity to further explore export strategies, and to evaluate where market investments should be made. However value chain competitiveness remains a crucial issue, and northern growers will need a commitment to longer-term market development and supply chain relationship building.
Growers’ expansion into export market options does not negate the importance of remaining viable and competitive in the domestic market. Lessons and experiences gained from the export value chain will enable growers in the chain to acquire both innovative and change management strategies applicable to being competitive in the domestic market. This may include, where appropriate, the future realisation of value adding initiatives including stockfeed manufacture (animal and aquaculture industries) and possibly bio-diesel ventures with industry partners in northern Queensland.

Acknowledgments

The authors would like to acknowledge the contributions of Tresno Soesanto (Auspac Investments); Danielle Morris, Austrade; Christene Brogden, Australian Quarantine and Inspection Service; Elle Glashoff, Patricks Logistics; and Emmanuel Atherinos, John Swire and Sons shipping representative; in providing additional information and data applicable to the context of this report. Market and trade information pertaining to Australian soybean production and market analysis in Australia was also provided courtesy of Prue Tatt and Andrew McCarrol of DPI&F Trade, Markets and Investment. Special thanks to DPI&F FutureCane project staff David Brown, Mike Hanks and John Hughes for their assistance with the soybean export initiative and regional industry information.

The Townsville Port Authority provided port access to value chain project members, port trading information and assistance in meeting facilitation between sector stakeholders. Burdekin Shire Council, Ayr, also courteously provided meeting facilitation and initiative support.

Financial support for the agribusiness case study was provided within the auspices of a DPI&F ‘Export Solutions’ trade strategy initiative; with funding provided by the DPI&F FutureCane project, Sugar Research and Development Corporation Travel and Learning Opportunity Project DPI016, and the Australian Government Austrade New Exporter Development Program. The authors also gratefully acknowledge the support and professional assistance within Indonesia of Austrade-Jakarta and the Queensland Trade and Investment Office-Jakarta, in the provision of market visit programs.

References


The potential for nematode problems in Australia’s developing soybean industry

Graham R. Stirling

Biological Crop Protection Pty. Ltd., 3601 Moggill Road, Moggill, Queensland, 4070

Abstract

Root-knot nematode (Meloidogyne spp.), soybean cyst nematode (Heterodera glycines) and reniform nematode (Rotylenchulus reniformis) have the potential to become serious pests of soybean in Australia. This paper outlines the risks associated with introducing soybean cyst nematode into the country and discusses the distribution and potential significance of the other two pests.

Introduction

Australia’s soybean industry is relatively small by international standards, as only 70,000 tonnes of soybeans are produced from about 30,000 hectares of land, mainly in Queensland and NSW. Nevertheless, there is considerable potential for expansion, particularly in coastal regions where soybean is proving an excellent crop for rotation with sugarcane (Garside and Bell 2001; Bell et al. 2003).

Since nematodes are important pests of soybeans and other oilseed crops and grain legumes in other parts of the world (Sikora and Greco 1990; Riggs and Niblack 1993), the Australian soybean industry needs to be aware of the nematode problems that could be encountered as it expands. This paper discusses the situation with regard to root-knot nematode (Meloidogyne spp.), soybean cyst nematode (Heterodera glycines) and reniform nematode (Rotylenchulus reniformis), the three most important nematode pests of soybean worldwide.

Root-knot nematode

At least six species of Meloidogyne have been reported to damage soybeans (Riggs and Niblack 1993), but M. incognita, M. javanica and M. arenaria are the most common species worldwide. Experience in the USA suggests that M. javanica and M. arenaria are the most important species in warmer climatic regions. All species produce galls on roots that vary in size from small beads about 1 mm in diameter to large swellings more than 10 mm in diameter that may completely envelop the major roots. Above-ground symptoms include chlorosis, slight to severe stunting, wilting during drought stress and yield suppression. Losses of 90% due to M. incognita have been reported in Florida (Kinloch 1974).

M. incognita, M. javanica and M. hapla occur on soybean in Australia (McLeod et al. 1994), but root-knot nematode has never been considered a significant pest, probably because the industry has been confined to relatively heavy-textured soils that are unlikely to suit the nematode (e.g. the clay, clay loam and alluvial soils of northern and north eastern NSW and south eastern Queensland). However, a few instances of severe root-knot nematode damage have been encountered in coastal regions where soybeans are increasingly being grown in rotation with sugarcane. Stunted plants with severely galled root systems have been observed following sugarcane at Bundaberg and Mackay, and since root-knot nematode occurs in about two-thirds of sugarcane fields in south and central Queensland (Blair and Stirling 1999 a, b), other instances of
root-knot nematode damage are likely to occur as soybeans are grown more widely. Root-knot nematode does best in coarse-textured soils, but the nematode can also cause damage in well-structured clay loam soils of volcanic origin.

The possibility that soybean yields could be reduced by root-knot nematode when the crop is grown after sugarcane, or that soybean could host enough nematodes to damage the following sugarcane crop, prompted a study of soybeans and other legumes at a site near Mackay that was infested with *M. javanica* and *M incognita* (Stirling *et al.* 2006 a, b). When soybeans were planted into the high nematode population densities that can occur soon after sugarcane is harvested, severe galling was observed on three cultivars (Leichhardt, Melrose and YY) and most of the plants died before reaching maturity. Galling was less severe when planting was delayed for eight weeks and the above soybean cultivars produced low to moderate grain yields. This result shows that the initial nematode population density is an important factor influencing the severity of damage by caused root-knot nematode. Crop losses can be reduced by delaying planting until nematode populations have declined to acceptable levels.

The soybean cultivar Stuart showed relatively little galling and performed much better than the other cultivars in the above trial, suggesting that it was relatively resistant and tolerant to the two *Meloidogyne* species present at the site. Further studies in the glasshouse showed that *M. javanica* and *M. incognita* did not increase significantly on a range of soybean lines from the CSIRO tropical soybean breeding program (Stirling *et al.* 2006b). Since resistance is the most feasible method of nematode control in a field crop such as soybean, these findings are encouraging because they suggest that there is some resistance to root-knot nematode in the soybean material currently in Australia. Interestingly, soybean cv. Leichhardt was badly damaged by a population of *M. incognita* from Mackay but not by a population from Bundaberg in a glasshouse study (Stirling *et al.* 2006b), indicating that soybean cultivars may respond differently to different populations of the same nematode species. This phenomenon has been observed previously in the USA (Davis *et al.* 1998) and demonstrates that any future attempts to improve the level of root-knot nematode resistance in soybean cultivars must start with a good understanding of the variability of the nematode in all soybean growing regions.

**Soybean cyst nematode**

*Heterodera glycines*, a major pest of soybean throughout the world, has not been recorded in Australia. It is probably a native of Asia, as it has been known for many years in China, Japan, Korea and parts of the former Soviet Union. The nematode was introduced into North America in 1954 and has now spread to the main soybean growing regions in the USA, Canada, Colombia, Brazil, Argentina and Chile.

As with most root-parasitic nematodes, the above-ground symptoms of soybean cyst nematode are non-specific and the only universal symptom is a reduction in seed yield. When severe infestations occur, yields may be reduced to almost nothing. In the USA, yield losses from soybean cyst nematode are greater than for any other soybean disease, with losses in 2003, 2004 and 2005 amounting to about 2.8 million tonnes per year (Wrather and Koenning 2006).

The situation in North America is a salutary lesson to the Australian soybean industry on the importance of keeping Australia free of soybean cyst nematode. After its introduction in the 1950’s, it took less than 40 years for the nematode to spread to every major soybean producing state of the USA and also into Canada. The widespread distribution of the nematode has meant that major breeding programs have had to be established to minimise losses through resistant
cultivars, and some of the issues involved in introducing nematode resistance into commercial soybean cultivars are discussed by Davis et al. (1998).

*H. glycines* is recognised as an important quarantine pest in the biosecurity plan of the Australian grains industry, but it is important that growers, consultants and other people associated with the soybean industry are aware of the risks of introducing soybean cyst nematode into Australia. The nematode’s survival mechanisms favour its dissemination, with soil in seed lots, farm machinery and plant products or on the shoes of travellers being the most likely source of entry into Australia. Growers and others visiting infested soybean-growing areas overseas should therefore be particularly vigilant and take steps to ensure that traces of soil are not brought into the country.

Soybean cyst nematode is not easy to detect because normal-looking fields may experience yield losses without any obvious above-ground symptoms (Wang et al. 2003). If the nematode is eventually introduced into Australia, it is most likely to be detected in situations where soybean crops are grown frequently. Relatively infrequent cropping of soybeans (such as its use as a break crop following 4-6 years of sugarcane) will limit the capacity of soybean cyst nematode to increase to readily detectable levels. One way of checking for the nematode is to look for white cysts on roots at or shortly after flowering. Plants must be dug out rather than pulled and the fine roots inspected for white or yellow, pin-head sized cysts. Another alternative is to collect soil in a systematic pattern from a field (at least 50 sampling points per hectare) and forward the sample to a nematology laboratory for analysis.

**Reniform nematode**

There have been few detailed studies of *Rotylenchulus reniformis* on soybean, but it is known to cause stunting and reduce yield (Riggs and Niblack 1993). The nematode has a wide host range (which includes most plants except grasses) and is widely distributed throughout tropical regions of the world. In Australia, it is common in coastal areas north of Bowen in Queensland. It should not be confused with another species of reniform nematode (*Rotylenchulus parvus*), which is common on sugarcane and other grasses and occurs throughout the Queensland sugarcane industry.

*R. reniformis* is often found on leguminous crops such as lablab and soybean when they are grown as green manure crops on sugarcane farms in north Queensland, but nematode populations are generally low to moderate (<2,000 nematodes/200 mL soil). If soybeans continue to be grown intermittently as a break crop between sugarcane cycles, this situation should continue and the nematode is unlikely to become a significant pest.

**References**


