Australian Nuffield Farming Scholars Association

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TOPIC: BEST MANAGEMENT PRACTICES THAT INFLUENCE THE AGRONOMIC AND ECONOMIC OUTCOMES OF GROWING CRISPING POTATOES

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Executive Summary

The six week Nuffield Scholarship Core Study Tour through New Zealand, Asia, Europe, Canada and the United States of America, demonstrated to me that potato farmers globally are all faced with the same problems. The environment, soil types, water supply, regulations, seed quality, machinery and market demand, are some issues faced by all.

I chose to tour Canada and The United States of America (US), because the crisping industry in Australia is owned and dominated by two US based global giants. Fritolay, who own Smith's Crisps and Cambell's who own Arnott's, take up approximately 90% of the Australian crisp chips market. The crisping potato industry world wide, is one that is growing at a rapid rate. In order to keep up with the technological advances and the expected end product, every aspect of the farm has to be evaluated. Plans need to be established, implemented, re-evaluated and updated.

Initially I embarked upon my study tour with the idea of addressing the different agronomic and economic issues involved in the crisping potato industry, from seed development to the commercial crop. Once over there I quickly realized that all of these issues were reliant on management practices specifically. Given the broad nature of my initial project subject, I have focused on Best Management Practices (BMP).

The introduction of quality assurance programs and BMP has highlighted individual needs of growers. The idea of BMP is about enabling growers to ensure survival in a competitive business by using a management program which delivers a healthier potato crop and end season profit, while maintaining their local environment. I believe that an investigation into BMP of farmers, in the same industry on a larger scale, would help me to consider whether my own BMP were at an internationally competitive standard.

My research into these practices covered the management of fertility, irrigation, seed sources, planting practices and crop rotation and green manure for soil borne pathogens. After crisscrossing the US and Canada, speaking with farmers, industry representatives and academics about their BMP on these topics, I was encouraged by the fundamental similarities between their management systems and the ones we currently use on our farm.

While sheer size enables America to influence the world markets in a lot of different arenas, it does not eliminate the rest of us from the race. With internet facilities, global positioning systems and greater use of computer technology, Australian farmers can resource the same, up to date information used by their American counterparts. The tour and research divulged to me that, scale doesn't matter.

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Introduction

In the US and Canada, best management practices (BMP), fertility, irrigation, green manure (GM) and crop rotation (CR) and development through breeding programs of new potato varieties, have been fundamental to yield improvement.

Through out the potato growing regions of the USA and Canada that I visited on my study tour, the predominant potato variety grown was the Russet Burbank. This particular cultivar served a dual purpose, in that it is used in the processing market as well as the packed fresh market. The Pacific Northwest states of Oregon, Washington and Idaho, produce over 50% of the US Autumn crop. The USDA estimates that Russet Burbank accounted for about 80% of Oregon and Washington crops and 97% of the Idaho.

Price premiums are paid for specific size grades in fresh, processing, and seed markets. Diseases in seed crops, sugar and dry matter in processing crops, and external/internal defects due to physiological or pathological causes, are common reasons for rejection of crops and economic losses. As we do here in Australia, to optimize grower returns for specific markets, the American and Canadian growers pay particular attention to best management practices (BMP), that influence size and other quality factors.

Several new varieties have not yet been sufficiently evaluated to provide information on determining plant population for specific market requirements. This need is widely recognized, both for new cultivars and for the introduction of existing cultivars into new production areas. Economic return to the grower is based on potato quality rather than the tons per hectare. There is a greater importance now on achieving maximum economic yield rather than the highest yield.

Fertility

As with Australian growers, US and Canadian growers recognize crop fertility as one of the areas in potato production that can be effectively managed, and feel that, with proper nutrition, the incidence and severity of many diseases could be markedly minimized. An improper nutrient balance, results in higher susceptibility to hollow heart, disease, stress, size and marketable yield. With a greater emphasis on precision stand establishment, not only should seed piece size and spacing be effective, but also fertilizer application based on accurate agronomy analysis should be adopted.

In recent years, public concern about drinking water quality has prompted growers and researchers to consider not only production aspects of fertilizer management, but environmental aspects as well. Developing a healthy balance in nutrient management practices that are both environmentally sound and economically viable for the farms is desirable. When I visited the Atlantic coast region of Canada, in particular the provinces of Nova Scotia and Prince Edward Island (PEI), it was demonstrated to me that the community at large were working together to establish this environmental and economic union. The departments of agriculture both in Nova Scotia and PEI have been very proactive in tackling these environmental problems because of the importance of agriculture to their economies.

Agriculture is the principal contributor of any resource sector, to the economic status of PEI. The Island was of particular interest to me as it had an intensive and expanding processing potato industry. Agriculture in general on the Island is a large generator of waste products. The expansive potato industry linked with a very short growing season and light soils, has created some major environmental problems.

The problems of pesticide runoff killing fish, nitrate levels high in the ground water supply and erosion problems when the snow melts, has prompted the government to introduce farm planning legislation. The “Crop Rotation Act” determines the minimum rotation length of a crop and disallows certain crops on slopes greater than 10 degrees. Potatoes are rotated with wheat and then hay. The levels of nitrate in ground water and surface run off into water ways are a concern not only in Canada but right through out the world. One of the major contributors to this on PEI was the spreading of animal waste such as pig, chicken and cow manure. With the environment under a lot of pressure, the government forced farmers to come up with an environmental plan for their farms. This plan was an assessment and action plan prepared by the farmers,

government bodies and outside consultants. The process is designed to be at no cost to the farmer by utilizing existing government departments. The plan includes an action plan and timelines with follow up visits from the coordinators to help maintain the process. The plan is meant to overlap quality assurance system like Hazard Analysis Critical Control Point (HACCP) that a lot of producers in Australia run.

To prevent fertilizer losses, it is essential, that an integrated approach to crop management be used. A sensible fertilizer program for potatoes should therefore, be based on soil test recommendation, tissue tests, yield goals and previous crop.

I will not deal with application rates of fertilizer as they vary widely with soil type, texture, structure, organic matter. As it is here in Australia, soil test results prior to planting provide the best information to the farmers for determining the crop response to applied fertilizer, it also indicates whether or not there is a need for most essential nutrients. Although soil tests can be used to predict fertilizer recommendations for crops the accuracy of the test can vary greatly under irrigation. This is because nitrogen can move rapidly in particular in irrigated sandy soils that the majority of crisping growers that I visited in the US and Canada preferred to grow in. To combat this problem the combination of soil testing, tissue analysis and the split application of nitrogen was being practiced. Tissue analysis was being used during the season to monitor nutrient deficiencies. This procedure was particularly useful for monitoring nitrogen and the impact it has on the end use of the potato. If the tissue testing revealed the potato plant to be lacking in nutrients, additional fertilizer applications through the irrigation system were implemented. This type of management was not only important from a crop production viewpoint but also an environmental one.

Keeping records of the nutrient levels over the years helped most of the farmers I spoke to, make fertilizer management decisions easier. This practice was also reinforced by Dr Miller of the Texas Agricultural and Mining University in College Station and Dr Rykbost of Klamath Falls Oregan, when I met with them in October 2003. Nitrogen, phosphorus and potassium recommendations are all based on the combination of the soil and tissue tests. The use of micro nutrients such as boron, zinc, copper, iron, manganese, molybdenum and chlorine can be applied depending also on the results of the soil and tissue tests.

Potatoes have a relatively shallow root system and it is common practice as it is here in Australia and in both the US and Canada to band the fertilizer two to three inches below and two to three inches to the side of the seed at planting. Fertilizer containing Phosphorus, Potassium and Zinc

were being effectively incorporated into the soil in the autumn before the onset of winter, when the ground froze over. Timing of fertilizer application and placement, was largely a matter of individual farmer's choice.

BMP should guide the growers both economically and agronomically, when selecting the most appropriate fertilizer for annual production. The nutrient requirement of the plants and soil, tissue results and desired yield levels and the impact the nutrient requirement has on quality, should be considered.

Irrigation

Water, as it has been in Australia for the 2003 season, has been an issue in Nth America. Acquiring it, keeping it, and how to use it more effectively are the common challenges that Australian and Nth American farmers face for the future. Managing water in agriculture will become increasingly important as competition for this resource outside agriculture in particular becomes more demanding. Urban expansion, environmental flows in river systems and secondary industries, are demanding more each year. The true cost of water is starting to be factored into the policy development of natural resources by governments at all levels. These water challenges present themselves in the form of environmental concerns, both legally and legislatively.

It is globally accepted that irrigation scheduling is critical to growing quality potatoes. Proper water management can result in high yields and increased net returns on the asset. In the US and Canada there has been a concerted effort by all sectors of the industry in getting the message across to farmers on the importance of irrigation scheduling on potatoes using sound, scientific data.

While visiting Washington State I had the opportunity to meet with Dr Robert Thornton a leading potato research specialist at Washington State University in Pullman, where I was able to discuss the following aspects of irrigation scheduling. Potatoes are more sensitive to moisture stress and fluctuations than most other major agronomic crops. The frequency and amount of irrigation will depend on the water holding capacity of the soil, the crop growth stage, and the weather conditions. Water stress affects the development of potato vines, foliage, roots and tubers. The most accurate nitrogen recommendation can literally be washed away with poor irrigation management. Good management of irrigation influences the development of a potato plant during the four stages of its growth cycle, 1) vegetative, 2) tuber initiation, 3) tuber bulking, and 4) tuber maturation. Water stress can also contribute to several diseases and disorders in potatoes. These disorders and diseases include such problems as common scab, brown centre, growth crack and verticillium wilt.

Over the years a number of scheduling methods along with appropriate decision criteria have been developed, this incorporates the irrigation management around the 4 stages of growth. In considering this during my tour through the USA and Canada, it was evident that the most popular form of irrigation was using the Centre Pivot system. This enabled farmers to implement their irrigation schedules. Compared to the Neilsen Gun traveling irrigator and Solid

Sets, which under windy conditions have lower irrigation uniformities, the advantages of using the Centre Pivot offered a more uniform and environmentally friendly application of water, therefore, the most appropriate system to use, to abide by the irrigation schedule. Another important aspect of this style of irrigation is that it is cost effective, furthermore, keeping crop costs down. The development of low pressure pivots to increase irrigation efficiencies was in a direct response to the increased energy costs.

Other analytical tools used to aid in irrigation scheduling other than the soil feel method are Tensiometers, Enviro-scans and Watermark Data Logging Systems to gauge soil moisture status. This status is read by setting the fullpoint, which is the wettest the soil can be around the potato root zone, and the refill point, which is the driest point before the plant demonstrates water stress symptoms. Evapotranspiration rates will impact on these readings, so in order to effectively irrigate, these said rates need to be considered when deciding on final water application rates. When visiting the Klamath Falls Research Station, it was shown to me how the evapotranspiration rates are calculated and subsequently recorded. These rates are widely advertised daily through the web, radio and newspapers.

Given that our country is one of the driest in the world and drought is a major influencing factor on crop survival, water presents as a precious commodity. BMP on our farm in Bundaberg will combine the two systems and will lead to the final irrigation scheduling being more efficient.

Seed

As it is in Australia, the potato growers of the US and Canada all acknowledge that seed quality is a major contributer to precision stand establishment and crop yield. Therefore, obtaining quality seed from a certified grower is essential. With a combined population of approximately 300 million, competition is alive and well in the US and Canada.

The certified potato seed growing industry is no exception and processing factories take advantage of this. Processing companies undertake scientific breeding programs to develop improved crisping varieties. Once a variety is bred, they contract the commercial growth of the nuclear stock out to plant breeding laboratories. Seed goes through 2 contracted growing stages before it is sold to crisping growers. Initially the nuclear stock growers have to bid for contracts every year, the competition for the said contracts is fierce. That stock is then sent out to contracted, certified seed growers throughout the US and Canada, for the next stage of growth. Unlike the breeding laboratories these seed growers are under longer term contracts. This certified seed is then on sold outside the open market under contract to contracted crisping growers. The annual bidding process for the nuclear stock growing contracts subsequently lower the cost of the seed to the crisping growers and takes the price fluctuation out of the open market price.

In Australia, competition is not as fierce for several reasons, the main reason is market volume. America's consumer size, puts them in a different category to our market, however, their ideas could be adapted to suit the Australian seed growing industry. If there was greater competition within the seed growing industry, grading, packing, transport and storage of the seed product would improve. This would then have a flow on effect to the end cost of the subsequent crop production.

Dr Campbell of the Californian Seed Company, suggested to me that the quality of the seed potato is the most important yield determining factor that the farmer can have some influence on. Farmers need to establish a healthy, long term relationship with 2-3 seed growers to reduce the risk of possible viral contamination or loss of seed through natural disaster. BMP see the farmer source seed only from certified growers, preferably early generation seed and varieties best suited to their specific geographic and agronomic conditions. As with US and Canadian seed supply, the development and use of written contracts outlining the grade, quality, delivery, payment schedules and price of the seed should be considered.

Planting Performance

With the cost of producing a crop of potatoes increasing each year due to domestic and international issues, as in Australia, farmers in the USA and Canada, have been focusing on the concept of precision stand establishment, or in simpler terms, getting a good strike. These concepts include knowing the physical age of the seed, precise machine cutting, bruise free handling of seed potatoes, seed spacing, fertilization and planting depths.

Seed piece spacing is one of the most important factors under a growers' control. In the US and Canada, specific plant population densities for standard cultivars, like the Russet Burbank (RB), have developed through trial and error, for specific markets and geographical locations. These trials were widely carried out by both researchers and growers. The most common plant densities in use for RB in the US and Canada was on 91 cm (36 inch) row spacing, and 28 cm (11 inch) between seed pieces. To obtain plant spacing and population it was suggested that only certified seed cut/whole, sorted by size, be used for planting.

Variability of planter performance can be attributed to many factors such as seed shape, size, tractor speed and design of the planter. After speaking with a representative of Mayo Manufacturing, Inc., which manufacture the Harrison Potato Planter, it was established that one of the largest problems that mechanical designers face, is that most growers use cut seed, the irregular shape of this cut seed makes designing difficult.

The difference between planter design and subsequent use, among seed and commercial growers, came down to the potential risk of spreading disease. In saying this, the US commercial growers felt comfortable using the needle planters, despite the risk of spreading disease via the needles, over the cup planter for several reasons. The main one being, the accuracy the needle planter gave them when using cut seed, this meant not having to man the planter to ensure even seed distribution. As the farmers used certified seed, they were able to use the larger cheaper seed, as apposed to the more expensive premium small seed because they were cutting it prior to planting. Ironically, both commercial and seed farmers of Australia have favoured the cup planter over the needle planter, as have the seed growers of Northern America, because cup planters have less chance of spreading disease compared to a needle planter.

In contrast with Australia, where most farmers use two and four row planters, through out the US and Canada the use of four and six row planters is popular, with eight row planters becoming more common. An assessment on the accuracy of planter performance was done in the US to ascertain the economic impact that skips, double ups and misses have on yield and return. As discussed with and concluded by Dr Mike Thornton of the University of Idoho, misses and

irregularly spaced potato plants do impact on grower returns. Dr Robert Thornton of the Washington State University suggested, along with growers and other researches, that plants were missing in the potato fields because more times than not, planters fail to plant consistently. New planters, such as the vacuum planters, in theory, seem to address skips, misses and double ups, however, the planter has not yet performed at a high level and therefore is not widely used by growers.

As part of the BMP, planters should be maintained and calibrated to plant seed at the correct depths, spacing and densities. Monitoring planter performance on a regular basis will lead to having a healthier precision stand establishment.

Crop Rotation and Green Manure

For crop rotation (CR) and green manure cropping (GMC) to be successful, it needs to be established what disease or soil borne pathogen is impacting on your crop. On the family farm in Bundaberg Root-knot Nematode (RKN) is the main issue to be addressed, however, preservation of soil fertility and erosion prevention would also be considered. A GMC will increase the nutrient and organic matter levels in soil, water infiltration rates, water holding capacity and aeration. Used in conjunction with appropriate CR, the biological changes that occur in the soil, will also lead to better management of soil borne pests. Providing the GMC or rotated crop does not present as the host for the most troublesome pathogen (nematodes are known to have a broad host range), the benefits will be advantageous to the ensuing cash crop. Many of the farmers I spoke to used forage sorghum as it is particularly effective when used as a GMC as it does not host RKN. It grows rapidly, smothers the underlying waste crop and weeds that may be pathogen hosts and then creates large quantities of biomass.

Studies being carried out at Washington State University were investigating the process of biofumigation. Whereby the brassica crops (such as rapeseed, mustard, and sudan grass) contain biologically active chemicals, which break down into isothiocyanates (ITCs) and can kill or suppress some soil borne diseases, nematodes, and weed seeds.

ITCs can vary in their toxicity to different pests. ITCs produced by plants are known as biofumigants. This research is ongoing.

RKN is a common pest in potato crops and has an extensive range of host plants. Many farms I visited on the tour had RKN problems and Dr Rykbost of Klamath Experiment Station stated that RKN is a prominent pest in irrigated potatoes in the US. The main reasons why GMC are used are because of the impact the chemicals are having on the environment, the availability of them in the future and the high costs involved in purchasing them. Many of the chemicals used have been or are being, taken off the market (for example Temik and Methol Bromide), thereby, prompting alternatives to be used. To successfully manage nematode populations, a range of strategies need to be employed including prevention of spread, CR, early harvest, planting GMC and treatment with nemacides. A combination of these will give the best results, however, results will differ with soil types, weather condition, incidences of pathogens and planting density.

In suggesting this, it is acknowledged that even though Temik was taken off the market due to the impact it was having environmentally, it was reintroduced in the North West states of Idaho, Washington and Oregon because it was the most effective control against RKN. In Australia, Temik is not registered for use in potato production.

Conclusion

Gaining a Nuffield Scholarship gave me a unique opportunity to visit growers and researchers in another country and bench mark my BMP with theirs. It is very difficult to come to a conclusion when bench marking due to so many variables such as climatic conditions and government legislation, but in saying this you can attempt to modify your management practices accordingly.

Whilst technically I believe we in Australia are on the same level, and in fact in some areas a bit more advanced, in particular in water scheduling due to the extreme conditions experienced here in Australia, and lack of agricultural land that has a supportive water infrastructure, Nth America is unquestionably the world leaders in farm logistics. The machinery that they plant, harvest and store with can move volumes. Competition within the industry has also afforded the consumer at all levels of the production chain a lot more choice than here in Australia.

When visiting a crisping potato grower in Florida I was amazed at the volume of potatoes he dug and shipped out in one day while still managing to maintain a high quality product. I asked him how he achieved this and he replied "Graham, I get it right in the field".

Successful potato crops are reliant on getting BMP right in the field. Openness to new technology and techniques, being able to identify inefficiencies, knowing unit costs, and having the ability to integrate these factors into your business pave the way to sound agronomic and economic best management practices.

Another vital aspect of BMP is complete and careful record keeping. Farmers need to know the cost of production for each unit of potato yield so they can modify management practices. The use of computer technology to collect and record this data is both possible and practical.

In this report I have identified several aspects of production of potatoes that I felt would be of benefit to managing our business. All of these aspects are ones which I can control, and through the use of BMP, allow the potato to achieve its maximum economic yield.

Every farmer has the capability to grow good potatoes. There is enough information and technology made available globally today that is easily accessible. Farmers can use this information to then formulate their own BMP.