Grain Production in Low Rainfall Environments: A World View

A report for

By Stuart Barden

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Foreword

In today's agriculture the world wide issue that is discussed above all others is water. Water is the limiting factor in many agricultural systems world wide and it is with this in mind that I have embarked on my Nuffield studies.

Perhaps rainfall is not limiting our grain growing as much as our thinking may be?

My study focus was "Grain growing in low rainfall environments"; my findings have been distilled from many discussions and evidence that conspired to form a consensus of opinion in my mind.

My hope is that these findings might assist others in doing better with the resources we have available. This report was compiled with my fellow Australian farmers in mind as to the audience.

A fellow in Western Australian 20 years ago told me the following and I feel it rings true today. "Many farmers don't miss production because they have never had it to begin with"

As farmers we often meet disappointment and over time our expectation of what is achievable is often lowered.

With passport in hand I travelled the world looking for what I would call 5% solutions which make up the pieces of the low rainfall grain production jig saw puzzle.

I also had in the back of my mind a quote from C.S.Lewis

"We all want progress, but if you're on the wrong road, progress means doing an about-turn and walking back to the right road; in that case, the man who turns back soonest is the most progressive."

C. S. Lewis

And with that I welcome you to my report and hope that it contains something of value for you.

Acknowledgments

- To my wonderful wife who held the fort at home whilst I was travelling, also our children who all rose to the occasion and pulled together in my absence.
- All those who chipped in to allow my absence from our business.
- Grains Research and Development Corporation (GRDC) for their support, as with out their support my study would not have been possible. A Nuffield scholarship is a once in a lifetime opportunity and I thank GRDC for investing in the Australian grain industry through Nuffield Australia.
- Jim Geltch who seems to know someone in every country and leaves nothing to chance on the organisational front.
- The Previous Scholars who passed on a great deal of valuable advice.
- My fellow Scholars whom have become friends and provided me with encouragement to do better.
- To the many overseas contacts who gave their time and attention to assist my studies.
- Chris, Jan, Ronald and Liz for your editorial assistance.

THANK YOU

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Executive Summary

This report is the combination of both new and existing views of the author. It covers how we as grain growers view rainfall and residues, as well as some blue sky thinking, together with the opportunities I see ahead to improve growing grain crops in low rainfall environments.

There are vast arable areas in Australia and over the world that are underutilized. Many areas currently grazing livestock, producing low meat and fibre yields, can and should be growing grain, as the conversion of water to grain is by far the most efficient use of these limited resources.

Protein from grazing animals on arable land that has sufficient rainfall is a luxury that the world may not be able to sustain into the future.

The results of my study into "Grain growing in low rainfall environments" have been a realization that Australian farmers are at the forefront.

In saying this, there are some very interesting lessons to be learnt from two particular grain growing areas I visited.

One was in Western Canada and the other was in Kenya. These environments have gentle grain-filling temperatures and even in what we in Australia would consider being low moisture availability seasons, these environments gave significantly higher yields than we could expect from similar amounts of available moisture in Australia.

My conclusion to this study topic is that if we are to have a significant improvement then we must look at moving our crop flowering and grain-filling away from the spring and into the softer/low evaporation conditions of late winter. This will involve additional scientific research to enable plants to tolerate lower temperatures.

There is other fine tuning also that will require us to manage our crop residues in a much more considered and targeted way.

Grain growing in the lower rainfall zones of eastern Australia has a bright future and it is my belief that in five to ten years we will see land that is now considered marginal change to being much more reliable cropping country.

In Australia Climate change has rightly or wrongly high jacked a great deal of research funding away from what I would call production research.

Nowhere else in the world did I see such an imbalance in funding for productive agricultural research as we have here in Australia.

In saying the above I had some Canadian researchers tell me that on occasions they do not seek government funding as 50 cents without an agenda is sometimes preferred.

I believe that low rainfall graingrowing is a challenge that we as an industry can largely overcome given research and innovation on the production side.

We hear a great deal of talk from Biotech companies running alarmist campaigns in relation to food security. This has been picked up by many academics who also promote the myth that we cannot feed our selves as a world into the future.

There is no inability to produce enough but rather an unwillingness to pay a value that encourages agriculturist to expose themselves to the risks associated with such production.

Introduction

Hello, my name is Stuart Barden and my wife and I operate a grain growing business in the central west of NSW. We grow principally wheat and chickpeas in three different locations that have between 80km and 250km between the various properties. This geographical spread is aimed at giving us some diversity in seasons.

My choice of subject is based on my belief that there is great potential to be realized in the lower rainfall cropping areas in Australia. These beliefs lead me to search the world for answers to questions some of which I had not yet asked. I attempted to have an open mind, looking for keys to help Australian farmers do better than we are at present.
My aim in this report is not to produce an expansive prescription on how to grow grain crops in low rainfall environments but rather keys towards unlocking the great potential that exists in our drier grain growing environments in Australia.

We are in a world of information overload and it is with this in mind that I have attempted to evaporate the water and just present the essence.

This report aims to encourage the reader to think differently about the constraints and opportunities we as grain growers are presented with.

My study was primarily focused on any techniques or different approaches with regard to the physical and financial aspects of growing grain crops in lower rainfall zones in Australia.

Chapter 1:- Looking at rainfall with different eyes, a paradigm shift, Micro water harvesting

How do we as grain growers look at rainfall? It appears that we look at it through the same eyes as we did 100 years ago. We talk in terms about receiving 25mm on our farm and our neighbour receiving 23mm or 27mm.

My view is that if we want to take a step forward in rain-limited grain growing systems then we should be looking at more than just millimetres. What I am suggesting is that we start to talk about the total rainfall over a given area and then confine our planting and fertilization to 20% to 30% of the total area. The balance of the inter row (the area between planted rows), would be essentially only water catchments and would also be devoid to a large extent of crop residues, both standing and loose. The ideal, of course, is to maintain 100% residue cover, although in many lower rainfall zones I feel that this is unrealistic with current genetics.

There is great scope with summer crops in combination with current skip row configurations and current best practice, (e.g. zero till/controlled traffic operations,) to direct crop residues onto plant line rows. The residues created by cereal crops, for example at grain yields of less than 2.5t/ha, struggle to do their job when broadcast over 100% of a field. In moisture limited environments this is a "Catch 22" situation i.e. you need residues to preserve moisture although you need moisture to grow residues.

I realize this is an age old problem and that is why I believe we need to view it differently. Once again, I believe that if we are to move in the right direction, there needs to be a shift from thinking about millimetres per hectare, to looking at the total rainfall on our farms. We need to start to think of rainfall as irrigation farmers do, in terms of mega litres available in total.

Micro water harvesting Negev desert, Israel

The above photo is an example in the Negev desert in Israel where low rainfall (80mm per annum) is supporting trees planted in micro catchments. This system maximises runoff from non-productive to productive areas. This is a very simplistic illustration and is making the point that there are different ways of viewing rainfall.

I believe that changing the way we view rainfall will assist us in developing better methods of producing the greatest yield per mm of rainfall, although there are obviously many issues to think about in relation to this approach. For example, evaporation is a major constraint to this approach although with better crop residue management I believe we can minimize the negatives and maximize the positives.

Farm A

100 hectares 600mm per annum rainfall

This farm is in what we would consider is a good rainfall zone (summer/winter distribution) and capable of producing approximately 3.5t to 4t hectare on average.

Farm B

150 hectares 400mm per annum rainfall

This farm is in what we would consider to be a low rainfall zone (summer/winter distribution) Traditional thinking would consider this rainfall to be marginal for crop growth. However if we start to think in terms of only planting and fertilizing row zones, using the inter-row as water catchments for the row zones then this opens up the possibility for greater/more stable yields.. Obviously, controlled traffic farming is also essential as placement is critical in planting operations.

Chapter 2 - Financial risk in lower rainfall environments, managing the financial risk

Economics are at the core of the decisions we make as grain growers in Australia and therefore not to touch on such issues would be remiss.

In terms of global comparisons I found few examples of leaner operations than in Australia. This however is not to say that many Australian grain producers are not over capitalized with regard to machinery because, in my opinion, many are.

Machinery cost is emerging as a significant issue in terms of remaining viable, particularly in lower rainfall zones around Australia. The following points look at this matter in further detail:-

- Wider geographic syndication of machinery. An example might be a Victorian farmer owning harvesting machinery in collaboration with a northern NSW farmer.
- Greater use of contractors for specific operations. With the lack of highly skilled labour on Australian farms there are certain machines that many farmers should not own. In low rainfall environments we must strive to run lean operations. Just as some operations are best done by a contractor so we must use our machinery to maximum advantage. This may mean that we also do contract work for other farmers to fully utilize our necessary equipment.
- Thinking outside the box in relation to minimizing the capital required to farm a given area will be key in the future to operating in a financially viable way in the lower rainfall zones of Australia.

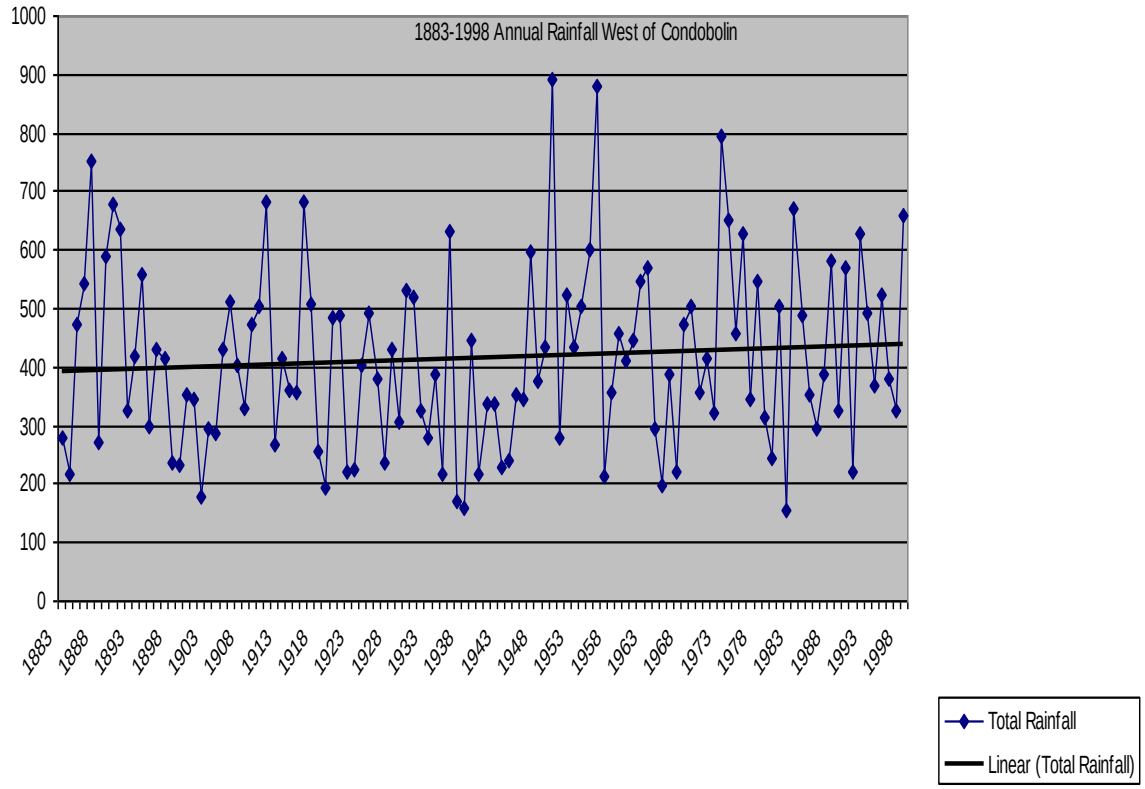
It is my belief that “profit is the reward for risk and therefore the better we are at managing risk then the more profit we can expose ourselves to”.

There are no simple formulas to assess risk whilst growing grain in lower rainfall areas although the following points are, I believe, somewhere to start.

- In low rainfall zones we must have a medium term view. By this I mean we must gear our business to be able to handle back to back loss -making years. Whilst no one likes to take a loss we must understand the volatility that comes with these lower rainfall environments. So not to misrepresent the profitability of these areas it must also be realized that the top 20% of operators are achieving around 10-15% return on investment over the medium term. Conservative gearing and or

geographical/financial spread are necessary to successfully survive and prosper while growing grain in these lower rainfall zones.

- We must study historical rainfall and use this information In order to make calculated judgments in relation to risk. Below is a graph showing 115 years of rainfall data from a site west of Condobolin. This variability from a low of 150mm to 900mm pa demonstrates the challenge in management.



The above Graph was created by the author using rainfall information from "rainman"

Chapter 3 – Climate - interaction with rainfall and their relationship to grain production

The Climate in which a particular rainfall occurs will obviously have a significant influence on the effectiveness of that rainfall. Elevation, evaporation, temperatures, humidity, wind speed and many other things make up what we collectively call climate.

The climate we as growers experience, will be unique to some extent, although this doesn't mean that there are not truths that apply to all.

Below is a photo of wheat being harvested at 8500ft on the northern side of Mt Kenya. Owing to the mild conditions that accompany this altitude the crop yielded 3.7 t/hectare in a drought year that only gave them 170mm of "In crop rainfall"

Photo above: Wheat harvest Mt Kenya at 8500 feet above sea level

It was a similar story in Alberta, Canada in the 2009 season where many well managed crops produced 3 to 4 t/hectare of wheat on 150mm to 170mm of total available water. This highlights the tremendous benefit that low evaporation/cool finish environments have.

In saying that, we in our winter-growing season in Australia have generally a low evaporation environment although it is the rising temperatures of our spring that cause our crops the greatest harm in regard to grain fill.

A huge improvement to lower rainfall environments grain yields could be obtained if we could reduce or eliminate the frost risk to our crops. (More on this in ‘Blue sky thinking)

I believe that a 25% yield increase would be easily achievable given the absence of frost risk and the resulting ability to have our grain crops filling in soft conditions. There should also be a massive reduction in losses associated with crown rot due to the lower stress filling conditions.

Chapter 4 - Biomass management, tools and techniques

In moisture- limited grain- growing systems, there needs to be a balance obtained between biomass production for a given yield, weed competition by the crop and the need to get ground cover to reduce evaporation from the soil surface.

These issues are in some ways in conflict with one another and therefore a systems approach is needed to negate the negatives and maintain the positives.

My current view is that we should be attempting to reduce the Biomass (the plant) and match this growth better to the grain yield so as to make the most efficient use of the limited water available.

Many other issues rear their head such as "If crop residue is so valuable then shouldn't we encourage it?"

My belief, after seeing rain fed crops around the world on the lower end of the rainfall spectrum, is that we must use our crop residues in a much more strategic way. (There is an explanation of one of these ideas in relation to the management of residues in a previous chapter "Looking at rainfall with different eyes,")

One of the most obvious ways to manage the water use of our crops is by using different crop types and hopefully in the future we will see lower biomass varieties of crop types that we currently shy away from in the lower rainfall areas of Australia. Canola is one such crop. Canada appears to have made some advances in lowering the biomass of Canola. This holds some promise for us in Australia that through breeding we may also have these traits available.

Research carried out in Western Australia by Dr Paul Blackwell over three years has clearly demonstrated the possibilities in regard to using wider rows with various plant densities. A summary of this work was published in the "Australian Grain" magazine in March/April 2007.

As with many agronomic tools we need to appreciate that one technique is just that, "One Technique", and to view it as just one ingredient as if making a cake. As with any recipe all the ingredients are required. That is where many times we fail, in not only commercial operations, but also many times in research. We must always think about the overall system.

I realize this is not earth shattering or new thinking although our short term project driven research in Australia needs a shake up as well as the grower thinking that "This type of planter will fix my enterprise"

On the topic of funding for research, I was told by three Canadian researchers that on occasions they have not sought government funds that were available for particular projects. Their view was that on occasions 50 cents spent without an outside agenda was more value than gaining another 50cents with strings attached.

In Australia it appears that climate change has hijacked (rightly or wrongly?) vast amounts of funding and those funds that are still available have many climate change strings attached. We as a grain growing industry probably should become much more independent of others agendas.

Chapter 5 - Crop types and their suitability for low rainfall environments

The author in a Canola crop in western Canada

The above canola crop is in Alberta Canada and is a good example of lower Biomass still giving good yields. This crop was estimated by Steve Larouque (Beyond Agronomy) to yield 1.8 to 2t per hectare. In comparison to canola grown in Australia there is less biomass for a given yield.

Obviously Canada has a different growing season, although the fact is that these and greater yields can be carried on this amount of biomass.

Whilst the great majority of Canola is Genetically Modified (GM) in Canada, it would be a mistake to think that GM is responsible for the increasing yields over time. In fact, it is the concerted breeding effort that has resulted in superior varieties and yields.

The GM side of the equation has been aimed at particular traits mainly in relation to herbicide tolerance.

Canadian producers also see a very real threat, in that one or two of the larger seed companies could establish an effective monopoly or duopoly of the canola seed market.

Chapter 6 - Residue, Low rainfall grain productions best friend

The first question to ask is "Will we ever have enough crop residues to have full ground cover?'' My opinion is that in a 350mm to 500mm rainfall zone (summer/winter distribution) full ground cover is unrealistic (with current genetics) and therefore we need to look at this issue with different eyes. I believe that we need to be much more strategic about how we deal with our valuable residues. Observations I made in Kenya crystallised my opinion that we must be more deliberate in how we use our crop residues.

I believe there needs to be a serious rethink on the residue placement issue, whether this is through using stripper fronts in cereal crops to leave more residue where it stands or new ways of spreading 100% of the residues on only 30% to 50% of the total area. Controlled traffic farming is a foundation block that will be necessary if we are to achieve the level of residue placement that will be required.

The photo below shows a Neem tree and the mulch created by it. This area in Southern Israel has an average rainfall of 15mm per year. Although these Neem trees do receive a small amount of irrigation, nature is showing us how important ground cover is.

Above Photo is of the leaf litter under a Neem tree in southern Israel

From Tanzania to Canada the theme is

RESIDUE

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BETTER MOISTURE INFILTRATION

↓↓↓↓↓↓↓

BETTER MOISTURE RETENTION

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MORE AVAILABLE PLANT WATER

↓↓↓↓↓↓↓

BETTER CROPS. Quite simple really!

Chapter 7 - Blue Sky ideas

This picture below is of a trial being carried out at a research farm in south west Saskatchewan. Research scientist Brian McConkey with the Semiarid Prairie Agricultural Research Center is trailing what he calls 'bunch seeding.' Using the same seed and fertilizer rates as the control, the trial has two spacings between the "bunches" (25cm and 50cm). As a biomass management tool this approach has merit. The early results have shown an equal yield to the standard configuration which surprised Brian. At the time of writing these trial results, although harvested, had not been collated.

In South West Saskatchewan the conditions do not favour tillering in wheat therefore I believe that this method should give a greater benefit in an Australian context as the competition within the bunch should reduce and enable better tiller number management This should reduce the water transpired by the lower biomass. As to how we as growers could plant in this manner, I am sure a system can be devised if the benefit is great enough.

The Above Photo is of a "bunch seeding trial" in south west Saskatchewan.

Work done by Lawrence V. Gusta at the University of Saskatchewan on supercooling water in plant cells, shows there is potential to control the freezing of plant cells. The publication"Plant Cold Hardiness from laboratory to field" (ISBN 978-1-84593-513-9) which is a "collection of invited and selected papers on plant cold hardiness that were presented at the 8th International Plant Cold Hardiness Seminar hosted by the University of Saskatchewan in August 2007"

The following extract from this publication sheds light on the possibilities that exist in relation to frost/freeze tolerance in grain crops.

"Possible new avenues for investigation include; screening for variation in supercooling ability and ice nucleation resistance or interruption of ice nucleation using externally applied agents; resistance to chilling damage; constitutive expression of chilling damage; constitutive expression of frost resistance; an unlocking the potential for expression of cold resistance genes during late stages of Development" (p 17 "Plant Cold Hardiness from laboratory to field")

Moving grain crops flowering/filling period into the cooler months would result in possibly the greatest step forward in grain production seen since zero till/no till techniques were developed.

There is a great deal of Australian research quoted in the above mentioned publication and this is encouraging .Research into developing frost/freeze tolerance/resistance in grain crops should be high on Australian grain grower's research priority list.

Recommendations/Conclusions

The recommendations that come from this report are.

1) Strong research focus needed on freeze/frost crop tolerances.
2) Ground proofing various residue placement strategies within a systems approach.
3) Greater effort needs to be made to reduce the biomass of common crop types to assist with the water use efficiency of crops.

References

Agronomy Journal (American Society of Agronomy Publications)

Plant Cold Hardiness, From the Laboratory to the field

Exploratory Soil & Agro-climatic Zone Maps of Kenya

Agriculture, Ecosystems and Environment Journal

Plain English Compendium Summary

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Objectives	The objective of my study was to identify techniques that have potential to add value to Australian grain-growers who grow crops in lower rainfall areas around Australia.
Background	Rainfall has long been a limiting factor to grain-growing in many regions of Australia. It is against this background that I set out to investigate potential advances/concepts that could be of assistance to Australian grain-growers.
Research	My research was conducted over six months and nine countries. This report has been distilled from meetings with researchers, farmers and observations both on farms and at research facilities. I have also studied specific research documents relevant to this study topic.
Outcomes	This report is in the form of some practical solutions/observations together with new questions. The greatest outcome will hopefully be a renewed focus upon the issues that limit grain-growing in lower rainfall environments.
Implications	The implications of this reports findings are that there are significant advances to be made in a number of areas. This should give grain-growers in lower rainfall areas some encouragement. Although this report is unlikely to influence specific research my hope would be that existing and future research may find solutions to limitations identified by my report.