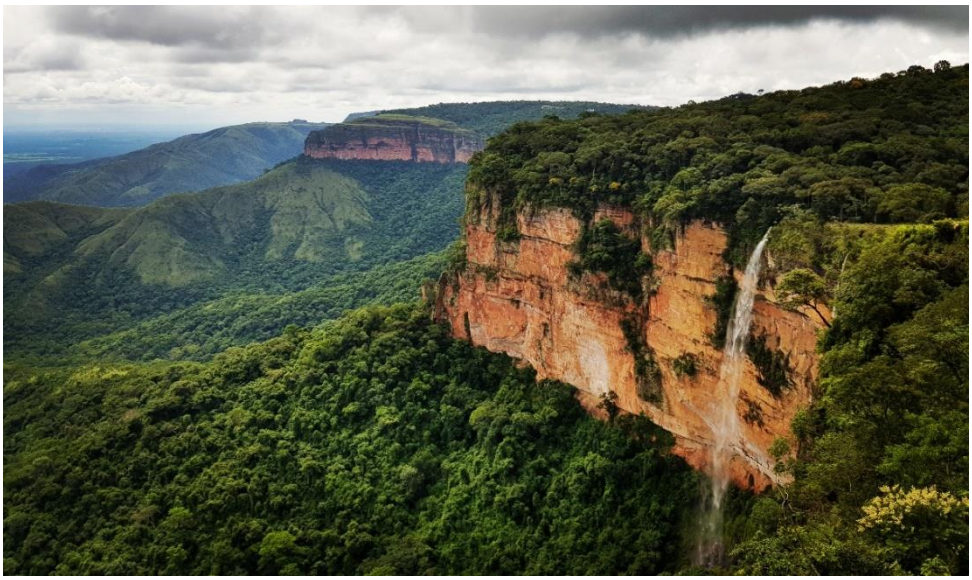
Brazil – O Novo Horizonte

A Report for

By Robert Yardley

John Platt Scholar 2017



Photograph by R. Yardley. (2018)

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1.0 Summary

- Weed resistance developed in six to eight years in the region of Mato Grosso following the introduction of GM crops.
- No-till row crop operations were observed to be an enhancing factor to yield output, whilst also aiding weed species to develop resistance toxins.
- Penetrometer mapping can act as a means to alleviate compacted soil profile zones and maintain yield output in a commercial agricultural environment where shareholders expect return levels to be maintained.
- Introducing significant levels of disorder are required to maintain an environment preventing species from adapting and overcoming any form of order.
- “We cannot solve our problems with the same thinking we used to create them” – Albert Einstein (Keyfacts, 2017).
- Methods of biocontrol surrounding pyrethroid use and Cabbage Stem Flea Beetle have significant levels of potential within UK agriculture.

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2.0 Forward

Returning to agriculture in my early twenties, after associating it with my happiest childhood memories of ‘carpet farming’ I accepted a job on an arable farm in Buckinghamshire. This quickly evolved as I chased my dreams of driving large pieces of machinery, allowing me to work in New Zealand, Australia and various places in the UK.

As I travelled and worked it became clear my interest in the topic of ‘agriculture’ was deepening, as I became passionate about all aspects of agriculture and how the interlinking aspects of tillage farming interact with nature and its evolution. Unsure of how to pursue my goals due to full time work, the answer came when I fortunately discovered Reaseheath College conducted a one day per week FdSc course in agriculture. It was here I discovered my love for science, research, trials, inquisitive nature, disruptive innovation and learning.

In 2016 I moved to North Yorkshire to join Velcourt, a leading farm management company whom I’d always aspired to work for throughout my agricultural career. Within Velcourt we (the company) are always challenging ourselves and reflecting on our current practices to ensure they’re sustainable, efficient, cost-effective and profitable. Enabling the businesses we manage have healthy future perspectives, are secure and can continue to reinvest in people, property, technology and the future of the business. Although we already do this, I feel there is so much more potential to unlock, both as a company and an industry.

During this period as a professional manager, influences from continuing political shifts and information feeding from other countries led me to analyse certain plant protection products (PPP’s) and their implementation strategies, as well as differing methods of crop production and the mind-set / perspective of the farmers who grow these crops.

For this area of study I had no idea where to travel, my choices were Eastern Europe, Germany, France, North America or even at a push South America. I had travelled to both Eastern Europe and Germany on previous trips. Feeling as though I would gain very little from returning to these countries again, I decided to push myself completely out of my comfort zone and opt for South America.

Specifically I decided to opt for Brazil, with the reasons for this being the following:

- Accelerated pathway development
- GM Crops
- Suspected glyphosate resistant weeds
- No.1 agricultural country for productivity (Andersons, 2017)
- Single, double & triple cropping
- 40 – 60 % clay soils in Mato Grosso region
- Main cropping areas entering commercial use in early 1980's
- Unique crops: soya, corn, cotton, sugarcane.

3.0 Acknowledgements

I would like to take this opportunity to thank Westchester Group Ltd for their continued support and special contribution towards the planning and organisation of the travel scholarship. Their help has aided me greatly in achieving the goals I initially set out to achieve and beyond. Utilising their unique framework and business structure has enabled me to gain access to pioneering technology and engage with like-minded individuals within agriculture on a global scale.

In addition to Westchester, may I also take this opportunity to thank my employer, Velcourt Ltd and in particular Farms Director - Ken Shipley, for his continued support and allowing me the time to conduct the scholarship.

I would also like to pay special thanks to the Cheshire agricultural society and Reaseheath College for providing the platform of the John Platt scholarship and to all members' of staff at Reaseheath College who have taught me over the years and helped to develop my way of thinking and personal development. In particular I would like to pay special thanks to Jane Richardson, Phil Gibbon and Mark Biddulph for their unique support and sacrificing their personal time over the years to help.

4.0 Introduction

Between the years of 470 BC – 399 BC lived a renowned Greek teacher and philosopher, known as Socrates. Throughout his life Socrates became known for often disrupting the status quo by questioning public views and creating controversy, altering the way many people viewed learning (Jamie, 2009).

Within the stratosphere of social media Twitter, Facebook and Instagram on the worldwide web, I have found myself during the last 18 months plagued by the luddite hashtag #glyphosateisvital. An exemplary demonstration of British farmers joining forces to campaign to keep a vital active ingredient, whilst also forgetting the minor detail that taxpayers pay approximately £100 per acre, allowing them the privilege to farm.

Today agriculture is moving at the fastest pace it has ever known. Whether it is the latest advancement in genetics or gene editing, new software for GPS telematics and milking robots, or the latest hardware in seeding technology or plough bodies now controlled by GPS – agriculture is a sweet shop!

In order to make the most of my travel award scholarship and the opportunity which was beginning to present itself, the challenge was to break-away from the constraints of typical British farmer thinking. That we are not the best at what we do, we do not play a part on the global stage and our techniques and efficiencies are dated and belong in the history books.

It was at this point I revisited the writings of Socrates students, Plato and Xenophon, in an attempt to develop my thought processes of self-education and learning, allowing me to question what we do as an industry, our technologies and strategies. Socrates believed on the topic of self-education that (Jamie, 2009):

- Wisdom begins in admitting your own ignorance
- Self-knowledge is the ultimate virtue
- People can arrive at truth through questioning

By pushing myself into the surroundings of an unfamiliar nature the aim was to challenge my own way of thinking, developing my level of ignorance. Allowing the question to be presented, *what is normal in agriculture?* in an effort to pursue self-knowledge. By entering into the unknown of my own headspace and challenging my

personal ways of thinking, the question or questions could be broken down into smaller ones, creating the opportunity for the possible recognition of contradictions and the creation of a road map leading to further questions and potential answers.

Socrates once said (Jamie, 2009):

"Although I do not suppose either of us knows anything really beautiful and good, I am better off than he is, - for he knows nothing and thinks that he knows, I neither know nor think that I know".

By pursuing a state of mind, the aim was to free oneself from the ties of everyday culture, allowing me to question the status quo of our contemporaries from around the globe and our own way of farming.

As agricultural practices have evolved over the years, so to have the herbicides and the political environment in which they're assessed. This report will aim to assess:

- The potential options available to UK farmers surrounding agricultural practices and mind-set.
- Are our contemporaries using technology not yet utilised in the UK
- What are our options should glyphosate not be renewed and
- How have Brazilian farmers accelerated themselves to the No.1 country in terms of productivity on the global stage

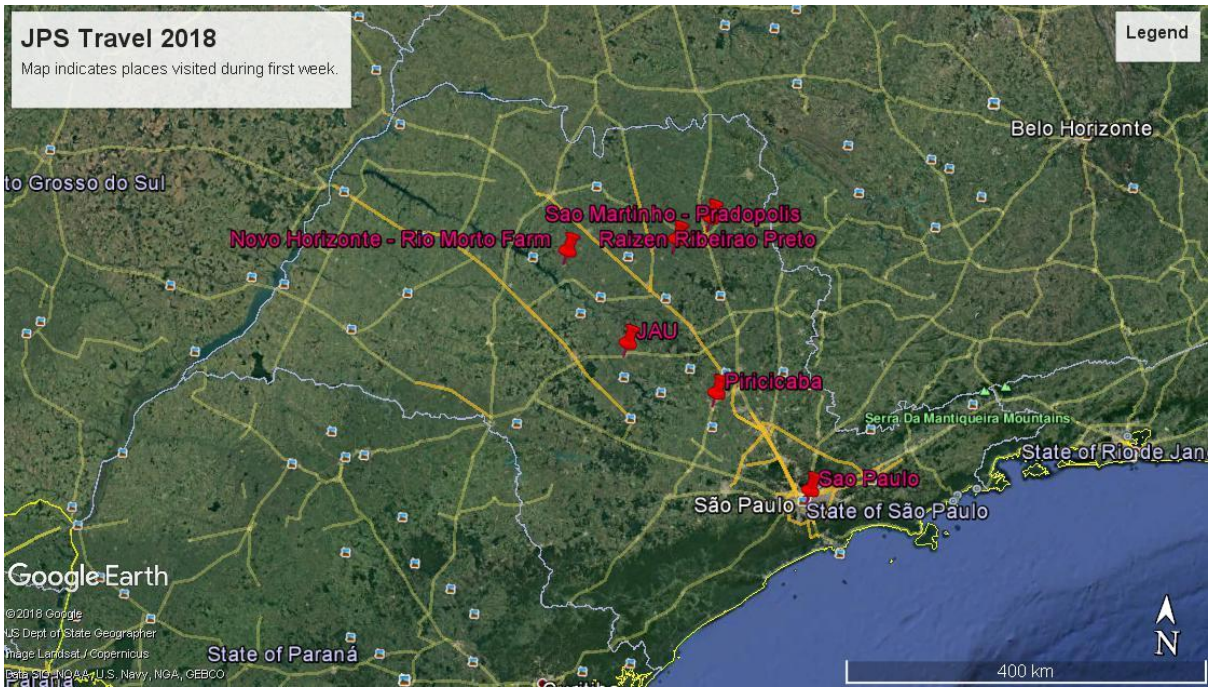
As well as this report aiming to discuss the above points, whilst travelling I also experienced new technology never seen by myself before in the form of bio-control for pests within crops and assessing new drone technology to prevent soil erosion.

I also learned of their education system regarding tillage techniques and how one farmer improved his mental health and personal development using various techniques, which shall be discussed briefly within this report.

5.0 Route of travel

The route of travel for the scholarship took me through Sao Paulo state for the first week observing the sugarcane industry and then to the state of Mato Grosso. It is this region which was of particular interest due to its high level of rainfall, annual average of 2000mm with soils consisting of 50 – 60% clay.

Figure 1: illustrates the route of travel through Sao Paulo state.

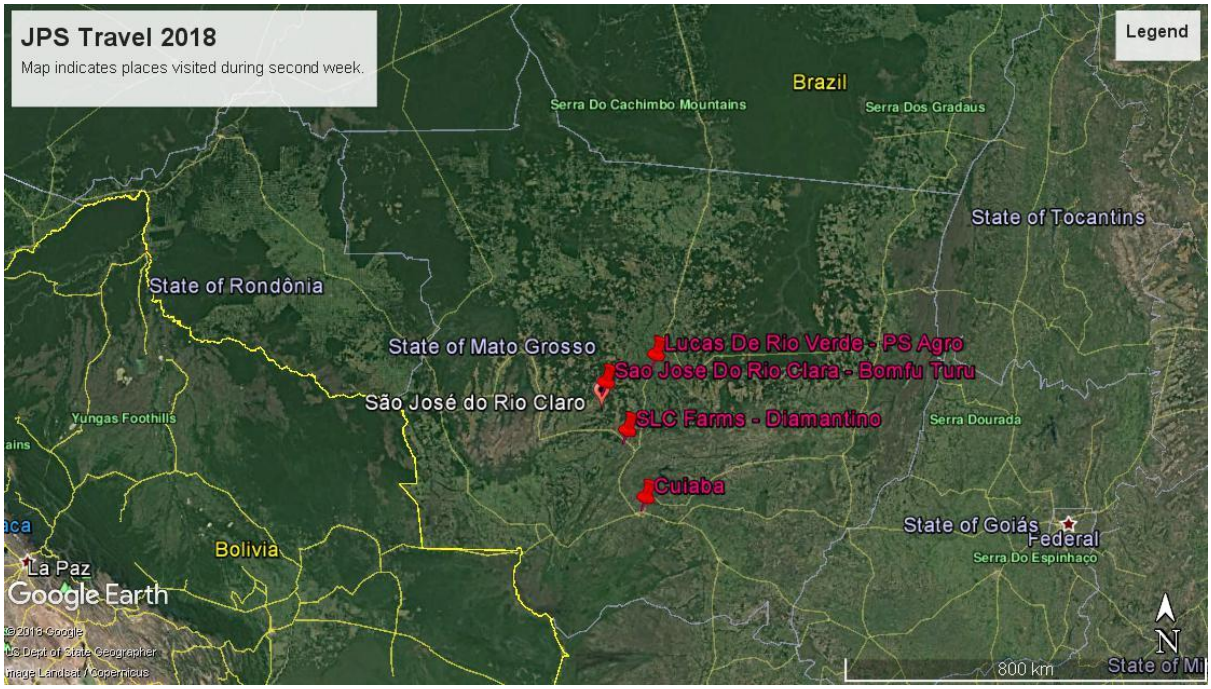


As illustrated in figure one, the route of my travel took the direction of Sao Paulo state, Piricicaba, Jau, Novo Horizonte, Pradopolis, Ribeirao Preto and finally returning to Sao Paulo.

This week consisted of observing and analysing the practices of the Palm Heart and Sugarcane industry. Although not a main focus of my intended studies for the scholarship, the additional visits were organised as they featured within the property portfolio of Westchester Group Plc. These were a welcome addition as it exposed certain practices of innovation which may be applicable to other sectors and opened my way of thinking away from the conventional.

The following image illustrates the route for the second week of travel which took place within the state of Mato Grosso.

Figure 2: illustrates the route of travel through Mato grosso state.



Thanks to the unique land acquisition portfolio of Westchester Group, the route enabled us to view some of the largest fibre and cereal crop enterprises within the state of Mato Grosso. Travelling from Cuiaba, we moved on to Lucas De Rio Verde, Diamantino, Sao Jose Do Rio Clara finally returning to Cuiaba. The farming enterprises visited were:

- PS-AGRO – farming in total 20’000 Ha’s. PS-AGRO first purchased 600 Ha’s of virgin land in early 1980, rapidly expanding in the years following.
- SLC Agricola – made up of sixteen farms and totalling in a group size of 400,000 hectares (Ha’s), we visited the largest member of the group cropping 32’000 Ha’s.
- Bomfu Turu – Farming 16’500 cattle over 4’600 Ha’s of temporary pasture land and cropping 11’000 Ha’s of cereals and sunflowers.

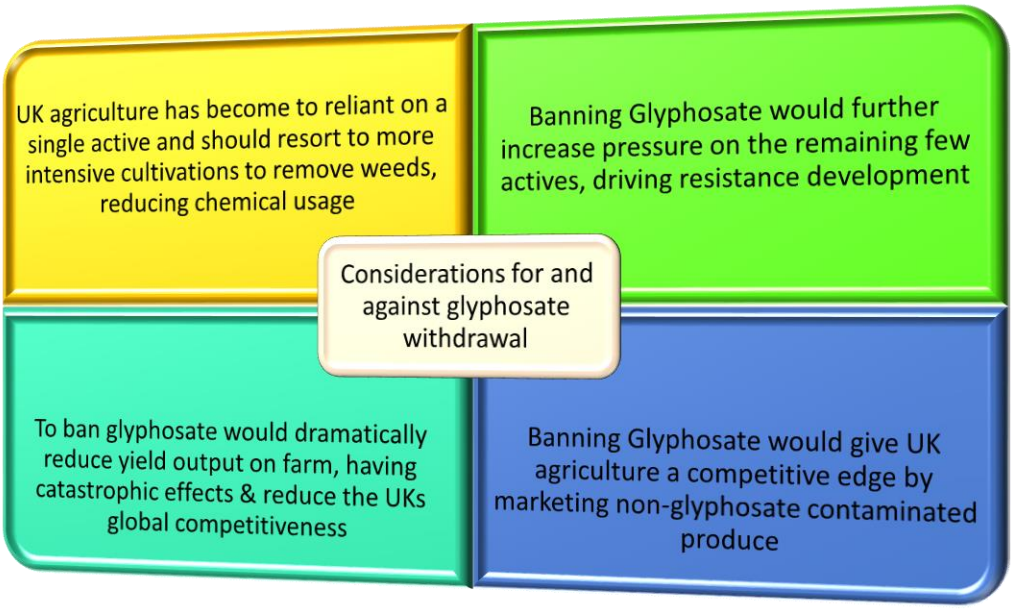
6.0 UK agriculture and glyphosate

In the early 1970's Monsanto patented the active ingredient 'Glyphosate', and by 1974 the product 'Roundup' was available to the market for its use. Since then it has been readily used by farmers all over the globe for the control of pernicious weeds in crops.

In 2017 the use of glyphosate was required to be re-authorised by the EU parliament in order to allow its sale and use, however, this was contended by NGO's who presented the case that glyphosate was probably carcinogenic to humans and likely to cause cancer. As a result Glyphosate came very close to being removed from the list of available actives to UK farmers.

There are a number of ways to analyse this issue, the table below aims to identify some possible options.

Figure 3: Assesses some of the drivers for and against the renewal of glyphosate



The table above presents four considerations towards the re-authorisation of glyphosate. Top left presents farmers have become too reliant on one active ingredient (glyphosate). However, the same could be said in relation to on farm cultivations and that farmers have become stagnant in their approach to tillage and sowing techniques, becoming too reliant on the plough.

Top right presents that the use of glyphosate is comparable to that of the plough, extreme no-till (e.g. Crosslot or John Deere 750A sowing machines) or even water in rice fields. The approach, aim and result of all four are almost in alignment with one another, to prevent the procreation of unwanted species within a growing crop. Therefore, if glyphosate is to be withdrawn, should we also consider withdrawing ploughing, water weed control and extreme no-till operations as all have their downsides?

In Brazil it was interesting to learn that farmers are paid a premium for producing and selling conventional soya over GM Soya, with the target market being Europe. The bottom left caption of figure three explores the argument to withdraw glyphosate and add a premium to British produce targeted at the countries who wish to withdraw its use.

The bottom left segment of figure three considers the on-farm effects post glyphosate withdrawal. Would the aftermath be catastrophic? Could farm income levels be sustained in order to pay wages, invest in new developments and machinery or would it have the opposite effect and fragment the industry initiating the demise of industrial scale arable cropping practices? Could farmers adapt quick enough to a sudden step change of this magnitude in order to survive and thrive?

6.1 Public money for public goods

As the UK progresses through the stages of BREXIT, the agricultural community is now beginning to catch glimpses from politicians such as Michael Gove, Secretary of State for Environment, Food and Rural Affairs of what the future British Agricultural Policy (BAP) may look like. Mr Gove revealed at The Oxford Farming Conference in January of this year that we are likely to see the structure of subsidies take the form of '*Public Money for Public Goods*'. This is likely to involve the values of soil organic matter (OM) content, water quality, air quality, and the biodiversity of that area being placed into a set of accounts, whereby its values can be measured.

An important consideration of this is that in order to implement 'no-till' as we view it here in the UK using John Deere 750A or Crosslot drills as they're commonly known, to build biodiversity and soil OM in the face of policy change, glyphosate is an essential tool as it is in any tillage system to prepare stale seed beds.

7.0 Mother-nature: order vs. disorder

During my career whilst on dinner break or when out for a walk, I have gazed upon the floors of the forests, roadsides and edges of footpaths, analysing and wondering how mother-nature determines its own outcomes, how it learns and how it remembers. How it determines which plants grow where, their natural competitiveness and the order in which it all occurs. I have asked myself, is it all a pre-determined order, is it merely chance or is there an under-lying regimented hierarchy of disorder which, is the mechanism for species development within mother nature.

Our business is growing crops on a commercial scale and in an orderly fashion to provide primary sources of food for either human and animal consumption or fuel production. Within this area it is a well-known fact that weeds reduce yield and their seeds contaminate crops, reducing value. For example, it is now estimated Blackgrass effects 1.2 million hectares of the UK's most productive cropping area and costs the industry £0.5 billion pounds per annum (Edwards, 2018).

7.1 Pesticide resistance development

As herbicide use has increased, the release of new modes of action has stagnated and the production of new chemical active ingredients has slowed, this in turn has resulted in further pressure being applied to the pesticide chemical active ingredients remaining and beginning a countdown timer that no one knows the initial starting time of.

Recently it has been discovered plants such as Blackgrass are developing new messaging genes, arming themselves in anticipation against herbicide applications as they become more frequent and of the same type (Edwards, 2018). Four thousand genes were researched in Blackgrass, this number was reduced to eight protein genes commonly found in all resistant blackgrass. This was further narrowed down to three gene types which, are commonly found in the human body and can become resistant to cancer treatments. The eight protein genes were finally reduced down to one protein.

The single common gene in all resistant forms of Blackgrass was named AMGSTF1. Absent in plants which are not resistant and haven't been treated for long periods of

time, this protein causes the plant to accumulate anti-oxidants, ‘switching-on’ the resistance mechanisms of the plant (Edwards, 2018).

Table 1: Presents possible reasons behind weed resistance development in the UK.

Reasons behind weed resistance development	**1 - Limited rotations**
	2 - High dependence on chemical control
	3 - Reduction in existing arsenal
	4 - Few new modes of action
	5 - Genetically diverse weed population

Table one explores the reasons behind the proliferation of weed resistance within the UK arable cropping profile. A key familiarity which separates the above into two categories is order vs. disorder, with mankind influencing reasons one to four and nature reacting in reason five.

Reasons one to four, although each presented in a different prescription, evolve around a central focus – ***order.*** Each one stacking its level of order onto the next and so on. Nature’s reaction to the introduction of order is to diversify its gene pool, creating disorder to confuse and out manoeuvre its enemy - mankind.

8.0 Mato Grosso

The region of Mato Grosso within Brazil is 903,957 km^2, whilst Germany is 357,376 km^2 to give an idea of scale. Favourable for double cropping because of its unique climate located on the Chappada, the predominant first crop is soya sown in September. Followed by a second crop of corn (maize) sown in January or February, other second crops are also cotton, sunflowers, cover crops and temporary pastures.

Whilst travelling through Mato Grosso the largest producers were visited, as detailed in *4.0 Route of travel*. During this time I learnt of the introduction of GM crops to the industry, the monopoly Monsanto have created surrounding royalties in their time and the challenges farmers have faced with weed control.

Mother-nature is the ultimate in organised disorderliness, presenting itself as chaotic or random in its choices, it is this chaotic and targeted random selectiveness itself which is its greatest strength.

Monsanto introduced GM technology in Brazil in two forms, *roundup ready* and *intact ready*.

Intact provided resistance against numerous species of crop damaging caterpillars, whilst roundup ready allowed crops to be sprayed with numerous applications of glyphosate as a means of effective and cheap weed control. The alternatives to this would be expensive selective herbicides and increased sprayer applications.

Figure 4: illustrates a GM roundup ready soya bean plant (Yardley, 2018).

Speaking to Smaniotto (2018) it emerged within Mato Grosso it had only taken six – eight years for specific weed species to develop total plant resistance to glyphosate. This first began by having to increase rates to achieve the same outcome, however, these methods quickly failed.

8.1 Resistant species

Once it emerged Mato Grosso had roundup resistant weeds, it became possible to source and photograph identifiable species.

Figure 5: illustrates roundup resistant species Digitaria Insularis, commonly known as Sourgrass (Yardley, 2018).

Figure five illustrates the characteristics of Digitaria insularis, one of the species to become fully glyphosate resistant. It is clear it has developed traits to favour this development:

- Small blade like leaf area, preventing moisture loss in a hot climate and creating a difficult target site for herbicide application.
- Leaves are only halfway up the plant, as a result when in a full grown soya crop the only part of the plant exposed is stem making it near impossible to hit with herbicides from an applicator.
- Aggressive tillering enables the plant to incur damage limitation. If targeted by an herbicide application, a number of tillers may survive.
- High seed return enabling genetic traits to be passed on to next generation in large numbers.

Although not such a significant problem in the region of Brazil, another species identified was Amaranthus palmeri or Pig weed. This is a significant problem within GM crops in North America and has now become resistant to Glyphosate (Patterson, 2016).

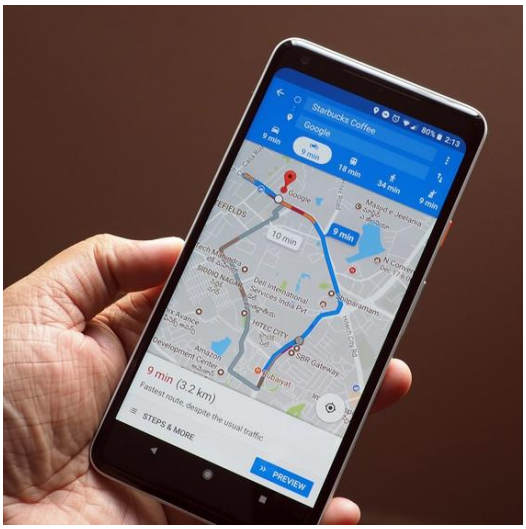
Figure 6: illustrates Amaranthus Palmeri, otherwise known as Pig Weed (Yardley, 2018).

Characteristics favouring Pig Weeds resistance development, illustrated in figure six, are its high level of seed return often reaching up to 200,000 seeds per plant per annum.

8.2 Google Maps

When travelling using a mobile device for navigation assistance, Google can present a message illustrating how a faster route saving you three minutes has been found, “Pease tap Accept or Decline”?

Figure 7: illustrates Google direction page (Jonnalagadda, 2017).



UK agriculture was almost in the same position in 2017 and may well be in 5 years’ time as Brazilian agriculture is today, when the authorisation of glyphosate runs out just as plants have become resistant in Brazil. Both countries are on course to the same destination *‘glyphosate is no longer effective’*, but via different routes and due to the introduction of GM crops, Brazil tapped ‘accept’ for the faster route.

When Brazil tapped accept, an extreme level of significant order was introduced into an agricultural system already present with order. This resulted in the ultimately organised disorderliness of ‘mother-nature’ in the form of Sourgrass, adapting its techniques easily to overcome an extreme order, such as repeated glyphosate use in GM roundup ready crops.

Farmers also revealed that during any one cropping cycle, typically 120 – 150 days, obtaining two crops per year plus a cover crop of two months, a crop may receive two or three applications of glyphosate for weed control. Resulting in any singular plot of land and the weeds within it receiving 7 applications (maximum) of glyphosate per year.

8.3 External influencing factors

A significant influencing factor within the resistance profile creation is ‘no-till’. No-till practices provide quick, easy and cheap establishment of crops ideally suited to the region of Mato Grosso with its high rainfall (approximately 200mm per annum), friable clay soils often 50 – 60% in content and supplemented with high levels of solar radiation, it acts as another layer of order in the cropping profile (Smaniotto, 2018).

Figure 8: illustrates a no-till drill layout in Mato Grosso and the field appearance post drilling.

No-till is a practice which fails to invert the top layer of soil or mix the profile. The benefit of inversion tillage practices is that they bury the contaminated soil profile at the surface (25 – 50mm in depth) below, and surfaces clean soil profiles from below. Used in combination with different actives and cultivation methods, the benefits of this practice will be that the clean profile surfaced from below should have very little or none of the protein AMGSTF1 present due to their lack of exposure to actives.

Whilst speaking with farmers it was also interesting to learn of the significant contribution no-till practices had made to the functionality, work-ability, moisture retention and weed suppression characteristics supplied by the technique of 'row crop production' as well as improvements in crop yields, establishment cost reductions and the issues now presenting themselves, such as compaction.

8.3.1 Soil functionality

The characteristics of the soil lend itself perfectly to no-till. Being of a 'heavy' nature it compacted / returned to its natural bulk density near the surface.

Figure 9: illustrates a soil pit which I dug at PS-AGRO (Smaniotto, 2018).

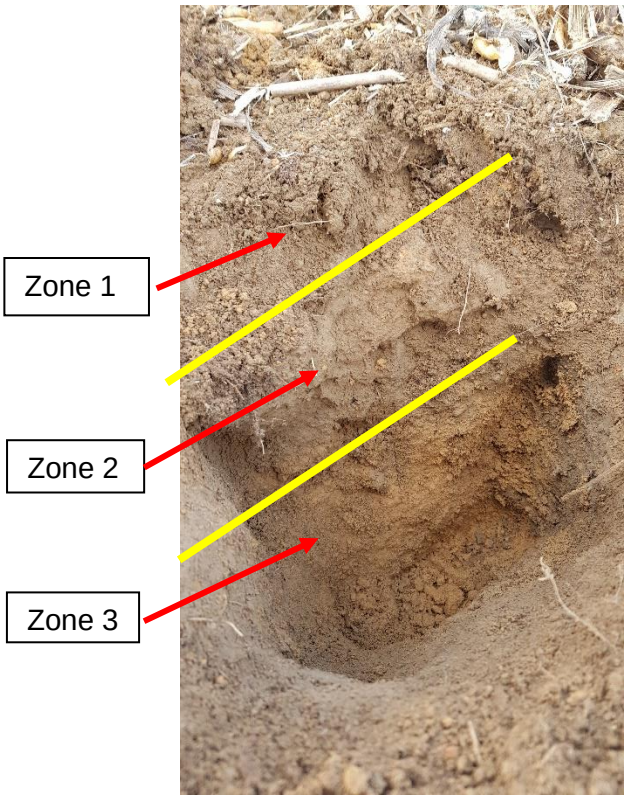


Figure nine shows the soils natural characteristics. Zone 1, approximately 25 – 50mm in depth is the natural friability achieved by no-till practices. This layer was very friable and would have easily allowed water to freely pass through. Zone 2 was approximately 100mm in depth below zone 1 and suffering slightly from elements of compaction. There were very few pore spaces and when teased with the pen knife only small, hard pieces came away requiring an element of effort to do so. Zone 3 returned to little or

no compaction, approximately 150mm in depth, the soil easily came apart with the knife.

In conjunction with these characteristics, the large front disc on the drill is the key to the functionality and success of the machine. Its large circumference and variable pressure being applied which ensure the disc is constantly running between 200 – 250mm in depth, breaking through the compacted layer, creating a root zone for the next crop to grow deep into the subsoil to access water reserves. Without the leading disc the functionality of the sowing machine would be very limited.

It was interesting when speaking to Smaniotto (2018) that they did not consider the layer of zone 2 to be even remotely compacted, and informed me that the field had been no-till since 1997. This outlook and mind-set presents new opportunity for UK farming to view soil and its profile from another perspective. It was also interesting to learn from Martins (2018) that no-tillage systems were a key focus within Brazilian agricultural studies at universities.

8.3.2 Yield benefits and crop residue

It was interesting to learn how row crop widths had developed to 45cm for soya and corn and 90 cm for cotton, allowing high yields to be maintained. This became apparent whilst we were with PS AGRO (Smaniotto, 2018).

Figure 10: illustrates soya (current crop) planted at 45cm and cotton (previous crop) planted at 90cm (Yardley, 2018).

Planted at alternating angles of 30 degrees, this spacing allowed maximum light penetration into the canopy, achieving optimum yields.

Rafael (2018), also indicated that the high level of crop residue left on the surface from no-till practices aided in the suppression of weed development by creating a layer blocking sunlight. Pre-emergent sprays still worked in these areas, but not as well as in areas of bare soil.

8.3.3 Rotation

The short but intense rotation of the Mato Grosso region, soya followed by corn, appeared to have been sustainable for 20 years, with no real disease or pest pressure. However, this is a significant level of order and one which is uncommon in UK agriculture. The rapid resistance development has also now forced extreme pressure onto their remaining actives, all of which being selective herbicides.

It was interesting to learn that due to the purity of cotton required to achieve the highest grade, the crop must be completely free of weed seed contamination.

Figure 11: illustrates cotton seed post sowing (Yardley, 2018).

This resulted in the seed having to be protected in a special coating to protect it during the early stages of development post sowing from the harsh pre-emergence sprays used to suppress weed growth.

In 2016 maize trials launched at Reaseheath College in conjunction with Pottinger and Agrovista saw cover crops being sown within the canopy to assess their benefits and other potential opportunities such as grazing. Whilst touring Bomfu-Turu, it was fascinating to hear how sowing a grass sward within a maize crop is standard practice, allowing them to graze the field for two / three months post corn harvest prior to sowing soya. The benefits of this were soil erosion was prevented, biodiversity and soil health were protected, whilst the farms land usage, efficiency and profitability were all increased (Bomfu-Turu, 2018). This allowed Bomfu-Turu to harvest three crops in one year, with the third being cattle for meat.

8.3.4 Compaction and penetrometer mapping

At SLC-Agricola it was interesting to learn how the company is beginning to see evidence of compaction within their no-till soils and reductions in yield as a result (Rafael, 2018). However, due to the company being on the stock exchange their biggest issue is communicating to shareholders that they're unable to plant the second crop due to compaction.

A sowing machine has the ability to cover 12 Ha's per hour, the extra investment required to subsoil in front of this operation is unjustifiable as it would require four high horsepower units plus implements (Rafael, 2018).

Figure 12: illustrates evidence of compaction in a no-till cotton crop (Yardley, 2018).

A characteristic of cotton is that its roots go as far below ground as it grows above ground. Figure twelve illustrates how the 'lazy' rooting system of cotton is easily affected by compaction in soil zones two and three, illustrated in figure nine.

In an attempt to alleviate the issue and sow a second crop, SLC-Agricola had introduced the practice of penetrometer mapping. Taking six samples per hectare, it allowed them to maximise yield and stay ahead of the planter with one unit as they were only cultivating areas requiring attention (Rafael, 2018).

8.4 Discussion – What are our options?

Travelling through Mato Grosso offered many lessons and time to reflect and challenge the 'norm' in UK farming as well as the 'no-till' pioneers, enabling me to question how can we improve practices and what are our options if glyphosate was to be withdrawn. Whilst it is easy to accuse farmers using conventional practices of being stuck in their ways, the no-till pioneers could also be challenged for plunging their system into a regimented entity of order.

To implement these options the aim should be to introduce new techniques / tactics and also re-visit old ones, adding new vision and knowledge to tailor their effectiveness. The purpose of this exercise should not be to reinvent the wheel, but question why the wheel was invented to begin with.

As described in section 7.3, the resistance of glyphosate occurred as a direct result of its overuse and the implementation of total order (Smaniotto, 2018). This could also be related to the potential withdrawal of glyphosate in the EU, raising the question, have we created our own environment of overuse and how can we avoid it?

Figure 13: illustrates a quick reference matrix to aid decision making on an individual field basis to create disorder.

Figure thirteen illustrates a field order matrix created as a quick reference guide. Split into four quadrants, its aim is to provide farmers and managers a tool to assess the level of order they're planning to implement within a field and how it relates to previous cropping years etc. One way this could be improved would be to introduce a scoring system, speeding up the process and making it easier for users. No rule / tactic should ever be performed more than twice in consecutive cropping years, helping to prevent mother-nature from adapting and developing mechanisms to overcome its challenges.

Table 2: illustrates an example of a high system order.

Crop	Cultivation	Sowing method	Pre-em spray	Pre harvest
Winter wheat	Ploughed	Vaderstad Rapid	Liberator	Glyphosate
Winter barley	Ploughed	Vaderstad Rapid	Liberator	Glyphosate
OSR	Ploughed	Vaderstad Rapid	Kerb	Glyphosate
Winter wheat	Ploughed	Vaderstad Rapid	Liberator	Glyphosate
Winter barley	Ploughed	Vaderstad Rapid	Liberator	Glyphosate
OSR	Ploughed	Vaderstad Rapid	Kerb	Glyphosate

Table 3: illustrates a system utilising the field order matrix.

Crop	Cultivation	Sowing method	Spray	Pre harvest	Other
WW	Min-till	Vaderstad Rapid	Liberator		
Sugar Beet	Ploughed	Precision drill	Bentanal maxxPro		Band widths
WW	Min-till	Vaderstad Rapid	Crystal + Xerton		
WW2	No-till	KUHN SD	Liberator		
CC's	Min-till	Vaderstad Rapid		Glyphosate	Penetrometer mapping (subsoil) Livestock to graze off
Spring Barley	No-till	KUHN SD	Axial + Starane highload	Glyphosate	
OSR	No-till	KUHN SD	Astrokerb	Swath	Penetrometer mapping (subsoil) + wider band widths
WW	Extreme No-till	Crosslot	Hurricane		
SBNS	Ploughed	Vaderstad Rapid	Defy + tinened weeder	Glyphosate	Wider band widths

Table two illustrates an example of a farming system with little or no increased level of disorder, allowing opportunistic species to adapt to a fixed environment. Table three shows an example of a farming system which has utilised the '*field order matrix'* operation profiling tool.

"We cannot solve our problems with the same thinking we used to create them". Albert Einstein (keysafety, 2017).

To overcome disorder requires either an overwhelming force of order, or the introduction of total disorder and anarchy, confusing ones enemy to the point where it can no longer adapt quick enough.

This reinforces the answer to the UK's farming issues related to this report and that they cannot be solved by a 'silver bullet' or the creation of a new active ingredient. The style of thinking from the 1960's / 70's is no longer effective in our arsenal as a standalone method. Table three illustrates the utilisation and implementation of the field operation matrix, created by the use of order it aims to form an environment unpredictable in its nature and constantly shifting.

Implemented in the correct manner it is believed this system has the potential to sustain the use of crops, cultivation methods, sowing methods and pesticides, preventing species from initiating the production of the resistance related anti-toxins and improve soil health. An argument against the matrix system is that it could possibly require further capital investment to implement. In response to this, as operations have been diversified, reducing the overall pressure on a singular machine to cover large hectares. An opportunity has been created for farms to reduce the size of specific items of machinery and diversify their machinery profile.

The necessity to scrutinise business operations and machinery profiling was also another valuable observation, emphasizing how businesses can tailor on farm horsepower with machinery to a higher degree, achieving the optimum per hectare. This is not necessarily the lowest figure, but one which maximises the flexibility and capabilities of the business. Freeing up capital invested and reducing depreciation, whilst also increasing the adaptability and resilience of the business in a rapidly mutating agri-business and political environment

Other key lessons learnt as a result of conducting the John Platt scholarship will be the introduction of penetrometer mapping as well as ‘no-till’ planting with a new prototype, but not in the fashionable ‘no-till’ sense. There is also potential to reduce one of the largest tractors in size by twenty one percent on farm by restructuring operations. Further areas of improvement lie within rotation diversification, variation of cultivation methods / practices, cover crop establishments / destruction, sowing practices, crop residue management, chemical applications and the consideration of livestock within the arable business. Improvements via routes of communication to relate the beneficial factors of exploiting natural resources and explore the possibilities of legislative literature as a means to disrupt the farming order will also be explored.

9.0 Biocontrol

An impressive aspect observed within the sugar cane industry was their approach and implementation of an Integrated Pest Management (IPM) strategy. Defined by Shelton (2018) as 'the reduction of pest populations by natural enemies and typically involves an active human role'. It was at the sugar mill of Sao Martinho in Pradopolis, where we observed and learned more of the 'active human role' involved in the creation and implementation of a bio-control system.

9.1 The pest

A natural occurring enemy of sugar cane within the state of Sao Paulo, *Diatraea Saccharalis*, commonly known as sugarcane borer, it causes reductions in cane yield and cane quality. Increasing the fibre content and the presence of a fungus associated with borings from *Diatraea Saccharalis* deteriorating sucrose molecules and overall sugar quality (F R Goebel, 2003).

9.2 The predator

Macedo (1993) states that as a result of the introduction of *Cortesia Flavipes* 'average infestation intensity by the pyralid (*Diatraea Saccharalis*) decreased from 6.64% to 3.7% in the period from 1975 – 1990'. Teixeira (2018) informed the author of this report that threshold levels of sugarcane borer were closely monitored during the growing season. If low to medium levels were detected, Cortesia Flavipes was introduced as a means of control, however, in the event high levels were observed an insecticide must be used for rapid control.

9.3 Biocontrol production process

In order to breed the natural predator *Cortesia Flavipes*, the laboratory must first produce *Diatraea Saccharalis*, the sugarcane borer.

The following illustrations in figure eleven and twelve depict the process of bio-control production methods.

Figure 14: illustrates Diatraea Saccharalis in larvae, pupae, eggs and adult forms (Sao Martinho, 2018).

As shown above the sugarcane borers are bred as a host to permit the production of Cortesia Flavipes.

Figure 15: illustrates the stages involved in the production of Cortesia Flavipes (Sao Martinho, 2018).

The above illustrates sugarcane borer eggs developing in a protein and energy paste (left), a female Cortesia Flavipes injecting her eggs in the Diatraea Saccharalis (middle) and the Cortesia post hatching ready to be released.

In total sixty six thousand plastic cups of Cortesia were produced each month as illustrated (right) in figure twelve, enabling biocontrol and the implementation of IPM to cover a total area of six thousand hectares per month.

9.4 Discussion

Since the withdrawal of neonicotinoid seed treatments in Oilseed rape (OSR) farmers have increased the use of pyrethroid foliar treatments for the control of *Psylliodes chrysocephalus*, commonly known as Cabbage Stem Flea Beetle (CSFB) (Kathage J, 2018).

In the field of bio-control UK agriculture could learn valuable lessons from the examples demonstrated within the sugarcane industry in Sao Paulo, Brazil. Bio-control has the potential, if implemented correctly, to dramatically reduce the use of pyrethroid insecticides in Oilseed rape (OSR) for the control of Cabbage Stem Flea Beetle (CSFB). By introducing such practices, it is conceivable UK agriculture could firstly implement improved IPM strategies, reducing insecticide use, and promote itself as protecting the environment, bio-diversity and ecosystems amongst aggressive Non-Government Organisations (NGO's) and the public.

10.0 Soil protection

A Sanskritt text written in (approximately) 1500 B.C. noted “Upon this handful of soil our survival depends. Husband it and it will grow our food, our fuel and our shelter and surround us with beauty. Abuse it and the soil will collapse and die, taking humanity with it” (Monbiot, 2015). Whilst travelling to Brazil the author of this report sourced a post from social media illustrated below.

Figure 16: illustrates a Twitter post (Twitter, 2018).

Figure sixteen illustrates British farmers conducting a soil erosion discussion group observing the effects of high rainfall on sloping light land and how to deal with its effects.

Within the sugar cane industry it was evident the potential for soil loss was very high due to the exposed level of soil in a growing crop, its friable nature, the annual level of high rainfall and the topography of the land on which sugarcane is grown. A direct result of this was the implementation of unique Drone technology to prevent soil erosion.

Figure 17: illustrates drone technology topography mapping (Raizen, 2018).

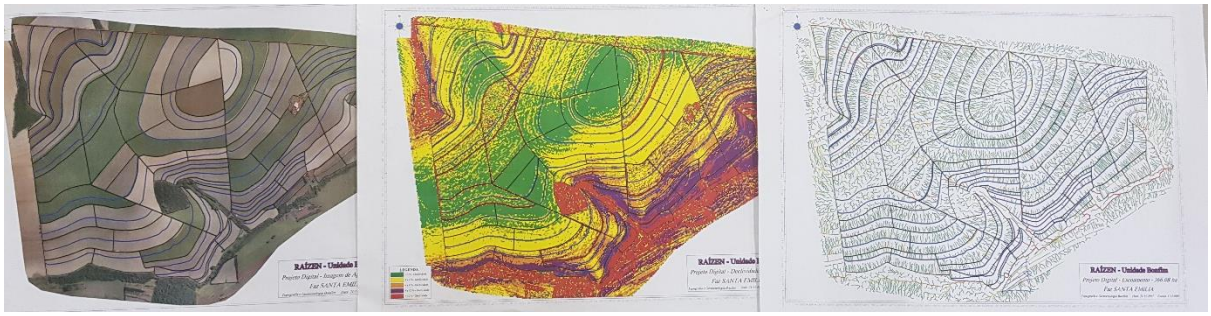
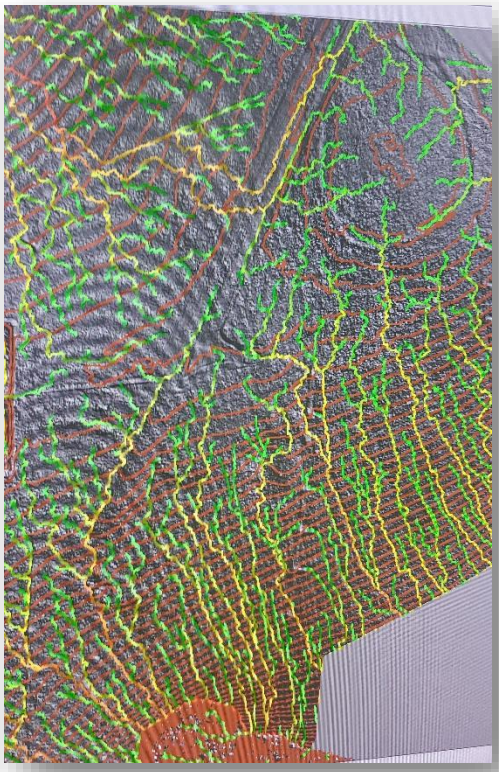


Figure 18: illustrates water infiltration mapping (Raizen, 2018).



Figures seventeen and eighteen illustrate mapping in preparation for a sugarcane crop. Figure seventeen (left) shows cropping blocks in relation to topography, middle and right illustrations show gradient and predicted routes of water infiltration / surface run-off. Figure eighteen is a clearer illustration of water infiltration and surface wash off mapping.

Whilst this level of technology may not apply to all due to topography, cropping or financial status within the UK. Innovators followed by early adopters of technology within UK agriculture may be able to implement such technology, creating discussion groups and encourage the diffusion of innovation throughout the industry, empowering farmers to adapt, learn and tailor their businesses to protect their assets (McDonald, 2017).

11.0 Mental health and succession

On the 30th January 2018 I travelled to the region of O Novo Horizonte (The New Horizon) region of Sao Paulo state to visit a farmer called Mario Whateli, at Rio Morto farm.

Having worked in numerous and often remote locations around the world and UK, it is not an uncommon theme in my career to have at some point experienced loneliness or difficulties regarding certain factors related to the job. It is only experience that has taught me how to deal with these challenges and manage the issues as they arise. However, I have always regarded this, as I'm sure many others have as a taboo subject within agriculture and one which is rarely spoken about.

For me it was the complete breakdown of these barriers which inspired and challenged me whilst visiting Rio Morto Farm.

11.1 Personal development

Mario aged 31, had in recent years taken over the day to day running of the farm from his father, much to the disgust of certain long standing members of staff. I found it fascinating to listen as he described the struggles of being undermined, ignored and laughed at by his staff and how he pursued new approaches to deal with these challenges.

Figure 19: illustrates myself and Mario Whateli (Whateli, 2018).

Listening intently, Mario described how his parents had sent him to practical therapy as a child since the age of six. Conducted every week, he would visit a therapist to play and who would encourage him to talk about any issues or concerns he may have. This helped him a great deal he said later in life when communicating and trying

talking to people about certain issues etcetera which, he may have had either professionally or personally. A common practice in Brazil for parents to send their children to practical therapy, Mario added he will definitely allow his children the same opportunity (Whateli, 2018).

One method employed by Mario to deal with the issues associated with succession and staff was the introduction of a mentor. He went on to explain how finding the right mentor wasn't any easy task. Having had three previously, he had now found the right one who understood his mind-set and direction.

Mario conducted a two hour session every two weeks via skype, he then went on to explain at times this process was very difficult as his mentor would push him purposefully out of his comfort zone. It was interesting to learn that mentoring was not viewed as counselling, but as a facilitator of personal development in order to enable Mario to approach and create the right environment, allowing him to mould and shape his surroundings to achieve the desired outcomes (Whateli, 2018).

11.2 Discussion

On reflection after speaking with Mario it was evident that his rare path, from practical therapy as a child, to professional mentoring as a business professional in agriculture had provided him with a unique personal perspective and ability to communicate. As an industry, I feel there is a great deal more we can do to improve the well-being and mental health of farmers within UK agriculture and although this section may not provide any answers, it will hopefully raise awareness and discussion of the topic.

12.0 Conclusion

In conclusion, the industry of UK agriculture and in particular the arable sector, must remove itself from a conditional way of thinking and challenge the conventional by developing a new mind-set. In doing so it has the potential to demonstrate UK farming remains competitive on the global platform, whilst also improving perception amongst the public domain and reducing conflict with NGO's and activists if communicated effectively.

Farmers are unintentionally falling victim to their own actions in relation to their practices, however, this can be prevented by exploring the alternatives and adopting a pro-active approach to disrupt the common order. Although often difficult in commercial agriculture due to the economies of scale, levels of investment, returns, parties and pressure involved. By forward planning, adopting new practices, disrupting the common order and pushing the boundaries of what is possible by embracing the impossible, newly available opportunities can be created.

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