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ALGERIE, LES LECONS DE L'AGRICULTURE AUSTRALIENNE

Photo : Semoir pour semis-direct John Shearer.

Recueil d'articles réalisé par Djamel BELAID
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INTRODUCTION

Certaines régions d'Australie présentent un climat proche du climat algérien. De ce fait certaines façons de faire des agriculteurs australiens peuvent être transposées en Algérie.

Nous proposons donc quelques exemples de réussites en Australie.

(à suivre)

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Australie/ Une agriculture compétitive et technologique

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Les conditions arides australiennes n'empêchent pas la production de céréales. Le niveau de rendement est certes limité, mais les agriculteurs se sont adaptés en maîtrisant leurs charges opérationnelles et de structure. Le semis direct y contribue. Le niveau technologique des matériels est plutôt bon à très bon, tout en étant amorti sur des structures de grande taille.

L'Australie vient de subir une série d'une dizaine d'années plus sèches que la moyenne, elle-même précédée d'une dizaine d'années plus humides que la moyenne. Les agriculteurs australiens se sont adaptés vis-à-vis de potentiels de rendement faibles et variables à la fois. La maîtrise drastique des charges, opérationnelles et de structure, est le maître mot. Sur des blés produisant en moyenne 20 à 40 q/ha selon les zones, les intrants sont apportés avec parcimonie.
Les charges de mécanisation et de main-d'oeuvre sont maîtrisées par des itinéraires très simplifiés et des exploitations de grande taille. En revanche, le niveau technologique des matériels est bon, voire supérieur à la France.

Une agriculture sous contrainte hydrique.
Nous nous appuierons sur l'exemple du Mallee et du Wimmera, deux grandes régions céréalières du sud-est du pays, au nord de l'état du Victoria (figure 1), à environ 500 km des côtes. Le Wimmera reçoit en moyenne 400 mm/an et le Mallee 250 mm/an (contre 600 à 1 000 mm/an en bord de mer). Les sols sont très hétérogènes : limons sableux superficiels sur calcaire, sols argileux profonds (jusqu'à 80 % d'argile)…

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Certains sols souffrent de salinité ou de toxicité en bore. Les exploitations, de grande taille (2 000 à 4 000 ha en moyenne pour les exploitations « professionnelles »), affichent un impressionnant ratio de 1 000 ha/UTH.

L'agriculture de
conservation a
supplanté le dry farming
En 20 ans, les systèmes de culture ont considérablement évolué. Auparavant, le dry farming, forme d'agriculture adaptée aux régions sèches, dominait, avec une rotation blé/luzerne annuelle/jachère travaillée. Le but de cette dernière était de stocker l'eau et l'azote dans le sol pour en faire bénéficier la culture suivante. La jachère était travaillée en profondeur avec une charrue à disques. Puis des façons superficielles détruisaient toute végétation susceptible de transpirer de l'eau. Ce système avait quelques inconvénients : charges de mécanisation élevées, surface de l'exploitation partiellement non productive, terre travaillée très propice à l'érosion éolienne. Le dry farming a été progressivement remplacé par le semis direct, qui représenterait aujourd'hui 90 % des surfaces du Mallee ou du Wimmera. Pourquoi un tel engouement pour ce qu'on appelle dans beaucoup de régions du monde l'agriculture de conservation des sols ? La prise en compte du contexte économique ne semble pas y être étrangère (réduction des charges de mécanisation et de main-d'oeuvre). Par ailleurs, son extension semble avoir été concomitante à la baisse du prix du glyphosate, herbicide essentiel à ce système de culture. Dans ce contexte aride, supprimer le travail du sol permet de réduire les pertes en eau par évaporation, ce qui est un argument de poids pour améliorer l'efficience de l'eau (quantité de grain produite par quantité d'eau tombée).
La succession des cultures varie en fonction de la pluviométrie moyenne du secteur, du type de sol et des pluies tombées avant le semis. Les céréales à pailles, notamment le blé, dominent les assolements. Le colza (canola) est un peu plus exigeant en eau. Les légumineuses le sont encore plus et sont réservées à des situations plutôt favorables. Les rotations peuvent être, par exemple, canola/blé/blé/blé/blé/orge dans le Mallee. Avec 400 mm/an en sol argileux dans le Wimmera, on peut trouver des rotations de type pois chiche/blé/lentille/ blé/canola/orge. Toutes les cultures sont semées en automne (avril-juin) et récoltées en fin de printemps (octobre décembre). L'élevage a largement régressé dans ces régions céréalières.

Une conduite « extensive » du blé

Le rendement moyen du blé est de l'ordre de 20 q/ha dans le Mallee et de 30 q/ha dans le Wimmera. Cela ne permet pas de rentabiliser beaucoup d'intrants, sachant que le principal facteur limitant est la disponibilité en eau. Le niveau de charges opérationnelles moyen pour la campagne 2008 est de 100-125 €/ha en incluant la fertilisation, la protection phytosanitaire, les semences et même le fuel !

L'itinéraire type commence par un entretien chimique du chaume grâce à un glyphosate pour éviter que des adventices ne transpirent le peu d'eau du sol. Le semis, à l'automne, est précédé par une application de glyphosate + trifluraline. Il est souvent réalisé avec un semoir à dents qui met en terre en moyenne 50 kg/ha de semences, souvent d'origine fermière. Le flux de terre créé recouvre la trifluraline et évite sa volatilisation. Des fertilisants sont apportés au semis en localisé (20 unités d'azote, 7 de phosphore). Le reste de l'itinéraire est ajusté selon l'année ou la parcelle : apport d'urée (jusqu'à 30 u si le potentiel est prometteur !), rattrapage sur dicotylédones(2.4 D le plus souvent) et ray-grass, très présent et surtout multi-résistant. Aucun régulateur ou fongicide n'est appliqué en général.

Dans des régions plus proches de la mer et plus arrosées (600 mm/an en moyenne), le potentiel moyen des blés approche les 40-50 q/ha. Les itinéraires sont adaptés en conséquence pour valoriser ces meilleurs potentiels : densité de semis plus importante, fertilisation plus généreuse, fongicide (triazole) au stade dernière feuille étalée, programme herbicide un peu plus complet…

Les adventices australiennes font de la résistance

L'Australie dispose d'outils pour gérer les adventices qui ne sont plus ou pas (encore ?) disponibles en France. De nombreuses substances actives retirées du marché français sont autorisées en Australie : trifluraline, atrazine, simazine, diuron… Le canola bénéficie de tolérances à certains herbicides (triazines, imidazolinones avec la technologie Clearfield®) ou même de résistances à certains herbicides (canola OGM Round Up ready autorisé depuis 2008 dans certains états).

Le contrôle des adventices n'en est pas pour autant facile. La dominance des céréales à pailles dans les rotations (proche de la monoculture parfois) a favorisé certaines adventices difficiles à détruire (ray-grass, ravenelle, brome…).

Pour les deux premières, des populations résistantes à de nombreux herbicides sont répertoriées. Les recommandations pour gérer ces résistances sont principalement l'alternance des familles d'herbicides utilisés. À ce titre, le mode d'action auquel appartient chaque herbicide est indiqué sur le bidon. La rotation des cultures est préconisée pour gérer les adventices avec, par exemple dans les cas extrêmes, le remplacement du blé par l'avoine qui a un meilleur pouvoir concurrentiel sur les adventices et qui sera pâturée ou récoltée en fourrage pour exporter les semences d'adventices… Le travail du sol n'est jamais évoqué pour gérer les adventices (enfouissement des semences avec un travail profond (coût, temps de travail et érosion le rendent économiquement impossible), faux semis qui fonctionnerait mal faute de pluies). Au contraire, il est évité, notamment lors du semis, par des agriculteurs ayant opté pour des semoirs à disques plutôt qu'à dents, de manière à limiter la perturbation du sol au semis qui favoriserait la levée d'adventices dans les cultures. Un minimum de perturbation est cependant recherché, car l'application de trifluraline avant semis est très fréquente.

La situation australienne au niveau de la résistance n'est pas liée au hasard. Le ray-grass a été introduit à l'origine pour les pâtures. En effet, le mouton et la laine furent à l'origine de l'expansion agricole australienne. Néanmoins, avec la chute des cours de la viande et de la laine, les producteurs se sont rabattus sur les cultures de vente, en premier lieu le blé bien adapté à la rigueur australienne. Le facteur économique est prépondérant en minimisation des investissements sur des cultures à très faibles potentiels. Il en résulte des rotations très courtes, proches de la monoculture de blé, des doses d'herbicides en culture très faibles et une absence de travail du sol. Dans le cadre de la résistance, ce sont les facteurs de risque principaux d'apparition de celle-ci.

Les recherches s'orientent vers des techniques de gestion mécanique des adventices, pas par binage ou hersage, mais par la gestion des semences d'adventices lors de la récolte. En Australie de l'Ouest, où la résistance aux herbicides constitue un phénomène très inquiétant, environ 50 % des agriculteurs brûleraient l'andain de menues pailles afin de détruire une partie des semences d'adventices. La récolte des menues pailles est une pratique moins répandue (environ 10 % des exploitations) en raison des contraintes induites : récolte ralentie, casse de chariots conçus à cet effet… Elle est cependant efficace (85 % des semences de ray-grass interceptées, 31 % pour la ravenelle selon une étude). Les menues pailles sont utilisées pour nourrir le cheptel ou tout simplement brûlées. D'autres matériels de type broyeur sont à l'étude pour compléter les leviers de gestion mécanique.

Des matériels aux tailles impressionnantes

Les exploitations du Mallee ou du Wimmera disposent de matériels de taille impressionnante, dont la surface d'utilisation est de l'ordre de quelques milliers d'hectares. Le semoir type fait 9 à 16 m environ et est équipé de dents semeuses qui assurent le placement de l'engrais et des semences. Le semoir est couplé à une trémie ravitailleuse et nécessite une puissance de traction de 350 à 400 cv. Le semis direct étant de plus en plus la règle, aucun matériel de travail du sol n'est utilisé.

La récolte est assurée par des machines conventionnelles ou à séparation forcée, de 250 cv environ. La faible quantité de biomasse à récolter permet de les équiper de coupes de 10 m ou plus. Le transport du grain est assuré par des transbordeurs et des camions. La pulvérisation est assurée par des matériels, traînés ou automoteurs, équipés de rampes d'environ 30 m. Les vitesses de pulvérisation sont importantes : 20 à 30 km/h. Les produits sont appliqués à bas volume (50 à 80 l/ha) à l'aide de buses à injection d'air.

En dépit d'un usage essentiellement tourné vers les produits génériques (principalement glyphosate, trifluraline et 2.4 D), le niveau technologique des pulvérisateurs est très bon : injection directe parfois couplée à une double rampe pour éviter les antagonismes entre matières actives, coupures de tronçon assistées par GPS, technologie Case permettant de faire varier la vitesse et le volume instantané de bouillie sans modifier la pression et la qualité de pulvérisation, capteurs commandant chaque buse pour ne pulvériser qu'en présence d'adventices sur chaume sous la buse (système weedseeker). Ces technologies sont plutôt répandues, et sont rentabilisées sur des milliers d'hectares déployés et suppléent à des conditions météorologiques peu favorables : températures élevées, hygrométrie faible, vent souvent important, présence de poussière inactivant le glyphosate, qualité des eaux parfois peu favorable à l'efficacité des produits…

De nombreuses communications (brochures, formations, services…) sont réalisées pour sensibiliser et accompagner les agriculteurs à propos des techniques et conditions d'application des produits phytosanitaires, à l'instar des celles proposées par Nufarm, firme d'origine australienne et représentant environ 50 % du marché phytosanitaire sur ce continent.

Le service Spraywise permet par exemple de donner sur téléphone portable une indication des conditions d'application par tranche horaire en couplant les connaissances sur les conditions d'application adéquates et les prévisions météo. Ce système est d'autant plus efficace que les conditions climatiques en Australie sont extrêmes (températures élevées, hygrométrie faible, sécheresse). Les fenêtres climatiques acceptables sont peu nombreuses et doivent donc être exploitées.

Le controlled traffic, une originalité australienne.

La « qualité » du sol est une motivation très souvent citée comme motif d'adoption du semis direct en Australie. Les attentes sont la réduction de l'évaporation de l'eau et de l'érosion éolienne, l'augmentation de l'activité biologique et l'amélioration de la structure du sol. Sur ce point, le tassement peut constituer un facteur limitant dans les systèmes de semis direct. Des chercheurs et agriculteurs ont imaginé réduire le tassement du sol en le « contrôlant », c'est-à-dire en créant des voies de passages figées pour le matériel. Ces zones sont sacrifiées au bénéfice du reste de la surface de la parcelle qui sera indemne de tout tassement plusieurs années de suite. Il faut idéalement que tous les matériels disposent de la même voie (par exemple largeur de 3 m) et soient guidés de manière précise avec un système GPS (idéalement système RTK précis à 2 cm près). Les largeurs des différents outils doivent être des multiples, par exemple 9 m pour la moissonneuse et le semoir et 27 m pour le pulvérisateur. En système traditionnel, on cherche à limiter le tassement en élargissant les pneus pour réduire les pressions de gonflage. À l'inverse, le controlled traffic réduit la largeur des pneus et des voies de passage permanentes, qui représentent des surfaces « sacrifiées ».

Le controlled traffic, déjà bien développé dans l'état du Queensland (nord-est de l'Australie) commence à se répandre dans l'état du Victoria. L'équipement complet (base RTK et autoguidage de la moissonneuse et de 2 tracteurs) représente un coût d'environ 60 000 €, sans compter la modification de la largeur de voie de certains matériels. v

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Photo: Les pulvérisateurs roulant à grande vitesse sur sol très sec génèrent de la poussière qui peut limiter l'efficacité du glyphosate. Des adaptations sont mises en place pour les buses au niveau des roues : pulvérisation à l'avant de l'automoteur, buses plus grosses permettant de surdoser le produit…
© ARVALIS-Institut du végétal, J. Labreuche

Appliqué dans les règles et avec peu de contraintes de transport sur route, le controlled trafic nécessite de disposer de la même voie sur chaque matériel. L'auto-guidage permet ici la localisation précise des rangs entre ceux de l'année précédente. Résidus marron de pois chiche semé tous les 76 cm et résidus grisâtres de son précédent blé semé tous les 38 cm.

L'essentiel: Les matériels, de taille impressionnante, sont utilisés sur plusieurs milliers d'hectares.

L'essentiel: Le controlled trafic est une application du GPS consistant à maximiser les surfaces jamais tassées dans une parcelle agricole.

Les systèmes de cultures avec élevage peuvent s'inspirer des techniques néozélandaises. Au premier plan, couvert permanent de luzerne qui est conduit sous une céréale une partie de l'année
et qui assure l'alimentation des ovins en été.

Le semoir à dents constitue un matériel de référence en Australie. Il permet le plus souvent de semer et de fertiliser en localisé en même temps.

L'essentiel: Le semis direct, moins gourmand en charges de mécanisation, a progressivement remplacé le dry farming.

Mixed farms taking advantage of zero till

SARAH JOHNSON p254-256 SANTFA The Cutting Edge WINTER 2012

[*Dans cet article, il est question de l'installation de sorgho en condition non-rriguée. L'agriculteur explique que le semis direct offre deux avantages. La culture précédente a été semée par SD donc, il y a une meilleure infiltration de l'eau de pluie. Le semis du sorgho, en se faisant par SD, l'humidité du sol est préservée. Notons deux particularités :*

-les parcelles concernées ont un sol profond avec de l'argile à 30 cm,

-les résidus de récoltes sont laissés sur le sol ce qui retient de l'humidité. Djamel BELAID] .

Using a disc seeder to sow summer forage crops can have many benefits for farmers with livestock, says disc seeding contractor Nathan Craig.

Disc seeders give farmers the flexibility to move between crops and pastures with very little disturbance, according to Nathan Craig. "I can see there are advantages to having livestock and cropping together. The disc seeder gives you a lot more options because it doesn't disrupt the soil and you can over-sow to boost production," said Nathan, a Victorian farmer and seeding contractor.

The way for planting summer crops

Since the Craig family sold their 1,465 ha farm, near Apsley, across the border from Naracoorte, in 2009, Nathan has developed a contracting business that sows up to 5,000 ha each year. Many of his clients successfully combine livestock and cropping.

Nathan uses a disc seeder that provides good seed placement and germination in 'crab-hole' country, improves the ability of young crops to access to soil moisture and opens the way for planting summer crops to provide extra feed for stock.

The Craigs were experimenting with summer crops for several years before they sold their property and bought a disc seeder the year before they sold. "Even though it was dry during the 2000s we were starting to double crop and grew some really good summer crops," said Nathan.

Sowing sorghum into harvested paddocks

"With a disc seeder you can just go straight in behind the header because you don't have to worry about handling the stubble. You can bowl straight through. "If you get rain during harvest you can sow sorghum into harvested paddocks while you're waiting for the remaining crops to dry enough to harvest. Ten weeks later, in March or April, you've got green feed for your sheep, right when you need it."

This was exactly what he did on a property he was managing in 2010, when 73 mm of rain fell while Nathan was harvesting canola. "The header was still in the paddock and we had a few days ahead of us waiting for the country to dry out. We sowed the harvested canola paddocks to sorghum.

"We used sorghum because the root systems go up to a metre deep and you can sow it up to 50 mm deep, which improves the chance of achieving a reliable germination.

Summer forage opportunity crops

"By the time we finished harvesting that lock of land we had sorghum out of the ground. It wasn't a fantastic-looking crop because that was the only rainfall we had that summer, but we still had sorghum 60 cm high to put the lambs on in autumn.

"Other farmers didn't get a summer crop because they waited four or five days after the rain and the soil had dried off too much. "In an area where the canola was washed out in winter the sorghum was 2.5 m tall because of the extra soil moisture, which showed it would be possible to grow some pretty amazing summer forage crops if we were prepared to treat them as the main crop rather than an opportunity crop.

"From what I've seen, if you grow a sorghum crop then go into wheat the next year you'll get three quarters of a tonne to the hectare higher yield,"

This made us think more about how to use this in rotation and to feed livestock. We've never had this response in summer grain crops."For summer forage opportunity crops Nathan advocates a speedy transition from header to seeder following a harvest rain to make use of the available moisture.

"I would either have half a tonne of seed on hand, especially if I saw a rain coming, or I'd make sure the supplier had a bit of sorghum seed with my name on it," he said. "I'd have everything set up and would be out sowing while the sappy moisture was still there.

"If our sandy loam got 25 mm of rain it would wet the soil to 30 cm but that moisture evaporates unless we grow something with it. It is critical to know how your soils wet up, as every paddock is different. No-till paddocks are definitely better for double cropping as they let more moisture deeper into the soil." He found planting sorghum as a summer crop also conditioned the soil, leading to increased yields from wheat crops the following season. “From what I’ve seen, if you grow a sorghum crop then go into wheat the next year you’ll get three quarters of a tonne to the hectare higher yield,” he said. “Even though the summer crop takes moisture out, there’s a synergistic effect that helps grow a better crop.

“Over summer the sorghum roots penetrate about a metre through the heavy clay. The paddock where I sowed the sorghum in 2010 had a duplex soil; 30 cm of lighter sand on top and 30 cm of heavy clay below that.

“Water doesn’t get through the clay very quickly, so we had a lot of waterlogging in the top 30 cm. The sorghum used that moisture to germinate then pushed its roots through the clay layer to access moisture from the subsoil. The roots of the following wheat crop followed the path of the sorghum and lived on the nutrients and moisture that they left behind.

“This was before we had the disc seeder and the results blew me away. I thought ‘we’ve got to do this properly with a disc seeder’. The disc seeder allows you to retain more moisture for the summer crops because you can seed into the stubble with almost no soil disturbance.”

Adding millet to a sorghum crop improves weed control

He has since found that adding millet to a sorghum crop improves weed control. In the wet summer of 2011 he sowed a mixture of millet and sorghum that grew more than two metres tall and produced about 3 t/ha of grain. The crop was harvested in mid April and he sowed the paddock to wheat the next day.

“The rest of the farm had two summer sprays – a knock-down and a pre-emergence spray – to prepare for wheat. We sowed straight into the millet and sorghum paddock, which had stubble a metre high and no summer weed, wire weed or ryegrass.

“The tall summer crop shaded the ground and out-competed the summer weeds. The millet roots bound the soil up so there was no room for more weed roots.

“It was an out-of-control paddock the year before, full of ryegrass, which is why we sprayed it out and planted the summer crop. It was nearly clean after the sorghum and millet.

“Some ryegrass came up in the wheat crop and we went in eight weeks later with a post-emergence herbicide, just because I wanted to tidy it up. That was the only weed control for that paddock for the whole year.

“I spent $50/ha on chemical for the rest of the farm trying to keep it clean.” The roots of the millet and sorghum also improved trafficability.

“A lot of our country was waterlogged because of the wet summer that year and I had to stop sowing the rest of the farm because I was leaving awful, deep tracks and nearly getting bogged. In fact I nearly got bogged on the sand hills driving across to the millet and sorghum paddock, but once I got into that paddock, I only needed two-wheel drive and had zero wheel slip.

“The soil was full of millet and sorghum roots, which were holding the soil together.

“It was a real eye opener to get down in that paddock, where I would normally have got bogged in those conditions, and find the soil had the strength to support the machinery due to the root structure.”

“No-till paddocks are definitely better for double cropping as they let more moisture deeper into the soil ».

A report for by Stephen Ball
2010 Nuffield Scholar
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[*Un rapport sur le semis direct en Australie. Il est rédigé par un étudiant et présente un angle d'approche original*]

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Foreword Over the last fifty years, the major increases in yields for crops sown in Southern Australia and overall profitability have come about due mainly to the changes in agronomy practises and management techniques and different crops. These include;
1. Ley Farming. A rotation of legume pastures and cereals, where the legume produces very good pasture productivity for livestock and nitrogen for the following cereal.
2. Better Rotations. Utilizing Grain Legumes in rotation as a cash crop and a Nitrogen source.
3. Semi Dwarf Varieties. To increase efficiencies by putting more nutrients into the grain yield rather than vegetative growth.
4. Grass Selective Herbicides. Allow control of grasses in pastures, but more importantly the control of these grasses in crops.
5. Canola. The introduction of Canola gave another income source in the rotation as well as benefits in rotation.
6. Nitrogen Fertilizer. Allowed farmers to have multiply cereal & oilseed crops in a row and still be able give them enough nitrogen to produce good yields.
7. Export Hay. As another option for a profit stream and as an integrated weed management tool.
8. Adoption of Minimum Tillage and No-Till. The use of single pass sowing and residue retention to lower costs and produce better yields in drier years.
9. Adoption of speciality crops such as Lentils.
10. There have been other impacts such as the strategic use of Fungicides.

As the terms of trade continue to reduce, the farming community is looking for the "Next Big Thing". At best, tradition breeding programs for wheat and other grains give us on average only 0.2 % yield increase per annum. Areas where the improvement can come from include; Genetically Modified Crops (GM's), Zero Tillage Farming Systems (ZT) and Controlled Traffic Farming (CTF).
The components of zero-till when used as a system have big benefits ranging from water use efficiencies and nutrient availability, through to creating a well functioning soil biota.
Over time the farmer can achieve an increase in yields, with a decrease in some inputs such as fertiliser and chemicals. The right machinery, set up correctly can also reduce seeding rates, due to higher germination percentages and lower fuel consumption.

Farmer bodies, government, scientists and agriculture researchers will need to ensure that as farmer innovators take up zero-till, the new trial programs that are funded and managed through bodies like Grains Research and Development Corporation (GRDC) are done so within the zero-till framework. The next group of farmers, the early adopters, will need and demand information that has been done in trials, such as the National Variety Trials (NVT) with an emphasis on zero-till to give them clear information and direction

about what is achievable and how to implement them.
There is still a place for longer term trials compared to the current thought of just three years. For most farmers to change from one farming system to another, takes a large amount of conviction and usually an equally large amount of capital. For these farmers to see zero-till working over time, gives them confidence to move ahead, particularly when given a long term view.
This research paper has been funded/ sponsored by GRDC who in turn are funded by government allocations and farmer levies. They funded a Nuffield scholarship to "Investigate zero-till farming systems in high rainfall cropping zones (HRZ) and its impact on soil biology and nutrient cycling". Its aim is to lay out the current sources of information in a logical sequence to better arm farmers who want to implement zero-till farming systems in their business.

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My first thoughts of Nuffield were when I worked for an older scholar and I also have a family friend who is a scholar and they inspired me with their management of not only their farm but their broader outlook past the immediate district, so thank you to Guy & Sue Wheal and Kim Kelly who planted the seed.
Another important influence was Tim Reeves who I met at Roseworthy who always made me think outside the square and made me look at Agriculture with global perspective.
Next thing I knew there was a phone call from the South Australian President, Andrew Johnson who encouraged me to apply. After two interviews, I was going to be a 2010 scholar.
I spent six weeks travelling around the world with seven other scholars on our Global Focus Program, thank you, you were excellent and I hope we have become lifelong friends.
On our travels for the Global Focus and Study Tour, we have met a lot of fantastic people and some excellent businesses, that have willingly shared their experiences and opened their homes to us, I thank you kindly. Without exception all of the farmers we met-,had the same hopes, aspirations and concerns as us.
There are a couple of people I would like to thank for their support and encouragement. I met Nikki at Roseworthy over the odd BBQ and beer and we now have four wonderful children, Kasey, Megan, Sam and Henry. They saw the opportunity which was presented to me and willingly gave up their husband and father for nearly 5 months. They only asked for a small favour in return. We caught up in New Zealand for a week skiing.

I would also like to thank Bugsy McInerney who leased our farm for the year which allowed me to gain the most from my starting year of the Nuffield scholarship and which also allowed Nikki to accompany me on my Study Trip.
As I am a farmer by choice and not by birth, my own parents Mick & Daphne, gave me lots of support to follow my quest to be a farmer. Nikki's parents Don and Bev gave us the opportunity to be involved in their farm business and now they help in our farm business. A big thank you to all of them.
Finally I would to thank two organisations. Firstly, my sponsor the Grains Research and Development Corporation (GRDC) who along with Nuffield saw the potential in me and funded my scholarship. Secondly to Nuffield, it is an organisation like no other giving farmers from around the globe the opportunity to be involved in the largest farmer network in the world and the huge benefits this brings.

Abbreviations
AAPRESID Argentinean No-Till Association AMF Arbuscular Mycorrhizal Fungi CA Conservation Agriculture CAP Common Agricultural Policy CFFA Canadian Food Fibre & Forestry CIMMYT International Maize & Wheat Improvement Centre CT Conventional Tillage CTF Controlled Traffic Farming GRDC Grains Research & Development Corporation GSR Growing Season Rainfall HRZ High Rainfall Zone MT Minimum Tillage NTA No-Till Alliance NT No-Till SANTFA South Australian No-Till Farmers Association SOM Soil Organic Matter SA South Australia USDA United States Department of Agriculture. UN-FAO United Nations Food & Agricultural Organization UV Ultra Violet WA Western Australia ZT Zero-Tillage

Executive Summary

"Residue is King" To continually be in the vanguard of efficiency and profitability, Australian farmers need to adopt new technology and management practices. Currently Zero-Till, Genetically Modified Crops and Controlled Traffic Farming are valuable tools that are available to them.
This report looks at zero-till farming systems as a whole and then breaks it down into its manageable components, so farmers can identify those areas in their farming business where this management option can be implemented. Having said this, the whole system needs to be implemented for any benefit to be realised. A+B+C = Healthy Soil A = Absence of Soil Tillage Tillage has been around for an exceptionally long time, but according to Faulkner "No one has ever

advanced a scientific reason for ploughing." To achieve the aim of no soil disturbance, there are a number methods; direct sowing with a disc seeder or broadcasting of crop seeds, and direct placing of planting material into the soil (Theodor Friedrich, 2008). For most farmers the use of disc seeders will be the preferred method and farmers should aim for no or absolutely minimal disturbance. Do not destroy what you and your soil biota are building.

B = Biodiversity One of the ways to create biodiversity is through sound crop rotations. They can include annual crops which are classified as; • Cool season grasses and broadleaf's e.g. Wheat & Beans. • Warm season grasses and broadleaf's e.g. Maize or Soyabeans. • Perennial crops e.g. Lucerne & Sulla.

As well as annuals there are perennial crops that can be used, for example Lucerne and livestock can be integrated, but need careful monitoring in order to keep permanent soil cover. Whilst it would be good to introduce warm season crops into the rotation, most of the HRZ's in SA & WA have a mediterranean climate with no or limited summer rainfall. With current cultivars, this would only allow them to be grown on stored moisture and hope for some rain to finish off the crop and then some grain will be harvested. There are some new cultivars which are cold tolerant and can be planted at a soil temperature of 10oC. Every situation and farm is different and determining the type of crops and their sequence can be a complex process.

C = Cover on the Soil This is the lynch pin. Aim to retain all of your stubble / residue to keep 100% soil cover. You are giving this back to feed the soil biota. This residue feeds the whole system. If the soil fertility is to improve under zero-till, it is imperative to increase its organic matter through retention of all biomass which is the residue that is left on the surface combined with root structures decaying in the soil. As well as having physical benefits to the soil, for example lowering erosion, the residue feeds soil organisms known as Biota. The biota carries out a wide range of processes that are important for the maintenance of soil "health" and fertility in both natural and managed agricultural soils.

The job that farmers require from their macro- and micro-organisms in the soil biota is to help; • Improve the soil structure e.g. Glomalin from Arbuscular Mycorrhizal Fungi's.(AMF's) • Organic matter turnover and movement through the soil profile, with soil ameliorants transported through the soil profile. e.g. earthworms and their castings. • Nutrient cycling, principally nitrogen, phosphorous & sulphur. • Disease incidence & suppression e.g. fungal feeding nematodes. • Agrochemical degradation e.g. glyphosate binding bacteria.

Research Area Scientists, agricultural researchers and research farm managers were interviewed across 3 continents with them contributing to the body of knowledge in the report. Also across these continents, innovative farmers were visited to see how they have implemented zero-till. Also a very large 3 day congress was attended in Argentina as a guest of the Argentinean No-Till Association (AAPRESID).

Disc Seeders Most of the disc seeders that are currently available in Australia are cost prohibitive to the majority of small to medium farmers. In South America there is a large range of disc seeders manufactured, particularly in Argentina and Brazil that are far more affordable. With some input from Australia farmers, the machines can be made to our specifications. A number of companies were interested in our input e.g. Avec, Bertini and Semeato.

These and others were all double or triple disc units and can handle in excess of 10 t/ha of stubble. So to retain all stubble and get through this residue, a disc seeder is the only realistic option. Other benefits include; • Superior seed and fertilizer placement. • Increase timeliness of sowing. • Reduced fuel consumption

Recommendations • Adopt the Zero-Till system • Obtain a quality double disc machine that has; a. No soil disturbance when in use. b. Seed firming mechanism, either a wheel or Keeton finger c. Closer unit that fills the trench with soft soil and some residue d. Realistic price so smaller farmers can access the technology to move to ZT. • Small / Medium size farmers can look towards South America to find suitably priced machines. They are slowly being imported into Australia. • Look upon all residue as precious and must be retained to form a permanent cover on the soil and as feed source for the biota. • Use as diverse a rotation as possible. Try to utilise cool and warm season crops. Get some cold tolerant maize cultivars from Argentina or Chile. • Use organic manures to increase SOM and as a very good source of both nitrogen, phosphorous and to a lesser degree potassium. • Re-inoculate soils with worm species particularly the Anecic type as this will help with soil ameliorants being moved through the profile and their burrows allow for increased water infiltration. Also the Endogeic type actually eats soil and move nutrients through the profile. This is of particular importance for phosphorous which is relatively immobile in the soil.

Introduction

"No one has ever advanced a scientific reason for plowing." Edward Faulkner from Plowman's Folly (1943)

As a professional food and fibre producer, who is constantly looking to be more economically and environmentally sustainable my choice of study topic for my Nuffield Scholarship has provided me with the opportunity to look at zero-till farming systems in detail. This will impact positively on our business as zero-till farming has shown to be the next positive step forward in sustainable farming systems. Wattle Vale Farm is a medium / small family run business in the heart of the South Australia's High Rainfall Cropping Zone as designated by GRDC.

For the last 13 years all of the cropping enterprise has been carried out using no-till (NT) techniques with knife points and press wheels. As much stubble as possible is retained, but in good years there is too much residue to handle. Then the stubble is broken down by mechanical means, such as slashing or prickle chaining or livestock grazing. Other methods employed are baling the straw or as a last resort, burning. There have been very good gains in productivity, but in the last five years these have plateaued with no noticeable improvements.

After hosting many international key note speakers for the SANTFA Annual Conference, they had a common message. To keep improving the soil, it was imperative to look at zero-till. By shifting from knife points to discs they stated that the soil structure will improve by itself through retaining all of the residue, and feeding the biota. This will in turn improve the overall soil health and lead to increased yields with fewer inputs.

A Nuffield scholarship was a great opportunity to find out if zero-till was the answer to "Where next?" and "What is the Next Key Driver?"

What transpired was an expedition over 4 continents, with some wonderful visits to leading edge farmers, top rate scientists and researchers. Also machinery manufacturers were called upon, mainly in South America. The result of this journey is the firm commitment that zerotill is the way forward and it is an option a lot of farmers will take up over the next 5-10 years.

Objectives The objective of the study was to investigate where the next leap in productivity was going to come from. Firstly the area of particular interest was zero-tillage systems, which is not only about using disc machines but the whole system where all biomass, stubble and residues are retained and a diverse rotation is put into practice. To complement this systems approach, an investigation of what is occurring in this residue layer and in the soil beneath it, in terms of nutrient cycling and soil biology was undertaken. Secondly to seek out the best disc machines that not only work under varying conditions, but are also available at a realistic price so that small to medium size farmers can purchase them and thus utilize the zero-till system. Thirdly, an investigation into new crops that could be utilized across high rainfall cropping zones in southern Australia. In particular, those which are suited to a Mediterranean climate, which could increase the diversity of our rotations.

Current farming systems and the need to change Throughout the Southern and Western Australian cropping zones the main farming system for crop production is no-till. This system is based around some residue retention and seeding via a tyned implement with knife points. In some years where the residue burden is too great to be able to be handled at seeding, it is removed by baling and burning or "walk out the paddock" by allowing livestock to graze over summer and autumn. In the rest of the world, mainly North and South America this is still considered a tillage practice with low benefits to the soil. Some farmers have been practicing no-till, Australian style, for around 15 years and have been retaining the residue. They have used slashing, rolling or harrowing to break it up into small enough pieces to allow seeding to occur with little or no blockages. These farmers have felt they have reached a plateau in the system with no added yields and improvement in soil structure and soil health.

Juca Så from Brazil has been instrumental in the movement to zero-till in Southern Brazil. He has shown what is happening in the zero-till system through the years of its initial and transition phases and then through the consolidation and finally at maintenance phase.

Table 1 Evolution of Zero-Till From 0 to 20 Years

Time (years)		
0-5	Initial phase	• Rebuild Aggregates • Low OM • Low crop residues • Reestablish microbial biomass • > N
5-10	Transition phase	• Increase soil density • Start incr. of crop residue • Start incr. in OM • Start incr. P • Imob. N ≥ Min.
10-20	Consolidation phase	High CR • High C • > CEC • > H2O • Imob. N < Min. • > Nutrient Cycling
> 20	Maintenance phase	• High accum of crop res. • Continuous N and C Flux • Very high C • > H2O • > High Nut. Cycling • Less N and P use

(Sá, 2004)

Evolution of a continuous zero-till system

Juca believes that our no-till systems will never leave the transition phase and therefore not receive the major benefits which occur later in the evolution. (Sa, 2004). He states "That we should dispense with a tyne and knife point to a system which abstains from tillage and retains all residue coupled with diverse rotations."

The Zero-Till (ZT) system This system is one that incorporates the use of no or minimal disturbance disc seeders with diverse rotations and continuous soil cover through retaining the entire residue on the soil surface and most times including controlled traffic

farming (CTF).
According to the United Nations Food & Agricultural Organization (UN-FAO), zero-till or conservation agriculture will have all of the above and can integrate other features such as perennial plants, inclusion of allelopathic and smother crops such as canola or saia oats, all to increase the biomass in the soil and feed the good macro and micro organisms in the soil.

For the zero-till system to be successful Rolf Derpsch a world expert in this type of farming system and cover crops, says all of the components of zero-till must be implemented together and if you miss one component then the system will break down. We have learned that almost all advantages of the no-till system come from the permanent cover of the soil and only a few from not tilling the soil (Derpsch, 2008). He likens it to a three legged stool with the legs named A,B & C. The three legs are stable but when one is removed it quickly topples. They stand for
A = Absence of Soil Tillage: No Mechanical Soil Disturbance. B = Biodiversity: Crop Rotation / Cover Crops or Integrating Livestock & Farming. C = Cover of the soil: Permanent Cover with Crop Residues.
A + B + C = Healthy Soils A = Absence of Soil Tillage and Disturbance Farming has been traditionally carried out with the use of such implements as the mouldboard plough, offset discs, cultivators and harrows. Farmers in this cycle of farming believe that to obtain a uniform and loose seedbed, which is weed-free, it was and still is necessary to till the soil. Even the No-Till seeding method has negatives. No-till seeding is carried out using a tyned implement with knife points with row spacing of 250-300mm. These points are generally 1215mm wide with tungsten facing. The soil has some cultivation particularly below the level of the seed and there is still quite a large amount of soil throw. Dwayne Beck, Rolf Derpsch & Carlos Crovetto believe this to be cultivation and don't see how it can be called no-till.
When the seeding system uses any plough, cultivator or even knife point seeders, a number of negative impacts have been found on the soil and conditions in it.
1. During the tillage operation there is an infusion of higher levels of oxygen. This results in a rapid decomposition of soil organic matter (SOM). This continues for a short time after tillage / seeding which gives a large flush of available nutrients to the plant, at a particular time when the plant only requires a limited amount.
2. The populations of larger organisms such as earthworms and arthropods are quickly decimated by physically damage to the organism itself and also damaging its habitat / burrow means they will not reproduce.
3. The action of the cultivating machine slices and dices delicate macro and micro organisms such as fine thread like fungi and worms. This results in the soil being dominated by the smallest organisms like single cell bacteria. (Blank, 2007)
4. The soil structure is damaged. Soil structure can become coarse, massive and platy on some soils, whilst there may be an increase in soil strength, water infiltration, retention and availability all decrease. On other soils tillage breaks down the soil structure into a fine powder so the soil is easily eroded by wind and water. These soils become waterlogged easily and become less fertile; less responsive to fertilizers and then a lot of energy needs to be expended to remediate them. (Benites, 2003)
5. The implements used for tillage often lead to the development of a hardpan, which is a horizontal compaction zone which is created by the smearing action at the bottom of the plough / seeder that reduces root growth and water infiltration into the lower levels of the soil profile.
6. Under tillage, the soils can become water logged, compacted and possibly anaerobic where there is a lack of oxygen. In most cases this leads to a decrease in beneficial micro organisms and leads to a large increase in different organisms, many of which are pathogenic (disease causing) bacteria and fungi e.g. Pythium and Phytophthora root rots.
7. As the soil with a hardpan has more water added from either rainfall or irrigation, the level of the water in the small area of the profile continues to rise up towards the surface, the area of aerobic conditions decrease and anaerobic area increases. This lowers the physical space available for living roots to live in. Dr Kim Coder states "The consequence of having smaller volumes of space for roots to grow means that roots and their resources are subject to much greater fluctuation in water, heat loading and mechanical damage. Drought and heat stress can quickly damage roots in this small layer of oxygenated soil." Some weeds which typically have shallow roots systems and shorter life cycles can out compete the crops that we sow. (Coder, 2000)
With the above reasons and more it is clear there is no reason to continually till the soil. At a field day in England, here is a condensed version of the conversation between two farmers. Farmer 1 "I have to plough the soil to control weeds." Farmer 2 "How long have you been ploughing." Farmer 1 "25 years." Farmer 2 "If you still have the same weeds, you are a slow learner." (Ball, 2010).

The excuse for ploughing is no longer valid. This particular farmer was using it as an excuse to continue the way he had been farming for 25 years. The other pointed out that in five years of Zero-till he had overcome the problem weeds because the grass weed

seeds needed to be buried to germinate and he kept them on the surface.
B = Biodiversity In agricultural cropping systems it is relatively hard to achieve diversity in any one year but it can be achieved by planting a different crop each year. In previous years and even today a number of farmers plant one cool season grass crop such as wheat and then a cool season broadleaf crop such as canola, the two crop sequence. This system has fallen down mainly in WA, as there was no real diversity. There was only 1 year to control broadleaf weeds in the wheat crop and the equivalent for the canola weeds. They put too much pressure on the chemicals and in a short period of time, the system soon collapsed as the weeds became resistant to the chemicals. Canola also has some allelopathic properties, which it produces to stop competitors. This unfortunately stops some micro-organisms in the soil from thriving. A major one is Arbuscular Mycorrhrizal Fungi(AMF), and we now know these AMF have a major role to play in our soils. Stacked rotations are being used to overcome some of these problems and help create a better system. Two crops of each type are grown in sequence. It enables weeds to be controlled and also disease issues are better accounted for in this system. A rotation may incorporate legumes and oilseeds for broadleafs and cereals such as wheat, barley & maize. It would be very good to find a warm season crop that could be grown in Mediterranean climates. It will be discussed later. The rotation currently used on Wattle Vale farm, is; Beans - Canola- Durum - Wheat - Vetch - Canola - Wheat - Cereal Crop or Hay
Within these crop rotations it is also ideal to have crops with different rooting systems to take advantage of nutrient and moisture differences in the soil profile.
All situations and rotations are different but some guiding priciples can be helpful and Dwayne Beck has given his Top 10 List.

1. Reduced and no-till systems favour the inclusion of alternative crops. Tilled systems may not.
2. A two season interval between growing a given crop or crop type is preferred. Some broadleaf crops require more time.
3. Chemical fallow is not as effective at breaking weed, disease, and insect cycles as is black fallow, green fallow or production of a properly chosen crop.
4. Rotations should be sequenced to make it easy to prevent volunteer plants of the previous crop from becoming a weed problem.
5. Producers with livestock enterprises find it less difficult to introduce diversity into rotations. a. Use of forage or flexible forage/grain crops and green fallow enhance the ability to tailor rotational intensity.
6. Crops destined for direct human food use pose the highest risk and offer the highest potential returns.
7. The desire to increase diversity and intensity needs to be balanced with profitability.
8. Soil moisture storage is affected by surface residue amounts, inter-crop period, snow catch ability of residue, rooting depth characteristics, soil characteristics, precipitation patterns, and other factors.
9. Seedbed conditions at the desired seeding time can be controlled through use of crops with differing characteristics in regard to residue colour, level, distribution and architecture.
10. Rotations that are not consistent in either crop sequence or crop interval guard against pest species shifts and minimize the probability of developing resistant, tolerant or adapted pest species.

C = Cover on the Soil Almost all of the advantages of the zero-till system come from the permanent cover on the soil surface. This really is the key to the system. Carlos Crovetto states “The grain is for man and the stubble is for the soil”. (Crovetto, 2006) The retention of 100% of the residue and use of disc seeders goes hand in hand. To be able to keep the entire residue from the previous year’s crop you need to use a disc seeder otherwise to be able to get through with a traditional tyned seeder you may have to compromise by either removing some as baled straw or feeding livestock to lessen the load. This results in not maintaining 100% cover and having also tilled the ground and undone the micro- and macro-organisms good work. The benefits to the soil include:

1. Erosion Control In a soil that is not tilled for many years, the crop residues remain on the soil surface and produce a layer of mulch. This layer protects the soil from the physical impact of rain and wind thereby allowing the soil to regenerate. According to Kris Nichols, she believes that a 10 tonne residue will result in 1mm of new soil. This has particular reference to Australian soils where most are extremely old and weathered. Not only can farmers stop erosion of our soils, but they can rebuild them. (Nichols, 2008)
2. Water Infiltration & Water-holding Capacity By having the residue on the surface, the speed of water over the surface is dramatically slowed and this gives it more time to infiltrate. Also as more organisms inhabit the soil they create micro- and macro-pores leading from the soil surface down to the subsoil and allowing rapid water infiltration in case of heavy rainfall events. Water holding capacity is increased as the SOM levels increase. This is enabled as the specific density of the soil decreases and pore spaces increase which allows more water to be held in the soil profile. This water is then available for the plant roots. According to Patriquin, 2003, the rough rule of thumb is for every 1% increase in SOM, the water holding capacity increase by 50%. (Patriquin, 2003). It will take time but Australian farmers can take the path to capturing more of the rainfall we do get and keeping it in the soil

as available moisture for our crops.
3. Soil Temperature & Lower Evaporation By keeping the residue on the surface, there is a big benefit for farmers to lower soil temperature by almost half when compared to a soil with no cover. Durceu Gassen from Brazil showed that a soil with no residue cover over summer had a temperature of 53.50C, where as one covered with maize residue had a temperature of only 25.50C. This has a double benefit in that microbial activity becomes extremely slow at temperatures above 300C. The other benefit is that the residue cover also lowers evaporation which means there is more plant available moisture. It has a stabilising effect on both temperature and soil moisture. These reasons alone should be enough to see Australian farmers take up Zero-till, with much of our farming carried out in low rainfall areas.
The combination of lowering evaporation and increasing both water infiltration and water holding capacity means that we can have a direct action to increase yields across Southern Australia. I feel the French-Schulze model will need to be changed. According to French & Schulze we should be able to grow 20 kilograms of wheat for every millimetre of rainfall in the growing season after evaporation is subtracted. This can be seen below in equation 1 & 2 using data from the Gilbert Valley in SA with a growing season rainfall (GSR) of 400mm.If all the residue is retained, we can reduce evaporation by 20%. This gives more water available for plant growth and this is shown in equation 3. Eq1 Yield Potential = (GSR-Evaporation) x 20kg
Eq2 5800 kgs = (400 – 110 mm) x 20kg
Eq3 6240 kgs = (400 – 88mm) x 20kg
In a simplistic way, this shows that by reducing the evaporation alone we could result in an increase in yield by approximately ½ tonne. If the amount of extra water available through increasing water holding capacity is also considered, the increase in potential will be above this ½ tonne. We can see the logic in this solution already, if we look to the humble veggie garden; it is common to put pea straw on to lower evaporation and help smother weeds and this has been done for many years.
4. Weed Barriers Over time as the system progresses more residue

4. Weed Barriers Over time as the system progresses more residue accumulates, this has a positive effect on weeds and weed seeds. The residue acts like a mulch in the veggie garden and smothers weeds trying to grow, thus making the plants more competitive. By not cultivating the soil some weed seeds will fail to germinate as they need darkness or contact with the soil to start life. This keeps the weed seeds on the surface and over time they are broken down by UV light.

5. Feed the Soil Biota As cover is the third leg on the stool, biota forms the core of that particular leg. The biota is the living fraction of the soil. Over time with total residue retention the numbers of soil organisms increase, both in total number and diversity. The residue and soil interface becomes a habitat for a number of organisms, from earthworms and larger insects down to soil borne fungi and bacteria.
Due to the fact that no mechanical implements are used that destroy the "nests" and channels built by micro-organisms, higher biological activity occurs under the zero-till system. Additionally, micro-organisms do not die because of famine under this system (as is the case under bare soils in conventional tillage) because they will always find organic substances at the surface to supply them with food.
Finally, the more favourable soil moisture and temperature conditions under zero-till also have a positive effect on micro- organisms of the soil. For these reasons more earthworms, arthropods, (acarina, collembola, insects), more micro-organisms (rhyzobia, bacteria, actinomicetes), and also more fungi and micorrhyza are found under no- tillage as under conventional tillage (Kemper and Derpsch, 1981; Kronen, 1984; Voss and Sidiras, 1985). Despite the fact that chemicals are used to kill weeds, higher biological activity occurs under zero-till, an indicator of a healthier soil.
The biota carries out a wide range of processes that are important for the maintenance of soil "health" and fertility in both natural and managed agricultural soils. The job that farmers want from their macro and micro-organisms in the soil biota is to; 1. Help with soil structure e.g. Glomalin from Arbuscular Mycorrhizal Fungi's.(AMF's) 2. Improve organic matter turnover and movement through the soil profile e.g. Earthworms and their castings. 3. Increase nutrient cycling e.g. nitrogen, phosphorous & sulphur. 4. Suppress disease and reduce the effects of these diseases e.g. fungal feeding nematodes. 5. Help with agrochemical degradation e.g. Glyphosate binding bacteria.
Help with Soil Structure One particular organism that inhabits the top layers of the soil profile is AMF's. They are the world's biggest organism where, for example, one individual fungi can cover a square kilometre under forests. They are ancient microorganisms that evolved with plants to aid in acquiring nutrients and they produce glomalin. This is a sticky substance secreted by the fungal hyphae that funnel nutrients and water to the plant roots. It acts like little globs of chewing gum on strings or strands of plant roots and fungal hyphae. Into this sticky "string bag" fall the sand, silt and clay particles that make up the soil – along with plant debris and other carbon containing organic matter. The sand, silt and clay stick to the glomalin, starting aggregate formation, a major step in soil creation. (S.F.Wright, 2004)

On the surface of soil aggregates, glomalin forms a lattice-like waxy coating to keep water from flowing rapidly into the aggregate and washing everything, including the carbon away.

As the builder of the formation "bag" for soil, glomalin is vital globally to soil building, productivity and sustainability, as well as to carbon storage. An interesting note from Kris Nichols is that she uses glomalin measurements to gauge which farming or rangeland practices work best for storing carbon. Since glomalin levels can reflect how much carbon each practice is storing, they could be used in conjunction with carbon trading programs. She has found that both tilling the soil and leaving land idle, such as in fallow, which is common in our climate decrease glomalin levels by destroying hyphal fungi networks. The networks need live roots and do better in undisturbed soil. When glomalin binds with iron or other heavy metals, it can keep carbon from decomposing for up to 100 years. Even without heavy metals, glomalin stores carbon in the inner recesses of soil where only slow acting microbes live. This carbon in organic matter is also saved like a slow release fertilizer for later use by plants and hyphae. Over all the AMF's and their product glomalin help build significant resilience in the soils. (Nichols, 2008)

Organic Matter Turnover and Movement through the Soil Profile The earthworms and other macrofauna such as termites and dung beetles are very important biological agents that fragment organic residues and cause a large surface area to be exposed for decomposition. These organisms macerate the mulch, incorporate it into the soil and decompose it so that it becomes humus and contributes to the physical stabilization of the soil structure and its porosity. They also help with the formation of soil aggregates and soil pores. Through these soil pores the organic matter and other organic and inorganic materials can be moved through the soil profile. With the aim of zero-till to not till the soil, this is one of the ways farmers can transport these to mix throughout the soil. Lime, gypsum and manures / compost are examples of soil ameliorants which are spread on the surface, but are needed and are best utilised further down in the profile. This process carried out by the living component of a soil or the soil biota, can be regarded as "biological tillage".

Photo 2 Biological Tillage by Macro-organisms In most cases these tillers are big organisms that burrow through the soil looking for their food. Earthworms "glaze" the passageway they create with a nutrient rich and microbial active slime layer that greatly enhances water holding capacity and soil structure. Earthworms and many soil arthropods also shed organic matter, grazing on the microorganisms present, and then excreting the nutrients in a plant available form. Together, all these small channels and pores serve as reservoirs and a transportation network for air, water, nutrients, roots and organisms. According to Danny Blank, water use efficiency has increased by as much as 50% in some regions of Australia by reintroducing absent soil biology. This means that the same amount of crop could be grown with half the amount of water. (Blank, 2007) Dwayne Beck reintroduced Night Crawlers (Anecic Earthworms) to the research centre paddocks and has been very happy with the results

Photo 3 Roots following Earthworm Burrows

There are a number of different Earthworms and they all live differently so their positive effects are also varied. In Australia there about 2000 species of earthworms and they range from tiny 2-3mm long worms through to the giant Gippsland worms at 2-3metres long. They all fall into 3 classifications i.e.: Epigeic (surface dweller), Endogeic (criss-cross burrows in the top surface layer), Anecic (deep vertical burrowing). (Mingin, 2010)

Epigeic worms live in the top soil, and duff layer on the soil surface. These small, deeply pigmented worms have a poor burrowing ability, preferring instead an environment of loose organic litter or loose topsoil rich in organic matter to deeper soils. Epigeic species feed in organic surface debris. They are the ones found in most worm farms and which need a lot of residue to live. And like the Anecic worms are easy prey for insects and bigger predators like birds living in the mulch layer.

Endogeic worms build complex lateral burrow systems through all layers of the upper mineral soil. These worms rarely come to the surface; instead spending their lives in these burrow systems where they feed on decayed organic matter and bits of mineral soil. They are the only category of worm which actually eats significant volumes of soil and not strictly the organic component.

Photo 4 Endogeic Worms in Action (Rolf Derpsch)

Anecic worms like the common Night Crawler build permanent, vertical burrows that extend from the soil surface down through the upper mineral soil layer. It is not unusual for their burrows to reach a depth of six feet or more. These worm species coat their burrows with mucous which stabilizes the burrow so it does not collapse, and build little mounds (called middens) of stone and castings outside the burrow opening. Anecic worms are able to recognize their own burrows, even in an environment where there are hundreds of other burrows present and return to these burrows each day. (Mingin, 2010)

The Anecic species feed in decaying surface litter, so come to the soil surface regularly, which leaves them exposed to predators. They have developed a spoon shaped tail that bristles with little retractable hairs, called setae, with which to grip the burrow wall and avoid being easily pulled out. They also tend to be very large worms. These worms have a long generation time and each only has one burrow. In the absence of this burrow, Anecic worms will neither breed nor grow. By utilizing a disc machine with very minimal disturbance less of these burrows will be destroyed.

Nutrient Cycling

Nutrient cycling is very important is all systems, but particularly so in cropping systems where we are trying to maximize the efficiency of the nutrients used. Soil organisms, including micro-organisms, use soil organic matter as food. As they break down the organic matter, any excess nutrients (nitrogen, phosphorous and sulphur) are released into the soil in forms that plants can use. This release process is called mineralization. The waste products produced by micro-organisms are also soil organic matter. This waste material is less decomposable than the original plant and animal material, but it can be used by a large number of organisms. By breaking down carbon structures and rebuilding new ones or storing the carbon into their own biomass, soil biota plays the most important role in nutrient cycling processes and, thus, in the ability of a soil to provide the crop with sufficient nutrients to harvest a healthy product. The organic matter content, especially the more stable humus, increases the capacity to store water and store (sequester) carbon from the atmosphere. (Bot, 2005)

The ability of soil to hold nutrients, is often measured by what is called Cation exchange capacity (CEC)—a measure of a soil's negative charge (usually in clays and organic matter). Rarely are soil organisms mentioned with regards to nutrient retention, however, in a healthy soil, vast reserves of important plant nutrients are stored within the bodies of bacteria, fungi and other soil organisms. Bacteria have the highest concentration of nitrogen of all other organisms both macro and micro. Fungi are typically the second most concentrated in nitrogen. (Blank, 2007).

Along with nitrogen they contain other critical plant nutrients—high levels of phosphorus, potassium, sulphur, magnesium, calcium, etc. Decomposition happens almost exclusively by these two sets of organisms, which in turn store nutrients from the decomposed organic matter in their own bodies, immobilizing nutrients, and thereby reducing leaching. Another example is calcium, which is held incredibly tightly by fungal hyphae in the soil. Without healthy fungal biomass, calcium is easily leached through soils. The presence of decaying organic matter in soil, broken down leaves roots, dead organisms, etc, along with diverse populations of bacteria and fungi is the key to immobilizing and storing nutrients in the soil. These nutrient-rich organisms then become the basis for the critical cycling of nutrients for our crops.

As mentioned above, fungi and bacteria have considerably more nitrogen in their bodies than other organisms. The carbon to nitrogen ratio for bacteria is around 5:1 and for fungi is 20:1. Nutrient cycling happens when other sets of soil organisms (primarily protozoa, bacterial and fungal feeding nematodes, micro arthropods, and earthworms) are present to consume the nutrient-rich bacteria and fungi and release nutrients in plant-available forms. A healthy soil contains diverse species and huge populations of protozoa, beneficial nematodes, micro arthropods, and earthworms. For example, one gram of healthy soil can contain 1 million protozoa. These protozoa, with a C:N ratio of 30:1, consume bacteria. Because the protozoa need less nitrogen, the excess is excreted in the form of ammonium ions. The ammonium ions are held more tightly to the soil particles than are nitrate ions, the most common (and leachable) form of nitrogen in commercial fertilizers. This predator-prey relationship between protozoa and bacteria can account for 40 to 80% of nitrogen in plants. (FAO - Soil Bulletin, 2002). Bacterial and fungal-feeding nematodes do a similar job. They consume vast quantities and have been found to turn over approximately 50 – 100 kg/ha/year. These nematodes are beneficial, unlike their close relative Cereal Cyst Nematodes (CCN), contributing immensely to plant available nitrogen.

These interactions and countless exchanges of nutrients between soil organisms occur in root zones of plants where the highest concentrations of organisms exist (because root exudates provide food for the bacteria and fungi which in turn attract their predators—protozoa, nematodes, micro arthropods and earthworms). Nutrient cycling by these predators also occurs with other valuable plant nutrients such as potassium, phosphorus, calcium, sulphur and magnesium, resulting in a less leachable form than what is usually applied in synthetic fertilizers.

Humus or humified organic matter is the remaining part of organic matter that has been used and transformed by many different soil organisms. These fractions of the organic matter in the soil are left over when decomposers have scavenged all they can from the residue and from their bodies when consumed by predators because chemically it is too complex to be used by most organisms. It is a relatively stable component formed by humic substances, including humic acids, fulvic acids, hymatomelanic acids and humins. (Bot, 2005) It is probably the most widely distributed organic carbon-containing material in agricultural soils. It has many functions which are listed below;

1. Improved fertilizer efficiency.
2. Longer life of Nitrogen for example urea performs for 60-80 days longer.
3. Improved nutrient uptake, particularly phosphorous and calcium.

4. Stimulation of beneficial soil life.
5. Provides magnified nutrition for reduced disease, insect and frost impact.
6. Humates “buffer” plants from excess sodium
7. Organic humates are a catalyst for increasing soil carbon levels

Other soil organisms are also involved in more direct forms of nutrient cycling. Nitrogenfixing bacteria, Rhizobium sp., convert atmospheric nitrogen into a usable plant form as they colonize the roots of legumes. Mycorrhizal fungi colonize root systems as mentioned before with staple grain crops as wheat, barley, maize and sorghum. In so doing, these specialized fungi cycle nutrients by secreting enzymes that solubilize calcium phosphate and pump the phosphorus directly to the plants, thus making an otherwise unavailable nutrient now available to plants. (S.F.Wright, 2004)
With the retained residue and increase over time of organic matter, there is a dynamic nutrient release over the whole season rather than peaks. (Jack Desbiolles 2010) In a tilled system with regards to nitrogen, there is normally a large spike in autumn after the first rains and subsequent cultivation and/or seeding pass with high disturbance. This is due to high amounts of oxidation occurring after tillage where there is a large increase of respiration and turnover by soil organisms. The new system follows the crops needs much more than the traditional and unnecessary spikes.

Disease Incidence & Suppression
Root disease can be a major restriction to plant production and therefore yield of grain or hay. The cause of this disease is that current practices have allowed a pathogenic organism to become dominant. (Better Soils Technical Committee, 1998) After the Zero-till sytem has been employed for a number of years there is evidence that the soil can become “supressive”. This is when the level of predator organisms has increased and keep the pests and diseases in check that were previously causing yield losses. A number of cases of this disease suppressive soils have been found on a number of the continents where zero-till has been used for a number of years. A couple of the diseases that have been suppressed are Rhizoctonia and Take-all. This supression seems to come from the fact that those organisms are being predated by beneficial organisms and that under the zero-till the plants are more healthy and are able to tolerate some pressure from disease. (Roget, 1998)
Agrochemical Degradation In some instances, with the build up of microbial action, agrochemical degradation has increased such as with glyphosate. “Agricultural chemicals are broken down in a similar way to organic matter where microorganisms produce the appropriate enzymes to degrade the compound. More complex structures degrade more slowly either because fewer microorganisms in the soil produce enzymes capable of degrading them or because of the inaccessibility to microbes” (Department of Agriculture Victoria, 2011). When agricultural chemicals are degraded, the microorganisms responsible obtain carbon (energy) from the chemical allowing these microorganisms to grow and multiply. Microorganisms capable of degrading a particular chemical grow and multiply until there is a higher proportion of them in the soil relative to other species. This can result in this community of microorganisms in the soil adapting to the point where the chemical can be broken down more rapidly than it would have previously. This can be a problem when rapid degradation of a chemical may reduce its effectiveness against pests.

The Result of ZT After starting either a zero-till or conservation agriculture system one of the most important immediate nutrient effects is the potential of the residue cover to restrict N availability. Residues with a high C to N ratio, such as wheat, maize, barley, sorghum, and ryegrass, commonly induce N immobilization in soil surface strata during decomposition, although the magnitude of this effect is dependent on residue quantity and quality, as well as the mineral status of the soil. (Bolliger, 2009)
Table 2 : Zero-Till Wheat Yield at Melton Mowbray, England Based on Long Term Average Paddock with 10 t/ha History
Year 1 8.75 t/ha 2 7.5 t/ha 3 6.5 – 7.5 t/ha 4 8.0 t/ha 5 8.5 – 9.5 t/ha 6 Back to 10 T/ha
(Reynolds, 2007)
The N immobilization process is most intense during the first years of zero-till but after 5 or more years it gradually diminishes due to the increased surface concentration of SOM acting as an N source and thereby effectively counteracting N limitations induced by residues. (Sa, 2004) One way to help with this process is to use those crops in the rotation with a lower C:N ratio such as beans, peas and other legumes. A stacked rotation of some of these crops in the first few years would be beneficial, particularly if you intended to grow a crop like hard wheat where extra nitrogen would be needed above normal application levels.
The residues of legumes have a higher nitrogen component and are closer to C:N ratio of the biota and are therefore broken down more quickly making the nitrogen available sooner. In tillage-based systems, mineralization is "boom and bust". Booms occur after tillage with busts following shortly after and therefore requiring a big nitrogen application. According to Juca Sa, after the transistion phase of zero-till systems, the nitrogen is being cycled at a more even rate which then levels out the amount of nitrogen available to the plant throughout the season. (Sa, 2004)

The ideal soil that is healthy has the right amounts of nutrients but also has those available to the plant roots and other organisms such as Arbuscular Mycorrhizal Fungi (AMF). This ideal soil would be one that does not limit productive capacity. (Better Soils Technical Committee, 1998). The major benefit that farmers will see by implementing the zero-till farming system will be an increase in yields, water use efficencies and soil biota activity. The whole system package will need to be implemented as shown by Ken Sayre and Bram Govaerts from CIMMYT.
Figure 2. Comparison of different farming system with residue retained or not. (Govaerts 2010)
Figure 1. Effect of contrasting tillage, residue and rotation management practices of rainfed wheat yields over 11 years under optimum management at El Batan, Mexico from 1996 to 2006
1500 2500 3500 4500 5500 6500 7500 8500
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Grain Yield (kg/ha)
Farmer Practice - Continuous Wheat: Conv. tillage: Residue Removed Best CA Practice - Wheat-Maize: Zero tillage: Residue Retained Worst CA Practice - Wheat-Maize: Zero tillage: Residue Removed

Summary of Soil Characteristics
In essence, farming systems that do not use tillage, maintain biodiversity and soil cover have a large impact. The soil physically will be changed by;
1. Lowering or even stopping erosion.
2. Increase total soil in 'A' horizon i.e. making new soil.
3. Increasing water infiltration.
4. Increased soil moisture holding capacity.
5. Improved aggregate strength.
6. Improved structure.
7. Improved temperature buffering.

The soil will also have more suitable and beneficial chemical properties with an increase in; 1. Organic matter and therefore organic carbon. 2. Nitrogen in all forms. 3. Phosphorous. 4. Potassium. 5. Calcium and Magnesium. 6. pH. 7. Aluminium saturation. 8. CEC (Cation Exchange Capacity).
And the soil biology will be a lot richer and more diverse with an increase in; 1. Earthworms. 2. Arthropods. 3. Fungal feeding Nematodes and Protozoa. 4. Fungi. 5. Mycorrhiza. 6. Cellulose degradation. 7. Microbial Biomass

Why disc machines? There are a few reasons as to why farmers are opting to use disc seeders and most of these relate to the retention of the entire residue and this has been discussed in previous chapters. Other reason for using the disc machines include; • Seed and fertilizer placement. • Increase timeliness of sowing. • Fuel consumption is reduced.

Seed and Fertiliser Placement.
A benefit of disc machines over the tyned openers is that they have a very consistent seed placement characteristic with discs tending to have exacting depth gauge wheels. When these depth wheels are on the sides of the discs, they don't allow them to dig any deeper and maintain an even depth of seeding for each of the individual disc assemblies independent of each other. Furthermore, in the disc seeders which have no chamfer on the discs for the angle of attack, the whole assembly does not throw soil over into the next furrow like most tyned and some single disc assemblies. Most assemblies have a parallelogram which keeps the disc in contact with the soil at most times. A walking beam does an even better job as it maintains consistent down pressure over all of the assemblies components. When a seed singulation unit is added, like a vacuum planter, the depth of seeding and the distribution along the row is very accurate.

Increase timeliness of sowing.
To get the best result from tyned machines, the working speed in most cases is around 8 km/hr. Disc seeders are able to get very good results at speeds of up to 15 km/hr. This can dramatically increase the area that can be seeded per day. This gets the crop into the ground at the optimum seeding dates which add to increased grain yield at the end of the season. In studies for timeliness of sowing in the Mid North High Rainfall Zone trials, in 19 of the last 20 years those wheat crops sown on or before May 10th yielded on average 0.5 – 0.75 t/ha more than those sown later in the month and further into June. A negative of this practice could be that farmers get their crop in too close together and have a weather event such a frost or a very hot day with excessive wind can devastate all of a particular crop that was sown very quickly, rather than spacing them out. According to Mick Faulkner, "The other 19 years more than make up for it." (Faulkner, 2010)

Fuel consumption is reduced. By using disc seeders in the Zero-till system fuel usage is dramatically reduced. A study by Sorrenson showed a decrease in fuel consumption of 66% compared with conventional tillage and the seeding operation and a 15% reduction when compared to the use of knife points and No-Till. (Christini Pieri, 2002)

Problems / Limitations with Current Disc Machines
A number of the current disc machines that are available on the market, have different problems in that they have: 1. Trouble coping with our high clay content soils, particularly when wet. 2. Too much soil disturbance. 3. High maintenance and servicing. 4. Not enough down pressure to engage properly. 5. Unable to cut residue and cause hair-pinning.

High Clay Content Soils. According to J. Desbiolles, 73% of farmers who participated in a survey stated that had problems with sticky soils where they have had clogged seed boot outlets, soil accumulation around the moving parts of the disc e.g. depth gauge &/or press wheels, overloading of scrapers and high drag forces causing stalling of the disc rotation. These can then result in irregular and poor seed placement, furrow bulldozing and delays in the seeding program. In most cases these same farmers have learnt to wait an extra day to start sowing again. They quickly catch up with the hectares that can be sown in a day with increased sowing speed afforded by disc seeders. (Mike Ashworth, 2010)

Photo 5 – Trial Site at Riverton Showing Problems with Sticky Clay Soils and Not Cutting

Too Much Soil Disturbance

A few of the machines that have come on the market have had a problem of maintenance issues. Of particular concern are the number of bearings that not only need regular greasing (on some assemblies they have 5 greasing point for 5 bearings multiplied by number of rows eg. 40 x 5 = 200), but also require changing on a regular interval. One farmer at Alma in SA used to spend two hours a day servicing and replacing bearings. This machine did not last very long on the property.

Some current machines can create too much disturbance, but this can be helpful to those who want to incorporate some herbicides at seeding (IBS). This is a trade off with burying some of the residue and some weed seeds at the same time. The other problem is that when soil is cultivated respiration and oxidisation occurs and lot of valuable plant nutrients are burnt off and therefore not be available later when the plant needs them as discussed earlier.

Down Pressure to Engage Properly Another problem has occurred when farmers were switching over Zero-till from Conventional-Tillage, and when after the years of heavy cultivation and traffic the soils are extremely hard and the disc machines do not have enough weight or down pressure. On the other side of the coin some farmers have found problems when changing from No-Till utilizing knife points, to Zero-till with discs as the soil was too soft and there was not enough resistance to help cut the residue and had hair pinning. Mixing of the straw and soil/mud also created a lot of build up that the scrapers could not handle. According to Dwayne Beck, single disc machines have the most problems with hair pinning as they do not have any scissor action to cut through the stubble which the double discs do, particularly the offset models.

Ideal Disc Machine According to Erbach the requirements for machine performance criteria are; 1. The need for a device to effectively cut residue. 2. Uniform penetration of the soil. 3. Sufficient tilling in the seed zone to obtain good soil-to-seed contact. 4. Uniform seeding depth. 5. Adequate covering of the seed. 6. Proper soil firming over the seed. 7. The capacity to follow land contours.

To fill these criteria I have a basic set of requirements that the seeder should have; 1. A double offset disc of two differing sizes. 2. Have a small seed firmer wheel. (Not a press wheel) 3. The depth wheel/gauge needs to be independent of any furrow closer i.e. put on front discs. 4. The depth wheel needs to hold the soil in place as the blade pulls from the soil. 5. Furrow closer e.g. Star or cast wheel.

In addition to this, Dwayne Beck has given some comments regarding the assembly attachment style:

1. The JD and similar machines have radial attachments, which mean the angle of attack is correct for only one spot in its travel. 2. The parallel (or parallelogram) linkage has the proper angle of attack as long as the frame of the implement is parallel to the soil surface (very level fields). 3. The walking beam attachment has the proper angle of attack at almost all times.

Innovations in Disc Machines

1. Walking Beams

The benefit of this method of attaching the assembly as shown in the picture allows the discs and closing mechanism to be truly ground following. The double disc assembly is connected to the walking beam and the beam then attaches to the main frame. In the model from Avec, all of the down pressure came from an air over hydraulic system for dampening and keeping each unit independent.

Photo 6 – Walking Beam Design on Avec Seeder

Pulling depth control wheel rather than pushing. With a large number double disc units, the depth control wheels are connected at the rear behind the discs. This system creates a pushing motion and a separating force pulling the depth control wheels away from the discs. Trends in the new designs incorporate a forward fixing point. The force generated by pulling rather than pushing the depth control wheels keeps them tight against the disc which reduces strain and fatigue on the steel. It can also help with cutting action applied to the residue.

Photo 7 – Pulling Spoke Depth Wheels with Seed Firming Wheel

2. Spoke design for depth wheels

Current designs of the depth control wheels are solid externally with a cavity in behind and this can fill with soil, mud and also residue. The preferable option now is to have spoke design which allows for this residue to escape and not build up.

3. Opening radial arm for depth wheel

The unit which pulls the depth wheels also can be fitted with pivot points that allows for them to pivot out of the way making it easier to change bearings or even the discs.

4. Seed firming wheels

They follow in behind the discs, running along the bottom of the furrow. These innovations along with the soil closure wheels, have taken the place of press wheels. The firming wheels are different, as they only act by pushing the seed into the soil at the bottom of the slot, not by compacted the soil around the seed and the above soil like press wheel. The germination percentage is lot better as the plant shoot does not have to emerge through hard and compacted soil.

Photo 8– Seed Firming Wheel in Centre

5. Soil closure wheels

These are made in a variety of design, but all have similar job to do. They work with the seed firming wheels to create an ideal germination and growth environment. They back fill the slot created by the discs, but not with a lot of pressure. This helps in the fact that once the seed germinates it has only soft friable soil and light residue to push through. The soil does not cap over like some traditional press wheels.

New Crops

Low soil temperature maize

Maize would be an ideal crop to grow in the Southern HRZ as it is a warm season grass that produces a large amount of biomass and would give us a very good opportunity to control current weeds and pests of the cool season crops, but the current varieties of maize / corn in Australia have a temperature requirement at planting to enable germination. The soil temperature needs to be 150C and rising. For the bulk of the HRZ area with a Mediterranean climate this does not occur until mid October and by this time the soil profile is drying out and little follow up rain. There are now some varieties in South America that have been bred and selected to be able to be sown when the soil temperature is only 100C. This occurs in the Lower North of South Australia in early August. This opportunity will not give the farmers a double crop for the year, but they will be able to plant it as the crop for that year. The maize will be planted on a full profile of water and rain for another two months. Farmers can cut this for hay / silage or let it go through to maturity and reap the grain.

Sulla – Hedysarum coronarium Sulla is an exciting new biennial forage legume suited to neutral – alkaline soils ideal for short pasture rotations in both mixed farming and livestock production systems. Sulla has a high yield potential and is highly palatable with excellent forage and fodder quality and outstanding animal performance. It can grow to almost 200cm. It also has the added advantage of potentially fixing high levels of nitrogen. Unlike lucerne, Sulla is non-bloating and has reputed anthelmintic qualities which may reduce worm burdens. (Woollard, 2010)

Photo 9 – Sulla Cut for Hay / Silage

Recommendations

There are a number of recommendations but the most important one is to; • Adopt the Zero-till system • Obtain a quality double disc machine that has; a. No soil disturbance when in use. b. Seed firming mechanism, either a wheel or Keeton finger c. Closer unit that fills the trench with soft soil and some residue d. Realistic price so smaller farmers can access the technology to move to ZT. • Small / Medium size farmers can look towards South America to find suitably priced machines. They are slowly being imported into Australia. • Look upon all residue as precious and must be retained to form a permanent cover on the soil and as feed source for the biota. • Use as diverse a rotation as possible. Try to utilise cool and warm season crops. • Use organic manures to increase SOM and as a very good source of both Nitrogen, Phosphorous and to a lesser degree Potassium. • Re-inoculate soils with worm species particularly the Anecic type as this will help with soil ameliorants being moved through the profile and their burrows allow for increased water infiltration. Also the Endogeic type that actually eat soil and move nutrients through the profile. This is of particular importance for phosphorous which is relatively immobile in the soil. • Make use of our own waste or other peoples waste, such as animal manures.

Appendices

Whilst on the Global Focus Program, Contemporary Scholars Conference and the Study Trip, a number of very interesting topics were discussed or seen. Following is some of those.

Vertical or Circular Integration • The most successful businesses visited were those that made use of all their products and by products. The Alvis Bros Company for example ran three dairies, one of which is organic. All the milk is used in the cheese factory and then sold through a number of supermarket chains and their farm shop. The whey is utilised in a company piggery. The animal waste from both the piggery and dairies is spread on the land. The Alvis Bros also has a half share in a contracting business which does their entire paddock work and also contracts out to other farms as well. • Fazenda Frankanna is a business in Brazil run by Richard Dijkstra. It is another which makes very good use of its waste products. They have a 400 sow piggery and 400 cow dairy. All of the effluent is screened and the solid's are removed and composted then spread over the paddocks. The liquid then goes through two methane digesters which then powers the dairy and piggeries heating needs. Once the water leaves the digesters, it is 99.5% pure. All of the water is used to irrigate a fair proportion of the farm. This farm land was worth between $12,500 to $15,000 per hectare, which is very similar to land in the Gilbert Valley around Riverton. Wattle Vale Farm produces one crop per year whereas Fazenda produces five different crops in two years, such a hay, grain and cover crops. • Bart Ruth in Nebraska is another successful farmer who utilises other farmers waste. He farms next to a 5000 cow dairy. The dairy is only interested in the cows and milking. They don't want to do anything outside of those two operations. Bart gets all of their solid waste and liquid. Each year he gets enough water to irrigate 300 hectares which equates to an addition 250mm of precipitation. He also gets slurry to inject into 70 hectares. He had to buy the centre pivots, but pays none of the pumping costs.

Rural Message to Urban Dwellers • Whilst touring through the USA and Canada, we saw a great number of signs promoting agriculture, whether it was a sign to say "Everyday a Kansas farmer feeds

250 people" or a billboard showing family line up on the lounge watching television. Above them the slogan said "A typical hog raising family". • Alvis Bros regularly catered for school groups of children who visited their farms. They also had teaching materials for the teacher and schools to utilise and were instrumental in developing and promoting this in schools. • The Daterra Coffee Company in Brazil again had school groups through but also included a camp for the students from schools and universities to study flora and fauna on their farms. 20% of their farm was dedicated to natural and regenerated Cerrado (Open Savannah and Closed Woodland) • A speaker at the No-Till on the Plains Farmer Group had a "lumberjack" forest farmer as a guest speaker. He spoke passionately about the need for farms of all types and need to promote agriculture to the next generation who will be getting a slightly stilted view from environmentalist groups etc. He set up "Adopt a Farmer" firstly in Washington State, then right across the country.

Commonality of Terms • Around the world there are a large number of farmers, researchers and scientists involved in farming or farming systems work. In each country or state / province different terms are used to signify the same farming system. For example in Australia, no-till describes the use of tyned implements with knife points and press wheels. Where as in Brazil and Argentina the term no-till means using only disc seeders with no disturbance. In Australia we call this zero-till.

Extra Recommendations • Find ways to utilise waste products of our own or other farmers such as piggeries and poultry facilities • Work with media. To give the different networks footage of modern farming practices such as zero-till to use as file footage. This would replace those old videos of farmers cultivating their land in a dusty paddock • Work with key farmer groups and others around the world to a get some uniformity of farming system terminology eg for Minimum Tillage, No Tillage and Zero Tillage. • Look for integration opportunities within the farming business to move from commodity to edible product. • Look to lease / buy land with high rainfall (700mm+) or irrigation.

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Plain English Compendium Summary
Project Title:
Nuffield Australia Project No.:
1006 Scholar: Stephen Ball Organisation: Hannaball Trust Phone: (08) 8847 310 Fax: (08) 8847 742 Email: farmdog64@bigpond.com Objectives To investigate Zero-Till Farming Systems (ZT) in high

rainfall cropping zones (HRZ), and its impact on soil biology and nutrient cycling.” Background Farmers are looking at different technologies, management practices and new crops to enable them to keep ahead of negative terms of trade and find the next “big thing” has enhances productivity and increases their efficiencies to improve profitability. Research The research took place over a period of six months during the first half of 2010. The countries visited were England, Wales, Canada, USA, Mexico, Brazil, Argentina, Uruguay, Chile and Australia. Throughout these countries, information was sought from farmers, scientists and researchers into Zero-till. Producer groups such AAPRESID and No-Till on the Plains were also contacted. A lot of machinery manufacturers were interviewed and their machines inspected in the factory, sales yards and working in the paddocks Outcomes Farmers in countries around the world are employing the techniques of ZT and using disc seeders and full residue retention. The benefits they are getting are huge. Australian farmers need to embrace ZT. Currently in Australia there are a few disc machines being manufactured but they come with a high price tag. There are a lot of machines available overseas that are a lot cheaper in comparison, and these would allow small to medium sized farmers to access this technology. Implications It is clear that ZT should be implemented across the HRZ cropping areas, where farmers have the ability to produce large amounts of biomass each year. This should be all retained to feed the soil biota. This practice will enable them to get better efficiencies from fertilizer and water. Where practical the substitution of inorganic with organic fertilizers such as compost and manures will help speed up the process to get a healthy fully functioning soil that requires less man made nutrients to achieve better yields.

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False start no-tiller now an advocate

Sarah Johnson

SANTFA The Cutting Edge AUTUMN 2012 p210-213

http://www.santfa.com.au/wp-content/uploads/Santfa-TCE-Autumn-12-False-start-no-tiller-now-an-advocate.pdf

Un article qui traite de l'expérience d'un céréalier. Les leçons d'un passage d'une conduite conventionnelle au semis-direct.

When drought struck in 2002, Mallee cropper Andrew Cass knew he could no longer stall the move to no-till farming. The Paruna-based farmer of 40 years, who was cropping up to 5,500 ha of mostly sandy loam soils at that stage, had long considered a no-till operation and attempted one season with an adapted Hesston seeder bar in 1997.

That first no-till venture involved removing alternate tines on his seeder bar, creating a row spacing of 355 mm to provide for trash clearance, replacing the remaining tines with Ryan tines, which had a higher breakout pressure, and fitting Harrington knife points and press wheels.

He broke even with his rye crops that year, but suffered a considerable loss with barley. Given that experience he returned to conventional farming, not prepared to continue with no-till until there was more expertise and support in his district. "We didn't do a very good job controlling the weeds, so we lost a significant amount of money from our barley crop," said Andrew.

50 millimetres of rain in the growing season

"We couldn't financially withstand the mistakes we were likely to make if we continued down that line so we decided to pull away from it until there was a bit more no-till knowledge and support available." It wasn't until the run of dry seasons in the new century that Andrew reconsidered his farming system and management of his 6,300 ha property.

"In the 2002 drought we only had about 50 millimetres of rain in the growing season. We lost a lot of topsoil and realised that we had to change our system," he said."That year really showed what lack of moisture can do and how devastating a drought can be to the soil."

Tines were very good at covering trifluralin

After completing the 2003 seeding program Andrew embarked on a no-till research trip, travelling to farms in Ouyen, in Victoria, and to Eyre Peninsula to talk to farmers using disc seeders and tined machinery to work out the best no-till equipment for Mallee conditions. The main issues he considered were repairs and maintenance, control of the soil fungus rhizoctonia and soil throw for trifluralin incorporation. He had doubts about the effectiveness of a disc seeder in all of these areas.

"I thought discs would be fairly high-maintenance, given the bearings, and I didn't know whether they would handle rhizoctonia. I also learnt that tines were very good at covering trifluralin," he said. Andrew purchased a new Conserva Pak CP5112 seeder bar for the 2004 season. The machine, which he is still using eight years later, has knife points on 300 mm row spacings and 50 millimetre-wide dedicated press wheels.

Unlike his first foray into no-till, the purchase of this dedicated no-till seeder meant there was no going back to conventional farming. "It was virtually a dedicated no-till machine, so I couldn't turn around and suddenly go back to the conventional way," said Andrew. "I was forced to burn some bridges, which was a good thing."

Good support from the local Conserva Pak agent, Ian Keller at Kelbro Machinery, and from the Conserva Pak team in Canada, boosted Andrew's confidence during set up and for the first seeding program.

"Ian was very good at assisting me in the early days and Conserva Pak even sent a representative from Canada to help us set up the machine and get it working in the paddock. We went into seeding with a great deal of confidence that it was going to do the job for us."

No risk of the seed falling into the fertiliser

Andrew is impressed with several features on the Conserva Pak bar, including its simplicity and the accurate placement of seed and fertilisers that minimises the risk of fertiliser burn. "It is a very simple system, with very few working parts in it," he said. "The press wheel determines the depth of the seed, which is not only positioned above the fertiliser, but also slightly to the side. The seed actually lands onto a firm seed bed and to the side of the knife-point furrow, where the fertiliser is deposited. There's no risk of the seed falling into the fertiliser."

And with the press wheels each attached to a tine assembly, rather than having a gang of press wheels on one shaft, they are able to work independently, reducing the risk of stones or hard ground affecting performance across the bar.

The seeder has also met Andrew's expectations for low maintenance, although one issue he encountered early was a lack of grease in the wheel bearings. "We had two wheel bearings collapse as the result of bearings drying out," he said. "We solved that and haven't had any problems since." He also ensures the knife points are repaired with new tungsten tips every second or third season.

The machine required one modification to ensure weed material didn't block the air flow in the fertiliser tubes. Andrew employed a local engineer to fit winged fertiliser boots either side of the outlet tubes, which sit behind the knife points. The boots are flat steel sheets welded onto the sides of the tubes, creating a clear space that prevents trash clogging the tube ends and allowing air to freely carry the fertiliser. "The air flow in the fertiliser tubes was being cut off by trash wrapping around the tine and blocking underneath the tube. That stopped air coming out, so fertiliser built up in the heads further up the air lines. Every time we went to fill up we found five to 10 blocked rows."

The seeding rigis powered by a 425 horsepower 9430T John Deere Track series tractor, which replaced an 8879 model two years ago. The 9430T provides better traction on the sand hills. Andrew has also upgraded to a triple-box John Deere air cart with variable rate technology he uses to adjust seed and fertiliser rates according to soil type. He believes the variable rate capability has been a valuable innovation for his farming operation.

Reduce our phosphorus inputs

"We've been able to vary the rates of fertiliser – phosphorous and nitrogen – as well as seed density on the different soil types," he said. Most of Andrew's soils are sandy loams, with some heavier, red sandy-loam flats and light sand hills. There are good soil phosphorous levels across the farm but Andrew has found they don't always translate to crop yield, especially from crops sown in heavier, restricting soils. The variable rate technology has allowed him to reduce the amount of phosphorus applied on the heavy flats and increase the rate on the farm's mid slopes where the crops respond well to the extra phosphorous.

"The variable rate machine allows us to place more phosphorus on the areas that give us better responses," he said. "Overall we've been able to reduce our phosphorus inputs quite a lot. Standard practice has been to put 10 units of phosphorous over the whole farm. With variable rate we are probably averaging five or six units, so we've saved 40 to 50 per cent on our phosphorus bill." But he is using more nitrogen now than he was a few years ago as his crop rotation no longer includes a medic-dominant pasture, which used to provide an organic source of nitrogen.

Difficulties controlling rhizoctonia.

Until 2007 Andrew used a fixed rotation of two years of crop followed by one year of medic-dominant pasture. But that changed when he engaging an agronomist. "We've taken on agronomy advice, so my strict rotational system has been challenged and changed." He now grows wheat for two or three years, then barley, wheat again, then rye ahead of a fallow. It is a change he regrets at times, due to difficulties controlling rhizoctonia.

The first major outbreak of rhizoctonia on Andrew's property occurred in 2006, his third year using the Conserva Pak seeder. "We were baffled why we had so much bad rhizoctonia, although we weren't the only ones with it. It was endemic in the region."

The only paddock that didn't suffer was one he had cultivated because it was newly-purchased property and very rough. "We hardly had any rhizoctonia problems in that paddock and it was the highest-yielding crop that year," he said. "When we saw the rhizoctonia damage over the rest of the property it dented our confidence in no-till. We were looking at a five bag (1 t/ha) crop on the pre-cultivated paddock, whereas the rest of our land yielded a three bag (600 kg/ha) crop on average."

Andrew's agronomist suggested that poor control of summer weeds and medics probably contributed to the problem. "The medics got going pretty quickly after a break in the season and we were behind the eight ball in terms of controlling them," Andrew said. "The idea that medics were part of the problem was very challenging for me, because I have always wanted to grow medics to fix nitrogen. I'm starting to think that again now, because in the past two years we've produced lower-protein wheat. That has taken us out of the premium hard wheat market, which is financially devastating."

The plants sown in that row were noticeably stronger

A broken knife point led to a significant discovery in 2006, the second year of no-till seeding. The broken point was replaced with a spare that was 15 mm or so longer than the others and the plants sown in that row were noticeably stronger than the rest of the crop."You could pick the better crop in those rows by thicker straw, longer heads and it was probably also a little higher," said Andrew. "The visual difference in the row sown with the longer time was consistent across all of our wheat, barley and rye crops and evident during harvest. It was unbelievable that you could sit on the harvesting machine and always pick the row, just by visual appearance.

"That proved to me that we needed to be spot on with our knife point depths and be very careful about keeping the points in good condition, especially if there was rhizoctonia present."

Summer weed control

Andrew is also paying closer attention to summer weed control. "We used to wait until after harvest before spraying the weeds but now we make it a priority to have someone available for summer weed spraying, which begins soon after harvesting is underway. This new regime means a second spray is needed if there are summer rains after a paddock has been sprayed. "You've got to turn around and spray it again and that becomes very expensive."

Andrew invested in a Nitro self-propelled sprayer ahead of the 2008 harvest. The new machine replaced two tow-behind spray plants, which tied up two tractors and two operators. "It wasn't difficult to work out the cost benefit of the self-propelled sprayer," he said.

The change released the tractors for use in the harvest operation and having a self-contained sprayer allows the operator to focus entirely on achieving the best weed control.

Stubble cover makes all the difference

Keeping weeds in check is a vital part of Andrew's moisture-saving strategy within his no-till operation. He has noticed improved moisture savings during summer due to stubble retention and the absence of cultivation. "Any rain we get goes into the furrows, and because we're not cultivating we're not exposing the soil to moisture loss."

He has also seen improved soil health, which has widened the sowing window.

"The soil structure is so much better. The paddocks aren't blowing away and the fences aren't getting drifted in," he said. "There's a lot more organic matter on the soil surface. Some years, you can actually see two lots of stubble on the ground, from the two most recent harvests. "We also have flexibility with the timing of sowing. It doesn't matter if you sow a bit later sometimes. In fact, it seems a bit odd, but some of our best crops have been sown later.

"If we were on a conventional system, the window of opportunity for sowing would be limited, because the later you sow a crop, the slower it gets away and the more prone it is to drift. With no-till, stubble cover makes all the difference."

Stubble management

Stubble management hasn't caused issues for Andrew, except in 2010, when he burnt stubble for the first time since changing to no-till. The stubble was left longer than usual because that season's crops were particularly tall and bulky and rain during harvest meant there was more pressure to get the harvest off as quickly as possible.

Garder les mauvaises herbes en échec est une partie essentielle de la stratégie de l'humidité d'économie d'Andrew au sein de son non-labour opération. Il a remarqué une amélioration des économies d'humidité pendant l'été en raison de la rétention du chaume et l'absence de culture. "Toute la pluie va nous obtenons dans les sillons, et parce que nous ne sommes pas cultiver nous ne sommes pas exposer le sol à la perte d'humidité."

Il a également vu l'amélioration de la santé des sols, ce qui a élargi la fenêtre de semis.

"La structure du sol est tellement mieux. Les paddocks ne sont pas souffler loin et les barrières ne sont pas se dérivaient dans ", at-il dit. "Il y a beaucoup plus de matière organique à la surface du sol. Quelques années, vous pouvez réellement voir deux lots de chaume sur le terrain, à partir des deux récoltes les plus récentes. «Nous avons aussi la flexibilité avec le calendrier des semis. Il n'a pas d'importance si vous semez un peu plus tard parfois. En fait, il semble un peu bizarre, mais certains de nos meilleures récoltes ont été semées plus tard.

"Si nous étions sur un système classique, la fenêtre d'opportunité pour les semis serait limitée, parce que le plus tard, vous semez une culture, plus il devient lent loin et le plus vulnérable, il est à la dérive. En l'absence de labour, la couverture de chaume fait toute la différence ".

la gestion chaumes n'a pas causé de problèmes pour Andrew, sauf en 2010, quand il a brûlé du chaume au la première fois depuis le changement de culture sans labour. Le chaume a été laissé plus longtemps que d'habitude parce que les récoltes de cette saison ont été particulièrement grand et encombrant et la pluie pendant la récolte signifiait qu'il y avait plus de pression pour obtenir la récolte aussi rapidement que possible.

He was reluctant to burn but felt he had little option, and the moisture stored as a result of the summer rainfall enabled him to sow reasonably early last season. Andrew has considered changing to a disc seeder but fears that, without knife points to shatter the soil, rhizoctonia could become an even bigger problem. Whether or not a disc machine would provide enough soil throw to cover trifluralin is also a concern.

"Knife points work reasonably well, but with a disc seeder is that we could perhaps leave the stubble standing higher and still sow directly into it," he said. "Standing stubble would probably improve moisture conservation, because wind removes moisture from the soil and allows the soil temperature to vary a lot more.

"I think it has been underestimated how much damage wind causes in reducing crop vigour and increasing evaporation from the soil.

"You could probably use a disc seeder to dry sow prior to an opening break as long as you have an extremely well-managed and rigorous weed control program. Given that we've got financial constraints and as farmers we don't always do things as well as we could, I think it could be quite a risk."

Andrew's advice to farmers considering a no-till system is: 'just do it'.

"There are enough farmers in all areas doing no-till now that mistakes can minimised by taking notice of the lessons learnt by the early adopters.

“Plus the management is so much easier in terms of fuel consumption and machinery costs. We’re not wearing out tractors any more. “Once established in a farm’s management system, no-till is the solid .

foundation for further developments like variable rate application and the introduction of new crop types. “I think no-till is ideal if you want to try to grow different crops like canola, chick peas and lupins. There is even potential to grow summer crops without the risk of erosion.

Seed placement like no other

Sarah Johnson

SANTFA The Cutting Edge WINTER 2012 259-260

Résumé :

Il s'agit du témoignage de Laurie, agriculteur installé avec sa femme et ses deux fils.,

-la ferme de 2200 hectares est entièrement en semis-direct. Le travail est réalisé par une entreprise spécialisée dans le semis. Environ 200 ha de pâtures sont également semées en semis-direct.

-le fait de passer par une entreprise de travaux agricoles permet de bénéficier d'un matériel moderne. D'autant plus que le matériel de semis à considérablement évolué.

-auparavant dans mes parcelles en pâturage, j'avais des rangs où les plantes n'avaient pas germé. Ce n'est plus le cas maintenant.

-nous avons 17 000 moutons et 500 bœufs ; nous avons souhaité rénover nos pâturages.

-nous avons souffert de la sécheresse ddurant 4 à 5 ans durant les années 2000 et notamment en 2006. Cela a beaucoup impacté nos pâturages. Avec le retour des pluies, nous souhaitons restaurer nos pâturages avec les espèces qui ont résisté.

-nous avons remarqué que la variété de phalaris « Holdfast GT » s'adaptait bien sur nos terres. L'an passé, nous l'avons semé à 3 kg/ha dans les parcelles rénovées.

-Holdfast GT est une variété résistante à la sécheresse et adaptée au pâturage mais vulnérable au semis.

-Le phalaris doit étre gérée avec précaution notamment concernant la protection contre les insectes et concernant le pâturage.

-Les premiers 12 premiers mois les moutons ont pâturé pour de courtes périodes et à des moments précis afin de permettre au phalaris de bien s'installer et pousser. Si nous réussissons la première année, nous sommes dans la bonne direction.

-Laurie pense que la profondeur de semis est la clé de la réussite : « semer de petites graines nécessite que les graines soient semées dans un lit de semences adéquat (“Sowing small seeds requires the seed to be sown at a consistent and very shallow depth,”

believes consistent seeding depth is the key to successful germination. “Sowing small seeds requires the seed to be sown at a consistent and very shallow depth,” he said. “We’ve been able to achieve that with the disc seeder because each disc follows the contour of the land. “This is important with our undulating surfaces. We’ve got clay, crab-hole soils where there are lots of variation and undulation in small areas of the paddock. The disc seeder is able to sow every seed as consistently as I’ve ever seen.”

My father was a very innovative farmer

The road to zero-till began more than 30 years ago for the Close family, who farm near Apsley, in Victoria, just over the border from Naracoorte. Fine-wool producer Laurie Close said his father started the ball rolling in the 1970s. “My father was a very innovative farmer and went into direct seeding of pastures at a very early stage of its development. “Since then we’ve trialled a variety of different machines including modified combines, Baker Boot points and triple discs. “We used no-till for quite some time, when it wasn’t as sophisticated as it is now. For 10 to 15 years we sprayed out paddocks and went straight in with modified combines.” Five years ago the family moved to a zero-till system, contracting all of their seeding work to Nathan Craig from Zerotill Farm Services. Nathan uses an Excel single-disc seeder to sow approximately 200 ha of pasture a year on the Close’s 2,200 ha property, which is located 10 km east of the SA border.

With a contractor I’m able to get the latest technology

“I haven’t seen a machine better at seed placement and soil contact than the machine Nathan is using at the moment,” said Laurie. “I’ve made a conscious decision not to pursue ownership of machinery. With a contractor I’m able to get the latest technology on the farm without significant capital investment.” Laurie believes pasture production has improved as a result of using the zero-till technology. “The technology of seeding equipment has advanced quite considerably and we’ve seen our crops improve as a result,” he said. “Just from my own observations, our germination has improved dramatically. “Our previous seeding machines and systems tended to result in patchy germinations. You’d look at a row and there’d be a metre where nothing had come up, then it would be lovely and then you’d go another metre and the pasture would be sparse. “With the disc seeder, the uniformity of germination is very good.”

Renovating their pastures

With 17,000 sheep and 500 head of cattle, the Close family’s main focus is on renovating their pastures. “Soils and pasture are the basis of our business,” said Laurie, who runs the farm in partnership with his wife Sue and sons Oliver and Xavier. Their pastures suffered during the dry years in the late 2000s. “We had a period of four or five years where we did very little pasture work, simply because we didn’t have spare feed for our stock. We couldn’t afford to put paddocks aside for renovation and invest in our future; we were just hanging on by the skin of our teeth," said Laurie. "The drought of 2006 had a big impact on a lot of our pastures." With improved rainfall in recent years the family has taken the opportunity to reinvest in their pastures and target paddocks where species haven't persisted.

Holdfast GT phalaris

Always on the look-out for improved species, they have found Holdfast GT phalaris works well in their farm environment and they sowed 3 kg/ha of this variety in the paddocks they renovated last year. Holdfast is drought and grazing tolerant but Laurie cautions that it is vulnerable as a seedling. "Phalaris has to be managed carefully with insect control and controlled grazing For the first 12 months," he said. "This means grazing sheep for shorter amounts of time and at specific times to allow the phalaris to get well established and crown out. Once we get past the first year, we're right."

Consistent seeding depth is the key to successful germination

Laurie believes consistent seeding depth is the key to successful germination. "Sowing small seeds requires the seed to be sown at a consistent and very shallow depth," he said. "We've been able to achieve that with the disc seeder because each disc follows the contour of the land. "This is important with our undulating surfaces. We've got clay, crab-hole soils where there are lots of variation and undulation in small areas of the paddock. The disc seeder is able to sow every seed as consistently as I've ever seen."

Keeping weeds under control

Keeping weeds under control is also aided by the disc seeder. "There's not quite as much weed germination because of the minimal soil disturbance. "Toad rush is one of the banes of sowing phalaris in this environment and soil disturbance is one of the things that stimulates toad rush." Laurie has also found that the lack of soil disturbance helps reduce the ryegrass population, which can be an issue when establishing small seeds. "The ryegrass does germinate, it's just not as bad."

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Wet conditions no problem for zero-till pasture

Sarah Johnson

Dossier : DISC SEEDING

Photo : SIMON ROBINSON, CHECKING ESTABLISHMENT OF A DISC-SEEDED CROP, HAS SEEN IMPROVEMENTS IN PASTURES AND CROPS AS A RESULT OF HIS CHANGE TO ZERO TILL

A shift to zero-tillage has seen Victorian farmer Simon Robinson reap benefits across his cropping and grazing operations. Simon changed to contract sowing in 2010, engaging Nathan Craig from Zerotill Farm Services to sow perennial pastures and cereal crops on his 950 ha property.

Using a contractor to do his seeding has allowed Simon to access superior seeding technology without the cost of upgrading or replacing his full-disturbance tined seeder. “I looked like having to upgrade our old machine, but given we’re only sowing 200 ha of crop a year, I couldn’t afford to spend a lot of money on it,” said Simon. “I decided the only way I could get the best technology in the paddock at a reasonable cost was to use a contractor.” Based at Langkoop, 10 km south of Apsley in the West Wimmera region, he has also used Nathan, who runs an Excel single-disc seeder, to complete a pasture renovation program Simon’s father started in the 1970s. “You can get so much more production from improved pastures in this area, so we’ve renovated all our pasture paddocks,” he said.

He now has 80% of the property under permanent pastures that support 1,650 Merino ewes, 1,100 Merino wethers and 1,250 first cross ewes plus a small commercial beef herd.

The renovation program was completed this year when the last pasture paddock sown to a mixture of phalaris plus trikkala and balansa clovers.

Renovation is a two-year process that begins with ripping and levelling the paddock and incorporating lime. *La rénovation est un processus de deux ans qui commence par l'extraction et la mise à niveau du paddock et incorporant la chaux* .The paddock is then sown with a cereal crop, either wheat or triticale, for two years. The two-year cereal phase provides an opportunity to eliminate most of the weeds in the paddock. Onion grass is a problem in his district and Simon’s weed control program for the pre-pasture cropping phase includes an application of 20 grams a ha of Glean in each of the cropping years.

Simon has noticed that pastures sown with the disc seeder perform very well. “We’ve had fantastic results with the small seed,” he said.“I really like the no disturbance of the disc seeder, especially in the wetter country. It doesn’t get all mushy in winter and it allows you to get stock on sooner and drive on it earlier. It also has very good seed to soil contact.

“Last year we sowed a lot of our wet country, which is by a creek line, and we achieved a magnificent result with the phalaris and clovers. It just came up like a crop.

“Nathan can get in where I couldn’t with my tined implement because his seeder is wider and doesn’t disturb the soil. “When we sowed with the 24-row conventional seeder we had to go around wet patches. With the disc seeder you can pull through the water. You might get a very small puddle in the middle that prevents establishment, but generally the perennial pasture germinates throughout the wet patch. It’s amazing what actually comes up in there.”

With permanent pastures now established on the wetter, low-lying regions of his property, Simon has set up his higher, better-drained land for continuous cropping, providing diversification in his enterprise mix. He had previously used a phase system in which he had cropped each paddock for two to three years then returned it to long-term pasture. Now his best 200 ha of land are set aside for cropping.

His cropping program starts with canola followed by two cereal crops. This rotation is repeated and the paddock is then put under balansa clover for two years. In the first year the balansa stand is managed as a pasture. In the second year it is grazed through to late August then cut for hay as a weed control strategy. The paddock is then returned to the cropping rotation.

In order to build up the organic carbon in the soil, Simon no longer burns his crop stubbles, choosing to manage them with strategic grazing.“The first priority is to get our perennial pastures under control. If there’s a huge residue at the end of spring we’ve got to get that bared down, although not completely. The rule of thumb is that you should be able to hit a golf ball out there into your soil and find it by April.

“After that, we graze the stubble; and there are great benefits in that. If we get a summer storm we don’t have to spray the weeds out, we just graze them.”Grazing the stubble provides extra feed for stock and rests the permanent pastures. Simon also uses stubble grazing as part of his regime to manage worms in his sheep flock; running drenched sheep straight into stubble in a worm-free cropping paddock.

This minimises the risk of re-infestation and maximises the efficacy of his worm control program. “Once you’ve finished grazing your stubbles you can return the sheep to virtually worm-free pastures. It’s a great tool.”

The rule of thumb is that you should be

able to hit a golf ball
out there and find it by April.

Only two years into disc seeding, Simon believes the jury is still out on the long-term combined effect of grazing and zero disturbance of the soil. He foresees compaction as an issue but plans to incorporate lime and gypsum with a tined implement every 10 years. “It won’t involve deep ripping the soil. It’s a matter of stirring up the soil to incorporate the lime and gypsum.” He is also considering following Nathan’s example and planting a crop of millet and sorghum to condition the soil.

“Instead of cutting the balansa for hay we could sow a crop of millet and sorghum in the last year of our rotation. It would provide summer feed and act as a good soil conditioner.”

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Manage weeds for the best start to disc seeding
Sarah Johnson
SANTFA The Cutting Edge WINTER 2012 p257-258

Good weed management is the key to a successful start to disc seeding, according to South East farmer and cropping consultant Nick Hillier. "Make sure your paddocks have a very low weed population. That's the secret to disc seeding," said Nick.

"Work out a crop rotation that is most suited to managing annual ryegrass and set up your paddocks four or five years in advance.
"It's important to reduce your ryegrass to an absolute minimal level, so your pre-emergent herbicide can manage it. "If you don't do the lead-up work you'll probably have a fairly big failure in the first year.
"If you have your weed management right you'll find a disc machine will help maintain or decrease that weed seed
problem."
This was the case on the Hillier farm, where weed control was 'less than ideal' when a disc seeder was first used on the 2,200 ha property four years ago.
The family – Nick and his wife Jackie, Nick's parents Gerald and Sue and his sister and brother-in-law Jane and Alistair – now use a variety of methods to control ryegrass.
"We don't try to battle it with just chemicals," said Nick. "We always have a legume in the cropping rotation and if a paddock is getting out of hand it goes out of rotation into the pasture phase, where we also cut hay."

feed as well as harvest them."
The family operated a no-till farming system for 10 years before graduating to a disc seeder four years ago.
They contract all of their seeding, using Nathan Craig on their Frances property and Michael and Roger Hunt near
Bordertown. Both contractors use Excel single disc seeders.
When Nick started farming 20 years ago the family was using conventional methods, but soon saw the potential of no-till for the sustainability of the land and their operation. "We could see the degradation of the soil.
My father wanted to retain more and more stubble, so we started developing machinery and new ways." Nick's work as a private cropping consultant has supported the family's progression to a zero-till system. He has 35 clients in the South East and has gained insight into a variety of sustainable farming practises, from protecting the soil to handling stubble, though his consultancy work.
The Hilliers have also learnt about stubble management through trial and error on their own properties, with hair pinning an issue in the first two years of disc seeding.

"Some people try to harvest as much straw as possible then smash the standing stubble up with slashers and drop it on the ground. I think you've got to cut it as high as you can and keep it off the soil as much as possible so there's no hair-pinning," Nick said. "We had a lot of hair pinning in the first couple of years. It causes the seed to be sown in the stubble base, which is full of air and as a result the seed doesn't germinate. We experienced between 20 and 30% hair pinning in those first two years.
"Now we leave the stubble longer and make sure we spread the header residue the full width of the comb at harvest time. "That's probably one area we've made savings – not having to deal with stubble. We harvest at a reasonable height and leave the stubble standing so when we sow into a paddock we know the seeder will go straight through it."
"Maintenant, nous laissons le chaume plus longtemps et nous assurer que nous répandons l'en-tête résidu sur toute la largeur du peigne au moment de la récolte . «C'est probablement un domaine que nous avons fait des économies - ne pas avoir à traiter avec du chaume. Nous récoltons à une hauteur raisonnable et laisser le chaume debout quand nous semons dans un paddock nous savons que la semeuse ira directement à travers elle "

Nick cautions that disc seeders are 'not the answer to everything', but is satisfied with the results so far. "I think the weed management is working well. There's no soil disturbance, so you're not encouraging the weed seeds to germinate in the inter-row.
"Secondly, I think we're getting great seed placement with the disc. The seeding depth is spot on and because the press wheels consolidate the soil around the seed, moisture is drawn up from the subsoil through capillary action."
This effect was particularly evident during seeding last year, when the top soil had dried out. "It was that dry and dusty that we couldn't see the air seeder box from the tractor cab

"Sub clovers fit into our rotation really well because we get to use them for stock feed as well as harvest them."

The Hilliers' farm is spread over several blocks, with two properties north of Bordertown, one at Hynam, were Nick is situated, and leased country south of Frances.

The family operates a mixed farming business, running 2,000 Merino ewes and a prime lamb enterprise and cropping 50% of their land.

Nick believes they have devised a good strategy for integrating cropping and grazing, based on growing clover seed crops, which are grazed for eight months of the year then harvested. "Grazing helps us control weeds and manage the canopy, then we let the clover go to seed. We harvest the sub-clover seed with a clover harvester and direct head the balansa clover.

"Make sure your paddocks have a very low weed population. That's the secret to disc seeding."

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"Sub clovers fit into our rotation really well because we get to use them for stock and yet the crop came up 10 days later," he said. "We had very wet subsoil from the wet summer and I think by the disc compacting the soil around the seed, it actually drew the moisture up. "With a tine machine in those conditions it probably wouldn't have come up for two to three weeks.

Sous trèfles entrent dans notre rotation vraiment bien parce que nous arrivons à les utiliser pour le stock et pourtant la récolte est venu 10 jours plus tard " , a t-il dit . «Nous avons eu du sous-sol très humide de l' été humide et je pense que par le disque de compactage du sol autour de la graine , elle a effectivement attiré l'humidité vers le haut. " Avec une machine à dents dans ces conditions, il ne serait probablement pas venu pour deux à trois semaines.

Farming a passion for Robinsons
Rubrique : FARMING SYSTEMS
SARAH JOHNSON
301-303 SANTFA The Cutting Edge SPRING 2012

[Un article intéressant. Les derniers paragraphes sont consacrés à la profondeur de semis. L'agriculteur indique qu'en conditions sèches une profondeur de semis de 25 mm est préférable à 32 mm. Djamel BELAID]

Charged with painting their kitchen ceiling on a rainy day in July, Hoyleton farmers Ashley and Tom Robinson welcomed the diversion of a SANTFA interview. The father and son farming team, who crop 1,540 ha west of the Clare Valley, need little encouragement to discuss agriculture. "Agriculture is basically the only thing we ever talk about," reveals 24 year-old Tom, who joined the farm three years ago. It is a passion inherited from four generations of Robinsons who have farmed the land near Balaklava since 1921. The connection stretches even further back, with Ashley's mother's family clearing scrub west of the current property in 1875. "It runs deep in the veins," said Tom. "I always wanted to be a farmer." With Ashley's father Greig, 91, still keenly interested in the farm, their enthusiasm for agriculture isn't likely to abate. Greig retired three years ago, but would still work the land if he could. What sets Ashley and Tom apart from their forebears is a drive to constantly evolve their farming systems. "My dad never changed," said Ashley. "For his entire farming life he did exactly the same as the day he started, except that he changed from a horse to a tractor. But he never stopped me from making changes and he's not stopping us now." Ashley was one of the fi rst no-till farmers in SA when he converted to a no-till operation more than 15 years ago and has owned a John Deere 1890 disc drill set up to sow on 190 mm spacing for the past 10 years. The change to zero-till in 2002, after fi ve years of no-till, was driven by the need to better manage residue, which remains a high priority today. His no-till seeder was a Gason 5100 Cultimaster with super seeder points on 228 mm spacings. "I wanted to keep more straw but had a lot of trouble with it blocking up all the time and having to go back and prickle chain," he said.

"There was only my father and I working the property and Dad was 80 years of age, so we had one old man and one getting older. Manpower was limited. "I got sick of not being able to get through all the straw and I didn't feel our depth of placement was good enough. I thought the disc would be able to cure those problems, so that's why I changed." After a decade of disc seeding, residue management remains at the top of their fix-it list. "We still haven't fi xed residue management, even after 10 years," said Ashley. "It's just got to be perfect, you can't compromise on it. "When you get it right the disc is magnifi cent; when you get it wrong, it's pretty ugly." Hairpinning caused the most issues in the early stages of disc seeding, with longer pieces of straw pushed into the seed slot. Now an accumulation of fi ne chaff is proving problematic. "If the long straw is lying in the same direction as we sow it doesn't seem to be a problem," said Ashley. "The fi nes are a problem now, because if the chaff is thick enough the seed is placed in it, rather than sown into the soil.

"You don't want the fi ne chaff any deeper than a centimetre because the disc has to cut through it and it seems that chaff is harder to cut than straw. Not only that, but you end up with a slurry of fi nes, water, dirt and the seed. It's a toxic brew." The Robinsons believe the solution is to spread the chaff evenly across the full width of the comb during harvest. After efforts to tweak their header to handle the volume of straw it was cutting they bought a Shelbourne stripper front a year ago to reduce the amount of straw going into the machine. They use the stripper front in cereal crops and are awaiting the arrival of a Redekop Maximum Air Velocity (MAV) Straw Chopper to better handle canola residue during the upcoming harvest. Both purchases followed farming research trips made by Tom; to New Zealand in 2010 and to the United States this year. "I've told him that he's only allowed to bring home ideas worth less than a quarter of a million dollars," Ashley jokes. Tom's excursion to New Zealand was part of a SANTFA-organised trip, during which he visited a farm using a stripper header. "It was the fi rst time I'd seen stubble loads like we have at home, so I came home and said to Dad, 'we need to get a stripper header'," said Tom; which they did after further research and testing one owned by a neighbour.

Photo : TOM AND ASHLEY ROBINSON IN THE PADDOCK.

Stripper fronts use rows of V-shaped stripping fi ngers to strip grain from the crop. They take mostly grain, leaving the full length of straw in the paddock, so there is minimal chaff. Ashley is pleased to see positive early signs in wheat paddocks harvested with the stripper header last season. "The crops in those paddocks look really good," he said. "There is no accumulation of residue anywhere and I think our potentials look pretty special." According to Ashley, the greatest challenge was perfecting the new equipment's set up. "I had to run the stripper lower in the crop than I expected. You have to present the crop at 45 degrees to the ground.

Plus the spinning rotor in the stripper varies from 400 to 600 revs a minute. I tended to run it too fast last season. This year I'll run it as slow as I can as long as I'm not leaving grain behind. If you do it right you actually leave the wheat's backbone behind and it performs really well." High temperatures also affected the stripper's effectiveness. "The hotter it gets the worse it performs and performance is affected over about 32 or 33oC. We found 28o to be an optimal temperature." Stripper fronts double header capacity, with grain rather than chaff taking up bin space, which the Robinsons found allow them some fl exibility in their harvest schedule. "When it gets too hot you can afford to knock off and wait until the evening when it cools down," said Ashley. "It goes against the grain to do this, because we want to harvest all the time, but if it's bad enough I'd prefer to leave the stripper on and wait until it cools down. The stripper does work better when the grain is a bit tough. "We can start an hour to two hours earlier than we used to and work longer into the night, as long as the moisture is right. It can be as tough as nails out there and there are no worries.

"One of the arguments against a stripper is that you lose a lot of grain, but we didn't have an issue. Our paddocks were very clean of volunteers, so I don't think we lost much grain at all." Ashley believes the stripper front has largely resolved residue management in their cereal crops, but the problem remains with canola. "Residue from canola caused us grief this year," he said. "That's why we're going to the MAV straw chopper on the back of the header. Plus if we do move back to peas, beans or lentils in our cropping rotation we're going to need the straw chopper to spread the residue across the full width of the outer comb. "It has an in-built fan in the chopping system that will produce winds of 257 km an hour to spread the chaff." The straw chopper, which cost $15,000, was a solution offered by leading wheat agronomist Phil Needham, with whom Tom spent time in the US. "I met a farmer in the US who is having the same residue problems that we are and he isn't using a stripper front. Phil said that you're paying for it and you don't realise it," said Tom. "It's costing us more than $15,000 a year in yield losses, so really 15 grand is cheap. I believe you've got to bite the bullet and do it." He spent a month in the United States during June and July, travelling from Mississippi in the south to the southern

Photo : RESIDUE MANAGEMENT REMAINS A CHALLENGE FOR THE ROBINSONS.

Photo : GREIG ROBINSON STILL TAKES AN ACTIVE INTEREST IN WHAT IS HAPPENING IN THE PADDOCKS HE FARMED.

During the trip he visited several progressive farmers and was impressed with their commitment to best practice during seeding and harvest. "I saw a lot of very good operators that take pride in their sowing operations," said Tom. "I've come home with a determination to iron out seeding and harvest imperfections on our property. It's about attention to detail in every single part of your farming operation. We are looking for absolute perfection.

As a result of Tom's trip, the Robinsons have formulated a new management regime for their cropping operation, which includes the MAV Straw Chopper and frequent disc replacement. "We've convinced ourselves we need nice, sharp discs," said Ashley. "Blunt knives don't work well in the kitchen and it's no different with discs in zero-till. "We replace our John Deere discs every year. We got 1,600 ha out of them this year and we pushed them towards the end. A John Deere disc starts at 45 cm and I don't think we'll go below 43 cm now. They tend to get dull after that." Ashley and Tom have also decided to place more weight on the seeding bar and run more down pressure on their discs. "We need to make sure they don't ride out of the ground at all," said Ashley. "This year we put old tractor weights on the bar to improve penetration but didn't position them as well as we should have. Tom saw an example of better positioning in the US, so we'll make that change. "We want every row to be exactly the same depth across the entire machine in every paddock. Every square inch we sow needs to be exactly the same depth, down to millimetres. If we set it at 30 mm every single seed in the paddock has to be 30 mm deep." They plan to shift the weights further back on the seeding bar and possibly increase the amount of weight. They will also increase the hydraulically-operated down pressure on the discs. "We've tended to run the down pressure in the safe limit, but from our research we can push it a lot higher," said Ashley.

ZERO-TILL CONVERTS 'CONCRETE' TO SPONGY SOILS

More than a century and a half of cultivation in the Hoyleton Valley produced patches of red clay soil resembling concrete, according to Hoyleton farmer Ashley Robinson.

"The red clays were horrible under the English system of ploughing and cultivation," recalls Ashley. "They used to turn to concrete and get waterlogged."

The Robinson's soils range from red sand to predominantly red brown earth, with some red clay country that has benefi ted from no-till.

"The Hoyleton Valley probably had its fi rst wheat crop in the 1860s, so it's relatively old farming country. They were never going to improve the soil with cultivation, but the advent of herbicides, better fertiliser and now no-till and zero-till have made a lot of difference," said Ashley.

"Our red clays have improved signifi cantly.

"There's no doubt we have better water infi ltration. The soils don't get anywhere near as wet as they used to and the paddocks are more traffi cable."

A decade of zero-tillage has produced fi rm soil during dry conditions and softer, spongy soil when it's wet. "The soils *have fi rmed up without becoming harder," said Ashley. "When they're dry they're very fi rm, but when they get wet it's like walking on underlay carpet.*

"That's the main difference I've noticed; the soils become spongy with moisture."

When it comes to assessing the evolution of their soil's health, Ashley's son Tom believes the best person to speak to is his grandfather.

A farmer for 75 years, Greig Robinson has seen massive changes on the property, especially since the family introduced no-till and zero-till practices.

"He'll come out spraying with me and say, 'that piece of ground there, I never grew anything'," said Tom. "And now it's one of the highest yielding parts of the paddock."

« We're probably drilling our wheat too deep »

"The reason many farmers don't run more down pressure is because it puts a lot of stress on gauge wheel bearings," added Tom. "But Phil Needham says he's never seen one blow a bearing because of too much pressure." The John Deere 1890 has required only fi ve bearing replacements in the past 10 years, although the Robinsons are doing more maintenance now, with new seeding boots needed and pins and bushes replaced. Tom's US trip also convinced them to refi ne their seeding depth. "I've realised that we're probably drilling our wheat too deep," said Tom. Phil Needham, an expert in wheat management and machinery, advised him that the best wheat yields are achieved when a crop emerges within three days. "Phil says that if the last plant emerges within three days of the fi rst plant in the paddock, that last plant will yield three times more than one that takes seven days after the first to come out of the ground," said Tom. "That doesn't mean sowing date; it's when the plant emerges. From the first seed emergence, you've got a three-day window. Plants that are delayed lose signifi cant yield potential. "It could be the difference between 2 t/ha and 6 t/ha. It's substantial." The Robinsons previously placed seed 32 mm deep but plan to reduce this to 25 mm next year.

25 mm is the optimum depth for wheat

"Phil has shown that 25 mm is the optimum depth for wheat," said Tom. "It's very exacting," said Ashley, "but wheat seems to be very sensitive. I was told years ago that if you sow too deep the plant won't tiller, but this advice from Phil is an even bigger bombshell." This advice means the Robinsons are having to re-evaluate their approach to moisture at seeding time, because in the past their seeding depth has been determined by moisture levels, with crops often sown deeper to reach moisture in the soil. "This year we were like everybody else; we chased moisture, making sure the seeds were placed near moisture," said Ashley. "Taking Phil's advice, we may have to sow our crop into dry soil, knowing that could delay emergence sowed because it's not wet enough.

Phil has shown that 25 mm is the optimum depth for wheat

"The question is: are the penalties from deep seeding greater than the penalties from sowing dry? Only experience is going to tell us the answer." By accident, they may have touched on the answer by sowing one paddock dry and shallow this season. "By default, we sowed a paddock at 25 mm this year," said Ashley. "The back wheels of the John Deere disc weren't touching the ground; it was maxed out and couldn't penetrate the soil any deeper than 25 mm. "When it did rain, the crop was up in three days. There were hedges in three days and it looks pretty impressive now. It probably has six or 7 t/ha potential, as long as the season fi nishes kindly. "It was sown shallow by accident and we wouldn't have realised the signifi cance of the shallower seeding depth if Tom hadn't found out about it in the US."

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New kid takes on no-till

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Like many fledgling farmers, Stuart Pope had ideas for change on his family's livestock property near Karoonda. "I always wanted to reduce our tillage; I was sick of seeing our soil blow away every year," Stuart recalls. He spent two years at Urrbrae Agricultural High School in Adelaide, where he learnt the principles of no-till. Returning home with cropping on his mind, he found a father resistant to change.

When I went home and told Dad what I wanted to do he didn't want a bar of it. He was very much into his sheep and defi nitely had the attitude that the only reason you grow a crop is for sheep feed," said Stuart. "So we parted ways for many years." From an agricultural point of view, Stuart put the intervening time to good use. He worked as a shearer initially, then took up an apprenticeship as a diesel mechanic with a farm machinery business. He continued as a mechanic for 15 years, working for his brother-in-law at WD Lewis & Co. in Karoonda, a position that kept him touch with farmers and enabled him to see fi rst-hand the potential of farming in the SA Mallee. "As a mechanic I travelled around the district visiting farms and seeing what farmers were doing," he said. "Some of them were achieving some quite unbelievable things with cropping on the same rainfall and the same soil types as our family farm. "When Dad decided he wanted to retire I decided to give cropping a go."

In 2002, Stuart and his wife Amanda took over the 1,050 ha farm and kickstarted their cropping operation with a demonstration Flexi-Coil seeder. Having a brother-in-law in the machinery business once again proving helpful. By 2004 they had converted to a no-till

NO-TILL

New kid takes on no-till SARAH JOHNSON

system and were using their third no-till seeder; a second-hand Flexi-Coil air drill from WA. The previous year they had modifi ed a John Deere 1010 bar to 228 mm row spacing. They also increased their property size to 1,400 ha during 2004, buying another 350 ha. Within two or three years Stuart and Amanda decided to increase their row spacing to 304 mm, reducing the number of sowing boots needed – a saving at a time when cash was tight – and the draught, which improved the tractor's towing ability. Stuart, who decided to make the change after seeing the positive results achieved by a neighbour using wider spacings, has also seen improvements in his system. "Ever since we converted to 304 mm row spacing the crop has shown a lot more vigour," he said. "It comes through the ground a lot quicker. "We are also able to get through heavier stubble and keep more soil cover. The

whole system seems to work a lot better." The wider row spacing allowed the Popes to increase their seeding depth, which has paid dividends in their problematic sandy country. "When I fi rst went into no-till everyone told me cereals should be placed half an inch deep and that lupins or canola should basically sit on top of the ground," said Stuart. "We were always running into trouble on our sandy country with crops not germinating. For years we followed advice and planted lupins with 30% of the seed out of the ground. On good ground it germinated without any problems, but unless the sandy soil received signifi cant rainfall straight away the plants just wouldn't come up. So for four out of fi ve years the seed just sat there." The Popes now sow all of their crops at a depth of 30 to 50 mm, which Stuart believes provides the best access to moisture in the sandy soil. From his observations this sowing regime has increased crop germination from 50% to 80% on sandy parts of the property. The conversion from livestock to cropping presented challenges. The main obstacle was a high population of grass weeds. "We probably underestimated how high the grass weed problem was," said Stuart. "There had never been any grass control on the property, no spray topping or anything like that, so the seed bank was quite big." Stuart and Amanda retained livestock on the farm until 2007, using pasture phases in their rotation to reduce grass weed levels. "I didn't want to get rid of the sheep until we had mostly got on top of the grass and I think we did that reasonably well," he said. "We tried to manage the natural medics that were there and thankfully the farm had quite good medic stands, so once we got on top of the grass they really fl ourished. We started to see some improvement then." Their grass reduction strategy involved using a grass selective herbicide early in the growth phase targeting as close to 100% grass kill as possible. This was

followed by a knock-down herbicide later in the season, which Stuart says worked well. Another part of their grass weed strategy included planting vetch as a brown manure crop, followed by canola; an approach that produced some outstanding results, said Stuart. Their most recent weapon is herbicidetolerant Clearfi eld wheat, which they are using for the fi rst time this year. "The Clearfi eld varieties are very helpful. I think they'll be a very good tool as long as we don't abuse them," he said. "Previously, if we wanted to plant a cereal crop after vetch and canola we had no cheap option to take grass out of the cereals. The Clearfi eld varieties are relatively inexpensive compared to what they were a couple of years ago, with seed costs now about $10/ha instead of $30. "It just gives us another control measure and the more methods we have, the more sustainable we're going to be." The Popes are also focussed on managing summer weeds, including melons, caltrop, fl eabane and volunteer cereals. Summer

weed control extends into autumn. "If we let the weeds get big prior to seeding we end up with a lot of root disease in the crop. Our weed control starts in the harvest period and goes right through to seeding to try to keep the paddocks as clean as possible." They have also entered the next phase of their no-till evolution, buying a Morris seeder they used for the fi rst time this year. They invested in a liquid fertiliser cart at the same time, allowing them to apply trace elements and fungicides in-furrow. "We don't really know what to put it down to, but we've got better results on sand this year. There's a more even germination and healthier-looking plants at this stage." Stuart and Amanda's cropping operation is 10 years old and they are optimistic about their farm's future, even if the former proprietor remains dubious. "Dad still thinks I'm crackers," reveals Stuart, "but I think he might be coming around a bit. He does show his old friends around the place every now and then, so obviously he thinks something is going right."

ALGERIE: POSSIBILITES LOCALES DE FABRICATION DE SEMOIRS POUR SEMIS-DIRECT

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En Algérie, l'implantation de céréales, fourrages, légumes secs et oléo-protéagineux par l'intermédiaire du semis direct (SD) s'avère très prometteuse. Si de grosses exploitations se sont déjà équipées en semoirs importés d'Europe ou du Brésil, les petites exploitations sont démunies face aux montants de l'investissement à consentir. Grâce à l'aide australienne, construire localement des semoirs de petites tailles est possible. Mode d'emploi.

Photo : Une ingénieur agronome syrienne conseille un artisan pour fabriquer un semoir pour semis direct selon un modèle australien.

Photo : Ce type de cultivateur CMA peut servir de base pour construire un semoir pour semis direct.

PRINCIPES DE BASES DU SEMOIR SD

Dès 2008, grâce à l'aide d'experts australiens agissant dans le cadre de l'ICARDA, la construction de semoirs SD a été lancée en Syrie, Jordanie puis Irak. Ces modèles sont inspirés du semoir australien de marque John Shearer. Il s'agit de modèles à dents (voir la documentation en fin d'article).

Une dizaine de dents sont installées sur un bâti composé de trois poutres en acier. Contrairement à un alignement sur une seule poutre, ce type de disposition permet d'éviter l'accumulation de paille sous le semoir. Les dents sont munies de ressorts leur permettant de se relever en présence d'obstacles.

Les dents comprennent un renforcement spécifique qui limite leur usure. Chaque dent est munie à l'arrière de deux tubes d'acier sur lesquels viennent se fixer les tubulures de descente en provenance de la trémie du semoir. Les dents présente un minimum de largeur permettant la réalisation d'un sillon d'une profondeur de 7 à 8 cm.

Fixées sur ce bâti sont installées deux trémies : une pour les semences et une pour les engrais. Ces trémies sont fixées relativement haut afin de faciliter la

descente des semences et des engrais dans les tubulures.
A l'arrière du bâti sont fixées des dents plombeuses. Elles ont pour rôle de rappuyer le sol juste au dessus des semences. Létroit contact sol-graines ainsi créé permet à celle-ci de profiter au maximum de humidité du sol. La présence de sillons de 7 à 8 cm derrière chaque dent permet de collecter l'eau de pluie et de la diriger vers les graines. Ainsi, il est permis d'assurer un maximum de levée à l'automne.

REALISATION PRATIQUES, CAS DU MATERIEL PMAT

La fabrication de semoirs SD peut se faire deux façons. Une construction à partir d'un modèle sur papier ou en transformant un semoir conventionnel en semoir SD. C'est cette deuxième option que nous nous proposons d'explorer à partir du matériel fabriquer par le groupe PMAT. Ce groupe fabrique en effet des semoirs conventionnels et des cultivateurs de 7 à 11 dents. Il nous semble qu'à partir de ces deux engins il est possible de fabriquer un semoir SD. En effet, le cultivateur possède des dents avec ressort.

L'idée est de positionner, en la soudant, la trémie et les tubulures de descente du semoir au dessus du cultivateur à dents. Il s'agit également de repositionner les roues du semoir sur le bâti du cultivateur et d'ajuster les chaines d'entrainement à la longueur désirée afin d'obtenir un débit proportionnel à l'avancement.
Il est nécessaire de souder derrière les dents du cultivateur des tubes en acier afin d'y fixer les tubulures de descente des semences puis celles de l'engrais. Les semoirs PMAT ne permettant pas de localiser les engrais de fonds (P – K), il s'agit donc d'équiper le bâti d'une deuxième trémie avec un système de distribution. Bien qu'apportant un net avantage, la distribution localisée des engrais n'est pas obligatoire pour de premiers prototype. Mais à terme, elle s'avère indispensable[1].

La dernière opération concerne la fabrication de roues plombeuses et leur fixation à l'arrière du bâti. A noter que cetains semoirs n'ont pas de telles roues mais uniquement une chaîne d'une dizaine de centimètres terminée par une plaque d'acier de 5 cm de diamètre. Sans remplacer totalement l'effet positif des roues plombeuses, un tel dispositif présente le mérite de remuer la terre au fond du sillon derrière chaque dent.

VERS D'AUTRES PERSPECTIVES

L'opération de transformation d'un cultivateur PMAT en semoir SD nécessite de renforcer le bâti et d'opérer des réajustements suite à de premiers essais sur le terrain. Ces opérations sont à la portée de tout artisan possèdent du matériel de découpe et de soudure de l'acier.
Cette transformation peut être demandée à l'initiative d'un agriculteur et réalisée par un artisan soudeur. L'intérêt d'une telle option consiste dans la proximité des deux opérateurs et des aller-retour indispensables afin de perfectionner le prototype.
Outre l'avantage de semer sans labourer et donc d'économiser sur le carburant, le SD permet de semer en sec dès le mois d'octobre. Il est ensuite possible de développer une activité d'entreprise agricole et de semer les terres de ses voisins. De tels semoirs sont capables de semer tout type de céréales, et de fourrages, notamment les mélanges de vesce-avoine ou de triticale-pois. Il est également possible de semer des légumes secs (lentilles, pois-chiche, fève et féverole) ainsi que des oléagineux dont le tournesol.
Ce type de semoir peut également être construit par des investisseurs désirant développer uniquement le semis chez autrui ou vendre des semoirs. En Syrie, ce sont pas moins de 8 ateliers de semoirs SD qui se sont ouvert à partir de 2008. Puis cela a été le cas de la Jordanie et enfin de l'Irak.
En Algérie, ce type de fabrication pourrait être également le fait de concessionnaires en matériel agricole ou de grands ateliers fabricants déjà du matériel agricole ou de transport.

Un candidat tout désigné à la fabrication de semoirs SD est bien sûr le groupe PMAT.dz qui dispose de moyens considérables et d'une base technique. Il est à espérer que ce modèle de semoirs SD proposé par l'Icarda soit repris également au niveau du département de machinisme tel celui de l'Ecole Nationale Supérieure d'Agronomie et de tout autre établissement lié à l'agriculture ou les fabrications mécaniques.

UNE DOCUMENTATION EN LIBRE ACCES SUR INTERNET

Les experts australiens travaillant à Alep (Syrie) dès 2005 ont importé un modèle de semoir SD à dents de fabrication John Shearer. Il en existe un exemplaire au niveau de la station ITGC de Sétif. On aurait pu penser que ces experts australiens poussent à l'achat de matériel australien. Ce n'est pas le cas. Ils ont permis à des Syriens, Jordaniens et Irakiens de s'inspirer des ces semoirs pour fabriquer des modèles locaux. De ce fait, des ingénieurs, artisans et agriculteurs ont collaboré à la mise au pont de prototypes. De là ont découlé de nombreux articles en libre accès sur internet de même que des photos et des vidéos.
Aussi, nous recommandons à chaque personne de rechercher cette documentation actuellement en ligne. Un des spécialiste australien, le Pr Jack Desbiolles a particulièrement publié sur le sujet. Nous

1 Pour les détails concernant la trémie à engrais des semoirs SD, on consultera l'abondante documentation en ligne sur internet notamment à partir des mots clé : « Icarda + seeder + zero till ».

recommandons en particulier le rapport détaillé qu'il a dirigé : « The Practical Implementation of Conservation Agriculture in the Middle East » Stephen Loss · Atef Haddad · Jack Desbiolles · Harun Cicek · Yaseen Khalil · Colin Piggin· Technical Report · Jul 2015.

Parmis les nombreuses vidéos nous recommandons celle de Mr Sani Jalili ; elles permettent de montrer les différentes étapes de réalisation d'un semoir SD.

ALGERIE, PRODUCTION DU BLE, UN PAS CONSIDERABLE FRANCHI PAR CMA SIDI BEL-ABBES.

Djamel BELAID djamel.belaid@ac-amiens.fr 6.04.2016

Nous avons longtemps espéré la construction en Algérie de semoirs pour semis-direct (SD). Non pas ces mastodontes tels ceux de Semeato, Kuhn, Versdät, Sola, John Shearer ou Gaspardo, mais des semoirs à prix abordables pour les petits et moyens agriculteurs. C'est là le seul moyen de vulgariser l'intéresante technique du semis-direct. Or, depuis quelques jours des informations nous sont remontées par différents canaux. Elles font état de la construction locale par CMA-Sola d'un prototype de semoir SD nommé « Boudour » dont nous avons pu voir une photo. C'est là un grand pas pour l'agriculture en Algérie. Ce progrès a été possible grâce, notamment à la coopération australienne.

Photo : Semoir CMA-SOLA fabriqué à Sidi-Bel-Abbès.

ITGC ET CMA DES MAITRES D'OEUVRE A FELICITER

Tout d'abord, les cadres Algériens qui sont à l'initiative de ce projet sont à féliciter ; de même que les techniciens et ouvriers qui ont contribué à produire le premier engin. Ce sont ceux, en première analyse, ceux de l'ITGC et de CMA Sidi-Bel-Abbès. Les premières informations font état d'essais en conditions réelles. Espérons que ceux-ci déboucherons sur une disponibilité de ce type d'engins.

Il semble que ce sont les ingénieurs de l'ITGC ainsi que des experts australiens agissant dans le cadre d'un projet international qui aient conseillé CMA-SOLA. On peut imaginer que le bureau d'études CAO de Sola a jouer un grand rôle. Si on ne peut que se réjouir de ce type de coopération croisée, on peut s'étonner du manque de créativité au niveau de CMA. Cette entreprise semble fonctionner uniquement en utilisant des modèles proposés par ses partenaires étrangers tels sampo ou Sola. Cela est étonnant de la part d'une entreprise qui a vocation à fabriquer et à faire évoluer le matériel agricole local. Pourquoi cette entreprise ne fait-elle pas plus confiance à ces ingénieurs ?

LES SEMOIRS SD A DENTS, DES OUTILS REVOLUTIONNAIRES

Longtemps après l'indépendance, l'agriculteur algérien a labouré les terres avec la charrue en acier introduite d'Europe. Or, le labour est l'une des causes de l'érosion des sols et de leur perte de fertilité. Les USA en ont fait l'amer constat après avoir défriché les grandes plaines. Dès les années 1920 des tempêtes ont provoqué d'importants nuages de poussières les « dust bowl » qui ont causé la ruine de nombre d'exploitations. L'écrivain John Steimbeck en a d'ailleurs tiré un best-seller. En Algérie, les mêmes causes ont créé les mêmes problèmes qu'aux USA. A cela s'ajoute l'effet désastreux de l'élevage du mouton. Résultats: une agriculture minière dévastatrice pour les futures générations. Arrêter le labour nécessitait de proposer aux agriculteurs une alternative. Celle-ci a été développée aux USA, au Brésil et en Australie : le non-labour avec semis direct.

Les semoirs SD permettent donc de lever la menace de l'érosion. L'expérience menée dans différentes régions semi-arides montrent qu'ils valorisent mieux l'humidité du sol. A ce titre, ils constituent des semoirs « anti-sécheresse ». Par ailleurs, leur système de localisation des engrais permet de résoudre l'éternelle question de l'insolubilisation du phosphore dans les sols algériens.

SEMIS DIRECT, L'EXCELLENCE AUSTRALIENNE

En matière de semis-direct, seule la coopération agricole australienne - dans le cadre de l'Icarda - a été en mesure de proposer à l'Algérie et à d'autres pays du Maghreb et de Proche-Orient, une technologie adaptée aux conditions pédo-climatiques et à la situation des petites et moyennes exploitations. La technologie australienne dépasse celle des autres constructeurs dans la mesure où les semoirs SD proposés sont à dents et qu'ils permettent de créer après leur passage de petits sillons. Ceux-ci permettent de collecter la moindre eau de pluie pour la diriger vers la zone où sont enfouies les semences. Par ailleurs, affrontant les mêmes risques de sécheresse que les paysans algériens, les Australiens ont ajouté à leur semoirs des roues plombeuses qui rappuyent le sol au dessus de la graine. Résultat, un meilleur contact sol-graine et donc une meilleure germination-levée même en conditions sèches. Il est donc possible de semer dès le mois d'octobre avant l'arrivée des pluies, d'où un gain de rendement. En Algérie, les semis se déroulent jusqu'à décembre ce qui pénalise les rendements.

« Cerise sur le gâteau » les experts australiens, dont l'infatigable Pr.Jack Desbiolles – l'Algérie s'honnorerait de lui décerner une médaille – a transmis aux cadres locaux le savoir-faire pour construire des semoirs SD « low cost » parfaitement adaptés répétons le aux petites et moyennes exploitations. Celles-ci sont souvent équipées de tracteurs de moyenne puissance de 65 à 80 chevaux et ne pourraient tirer les lourds semoirs SD importés. Précisons que concernant les grandes exploitations, leurs managers possèdent les moyens d'importer des semoirs de grandes tailles.

Le semis-direct est la la pratique qui revisite le dry-farming des années 50-60 et jusqu'à maintenant encore pratiqué en Algérie ;.

CE QUI EST DORENAVANT POSSIBLE EN ALGERIE

Les semoirs SD ont la capacité de favoriser une meilleure utilisation de l'humidité du sol. Ils ont deux autres avantages. Ils libérent l'agriculteur de la corvée du labour. A ce titre, ils permettent des économies de temps et de carburant. Outre le carburant c'est toute une série d'opérations culturales qui deviennent obsolètes : labour et recroissages pour la réalisation du lit de semences. Ainsi, le SD se traduit par une baisse des charges de mécanisation. Les décideurs du MADR ont là une occasion de réduire ou de ne pas augmenter les subventions aux céréaliculteurs – surtout ceux disposant de grandes surfaces. En effet, les gains de productivité permis par le passage au SD peuvent compenser l'inflation des intrants agricoles. Encore faut-il que ce type de semoirs soit rapidement disponible et qu'une vulgarisation efficace ait lieu. En effet, pour beacoup d'agriculteurs, le labour a une portée symbolique forte. Et l' abandonner est pour beaucoup d'entre-eux une hérésie. Cependant, la récente hausse des carburants peut pousser les agriculteurs à aller plus rapidement vers cette nouvelle pratique.

LE SEMIS-DIRECT POUR RESORBER LA JACHERE

En rendant inutile le labour, le semis-direct permet d'ensemencer la même surface de terre six fois plus vite qu'auparavant et à moindre coût. C'est d'ailleurs cet argument qui a poussé de grandes exploitations céréalières en Algérie, Maroc, Tunisie à s'équiper en semoirs SD importés. Semer plus vite permet un rêve caressé depuis des décennies par les cadres du MADR : résorber la jachère.

Les semoirs SD offrent en effet la réponse idéale. C'est le cas concernant la vitesse et le coût réduit d'implantation des cultures de céréales, fourrages mais également légumes secs – il est même envisageable de semer du tournesol avec de tels engins. Les semoirs SD constituent également une réponse idéale pour leur meilleure valorisation de l'humidité du sol. Ils sécurisent ainsi la récolte future et peuvent inciter les céréaliers à emblaver plus de superficie. Ceux-ci sont souvent échaudés du fait des sécheresses à répétition. Ils préfèrent moins semer et laisser les moutons pâturer sur les parcelles en jachère. Avec le semis-direct, l'incertitude climatique et donc l'incertitude de revenu liée à la culture des céréales est donc levée. Il s'agit là d'un aspect trop souvent négligé par les fonctionnaires des services agricoles assurés de leur revenu à travers leur paye mensuelle.

Un aspect est à approfondir. Il s'agit de la possibilité de semer des fourrages. Semer du fourrage de vesce-avoine ou pois-triticale est possible avec des semoirs SD. Le défi à venir serait de pouvoir semer sur les jachères pâturées des mélanges fourragers. Ceux-ci sont souvent constitués de petites graines. Le semoir SD Néo-Zélandais Grass Farmer permet cette opération appelée « sur-semis ». Sera-t-il possible de le faire avec le semoir SD-DZ Boudour ou avec ses différentes versions ?

ALGERIE, LE SEMIS-DIRECT POUR TOUT LE MONDE ?

Actuellement en Algérie, le semis direct n'est accessible qu'à une caste privilégiée d'agriculteurs : ceux ayant le moyen d'acheter de gros semoirs européens ou brésiliens et ceux bénéficiant des travaux réalisés par les unités motoculture des CCLS. Démocratiser cette technique passe bien sûr par une production de masse des semoirs Boudour de CMA-SOLA et du seul constructeur privé algérien : les établissements Refoufi (père et fils) de Mezloug (Sétif). Chacun l'aura compris, ces deux entreprises en sont à leur début.

Une alternative consiste dans la transformation ou upgrading des semoirs conventionnels en semoirs SD. Cette démarche a été suivie avec succès en Irak et Syrie par des céréaliers et de petits artisans soudeurs bénéficiant de l'aide des experts australiens. Il s'agit pour cela de fabriquer des kits : éléments semoirs à dents et roues plombeuses. Cette tâche est réalisable par des entreprises privées et par CMA par exemple. C'est là une tâche urgent. La technologie est relativement simple. Peuvent faire l'objet d'un upgrading les semoirs conventionnels mais également les épandeurs à engrais en ligne ou les cultivateurs à dents de marque PMAT.dz sur lesquels il pourrait être possible de fixer trémie à semences-engrais et système de distribution proportionnel à l'avancement (DPA).

Les experts australiens et ceux qui ont été formés en Syrie et Irak mettent en ligne des dossiers complets sur internet. Ces informatoins détaillées sont accessibles en tapant « Icarda + ZT + seeder » sur google.

CMA-SOLA, Ets REFOUFI LES NOUVEAUX DEFIS

Les entreprises privés et publiques CMA-SOLA et Ets REFOUFI sont devant de nouveaux défis. Bien sûr le premier est d'améliorer leurs prototypes afin de produire un produit répondant aux spécificités locales. Il s'agit ensuite d'une production de masse et de la fabrication de kit pour upgrading. Par leur contribution à la réduction des importations alimentaires, ces entreprises ont besoin d'une aide stratégique de la part des pouvoirs publics : aides financières bien sûr ou par exemple limitation de l'importation des semoirs SD étrangers pouvant concurrencer cette production nationale naissante. Les entreprises privées constituent un allié puissant pour les pouvoirs publics. En effet, leur localisation rurale au contact direct des agriculteurs utilisateurs de leurs semoirs leur permet de les améliorer et d'assurer une maintenance. La volonté de grandir de ces petites entreprises constitue par ailleurs, un puissant levier de vulgarisation du semis-direct. Levier plus puissant que les agents des services agricoles. Par ailleurs, elles participent à la création d'emplois.

Concernant les Ets REFOUFI Fils, la mise au point d'un prototype basée sur l'observation du modèle de semoir SD syrien Aschbel en fonction à Sétif est à souligner. Avec des moyens limités, cette jeune entreprise s'est lancée dans un projet ambitieux. Il est à espérer que d'autres petits constructeurs privés s'inspirent ce cette démarche.

Pour ces entreprises, il s'agira ensuite de proposer des versions de semoirs SD utilisables sous pivots dans les sols sableux au grand Sud ou utilisables en sol steppique. Bien que sujet à caution, les effets les plus néfastes de ce type de mise en valeur peut être atténué par le SD. En effet, labourer sous pivot ou en steppe – cas des sols plus profonds des dépresions – constitue une hérésie. Il est urgent de leur proposer de tester le semoir SD Boudour ou tout autre solution dont le type de semoir Agric PSM 30 à double spire.

Les entreprises DZ ont l'extraordinaire chance de pouvoir bénéficier de l'aide désintéressée de la coopération australienne et en particulier de la présence ponctuelle en Algérie du Pr Jack Desbiolles. Cette situation risque de ne pas durer ; l'aide technique australienne est progressivement ré-orientée vers l'Asie. Or, l'expérience étrangère est fondamentale ; ainsi, l'utilisation de pointes de dents en acier ordinaire peut conduire à une usure rapide et à la formation d'un lit de semence inadapté.

Les autres défis auxquels est confrontée la filière céréales concernent la maîtrise du désherbage indispensable en SD. Traditionnellement mené chimiquement, le désherbage nécessite la disponibilité en pulvérisateur et herbicides. La production locale de pulvérisateurs low-cost de marque SFT met aujourd'hui le désherbage chimique à portée de toutes les bourses en Algérie. A ce propos, les efforts réalisés par les cadres de l'ITGC afin de vulgariser la technique du désherbage chimique auprès des agriculteurs est à souligner.

Avec le semi-direct, l'agriculture est à l'aube d'une révolution technique que seule une mobilisation de toute la filière céréale permettra de concrétiser.

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APPORT D'ARGILE SUR SOL SABLEUX

Spread, delve, spade, invert a best practice guide to the addition of clay to sandy soils

INTRODUCTION Follow the rules to improve sandy soils with clay

[Quelques extraits d'un guide australien très intéressang sur l'amélioration des sols sableux par l'apport d'argile. Une partie aborde les règles de base et une autre comporte des témoignages. Il en ressort que les rendements peuvent être améliorés. Mais il s'agit d'être conseillé par un agronome et de préférence par un pédologue. Djamel BELAID. 20.05. 2016]

Across Western and South Australia there are many millions of hectares of deep sand or sand over clay-rich subsoils that are used for agricultural production. However, these sandy soils present a range of challenges due to their poor water holding capacity, inherent low fertility, extremes of pH, low levels of microbial activity and vulnerability to wind erosion. In addition, many sandy soils are non-wetting, which causes uneven germination resulting in poor weed control, low levels of soil cover and reduced productivity . Sands and loamy sand soils have less than five per cent clay content. As clay protects organic material from decomposition these soils are also low in organic carbon. Raising the clay content changes the soil texture class, which increases the capacity for the soil to store water (Table 1 page 6), nutrients and soil organic carbon. Experience has found that it is feasible and profitable to raise the percentage of clay in the soil to above five per cent. For example, adding 200t/ha of soil containing 30 per cent clay would raise the clay content in the topsoil from 0.5 to about five per cent, if incorporated to 10cm. Provided that appropriate methods are followed, remediating sandy soils with clay-rich subsoil can result in substantial yield improvements. Trials in WA and SA have reported yield improvements of 20 to 130 per cent across cereal, lupin and canola crops in the years following clay additions. However, achieving the correct rate of clay addition and understanding the chemical nature of the clay-rich subsoil to be used is vital, if the process is to be successful. The depth to clay-rich subsoil determines which method of clay addition is most appropriate. Deep sands can only be addressed through spreading of clay-rich subsoil excavated from a pit, spread across the soil surface and then incorporated. Sand over clay soils (Duplex soils, Figure 1) offer the potential to provide a source of clay that can be incorporated in the upper sandy horizons. Clay at between 30 and 60cm can be brought to the surface by delving. Where clay is less than 30cm below the surface a rotary spader or possibly a mouldboard plough can be used to lift and incorporate the clay in the topsoil. Adding clay is relatively expensive and time consuming and if done incorrectly can result in negative effects that are difficult to reverse. Consequently, detailed planning of each stage of the process and following best practice is essential. Drawing together over 30 years of research and grower experience, this publication answers the key questions that must be addressed for a successful claying program to be achieved.

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Check list Thinking and planning are cheaper than doing and fixing.

Why clay – is there a valid reason? ✓Overcome non-wetting sands. ✓Stabilise sand hills, reduce wind erosion. ✓Increase water holding capacity (small). ✓Improve nutrient retention (depends on type of clay). ✓Reduce frost risk (not consistent). ✗ The neighbours have added clay to their paddocks.

Do some investigations • Dig some holes, to locate clay-rich subsoil. • Establish how deep the appliedclay-rich subsoil needs to be incorporated • Use an EM survey to assess variation in depth to the clay-rich subsoil, if considering delving, spading or mouldboard ploughing. • Test the clay percentage and chemical composition of the clay-rich subsoil.

Do some numbers • How much do you want to increase the clay percentof the topsoil and subsoil? • How much of your clay-rich subsoil is required to achieve this change taking into account the clay percentage and incorporation depth? • Can this rate be achieved? • What area do you have the time and money to remediate? • If spreading, how far away will the pits be located?

Choose the method • What methods can be chosen for this site? • Who will spread/delve the clay? • What equipment is required and what is available? • Who will incorporate the clay, how and to what depth? • Consider the timing of the operation and how this impacts on current and future production/rotations.

Executing the plan • Draw a paddock plan; mark areas to be spread/ delved/spaded or mouldboard (inversion) ploughed. • If delving and spreading are to occur in the same paddock, in the same year, spread first. • Mark the locations of clay pits on the plan and highlight potential hazards. • Mark the direction of delving, spading or mouldboard ploughing on the plan. • Ensure the paddock is levelled and the amount of organic matter can be dealt with by the chosen equipment. • Smudge and incorporate spread clay promptly but allow delved, spaded or mouldboard ploughed clay time to breakdown before incorporation.

After claying •Soil test to identify changes in soil characteristics and nutrient availability. • Grow crops that will not be impacted by issues including; if carbonate or salt is present in the added soil, do not grow sensitive crops such as lupins. If the seed bed is soft following incorporation do not select crops that need accurate sowing depth. • Yield map to assess changes in production and the return on investment.

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Case study one

Spader man a pioneer Delving plus spading to mix clay has boosted grain yield dramatically on Roger Groocock's farm in southeast South Australia.

Felicity Pritchard

Roger Groocock's entire property has been delved or clay spread to eliminate non-wetting properties. Improved incorporation using a spader is the latest development in his on-going soil improvement program.

FARM DETAILS

Grower: Roger Groocock Location: Bordertown, South Australia Average annual rainfall: 450mm Farm size: 1400ha, 950ha cropped area and 450ha pasture. Enterprises: mixed farming with sheep Soil types: bleached loamy sand over a brown mottled clay Area clayed: the whole farm has been treated one way or the other; now just fine tuning small areas in paddocks or spading previously spread areas. Claying history Clay spreading began in the early 1990s and delving began on more shallow sands in 1993. Clays were mixed with a home-built 'Alabama' machine that was replaced with a spader in 2005. Spading is continuing on the property.

Roger Groocock is one of Australia's clay spreading pioneers. In the early 1990s, Roger and his peers in the Bordertown Landcare group did all they could to overcome the scourge of non-wetting sands that were afflicting their farms. Capeweed and silvergrass dominated pastures on deep sands, while crop rotation options were unsustainable on the shallow sands, the 'good country'. While minimum tillage and no-till with full stubble retention were tested, these did nothing to alleviate water repellence. Eventually they hit the jackpot by spreading clay over sand, after learning of this techniques success on Clem Obst's farm. "We recognised the benefits as soon as we did the clay spreading," says Roger, who was group leader at the time. Clay was not spread on paddocks with shallower sands, as these were considered most productive and ideal for subclover pasture. However, once continuous cropping was adopted, water repellence became an ever-increasing issue. This was due to waxes, created from the breakdown of extra organic matter produced by cereals, coating the sand particles. Wax levels after lucerne, phalaris and annual ryegrass were quite bad as well. Realising water repellence was actually worsening with cropping, the group decided to test ripping-up the clay-rich subsoil.

The idea of delving the clay-rich subsoil was initiated by former CSIRO soil scientist Dr Bob Fawcett, after he visited a soil pit on Roger's property. Armed with this idea and information gleaned from a water repellence workshop Roger attended in Western Australia in 1993, trials were undertaken using a trench digger to 60cm depth and 1.2m spacing. They found water repellence did not return on the delved shallow sands. Funding for the Landcare project (Operation Finetune) enabled the first clay delver to be built by University of South Australia in 1994. "Very quickly, contractors and farmers recognised the opportunity to amend soils by delving. Within three years, it really took-off in this district," says Roger. In 1997, Roger decided more spreading was needed on his farm. He bought a Lehman scraper to extend the area of clay spreading further down the sand hills. The expense was covered by the uplift in productivity brought about by clay spreading. Roger began contract clay spreading for an additional income stream. Roger's entire property has now been delved or clay spread, with some paddocks spread twice where light rates were used. Clay spreading took place on sands deeper than 40cm, while delving was used for shallow sands over clay. He has since sold his Lehman scraper but Roger still owns a small delver. In early days, nearly all his country was delved with the small delver. In the last five years, Roger has used contractors to delve in areas with clay too deep for his small delver.

Deep incorporation Roger built his own clay mixing 'Alabama' machine, in 1993. This created furrows about 25cm deep using V-shaped shares to mix both the spread and delved clay. A spray nozzle, mounted 30cm behind each shank and 30cm above the soil, was added to spray trace elements into the furrow. After levelling the trace elements would be located between 7.5 and 20cm deep. Liquid copper, zinc and manganese sulphate were applied at 2.5kg/ha of each element to the whole paddock. A 4.5m wide railway line was dragged behind the 'Alabama' to level soil. Roger continues to push the boundaries of soil manipulation. In 2007, he was awarded a Churchill Fellowship and travelled to the Netherlands to research spaders. He had learnt of their existence from his Dutch farm worker, who said they were better than the 'Alabama' machine. These digging machines thoroughly mix soil to incorporate clay or other materials to a depth of about 30cm. He was so impressed with the results that he imported the first spader into Australia, to replace the 'Alabama' clay mixer. Farmax, a producer of spaders, then offered Roger the Australian agency for their machines. Roger is in the process of spading all his delved and clay spread paddocks. After three years experience, he finds the benefits are clear. Grain and pasture yields after thorough deep mixing have increased by 70 to 80 per cent on delved paddocks. Before delving wheat yields were about 2.2t/ha now they average 3.8/ha. On clay spread areas following spading yields have doubled from 1.8 to 3.6t/ha. These paddocks can now support a more intensive crop rotation. Roger has been fortunate, not all growers achieve such startling results from clay spreading. According to Roger, it is essential to know details of the soil profile before embarking on clay spreading or delving. "With experience, we found we can use any clay on our farm. Some farmers have had trouble with high magnesium, chloride, carbonates or low pH in their clay," says Roger.

Types and rates The top 30cm of Roger's clay-rich subsoil are sodic, however he considers these fine for spreading as the sodicity is readily ameliorated with gypsum. The subsoil below that layer has a higher calcium carbonate content, so rates are reduced. The clay-rich subsoil's pH (in water) ranges from 6.8 to 9.7. After delving or spreading clay, the topsoil pH is increased from about pH5.5 to ph6.5 to 7.5. Reducing topsoil acidity benefits crop growth and nutrient availability. In the district most clay spreading and delving is undertaken after harvest. However, Roger has delved mostly in spring and spread clay in autumn, the optimal time. The spader allows more flexibility in the timing of these operations, although summer is not ideal due to the risk of erosion.

Liquid trace elements are sprayed on the surface before incorporating the clay-rich subsoil with the spader.

In the early days, Roger engaged contractors to spread on sandhills 200 to 250t/ha of clay-rich subsoil, which comprised of 35 to 40 per cent clay. This was fully incorporated to 10cm. The clay was removed from strategic points to create dams or water courses in low lying areas. Finding his clays were 'friendly', free from major toxic elements, Roger decided to test heavier rates with deeper incorporation. Rates were doubled (400 to 500t/ha) as was the incorporation depth (20cm) resulting in the same clay percentage as the lower rate but distributed through a large volume of soil. "About five per cent clay is adequate for long-term amelioration of water repellence. So, provided we have no more than five per cent clay, we are unlikely to create problems; the deeper we have mixed the clay, the lower the haying-off effect has been,"

Method Roger now believes it is only worthwhile delving soil where the clay-rich subsoil is less than 30cm from the surface. When delving with a 1 to 1.5m tyne spacing, he has found his soil is disturbed up to 90cm deep depending on depth to clay. Clay clods (football-sized or bigger) are brought to the surface. Delved soil is initially left to dry, allowing clods to break down with weathering over summer. The ground is then levelled (smudged) with a scarifier or levelling bars. Trace elements are now sprayed before incorporating the clay-rich subsoil with the spader. Spading is carried out at between 35 and 55 degrees to the delver lines to improve clay mixing throughout the tyne inter-row area. The rotation on delved soil is canola, wheat then barley. He believes canola provides greatest root penetration of the deep ripped layer once hardpans are removed. Pulses have been difficult in the past, but on delved and spaded soil, beans can be profitable. Balansa clover is sometimes used in lieu of a pulse. Roger is always looking for a better rotation, for example he has tried growing fodder rape as a summer forage. The addition of nitrogen through legumes is a major benefit of Roger's rotation.

On clay spread paddocks, Roger grows two cereal crops followed by long-term legume-based pasture for livestock. His aim is to raise soil organic matter levels. After spading old pastures, he returns to two years of crop then spades in all straw. While spading works to 40cm depth, it generally mixes soils and straw to 30cm. Three years in ten, a spring fodder rape crop has been sown pre-delving and used for finishing fat lambs through to March, then the area has been smudged

and clay incorporated ready for a winter crop.
Benefits A number of benefits have come from claying his country, these combine to help improve yield. Root penetration has increased on delved paddocks, providing entry points for roots to access previously unavailable soil moisture, increasing water use efficiency. Sandy topsoils now have better structure, trafficability, and more nutrient and water holding capacity. Soil erosion from slopes is also lower. Weeds now germinate on the first rain providing better control with knockdown herbicides. Post-seeding weed control is better too, while less frost damage is another improvement. Roger has seen a significant improvement due to better nutrition. The introduction of clay to the topsoil helps retain the applied nutrients in the root zone. In nine out of 10 years Roger has covered the costs of delving and spreading after the first year. However, he knows owning his own machinery means his costs are less than the contract rate, for example $120/ha for delving. Roger remains an advocate of clay spreading and delving. His persistence, ingenuity and enthusiasm have led to a major change in practices and attitudes of farming sandy soils in the Mallee and beyond. "The interaction between soil scientists and farmers has been pivotal to the success of this soil amelioration process." More details: Roger Groocock, 08 8754 6025 or 0427 546 025, grooks@internode.on.net

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Case study four

Mates rates Less is more when highly calcareous clay is used to improve sandy soils.

Emma Leonard

FARM DETAILS
Growers: Shane and Beth Malcolm Location: Wharminda, South Australia Average annual rainfall: 325 to 350mm Farm size: 1600ha in three blocks, 30km apart Enterprises: wheat, malting barley, lupins, canola, peas, vetch (for green manure); 300 Merino ewes, plus crossbred lambs Soil types: sand over calcareous clay, deep sand and red loam; topsoil pre-claying pH 6 to 7, subsoil pH8 plus; clay depth varies from 15cm to over 1m below the surface Area clayed: 300 hectares Claying history The Malcolm's first experience of claying was in 1986 when Shane's father built a roadway through the middle on the farm. The material removed was spread over light sandy areas prone to erosion. The improved plant cover and performance seemed encouraging. However, it was not until Shane and Beth were managing the farm that they tried their first 'true' clay spreading to reduce non-wetting properties and soil erosion. That was in 1997; fourteen years later they still have an on-going program of clay delving across the properties.

Despite the low rainfall, wheat yields of one and a half tonnes per hectare are not uncommon in the Wharminda region, providing crops are sown early and receive in-crop rainfall. However, in paddocks suffering from non-wetting sand, plant establishment is reduced leading to low soil cover and the potential for wind erosion. The non-wetting properties also result in staggered weed germination, especially of competitive weeds such as brome grass. In pastures, stock tend to camp in these non-wetting areas causing further loss of cover and susceptibility to wind erosion. All of these factors can substantially reduce a paddocks production and were the reasons why Shane and Beth Malcolm decided to try clay spreading. "I hate soil erosion and drift and want to achieve timely sowing and good establishment to maximise yield potential," says Shane.
Having seen the potential improvement in crop and pasture establishment on the areas spread with the clay spread from the road building process, Shane and Beth Malcolm decided to try spreading clay on patches known to be non-wetting.

Patch spreading
In 1997, a 10 tonne, Marshal belt-spreader was purchased with the aim of spreading up to 150ha across a new property the Malcolms had purchased in 1994. A CAT951 track loader with a 1.5m3 bucket was used to extract the clay from a pit and fill the spreader. Plastic trays were laid out across the spread width, which was up to 18m, to establish the clay rate. Roughly, the rate spread was 50t/ha with 10t/ha of clay spread per pass but much of this was as large lumps. Shane remembers this as being a very slow process. The clay was spread during the summer and worked in at seeding by two workings with a full cut shear. While the clayed areas did result in better establishment, not only of cereals but also of lupins and canola, these areas now suffered from two new challenges; snails and manganese deficiency. The clay in this region can be highly calcareous (calcium carbonate) or referred to as containing free-lime. The additional calcium makes these areas especially attractive to

Photo Delving is now the Malcolms preferred method of claying because spreading too higher rates of calcareous clay has had a long-term negative effect in drier seasons.

snails, so baiting was required. The additional carbonate can impact on nutrient availability and the residual effects of some herbicides. The manganese deficiency is caused because the previously available nutrients become locked-up by the added calcareous clay. Over the years, Shane has established that his clayed paddocks require up to three applications of manganese sulphate (see breakout).

Paddock spreading

In the same year the Malcolms also experimented with spreading larger areas using a Landplane scraper. This contractor machine was selected as it allowed larger areas to be spread quickly, with clay rates of about 100t/ha, for the least cost per tonne. The Landplane can spread up to 350t/ha, while the Claymate's maximum rate is about 150t/ha but the contractor rate for each machine was about $125/ha, irrespective of tonnes spread. This is approximately, the same cost as using the Marshal spreader to achieve a rate of 50t/ha. The Landplane spread the clay in strips a little over 4m wide and left the surface very uneven. To achieve the required rate a 1m gap was left between each run. As with many operations the evenness of spread is very dependent on the operator. The clay was worked in by a wideline cultivator with a prickle chain looped behind, which smashed up the clay lumps and incorporated it to about 12cm. The clayed paddocks were cross worked about six times at work rates of about 10km/hr. Even after all these workings enough clay was left on the surface to prevent wind erosion.

for our soil 100t/ha was far too high.

The high rates of clay did result in improved crop establishment and more even germination of weeds, enabling more effective weed control after the opening rains. However, the overall yield outcomes from the high rates of clay were very seasonally dependent. In a year with an even distribution of rainfall and adequate falls in spring, a wheat yield of 1t/ha was achieved on the un-clayed land and 2.5t/ha on the clayed. However, in a dry year these figures reverse with the un-clayed land still producing about 1t/ha but the clayed land only producing 0.4t/ha. In some situations the clayed areas in dry years resulted in complete crop failure. "We have learnt the hard way; knowing the properties of the clay and setting the appropriate rates are essential; for our soil 100t/ha was far too high." At this stage in their experience the Malcolms had not tested the chemical composition of the clay being applied. After the clay had been spread and the issues of snails, manganese deficiency and crop failure had been encountered they started to look for the reasons. Testing the clay from different parts of the pit established that all the clay was highly calcareous, with hostile levels of pH, free lime, boron and salt all increasing with depth.

"I encourage anyone who is going to incorporate clay into sandy topsoils to test the chemical content before they set a rate; not all clay is good for crop growth."

little can be done to reverse the reduced moisture availability in dry years

The high rates of clay spread using the Landplane increased the clay and the carbonate content of the topsoil sufficiently to lock-up both nutrients and available soil moisture. While the manganese deficiency is an annual problem that can be treated with foliar fertiliser, little can be done to reverse the reduced moisture availability in dry years. "Once clay has been incorporated it is very hard to reverse the process or reduce any negative effects. Where we have the rates right we are gaining on-going benefits." A couple of years later, the areas spread with 100t/ha of clay were worked as deeply as possible, to about 13cm with a two-way, concave disc. The aim was to distribute the clay to a greater depth and dilute the negative effects of the free lime. An application of 2.5t/ha of gypsum was also tried to help stabilise yield. The results were mixed and the tillage left the soil vulnerable to wind erosion until the next crop was established.

Minimising manganese deficiency

All cereal crops growing in clayed paddocks or clayed patches receive a foliar application of manganese sulphate (0.6 to 1.5kg/ha) at the three leaf stage. At this stage growth has not been severely checked and the plant has enough leaf area to absorb sufficient nutrient. A second application is made when the first sign of a colour difference between the clayed and unclayed paddocks is visually observed. This is at the same rate and generally occurs about early tillering with the rest of the paddock. If the colour difference returns later in the growing season a third application can occur.

Delving

For the Malcolms, delving is now their chosen method of introducing clay into the surface soil. Although delving is

Photo High calcareous clay (right) and good clay (left) brought to the surface in the same pass with the delver. Using simple on-farm tests is essential to establish the composition of the clay being added.

relatively slow and the paddocks are left very rough, the Malcolms find this method provides an adequate clay rate and does not bring too much very hostile clay to the surface. Areas of a paddock with shallow rocks are avoided. Following the success of some trial strips delved in 2006, Shane built his own light-weight delver, which draws clay from 50cm deep into the upper soil profile. He admits that it took four very dry years before he was convinced that delving was the correct procedure. In 2009, he recorded a half tonne per hectare difference in wheat yield between delved and undelved ground. “In 2010 we still saw the benefits of the original delving but without a yield monitor its hard to put a figure on the different parts of the paddock. Shane estimates that delving and levelling a 60 hectare paddock takes approximately 100 hours. Delving is carried out in late summer, when the clay can be wet or dry. This is followed by two cross workings with a chisel plough fitted with 35cm sweep shears and trailing a prickle chain loop. The first working is in the same direction as the rip line and must be done within a day of delving while the clay still retains some moisture. The second working is at 45 degrees to the rip line. Even after two or three workings the surface is still rough. While Shane is keen to do more delving, Beth who drives the boomspray is less enthusiastic about the prospect of more rough paddocks. In a trial, a spader was used to incorporate the clay. While the surface was left smoother, the Malcoms were very concerned that the spader left the paddock too even and vulnerable to wind erosion. To help retain ground cover, paddocks coming out of cereal are selected for delving. The crop following delving is usually a cereal as lupins are more susceptible to damage from the increased carbonate level. While the negative influences have been minimal due to the lower clay rate achieved with delving, they have not found

the uniformity of weed germination to be as great as

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with spreading. The manganese problem remains with all claying methods tested by the Malcolms, although is less extreme with delving. Shane has also noticed that where he has delved there has been an increase in the pH of the topsoil and barley has suffered more severely from net blotch. As yet he is not sure if this is also linked to a nutrient deficiency. In February 2011, the delved paddocks were worked once with a two-way disc for further levelling and to assist seeding through thick stubbles.

The future

Shane Malcolm is keen to continue remediating the nonwetting sands using clay. Once he has delved all areas of the farm where the clay is within 50cm he will consider revisiting clay spreading, however with reduced rates perhaps 50t/ha and avoiding the use of hostile clay.

Key points from Shane and Beth Malcolm’s experience with claying

ν Always test the carbonate content before setting the rate and during digging. If the acid fizz test (see page 12) indicates high carbonate stop digging or reduce the rate.

ν Keep clay rates to a minimum.

ν Incorporate clay-rich subsoil as deep and evenly through the topsoil as possible.

ν Redder clays tends to be better clay.

ν Delving leaves the surface rough but results in less nutrition problems.

ν All treatments have a similar cost per hectare irrespective of clay rate.

ν Some leaf diseases are more prevalent on clayed country.

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