No-tillage Development at Livingston Farm, Moree and the NW Plains of NSW

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Abstract

The development of no-tillage farming systems at Livingston Farm, Moree and the North West Plains of New South Wales is studied. Seeder development, spraying technology, the use of sheep, and the advantages and ongoing challenges of no-tillage are discussed. Future directions for no-tillage farming systems are examined.

Key words

Bluff plate, no-tillage, seeder, sheep, sprayer, weed.

I was somewhat surprised when advised that the Australian Society of Agronomy had honoured me with the Donald medal on this occasion. I do not regard myself as a gifted academic researcher, just a tertiary educated farmer who has sought to innovatively apply the research findings of others to a large scale farming enterprise, and once convinced of the worth of the technology, to demonstrate the rewards to others in the farming community.

After an early career with NSW Agriculture working with Jeff Colwell of CSIRO on the merits of phosphorus application to cereal crops in N. NSW, I joined the University in 1967 as the farm manager at the Plant Breeding Institute at Narrabri. There I was first introduced to the concept of no-tillage farming. Breakwell and Jenkins (4) did pioneering work, followed by Crofts, Geddes and Carter (5) with the sod seeding of oats into coastal pastures, and from 1968-71 Bob Fawcett (11) did initial research at the P.B.I. This showed that by retaining residue and eliminating tillage, an extra 30-50mm of water could be stored in NW NSW cropping soils during a cereal fallow period, compared to traditional burning and tillage systems. Andrew Badley (ICI) handled the herbicide application and research that was confined to Paraquat, Diquat, and some of the phenoxy herbicides at that time.

Also during the early 1970's Lindsay Ward and Chris Norris of the QDPI undertook a separate project. They demonstrated North American sweep tillage implements, and deep furrow drills at various locations to Darling Downs and Maranoa grain growers. This approach fostered grower interest and consideration of the merits of each implement.

In 1976 I was appointed to Livingston Farm, and was advised by Prof. Frank Crofts to initiate large scale evaluation of minimum and no-tillage farming systems, as 'this was the way that farming was going to go'. Fawcett had shown the benefits of stubble residue on moisture storage, whilst the NSW Soil Conservation Service had shown the advantages of residue in reducing run off and erosion. It was up to us to now demonstrate on a commercial farm scale that no-tillage agriculture could be a new means of increasing crop yields, reducing soil erosion, decreasing energy costs, and generally improving profits.

From 1977 until today Livingston Farm has gradually changed from a system of conventional monoculture grain growing with cultivated fallows to a no-tillage conservation farming system with retention of all residues, major reliance on herbicides for weed control, and timely seeding of crops into moist soil with press wheel drills. Intelligent rotations with alternate winter cereals, winter and summer pulses, summer cereals, oilseeds, and forage crops have been developed (5). Sheep have been used to control weeds on crop stubbles and so can greatly reduce herbicide usage and further increase profits.

Under the terms of the Livingston bequest, the University of Sydney was required to demonstrate on a large scale the economic value of scientific farming systems to the agricultural community of the NW

Plains of NSW. I was convinced of the worth of this system, so it was not difficult to be enthusiastic. I had stepped from the ‘research’ camp to the ‘farmer’ camp. This put me in the enviable position of being able to put into large-scale practice some of these principles. We had a policy of ‘open house’ to show in a practical way what we were doing (even the odd disaster). Over the last 24 years, groups of farmers, researchers, agribusiness personnel, students, travellers, and other professionals associated with agriculture have walked the fields, observed, discussed, and often argued the point. It has I trust made many think and ultimately adopt some or all of these farming systems.

I was also able with others to form a local conservation farming group to share knowledge and experiences and encourage doubters to ‘give it a go’ There were many opportunities to speak at field days and seminars as well.

Doyle & Marcellos (8) showed that each winter cereal variety in NW NSW should be sown in a 10-20 day ‘window’, and that by sowing later, farmers would suffer 7% per week in yield penalty. Yet the ‘Australian Rainman’ (2) computer simulation indicates that at Moree, for the 30-day optimum planting period for all wheats (26 April to 28 May), there is only a 50% chance of receiving a planting rain of 20mm. The problem is how to plant in those 50% of years without a sowing rain, still planting on time, so that crop yields will be optimised.

We reasoned that, if we retain the full residue of the previous crop, evenly spread the tailings from the harvester on the soil surface, and control weed growth without tillage, soil moisture would be available near the surface for sowing, germinating and establishing the next crop at the appropriate planting time almost every year. We further reasoned that if we could move the dry topsoil where necessary, firmly place the new seed in the moist layer with the aid of a special tine and press wheel, we would secure immediate germination and establishment, thus avoiding yield penalties due to late plantings. On Livingston Farm we have sown winter crops up to 80 days after rain, and achieved a satisfactory stand. This practice is now commonplace on Northern Australian farms with the development of deep furrow drills suitable for no-tillage planting.

The first real test of the worth of no-tillage farming was in 1982. The season started well, with around 250mm of rain from November 1981 until late March 1982. The rain stopped in late March, and it did not rain significantly again until April 1983. Despite the dry, we commenced planting in April, and continued until June of 1982. Results were:

Treatment	Wheat yield	Plants with secondary roots
No-tillage and deep furrow drill	2.2 t/ha	80%
Stubble mulch tillage using sweep implements and ‘combine’ drill	1.5t/ha	20%
Conventional tillage	0	0

This was tangible evidence to the farming community of the worth of the system, and interest grew enormously.

Around the same time, northern Australian farmers became aware of the ‘ecofallow’ system as used on the Great Plains (14), and much of this technology has been directly applied to grain sorghum growing in this area. The system includes a 10 month no-tillage fallow using atrazine as the main herbicide followed by grain sorghum planted into this fallow. A specialised row crop planter is used leaving the winter cereal stubble undisturbed (9). We have successfully used this technology for 20 years (10), and never had a complete crop failure.

Although ecofallow sorghum was the first crop grown, this no-tillage system has now been successfully modified for many other row crops such as corn, cotton, soybeans, mung beans, sunflowers, chickpeas and faba beans.

Seeder Development

Machinery development, especially for seeding, has been an ongoing saga of trial and error. Initially Livingston Farm and local farmers used the standard 'combine' (seeder/cultivator). Most years the residue would have to be burnt before planting to allow the seeder to operate. We then moved to modified chisel ploughs and heavy-duty cultivators fitted with adaptors and press wheels. The larger implement manufacturers initially showed little interest in equipment development. However several short line manufacturers have been very co-operative, and a whole line of no-tillage planters has arisen. We have progressively moved from modified cultivators to specialised no-tillage planters.

We have persisted with tine opener seed drills fitted with press wheels and a capability to penetrate through dry topsoil. In dry years Northern farmers set units to penetrate 10-15cm (4-6 inches) to reach the moist soil. Disc openers (either single disc or double disc) are not generally satisfactory, as they need too much weight to penetrate. Also in wet years the soil sticks to the discs, and the machine easily plugs with mud. Ward (15) showed that tine opener units are superior in most situations and this has been our experience.

We have come a long way in seeder development, but there is still a long way to go. Tine opener drills sometimes have too much moisture loss in the slot, and a patchy stand results. *In principle*, the Baker (3) cross-slot single disc opener is the best yet developed. However *in practice* this unit has only been marginal in performance.

Sprayer Technology

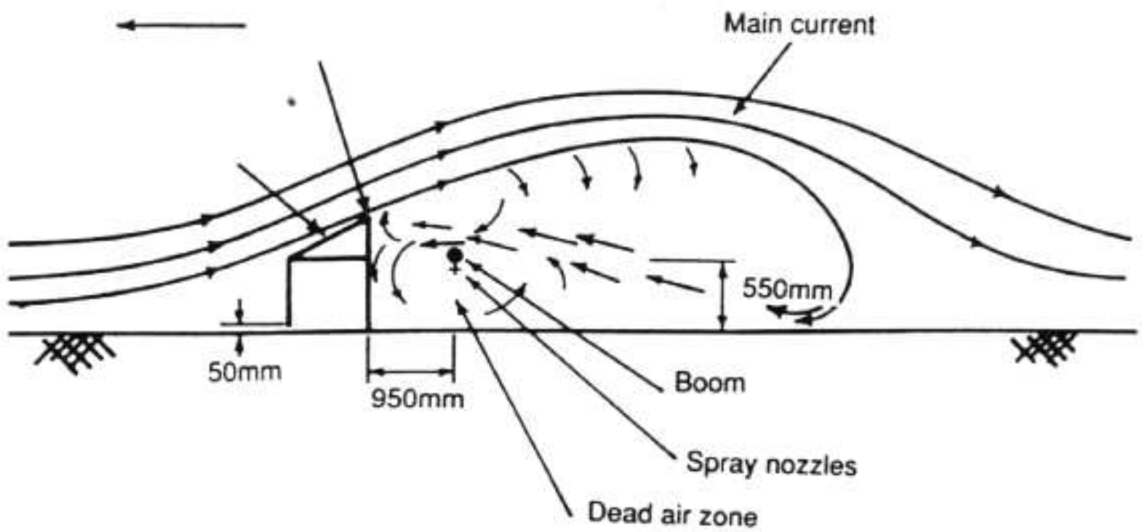
On Livingston Farm we traditionally use the standard boom spray for pesticide application. Units are either mounted on, or drawn by tractors, or fitted to farm vehicles. Although satisfactory in performance, I have been aware of the extreme shortcomings of the standard boom spray, in that once the droplet leaves the nozzle, we have lost control of it.

In recent years there has been some use of shielded booms, and drift reductions of up to 50% have been observed. However the benefit can largely be negated if one travels too fast or cuts back on water rates. Air jet and bubble jet nozzles as well as large droplet 'Lo Drift' nozzles fitted to standard booms have become popular in recent years. Some have tried air assistance systems.

There has been some development of weed sensing systems, using reflectance technology. This is still largely in the early improvement stage. There are a few units in the field, but they are very expensive and out of the reach of most farmers. They have potential to cut back drastically on herbicide use by spot spraying low density weed infestations in fallows, or by inter-row spot spraying in row crops, using suitably shielded units.

In 1989 I became aware of the work of Geoff Furness (13) from South Australia who developed the concept of the 'bluff plate' boom spray. He proposed that rather than using air-generating units to propel droplets to the target, why not use the disturbed air from the forward motion of the boom to do the same job. No moving parts would be required.

The bluff plate sprayer is essentially a wedge shaped plate airfoil. It deflects oncoming air over the top of the plate, and a zone of stalled, tumbling air, which follows immediately behind the plate is dragged across the ground by the plate at the speed of the spray vehicle. The nozzles are located behind the bluff plate in the stalled air so that spray droplets are actively blown at the target. This increases the amount of spray deposited on the target, enables a finer droplet to be used, permits higher spraying speeds and reduces spray drift. However energy is required to displace the air mass, and both the boom and towing unit must have a good suspension to operate on farmland at relatively high speeds.



Principle of operation - bluff plate boom

A local engineer made up an 18m. unit in 1990, and this was successfully used for some years. Engineering students, under the supervision of Dr. Andrei Lozzi from the Dept. of Mechanical Engineering at the University of Sydney designed a later model that is more robust, yet lighter in construction (7). Further work by another student (1) has shown that even stronger, lighter units are possible. Furthermore, alternative airfoil shapes are available which will allow a superior, more robust unit to be designed.

Generally, the bluff plate principle has performed as expected, with much more development possible.

Sheep in No-tillage Farming

Some farmers have an additional weapon that can greatly assist in many parts of the no-tillage operation. For example on Livingston Farm we have had up to 5800 sheep. The main purpose of the sheep is for fallow weed control. In this role sheep can significantly replace herbicides as a method of weed control in the fallow. Sheep are introduced after harvest, and after each weed germination, and the field is ‘crash grazed’ for periods of 6 hours to 10 days. The aim is to heavily graze out all the weeds, remove the animals the day after the weeds are eaten, yet before they start to eat significant quantities of residue. Although many farmers dislike sheep in no-tillage farming systems, I consider that properly used, sheep can be very valuable. Sheep grazing of weeds became an integral part of integrated weed management. We successfully used this system on Livingston Farm from 1989 until 1998 and found it a highly profitable system.

Crop Species

Some of the no-tillage crops we have grown include:

- **Winter cereals**: wheat, barley, oats, triticale, rye corn.
- **Winter pulses**: chickpeas, faba beans, field peas, fenugreek
- **Summer cereals**: sorghum, corn
- **Oilseeds**: canola, linseed, safflower, soybeans
- **Summer pulses**: mung beans, peanuts, pigeon peas, cowpeas, tepary beans, dolichos lab lab.

- **Forages**: oats, forage sorghums.

Cotton has not been attempted due to the specialised requirements of the crop, and the proximity of Livingston Farm to the Moree urban area. However other district farmers are successfully no tilling this crop. We have not grown sunflowers either due to potential bird problems.

Advantages of No-tillage

Most of the reasons for going no-tillage are probably similar to the experience elsewhere in Australia and overseas. Both research results and our experience have shown significant benefits of no-tillage such as:

- Maximum residue retention has reduced run off and soil erosion. Instead of an erosive event annually, we only have one major runoff occurrence every 5-7 years. Erosion has reduced by 90% as per the results of Freebairn (12)
- Reduced evaporation has resulted in additional water storage. This has been expressed in improved crop yields.
- Organic matter and soil structure has been maintained and improved. There is less ponding of water on the soil surface after rainfall, and the soils are more trafficable in most weather conditions.
- Preservation of earthworms and mycorrhizal fungi has been assisted.
- Optimum planting time is longer. This has allowed a bigger area to be planted and we have been able to farm with less machinery and labour. In the last 18 years we have been able to plant practically all crops on time, giving significant yield increases.
- The chance and reliability of double cropping is increased. An extra crop can often be grown in wet years by sowing into the undisturbed residue a few days after harvest of the previous crop.
- Reduced tractor hours have meant less machinery repair costs and lower fuel use. At Livingston Farm, we have been able to reduce our major tractor units by one, and instead rent a tractor for a few weeks at the principal planting time.

However the process has not been without pain. It seems that every year since we first started, we have taken two steps forward, and one step back, as new problems have appeared. These have to be overcome or sidestepped before we can go forward again.

Ongoing Challenges

To obtain the greatest rewards from no-tillage agriculture we need to:

- Upgrade spraying skills of many farmers, along with knowledge and identification of weeds, herbicides and their action, and correct formulations of herbicides to do the best job.
- Reduce the shift to ‘harder to kill’ weeds including perennials, and weeds resistant to some herbicide groups.
- Continue development of resistant varieties and rotational strategies to control residue borne plant disease.
- Develop residue clearance of seed drills. Is there a unit which will handle wet soils, dry soils, heavy residue, sticky soils and obstacles and achieve a good result every time?
- Improve nitrogen application systems in no-tillage. How can we efficiently get the N near the plant, without sacrificing soil moisture and residue cover under a whole range of conditions?
- Manage field fauna such as mice, as they have habitat and food most of the year.
- Avoid the need for post harvest tillage for the control of over wintering pupae of some insects. Are there alternative ways?
- Convince urban dwellers and media people that no-tillage is environmentally friendly. If not, this may translate into pressure on farmers by way of regulation and other measures.

Where to from here?

Northern Australian farmers will continue to embrace no-tillage, despite existing challenges. I would estimate that currently around 50% of the cropland of NE Australia is farmed using conservation farming techniques and 15% is no tilled. As the price of fuel escalates, no-tillage farming will continue to expand.

New pesticides will be found as well as new uses for older products. Unfortunately some of the ‘old guard’ chemicals may disappear or be severely restricted and we must show the community that we are responsible users of pesticides in order to keep these products as part of our arsenal.

Seeder development will continue. New inventions and innovations by farmers, manufacturers, research workers, and the innovators of this world will result in better and more reliable seed drills.

Improved spraying technology will become more evident, with units being able to operate at higher speeds under a wider range of environmental conditions. Water rates will drop and airfoil booms, precision sprayers, and weed-sensing sprayers will be developed further. This will ultimately be translated into lower rates of pesticides being used.

Rotational strategies utilising pulse crops, bio-fumigation, pastures and grazing animals, alternate cereal types and oilseeds will become more important as a means of weed, insect, fertility, and disease control. If the current economic conditions prevail, I predict that pasture rotations will assume greater importance, as we may need to ‘grow our own nitrogen’ if the cost of fertiliser nitrogen continues to escalate.

Farmers will need to be smarter and more ‘switched on’ to handle no-tillage. The majority of grain growers in our area now employ consultants, or utilise local agri-business agronomists to assist in such things as pesticide strategies. As well as the farmer’s own spray rig, contractors are assuming a bigger role in the spraying operation.

Herbicide resistance will probably get worse if we do not start to address the problem now. Already we have some weeds resistant to some herbicide groups.

Pressure from some sections of the urban community will probably increase to reduce pesticide use. We must be responsible, and vigilant in accurately using pesticides so that all of the material is deposited on the target (be it weed, crop, or soil) and little or none is lost off target to drift away and cause problems elsewhere in the environment.

Vision for the Future

I envisage a future where no-tillage systems will dominate most of our broad scale farming operations and that no-tillage will be combined with a diversity of cropping and livestock production enterprises, carefully balanced in the long term to satisfy the economic and environmental requirements of the day.

Acknowledgments

Over my 40 years in grain production, I must acknowledge my many mentors and colleagues from all spheres of the industry. Over the years I have ‘picked the brains’ of contemporaries from NSW Agriculture, CSIRO, many Universities, Qld Dept. of Primary Industries, Qld Dept. of Natural Resources, agribusiness, private consultants, G.R.D.C, multinational pesticide and seed companies, agricultural machinery companies, and innovative farmers who have all willingly provided research data and information to assist in development and implementation of no-tillage systems on Livingston Farm.

I also acknowledge the forbearance and patience of staff at the University of Sydney, especially the Properties Office, my colleagues Prof. Frank Crofts and Prof. Lester Burgess, overseer Greg Ticehurst and the staff at Livingston Farm. Without their help the job could not have been done.

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