Challenges to agronomic science and practice

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When we talk about the future of agriculture in Australia and the place of agricultural science, our main theme must always be productivity; how to increase yield, how to intensify farming. Perhaps the Australian farmer is getting behind in productivity and perhaps the agricultural scientist is even letting the side down a bit. I want to discuss productivity by looking first at the past and then the future.

Productivity

Two examples illustrate the striking development that can occur within an industry.

My first example contrasts fruit growing at Tatura in Victoria in the early 1950's with a modern system.

The orchardist planted his trees at 5.5 m spacing, picked a small crop 5 years later and a full crop after 10 years. Each winter he pruned his vase shaped trees by hand, applied pest and disease sprays by hand, cultivated in spring to kill weeds and prepare for irrigation, set up a basin flooding system of irrigation around each tree, irrigated every 14 days, cultivating after each and setting up again, thinned excess fruit in early summer, then harvested by hand into boxes for market or processing.

Nowadays the modern innovative orchardist sets up a Tatura trellis, plants the trees close in the row and trains the trees onto the trellis so they rapidly develop a full canopy; he picks his first crop the next year. He selects modern fruit varieties that have few of the problems of the old. Before planting he deep ripe his soil for best drainage and irrigation and banks up the surface soil to the tree, prunes in winter. Each year he applies fertilizer and weedicide in spring, adds straw mulch and avoids cultivation to maintain soil structure and spray irrigates every few days. He applies a limited program of pesticides, integrating with biological control. He can prune and harvest by hand and these are made simple by the easy access to the trees; or he uses a machine for both.

This modern system requires much less labour than the old because of mechanization, is simple, cheap and attractive to manage, produces a quality product and yields up to eight times the old system.

My second example contrasts tomato growing in the 1960's in south eastern Australia. The grower produced seedlings in a frame, hand planted them, hand irrigated in short rows, cultivated for ***weed*** control between each irrigation, reconstructing channels and drains after ***each*** cultivation, hand weeded, hand sprayed or dusted for pests and diseases, hand spread fertilizers and hand picked into fruit cases several times as the fruit ripened. Because the soils could not tolerate the frequent cultivation and because diseases built up, the grower rented pasture land each year.

Nowadays the tomato grower can use the same land every year because all varieties are resistant to soil borne diseases and modern soil management methods maintain soil structure. The grower land—forms his farm with laser control to give long runs for easier irrigation, sowing, soil management and harvesting. Then each spring he cultivates, forms hills, applies pre-emergence weedicides, bands in fertilizer, and direct drills the seed, if necessary in one operation. Irrigation is now simple, and no cultivation nor hand weeding is required. The varieties that he sows are resistant to disease and rain damage, ripen at the one time for mechanical harvesting, are egg shaped for easy mechanical handling, shake off the bush easily, and are high in solids for a better product. The tomato grower now achieves very high yields - 100 t/ha has been achieved. Grown on a large area and with these high yields, the cost of production is low.

With the old system, Australian processing tomatoes were not even competitive with overseas production - California, Taiwan - on the Australian factory floor. But now overseas tomatoes pose no threat.

In both examples the farmer has used technology to increase crop yield, to increase labour productivity, to conserve his soil and so remain competitive in the market place.

But productivity is the most important issue - the output per unit input - because increasing this is the most important way that a farmer can keep his cost of production down. For example, gross margins increase greatly as yield increases as Table 1 shows, so that *each* additional tonne returns to the farmer many additional dollars. In fact, most agronomists are trying to find ways to increase yields whether by fertilizers, better varieties, soil management or disease control.

Table 1. Effect of Crop Yield on Gross Margin

Wheat		Sunflower		Potato	
Yield (t/ha)	GM ($/ha)	Yield (t/ha)	GM ($/ha)	Yield (t/ha)	GM ($/ha)
1.5	52	0.6	23	25	39
2.0	94	1.2	159	32	669
2.5	135	1.8	295	40	1389

N. Ward, Dept. Ag. S.A. 1984

However, we all know that higher yields lead to problems. Many farmers see higher yields causing over production and this forcing some farmers out of business, many feel threatened by new technology for other reasons. Politicians see votes lost. Conservationists relate increased productivity to plundering. Marketing people worry about how to sell the increased production. One answer is to get critics to realize that increased yield is essential for farmers to remain competitive and that they can do this without increased total production.

The other answer is to develop markets. Exporting represents a means of increasing national income, creating employment and raising living standards; it allows producers to operate at higher levels of output and thus more efficiently, achieving economies of scale, higher employment and better profits and encourages a more competitive attitude in industry. In a small economy like Australia's these features are so important that the exports of Australian agricultural products must continue to grow. However, Australia will develop new customers as Europe fades as an export market for agriculture and our trade grows in the West Pacific basin: Japan, China, Indonesia and the other nations in the area. This Western Pacific *area* is growing rapidly - for example, its Gross Domestic Product will pass that of North America early next century. These rapidly growing economies will need Australian agriculture and Australian agriculture will change to a considerable extent in order to meet these needs: more crop products such as rice, sorghum and perhaps special fruit and less animal products like meat, wool and dairy. The long term forecast could be for slow growth of non-export products such as dairy, poultry, pig meat, most fruit and vegetables, slow growth of some of our current exports including wool and wheat and more rapid growth of products required in the Western Pacific region, for either human consumption (eg., rice), animal feeding (eg., sorghum) or manufacturing (egg., oil seed). So Australia is fortunate to be located in a region with a very large population and whose economy is growing rapidly as its nations industrialize. Higher incomes in Asia will translate into greater demand for our agricultural products and this will bring about profound changes in our agriculture. In fact we shall face an escalating demand for our agricultural products and crops like soybeans and maize that produce at nowhere near their potential, will be properly exploited.

The significant thing about increasing our productivity is that there is plenty of room to do so. Compared to the beat production overseas our yields are low and compared to theoretical maxima our yields are very low. Table 2 gives overseas examples of rapid rates of increase of yields and compares these with low yields in Australia.

Table 2. U.S. Maize and U.K. Wheat Yields

	U.S. Maize (t/ha)	U.K. Wheat (t/ha)
1930	1.2	
1940	1.3	2.6
1950	2.0	2.8
1960	3.1	3.3
1970	4.9	3.9
1980	6.8	5.9
Best farm	11	12
Aust. Av.	2.0	1.5

Trends in research

If substantially increased productivity is the aim of agronomists in the future, we need to consider the likely avenues for achieving this.

Soil Improvement

In the past 50 years agricultural science has largely overcome plant nutritional difficulties. In the next 50 years we shall see equally important increases in productivity from improvements in the physical properties of soil, including drainage, compaction, poor water infiltration, permeability, water supply, hard setting surface soils, dense subsoils and crusting. The key to improving our soils is through increasing the biological activity in them - roots, earthworms and other animals and microorganisms. We shall break up the A horizons and many of our B horizons. We shall then improve them and sustain the improvement through biological activity. Less cultivation and compaction, more organic matter, slower soil drying, better drainage and higher soil nitrogen will be involved.

Whole Plant Physiology

The important issues here will be the rate of canopy development, designs for leaf arrangement, plant nutrition efficiency, flow of water through the soil-plant system, root/top interactions, control mechanisms including hormonal, and interactions between the plant and environment. These will lead to more precision in the management of the plant and especially to the design of new architectures for the plant top and the plant root.

Plant Improvement

Cains in productivity from plant improvement have been spectacular in the past and this will continue. We shall breed pasture lines for more specific environments, horticultural crops with a wider diversity and a continued improvement in the main grain crops especially those where no major effort has yet occurred, such as sorghum. All of these advances will be assisted more and more by genetic engineering, which will offer greater numbers, greater diversity and more precision. The enormous task of field testing will be assisted by industry and by better screening through improved understanding of the plant.

Peat and Disease Control

We shall see much more disease-free material available to farmers, breeders producing a wider range of disease resistant cultivars and an increase in biological control. Chemical control of pests and diseases will be better timed and applied from information that will predict outbreaks of, for instance, plague locusts, and stripe rust. We shall see more control of pests and diseases by integrated management such as 'eppre' in wheat and by a range of crop management techniques such as critical irrigation timing for powdery scab of potatoes. Genetic engineering will be an important tool in control.

Salinity

The threat of increasing salinity throughout Australia will be contolled by a variety of methods, depending on the local cause. Important will be drainage, using normal techniques such as tile lines and aquifer pumping. In areas were the cost of these measures is too high, salt tolerant varieties, reuse of ground waters and special techniques such as interceptor and mole drains will be used. But most important will be the control of water intake through vegetation and better irrigation practices, as we develop our understanding of the hydrology of our agricultural regions and match it to intake.

Irrigation

Most nations with irrigation are increasing the area irrigated. Australia's increase will be mainly in the north. In addition, irrigated agriculture will increase its productivity - current biomass production is about 10 t/ha whereas the potential is over 60. The gross value of product per ha in irrigated Victoria for example is $700 whilst in Israel it is $9000. Yield increases will be achieved through improving soils, cultivars that are better suited, more mechanization, larger farms, more valuable crops and more precision in water application especially from land forming and from timing. We shall see much more pressure-based irrigation, greater precision in amounts of water applied and more automation.

Continuous Cropping

Driving the 1500 km from Denver to Chicago in the U.S., where farmers crop practically every paddock, challenges us to ponder on continuous cropping in Australia. **As** the problems of water supply, soil structure and pest and disease are overcome continuous cropping, will become common.

Fodder

Pastures - we shall increase productivity by developing cultivars to suit particular environments, by developing ways to ensure a high seedling population and by improving soil fertility especially physical properties of the soil including better drainage, deeper rooting, deeper water penetration and less compaction.

Lucerne and other perennial fodders -we shall increase productivity through more suitable cultivars for particular locations, by soil amelioration and management and by improved harvesting techniques to increase protein as well as yield. We shall see a resurgence of lucerne production as these techniques are developed, because lucerne is so important as a source of protein and energy for animals.

Fodder crops - production will increase greatly in Australia as animal industries continue to intensify. Yields will increase through better varieties, a better understanding of crop physiology, and marked improvement in soil amelioration and soil management. The lower cost of production will induce farmers to grow more fodder at the expense of the less productive pastures. This has already happened in North America and Europe, with better machinery and rapidly improving yields.

Productivity on farms

It is vital for Australia to maintain its agricultural base and the challenge for our agronomists is to develop our science and technology to enable Australian agriculture to keep ahead of our competitors. And it goes without saying that when our farmers can compete in the world market place, the Australian consumer is buying food and fibre that is efficiently produced.

We shall see many changes in our industries during the next 30 years or so. Because productivity is so very important in keeping costs low, we can predict continued intensification of agriculture in Australia. We shall see shifts in the location of agricultural industries including more agriculture in northern Australia which has water, high radiation, suitable land and a developing infrastructure. There will be less pastoral agriculture in arid areas - for instance to the north and west of central New South Wales. There will be more cropping in the higher rainfall areas of southern Australia. We shall *see* shifts away from pastures towards crops because of the higher productivity from them. Livestock production will increase only slowly

whilst the value of crops will increase to well over three quarters of the total. We shall have substantial increases in rice, barley, sorghum, maize, oil seed, grain legumes and some horticulture. We shall see continued irrigation development, slowly in the south but remaining high in the north - wherever water, storage sites, suitable soil and access are available, irrigation will develop; supplementary irrigation will become more common. We shall see new markets as we focus more and more onto the Western Pacific nations and adapt our agriculture to suit the requirements of those markets. We shall see the market, especially the home market, demanding higher quality, higher nutritional value, a greater variety of product and year round supply. We shall develop methods of farming that prevent land degradation.

The other point to make about productivity on farms concerns our tradition of cheap farming in Australia - low input, low output - brought about by cheap land but expensive labour and capital. I suggest that this approach to agriculture is exploitative and that eventually it will be expensive farming. Our soils are continuing to acidify and one day we shall have to lime and this will cost a lot, our soils are continuing to become compacted and renovation will be expensive, we are continuing to salt up our land and this will cost a lot to repair, we are building up water tables especially in our irrigation areas and this will cost us, we are building up pests and diseases in some of our monocultures, we are destroying soil structure in much of our cropping belt and we are causing erosion.

A awing to higher productivity will be the only way that we shall be able to pay for the cost of sustaining our agriculture.

Agricultural science

All of this has considerable implications for our profession of agricultural science, because the profession will be deeply involved in most of the developments that I have been talking about. However, we shall need to really improve our act. I suggest that in the past our basic research has been too remote from farming, our applied research has consisted of narrow experiments, our extension concerned with farmers' day to day problems. In my travels, I still find research establishments where most research people are working independently of the others at the institute and I still find extension officers responding to the telephone.

I suggest that we need to shape agricultural industries. That is, decide on industries with promise, define the potential productivity on farms, set goals for farming productivity in a given region, then set up teams that involve research workers, extension workers and farmers. With clearly defined goals, good leadership and a range of relevant discipline specialists involved, whole industries can be lifted, like those in the two examples I gave at the start.

Agricultural scientists have a crucial role in the future development of Australian agriculture and the one vital ingredient that we need for success in our future task is confidence. Genneth Clark talks about confidence in his book "Civilization" and his comments relate well to our job: "civilization requires confidence — confidence in the society in which one lives, belief in its philosophy, belief in its laws and confidence in ones own mental powers. Vigour, energy, vitality: all the great civilizations have had a weight of energy behind them".