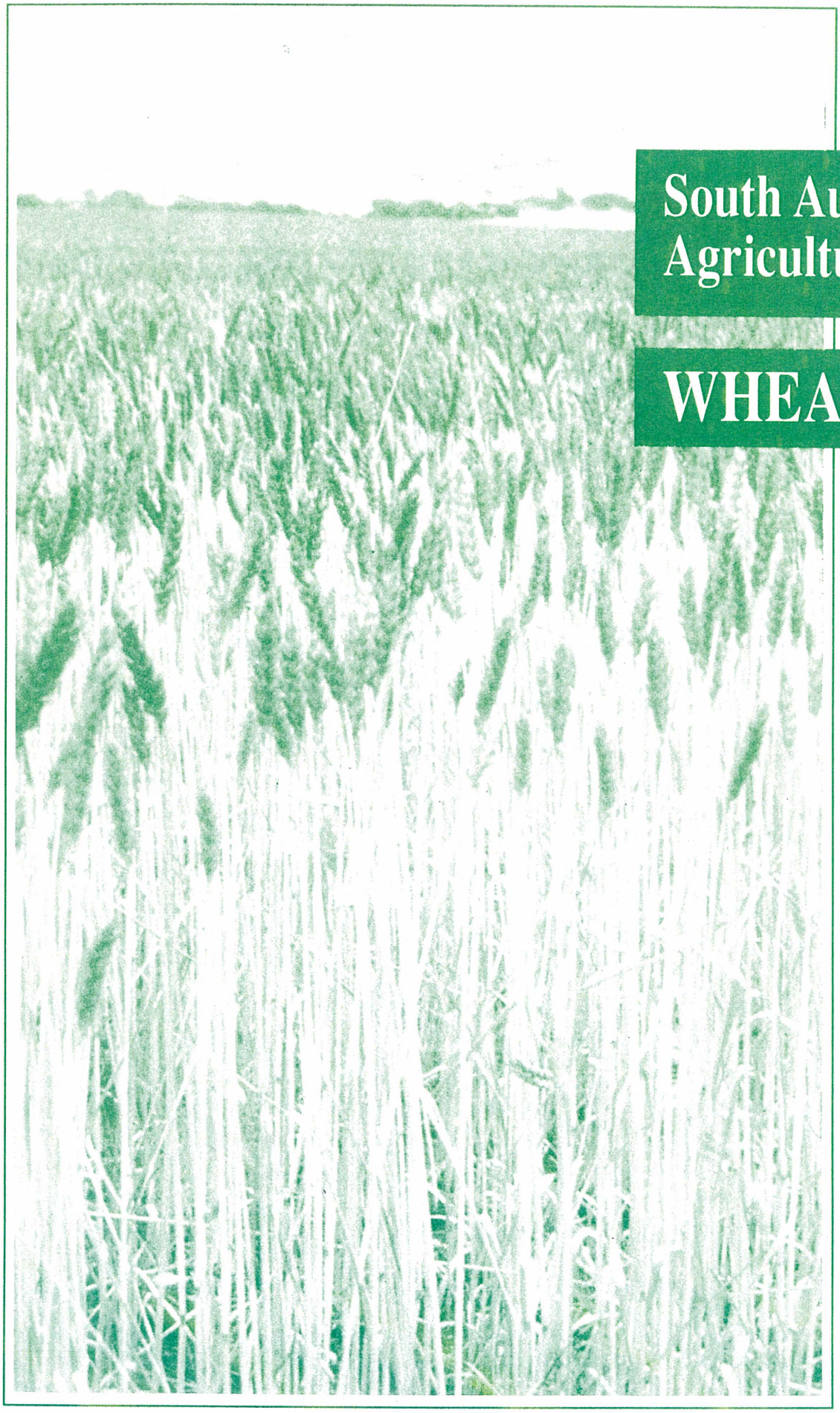
AGDEX 112/910

South Australian Agriculture

WHEAT



DEPARTMENT OF AGRICULTURE
SOUTH AUSTRALIA

January, 1992

PRESENT AND FUTURE DIRECTIONS OF THE SOUTH AUSTRALIAN WHEAT INDUSTRY

EDITED by A.J. DUBÉ and R.P. COOK

DEPARTMENT OF AGRICULTURE SOUTH AUSTRALIA

FOREWORD

This strategic plan is one of a series which has been developed for the principal South Australian agricultural industries and the services provided by the Department of Agriculture.

Agriculture contributes a greater proportion of returns to the State's economy than that of virtually any other state in Australia. It is therefore important to review the potential for the further development of agriculture in South Australia. These plans have been prepared by the staff of the Department of Agriculture in association with representatives of the respective agricultural industries and farmer organisations. The aim has been to identify the production potential and the market potential for the respective commodities and to thereby evaluate the opportunity which the state has to further develop its agricultural industries. At the same time, consideration has been given to identifying the most important issues to be addressed in the coming years to enable the state to achieve its maximum economic potential from agriculture. These plans will be valuable for determining the future provision of services to the rural community.

I should like to acknowledge the hard work and creative thought which both departmental staff and participants from industry and the farming community have put into the preparation of these plans.

John C. Radcliffe

(John C Radcliffe)
DIRECTOR-GENERAL OF AGRICULTURE

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WHEAT INDUSTRY

Wheat production is a major, agricultural industry in South Australia. It consistently earns valuable export income for the state and supports a range of manufacturing, marketing and agribusiness agencies. The cereal/sheep zone of South Australia comprises around 15% of the states' land area, being restricted to that area receiving between 250 and 500 mm of annual rainfall. About 95% of the area assigned to wheat is concentrated in the Eyre Peninsula, Yorke Peninsula, Lower North, Murraylands and Northern statistical divisions which produce about 93% of the states annual production. Management practices vary considerably within the wheat zone, being mainly a reflection of the soils, climate and the rotations practised. Grain yields and quality are overwhelmingly influenced by the seasonal conditions experienced (including a variable probability of drought) and the management practices employed. While farmers have learned to operate within their environmental constraints, the increased cropping frequency on farms in some areas has made some farmers more vulnerable to adverse seasonal conditions, diseases and to greater income variations. The profitability of wheat production in Australia has been in a precarious position for several years, being influenced both by falling and volatile market prices and increased costs of production.

PRODUCTION STATISTICS

Over the three years to 1988/89, the average gross value of wheat produced in South Australia was $309 million per year, representing 15% of the gross value of all agricultural production in this state. In 1988/89 Australia produced 1,374,000t of wheat but this figure has been as high as 2,843,000t in 1983/84. South Australia produces on average approximately 10% of the gross value of the total Australian wheat crop.

EXPORT MARKETS

About 80% of Australia's wheat production is sold on the world markets, and thus the viability of Australia's wheat industry is linked to world markets. The volume of wheat traded on international markets has increased, on average by 3.6% p.a. although significant variations occur from year to year. The USSR, China, Japan and Egypt account for nearly 50% of all world imports.

DOMESTIC MARKETS

About 20% of Australia's wheat production is used domestically as flour to manufacture various end products. The main processed wheat products are:-

1. bread - accounting for about half of the flour used in Australia
2. cakes, pastries and biscuits
3. starch and gluten - around 25% of the flour milled in Australia is used for the manufacture of these substances
4. pasta - use of Durum wheat
5. noodles.

INDUSTRY REGULATIONS

The Commonwealth Wheat Marketing Act 1989 established the Australian Wheat Board (AWB) and specifies its powers and functions. This regulatory statutory marketing authority is involved in the marketing and sale of wheat, the receival and payment regulations, some trade in other grain crops overseas and the development of trading organisations operating independently of the national pool system. The AWB also determines the criteria for payment to growers, and the level of the 'harvest advance'. These amounts previously were developed in coordination with the guaranteed minimum price determined by the Minister for Primary Industries and Energy.

All wheat growers are levied to provide funds for wheat research and the establishment of an industry fund. The research component must be at least 0.25% of farm gate wheat value and the wheat industry fund component must be at least 2%.

INDUSTRY POTENTIAL

There is a significant potential for increased production in South Australia.
It is estimated that 11.3 million hectares of South Australia is suitable for cropping to cereals. On present figures only some 27% of that potential area is currently used. The areas sown to wheat in South Australia has increased over the past 40 years with a major increase in the past 10 years. The last decade has seen a rate of increase which has averaged about 20,000 ha per annum. Wheat yields also fluctuate significantly with seasonal conditions and environmental changes. It has been suggested that yield increases of at least 50% are possible in some areas with better management. There also appears to be significant potential for improved quality of S.A. wheat, this includes:

1. physical quality - Australian wheat currently enjoys a good reputation but this must be maintained.
2. protein content - the average protein content of ASW wheat grown in South Australia has declined progressively since 1978.

BARRIERS, ISSUES, OPPORTUNITIES AND PROBLEMS

PRODUCTION CONSTRAINTS

A range of technical constraints limit production including detailed information on land degradation, fertiliser usage, disease control, lack of suitable machinery and limited knowledge on systems sustainability. The ineffective or variable control of weeds/insects and some diseases in rotations and also the declining fertility status of soils (especially N, P, Zn, Mn), are considered the most significant constraints to production presently.

CONSTRAINTS TO THE ADOPTION OF TECHNOLOGY

Many adoption constraints have been identified but can be summarised with the following:

- poor producer motivation and poor long term planning including inadequate use of business recording systems
- inadequate extension and advisory services
- inadequate availability of proper training courses for farmers and limited publications on wheat production technologies.

ECONOMIC CONSTRAINTS

ON FARM CONSTRAINTS

- continuing cost/price squeeze on farmers
- poor definition of costs and benefits of new technology
- lack of adequate decision support software to enable farm management decision making.

OFF FARM CONSTRAINTS

- high off-farm costs
- impact of overseas government policies - and volatility of global wheat production affecting export prices.

GRAIN QUALITY CONSTRAINTS

1. Production of low quality grain in some areas of South Australia.
2. Better definition of areas for growing wheat with specific quality characteristics.
3. Poor adoption of hygiene procedures for on farm storage of grain.
4. Poor grower confidence in the accuracy of AWB services for grain protein testing.

DEPARTMENT OF AGRICULTURE PROGRAMS

The table below shows the estimated cost, by source and function, of Department activities in the wheat industry, 1989/90.

ESTIMATED COST OF DEPARTMENT ACTIVITIES IN THE WHEAT INDUSTRY*, 1989/90.

	$M
Source	
State	2.877
Rural Industry Research Funds	1.334
Commonwealth	0.834
Deposit Accounts for payment of services rendered	0.316
	5.361
Function	
Research	1.364
Extension	1.267
Regulation	2.152
Diagnostic	0.080
Administration	0.395
Industry Development	0.103
	5.361

* Excludes costs of support from Research Station infrastructure and from the Economics Unit.

ACKNOWLEDGMENTS

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We also acknowledge the efforts of R. Cook in preparation, collation and some editing of the plan, Annette Hutson for typing and Peter Preece for computing.

INTRODUCTION

Wheat production is a major, agricultural industry in South Australia. It consistently earns valuable export income for the State and supports an important industry and a range of manufacturing marketing and agribusiness agencies.

During the review process which led to the development of this Strategic Plan, the recognised strengths and weaknesses of this vital industry were reviewed (Industry Statement (p.2) and Barriers To Achieving Industry Potential (p.26)). An assessment was also made of its potential for the coming decade (Industry Potential (p.21)).

The significant barriers to achieving this potential were identified, and prioritised by committees in the Department (Barriers To Achieving Industry Potential (p.26)).

Research and extension initiatives were then developed to achieve realisation of the long term potential of the wheat industry in S.A. (Objectives And Outcomes Of The Strategic Plan (p.30)). Within these new initiatives, opportunities exist for increasing collaborative research and extension programs between SADA, other research organisations, agribusiness, the AWB, and wheat producers.

The plan was developed in consultation with representatives from farmer groups and industry specialists.

INDUSTRY STATEMENT

Characteristics of the Wheat Zone

Climate, Soils, Land use and Management.

The cereal-sheep zone of South Australia comprises around 15% of the State's land area, being restricted to that area receiving between 250 and 500mm of annual rainfall. About 95% of the area sown to wheat is concentrated in the Eyre, Yorke and Lower North, Murray Lands and Northern Statistical Divisions which produce about 93% of the State's annual production (Table 1).

Table 1: Wheat Production in South Australia 1980-81 to 1989-90

Year	Area ('000 ha.)	Production ('000 tonnes)
1980-81	1445	1650
1981-82	1427	1695
1982-83	1398	692
1983-84	1564	2843
1984-85	1378	2031
1985-86	1432	1737
1986-87	1616	2255
1987-88	1556	1803
1988-89	1520	1361
1989-90	1605	2730
Average	1494	1880
1990-1991 *(a)*	1477	1951

(a) estimated by S.A. Department of Agriculture

Wheat is grown on a wide range of soil types in rotation with legume-grass pastures, grain legume crops, oil seeds and other cereals.

The soils of the S.A. wheat zone in their virgin state are predominantly old, weathered and naturally infertile. Their physical state and texture vary widely. The nutritional status of the soil profile is low by world standards and highly variable between soils. The sub soils are typically less fertile and can be structurally poorer than the surface

horizons. The surface soils are fragile due to excessive cultivation and often vulnerable to wind and water erosion.

Mixed enterprises dominate the S.A. cereal zone. Commodity diversification has been a feature of land use practised in the 1980's especially in the higher rainfall areas.

The rotations practised tend to be flexible (being related to forecast commodity prices) and vary appreciably both between and within regions. In the more favoured areas, more grain legume and cereal cash crops are grown, whereas in the lower rainfall areas, less intensive ley farming rotations are the most prevalent form of land use.

Management practices also vary considerably within the wheat zone, being mainly a reflection of the soils, climate and the rotations practiced. From the mid 1970's a discernible trend towards more intensive cropping occurred, together with a wider adoption of reduced tillage and trash retention systems for land preparation. The evolution of herbicide resistant weeds is a recently recognised phenomenon and followed the greater use of selective grass herbicides in the cereal zone. The distribution and impact of cereal diseases became widely recognised requiring changes in rotations and the use of disease resistant cultivars.

Fertiliser practices also altered during the 1980's. Imported high analysis NP (Nitrogen, Phosphorous) and P fertiliser products partially replaced the traditional use of single superphosphate. Little if any fertiliser was applied to pasture leys, which also became increasingly legume deficient.

Wheat quality varies appreciably with seasonal conditions, between regions and with farming practices and rotations.

Economics of Production

The average equity (i.e. the proportion of the farm business owned by the landholder) of cropping farmers in Australia is 82% compared with a 93% equity for graziers (Australian Bureau of Agricultural and Resource Economics (ABARE) survey data, 1989). The lower equity is indicative of the greater borrowings required for machinery and working capital used in cropping enterprises and a reflection of higher land prices paid.

While a range of production activities are undertaken on any farm in the cereal-sheep zone of S.A., the dominance of wheat as the most important crop is clearly shown in the 1987/88 financial profile of the accounts for an 'average' farm (Table 2).

Table 2: A financial profile of an "average" farm in the cereal/sheep zone of South Australia (1987/88)

ITEM	
Farm statistics	
Average farm area	1 370 ha
Wheat sown	425 ha
Sheep carried	878
Beef cattle carried	13
Area harvested	
- wheat	419 ha
- other grains	139 ha
Wheat harvested	431 t
Sheep sold	451
Beef cattle sold	6
Sheep and lambs shorn	931
Wool produced	4 478 kg
Income ($)	
Sales	
- wheat	65 880
- other crops	22 230
- sheep	10 490
- beef cattle	2 290
- other livestock	7 680
- wool	20 080
Off-farm share farming	4 420
Off-farm contracts	590
Other income	5 340
Total cash receipts	$ 139 000
Costs ($)	
Purchases	
- sheep	4 250
- beef cattle	230
Hired labour	730
Shearing and crutching	1 480
Materials (fuel, fertiliser, seed)	41 870
Services	20 540
Interest paid	10 440
Rent paid	920
Payment of share farmers	4 360
Total cash costs	$ 84 460
Farm cash operating surplus	$ 54 540

Source: Australian Bureau of Agricultural and Resource Economics (ABARE), 1989.

In any given year, financial returns derived from cereal farming are dominated by the yields attained, the market prices received and to some extent by the level of enterprise diversification that is possible. Grain yields and quality are overwhelmingly influenced by the seasonal conditions experienced (including a variable probability of drought) and the management practices employed. While farmers have learned to operate within their environmental constraints, the increased cropping frequency on farms in some areas has made some farmers more vulnerable to adverse seasonal conditions, diseases and to greater income variation.

The sensitivity of wheat returns to variations in yield and wheat prices is clearly evident in Table 3 for a wheat crop grown on Lower Eyre Peninsula.

Table 3: Effect of variations in grain yield and price on estimated gross margins for wheat grown on Lower Eyre Peninsula (1989-90).

Wheat Price on farm($A/t)	Yield (t/ha)						
	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	Gross Margin ($/ha)						
100	18	68	118	168	218	268	318
120	37	97	157	217	277	337	397
140	56	126	196	266	336	406	476
160	75	155	235	315	395	475	555
180	93	183	273	363	453	543	633
200	112	212	312	412	512	612	712

A typical gross margin estimate for wheat grown on Lower Eyre Peninsula is given in Table 4.

Table 4: An indication of a typical gross margin for a 1.5 t/ha wheat crop grown on Lower Eyre Peninsula (1989-90).

Income		$/ha
Average yield (net of C.B.H. tolls, levies and charges)	1.5t/ha @ $140/tonne	210.00
	TOTAL INCOME	$210.00
Expenses		$/ha
Seed	60 kg/ha @ $160/tonne	9.60
Fertiliser 19:13 Nitrogen:Phosphorous	70 kg/ha @ $344/tonne	24.08
Chemicals		
seed treatment		2.40
weed control		18.62
pest control		0.00
disease control		0.00
Fuel		8.94
Repairs oil & grease		8.85
Freight		
grain		8.83
fertiliser		0.35
Contract work		0.00
Insurance		2.55
	TOTAL EXPENSES	$84.22
	GROSS MARGIN per hectare	$125.78

The profitability of wheat production in Australia has been in a precarious position for several years, being conditioned both by falling and volatile market prices and increased costs of production paid by farmers (Figure 1). In 1990-1991 the AWB estimate of pool return before charges fell to $120/t compared with $195/t in 1989-90.

One factor of particular importance to wheat growers in South Australia is that wheat is exported from seven ports. While costs of transporting wheat from farms to terminal ports in SA are relatively low, shipping costs can be high with the need for two port loading as a result of shipping from a large number of shallow ports.

Although farmers' terms of trade (ie the ratio of prices received to prices paid) have been declining since the 1950's, the effects up until mid 1970's were offset by productivity gains in some regions, and especially since the 1960's by farm amalgamations leading to economies in the scale of operation. Crop diversification (especially grain legumes) during the 1980's has also minimised the terms of trade effect in the more favoured areas of SA.

The terms of trade for wheat have continued to deteriorate during the past five years (Figures 2a and 2b) and are clearly not matching rises in the consumer price index. Higher domestic interest rates payable since 1984 and higher exchange rates in the past year have exacerbated the financial plight of wheat farmers.

Figure 1

INDICES OF PRICES PAID FOR SELECTED INPUTS BY S.A. FARMERS (1985 - 90)

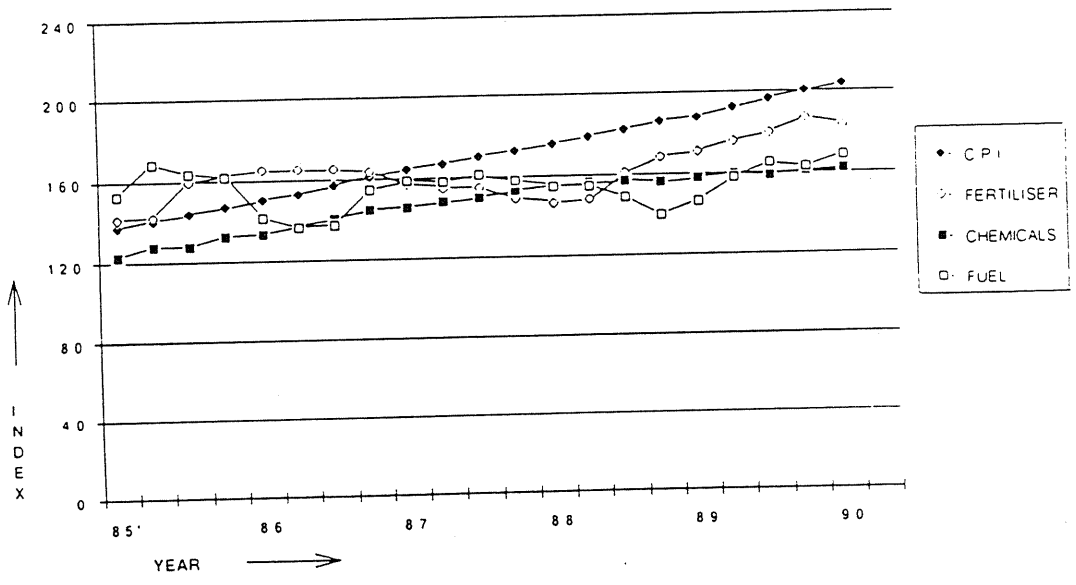


Figure 2a

INDICES OF PRICES PAID & PRICES RECEIVED BY S.A. FARMERS (1985 - 90)

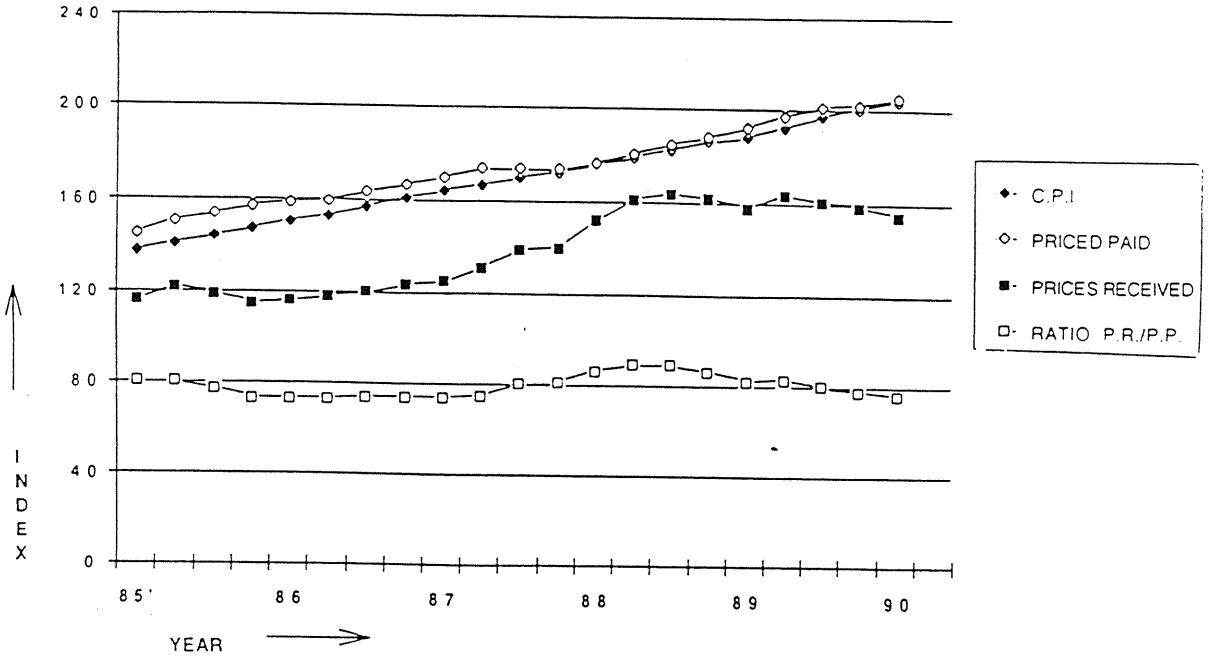
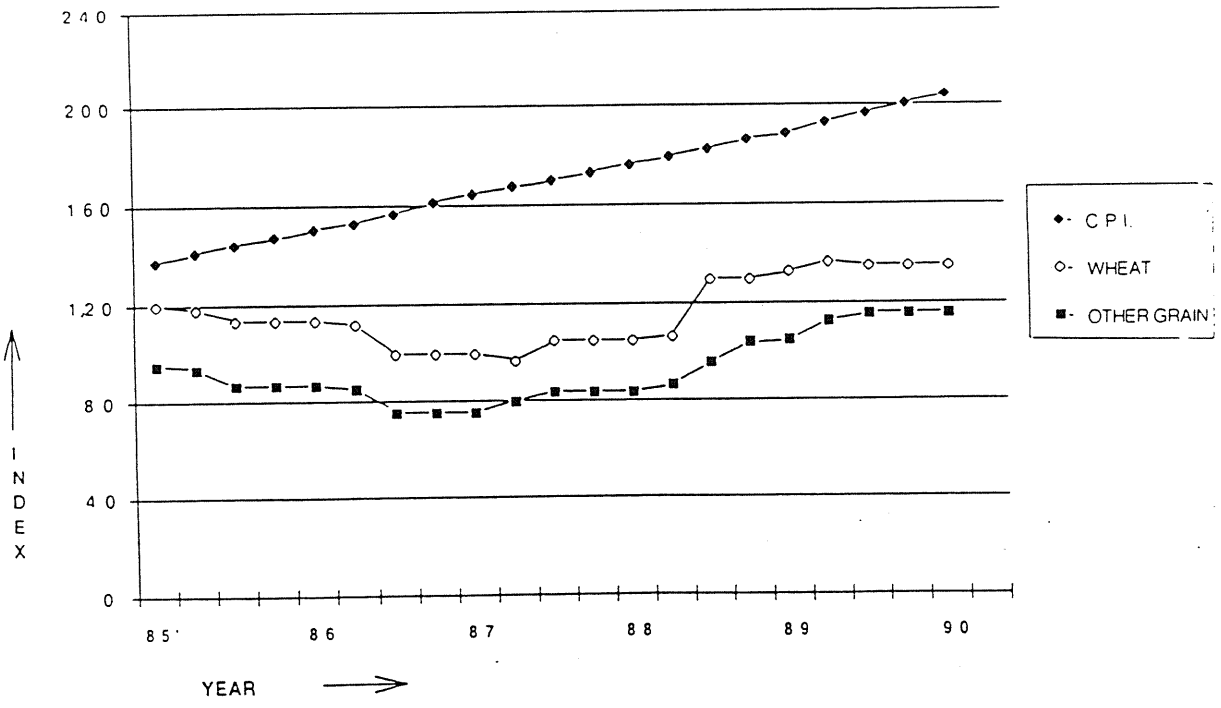


Figure 2b

INDICES OF PRICES RECEIVED FOR WHEAT & OTHER GRAIN BY S.A. FARMERS (1985 - 90)



Production Statistics

Wheat production plays a major role in the Australian and South Australian economies. Over the three years to 1988/89, the average gross value of wheat produced in S.A. was $309 million per year (Table 6, p13), representing 15% of the gross value of all agricultural production in this State. In 1988/89, S.A. produced 10% of the gross value of the total Australian wheat crop.

The total wheat production and average yields in S.A. fluctuates widely from year to year (Tables 1 and 5; Figures 3 and 4). Climatic conditions during each growing season have a dominant influence. Over the past 30 year period (shown in Table 5) the area sown to wheat has clearly increased slightly and average yields have tended to increase. However, in most seasons the average yield for S.A. has tended to be lower than the national average yield.

It needs to be borne in mind that these state averages conceal considerable variability across the State. While the State average yield has been relatively stable over the period shown, yields in some areas of the State have increased while others have decreased, as shown in Figure 5.

Figure 3

S.A. WHEAT PRODUCTION & AREA SOWN (1965 - 90)

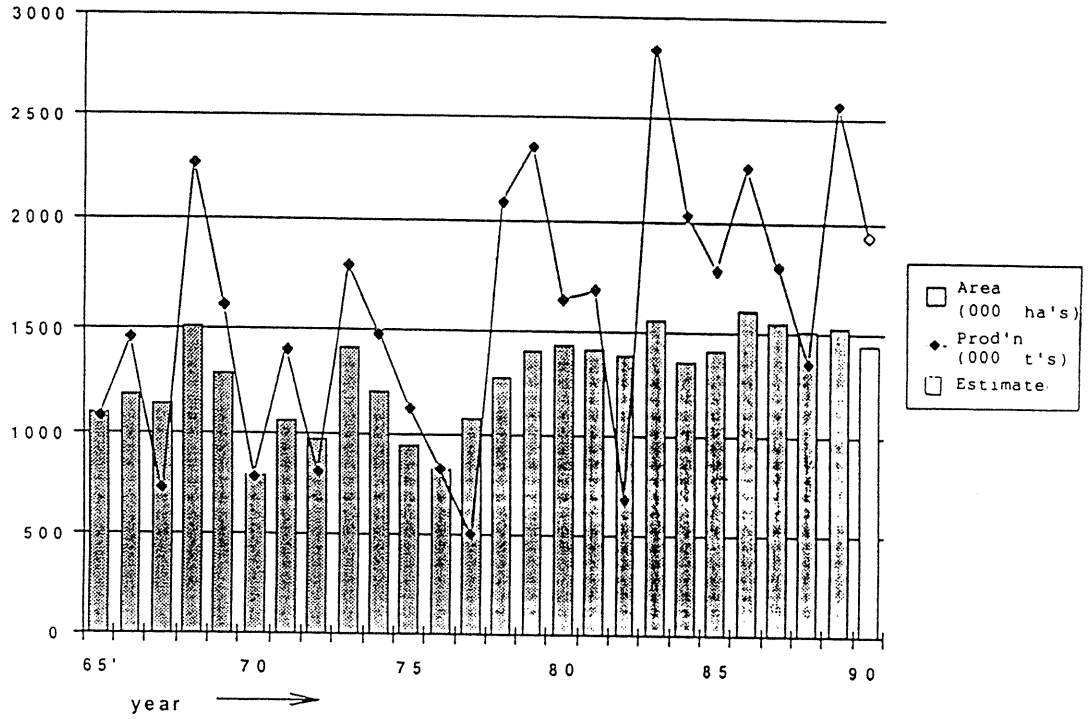


Figure 4

S.A. WHEAT YIELD & 5 YEAR AVERAGE YIELD (1965 - 90)

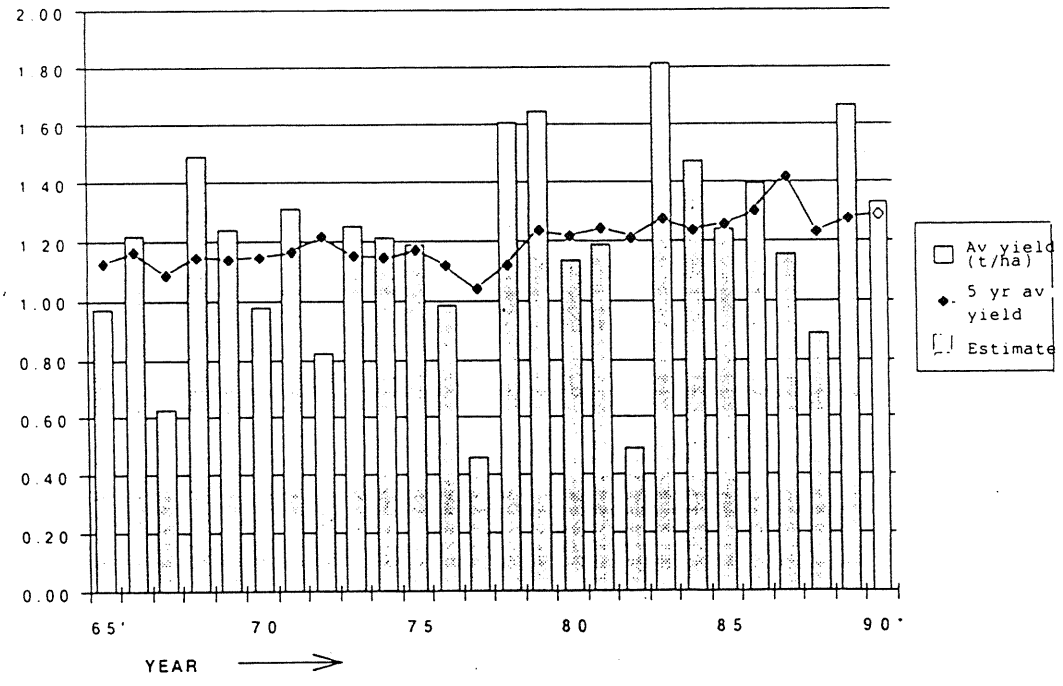


Table 5: National and State wheat production statistics

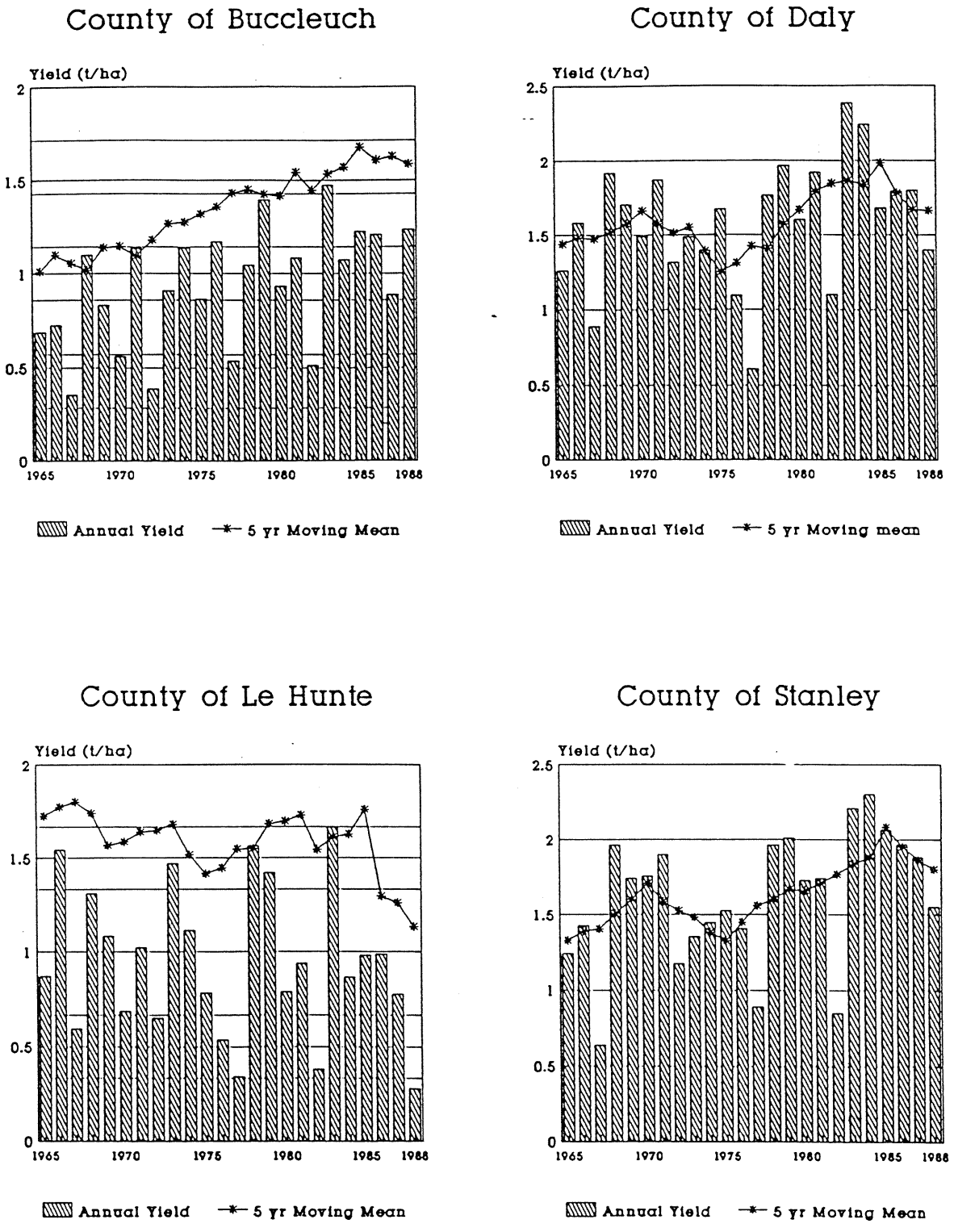
Season	Area '000 ha	Production '000 t	Gross Value ($mill)*	Yield (t/ha)	Australia average Yield (t/ha)
1959-60	627	325	16	0.52	1.10
1960-61	797	1 263	68	1.58	1.37
1961-62	902	922	51	1.02	1.13
1962-63	1 050	1 043	56	0.99	1.25
1963-64	1 134	1 469	78	1.30	1.34
1964-65	1 104	1 437	75	1.30	1.38
1965-66	1 111	1 088	60	0.98	1.01
1966-67	1 198	1 465	80	1.22	1.51
1967-68	1 159	737	42	0.63	0.83
1968-69	1 157	2 263	113	1.49	1.37
1969-70	1 299	1 610	82	1.24	1.11
1970-71	802	790	41	0.99	1.22
1971-72	1 069	1 407	76	1.32	1.19
1972-73	986	815	45	0.83	0.85
1973-74	1 432	1 795	196	1.25	1.34
1974-75	1 220	1 486	163	1.22	1.37
1975-76	958	1 139	118	1.19	1.40
1976-77	839	832	73	0.99	1.32
1977-78	1 090	511	50	0.47	0.94
1978-79	1 295	2 086	265	1.61	1.77
1979-80	1 424	2 349	357	1.65	1.45
1980-81	1 445	1 650	253	1.14	0.96
1981-82	1 427	1 695	269	1.19	1.38
1982-83	1 398	692	120	0.49	0.77
1983-84	1 564	2 843	466	1.82	1.70
1984-85	1 378	2 031	374	1.47	1.55
1985-86	1 443	1 944	302	1.31	1.37
1986-87	1 616	2 255	335	1.40	1.45
1987-88	1 556	1 803	304	1.12	1.38
1988-89	1 503	1 374	286	0.91	1.28

*in nominal values
Source: Australian Wheat Board, Australian Bureau of Statistics

Market Specifications for Wheat Quality

Quality specifications for wheat are essentially market attributes, which are becoming more stringent (both in the domestic and export market place).

Figure 5. Annual trends in the yield (t/ha) of wheat in four South Australian counties



A unique feature of the Australian wheat industry is that only white-grained varieties are grown and all receivals are classified using the same grading standards (see Appendix 1). The grades are segregated on variety, protein level and region of production which ensures that Australian wheats can be marketed on their quality specifications. These grades attract different prices (see Table 6).

Table 6: Post harvest payments by the Australian Wheat Board for different wheat classes.

Wheat classes	Post harvest payments ($/t) 1989-90
Prime Hard	183
Hard	178
ASW	171
General Purpose 1a	170
General Purpose 1b	165
General Purpose 2	153
Feed	142

During the past decade, on average, 76% of the wheat produced in S.A. was classed as ASW, and a further 21% as hard wheat. However, considerable variations occur in production of different grade wheats from year to year (Table 7).

Table 7: The percentage of different wheat classes produced in S.A. during the 1980's

Season	Australian Hard %	Australian Standard White %	Australian General Purpose %
1979-80	12.8	82.1	5.1
1980-81	24.8	71.6	3.4
1981-82	28.6	70.1	1.3
1982-83	40.1	58.4	1.5
1983-84	13.7	80.4	5.9
1984-85	22.2	74.5	3.3
1985-86	15.6	78.6	5.8
1986-87	10.7	86.4	2.9
1987-88	14.5	83.7	1.8
1988-89	23.2	73.9	2.9
Average	20.6	76.0	3.4

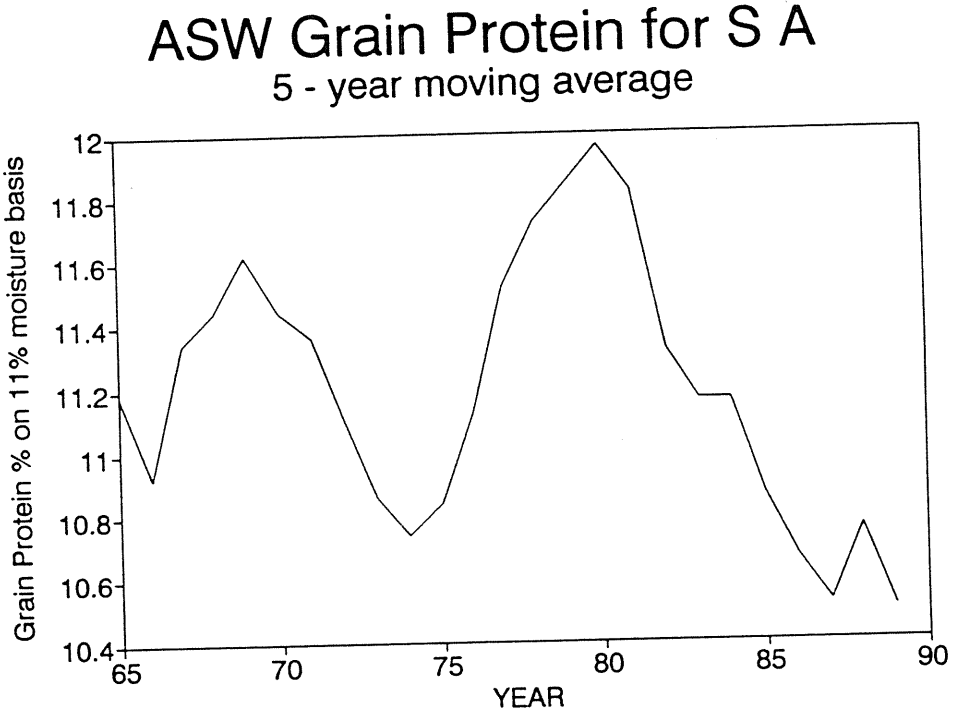
Three attributes of wheat quality are important to consumers: physical quality, protein levels and protein quality.

The physical characteristics of Australian wheats (their white colour, low moisture content and relative freedom from insects, diseases and admixtures) are highly regarded by domestic and overseas buyers.

Protein levels in ASW wheat are progressively falling in many regions of Australia (see Figure 6), but these trends have not been universally observed in all areas of the SA wheat zone. Climatic conditions (especially in spring) and management practices (resulting in low soil nitrogen status) dominate fluctuations in protein levels.

The recent decline in protein levels in ASW wheat has concerned the Australian Wheat Board (AWB) for several years, as overseas buyers are beginning to specify minimum protein levels in wheat. In 1989/90 the AWB introduced a small financial incentive as a signal to producers to increase protein levels.

Figure 6



Previously, all ASW wheat attracted the same price, irrespective of its protein level. Now, each 0.1 per cent of protein above the 10 per cent ASW benchmark attracts a premium of 20c/t and deficiencies are docked at 30c/t for each 0.1 per cent below 10 per cent. In 1989, 80% of the wheat was marketed on this basis.

Current Markets

Export Markets

About 80 per cent of Australia's wheat production is sold on world markets, and thus the viability of Australia's wheat industry is linked to world markets.

Table 8: The main buyers of Australia's wheat over the period 1980-81 to 1988-89 (in '000 tonnes).

1980-81	USSR	1 736	Egypt	1 612	China	1 153	Japan	913
1981-82	USSR	2 047	China	1 674	Egypt	1 577	Japan	821
1982-83	Egypt	1 507	USSR	1 004	Japan	933	China	759
1983-84	China	2 216	Egypt	1 904	Iran	1 873	USSR	1 805
1984-85	Egypt	2 430	USSR	1 805	Iran	1 368	China	1 365
1985-86	USSR	3 174	China	2 921	Egypt	2 298	Iran	1 077
1986-87	China	3 716	Iran	2 210	Egypt	2 172	USSR	1 292
1987-88	Egypt	1 774	Iran	1 749	Japan	1 035	China	1 007
1988-89	Egypt	1 995	China	1 591	Iran	1 488	Iraq	1 484

Over the last 20 years, international trade in wheat has represented about 14 per cent of total world production (see Appendices 2 and 3). The volume of wheat traded on international markets has increased, on average, by 3.6 per cent per annum, although significant variations occur from year to year. The USSR, China, Japan and Egypt account for nearly 50% of world imports (appendix 4).

Increases in the world population and per capita income levels have increased world demand for wheat. However, population and income growth in the 1980s have been much slower than in the 1970s. A number of other factors have also restrained demand growth in recent years. These include:

- balance of payments constraints;
- the grain production and consumption policies of major grain importing countries;
- year to year domestic production surpluses and shortfalls in key importing countries;
- reduced stockfeed demand, due to greater productivity in animal conversion and wider choice of substitute feeds.

A range of factors also influence world wheat production, which either encourage or constrain production. One significant factor has been the inflexibility in levels of domestic demand in developed exporting countries. This limits their ability to absorb marked changes in their own domestic production. Variable amounts available for export is the result.

Another factor is expanded production in the major exporting countries in response to

increases in world demand. In countries which subsidise production (e.g. USA and the European Community) there are impediments to reducing production when demand declines.

Domestic Markets

About 20% of Australia's wheat production is used domestically as flour to manufacture various end products (Table 9) and as feed.

Table 9: End products for wheat in Australia.

End use	Quantity (t)	% of total
Bread	539 839	47.4
Pastrycooks, etc	99 920	8.8
Biscuit manufacture	73 229	6.4
Pasta manufacture	35 189	3.1
Packeted flour	84 555	7.4
Food manufacturers	46 155	4.0
Starch/gluten industry	258 501	22.7
Brewing adjuncts, other industrial uses	2 109	0.2
Total	1 139 497	100.00
Export flour	60 567	
Grand total	1 200 064	

Processed Wheat Products.

Pan Bread

About half of the flour used in Australia is made into bread.
A flour of medium to high protein content (10.5 - 13.5%) is required for leavened breads. Such flours are obtained from wheats which are about 1% higher in protein (i.e. 11.5 - 14.5%). The wheat should be hard grained and free milling to give a high flour extraction and a moderate degree of starch damage.

Flat Bread (Arabic Breads)

Several types of traditional Arabic breads are produced, differing from one another in shape, size and flavour. Flours that appear to produce the best two layered Arabic breads are those milled from hard grained white wheats with an optimum wheat protein of between 10 - 12% and medium dough strength.

Steamed Bread

Dough for Chinese steamed bread is made from fermented wheat flour and the product is cooked in a steamer above boiling water. There are two major styles of steamed bread in China. The style preferred in Northern China has a chewy and dense texture whilst that preferred in Southern China has a more open and softer texture. Initial research suggests that flour derived from Australian wheat cultivars with medium protein content (10 - 12%) and medium dough strength are most appropriate for steamed bread.

Cakes, Pastries and Biscuits

Cake flour is generally milled from soft, lower protein wheats or separated from certain fractions of high protein wheats during milling. A flour of small uniform particle size is important to produce cakes of fine, even crumb and tenderness.

Flours of medium strength and protein content are required for flaky and puff-pastry and pie bottoms, whereas weak dough qualities are required for short crust pastry.

The term 'biscuits' covers a wide range of products, but basically they can be subdivided into two broad categories - crackers and cookies.
Crackers are dry, unsweetened, wafer-type biscuits produced from a medium strength, yeasted dough, produced from ASW wheat of about 11% protein content.
Cookies are sweet biscuits produced from soft wheats of low protein content.

Starch and Gluten

Of the two products, gluten is the more valuable. However, price fluctuations frequently determine which is of greater commercial importance. Most manufacturers seek a high protein wheat (12 - 14.5%) as a starting material and would prefer a soft-textured grain, if it were available, in order to reduce losses of starch through milling damage. Such wheats are difficult to obtain in commercial quantities. Manufacturers who are seeking to optimise the yield and quality of the protein product use prime hard varieties having strong extensible gluten. Other manufacturers, more concerned with the quality of the starch product use softer wheats of lower protein content.

Pasta

Durum wheat is preferred for pasta production because of its colour, hardness and the granular texture of the semolina produced on milling. Supplies have been limited and considerable quantities of pasta goods manufactured in Australia have been made from bread wheats. Semolina (coarse, gritty) prepared from such wheats lack the bright, clear-yellow colour preferred by traditional pasta customers and tend to impart a pale grey colour to the finished goods.

A minimum of 12% protein in the semolina is necessary to make pasta products which remain firm on cooking.

Noodles

Many different types of noodle products are consumed in Japan, China and South-East Asia.

Australian wheats are favoured for noodle production because of the proximity of supply, and also because, being white, they give a good colour to the product. They are also clean, sound and dry, free from excessive enzyme activity, moulds or bacteria and have excellent milling properties. This grain yields flours with a desirable balance between starch damage and dough strength required for noodle processing. Flours with a high starch paste viscosity (measured with the Amylograph) are preferred for production of noodles because a strong gel is required on boiling.

Yellow pigments in Australian wheats are an advantage for production of noodles for S.E. Asia.

For each type of noodle there is an optimum protein level and starch properties required to produce the desired elasticity and firmness in the boiled product. For Japanese style noodles (Udon), for example, a 9.5% protein flour is used. For the best Chinese style raw noodles, the flour should contain around 12% protein. Higher protein levels produce a better eating quality noodle, however, this has to be balanced against a deterioration in colour. Some compromise in these two quality factors has to be accepted.

Industry Regulations

Australian Wheat Board

The Commonwealth Wheat Marketing Act (1989) established the AWB and specifies its powers and functions. Complementary State Legislation (the South Australian Wheat Marketing Act, 1989) gives the Board power to trade within South Australia. The major powers and functions of the Board are to:

- market and sell all wheat destined for export.
- receive wheat direct from farmers. All wheat used in Australia can be traded freely, either through the AWB or sold directly to domestic buyers (millers, stock feed manufacturers, grain traders).
- trade in other grain crops produced in Australia and overseas. The AWB can seek wheat related joint ventures and value added services.
- establish separate trading organisations (where appropriate) which operate independently of the pool system.

The AWB also determines the criteria for each wheat pool, and the level of advance payment to be made to wheatgrowers, which previously were linked to the Guaranteed

Minimum Price determined by the Minister for Primary Industries and Energy. This change gives the AWB greater flexibility, particularly the opportunity to establish pools which more closely match market requirements and to operate more than one pool in a season.

The Government guarantees AWB borrowing (at a level in 1989/90 of 90 per cent of the estimated aggregate Net Pool Return to be phased down to 80 per cent over five years). This enables the AWB to make advance payments for pool deliveries and to achieve even better commercial rates on its borrowings than would otherwise be available.

Wheat Industry Fund and Levy

All wheatgrowers are levied to provide funds for wheat research and the establishment of an industry fund. Before the commencement of each season the Grains Council of Australia determines the size of the levy. However, the research component must be at least 0.25% of farm gate wheat value and the wheat industry fund component must be at least 2%.

Storage, Handling and Transport

The AWB must use the most cost effective method for moving wheat from the point of delivery to the point of sale. In South Australia, the Bulk Handling of Grain Act established the SA Cooperative Bulk Handling Ltd to be the receiver of bulk grain in this State. There is to be a Government review of the Bulk Handling of Grain Act to examine its appropriateness in the current environment favouring deregulation.

Level of industry assistance

Many government policies combine to determine the overall assistance provided to the wheat industry. Some, such as tariffs and taxes on inputs, apply to many industries. The wheat marketing arrangements are specific to the wheat industry.

The Wheat Industry has minimal government assistance. Over the last two decades the annual effective rate of assistance received by the wheat industry has varied from -9 to 11 percent, averaging 5%, which is low compared with other industries.

With the introduction of the Wheat Marketing Act, 1989, the wheat industry lost the underwriting provisions of the earlier Act. In 1986-87 those underwriting provisions were triggered, with the wheat industry receiving Government payments of $220 million. The industry also lost the provision in the new Act to administer the domestic wheat price.

Under the new marketing arrangements, effective rates of assistance to the wheat industry are likely to be less than 5%.

Assistance to manufacturing industry by tariffs and other mechanisms imposes considerable costs on the agricultural sector by increasing costs of imported inputs and maintaining the Australian exchange rate at a higher level than would otherwise be the case. One study has shown the cost to farmers of this assistance is around $3 000 per farm per year.

The Department of Agriculture's role in the wheat industry

The S.A. Department of Agriculture has extensive roles in research, extension, regulation and policy issues relating the wheat industry. The Department also advises the Minister of Agriculture in matters relevant to the industry.

The Department plays a major role in the Advisory Committee on Wheat Quality and a member of the Department is on the state committee of Grains Research and Development Corporation. It has long established links with the major national and state research and teaching institutes and with the AWB and agribusiness. Its staff participates in the activities of the Australian Grain Institute.

Through the Standing Committee on Agriculture the Department makes inputs into policy decisions affecting the Australian wheat industry.

INDUSTRY POTENTIAL

Potential for Increased Production

It is estimated that 11.3 million ha of S.A. is suitable for cropping to cereals. The total area cropped to cereals and other crops over the past 5 years has been at record levels, 2.85 - 3.03 million ha while the wheat area has been second only to that recorded in 1930-31 (1.69 million ha) Wheat's share of total state cereal production will depend largely on the relative profitability of wheat production compared with that of other crops.

The area sown to wheat in South Australia has increased over the past 40 years with a major increase in the past 10 years. The average area sown during the 1980's was more than twice that of the 1950's and at least 30% more than was sown in both the 1960's and 1970's. Within the past 10 years the rate of increase has averaged about 20,000 ha/annum and between season variation in area sown has been much less than in the previous 20 years.

Wheat yields fluctuate widely with seasonal conditions and 65% of this variability is associated with rainfall in the April-October period. Yields also vary within and between districts and within and between individual paddocks on the same farm.

Sub-optimal production can be related to deficiencies and inefficiencies in farming practices and to site specific factors. Net crop income is related to these issues, to fluctuations in wheat prices and to on- and off-farm costs.

On a state-wide basis wheat yields can be increased significantly over that currently being achieved.

Surveys by French and Schultz and Wegener suggest yield increases of at least 50% could be possible in some areas. The greatest potential for increase exists in the more favoured areas of the cereal zone.

Over the past 20 years total wheat production in S.A. ranged from 0.51 million t in 1977/78 to 2.84 million t in 1983/84 and yields varied from 0.47 t/ha in 1977/78 to 1.82 t/ha in 1983/84.

Other crops particularly barley, grain legumes, oil seeds and grazing enterprises compete directly with wheat. With the current financial pressures more intensive cropping programs have evolved particularly as the gross margins for cash crops and especially wheat were higher than those for wool. The recent fall in wool prices will almost certainly accentuate this trend. In many cases, particularly in the longer term, there is concern that some of these intensive rotations will not prove to be sustainable although the use of reduced tillage and stubble retention systems and more regular use of nitrogen fertiliser could slow any degradation of the soil resource.

If wheat prices were to remain at 1989-90 levels then there is the potential for the wheat area in South Australia to slowly trend upwards to possibly 1.8 million hectares by the year 2000 with average annual production reaching 2.5 million tonnes. However in view of prices being offered in early 1991 any such increase is unlikely and it is doubtful at least in the short to medium term that the area sown will exceed 1.5 million hectares. Any reductions in area are more likely to be in marginal areas.

Potential for Improved Quality

Several facets of wheat quality are important. These include :

(1) **Physical Quality**
Australian wheat enjoys a good reputation overseas. These high standards must not be relaxed and need to be monitored continuously.

(2) **Protein Content**
The average protein content of ASW wheat grown in S.A. has declined progressively since 1978 even though seasonal conditions dominate the variations observed e.g. 14.0% in 1977/78 and 9.5% in 1989/90. However, the falling protein trends have not been observed universally across S.A. There is a negative correlation between yield and protein content and it is evident that grain protein level is a manifestation of soil nitrogen stress.

Many overseas customers are now specifying minimum protein levels in wheat and in 1989 the AWB introduced a sliding scale of payments for protein levels between 8% and 14%. However, it appears that these premiums will be not sufficient to induce wheat growers to strive for higher protein levels as many farmers have an erroneous belief that this must lead to lower yields. The AWB has, however, indicated that the premiums offered accurately reflect market signals.

Given the current financial situation it is likely that many farmers in the short to medium term at least will aim to crop more intensively and seek higher productivity irrespective of wheat protein levels. However in areas where current protein levels are low, increases in both yield and protein content can be expected through increased soil nitrogen levels.

(3) **Protein Quality**
This is mostly an inherent characteristic of the wheat variety. It is the basic reason why different varieties are more suited for different end products such as bread, noodles or biscuits. A range of factors including grain hardness, dough properties and milling performance are important parameters which can only be determined accurately by extensive laboratory testing. Improved protein quality through breeding is achieved by selecting parents with suitable 'quality characteristics'. On-going research indicates that both and high and low molecular weight glutenin sub-units affect both dough strength and extensibility. The correct balance of these proteins is required for each end

product. Continued research on S.A. varieties is necessary to further understand the relationships between the various band patterns and dough properties. This involves both breeders and cereal chemists.

Opportunities for Market Development

National

Over 80% of the wheat produced in S.A. is exported and because of this we need to be aware of the requirements of those markets particularly in relation to quantity and quality of protein. The majority of S.A. wheat is received into the ASW category and is sold to a range of consumers ranging from the more price conscious to the more discriminating markets. The freight disadvantage of S.A. relative to some other states needs to be recognised.

Commercially, the amount and the continuity of supply of special wheat types together with the increased costs incurred in segregation, storage and shipping are very important considerations. The corporate plan of the AWB specifies the development of niche markets as an objective of the Board.

The mainstream wheat type produced in S.A. (hard-grained ASW of 10.5% - 11.5% protein) has found a market in the Middle East but other niches for other wheat types should be examined.

International

Over the second half of the 1980's, world wheat production averaged 515 million tonnes, and the world wheat trade 94 million tonnes.

The share of world wheat trade held by principal exporters is:

United States	36%
Canada	19%
European Community	16%
Australia	14%
Rest of World	15%

While Australia is a significant exporter, it is a "price taker" on international markets. World prices are distorted by production and export subsidies used in the United States and Europe, hence Australia is disadvantaged because of its "price-taker" position in the international market place.

The Australian Wheat Board is the sole exporter of Australian wheat, a status conferred by the Commonwealth Wheat Marketing Act, 1989.

South Australian exports of wheat by class in 1989-90 were ('000 tonnes):

Australian Prime Hard	-
Australian Hard	185
Australian Standard White	1972
Australian General Purpose	-

Soft Wheat

South Australian demand for low-protein soft wheat for biscuit-making is relatively static at around 5000-8000 tonnes a year.

Export markets for east-coast Australian soft wheats are limited. The AWB has reported a preference for the quality characteristics of Western Australian soft wheats.

However, opportunities for South Australia existed last season for exports of between 3000-10,000 tonnes of soft wheat, predominantly the variety Tatiara, to countries such as New Zealand.

There is also the potential to segregate high protein soft wheats (Rosella type wheat).

Organic Wheat

Currently this style of wheat in South Australia is produced in small quantities throughout the wheat-belt.

The AWB has reported that the domestic market for organic wheat is about 8000-10,000 tonnes and there is some possibility of developing an export market to Europe. Quality of export wheat is critical and high protein, around 13 per cent, is required. Returns last year were in the range of $140 - $170 per tonne. There is a classification process that growers need to satisfy before their wheat can be accepted as organic.

The export demand for organic wheat predominantly lies with Europe where the market is estimated to be 50-60,000 tonnes a year.

Europe currently produces 40,000-50,000 tonnes of organically grown wheat a year. The main exporters to the EC are Canada, the USA and Hungary. These are mainly containerised shipments of high protein (more than 13 per cent protein) used to improve the quality of the EC product.

Australia has the potential to satisfy some of the demand with 13 per cent protein wheat. However high shipping costs associated with small consignments (containers) and the current levy system in Europe makes Australian wheat expensive to EC buyers.

Japan has the potential to become an importer with its expected increase in demand for organic produce. Queensland is likely to be the preferred source for commercial reasons.

Prime Hard

The AWB advises that any push to develop prime hard quality wheats in S.A. needs to be tempered with some commercial realities:-

- There is only one major market for Prime Hard - Japan
- The market, for logistical reasons, prefers to source wheats out of WA, QLD or NSW because of the freight advantage.
- Even if Prime Hard wheats were developed a major effort would be required to convince the customer that the wheats were acceptable.

A small quantity of wheat possibly could be sold into the Middle East, however mills in this region are currently receiving Australian Hard (AH 13%) and may be reluctant to pay Prime Hard prices for what may not be significantly superior to AH 13%.

Hard

South Australia exported around 185,000 tonnes in 1989-90, representing some 10% of S.A. exports. There would appear to be scope for further market development in this area, especially throughout the Middle East.

Development of these niche markets would require continued effort and commitment and in some cases financial incentives but should be advanced slowly with due consideration given to longer term implications.

Durum

The AWB sees some scope for development of durum wheats for the domestic market given that there are major national processors such as San Remo based in Adelaide. With respect to the overseas market, however, the AWB believes there is very limited scope for development of markets given the strength of competition from other major producers. Even so, competition is severe for all wheat markets, and that fact should not preclude efforts to develop durum wheat markets.

Opportunities for processing

Studies by the AWB into a number of wheat based processed foods have indicated marginal commercial viability with only relatively low tonnages of wheat (< 20,000 tonnes per annum). The most obvious product is noodles.

The AWB has studied closely a number of potential markets. Because of the premiums imposed on imported wheat the Japanese market is one which offers opportunities with respect to lower raw material costs. However, the freight cost and import duty negate any advantages that accrue from manufacturing in Australia. Analysis of the commercial viability of such a project show an unacceptable return on investment.

There are a number of opportunities for manufacturing noodles in Australia and exporting them into the Asian region. It should be noted however that tonnages are relatively minor. The establishment cost of a noodle plant with an annual output of 5,000 tonnes is around A/$3 - 4 million.

Joint venture conditions with a company based within the importing country is another possible procedure.

Greater evaluation of S.A. varieties is needed to determine their suitability for the various end products. This may involve travel to the appropriate country to obtain the expertise or bring suitably qualified end product researchers into South Australia.

BARRIERS TO ACHIEVING INDUSTRY POTENTIAL

The barriers listed below are in order of priority as determined by the Wheat Commodity Committee. The relative importance of the barriers vary between wheat growing districts. Constraints identified by the 1987 District Needs Analysis (Appendix 5) are included in this list.

Production Constraints

1. Ineffective or variable control of weeds, insects and some crop diseases in rotations.
2. Low, variable and declining fertility status of cereal soils (especially N, P, Zn and Mn), including the infertile status of subsoils.
3. Limited knowledge on the sustainability and profitability of rotation sequences for different soils and climatic zones.
4. Ineffective utilisation of proven farming practices for maximising water use efficiency and financial returns from growing wheat.
5. Inefficient fertiliser practices in relation to timing, placement, rate and type of fertiliser used, the irregular use of soil and plant testing, and the effect of the nutritional status of sown seed.
6. Adaption to climatic conditions affecting productivity and farm incomes.
7. Inadequate collection and use of data bases and survey information to identify productivity constraints.
8. Limited or variable knowledge on the chemical and physical stability of soil resources for evolving tillage systems, rotations and crop husbandry practices.
9. Need for development of farm machinery (seeders, spray applicators, tillage equipment) for evolving farming systems.
10. Inadequate knowledge on the long and short term impact of herbicide use in rotations in relation to weed and disease populations and to the nutritional status of crops and productivity.
11. Imprecise knowledge on the suitability of wheat genotypes for specific soils and climatic zones.
12. Potential problems of soil compaction where intensive cropping is practised on some soils.

Economic and Marketing Constraints

On-farm Constraints

1. Poor definition of the costs, benefits, returns and risks associated with tillage systems, methods of handling stubbles, and with growing legume-based pastures, grain legumes and other cereals in rotation with wheat. Poor knowledge of the use of hedging mechanisms such as wheat future markets.
2. High investment cost in farm machinery, high interest rates, high land prices.

3. Declining terms of trade for wheat production.
4. Variable yield and price expectations both within and between seasons.
5. High land prices.
6. Lack of decision support models to enable *within-season* adjustments to be made to farming practices to optimise returns in different seasons.
7. Poor access to commodity prices to enhance flexibility in planning farm rotations and diversifying farm income.
8. Lack of an economic planning model for sustainable farming systems for different environments.
9. Poor definition of gross margins for different rotation sequences. Poor access to gross margins for wheat compared to other enterprises.

Off-farm Constraints

1. High off-farm costs.
2. Impact of foreign government policies.
3. Volatility of global wheat production and demand affecting export prices.

Grain Quality Constraints

1. Production of low protein grain in some areas of South Australia.
2. Better definition of areas for growing wheat with specific quality characteristics.
3. Poor adoption of hygiene procedures for on-farm storage of grain.
4. Poor grower confidence in the accuracy of the AWB service for grain protein testing.
5. Poor quality pastures.

Constraints to the Adoption of Technology

1. Inadequate use of business recording systems often resulting in poor forward planning of farm businesses.
2. Poor educational status of farmers. Lack of effective extension operation.
3. Poor long term planning of rotation sequences and farming practices which leads to inflexible reactions to forecast changes in commodity prices.
4. Few opportunities for post graduate/specialist training of extension and agribusiness staff. Inadequate succession planning for extension services.
5. Poor motivation for some producers to change their farming systems and to initiate farm improvements.
6. Inadequate availability of formal training courses for farmers.
7. Infrequent and irregular use of existing services by producers to integrate and adjust their farming inputs and decisions.
8. Limited or irregular use of formal surveys to identify constraints facing wheat producers in different regions.
9. No specialist farm management economist to evaluate research data, to monitor wheat prices and to assess economic risks associated with adopting new technology.

10. Lack of decision support software to integrate and aid decision processes on farms.
11. Limited publications on wheat production technology.
12. Limited opportunities for extension staff to attend national conferences and workshops.

Constraints for Value Added Products

1. Limited economical opportunities appear to exist for wheat based processed foods. Small numbers of large manufacturers dominate the breakfast and snack food markets.
2. Limited market potential for 'organically produced' products.
3. Freight costs and import duties especially in Japan for manufactured noodles.
4. High costs of establishing manufacturing plants.

OBJECTIVES AND OUTCOMES FOR THE WHEAT INDUSTRY

Rural Industry Research and Extension Objectives

Under the Rural Industries Research Act, 1985, wheat research, extension and marketing projects were funded by the Wheat Research Council (WRC, funding ventures of national significance) and the Wheat Research Committee for S.A. (WRCSA, funding projects of specific importance to S.A.). This dual structure recognised the wide diversity of environments within the wheat zone of Australia.

Funding was provided from grower levies and matched by Commonwealth Government grants. In S.A., an additional, voluntary levy was introduced in 1983 (Amendments to the Wheat Marketing Act) to increase the level of funding available for S.A. projects. Historically, both the WRC and the WRCSA have funded other projects (e.g. oats, pasture and grain legume research) closely linked to the wheat industry.

The Grains Research and Development Corporation (GRDC) will commence from October 1, 1990. This corporation will develop a new infrastructure for Wheat Research and Development. In the interim the corporation has invited the Wheat Research Committee for S.A. and Wheat Research Council to continue. It is likely that a parallel Grains R&D Committee will be established in the future in S.A. to fund cereal projects of importance to S.A. and provide regional advice to the nationally focussed GRDC.

Because the GRDC is in its infancy, and has yet to develop its objectives and strategies, initially it will probably be guided to some extent by the five year development plans of the WRC (1989-1994) and the WRCSA (1986-1991). See Appendices 6 and 7.

Existing Department of Agriculture Programs

The table below shows the estimated cost, by source and function, of Department activities in the wheat industry, 1989/90. The estimate is derived from computer records for projects coded for field crops.

ESTIMATED COST OF DEPARTMENT ACTIVITIES IN THE WHEAT INDUSTRY*, 1989/90

Source	$M
State	2.877
Rural Industry Research Funds	1.334
Commonwealth	0.834
Deposit Accounts for payment of services rendered	0.316
	5.361
Function	
Research	1.364
Extension	1.267
Regulation	2.152
Diagnostic	0.080
Administration	0.395
Industry Development	0.103
	5.361

* Excludes costs of support from research station infrastructure and from the Economics Unit.

Most Plant Services Division State funded research staff and regional research and development specialists initiate, develop, supervise and participate in rural industry research funded projects. Appendix 8A details the research projects related to wheat growing that are supported by rural industry research funds in 1990/91.

A considerable research centre infrastructure exists within SADA to support research related to wheat growing. In addition to Northfield Research Laboratories, regional research centres where these activities are located are Minnipa, Wanbi, Turretfield and Struan.

A significant proportion of the time of SADA Scientific Officers, District Agronomists, Plant Protection Agronomists, Soils Advisors and Regional Economists is involved in extension activities related to wheat growing.

Specific research- and extension- related services offered by the Department of Agriculture include grain quality and plant tests by the Chemistry Branch; the S.A. Soil and Plant Assessment Service (SASPAS), the Agricultural Chemicals Evaluation Scheme; and plant, disease, insect and nematode identification.

Department regulatory activities that impact on wheat production include those of the plant quarantine service, the grain export inspection service, the seed certification

scheme, the registration of pesticides and the Animal and Plant Control Commission.

The Department Economics Unit and a marketing group, both based in Adelaide, generate economic and farm management analyses and marketing activities that support the wheat industry.

Other organisations that carry out major research activities supporting the S.A. wheat industry include the University of Adelaide Waite and Roseworthy Campuses and CSIRO Division of Soils. Lists of 1990/91 projects supported by rural industry research funds related to wheat growing that are carried out by these institutions are shown in Appendixes 8B, 8C, and 8D respectively.

Priority Issues and Proposed Initiatives

Crop Improvement

Given the dominant effect of yield on farm profits and the increasing prominence of grain quality in preserving our wheat export reputation, the viability of the wheat industry relies heavily on new developments in crop improvement.

Genetic Resources

Since agricultural settlement there has been considerable progress in the identification and manipulation of genetic resources towards developing wheat varieties adapted to Australian climatic and edaphic conditions and land management systems. Nevertheless, the genetic resources are ultimately exotic, and there remain many aspects of our current varieties not fully in harmony with our adaptive and marketing requirements.

The primary store of genetic resources in Australia is the Australian Wheat Collection housed by the N.S.W. Department of Agriculture at Tamworth. The local breeding programs and associated scientific research provide the mechanisms to utilise these resources, developing a more stable and productive industry.

Wheat Breeding

Wheat breeding programs are pivotal between the identification and manipulation of useful genetic traits and the exploitation of these traits in agriculture.

Essentially breeding can be regarded as a form of 'packaging', producing a balanced combination of genetic material in the form of an improved variety. Breeders link much of the specific research and development undertaken by agricultural and cereal scientists with the rest of the industry. For this reason continued strong support must be maintained with the wheat breeding program of the University of Adelaide.

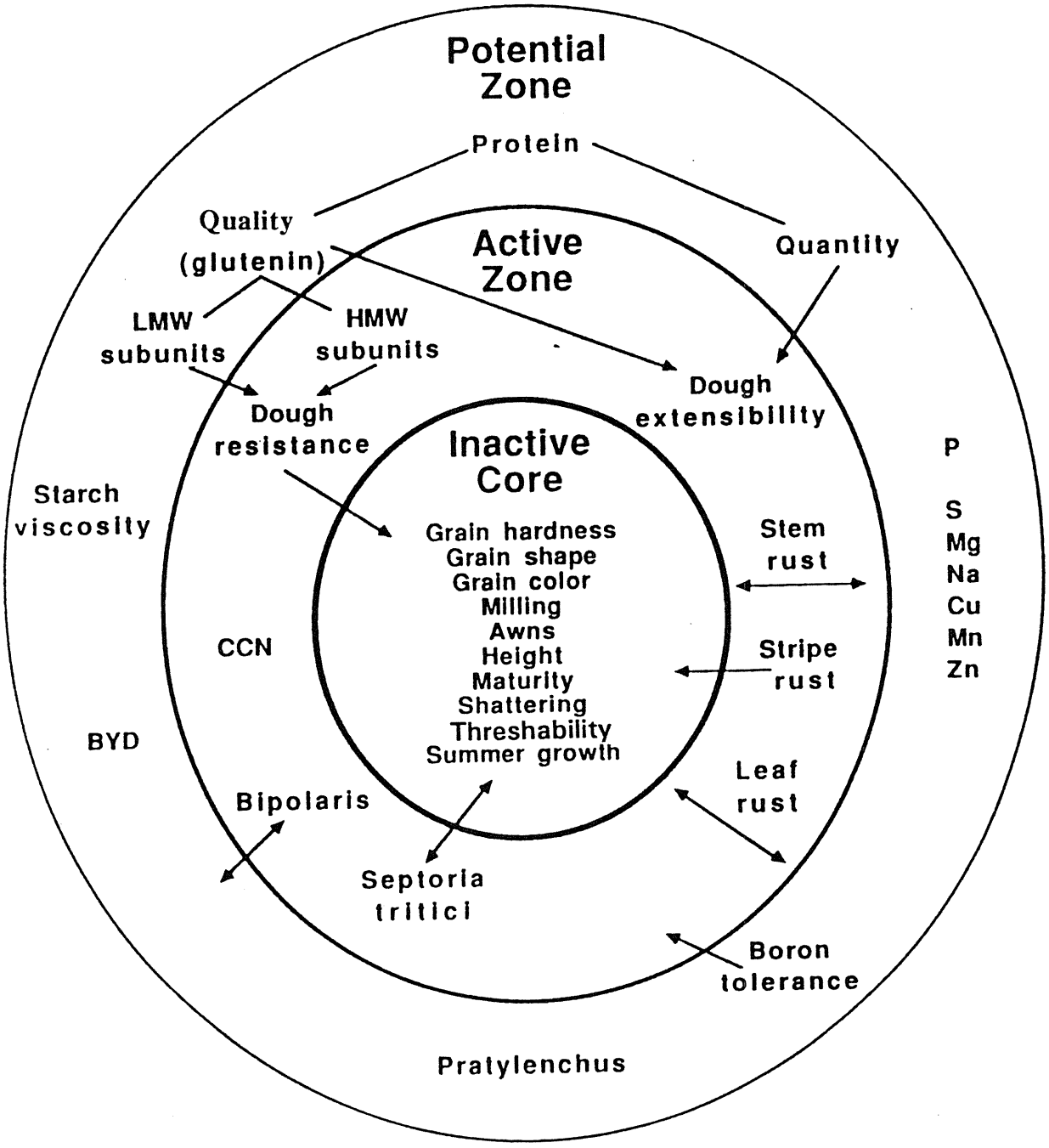
There are strong links between the wheat breeding programs and many of the research activities within the Department of Agriculture so for practical purposes the continuum

between specialised sciences, varietal improvement and industry exploitation of scientific advances already exists. It is essential that this should be maintained or even strengthened to ensure that a continuing flow of improved varieties is released to farms to cover the diverse edaphic, climatic, management conditions, and market requirements.

The inter-relationships between the objectives of the breeding and the associated scientific investigations is summarised in the accompanying diagram. In the centre are characteristics which are virtually (genetically) fixed in the Australian wheat varieties - objectives which dominated breeding programs earlier this century. The "active" zone encompasses the major current objectives, while the "potential" zone, those traits which are under active scientific investigation to determine their economic importance and genetic diversity and to devise methods for selecting improved genotypes.

The choice of the breeding systems, progeny, pedigree or back crossing, and the methods of handling segregating populations contribute to the efficiency of the breeding programs. For instance, the program for selection for boron tolerance has been undertaken on Eyre Peninsula as this region is particularly prone to the toxicity. In contrast, much of the selection for resistance to *Heterodera avenae* Cereal Cyst Nematode(CCN) has been undertaken in controlled environments at the Waite Institute as the nematode fails to reproduce at temperatures over 18° C so field evaluation is limited to a few winter/spring months. Selection for poorly defined aspects such as grain yield must be undertaken in representative conditions across the whole wheat growing region. Hence breeding programs need to be large and well funded.

The varietal "package" of genetic traits varies from one region to another. In the high rainfall areas such as the South East, this must include high levels of resistance to stripe rust, CCN, long growing period with a soft grain and weak extensible dough for biscuit manufacture. On Eyre Peninsula, stem rust resistance, early maturity, boron tolerance, and hard grain with strong extensible doughs are the most marketable types.



Wheat Breeding Objectives at
The Waite Agricultural Research Institute

Some of the resources devoted to breeding are employed merely to maintain our current production. Changes in the races of stem and stripe rusts, without the introduction of new resistant varieties, would lead to a deterioration in the productivity of the industry. Other breeding resources are devoted to replacing other, more expensive methods of alleviating unfavourable conditions, for example, CCN resistant varieties are an alternative to expensive chemical control methods. Finally there are the efforts to improve yield or marketability per se.

Substantial attention is being devoted by the breeding programs towards diversifying the marketable end products of the South Australian wheat industry. Small domestic markets (and potential export markets) exist for durum, biscuit, noodles and prime hard wheat varieties, and these can be fostered by the release of varieties specially developed for specific areas of the wheat zone.

Variety Evaluation

Strong government and industry support must continue for the state-wide Variety Evaluation and Interstate Wheat Variety programs in order that new potential cultivars from Australian wheat breeding programs are thoroughly tested and ultimately recommended.

A State-funded position should be created to coordinate the Field Crop Variety Evaluation Program in S.A.

In these programs priority attention must continue to be directed towards:

- understanding the environmental factors (soil, climatic, biotic) which influence the yield performance and quality attributes of genotypes (the genotype x environment interaction)

- developing methods for rapidly assessing the sensitivity of wheat genotypes to environmental stresses (e.g. disease resistance, nutrient efficiency, nutrient stress, herbicide tolerance, drought susceptibility, competitiveness with weeds)

- identifying areas and management practices whereby different wheat varieties can be grown satisfactorily, and as well, meet specific market requirements for quality

- describing known beneficial traits and deficiencies of varieties and promoting appropriate variety choice within the wheat zone

- monitoring trends in variety use across S.A. and documenting producer experiences with different varieties.

Grain Quality

Across the Department's wheat research and extension programs immediate efforts must

be made to test, document and interpret the effects of management, land use, and the environmental factors on protein levels and dough quality characteristics in wheat. In addition, protein data from the AWB protein testing service should be correlated with paddock information to further elucidate which site and seasonal factors most closely associate with grain protein levels. These data collected by the Department and the AWB should be made available to the 'Protein for Profit' extension program.

The reliability of the AWB protein testing service at wheat receival points needs to be evaluated to allay growers' current concerns.

Specific attention also needs to be directed towards developing rapid screening procedures to assist breeders assessing the grain quality parameters of early generation genotypes which have the potential to be used in a range of end products.

This may include techniques such as electrophoresis, ELISA and liquid chromatography to determine specific protein types or specialised small scale tests such as starch swelling power to predict starch properties for noodle wheats.

In association with the AWB, particular attention must be given in, the short term, to defining the quality requirements of overseas markets for the types of wheat which can be grown successfully in S.A. (see also *End Product Research* (p46)).

Biotechnology

Plant biotechnology is a new area of science which will in the medium to long term contribute important advances and products to the Wheat Industry.

Plant biotechnology is composed of two critical interacting components, tissue culture and molecular biology. Recent advances in molecular biology have lead to the development of techniques to isolate and analyse genetic material (DNA) and to transfer foreign DNA into certain plants. In addition cell tissue culture techniques are being improved and are an integral part in the multiplication of the genetically improved plants.

There are several opportunities for the utilisation of these techniques. One primary objective might be in the identification, isolation and successful transfer of a desirable genetic trait such as a gene for disease resistance, or for grain quality into a wheat variety which is otherwise agronomically acceptable. Another may be to develop specific probes (nucleic acid or protein based) to use in diagnostic testing for specific diseases (e.g. Takeall and Rhizoctonia) or to assist the plant breeders in developing lines with a particular genetic trait by monitoring its transfer during the crossing programme.

The true benefits of plant biotechnology will only be realised through continued interactive research between biotechnologists, plant breeders and agronomists to obtain a more complete understanding of plant growth and development and of the structure, function and expression of agronomically important genes.

Crop Production

The declining terms of trade within which the wheat industry has operated for many years necessitates that the production cycle remains both efficient and as profitable as the market and seasonal conditions will allow.

Farm Machinery Improvements

Many improvements in the design of farm machinery continue to originate from workshops of innovative farmers. Few new major concepts develop from the R&D divisions of major farm machinery manufacturers. The initial cost and the repairs to farm machinery are a considerable part of farm budgets.

SADA (in collaboration with the mechanical engineering section at SAIT), needs to appoint and locate at least two farm machinery specialists to identify machinery constraints, to monitor farmer innovations, to test and evaluate new machinery concepts and to promote machinery designs to wheat growers across S.A. These appointees should have the opportunity to travel widely within the cereal zone.

Immediate priorities include:

- developing suitable tillage implements for trash retention systems and promoting modifications to existing seeders to ensure that cereal seed is sown at optimal depth in trash/direct drill and minimum till situations.

- accelerating progress towards commercialising the aerofoil-bluff plate spray applicator being developed at the Loxton Research Centre. It is considered that this innovation will increase the adoption rate of reduced tillage systems by reducing herbicide costs and improving herbicide efficacy.

Optimum Sowing Time

In each district there is an optimum time for sowing wheat which has a critical impact on the yield and protein level. Delays beyond this relatively narrow period reduce yield (primarily by lowering water use efficiency by the crop) and raise protein levels. In drier areas, sowing wheat early on marginal rainfall events has resulted in spectacular yield increases, but this effect has not been observed universally. This type of early sowing is dependent upon grass control in the year before. Problems exist in this year with grazing management and soil erosion. Seasonal and soil conditions and management decisions interact to modify the outcome achieved.

Optimum sowing time needs to be defined for the environments of the wheat zone. This information must be extended widely to farmers. In addition, farming practices (e.g. weed and disease control, nutrition, tillage practices, sowing rate, cultivar choice) need to be developed and understood which permit optimal sowing time to be achieved in all regions for the range of seasonal conditions normally experienced.

Nutrition

Single and multiple nutrient disorders exists on the diverse range of soils in the wheat zone. The nature and degree of stress are clearly site-specific properties of the soil and the farming system used. The more intensive forms of land use undertaken during the 1980's have been exploitative on soil nutrient reserves. These reserves need to be restored by appropriate fertiliser inputs and effective rotations to ensure that a balanced supply of nutrients is available for crop growth. Fertiliser costs have risen sharply since the mid 1970's and current fertiliser costs now comprise up to 50% of the total variable costs associated with cereal farming.

Continued emphasis needs to be placed on developing and calibrating improved soil and plant tests for assessing the fertility status of surface and subsoil horizons and the nutritional status of crops. Multi-nutrient testing services need to be promoted more widely. Farmers use of existing commercial services is low. There appears to be a lack of confidence in soil and tissue testing. If contract services were available for sampling or if financially sound fertiliser advice was also provided with results, these strategies may improve level of use. Also SADA should foster commercial firms activities and monitor their work.

Efficient fertiliser practices need to be defined for *representative* soils of the wheat zone. A network of long term field experiments is needed to evaluate the extent to which fertiliser and soil nutrients cycle within commonly used rotations or are immobilised by soil constituents. The effects of farming practices (e.g. tillage systems and fertiliser use) on the distribution of nutrients within the rooting zone must also be identified and monitored in these experiments. Primarily emphasis should be given to estimating the residual value of previously applied phosphorus, nitrogen, sulphur and zinc.

Research on fertiliser efficiency should also include:

- determining the most efficient method for applying phosphatic fertilisers within rotation sequences (timing and placement of fertiliser inputs) and for enriching the soil reserves with organic nitrogen.

- assessing new fertiliser placement techniques for enhancing the longer term effectiveness of phosphatic fertilisers within the rooting zone of wheat and subsequent crops and pastures.

- assessing the effect of seed nutrient reserves and seed nutrient coating techniques on nutrient efficiency processes.

- ranking wheat genotypes for their efficiency in acquiring and utilising soil and fertiliser nitrogen and phosphorus.

- identifying the extent to which crop diseases and applied herbicides modify root and shoot growth and thereby influence the nutritional status of plants.

New advances in fertiliser technology must be promoted and demonstrated to wheat producers. Specific attention must continue to focus on the restoration and nitrogen enrichment of organic matter reserves in soils of the wheat zone.

Future research on nutrition should focus on providing strategies to produce products of specified quality parameters demanded by markets.

Soil structural stability

The structural instability of the cereal zone soils is well known, but is often insidious in nature. Protection of the soil resource from further degradation (e.g. wind and water erosion, sodicity, compaction, salinity and acidification) is now receiving increased community attention and government financial support. Where degradation has occurred, productivity can be markedly depressed (based on water use efficiency criteria), land access and farm income are reduced, and indeed the viability of farming itself becomes precarious.

During the Decade of Land Care, the Department has a clear obligation to support the community Land Care programs in both a technical and advisory capacity. The benefits and costs associated with implementing sound land management and soil conservation structures need to be identified and continually promoted to landholders.

Continued support must also be applied to long term experiments which are assessing the consequences and sustainability of 'conservation farming' practices (tillage, stubble retention systems) and rotation sequences on productivity, grain quality, amelioration and improvement of soil structure. Some of these experiments need to be located in the more marginal areas of the wheat zone.

There is an urgent need to develop or refine a reliable field test to allow farmers and advisers to assess the structural stability of soils and soil aggregates *in situ*.

Research attention must also focus on determining the distribution of earthworm species, their activity and impact on nutrient cycling and soil structure. The potential role of green manure crops, grass pastures, straw, lime and gypsum also needs to be established as medium or long term ameliorants for structurally degraded soils.

Minor effort should be directed towards monitoring farms which produce 'organically' grown products.

Agricultural meteorology

Seasonal conditions dominate the yield and quality of wheat. Farmer skills and knowledge in how they manage their land largely determines how efficiently crops utilise available soil water in any given year. Improved knowledge is required in two areas to optimise water use efficiency by wheat, viz:

- the appointment of an experienced agronomist to study factors affecting the

behaviour and architecture of root systems. In the past, the dynamics of root growth has been neglected, and this knowledge needs to be linked both to shoot growth and the potential grain yield concept developed by French and Schultz.

- the appointment of a State funded systems analyst to compile historical rainfall data and rainfall deciles for locations within the cereal zone. It is envisaged that definite scope exists for using these data (together with prospects for better medium-term weather forecasting) to progressively monitor seasonal rainfall after sowing and thereby estimate potential yield expectations. This in turn would permit better within-season advice being given on likely returns and risks associated with using expensive farm inputs on crops after sowing time. This concept once developed would become an important extension tool or farmer service.

Extension Packages

Most management decisions made by producers need to be integrated and planned in advance to optimise profitable outcomes. When integrated, often these crucial decisions (and farm inputs) have a synergistic effect on yield and farm income.

Successful wheat production therefore relies heavily on promoting an integrated system of land use and appropriate husbandry practices which are both cost efficient and relevant to individual districts or farms. The development of these technical 'packages' involves research and extension staff and producer groups working together.

Advisers and researchers need to concentrate more attention on formulating and contrasting the economic benefits and risks associated with these packages. SADA must invest resources into developing decision support software and expert systems and into training advisers to use these computer aids.

Crop Protection

At the farm level, minimising the impact of weeds, diseases and pests is crucial for maintaining and improving productivity and profitability.

Weed Control

Weeds reduce yields, harbour some cereal diseases, hinder harvesting operations and are a source of grain contamination. Poor weed control has been identified as imposing a major constraint on yields in South Australia in some areas and farmer surveys in other areas have identified individual weeds as amongst the worst on-farm problems. Effective on-farm weed control programs need thorough forward planning, good timing and a high level of technical expertise in their execution.

Herbicides

Herbicides are the major tool used for weed control in wheat production. Their major contribution to the efficiency and sustainability of agricultural systems needs continuing research and development.

Continued support is needed for evaluating the efficacy and tolerance of new herbicides to assess their usefulness in South Australian wheat growing systems. Older, registered herbicides need to be assessed to derive more and better uses for overcoming particular weed problems, including the use of adjuvants and seed protectants. There is a need to develop a systematic herbicide screening system in South Australia for potential new cultivars so that vital crop tolerance information is available when these cultivars are released. The Department must also maintain strong technical links with the Agricultural Chemicals Industry.

Improved, more efficient herbicide delivery systems in broad-hectare agriculture are important and in this context continued progress towards commercialisation of the aerofoil - bluff plate spraying system is necessary.

An adverse result of continued herbicide application has been the emergence of weed populations that are resistant to herbicides, in particular annual ryegrass and wild oats. Ongoing research in this area at the WARI needs support. The long term effectiveness of strategies that minimise or circumvent herbicide resistance in annual ryegrass need validation. The Department should mount an awareness campaign that provides producers with management options that meet this problem.

Difficult weeds

Continued, state funded support must be given to research programs for weeds that have proven very difficult to control in cereal farming systems in South Australia. These include deep-rooted herbaceous perennials such as cutleaf mignonette, silverleaf nightshade, skeleton weed and bindweed; annual grasses such as brome grass, sand fescue and silver grass; and annual broadleaves such as bifora and bedstraw.

Economics/Management

The disease host status of grass weeds should be researched.

As a related issue the benefits and risks in removing grasses from pastures prior to cropping must be clearly documented and research undertaken on identified knowledge gaps.

Continued Department support must be given to generation of appropriate, effective extension material, such as the Cereals Weed Spraying Guide, that provide producers with up-to-date weed control advice. The benefits of an expert system computer program for weed control advice should be assessed. While it is a difficult field of research significant cost and environmental benefits could be obtained from derivation

of a decision model for weed control in crops and pastures.

Research is also necessary to identify the extent and severity of herbicide and nutrient interactions in wheat, and to identify cost effective solutions to this problem.

Research on reducing herbicide rates in cereal crops should also be supported. Such research would also help meet concerns from the environmental lobby over the levels of pesticide use on farms.

Non-chemical control methods

It is important that inter-state research on biological control of weeds should continue.

Research in South Australia into non-chemical methods of weed control in cereal production that are also environmentally sustainable should be supported. Such methods include strategic and timely tillage operations, increased crop density and greater use of appropriate fertilisers (especially N).

Disease Control

Research to combat the serious effects of root and foliar diseases of wheat is well developed in S.A. and in particular in the Department. Cereal pathologists are developing and are promoting the use of:

* disease resistant cultivars of wheat. This includes understanding of the genetic base of resistance in adapted varieties, introducing new sources of resistance and the improving screening of breeders lines. As well utilising both tissue culture and the relatively new techniques of molecular biology to assist the breeding programme. Identifying resistance genes with RFLP molecular markers used in conjunction with tissue culture to optimise selection.

* management options to minimise the impact of diseases in wheat (e.g. reducing pathogen populations by rotation sequences, use of disease resistant wheats and tillage practices).

* tests for detecting specific pathogens of wheat.

Additional applied research and extension on cereal diseases is undertaken by regionally based Crop Protection advisers and is coordinated through the Plant Industries and Natural Resources Division.

The changing spectrum and levels of diseases as a result of rotations and management practices of diseases should be monitored. Race surveys and crop monitoring are required to detect at an early date the occurrence of new pathogens and variations in the virulence of established pathogens so that resistant cultivars can be developed rapidly.

Clarification of the role of grasses in hosting cereal diseases is needed. The interaction between disease and nutrition needs to be investigated.

Although the research and extension activities of the Field Crop Pathology Unit are largely supported by RIRF grants, an experienced mycologist should be appointed on State funds to lead and coordinate the diverse range of projects now in this area.

Invertebrate and Vertebrate Pest Control

Depending on seasonal conditions unspecified damage to wheat crops by red-legged earthmite and lucerne flea occurs across South Australia. During crop germination and establishment phases major losses can also be caused by wireworm, false wireworm, cereal curculio and scarab species, especially under short fallow, reduced tillage systems. The damage may require crops to be resown. There is a need to develop a chemical control recommendation for yellowheaded cockchafer (scarab).

Several caterpillar pests (armyworms and cutworms) occasionally cause damage to wheat crops in South Australia. Control measures are available and no new research initiatives are needed for these problems.

Cost effective, integrated procedures for controlling insects in legume-based pastures is an important area for future research and extension, and must be undertaken to ensure that vigorous, dense legume growth is achieved and maintained in pastures and rotations. Economic thresholds need to be estimated for recommending insecticide applications to pastures.

White and conical snails contaminate some wheat crops in South Australia. This contamination poses a threat to export markets and continuing SADA, CSIRO and RIRF support for research on snails is necessary.

On farm storage of wheat necessitates that stringent grain hygiene procedures are adopted and maintained, and that insecticides are used correctly to avoid residue problems, both of which could affect the States' export markets. To this end, a State-funded entomologist on stored products may need to be appointed to monitor pesticide residues in grain and promote accepted codes and principles of correct grain hygiene in all stored grain produce. Given that the AWB already carries out extensive testing, this issue may be able to be resolved using AWB resources.

Continued support is needed to develop strategies for predicting mice plagues. Additional research is also required to develop and register suitable rodenticides for mice control.

Farming Systems and Management

Network of Long Term Experiments

Few experiments exist within the cereal zone of S.A. which allow the identification and

monitoring of the long term consequences of changing land use and farming practices. Those that do exist do not represent the range of soils and climatic conditions experienced in the wheat zone. In some respect our advice to farmers on sustainable farming systems is somewhat impotent, relying heavily on the experimental data from a few locations.

To this end, the S.A. cereal industry needs to support and initially fund the establishment of a few long term experiments (with flexible designs) across the cereal zone of S.A. (see also *Nutrition (p38)* and *Soil structural stability (p39)*). These experiments should be under the control of SADA, and some could be located on research centres. When established the experiments would become a focus for:

- interdisciplinary research involving SADA and other research agencies
- extension programs on dryland farming systems.

Economic Justification of Rotation Sequences

SADA *urgently* needs to develop for producers and advisers an economic model which distils the short to long term financial consequences (incorporating likely costs, returns and risks) associated with the diverse range of rotation sequences and husbandry practices commonly used in the cereal-sheep zone of S.A.

A specialist team of economists, agronomists and extension staff need to develop flexible and user-friendly models for S.A., similar to the models MIDAS and WHEATMAN developed in W.A. and Queensland respectively. This activity should have high immediate priority.

Linked to the above initiative are pressing needs to:

- monitor, interpret and alert producers to changes in forecast market prices both before sowing time and during the winter-spring period.
- develop decision support software to justify *within season* adjustments being made to farming practices which optimise farm returns in different seasons and areas of the wheat zone.

Legume based pastures

Extension programs, linked to the 'Protein for Profit' program, need to emphasize that dense, vigorous legume-based pastures need to be grown when cropping soils are spelled. Economic models to determine optimal grazing intensities are required. Grazing should be regarded as part of a production system, not seen as a separate farming activity totally divorced from cropping activities.

Storage, Handling and Transport of Wheat

It was identified in the Industry Statement section that off-farm costs associated with storing, handling and transporting wheat from farms to export market destinations constitute a major burden on wheat farmers. SADA should support any moves that engender new efficiencies to this system.

As domestic and export wheat buyers become more discriminatory in their purchases, the industry storage and marketing agencies must give attention to providing increased segregation facilities for different wheat types and grain products at their receival points and ports.

Attention must also be directed towards maintaining stringent quality standards for grain hygiene, and particularly for wheat stored in on-farm silos. Pesticide contamination of grain must also be maintained at minimal levels and monitored regularly (see also *Invertebrate and vertebrate pest control (p43)*).

End Product Research

Wheat grain

It is imperative that wheat specialists in South Australia are aware of all of our market requirements. More knowledge is required in the mainstream products of S.A. wheats, namely Middle Eastern flat breads. Lack of first hand experience of overseas quality requirements for products such as flat breads and noodles limits the marketability of S.A. wheats. If any of the potential new opportunities of noodle, biscuit and steamed breads for the South East Asia area are to be tapped a team of wheat specialists (namely, breeders, cereal chemists, AWB representatives and growers) need to visit the region and identify the market issues before further research and development occurs.

Small domestic markets also exist for durum wheat used to manufacture pasta products, and for 'organically grown' wheat.

Consideration needs also to be given to growing prime hard wheat varieties in the drier regions of S.A. (Upper Eyre Peninsula, northern Mallee) to attract the premium offered by the AWB for this wheat grade. Also consideration should be given to the growing of softer grained low protein types of wheat in areas which now grow hard grained low protein wheat. These wheats could be used for noodle production and steamed breads.

Value Added Products (see *Processing Opportunities* (p25))

Communication of Technology to Wheat Farmers

Communicating new technology within the wheat industry is clearly a two-way process. Firstly, the past experiences and needs of farmers, and their capacity to adopt proven advances must be considered. Secondly, adoption will be accelerated when relevant technology is presented to farmers in a form whereby the yield benefits, costs, returns

and risks are demonstrated.

In addition, the industry involves many clients (e.g. farmers, agribusiness, consultants, bankers, policy makers, extension and research staff, AWB, CBH, RIRF agencies). Thus, the products of research must be disseminated widely, and integrated or adapted to suit the evolving farming systems of S.A.

Barriers to the adoption of new technology were identified in Barriers to Achieving Industry/Market Potential (p26). The extension and training initiatives described below to enhance prospects for greater technology transfer require that the Department:

- accepts in principle that Departmental extension services are provided for the 'public good' and that group extension is cost effective.

- plans and implements a revised extension service to reflect the needs of the cereal zone. The existing service is considered to be under resourced in skilled district agronomists, who have inadequate time to properly plan their large advisory programs.

The proposed initiatives are as follows:

- encourage more advisers into the cereal zone

- plan for succession within the Departmental extension services

- initiate post graduate or specialised training programs for district agronomists

- initiate 'adviser-in-training' programs to recruit and train young advisers

- examine opportunities for staff exchange and secondments between organisations

- develop suitable training courses for farmers wherein the principles of existing and new technology can be demonstrated in a practical way

- develop training programs for private sector clients and Departmental staff

- train agricultural students in extension methodology, including practical training

- provide high quality extension aids to advisory staff

Departmental Services

The Plant Industries and Natural Resources Services Division provides user-pay services to individual cereal farmers and industry, viz:

- Annual Ryegrass Toxicity Testing Service

- Seed Testing
- Seed Health Testing
- S.A. Soil and Plant Analysis Service
- Agricultural Chemicals Evaluation Scheme

In addition, diagnostic services are provided to Departmental advisers for weed, insect and disease identification and soil and plant analysis. These essential services must be retained. Scope exists for combining and rationalising these services and for initiating new services, viz:

- herbicide resistance screening service
- a service providing regular commodity price updates
- annual district and State summaries of protein levels in ASW wheat
- surveying and monitoring trends within the wheat zone.

Farmers' attitudes and problems also need to be sought and summarised on a reasonably regular basis through the medium of formal and informal district needs surveys.

It is also considered that a quarterly edition of the Journal of Agriculture should be reinstated as a means providing packages of information to farmer. These packages could be funded jointly with GRDC.

Departmental Policies

Debates must occur within SADA to formulate policies on the following issues:

(1) Clarification of the future role and funding for the Department's extension services: i.e. will the Department ultimately adopt the 'user pays' principle for its extension services, or will the services be supported by government for the 'public good', given the high export earnings of the agricultural sector?

(2) Clarification of tenure for staff employed for long periods on external grants.

(3) Clarification as to whether SADA should compete with the private sector in the provision of commercial diagnostic services for landholders.

(4) Clarification as to whether SADA should provide analytical services for its research, extension and regulatory functions, or in some instances, seek quality services elsewhere at competitive prices.

(5) Development of standard fee formulae for contract research and extension, national and international consultancies and for reimbursing landholders for use of their land in research programs.

(6) Development of guidelines for selling the rights to SADA's intellectual property (including plant variety rights) and commercialising the products of research.

(7) Development and use of strategic plans whereby SADA's resources are efficiently directed to areas of highest priority.

(8) Development of adequate laboratory safeguards for research on biotechnology.

(9) Development of policies whereby genetically engineered organisms and beneficial natural organisms are safely released within S.A.

(10) Development of a staff succession plan for SADA research and extension services, which includes a proactive recruitment and training program.

Appendix 1. Wheat Classes

Australian Prime Hard. This class is limited to a selected number of high quality, hard-grained varieties. Prime Hard wheat has excellent milling quality and is marketed at 15, 14 and 13% minimum protein levels.

Australian Hard. This class is also limited to hard-grained wheat varieties that have good milling and dough characteristics. Australian Hard wheat is segregated in each State, and different wheat varieties dominate in the various grades of each State. Australian Hard is marketed at 14, 13, 12 and 11.5% minimum protein levels.

Australian Standard White (ASW). ASW wheat is segregated throughout Australia and for this reason there is a wide range of qualities available. In order to meet their particular needs, buyers have purchased ASW wheat from certain regions of production. Accordingly, attempts are made to ensure that there is some uniformity and continuity in the quality of wheat produced from these regions.

Australian Soft. This class is segregated in New South Wales, Victoria and South Australia for domestic flour milling. Western Australian segregates and exports large quantities of this class: a specific soft wheat with low protein and weak extensible dough properties which is ideally suited for biscuit manufacture and other soft wheat end uses.

Australian Durum. Currently there is a very limited production of this class of wheat. It is mainly utilised domestically for the production of semolina for pasta manufacture.

Australian General Purpose. This class comprises wheats that have failed to meet the minimum receival standards for milling wheat grades, either on account of low test weight, presence of screenings, foreign material, excessive weed seeds or a mild degree of sprouting.

Australian Feed. This class consists of severely sprouted wheat which is suitable only for feed-milling purposes.

Appendix 2. World wheat production (five year averages)

	Annual Production (million tonnes)			
Period	United States	Canada	Australia	World
1950-51 to 1954-55	29.8	14.5	4.9	188.0
1955-56 to 1959-60	29.8	12.3	4.6	230.1
1960-61 to 1964-65	33.3	14.5	8.3	248.5
1965-66 to 1969-70	39.0	18.5	10.5	304.8
1970-71 to 1974-75	43.6	13.5	9.3	352.1
1975-76 to 1979-80	55.7	19.8	13.5	410.1
1980-81 to 1984-85	70.5	23.7	15.4	478.7
1985-86 to 1988-89	57.4	24.4	15.0	514.8

Appendix 3. Annual wheat and flour exports by major exporter, 1950-51 to 1988-89 (five year averages)

	Argentina	Australia	Canada	United States	Soviet Union	European Community	Others	World
Export volume	Mt	Mt	Mt	Mt	Mt	Mt	Mt	Mt
1950-51 to 1954-55	2.2	2.7	8.2	9.1	0.7	-	-	26.1
1955-56 to 1959-60	2.6	2.6	8.0	12.2	4.1	-	-	34.0
1960-61 to 1964-65	2.7	6.1	11.1	19.5	3.6	3.6	1.3	47.8
1965-66 to 1969-70	3.5	6.5	11.3	18.9	4.5	5.5	3.0	53.1
1970-71 to 1974-75	2.0	7.5	12.8	25.6	4.6	5.4	2.5	60.3
1975-76 to 1979-80	3.9	10.0	13.9	31.7	1.4	6.7	4.1	71.7
1980-81 to 1984-85	6.7	11.5	19.3	41.1	0.6	14.6	5.0	98.8
1985-86 to 1988-89	4.5	13.6	18.6	34.3	0.4	16.1	7.0	94.1
Market share	%	%	%	%	%	%	%	%
1950-51 to 1954-55	9	10	31	35	3	na	na	100
1955-56 to 1959-60	8	8	23	36	12	na	na	100
1960-61 to 1964-65	6	13	23	41	8	8	2	100
1965-66 to 1969-70	7	12	21	36	8	10	6	100
1970-71 to 1974-75	3	12	21	42	8	9	4	100
1975-76 to 1979-80	5	14	19	44	2	9	6	100
1980-81 to 1984-85	7	12	20	42	-	15	4	100
1985-86 to 1988-89	5	14	20	36	-	17	7	100

While Australia is a relatively small producer of the world wheat crop (around 3%) it is a significant exporter (14% of world exports).

Appendix 4. Average quantities of wheat purchased by major importing countries (1986-88).

Importer	Mt
Soviet Union	18.0
China	13.7
Egypt	7.1
Japan	5.6
Korea, Republic of	3.9
Iran	3.4
Algeria	3.0
Iraq	2.9
European Community	2.5
Poland	2.1
Brazil	2.0
Morocco	1.7
Total	65.9
WORLD	98.2

APPENDIX 5.
NEEDS ANALYSIS - 1987

1. PRODUCTION CONSTRAINTS

Water Use Efficiency

How to achieve a crop's yield potential
What are the limitations and how to overcome
What is the optimum sowing time in various districts, soil types and how to achieve
How to sow earlier to maximise use of available moisture
Use of rainfall decile data to predict seasonal risks in productivity and management options

Low Soil Fertility

How to satisfy a crop's nutrient requirements on deep siliceous sands
Rate, timing, placement and economics of nitrogen application in relation to yield and grain protein
How is soil fertility (especially organic carbon and nitrogen) most effectively and economically increased under various systems
The effect of addition of gypsum and lime on amelioration of soil and on soil acidity
Long term effects of D.A.P. and alternative fertilisers on soil acidity and availability of other nutrients
Use and interpretation of soil and plant analysis to identify and correct nutrient deficiencies. Development of on-the-spot test kits
Improving the reliability/credibility of soil analysis
Managing water repellence soils to facilitate wetting and enable earlier sowing
Improving the drainage of duplex soils with an impervious clay layer to improve yields
Deep ripping of compaction layers
Boron toxicity on calcareous and/or on soils with high sodium levels
Management options for raising grain protein levels in wheat
Adequate levels of available phosphorus need defining on some soil types
Responsiveness of different cultivars to nitrogen fertility
Incidence and degree of severity of zinc deficiency
Fertiliser placement and effect of placement at varying depths

Soil Stability/Tillage Systems/Rotations

Effect of stubble retention on soil organic matter and nitrogen levels in the short and long term
Effect of stubble retention on wheat yields, root and leaf diseases, pastures and soil fertility factors
Techniques for handling stubbles in stubble retention systems, especially those which do not require investment in high cost machinery

Manipulation of rotations to improve yield and grain quality whilst maintaining adequate soil fertility and stability
Rotations and plant resistance which enable disease control
Long term effects of tillage practices and rotations on profitability and sustainability
Effect of various tillage practices on yields, organic matter, soil erosion, disease and weed control (direct drilling/reduced tillage/conventional tillage)
Control of wind erosion on water repellent sands
Effect of intensive/continuous cropping systems on soil fertility, soil structure, yields and grain protein
Identification of intensive cropping systems resulting in declining soil fertility
Benefits of conservation farming practices (e.g. direct drilling and stubble retention) on water infiltration, soil stability and fertility
How to improve crop establishment on hard setting red brown earths

Weather Forecasting

Climatic/scientific data for making crop management decisions
Improve accuracy and reliability of short and long range forecasting

Other

Determine coleoptile lengths of commercial cultivars

Farming Practices Package

Development of crop monitoring skills to assess wheat crop requirements and thereby improve yields - viz identification and effective control of weeds, disease and nutrient deficiencies

2. ECONOMIC CONSTRAINTS

High Machinery Costs

How to most effectively finance machinery purchase
Machinery ownership - Buy or Lease? When to replace. How to cope with machinery costs. Economics of machinery replacement versus repairs to existing.
How to calculate operating costs/employing contractors
Economics of cropping - Self or Sharefarmer

Relative Gross Margin of Wheat Compared with other Enterprises (Including Pastures)

Gross margins analysis to assist with enterprise choice, cash flow budgeting and forward planning of finance
Budgeting and financial management
Financial analysis skills to assess enterprise and overall farm profitability
Assessment of profitability of different farming systems

How to cope with the cost-price squeeze and how to improve farm profitability
Rising input costs, variable seasons and yields increase the need for effective risk management

Market Intelligence

Improve market predictions to facilitate decision making
Market forecasting - prices and trends
How to develop local and overseas markets

Investment Risks - 'On' and 'Off Farm'

Source of assistance on financial advice
Independent sources of financial advice needed
Short and long term off-farm investment advice

Machinery

Implement design needs to be more suited to sandy soils to minimise erosion
Selection of machinery, size, matching
How to improve fuel efficiency
How to improve efficiency of machinery use
Machinery design and modification of machinery to control seed placement and seed depth
Modification of machinery to enable placement of high rates of nitrogen fertiliser at seeding such that emergence and establishment are not severely affected
Current machinery poorly adapted to handling trash in stubble retention - direct drill systems
Share design needs improving to enable minimal soil disturbance, effective seed and fertiliser placement and disease control

Cost - Benefits of Technology

Research and extension needed to evaluate the financial benefits of technology in the farming system

3. CONSTRAINTS TO ADOPTION OF TECHNOLOGY

Relevant, financially based and technically sound information on wheat crop and systems management is not reaching and/or being understood by farmers
Decision making - to what extent will benefits be derived from various practices

Appendix 6.

Long term objectives and strategies of the WRC (WRC Five Year R&D Plan 1989-1994)

OBJECTIVE 1

Encourage the development of a range of profitable and sustainable production systems closely matched to market needs.

Strategies

1 Develop varieties that are regional-specific for both yield and quality characteristics.
2 Increase the provision of grain quality information in variety testing trials.
3 Maintain and improve yields by research into improved pest and disease control, water use, soil factors and plant nutrition.
4 Identify barriers to continued production, and develop a range of sustainable production systems.
5 Investigate and evaluate alternative production systems that are less dependent on agricultural chemicals.
6 Investigate the economic performance of differing production systems.
7 Study the impact of short-term and regional variations in weather on wheat production and consider the likely influence of longer-term climate change.
8 Provide risk management strategies that help growers cope with rising input costs, varying commodity prices, and fluctuating climate, and also, to achieve sustainability.

OBJECTIVE 2

Improve product specification and enhance marketability.

Strategies

1 Develop improved, objective methods for rapid and reliable testing of grain quality.
2 Devise ways of ensuring that wheat is as free as possible from biological, chemical and physical contaminants.
3 Investigate methods of adding value to wheat and its by-products.
4 Investigate the development of new products and identify potential markets for such products.

OBJECTIVE 3

Increase industry understanding of market processes.

Strategies

1 Develop market research techniques suited to the wheat industry.
2 Develop an objective basis for the provision of market-related information to growers to enable them to produce grain with the desired quality characteristics in a cost-effective manner.
3 Study the world wheat market with a view to enhancing existing markets and developing new opportunities.
4 Develop a comprehensive industry database.

OBJECTIVE 4

Improve efficiency in the storage, handling and transport systems so as to maximise both marketing opportunities and returns to growers.

Strategies

1 Investigate technologies that allow storage, handling and transport costs to be lowered or contained.
2 Study technologies and procedures that allow environmental acceptability to be ensured.
3 Identify and assist the development of market-oriented segregation systems.
4 Develop a national database of grain storage capacity to improve segregation and marketability.
5 Identify and develop improved management systems to facilitate cost-effective grain movements.

OBJECTIVE 5

Improve the adoption of research results.

Strategies

1 Understand the process of adoption and technology transfer and identify and address constraints to the uptake of R&D findings.
2 Ensure R&D results are incorporated into crop and farm management packages.
3 Further develop models as tools to aid managerial decision making.
4 Increase the commercial exploitation of Council-sponsored R&D in partnership with manufacturing and service industries.

5 Devise improved ways of transferring research findings to the industry via commercial sources, private consultants, farm groups, and others.
6 Utilise pilot scientific and/or farm group communicators in each state.

OBJECTIVE 6

Improve the management of R&D to maximise benefits to the industry.

Strategies

1 Develop a Secretariat with the capacity to manage improved evaluation of project submissions in conjunction with State Committees.
2 Evaluate previous and ongoing research to determine its effectiveness and benefits.
3 Investigate and identify priority areas of new research and technology for proactive support.
4 Support basic research needed to underpin Council-funded tactical and mission-oriented strategic research.
5 Encourage the training and retention of sufficient high quality scientists to meet medium term industry research needs.
6 Ensure access to the interactive grains research database for Grains Research Councils and State Committees, and further develop this database as required.
7 Develop improved consultative and co-ordination arrangements for priority setting and strategic planning with industry bodies, other research funding organisations and clients.
8 Develop improved communications and reporting to the industry on R&D outcomes.

Appendix 7.

Categories of priority funding for wheat developed by the WRCSA (summarised from the WRCSA Annual R&D Plan, 1989-90)

1. CROP IMPROVEMENT

. Breed improved wheat varieties for the environments of S.A. (yield, quality, disease resistance).
. Support the introduction of CCN resistant wheat varieties.
. Support the incorporation of beneficial genes into wheat for improving fungal disease resistance and the nutritional value of cereal proteins.
. Breed wheats tolerant of boron toxicity.
. Support the continuing release and maintenance of wheat cultivars.
. Support grain legume and oat breeding and evaluation.
. Rank wheat genotypes for their responsiveness to applied nitrogen fertiliser.
. Breed for resistance to 'Takeall'.
. Support studies on wheat physiology.

2. CROP PRODUCTION

Agronomy:

. Develop cost efficient, crop husbandry practices into integrated technology transfer packages. This includes:

- ascertaining the benefits and constraints of rotation sequences
- assessing the adaptability of breeder's advanced selections
- evaluating the genotype x environment interactions for wheat grown in S.A. (especially in Eyre region)
- improving the agronomic performance of grain and pasture legumes (especially in Eyre region)

Soils:

. Develop suitable tests for characterising the fertility status of soils.
. Determine the effects of boron deficiency and toxicity on cereal yields.
. Develop sampling methods for identifying soil-borne diseases.
. Develop information on rotations which maintain economic productivity, and maintain or improve soil structure.

Nutrition and Fertilisers:

. Develop suitable plant nutrient tests.
. Study interactions between trace element deficiencies and toxicities.
. Improve the efficient use of nitrogen and phosphorus fertilisers.
. Study alternative organic and inorganic nitrogen sources for wheat.

3. CROP PROTECTION

Diseases:

. Develop strategies (breeding, agronomy) for overcoming the effects of root pathogens.
. Study the effects and control of stem and stripe rust.
. Develop controls for cereal cyst nematode, Rhizoctonia and known leaf diseases, including agronomic practices and rotations.
. Quantify the effects on yield of barley yellow dwarf virus in the low rainfall areas.
. Evaluate the effects of herbicides on yield losses caused by Rhizoctonia.
. Develop practices for managing Rhizoctonia.

Insect Pests:

. Identify insecticides for the economic control of yellow headed cockchafer and cereal curculio.

Weeds:

. Chemical and agronomic practices (e.g. tillage) for controlling grass weeds in wheat.
. Evaluate advantages of herbicide mixtures.
. Develop improved herbicide technology (e.g. timing, rates, mixtures and application methods).

Engineering:

. Improve the performance of tillage implements and sowing equipment.

4. FARMING SYSTEMS AND MANAGEMENT

. Support research in this area.

5. STORAGE, HANDLING AND TRANSPORT

. Support research in this area.

6. PRODUCT RESEARCH AND MARKETING

. Provide wheat quality information and data, particularly to aid breeders in releasing new varieties.

7. COMMUNICATION AND TRAINING

. Support projects with a defined extension component.
. Support appropriate extension projects.
. Support publications and media bulletins.
. Support conferences and seminars relevant to research priorities.

APPENDIX 8A.

DEPARTMENT OF AGRICULTURE

External Funding for Major Projects Directly Related to Wheat Growing, 1990/91

1. CROP IMPROVEMENT (see also projects superscripted (1))	
Project	**Funding Source**
Commercial release and maintenance of wheat and barley cultivars.	WRCSA
Integrated field crop variety evaluation and services for S.A.	WRCSA
Developing wheat and barley efficient in use of soil and fertiliser phosphorus.	WRCSA
Coordination of interstate wheat breeders trials and interstate barley breeders trials.	WRC
Genetics of resistance and tolerance to cereal cyst nematode and testing of the interstate wheat variety trial entries for resistance and tolerance.	WRC
The development of plant tissue culture techniques to aid disease resistance breeding in barley.	BRCSA
TOTAL, CROP IMPROVEMENT	**$533,430**

2. CROP PRODUCTION	
Project	**Funding Source**
A study of seeder related crop establishment factors.	WRCSA
Nutritional status of mallee cereals.	WRCSA
Improved bases for predicting economic application rates of nitrogen fertiliser for increasing the yield and quality of wheat and barley.	WRCSA, TOP AUSTRALIA LTD
Residual benefits of fertiliser zinc applied to S.A. soils.	WRCSA
Phosphorus fertilisation in wheat-pasture rotations.	WRC
Producing consistent prime soft wheat quality.	WRC
TOTAL, CROP PRODUCTION	**$217,279**

3. CROP PROTECTION	
Project	**Funding Source**
Investigation of resistance in cereals to root rots (1).	WRCSA
Control of leaf and stem diseases of wheat (1).	WRCSA
Management of *Rhizoctonia* bare patch using modifications to tillage and sowing machinery and systems.	WRCSA & NSCP
Adoption of new CCN resistant wheat (7).	WRCSA
Root and crown diseases posters (7).	WRCSA
Chemical control of the weevil *Polyphrades laetus*.	WRCSA
Strychnine residue levels in cereal crops.	WRCSA
Impact of herbicides on the nutritional of status wheat and medic.	WRCSA
Control of difficult weeds in wheat rotations.	WRCSA
Control of stem nematode.	WRCSA
CCN resistance and tolerance assessment (1).	WRC
The development of a diagnostic service for the detection of cereal cyst nematode (CCN).	WRC
Cereal leaf diseases book (7).	WRC
Design and evaluation of an air assisted bluff plate spray boom.	WRC
Control of difficult weeds in barley rotations.	BRCSA
Upgrading field crop pathology equipment.	BRCSA
Field Screening for CCN resistance (1).	BRCSA
Application of monoclonal antibodies for the development of an assay for rhizoctonia.	BRC
TOTAL, CROP PROTECTION	**$680,281**

4. FARMING SYSTEMS AND MANAGEMENT	
Project	**Funding Source**
The Tarlee crop rotation trial	WRC
Conservation tillage and stubble systems, improved rainfall infiltration, and sustainable crop production	BRC
TOTAL, FARMING SYSTEMS AND MANAGEMENT	**$24,745**

5. STORAGE, HANDLING AND TRANSPORT

6. PRODUCTS

7. COMMUNICATIONS AND TRAINING

(See projects superscripted (7), above)

8. LEGISLATION AND POLICY

TOTAL ALLOCATIONS	**$1,455,735**
of which:	
WRCSA	870,879
WRC	313,476
BRCSA	172,863
BRC	24,098
TOP AUSTRALIA	14,942
NSCP	59,477

NOTES

1. $ Value of new projects is subject to variation, mainly due to negotiations over 20% Salary on-costs claims, currently in progress.

APPENDIX 8B (i)

UNIVERSITY OF ADELAIDE WAITE CAMPUS

External Funding for Major Projects Directly Related to Wheat Growing 1990/91

PROJECT	Funding Source
General selection markers for the transformation of Eukaryotes and their application to the winter cereals	ARC
Molecular interactions during the establishment of mycorrhizal infection	ARC
Biological chemistry of 'Takeall' and high performance electrophoresis	ARC
Induction of homologous pairing between wheat and barley chromosomes and isolation of wheat-barley recombinant lines	ARC
Control of starch synthesis in the developing endosperm of wheat: the plasmalemma and the amyloplast envelope as possible regulatory sites	ARC
Development of high protein germplasm in Australian bread wheats	WRC
Annual ryegrass resistant to herbicides	WRC
Induction of wheat-rye recombination to overcome sticky dough problem associated with 1bl.1rs translocation in wheat	WRC
Development of molecular markers for chromosome 6R of rye linked to CCN resistance	WRC
Genetic links between resistance to root diseases and trace elements deficiency in wheat	WRC
Genetic variation between populations of take-all fungus *Gaeumannomyces graminis*	WRC
Barley yellow dwarf virus in low rainfall wheatbelt of S.A.	WRC
Wheat anther culture	WRC
Genetic analysis and agricultural evaluation of highly boron-tolerant varieties (tolerances greater than that in Halberd)	WRC
Introgression of agronomic characters from *Aegilops ventricosa* into wheat	WRC
Amelioration of structurally degraded soils using calcium and organic materials	WRC
Identification and use of polypeptide markers for CCN resistance in wheat	WRC

PROJECT	Funding Source
Genetically enhanced grain protein in wheat : development of germplasm and screening procedures	WRC
Molecular probes as markers for wheat breeding	WRC
Relation between HPLC protein profile and the bread-making quality of flour	WRC
Mechanisms of herbicide resistance in annual ryegrass and wildoats	WRC
Breeding for characteristics controlled by major genes	WRCSA
Developing take-all resistant wheats using rye germplasm	WRCSA
Structural amelioration using gypsum and/or lime	WRCSA
The residual value of nitrogen fertiliser	WRCSA
The biology of *Pratylenchus minyus* and its role in root damage	WRCSA
Practical methods for combating herbicide resistance in annual ryegrass	WRCSA
Wheat breeding	WRCSA
The use of isogenic lines for developing a grain analysis test for recommendation of boron tolerant wheat varieties	WRCSA
Trace element limitations to wheat production	WRCSA
Rhizoctonia and zinc deficiency in wheat	WRCSA
Epidemiology of BYDV transmitting aphids in S.A.	WRCSA
Transfer of CCN resistance from rye chromosome 6R into wheat	WRCSA
Better legume pastures for more profitable cereal crops	BRCSA
Development of an improved digestion technique to enable the determination of nitrogen by ICP	BRCSA
Physiological basis of multiple herbicide resistance in annual ryegrass	BRCSA
Annual ryegrass resistant to herbicides	BRC

APPENDIX 8B (ii)
UNIVERSITY OF ADELAIDE ROSEWORTHY CAMPUS

External Funding for Major Projects Directly Related to Growing Wheat, 1990/91

PROJECT	Funding Source
Biological Farming for Agricultural Production	NSCP WRC
Controlled Traffic Cropping Systems	BRC, WRC ORC, GLRC
Wheat Breeding	MFE WRCSA
Evaluating Wheat Genotypes at Remote Sites	WRCSA
Determining ways of extending the optimum sowing period of wheat	WRC

APPENDIX 8C

CSIRO DIVISION OF SOILS
(Adelaide Laboratories)

Major Projects Directly Related to Growing Wheat 1990/91

PROJECT
Occurrence and management of boron toxicity and deficiency in Australian soils
Nitrogen cycling and soil organic matter turnover in agro ecosystems
Clay-organic complexes in cereal soils
Ultrastructure of soils and roots in relation to soil stability and root biology
Development of sustainable agriculture systems through control of root diseases
Soil physical factors and the ecology of soilborne root diseases
Control of soilborne diseases of cereals and horticultural crops using soil bacteria
Suppression of soilborne root diseases of wheat by crop and soil management
Management of earthworms to enhance the long-term productivity of soils in S.E. Australia
Soil and landscape processes affecting dryland salinity, waterlogging and abrasiveness

APPENDIX 9.

ACRONYMS

ARC	-	Australian Research Council
BRC	-	Barley Research Council
BRCSA	-	Barley Research Committee for South Australia
GLRC	-	Grain Legumes Research Council
MFE	-	Minister of Further Education, miscellaneous grants
NSCP	-	National Soils Conservation Program
ORC	-	Oilseeds Research Council
RIRDC	-	Rural Industry Research and Development Council
WRC	-	Wheat Research Council
WRCSA	-	Wheat Research Committee for South Australia