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FARMERS' ADOPTION OF PRACTICES TO INCREASE PROTEIN OF ASW WHEAT

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The objectives of this paper are to identify the characteristics of innovative wheat farmers in the Central Wheat Belt of Western Australia, their perceptions of wheat protein issues, and their adoption of practices to increase the protein of ASW wheat. Diffusion of Innovation theory was used to gain an understanding of why and how farmers were trying to increase ASW protein. While this theoretical framework has been used extensively in looking at farmers' adoption of practices to change the quantitative outcome of their farming endeavours (ie, yield enhancing technology), in this study, the innovations in question were meant to have a qualitative outcome (increase the protein content of wheat).

Wheat Protein

The issue of increasing the level of ASW (Australian Standard White) wheat protein has implications along the wheat marketing chain. For example, producers' objectives have expanded from increasing yield alone to increasing both yield and protein, and agents involved in distribution are undertaking the segregation of wheat into appropriate categories to meet the requirements of niche markets.

The Australian Wheat Board (AWB) has been able to supply a range of markets because of the range of wheats it has to offer. This has resulted in a greater emphasis on quality, and on the AWB's ability to source wheat which has a particular end use, in order to maximise returns (McDougall 1994).

Western Australian wheat growers produced approximately half of the nation's crop in the 1993-94 harvest. There was however a significant difference in the quality which each grower produced. Thirty-seven percent of Western Australia's wheat produced from 1991/92 to 1993/94 had a protein content greater than 10 % (GRDC 1994).

Higher protein wheats are used in the production of higher quality bread products. According to McDougall (1994), wheat to be accepted into the ASW wheat grade needs to have a protein level of 10.0% to 11.5% for end uses such as flat breads, instant noodles, yellow alkaline noodle, steam bread and pan breads. The introduction of improved protein measurement at the point of wheat delivery means protein is one of the easiest quality specifications for buyers to fix on in their effort to produce quality products (Nicol 1994).

Prior to 1991 growers were not encouraged with price incentives to attempt to increase ASW wheat protein levels. A protein bonus system initiated in 1991 has seen an increased return to farmers for wheat over 10% protein and a discount on wheat below 10% protein.

Prior to the introduction of premium payments for protein, the pooling system prevented price signals from being directed back to the producers of higher protein wheat (Brennan et al 1993). Markets are still available for ASW wheats with protein below nine per cent but at a discounted price. Wheat that has less than 10% protein will now be sought only by less quality conscious buyers with price as their principal consideration (Nicol 1994 v).

As part of an industry push to alert wheat growers to the need to grow quality wheat and obtain premium payments, the Australian Wheat Board launched a campaign in 1994 to challenge farmers to achieve an average crop yield of two tonnes per hectare of 10% protein by the year 2000. The scheme, entitled "Two by Ten by 2000", is intended to pass on the signals AWB is receiving from world wheat markets.

The environment in which the wheat crop is grown has a large effect on the final protein content of wheat. Higher temperatures, deficiencies of water, and sufficient nitrogen during grain filling result in higher protein content (Crosbie and Fisher 1987). Of these three influences on wheat protein, only available nitrogen can be manipulated by the farmer.

Adoption of appropriate agronomic practices is required if farmers are to increase their wheat protein. Practices, developed by the Department Agriculture of Western Australia for farmers to produce high yielding wheat, have been modified to fulfil the requirement to achieve high protein.

As a short-term strategy to increase protein levels in ASW, options available to farmers include selection of soils with higher nitrogen levels, increasing the level of fertiliser nitrogen applied to the crop, and improving grass control to reduce competition for nitrogen supplies (Crosbie and Fisher 1987).

Over a longer period, the use of a pasture or grain legume rotation increases the level of organic nitrogen in the soil. Mason (1987) pointed out that "wheat protein level will be increased under a long legume pasture phase of the rotation so that soil nitrogen levels are built up far higher than is required to supply the growth needs of a wheat crop". The effect of a grain legume crop is similar, with farmers choosing the appropriate rotation according to profitability and suitability to each soil type.

Diffusion of Innovations

Agricultural scientists and farmers have long been involved in improving the productivity of agriculture. Through experimentation, innovation and education, improvements are constantly occurring in agricultural technology, agricultural practices and management (Coelli and Kingwell 1992). The adoption of innovations is often characterised by lengthy periods from the time when they first become available, to the time when they are widely adopted.

Research on the diffusion of technical innovations has tended to focus attention on the characteristics of the innovation itself and of the adopting firm. The basic tenet of this conceptualisation of the spread of an innovation is that the adoption of an innovation is primarily the outcome of a learning or communications process. Therefore, a fundamental step in examining the process of diffusion is identifying factors related to the effective flow of information, the characteristics of information flows, and information reception and resistance to adoption (Rogers 1983).

Methodology

To gather information for the study, a census of 220 farming enterprises in the Narembeen and Quairading Shires in the Central Wheatbelt region of Western Australia was conducted. A mail questionnaire was used to collect the data. The questionnaire was posted after farmers had completed their crop sowing programmes for 1994. At the time of mailing the questionnaire, wheat crops were well established, which allowed farmers to evaluate their potential yields and protein target.

All of the farmers selected for the survey deliver wheat to the AWB and were drawn from the Australian Wheat Board's database of growers in the Quairading and Narembeen postcodes. Wheat is grown throughout both shires.

Information collected included area of wheat sown, wheat production, whether practices had been modified to increase ASW wheat protein, and the practices used to

increase protein. Information gathered regarding the farmer and farm characteristics included practices adopted in the farm business, membership of farmer organisations, sources of agricultural information, size of farm and tenure, and sources of farm income. Demographic information was also collected.

A response rate of 45 % was achieved, with 99 useable questionnaires being returned.

Results

A series of questions was asked to first gauge the farmers' "perceptions" regarding growing high protein wheat and to determine what "actions" farmers had taken to increase the protein level of their wheat.

Farmers were asked to rank statements about growing higher protein wheat in terms of agreement and disagreement. In response to the statement that "growing higher protein ASW wheat was profitable", 67% of the respondents agreed and 8% disagreed, with 26% undecided (see Table 1). The farmers were also asked if they perceived that growing higher protein wheat was "not worth the extra income," to which 16% agreed and 53% disagreed, with 32% undecided.

Twenty-seven percent of the farmers agreed with the statement that growing higher protein wheat was too difficult, and 45% disagreed with this statement, while 27% were undecided. Thirty-five percent agreed with the statement that growing higher protein wheat was too demanding on resources while 32% disagreed, and 31 % were undecided.

Farmers were asked if they had modified their crop management practices to increase wheat protein (see Table 2). Eighty-one percent of the farmers had modified practices to increase wheat protein. Farmers who had modified their management practices to increase the protein level of their ASW wheat were asked what barriers they believe were preventing them from further increasing the level of protein. A list of six barriers that farmers commonly identify for not producing high protein ASW was constructed to see how widespread the barriers were considered (see Table 3). The group of barriers that may be categorised as "uncontrollable" had the highest number of responses (rainfall, 70%, economics, 63%, soil type, 60%). The group of barriers definable as "controllable" had fewer affirmative responses (rotation, 49%, varieties, 44%, technical knowledge, 27%).

Those farmers who had modified their crop management practices were also asked to indicate the year they first attempted to increase ASW protein levels. A range of years from 1989 to 1994 was given, since 1989 was the first year that premium payments for protein were introduced. Eleven percent of the farmers first tried to modify their practices in or before 1989. From 1990 through 1994, the percent of farmers modifying their practices increased each year, as is indicated by Figure 1.

Farmers who indicated that they had modified management practices to increase protein were asked what practices they had used in preparation for and management of their 1994 wheat crop. A list of five agronomic practices recommended by the Western Australian Department of Agriculture was compiled along with the practice of sowing later (see Table 5). Later sowing was not recommended by the Western Australian Department of Agriculture but was suggested in some areas of the industry. While late sowing is effective in increasing protein, the yield potential of the wheat crop is limited.

Short term measures were the most popular methods of increasing protein. Increasing nitrogen fertilisers was the most popular, with 87% using this method. Improving grass control was also used extensively, with only slightly fewer farmers (84%) using this practice than were using nitrogen fertilisers. Longer term strategies of sowing more grain legumes (51%) and improving legume pastures (64%) were undertaken by several farmers. Sowing wheat later was not used widely, with only 20% of farmers undertaking the practice. Some farmers did note in the survey that they sowed later due to the season breaking late, rather than as a deliberate strategy.

A "protein adoption score" was calculated to indicate the number of practices adopted. This calculation involved dividing the number of practices adopted by the total number of practices available. Forty-nine percent of the farmers obtained a score of 0.50 or greater (see Table 6).

Recent innovations in the growing of wheat were collated to form a list of ten practices available for wheat growers to adopt. During analysis, this list was used to create a "general innovation adoption score" which would indicate a farmer's general tendency to adopt innovations (see Table 7). The score was calculated by dividing the number of practices the farmer had adopted by the total number of practices listed. Sixty-six percent of the farmers had scores of 0.50 or greater.

Respondents were classified into two groups to determine if farmers who adopted practices to increase ASW wheat protein earlier could be distinguished from those who were later to adopt or had not yet adopted. Innovators (early adopters) were defined as those who adopted between 1990 and 1993, this being the period after the introduction of protein payments in 1989. Table 8 and Table 9 compare the characteristics of the innovators and their farms to the remainder of the population.

Table 8 shows that innovators were younger than other respondents and had a slightly higher level of education. The majority of innovators were members of farm management organisations and were more likely to have been an office bearer of a farm organisation of which they were a member. While innovators had higher protein and general adoption scores than the remainder of the respondents, only the protein adoption score was statistically significant (see Table 11).

Table 9 shows innovators as having had larger farms and sowing a slightly higher percentage of their farm to wheat, of which ASW was a higher proportion. Importantly, innovators had a higher proportion of their wheat 10 % protein or greater. Innovators also earned a higher percentage of gross income from wheat.

The source of information preferred by the farmers was analysed according to adopter category. The highest rated information source was "Rural Newspapers and Magazines". All innovators rated rural newspapers and magazines as a good source of information, with 94.4 % of the remainder also rating them as a good source. "Neighbours or friends" was rated as second best by the remainder while "radio" was rated second by innovators. "Private consultants" and "farm input company representatives" were rated significantly higher by innovators. All other sources of information were rated similarly between groups (see Table 12).

Table 1. Farmers' Perceptions Regarding Increasing Protein Content of ASW Wheat

perception	total	percent
"Profitable"		
agree	65	67
undecided	26	26
disagree	8	8
"Not Worth Extra Income"		
agree	16	16
undecided	32	32
disagree	52	53
"Too Demanding on Resources"		
agree	35	36
undecided	32	32
disagree	32	32
"Too Difficult"		
agree	27	27
undecided	27	27
disagree	45	46

Table 2. Modification of Practices to Increase ASW Wheat Protein

modified practices	number of farmers	percent
no	18	18
yes	81	82

Table 3. Barriers to Further Increasing ASW Wheat Protein as Perceived by Farmers who had Modified Practices

barriers	number of farmers	percent
<u>uncontrollable</u>		
rainfall	57	70
soil type	49	60
economics	51	63
<u>controllable</u>		
rotation	40	49
varieties	36	44
technical knowledge	22	27

Table 4. Year First Attempts Were Made to Increase ASW Wheat Protein

year increase in wheat protein first attempted	number of farmers who had modified practices (percent in parenthesis)	percent of all respondents
1989 or before	11 (14%)	11
1990	4 (5%)	5
1991	9 (11%)	9
1992	10 (12%)	10
1993	22 (27%)	22
1994	25 (31%)	25

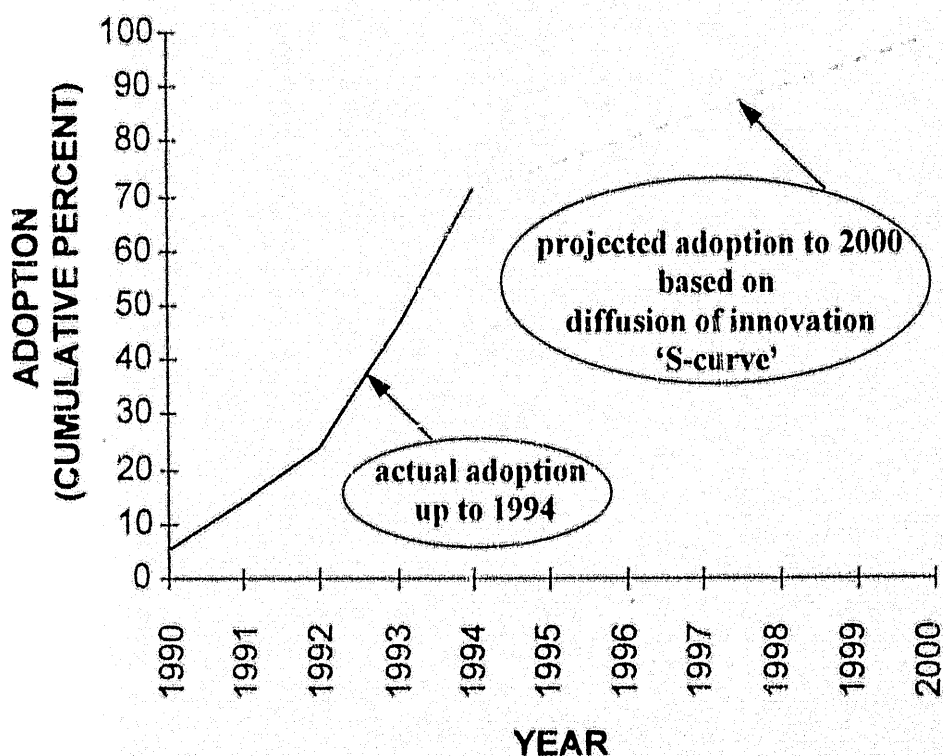


Figure 1. Cumulative Adoption of Practices to Increase ASW Wheat Protein

Table 5. Practices Adopted to Increase Wheat Protein

practices adopted	number of farmers who had modified practices	percent
<u>short term</u>		
increase nitrogen fertiliser	71	87
improve grass control	68	84
sowed later	16	20
<u>long term</u>		
improve legume pastures	41	51
sow more grain legumes	52	64
use selected soil types	19	23

Table 6. Protein Adoption Score for all Respondents

score (practices adopted / practices available)	number	percent
0 00	19	19
0 17	9	9
0 33	22	23
0 50	24	24
0 67	22	23
0 83	3	3
1 00	0	0

Table 7. General Wheat Production Practice Adoption Score for all Respondents

adoption score	number	percent
0 00	5	5
0 10	5	5
0.20	5	5
0 30	4	4
0.40	14	14
0 50	23	23
0.60	13	13
0.70	17	17
0 80	10	10
0.90	3	3
1 00	0	0

Table 8. Farmer Profile by Adopter Category

characteristic	adopter category			
	innovator		rest	
	number	percent	number	percent
age (mean years)	42.4	n/a	44	n/a
highest education level				
year 10 or less	22	49	29	54
more than year 10	23	51	25	46
Farm Organisations				
non-member	11	24	29	54
member	34	76	25	46
recent office bearer	17	39	11	19
Protein Adoption Score	0.47	n/a	0.34	n/a
General Adoption Score	0.56	n/a	0.50	n/a

Table 9. Farm Profile by Adopter Category

farm characteristic	adopter category	
	innovator	rest
total area farmed (mean hectares)	2779.3	2511.5
percentage of farm owned	90.5	93.43
percentage of total area in wheat	35.9	34.4
percentage of wheat area in ASW	70	67
tonnes of ASW in 93/94 season (mean)	1661	1584
percentage of 93/94 crop with protein of 10% or greater	38	31
percentage of gross income from wheat	57	54

Table 10. Preferred Information Sources by Adopter Category

information source	adopter category			
	innovator		rest	
	number	percent	number	percent
rural newspapers/magazines	45	100	51	96
radio	41	91	46	85
neighbours/friends	40	89	48	89
Department of Agriculture <i>farmnotes</i>	39	87	45	83
input company representatives	36	80	34	63
mailed pamphlets	35	79	46	85
family member	34	76	39	72
Department of Agriculture books	34	76	42	78
Department of Agriculture staff	34	76	39	72
private consultants	34	76	29	54
social occasions	34	76	41	76
marketing organisation	28	62	33	61
farm industry organisation	27	60	32	59
information cassettes	24	53	25	46
television	21	47	31	57
universities	7	16	9	17

Table 11. T-test of Significance Between Adopter Categories

Characteristic	Innovators	Rest	Mean Difference	T-value	Level of Significance
age	42.4	44	-1.6	0.092	0.762
protein adoption score	0.47	0.34	0.13	9.409	0.003**
general adoption score	0.55	0.49	0.06	0.617	0.434
area farmed (hectares)	2779	2511	267.7	0.140	0.709
% farm owned	90.5	93.4	-2.9	1.145	0.287
% total area in wheat	35.9	34.3	1.6	0.130	0.719
% total wheat ASW	69.7	67.4	2.3	0.183	0.670
tonnes wheat produced	1661.3	1584.1	77.2	0.145	0.704
% gross income wheat	56.9	53.8	3.1	9.149	0.003**

** Significant at 95%.

Table 12. Chi-Square Test for Significance Between Adopter Categories

Characteristic	Number		Chi-Square Value	Level of Significance
	Innovators	Rest		
50% or more of wheat 10% protein	29	36	0.0111	0.91
<u>Sources of Information</u>				
television	21	31	0.5996	0.44
rural newspapers/magazines	45	51	5.0329	0.02 **
radio	41	46	2.1723	0.14
mailed pamphlets	35	46	0.1315	0.72
information cassettes	24	25	0.9042	0.34
neighbours or friends	40	48	0.4648	0.50
family members	34	39	0.6292	0.43
social occasions	34	41	0.1699	0.68
Department of Agriculture staff	34	39	0.6291	0.43
Department of Agriculture <i>Farmnotes</i>	39	45	1.0311	0.31
Department of Agriculture books	34	42	0.0464	0.83
private consultants	34	29	6.4851	0.01 **
farm industry organisations	27	32	0.1536	0.70
marketing organisations	28	33	0.1959	0.66
farm input company reps	36	34	4.8373	0.03 **
universities	7	9	0.0010	0.97
<u>farmer characteristics</u>				
education (≤ 10 years)	22	29	0.1513	0.70
farm organisation				
office bearer	17	11	4.3120	0.04 **
member	34	25	8.3114	0.00 **
<u>perceptions</u>				
profitable	29	36	0.0180	0.89
not worth the extra income	7	9	0.0010	0.97
too demanding on resources	15	20	0.0343	0.85
too difficult	14	13	0.8909	0.34

** Significant at 95%.

Conclusion

The purpose of this paper was to determine the relationship between socio-economic characteristics of farmers and their adoption of practices to achieve a 'qualitative' production objective, increasing the protein content of ASW wheat. Diffusion of Innovation theory was used here to gain an understanding of why and how some people are trying to increase ASW protein.

Farmers who responded to the survey were classified as "innovators" based on when they first altered their management practices. Those who did so between 1990 and 1993 were innovators.

Differences in the membership of farm management organisations was statistically different between adopter categories. Among innovators there was a higher percentage of farmers who were members of farm management organisations.

The average age of farmers classified as innovators, while not being statistically significant, was less than the rest of the respondents. It should be noted that farmers who adopted agronomic practices to increase ASW protein early after introduction of protein payments, would have adopted at a younger age than their age at the time of the survey. Innovators had a slightly higher level of education.

Innovators had slightly larger farms. They also had a slightly higher percentage of their farms in wheat, and a higher percentage of their wheat was ASW. Innovators produced more wheat in the 1993/94 season and had a higher proportion of ASW wheat with a protein level of ten percent or greater. Innovators did own marginally less of their farms compared to later adopters, however it was not statistically different.

Gross income from wheat as a proportion of all farm income was statistically different between adopter categories. This was partly due to the higher proportion of the farm being planted to wheat. It would appear that farmers who were more specialised in wheat production had been more inclined to adopt practices to increase ASW protein levels.

A general adoption score was constructed to identify practices that farmers were currently using on their properties. The general adoption score was based on recent innovations related to cropping, with the exception of pasture manipulation/spraytopping which was related to both cropping and livestock production. While not covering all conceivable innovations, it gives an indication of the innovativeness of the farmers who responded and was able to link general innovativeness to the adoption of practices to increase ASW protein. Farmers who were classified as innovators based on early adoption of practices to increase protein had a higher general adoption score than the rest of the respondents. This difference was not statistically significant.

The innovators adopted the recommended practices to a greater extent than the rest of the respondents. They had a higher protein adoption score which reflected their adoption of more practices to increase ASW protein. This was statistically significant between the two groups. Not only did the innovators adopt practices earlier in an attempt to increase ASW protein, but in the years following the introduction of protein price premiums, they also undertook a wider range of practices.

Many farmers were increasing nitrogen rates and improving grass control in an effort to increase wheat protein. To a lesser extent, farmers were improving legume pastures and sowing more grain legumes as a long term strategy to increasing soil nitrogen.

levels. The census did show that only a small percentage of farmers sowed their ASW later in an effort to increase protein.

A farmer's perception of an innovation affects the rate of adoption with favourable perception leading to faster rates of adoption. Barriers that farmers were unable to control were perceived as limiting, more so than barriers which they can control.

Many farmers viewed growing higher protein ASW as being profitable, however fewer farmers viewed it as being worth the extra income. Farmers recognise the financial rewards of producing higher protein ASW, but believe the extra effort involved was not worth the extra income. In terms of marginal economic analysis, it would seem that the marginal (explicit and implicit) cost of producing higher protein wheat may be perceived as being greater than the marginal revenue. This may suggest that if premium payments for protein were increased then more farmers would be prepared to increase protein due to the higher financial incentive.

Innovators rated all communication sources as a good source of information more than the rest of the respondents. This suggests that innovators found sources of information, as a whole, more useful. The preferred communication channel of all farmers was rural newspapers and magazines. Innovators in particular rated rural newspapers and magazines highly with 100 % believing they were a good source of information.

Private consultants and farm input company representatives were rated as a good source of information by more innovators than the remainder of the respondents. More contact with change agents is a characteristic identified with innovators according to Diffusion of Innovation theory.

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