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Explaining adoption of durum wheat in Western Australia

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1. Abstract

Despite efforts at development and extension, the durum wheat industry in Western Australia remains small. In this study, data from a survey of Western Australian grain growers are used to characterise the use and perceptions of durum wheat. The main objective was to identify opportunities for extension to increase the level of durum wheat adoption throughout the grain growing regions of Western Australia. Perceptions of durum wheat characteristics were elicited along with other variables used to model the economic value of durum wheat in the local cropping system. Logistic regression analysis found that perceptions of the yield potential were most influential, with almost half of respondents believing current durum wheat varieties were unsuitable for Western Australian conditions. Perceptions of durum rust resistance were also significant in the adoption decision. Informational variables were shown to be of influence; however, critically, past use was not a significant predictor of future use. Before broad extension and promotion of the trialing of durum can be successful, efforts in Western Australia will need to focus on research to ensure that early adopters of durum wheat can generate positive messages relating to yield and profitability.

2. Introduction

Durum wheat (*Triticum turgidum var.durum*) is closely related to bread wheat (*T. aestivum*) and is grown mainly for processing into semolina for the manufacture of pasta. Adoption levels of durum wheat in Western Australia have failed to reach the levels seen in the eastern states of Australia. According to estimates made by the Department of Agriculture, Western Australia is capable of producing at least 0.5 million tons of durum wheat when the industry matures (Impiglia, 2000). This figure was based on the estimated 3 million hectares of land in South Western Australia that is

deemed suitable for growing durum wheat. Despite these positive estimates for the Western Australian durum wheat industry, production levels remained very low (Table 1), with production of 4000 and 3900 tonnes in 2000 and 2001, compared to 5.8 and 7.8 million tonnes of wheat in those same seasons prior to the 2002 drought. More recent production has also remained low (Table 1).

Table 1: Total Western Australian durum wheat production figures 1998-2005 (from WA Department of Agriculture and Food).

Season	Total durum production (tons)
98/99	1200
99/00	6100
00/01	4000
01/02	3900
02/03	<1000
03/04	8108
04/05	2229
05/06	2509

Studies have shown that farmer perceptions of innovation characteristics can have a significant influence on a farmer's adoption decision (Adesina and Baidu-Forson, 1995; Negatu and Parikh, 1999). One distinguishing aspect of an innovation characteristic is profitability. Since the pioneering work by Griliches (1960), innovation profitability has since been identified as perhaps the single most important determinant in the final adoption decision (Lindner, 1987).

Farmer perceptions of characteristics likely to affect the perceived profitability of an innovation can be identified. Where such perceptions are found to be influential in the adoption decision and there is scope for information to influence the perceptions (learning) they can be effectively targeted in an extension program (Llewellyn et al 2005). This targeted information-learning approach will lead to more informed adoption decisions but not necessarily adoption; the final decision to grow durum being largely dependent on actual profitability informing perceptions of profitability.

The study presented here stems from interest in the potential for development and extension activities to lead to growth in the durum industry from the Department of Agriculture and Food Western Australia, which was already running a durum industry development project, and grain marketer AWB Ltd. The objective of the study was to identify any opportunities for more effective targeting of extension in developing the durum wheat industry. An economic approach to considering durum adoption is presented followed by data on adoption and perceptions of durum wheat from a survey of Western Australian grain growers. Factors found to be influential in the adoption decision using logistic regression analysis of this are presented, followed by implications for durum wheat research, development and extension in Western Australia.

3. Durum wheat adoption model

It is assumed that adoption decisions are made based upon the utility of innovation use. This study takes the approach used by Abadi Ghadim and Pannell (1999) in which a new cropping enterprise needs to offer greater utility than existing cropping options that could be grown on the land. Therefore in the case of durum wheat, a farmer is expected to adopt when the expected utility (EU) of the durum wheat is greater than the utility of bread wheat on a suitable management area of the farm (1). A farmer's utility function consists of a range of factors, including perceptions of characteristics influencing profitability (see Batz et al., 1999) and other variables as described in the previous section.

Wheat is typically grown in the cropping belt of Western Australia stretching from Esperance to Geraldton. Bread wheat is one of the chief products of Western Australian agriculture. Farms in this area are typically large with most ranging from 1000 to 5000 hectares.

As with bread wheat, there is a price differential paid for durum which varies according to the grain protein level. The prices for durum wheat are consistently higher than those for bread wheat (www.awb.com.au). In order to maximise the protein level in the grain growers can choose clay or clay loam soils and often either apply nitrogen to the crop or include a nitrogen-fixing legume crop in the rotation (Impiglia, 2000).

In the utility equation below bread wheat is the alternative to durum wheat in the post-legume crop phase of the rotation where increased grain protein levels are more likely.

Therefore:

$A_D > 0$ if $EU_D > EU_B$ (1)

And:

$EU = f(T, G, F, I)$ (2)

Where:

A_D = area of land allocated to durum wheat

EU_D is the expected utility of growing durum wheat

EU_B is the expected utility of growing bread wheat,

T = vector of perceived durum wheat characteristics

G = vector of farmer characteristics

F = farming system characteristics

I = vector of informational variables

Perceived durum wheat characteristics include perceptions of its on farm performance, and economic value relative to the bread wheat. Perceptions of innovation characteristics have been shown to be significant in influencing the adoption decision (Adesina and Zinnah, 1993; Negatu and Parikh, 1999; Adesina and Baidu-Forson, 1995). Farmer characteristics include age and experience. Here experience refers to whether or not a farmer has grown durum wheat in the past.

Farming system characteristics include factors such as the current cropping schedule, farm size, and soil type. These will determine how well durum wheat will fit in with the current farming system. Informational factors include the number of neighbours known to the farmer that have grown durum wheat in the past and extension variables. Learning is an important aspect of the adoption decision therefore the amount of information a farmer has access to can influence the adoption decision (Marsh et al., 2000; Fischer et al., 1996; Feder and Slade, 1984

3. Methods

Survey of grain growers

A survey was developed based on a fully specified questionnaire and informed by a scoping survey conducted at four cropping information days held in February 2004. The scoping survey highlighted the relatively low level of adoption and land area sown to durum by adopters, and the relative uncertainty about the durum industry and agronomy compared to traditional bread wheats. The main survey was conducted by mail after crop sowing in mid August 2004. The questionnaire was sent to 253 farmers included on a database from the Department of Agriculture. Farmers on this database were either past adopters, growers that had expressed some interest in growing durum in the coming season, or are growing durum this season. The survey response rate was 24.1%

Measuring durum wheat adoption

Past use was measured by asking growers whether or not they had grown durum wheat prior to the 2004 cropping season. Growers were also asked about their intended future use of durum wheat for the following three seasons, beginning with the year after the survey was conducted (2004). Future intended use was measured as a percentage of a growers total arable area.

The feasibility of successful durum wheat production depends upon factors such as rotation and soil type. For durum wheat, price differentials are paid depending on the grain protein level. Growers can increase the grain protein level with the addition of nitrogen or a good legume crop rotation can increase the nitrogen levels in the soil by fixing atmospheric nitrogen. Growers were therefore asked about the percentage of total arable area on their farm sown to legume crops in 2004.

Durum wheat in Western Australia is best grown on red clay loam soils with neutral or alkaline pH (DAWA, 2000). Growers were therefore asked about the percentage of total arable area on their farm that is red clay loam. Perceptions of the proportion of their land suitable for durum production were also elicited by asking farmers to estimate the percentage of the total arable area which has soil suitable for growing durum wheat

Measuring perceptions

Grower perceptions of durum wheat characteristics relating to the economic value of durum relative to bread wheat were elicited using two methods. The first method involved asking growers to estimate the expected yield and protein level of durum wheat and bread wheat if they were grown on the best wheat paddock on their farm. Perceptions of price and gross margins were also elicited using this method. Growers were asked to estimate the expected gross margin and price received for durum wheat if the gross margins and price received for bread wheat were $230/ha and $230 respectively.

The second elicitation method used a Likert attitudinal scale. The scale ranged from 1 to 7, with 1 being strongly agree and 7 being strongly disagree. It was assumed that 4 indicated a neutral attitude. Using this scale growers were asked to indicate their attitude towards a number of statements regarding durum wheat characteristics relating to its economic value. These characteristics include perceptions of yield, price, expected grain protein levels and gross margins all relative to bread wheat. Perceptions of the disease characteristics of durum wheat, distance, suitability of current varieties for WA conditions and the importance of extension information were also elicited using the Likert scale.

Measuring information variables

Growers were asked about the number of extension events they had attended in the past year that had included information about Durum wheat. Growers were also asked about the number of neighbours they knew that had grown Durum in the past, and also whether or not they employ a cropping consultant to give advice about cropping.

Statistical model

A binary (adopt/not adopt) dependent variable was used in the adoption model. This reflects the primary interest of the study i.e. factors that might lead a farmer to decide to trial some durum on their own farm, rather than the factors that might lead a farmer to increase their area of durum. A logistic (logit) regression model using maximum-likelihood procedures was used to estimate the probability of durum adoption (P_D) i.e. $A_D > 0$. A logistic distribution is assumed, so the model can be described as:

$$P_D = \frac{1}{1 + e^{-f(T_i, G_i, F_i, J_i)}}$$

Marginal effects were used to examine absolute changes in the independent variable and their influence on the probability of adoption i.e. if there was a one unit increase in the independent variable. Elasticities were used to show the percentage change in the probability of adoption per one percent change in the dependent variable. In each case other variables remain at the mean.

4. Results

Grower and farm system characteristics

Of the respondents 64% had grown some durum wheat in the past. The average grower's age was in the range 44-55 years, with a farm size of 3239 ha and an average annual rainfall of 337 mm. Table 2 gives an indication of the current and intended intensity of durum wheat adoption for past adopters and non-adopters. Less than 30% of growers who had grown durum in the past intended to grow durum in the future.

Table 2: Current and intended intensity of durum wheat adoption by past and non-adopters of durum wheat

	Past adopter[1]	**Non-adopters[2]**
Percent of growers growing durum this season	29	0
Average % of arable area in crop to durum this season (2004) [3]	5.6	0
Percent of growers expecting to be growing some durum in next season	26	17
Percent of growers expecting to be growing some durum in next three years	26	26
Average % of arable area growers expect to crop with durum next season[3]	6.7	3.2
Average % of arable area growers expect to crop with durum in three years[3]	13	6

[1] – 38 past adopters included in the survey

[2] – 23 non-adopters included in the survey

[3] – Only includes growers that expect the % of arable area cropped to durum > 0

Table 3 shows the farm system characteristics of the growers surveyed. On average, 10% of a grower's total arable area was sown to legume crops this season with 75% of growers including legume crops on their farm. On average, grower perceptions of the proportion of his farm suitable to durum is similar to the proportion of their land with red clay loam which is the soil type most suited to growing durum. All of the growers surveyed stated that they considered at least some of their land suitable for growing durum wheat.

Table 3: Farm system characteristics of the farmers surveyed

	Average	**SD**	**# responses**
% of arable area sown to bread wheat	47.5	22.3	61
% of arable area sown to legumes	10.7	10.3	61
Perceived % of arable area with soil suitable for growing durum wheat	28.8	20.6	59
% of arable area with red clay loam	30.5	23.7	60

Table 4: Average yield, protein level, gross margin and price farmers expect to receive from durum and bread wheat if grown on their best wheat paddock

	Av expected yield (tonnes)	**Av expected grain protein level (%)**	**Av expected gross margins ($/ha) [a]**	Av expected price ($/t)[b]
Bread wheat (s.d.)	2.5 (0.82)	11.4 (1.6)	230	230
Durum wheat (s.d.)	2.0 (0.68)	12.3 (1.5)	234 (89.6)	265 (39.0)

[a] – If the gross margin of bread wheat was $230/t, N = 34

[b] – If the price received for bread wheat was $230/t, N = 37

Table 5: The % of farmers surveyed that perceived these variables of profitability are higher the same or less then for durum wheat compared to bread wheat on the same paddock

	Higher	**Same**	**Less**
Gross margins	45.2	9.7	45.2
Price	91.9	2.7	5.4
Yield	0	18.9	81.1
Protein %	53.4	26.9	9.6

Perceptions of profitability

As shown in Table 4 growers on average expect durum wheat to yield 0.5 t/ha less than bread wheat. None of the farmers surveyed perceived that durum wheat will yield higher than bread wheat. Growers expect the grain protein levels of durum wheat on their farm will be higher on average then the protein levels of bread wheat. Eighty percent of growers believe durum will have higher grain protein levels than bread wheat (Table 5).

The expected gross margin and price of durum wheat and bread wheat if grown on the best wheat paddock on their farm were also elicited from growers. Growers on average expected the price of durum wheat to be $35/tonne more at harvest than bread wheat. Growers were equally divided as to whether durum would have a greater or lower average gross margin than bread wheat (Table 5).

Perceived durum wheat characteristics

As shown in Table 6, almost half of those surveyed believe current durum wheat varieties are unsuitable for Western Australian conditions. Also shown are grower perceptions of the disease characteristics of durum wheat. The majority of growers surveyed agree that durum wheat is more resistant to rust diseases compared to bread wheat on their farm. Over fifty percent of growers surveyed agree that durum wheat is more susceptible to crown rot on their farm compared to bread wheat.

Table 6: Grower perceptions of durum wheat characteristics

Statement	% Agree	% Neutral	% Disagree
The current durum wheat varieties available are suitable for Western Australian conditions	21.0	31.6	47.4
Durum wheat is more resistant to rust than bread wheat on my farm.	61.8	27.3	10.9
Durum wheat is more susceptible to crown rot than bread wheat on my farm.	51.7	35.7	8.9

[1] – Attitudes were elicited using a Likert attitudinal scale from 1 to 7, with 1 being strongly agree, 4 assumed to be neutral and 7 strongly disagree

Regression analysis

Due to the limited number of response not all of independent variables measured could be included in the final regression analyses. The dependent variable also changed to estimate a grower's future intent of durum wheat adoption rather then their intended adoption in the following year. Logit regression analysis was used to empirically estimate the durum wheat adoption model presented earlier. Table 7 shows the summary statistics of the independent variables used in the regression analysis.

Table 7: Summary statistics of the variables used in the regression model

	Average	SD	Observations
Average farm size of the growers surveyed (ha)	3240	2694	59
Average % of soil suitable for growing durum	28.9	20.6	59
Expected yield ratio Durum : bread wheat	0.84	0.18	53
Expected protein ratio Durum : bread wheat	1.07	0.08	52

Table 8: Results from the Logit regression

Independent variable	Coef.	Std. Err.	Z	P> | z |
Perceptions of soil suitable for growing durum	0.054	0.034	1.62	0.106
Expected yield ratio Durum: bread wheat	9.18	4.05	2.26	**0.024
Expected protein ratio Durum : bread wheat	-8.41	7.56	-1.11	0.266
Perception of the rust resistance of durum relative to bread wheat	-1.67	0.73	-2.28	**0.022
Extension	0.82	0.41	2.00	**0.046
Past	1.24	1.63	0.76	0.449
Farm size	5.11E-4	2.9E-4	1.74	*0.082
Age	-0.77	0.64	-1.21	0.224
Constant	3.55	7.93	0.45	0.654
	Pseudo R^2 = 0.54		Log Likelihood = -14.09	

Statistical significance indicators: ** at 0.05, * at 0.1

Correct predictions: 84% (91% of adopters; 78% of non-adopters)

Probability of adoption = 0.47 at means

Results from the regression analysis are shown in Table 8, with 84% of growers correctly predicted as adopters or non-adopters. Perceptions of durum wheat yield relative to bread wheat had a large significant ($p< 0.05$) influence on a grower's adoption decision. Grower perceptions of the rust resistance of durum wheat on their farm compared to bread wheat had a significant influence on the adoption decision ($p< 0.05$). In other words if a grower has the perception that durum wheat is more resistant to rust then bread wheat on their farm then they are more likely to adopt. Of the statistically significant variables, a percentage change in the yield of durum wheat relative to bread wheat has the largest influence on the probability of adoption (Table 9).

Farm size, also significantly influences ($p< 0.1$) a grower's future adoption decision (Table 8). In terms of marginal effects, a percentage increase in a grower's total arable area is estimated to increase the probability of adoption by almost a percentage point (Table 9). The number of extension events a grower attends is significantly associated with the likelihood of a grower expecting to be a future adopter (Table 8). In terms of marginal effects, if a grower were to attend one more extension event that included information on durum then the probability of adoption will increase by 0.21 (Table 9). Past experience with durum wheat does not significantly increase the likelihood of future adoption of durum wheat (Table 8).

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Table 9: The effect of a one unit change in a single variable from the mean on the probability of adoption (dy/dx) and the percentage change in the probability of adoption resulting from a one percent change from the mean in a single variable (ey/ex)

Independent variable	dy/dx	ey/ex
Perceptions of soil suitable for growing durum	0.013	0.82
Expected yield ratio Durum : bread wheat **	2.28	4.06
Expected protein ratio Durum : bread wheat	-2.093	-4.77
Rust**	-0.417	-2.49
Extension**	0.21	0.64
Past	0.29	0.45
Farm size*	1.27E-4	0.94
Age	-0.19	-1.60

Statistical significance of variable in regression model: ** P<0.05; *P< 0.1

5. Discussion

The result that the growing of the crop in the past does not significantly explain future adoption has important implications for durum wheat extension in Western Australia and is cause for concern. The result suggests that broadly encouraging more growers to trial durum is not likely to be the most effective strategy until new adopters are more likely to generate a successful result. This result is in contrast to a 1994-1997 study of chickpea adoption in Western Australia (Abadi Ghadim et al 2005) which found positive learning by those trialing the chickpeas and past use to be a significant predictor of future use. In a diffusion study of the widely adopted new lupin varieties in Western Australia over the 80's and 90's, Marsh et al 2000 also concluded that past experience was an important factor in explaining adoption.

The results for durum presented in this paper suggest that the diffusion process is likely to stall unless new potential for profitability can be generated that leads to more positive experiences by early adopters. In the absence of substantial price rises, this will require improved crop performance. Currently the durum varieties used in WA are mainly bred for eastern states conditions. This is reflected in the results, with only 21% of growers agreeing that current durum varieties were suitable for Western Australian conditions.

However, the results show that extension activities relating to durum wheat are associated with increased likelihood of a grower trialling durum wheat. Knowledge of the industry and agronomy of durum wheat are currently relatively low, and perceptions of some beneficial characteristics such as rust resistance may be able to be effectively targeted in extension programs to allow for more

informed decision-making. Perceptions of durum's relative rust resistance were shown to be influential in the adoption decision. Durum wheat is typically resistant to the three rusts: stem rust (*Puccinia graminis*), leaf rust (*Puccinia recondite*) and stripe rust (*Puccinia striiformis*). The results suggest that the rust resistance of durum may not be fully recognised among non-adopters and extension relating to this characteristic could influence adoption decision-making.

6. Conclusion

Current perceptions of durum wheat suggest that the traditional diffusion model based on information disseminating from past users is not likely to lead to rapid or high levels of sustained adoption, largely because of the low yield expectations being generated. The main recommendation of this study is that industry efforts should focus on ensuring that early adopters of durum wheat in Western Australia can generate positive economic results and messages about the economic value of the crop, and yield in particular. Unless profitability can be demonstrated, most extension efforts will be premature and have low impact. Rather than broad extension initiatives, a more effective approach may involve working closely with a few selected early adopters in areas with a high likelihood of success, or most likely, ensuring higher-yielding varieties are available before extensive promotion of the trialing of durum by growers is undertaken.

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