KARNAL BUNT: THE ECONOMIC RISK IMPOSED AND THE ECONOMIC IMPACT OF QUARANTINE AS CONTROL MEASURE

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Abstract

The aim of this article is to estimate the risk imposed by Karnal bunt *and then to explore the economic impact of both quarantine as control measure, and of regulation concerning Karnal bunt, on the South African wheat industry. This disease occurred in South Africa for the first time during the 2000/01 wheat production season on a farm near Douglas in the Northern Cape. The economic impact of various control measures and regulations with regard to Karnal bunt can be assessed by means of an efficiency analysis using a cost-benefit approach. It was found to be economically acceptable to implement quarantine on the Douglas area in only a "worse case" scenario. In all other scenarios it did not made any economic sense to impose a quarantine on the Douglas area.*

1. INTRODUCTION

Karnal bunt (*T. indica*) is one of five bunt and smut diseases that affect wheat. It occurs in confined areas of India, Pakistan, Mexico, Iran, and the USA. Karnal bunt is non-toxic to humans or livestock, but can affect the appearance and smell of grain products (CIMMYT, 1996). The damage caused by Karnal bunt is twofold: infected plants produce less grain and the quality of the grain itself is affected (Murray & Brennan, 1998). Flour made from highly infected grain is discoloured and has an unpleasant, though harmless, odour and taste. Karnal bunt generally replaces part of the wheat seed with a black powder consisting of thousands of teliospores. The development of Karnal bunt depends on favourable weather conditions for infestation and disease development. Moderate temperatures, high relative humidity or free moisture, cloudiness and rainfall during anthesis favour disease development (CIMMYT, 1996; Murray & Brennan, 1998; Fuentes-Davila, 1996, 1998;

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Nagarajan *et al.*, 1997; Bonde *et al.*, 1997). Obviously, overhead irrigation of the cereal crop during heading and anthesis would also provide favourable conditions for infection (Murray & Brennan, 1998).

During the 2000/01 wheat production seasons, Karnal bunt was detected in the Douglas district in the Northern Cape province of South Africa for the first time. It was found in one locality only, where wheat is produced under irrigation. GWK Ltd is the major agribusiness in the region and owns the silo where the infected grain was stored. The questions which immediately arise were what is the risk imposed for the South African wheat industry by this outbreak, and what should be done to manage such risk?

The aim of this article is to estimate the risk imposed by Karnal bunt and then to explore the economic impact of quarantine as a control measure and of regulation concerning Karnal bunt on the South African wheat industry.

2. ASSESSING THE ECONOMIC RISK

In assessing the economic risk imposed by Karnal bunt to the wheat industry in South Africa the spread potential of the disease and the potential economic risk must be estimated (Brennan *et al.*, 1992; Murray & Brennan, 1998).

2.1 Spread potential after establishment

The area under risk because of Karnal bunt is a determining factor in the economic assessment for South Africa, therefore information in the literature and from international experience from countries with Karnal bunt was used in developing various scenarios that may apply to the South African case (Murray & Brennan, 1998; Fuentes-Davila, 2001; Brennan *et al.,* 1992). As a result, the following areas were used as possible areas of risk of infestation and spread in the assessment of risk:

1. The total area of irrigated wheat production in South Africa
   (area 105 000 ha, yield 5.75t/ha);

2. 50% of the total area of irrigated wheat production in South Africa
   (area 52 500 ha, yield 5.75t/ha); and

3. The total Northern Cape wheat production area
   (area 52 400 ha, yield 5.40t/ha).

Karnal bunt mainly presents as a risk in irrigated wheat producing areas (CIMMYT, 1996), thus the total irrigated area under wheat in South Africa is potentially vulnerable (Scenario 1). However, the disease also requires specific weather conditions in the critical life cycle stage of the crop to develop and spread, thus the total irrigated wheat production area was reduced by 50% to incorporate these specific weather requirements (Scenario 2). The risk of spread is then further reduced by only including the Northern Cape as possible area of spread (Scenario 3). This scenario was explored due to the appearance of Karnal bunt in a commercial field in the Northern Cape and to test the possible impact if the disease is to affect only this area.

2.2 The potential economic risk

Factors that should be considered to assess the potential economic risk are related to losses and increased costs associated with Karnal bunt.

Losses from Karnal bunt were divided into two types in a study done in the affected areas of Northwest Mexico (Brennan *et al.*, 1992), namely direct and indirect economic costs.

Direct economic costs include:

a) The value of yield loss;

b) The value of quality loss; and

c) The economic cost of the loss of markets (e.g. export losses) through quarantine or marketing restrictions imposed following the presence of the disease.

Indirect or control costs aimed at preventing the spread of the disease or reducing its severity include:

a) Losses from planting restrictions;

b) Costs of quarantine or regulatory restrictions imposed on the production and/or marketing of the crop;

c) Regulatory costs associated with monitoring the disease;

d) Costs associated with extra processing or fumigation of the output from infested areas;

e) Rejection losses for seed growers; and

f) Additional transport costs.

Brennan *et al.* (1992) found that losses from quality, seed exports and planting restrictions dominated the total losses from Karnal bunt in Mexico. Murray & Brennan (1998) found this phenomenon also applies to the Australian case.

2.2.1 *Yield loss*

Karnal bunt generally has minimal impact on wheat yields through the loss of weight of infected grains. Yield losses reported in the literature vary from <1% to up to 20% (CIMMYT, 1996), although some scientists dispute the latter Fuentes-Davila (2001). Yield losses generally average less than 1% in T. *indica* infested areas of India, Pakistan and Mexico. Yield loss was found to be about 0.16% in an epidemic year in the foothills of the Himalayas and 0.12% per year in northwestern Mexico (CIMMYT, 1996).

The quantity loss associated with Karnal bunt does not only impose a direct cost on the producer side due to lower yields. In the case of a net importing country, as in the case of South Africa, additional import costs should also be accounted for where wheat is imported to accommodate the shortage, which can be ascribed to a quantity loss. In this analysis the related cost is accounted for as the miller's cost.

For the South African case a yield loss of 0.5% was used in the analysis, after consultation with the Agricultural Research Council - Small Grain Institute (ARC-SGI, 2001). This amounted to R4.75/ton (R950/ton x 0.5%) cost to the producer of wheat and R1.50/ton {R300 (the difference between the local price and import price of wheat) x 0.5%} to the millers with respect to the assumed infested areas.

2.2.2 *Quality loss*

Karnal bunt can reduce the quality and marketability of wheat grain. According to international standards grain containing more than 3% bunted seeds is unfit for human consumption and is downgraded to feed wheat (Fuentes-Davila, 1996, 1998). The loss in value of infected wheat was taken as the price discount for feed wheat (which has averaged about R350/t in recent years).

For South Africa the severity of wheat quality loss associated with Karnal bunt infestation is not yet certain. Murray & Brennan (1998) assumed a 33% quality loss for Australia with the assumption that if Karnal bunt were found, it seems likely that all infected wheat would be downgraded to feed uses, not just the more heavily infected loads. Singh (1998) estimated the loss in epidemic years in northern India to be 0.96%. Brennan *et al.* (1992) estimated the quality loss at 0.69% of the value of the crop in infested areas of Mexico. However, it is important to note that it is unlikely that these quality losses will occur every year. In Mexico the experience is that the disease occurs once every four years (Fuentes-Davila, 2001).

To explore the possible impact of quality loss for the South African case, three levels of severity were tested, namely 1%, 10% and 20% of production respectively. According to Fuentes-Davila (2001) the Mexican experience shows that a 1% to 10% loss is a more likely scenario, with a 20% quality loss being regarded as an extreme case.

As in the case of quantity loss, the quality loss associated with Karnal bunt not only imposes a direct cost on the producer side due to the price discount associated with low quality of wheat. Additional import costs should also be accounted for where wheat is imported to accommodate the shortage in wheat, which can be ascribed to a quality loss. In this analysis, the related cost is also accounted for as the miller's cost.

2.2.3 Export loss

Export loss is the cost associated with the income foregone due to the international trade restrictions on Karnal bunt infected wheat, as importing countries are likely to avoid buying wheat that could be infected with Karnal bunt. According to an Australian study the export loss associated with Karnal bunt was calculated to be almost 50% of total cost (direct and indirect costs) or 66% of direct cost associated with Karnal bunt. In Mexico export losses were calculated to be 16% of the total cost or 27% of direct losses. Mexico and Australia are wheat-exporting countries. Thus, for exporting countries of wheat the cost of Karnal bunt can be huge, because of the loss in export markets. However, South Africa is a net importer of wheat, therefore the economic risk of Karnal bunt with regard to export losses can be regarded as insignificant. If, however, South Africa in the future were to explore more export markets the impact might be higher.

2.2.4 Other marketing losses

Domestic users may also avoid buying wheat originating from areas infested with Karnal bunt, or request a discount on such wheat. The local users may also use the pest to argue against the wheat tariff currently implemented by the government. While this quality related cost has a negative impact on the producer side within the wheat industry, it can be regarded as a gain to processors. Therefore, the net economic risk of this quality related cost is zero within the wheat industry and is not accounted for in this analysis.

2.2.5 Estimated economic risk of Karnal bunt to the wheat industry

The economic risk was estimated taking into account the abovementioned direct costs of Karnal bunt only. In this section the results of the various scenarios are tabled. These scenarios are:

Scenario 1
Area infected with Karnal bunt:
All irrigated wheat production areas in South Africa
Direct costs: Quantity loss: 0.5%
Quality loss: 1%; 10%; and 20%

Scenario 2
Area infected with Karnal bunt:
50% of all irrigated wheat production areas in South Africa
Direct costs: Quantity loss: 0.5%
Quality loss: 1%; 10%; and 20%

Scenario 3
Area infected with Karnal bunt:
All wheat producing areas in the Northern Cape infected with Karnal bunt
Direct costs: Quantity loss: 0.5%
Quality loss: 1%; 10%; and 20%

The economic risk is expressed in terms of a total Rand value and Rand value/ton for the producer, the miller and the total industry (Table 1). For example, according to the first scenario, a 10% quality loss in all irrigated wheat producing areas would result in a R43 017 187 economic loss. This could also be translated to a value of R71.25 per ton. In such a scenario, the cost to the producer amounts to R23 999 062 or R39.75 per ton and to the miller R19 018 125 or R31.50 per ton. In this scenario, it was also found that a 20% quality loss with all irrigated wheat producing areas infected would result in a total economic loss of R82 260 937, which is 4.48% of the average gross value of the wheat crop in South Africa.

Table 1: The economic risk imposed by Karnal bunt to the wheat industry

Sources of economic costs	Cost to producer		Cost to miller		Total economic cost	
	R	R/ton	R	R/ton	R	R/ton
Scenario 1: All irrigated wheat production areas infected with Karnal bunt (Area: 105 000 ha; Yield: 5.75 t/ha)						
1% Quality loss						
Total cost	4 980 937	8.25	2 716 875	4.50	7 697 812	12.75
Total cost as % of gross value of wheat crop	0.27%		0.15%		0.42%	
10% Quality loss						
Total cost	23 999 062	39.75	19 018 125	31.50	43 017 187	71.25
Total cost as % of gross value of wheat crop	1.31%		1.03%		2.34%	
20% Quality loss						
Total cost	45 130 312	74.75	37 130 625	61.50	82 260 937	136.25
Total cost as % of gross value of wheat crop	2.46%		2.02%		4.48%	
Scenario 2: 50% of all irrigated wheat production areas infected with Karnal bunt (Area: 52 500 ha; Yield: 5.75 t/ha)						
1% Quality loss						
Total cost	2 490 468	8.25	1 358 437	4.50	3 848 906	12.75
Total cost as % of gross value of wheat crop	0.14%		0.07%		0.21%	
10% Quality loss						
Total cost	11 999 531	39.75	9 509 062	31.50	21 508 593	71.25
Total cost as % of gross value of wheat crop	0.65%		0.52%		1.17%	
20% Quality loss						
Total cost	22 565 156	74.75	18 565 312	61.50	41 130 468	136.25
Total cost as % of gross value of wheat crop	1.23%		1.01%		2.24%	
Scenario 3: The whole Northern Cape infected with Karnal bunt (Area: 52 400 ha; Yield: 5.40 t/ha)						
1% Quality loss						
Total cost	2 334 420	8.25	1 273 320	4.50	3 607 740	12.75
Total cost as % of gross value of wheat crop	0.13%		0.07%		0.20%	
10% Quality loss						
Total cost	11 247 660	39.75	8 913 240	31.50	20 160 900	71.25
Total cost as % of gross value of wheat crop	0.61%		0.48%		1.10%	
20% Quality loss						
Total cost	21 151 260	74.75	17 402 040	61.50	38 553 300	136.25
Total cost as % of gross value of wheat crop	1.15%		0.95%		2.10%	

Source: Own calculations.

3. METHODOLOGY TO DETERMINE THE ECONOMIC IMPACT OF QUARANTINE AS CONTROL MEASURE

The economic impact of various control measures and regulations with regard to Karnal bunt can be assessed by means of an efficiency analysis using a cost-benefit approach (Anandajayasekeram *et al.,* 1996; Marasas *et al.,* 1997; Wessels, 1998). The costs and benefits associated with control and regulatory measures are systematically compared and summarised as a single measure of the value, such as the net present value (NPV). Basically the technique of cost-benefit analysis is the comparison of costs and benefits, with and without a related activity, over a period of time to derive an incremental net benefit stream. This stream of incremental net benefit is then converted into values that can be compared by discounting, which takes into account the time value of money. The summation of the discounted incremental net benefits yields the NPV. The NPV indicates positive benefits when the value derived is greater than zero.

Each type of control measure has a specific related cost implication for each participant in the wheat industry. The "with" scenario consists of comparing only the direct costs imposed by quarantine with the assumed benefit of implementing such regulation measures on a specific area, i.e. the net benefit for such action is derived. Management and administrative costs related to quarantine regulations are not known for the South African situation at this stage, therefore these costs were not included in the cost benefit analysis. The net benefit for the "without" scenario is calculated by comparing the benefits and costs for not implementing quarantine on a specific area. This analysis is conducted for a 5-year period of quarantine. The NPV calculated from the incremental net benefit stream for the "with" and "without" scenarios can be used to indicate the cost effectiveness of such regulation measures. For this analysis a 10% discount rate was used based on the prime lending rate and inflation. The NPV was also calculated using various discount rates ranging from 5% to 15% to test the sensitivity of the NPV. However, it was found that the conclusions remained the same. In this analysis, a positive (+) NPV indicates that quarantine can be regarded as a cost-effective control measure. On the other hand a negative (-) NPV indicates that quarantine can be regarded as a cost-ineffective control measure.

4. THE ECONOMIC IMPACT OF IMPLEMENTING QUARANTINE IN THE DOUGLAS AREA

The quarantine measures imply that no wheat, wheat products or any possible Karnal bunt contaminated items could be moved from the specific area, and wheat may not be produced for a provisional period of at least 5 years.

For the cost-benefit analysis the following costs were included: the direct cost of production foregone due to the production restriction of 5 years; and the loss associated with the wheat which is currently stored in the silo in the quarantine area. The benefit was regarded as the losses prevented by implementing quarantine.

The direct cost of wheat in the Douglas silo under quarantine regulations, which will be destroyed amounts to R55 000 000 (44 000 ton wheat @ R1 250/ton). Contract obligations may pose an additional cost related to this wheat loss that will most probably be accommodated by imports. This amounts to an additional cost of R13 200 000 (44 000 ton @ R300/ton).

In this area, wheat is the most profitable crop. Therefore, the cost of such a crop restriction would be high for the producers in the area. According to GWK Ltd (2001) no real substitute for wheat exists for the area, thus the loss may be as high as R13 200 000 {6 000 ha @ R2 200/ha (gross margin of wheat)} annually for producers in the quarantine area. This production loss will also result in an annual economic loss for the five-year period to GWK due to a loss in the trade of wheat (6 000 ha x 5 ton/ha @ R300/ton).

Additional direct economic costs as a result of quarantine, which are not taken into account in this analysis, but should be recognized, include the cost implications to the producers in the Douglas district not under quarantine. These costs may include, for example, additional transport costs to the producer for delivering the wheat crop to alternative silos in the GWK region due to the Douglas silo being under quarantine.

According to the results of Scenario one, a positive NPV was derived only in the case of 20% quality losses. In other words, if all assumptions apply it should be economically acceptable to implement quarantine on the Douglas area if this scenario should prevail.

In the case of Scenarios 2 and 3, where the areas under risk to Karnal bunt is varied, it will be economically unacceptable to implement quarantine in any of the situations. According to the results from Scenario 3 it is evident that imposing quarantine on Douglas, to reap the benefits of preventing losses in the Northern Cape region only, seems to be economically inefficient.

Table 2: The NPV values when implementing quarantine in the Douglas area

Scenario 1: All irrigated wheat production areas infected with Karnal bunt			
	1% Quality loss	**10% Quality loss**	**20% Quality loss**
NPV (10%)	-	-	+
Scenario 2: 50% of all irrigated wheat production areas infected with Karnal bunt			
	1% Quality loss	**10% Quality loss**	**20% Quality loss**
NPV (10%)	-	-	-
Scenario 3: The whole Northern Cape infected with Karnal bunt			
	1% Quality loss	**10% Quality loss**	**20% Quality loss**
NPV (10%)	-	-	-

Source: Own calculations.

5. CONCLUSION

Karnal bunt is viewed as a serious disease for international trade in wheat because it reduces grain quality and has a restricted distribution, being limited largely to the Indian subcontinent and a small area of Mexico and the south-western United States of America (Fuentes-Davila, 1996, 1998). This disease occurred in South Africa for the first time during the 2000/01 wheat production season near Douglas in the Northern Cape. The questions which immediately arise are what is the risk imposed for the South African wheat industry by this outbreak and what should be done to manage such risk? Each type of control measure has a specific related cost implication for each participant in the wheat industry.

In this article, a cost-benefit approach was applied to determine the cost effectiveness of implementing quarantine on the currently affected areas. By comparing only the direct costs imposed by quarantine with the assumed benefit of implementing such regulatory measures on a specific area, the net benefit for such action is derived. This analysis was conducted for a 5-year period of quarantine. The NPV calculated from the net benefit stream could be used to indicate the cost effectiveness of such measures.

It was found to be economically acceptable to implement quarantine on the Douglas area in a "worse case" scenario only. In all other scenarios it did not make any economic sense to implement quarantine on the Douglas area.

It is important to emphasize that there are no data available on the cost-benefit of quarantine regulations implemented in Mexico since 1987 and in the USA since 1996. However, it is apparent that quarantine regulations have had a negative economic effect since in both countries regulations have been relaxed (Fuentes-Davila, 2001).

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