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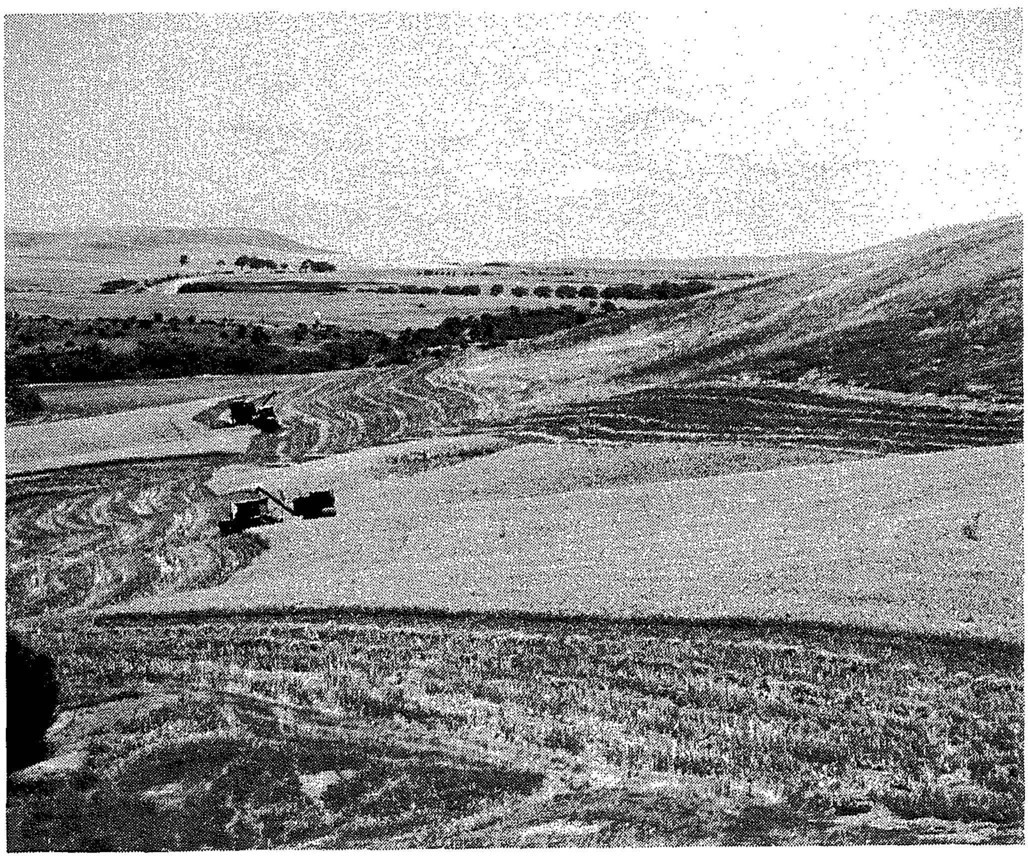

Jill Wilson

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Analysis of black point in wheat

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Contents

List of tables

List of figures

1. Introduction

Downgrading resulting from fungal staining has become of special concern to farmers over the last few years because of dockages for any loads with more than 5 per cent of grain affected. Also commonly referred to as black point, the condition appears as a blackening of the grain which causes marketing difficulties.

During recent harvests a large quantity of wheat grain was downgraded to GP1 or below because of excessive black point. Concern among growers lead to a meeting between Yuna farmer, and member of the Wheat Research Committee of W.A. (WRCWA), Mr Bill Creasy, and Department of Agriculture officers to determine whether any course of action should be taken. As a result, I was approached in April 1991 by representatives of the WRCWA and asked if I would be interested in submitting a short project to address some of the problems. Because of previous concerns, and in collaboration with Ms Gillie Brown, I had already obtained some figures relating to amounts of different wheat varieties downgraded during 1987-1989. The data appeared to be very interesting but required processing and analysis before any conclusions could be made. Such analysis formed the basis of this project, using receival data supplied by the Australian Wheat Board (AWB) for the Geraldton Shipping Zone for the five years, 1987-91. Such data can indicate differences between varieties and locations with respect to black point. To a limited extent, the data can also be examined together with climatic data to assess the effects of seasonal factors such as rainfall.

As well as grain receival figures, limited amounts of trial data also exist. These data have been collated and analysed with a view to assessing whether reported differences between varieties have any substance in fact. As the trials included such factors as time of sowing and nitrogen application, some inferences can also be made as to the agronomic effects of various management regimes.

One of the most important considerations with a problem such as black point is the cost to the industry (and consequently to the State). Using receival data, together with representative pricing regimes, estimations have also been made as to the cost of black point in the Geraldton Zone.

This report relates mainly to the region around Geraldton; most of the data used are from receival bins or trials in the area bounded by Binnu in the north, Carnamah in the south, and Perenjori in the east. With respect to receival data, only figures relating to the Geraldton Shipping Zone of the AWB have been included in statistical analyses. However, some receival and trial data from more southerly regions of the State are referred to in some sections.

Jill Wilson

2. Summary of main findings

1. Fungal staining (black point) of wheat can reduce the quality of grain. The most serious problem is a discolouration of products.
2. Discolouration is a consequence of infection by microorganisms. The most likely cause in Western Australia is a species of the common fungus *Alternaria*.
3. Infection and discolouration occur between flowering and grain maturity, and the optimum environmental conditions are probably consecutive days of high relative humidity together with warm temperatures.
4. The problem is more significant in northern, rather than southern areas of the State. This is partly because of the prominence in the north of varieties such as Eradu and Gutha which are more prone to staining than varieties commonly grown in southern parts. It also probably results from differences in climatic regimes; wheat-growing areas to the south are either inland sufficiently to have low relative humidities at the end of the season, or for those near the coast the temperatures are relatively low and thus less favourable for fungal development on the grain.
5. In the northern wheatbelt, staining is most common in coastal locations such as Northampton and areas around Geraldton, though in some seasons, notably 1988/89, significant black point also occurred at inland sites. There is a low risk of staining at sites such as Carnamah and Canna.
6. The cost of fungal staining to the industry varies for different sites and varieties. It is also dependent on the pricing structure used in the calculations. Using 1990/91 prices for comparison, the estimated loss to wheat returns in the Geraldton Shipping Zone varied between $80,000 (0.15%) in 1987, to $4.5 million (4.5%) in 1988/89. The greatest losses for an individual site (on a proportional basis) was at Northampton in 1988 when 10.4% of total monetary returns were lost because of downgrading. This reflected an overall average downgrading of approximately 78%.
7. There are significant differences between varieties in the extent and frequency that they become stained. Of the 16 varieties most commonly grown in the northern region, those most prone to staining were Warimba, Eradu, Millewa and Gutha. Those least prone to staining were Wilgoyne, Schomburgk, Madden and Bodallin.
8. Risk analysis is recommended for farmers interested in growing varieties such as Eradu and Gutha. This can be done relatively easily using the computer program "Padrank", as long as good estimates are available of relative yields, expected proteins, and history of risk from staining. Eradu and Gutha are very risky varieties for locations such as Northampton, Binnu, West Mingenew, Dongara, Walkaway and Moonyoonooka, and western parts of the Chapman Valley.
9. Very little is known about the process of staining, or the factors that contribute to its severity. While head architecture may be important, further information is required before its relationship to staining could be confirmed.
10. Management factors also affect the severity of staining and there is evidence black point is reduced by applications of nitrogen fertiliser, and by delayed planting. The interaction with time of planting may be complicated by the maturity type of the variety as in several trials the short season variety Kulin suffered worse staining at a later sowing time.
11. Considering the losses currently being incurred, and that most varieties are prone to at least moderate amounts of staining, there is justification for more research to be undertaken on the topic. Some of the aspects that deserve further attention are as follows:
    - the biological processes of infection and blackening, including how and when they occur
    - the climatic conditions that increase staining severity
    - the plant structural attributes that affect staining severity
    - the management factors that reduce staining severity, with particular emphasis on nutritional factors
    - the possibility of successfully breeding for "resistance"
    - cost structures, and management of financial risk

3. Background - what is black point?

This section describes the phenomenon of black point, and discusses some of the theories about its cause, and the biological and environmental factors that contribute to its development. While the topic has been investigated in several scientific studies, there are still many gaps in our knowledge, and much of the information cited as fact is based on speculation rather than on empirical data.

Black point, also commonly referred to as fungal staining or kernel smudge, is a brownish or black discolouration of cereal grains. Discolouration is usually limited to a small area at the embryo end, but occasionally more than 50% of the seed can be discoloured. Discolouration of the brush end only is usually referred to as black tip.

The problem has been of particular concern in durum wheats (used for semolina, macaroni and other pasta products), because grey specks occur in products manufactured from discoloured wheat (Hanson and Christensen 1953). Consequently most studies have been conducted with durum rather than bread wheats (Kilpatrick 1968, Southwell *et.al.* 1980). However, the AWB is concerned about several quality characteristics, including colour, of other Australian wheats. Whiteness of bread wheats, and a bright creamy colour of Japanese noodle wheats are both demanded by existing markets. The grey discolouration sometimes imparted by staining is highly undesirable, and discerning markets will only accept visually stained grain at a reduced price for stock feed or industrial purposes. Hence strict quality standards are being imposed at grain receival bins for all types of wheat. Similar standards are imposed on barley receivals.

The causal organisms of black point

Many commonly-occurring organisms, both bacteria and fungi (and including more than 100 different fungal species), have been shown to be associated with stained grain (Wiese 1977). However, those most usually implicated are species of the fungus *Alternaria*, especially *A. alternata* and *A. tenuis* (Klein 1987, Rees *et al.* 1984, Shaw and Valder 1952, Shipton and Chambers 1966, Southwell *et.al.* 1980). Shipton and Chamber's study was conducted in Western Australia, and found 20 fungi and one bacterium associated with blackened grains, with *Alternaria tenuis* being the most frequently isolated organism. It is important to note that most of the fungi implicated are ubiquitous, and are commonly associated with the spoilage of inactive carbohydrate material. Thus their control by chemical methods would be very difficult.

In North American studies, the plant pathogen *Helminthosporium sativum* (now named *Bipolaris sorokiniana*) is also frequently implicated (Hanson and Christensen 1953, Huguelet and Kiesling 1973, Kilpatrick 1968). It appears that black point associated with infection by *Bipolaris sorokiniana* displays more severe symptoms than that associated with other organisms. Grain infected with *B. sorokiniana* was usually darker, frequently smaller and sometimes shrivelled, compared with that infected with species of *Alternaria* (Adlakha and Joshi 1974, Huguelet and Kiesling 1973, Rees *et.al.* 1984). *Bipolaris sorokiniana* causes the disease of wheat and barley called common root rot, which occurs in several parts of Australia, including South Australia, southern Queensland, northern New South Wales and the northern wheatbelt of Western Australia (Wilson and Hamblin 1990). While it has been isolated in low frequencies from discoloured wheat grains in several different areas (Klein 1987, Rees *et.al.* 1984, Shipton and Chambers 1966), it has not been implicated as a major or common cause of black point in Australia.

Infection and discolouration

One of the most interesting findings of scientific studies is that infection does not necessarily lead to staining. Grain is frequently infected with one of the causal fungi without showing any signs of discolouration (Klein 1987, Rees *et al.* 1984, R. Loughman, unpublished data). This is particularly true when the infection involves *Alternaria* rather than *Bipolaris* (Hanson and Christensen 1953). As a corollary to this observation, discolouration may also extend beyond the area of infection (Bhowmik 1969). Thus it is probable that infection and discolouration are two separate processes, and may be affected differently by external factors such as climatic conditions.

Pink grain

Another grain defect commonly associated with black point is that of pink grain. The receival standards for this defect are even more stringent than those for black point, principally because the condition is sometimes associated with mycotoxins such as the trichothecene vomitoxin (Simmonds 1989, Snijders 1990). Where a toxin is present the causal organism is usually *Fusarium graminearum* (Group 2), but while this fungus occurs in grain from northern New South Wales and Queensland (Klein 1987), it is not known to be present in Western Australia.

Pink grain was a significant problem in receivals from the Geraldton region in 1988, and an unpublished study of Dr R. Loughman on this material isolated no *Fusarium* species and showed that the predominant organism in pink grain was *Pyrenophora tritici-repentis* (R. Loughman, *pers.comm.*). This fungus is also the causal organism of the leaf disease yellow spot, and has also been implicated in the development of pink grain in New South Wales (Shaw and Valder 1952, Klein 1987).

Although pink grain from Western Australia is not associated with toxins, because there is a potential problem the market views all pink grain as low quality, and such grain is consequently downgraded by the AWB.

In Canada and Europe, pink grain has also been caused by the bacterium *Erwinia rhapontici* (Wiese 1977), but it is not known whether this has occurred in Australia.

The infection process

This is an area of considerable conjecture, and few hypotheses in the literature are supported by either data or observation. However, infection is almost certainly initiated by propagules external to the plant. Microscopic studies by Bhowmik (1969) provided

evidence that infection is not systemic, and Southwell *et al.* (1980) showed that the intensity of black point is related to the concentration of spores introduced externally with an atomiser. Huguelet and Kiesling (1973) also used external inoculation successfully to demonstrate competitive interactions between different inoculant fungi.

There is confusion regarding the timing of development of black point, but various theories have been proposed, often related to the relative positions of the glumes and the seed. Machacek and Greaney (1938) suggested that maximum infection occurs when the glumes are pushed apart, either at anthesis, or during grain development when large grains force them open. However, the available data are scant and rather inconclusive. Inoculation studies by Adlakha and Joshi (1974) showed greatest incidence of black point when the fungi were introduced at the post-anthesis stage, rather than the boot, pre-anthesis or dough stages. In contrast, Southwell *et al.* (1980) showed that black point increased with the stage of development at the time of inoculation; that is, that black point was greater when heads were inoculated at for instance the milky-ripe stage than when inoculated at anthesis. Other workers have successfully produced black point by inoculating heads at various stages between anthesis and late dough (Bhowmik 1969, Kilpatrick 1968), but there are no other studies where a series of inoculation times were compared. While the evidence is limited, it is most likely that infection occurs at or after anthesis and before grain maturity. There is no information specifically related to the blackening process, and whether discolouration will continue to occur once the grain is mature is not conclusively known. Recent tests do, however, suggest that mature grain will become further discoloured if subjected to high relative humidities for several consecutive days (J. Wilson, personal observation).

The fact that discoloured grain is frequently larger than clean grain has also been used as evidence for infection occurring preferentially on particular areas of the head where the grains are largest, such as mid-spike kernels (Hanson and Christensen 1953), but the data on this are also rather weak.

Climatic conditions affecting the development of black point

It is commonly believed that rain during the grain-filling stage is the climatic factor most responsible for the development of black point. In fact, analysis of this factor forms the basis of the Section 7, but as discussed there, the evidence for a direct association is not strong. While both high rainfall and irrigation regimes have been implicated in the development of high levels of black point (Kilpatrick 1968), it is likely that relative humidity is of greater importance (Hanson and Christensen 1953). Dew may also be significant (Kilpatrick 1966). While field data on this are non-existent, a glasshouse study on durum wheats in New South Wales showed that maximum black point developed when wheat heads were maintained at a high humidity for 48 hours. Black point increased linearly as the dew period was increased from 0 to 48 hours, but did not increase further when the dew period was prolonged to 72 hours (Southwell *et al.* 1980). In a study of fungi present in stored grain, Hyde (1950) found that there was a good correlation between the relative humidity in the few weeks before harvest and the amount of internal fungi in the grain. While these fungi were not necessarily associated with black point, it is further evidence for the significance of relative humidity in the infection process.

Temperature is another factor that may directly influence the development of black point. Hanson and Christensen (1953) cited high temperature as a causal factor, in association with high humidity, but there is no empirical evidence to support their observation.

Because of the imputed importance of grain moisture content in the development of black point, the rate of wetting and drying of the heads should also be considered. This will be influenced partly by temperature, but also by the prevalence of drying winds. While there is no information in the literature about the relationship between drying conditions and black point, there are some interesting observations about factors of head architecture that may affect grain wetness. Water uptake by grains was increased by the presence of awns, and by club heads (King and Richards 1984, Pool and Patterson 1958), but pubescence (hairyness) and glaucousness (waxyness) had variable effects. Awns can also increase the rate of drying of grains (Pool and Patterson 1958), but this may not be effective if there is free water present (King and Richards 1984). Studies on the effect of spike nodding angle on grain quality of barley also highlight the importance of the structural characteristics of the head (Brinkman and Luk 1979). Unfortunately there have been no studies of the effect of head architecture on the development of black point.

Effects of black point on grain quality

As mentioned above, the main effect of black point is to discolour the flour or products produced from affected grain. Quality characteristics apart from flour colour are affected by black point, but the effects are very slight and are not considered to reduce the value of the grain for products such as bread. In a Queensland study, test weight, falling number, total flour yield, break flour yield and dough stability were slightly lower, and grain weight, pollard yield, flour colour grade and water absorption were slightly higher in samples with high levels of black point (Rees *et al.* 1984), but baking quality was not affected, and the overall effects were considered to be very slight. For instance, 50% black point reduced the falling number value from 500 to 450, but this is still well within the levels required by current markets.

There is also evidence, however, that the quality of products such as Indian chapati and Arabic flat bread is affected by black point. Higher extraction rates are used to produce the flour for these products, and wheat affected with black point can cause minor changes in both the dough characteristics and taste (AWB 1988).

The literature contains considerable discussion on whether black point increases or decreases grain size. This probably depends on the identity of the causal organism. When *Bipolaris sorokiniana* is involved, grain size is smaller than usual, and may be shrivelled, (Huguelet and Kiesling 1973) but when the cause is a species of *Alternaria*, grain size may be as much as 7% larger (Hanson and Christensen 1953, Rees *et al.* 1984).

Another consideration for farmers is whether black point affects the quality of grain for seeding in subsequent years. After the high levels of downgrading in the 1988 harvest, tests were carried out on samples of grain from the Geraldton region, but neither seed germination nor seedling emergence were reduced by black point, even in an artificial sample in which 100% of seeds were discoloured (J. Wilson and J. Weir, unpublished data). Rees found that emergence of seedlings was reduced by 3% when black-pointed seed was used, but most workers have found detrimental effects on germination and emergence only when *Bipolaris sorokiniana* was the causal organism, rather than one of the *Alternaria* species (Rees *et al.* 1984, Hanson and Christensen 1953, Machacek and Greaney 1938).

Control of black point

At present there are no useful control measures. There are assertions that seed-borne fungi can be controlled by fungicides applied after ear emergence (Gedye *et al.* 1981), but there are no data to support this claim. Cultural methods may reduce black point, but there are limited data on this topic. Hanson and Christensen (1953) observed varietal differences in susceptibility, together with variable responses of varieties of different maturity types (see also Sections 5 and 8 of this report), and there appears to be adequate genetic variation available for resistant types to be developed (Statler 1975). Unfortunately black point is usually low on the priority list of wheat breeders.

4. Analysis of bin receivals 1987-91

Data for bin receivals and downgrading for the Geraldton Shipping Zone were supplied by the Australian Wheat Board. This zone consists of 22 sites, but for most of the analyses only 10 sites were used. For comparative accuracy, most of the analysis was done on a selection of 16 representative varieties. Details of the type of data used, including the individual sites and varieties, are listed in Appendix 1.

Comprehensive receival information is presented in Appendices 1 and 2, with tabular data in Appendix 1 and graphical representation in Appendix 2. In this report it is not possible to discuss all facets of the data, and readers are directed to the Appendices for further detail on particular sites or varieties that may interest them.

A summary of receivals and downgrading for the Geraldton Shipping Zone is shown in Table 1. There is considerable variation in the amount of grain downgraded each year. Over the five year period 1987-91, staining was clearly worst in 1988/89, with 1989/90, 1990/91 and 1991/92 having moderate amounts of staining. Downgrading was exceptionally low in this zone in 1987/88. In further sections of this report these trends are analysed more closely, and data for individual sites and varieties are presented.

The variation in the amount of grain downgraded each year and from site to site is usually attributed to differences in weather conditions from season to season, but it is also complicated by the fact that the proportion of different varieties in the receivals is not constant. If a variety that is prone to fungal staining is widely grown, then the proportion of fungal-stained grain received may be much higher than expected. For instance, downgrading because of staining was higher than usual for all sites and varieties in 1988/89, but the figures were also inflated by the high proportions of Eradu and Gutha in the receivals.

Eradu and Gutha are both prone to staining (see Section 5), and in this year they together constituted almost 60% of total receivals in the Geraldton Shipping Zone. The converse is also true. For instance in 1991/92 more than a quarter of receivals in the Geraldton zone were of Reeves. Reeves does not appear to be very susceptible to staining, which contributed to a lower than expected overall staining result for the zone.

In order to represent more accurately the magnitude of the staining risk over the five years 1987-91, data for Northampton for three selected varieties are presented in Figure 1. The varieties are Eradu and Gutha, both of which are prone to staining, and Kulin which usually sustains only a moderate staining incidence. The data suggest that at this site, which is one consistently faced with a staining problem, 1991/92 was potentially as serious a staining year as 1988/89, with all three varieties suffering as much, or more, fungal staining in the latter year. The overall data , however, show that for total receivals the staining problem was reduced in 1991/92. This was reflected in reduced costs to the industry (See Chapter 9). The best explanation for this is that the proportion of different varieties received changed in the period .

Changes in the proportions of different varieties delivered are demonstrated in Table 2 where data for Eradu, Gutha, Kulin and Reeves are compared for Northampton, Mullewa and for the whole of the zone. At Northampton, where staining is a consistent problem, the proportion of Eradu dropped markedly over the

Table 1. Receivals and downgrading for Geraldton Shipping Zone, 1987-91.

	1987/88	1988/89	1989/90	1990/91	1991/92
Total receivals (t)	477,884	894,155	786,590	1,036,577	735,835
Grain downgraded (t)	4577	356,312	87,036	120,436	57,647
% Grain downgraded	1.0	39.9	11.1	11.6	7.8

N.B. All available data, including all sites and varieties, were used for this table

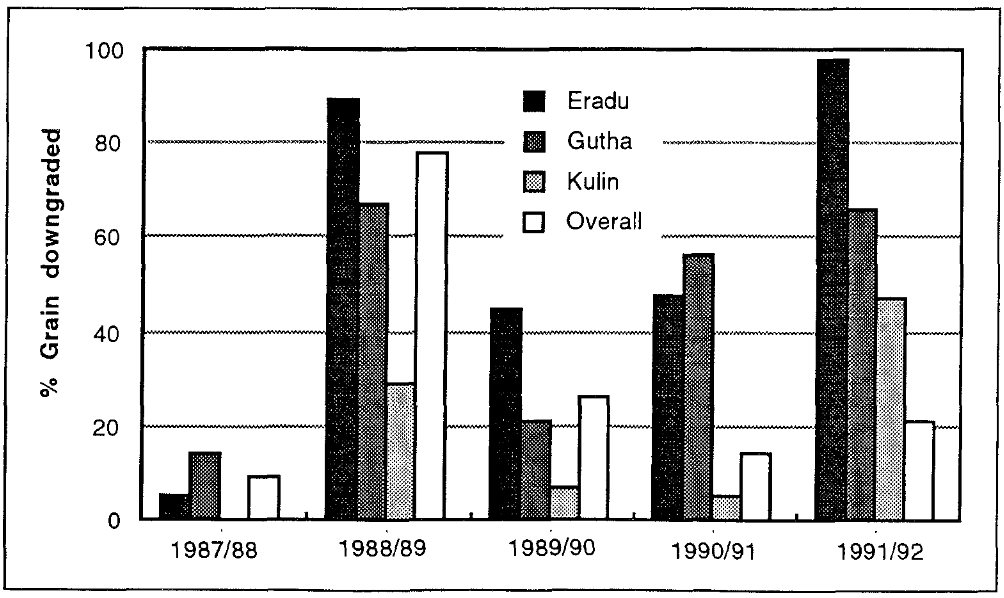


Figure 1. Seasonal differences in grain downgraded, Northampton. 1990/91 data for fungal staining only. "Overall" relates to 15 varities(see Appendix 1).

Table 2. Changes in the proportion of different varieties delivered 1987-91 (*percentage of each variety received*).

	1987/88	1988/89	1989/90	1990/91	1991/92
Northampton					
Eradu	71	61	41	17	3
Gutha	13	11	9	2	<1
Kulin	<1	6	14	28	13
Reeves	0	0	0	5	45
Mullewa					
Eradu	19	19	32	55	56
Gutha	67	62	46	20	8
Kulin	0	<1	<1	3	2
Reeves	0	0	0	<1	13
Overall - Geraldton Shipping Zone					
Eradu	17	18	18	18	16
Gutha	46	42	31	19	9
Kulin	<1	3	8	12	11
Reeves	0	0	0	3	29

Data taken from information in Appendix 1.
Overall data are for 15 selected varieties.

period 1987-91, but at Mullewa it increased significantly. Mullewa does not usually experience a serious staining problem, so a high value crop such as Eradu is very attractive. Note that the premium for noodle wheats such as Eradu was first introduced in 1989/90. The receival figures for Reeves are also very interesting, with rapid adoption at most sites after its first introduction in 1990/91, so that in 1991/92 it constituted 45% of receivals at Northampton and 29% overall. However, for the reasons given above, it did not replace Eradu at Mullewa. Although Reeves is high yielding, and appears to escape serious staining, it has other quality problems and unfortunately is no longer accepted into ASW. It will be interesting to note in the future what effect this will have on the relative proportions of other varieties grown, and consequent effects on the staining problem.

Because of the complications caused by different proportions of different varieties, it is difficult to make accurate comparisons between years or sites, particularly if total receival figures are used. Hence much of the discussion in this report is based on comparisons made for selected site/variety combinations.

5. Varietal differences

Circumstantial evidence suggests that no varieties are resistant to black point. For most varieties there are anecdotal examples of crops suffering severe downgrading because of fungal staining. However, some varieties appear to be more likely than others to become stained, while others are more likely to avoid serious staining.

The concept of susceptibility or resistance to staining is technically a difficult one, as to most scientists it infers a genetic interaction. As we know very little about the mechanism of staining, or avoidance of staining, it is wise to use such labels cautiously. It is possible, for instance, that variation between varieties with regard to staining incidences is partly a result of interactions between such factors as varietal maturity type, time of planting, and agronomic management. Such factors need further examination, and comparisons of varieties under standard conditions need to be made, before firm conclusions about susceptibilities can be drawn. Hence, the phrases "prone to staining" or "avoids staining" are used as descriptors in preference to "susceptible" or "resistant".

Analysis of bin receivals

Because of problems caused by the proportions of different varieties in the receivals (see Section 4), analysis of varietal differences was made on a subset of data for two sites only: Northampton and Geraldton. For varietal comparisons to be accurate it is preferable that measurements reflect consistent staining pressure, and these bins were chosen because they both receive high levels of stained grain every year. It was assumed that this reflects the fact that staining is a regular problem in the surrounding catchment areas.

Sixteen varieties were compared over five years at two sites, the latter being used for the purposes of replication. Analysis of variation demonstrated significant differences between the varieties, but there was no interaction between variety and year. That is, the varieties behaved similarly at these sites regardless of the year.

The varieties most prone to staining were Warimba, Eradu, Millewa and Gutha. Those least prone to staining were Bodallin, Madden, Schomburgk, and Wilgoyne. The data are shown in Table 3. Ranking labels of "High", "Moderate", and "Low" are given as a guide; however, these should be treated with caution as there was considerable statistical overlap.

Table 3. Analysis of differences between varieties. Data from two receival bins over five years.

	% Stained grain	Statistical comparison	Ranking
Warimba	53	a	High
Eradu	44	ab	High
Millewa	42	ab	High
Gutha	38	ab	High
Canna	33	bc	Moderate
Gamenya	31	bc	Moderate
Spear	30	cd	Moderate
Machete	22	cd	Moderate
Blade	21	cd	Moderate
Kulin	20	cd	Moderate
Aroona	20	cd	Moderate
Reeves	18	cd	Moderate
Wilgoyne	12	d	Low
Schomburgk	11	d	Low
Madden	10	d	Low
Bodallin	9	d	Low
lsd	15		

Values with the same letter are statistically similar ($p \leq 0.05$). Note that there is considerable statistical overlap

Analysis of variety trial data, with reference to Cadoux

Collation of data from field trials provides one of the best ways of assessing the differences between varieties as trials subject all lines to the same agronomic and climatic conditions. As long ago as 1980, data from the Western Australian Department of Agriculture's testing program suggested that varieties such as Warimba, Gutha and Eradu were prone to staining. Unfortunately information is still limited. The significance of staining to the industry has only recently become apparent, and routine measurement of this factor is a relatively recent introduction to the breeding and variety testing program.

Table 4 shows some of the most recent data available. This particular data set has been compiled to assess the characteristics of the new variety Cadoux (previously 77W:884) and to compare it with other varieties that are commonly grown. Cadoux was registered and named in October 1992, and has been accepted into the ASW Noodle Pool which will receive the noodle market return of about $10 to $30 above ASW returns at similar protein levels. The most popular noodle variety is currently Eradu, but problems presented by staining have tended to concentrate its production in the medium and low rainfall areas. A noodle wheat which is not prone to staining and which is suitable for the high rainfall areas would be very welcome. Hopefully Cadoux will fit this niche. As shown in the table, Cadoux is less prone to staining than either Eradu or Gutha, and usually behaves similarly to Gamenya with respect to this characteristic. It is also interesting to note that Cadoux is likely to outyield both Eradu and Gamenya in most zones, except for some low rainfall areas, particularly on light soils and in early plantings. These yield advantages, together with reduced staining risks, should ensure that Cadoux will be adopted by farmers in the medium to high rainfall areas.

Data from trials in the northern wheatbelt in 1991 support the conclusion that Cadoux is less prone to staining than Eradu, Gutha or Gamenya. Table 5 shows data from three trials in locations where the staining pressure was particularly severe in 1991.

Of the lots shown, all except three would have been downgraded to GP1B (Reeves at Northampton and Binnu, and Spear at Northampton would all have been accepted into the ASW grade). The samples were assessed by CBH Geraldton, and data are presented as

Table 4. A comparison of staining levels of four varieties. Data from various variety trials, 1987/90

			Percentage of black point affected grain			
Site	Zone	Year	Gutha	Eradu	Gamenya	Cadoux
Nabawa	M1	1987	10	N	N	3
		1988	42	39	23	18
		1990	24	28	11	10
T Springs	M1	1988	7	13	4	0
		1989	N	0	1	0
Badgingarra	H2	1989	N	3	6	10
		1990	N	24	6	8
Wongan Hills	M2	1987	1	N	N	3
		1988	20	18	23	4
Northam	M3	1987	1	N	N	0
		1988	12	8	5	4
		1989	N	7	6	3
Merredin	L3	1988	7	2	2	1
		1990	0	1	0	0
Newdegate	M4	1987	1	N	N	0
		1990	0	4	1	0
Narrogin	M4	1989	N	2	1	2
Salmon Gums	L5	1990	6	6	3	2

N: data not available
Source of data: Graham Crosbie, Grain Products Laboratory, Western Australian Department of Agriculture

Additional data from 1992 trials

Two variety trials from 1992, located at Northampton and Allanooka, were also assessed for black point. The data, which are shown in Table 6, confirm that Millewa, Eradu and Gutha are very prone to staining, and that Schomburgk has a relatively low staining risk. Results for some of the varieties such as Wilgoyne, are contradictory, and may be related to interactions between varietal maturity, time of planting and staining, as discussed in Section 8.

The response of a variety to staining may be complicated by interactions between the maturity type of the variety and the time of planting. Such complications are discussed in Section 7 where the results of trials on agronomic effects are presented. Another factor we know little about is the significance of head architecture (see Section 3). While awns have been claimed to contribute to staining severity, an awnless variety such as Gamenya still usually suffers moderate amounts of staining.

Table 5. Analysis of differences between varieties. Data from three trials in 1991

	Number of stained grains per 500 grains			
Variety	*Binnu*	*Northampton*	*Irwin*	*Mean*
Eradu	140	87	246	158
Gutha	134	N	N	139
Gamenya	133	49	184	122
Cadoux	75	58	122	85
Spear	51	12	98	54
Reeves	14	6	N	39
Mean	91	50	157	99

N: data not available

stained grains per 500 grains. The maximum number of stained grains allowed for the various grades is: ASW, 25; GP1A, 50; GP1B, 100; GP2, 100; FEED, 250 (/500 grains). These figures are equivalent to 5%, 10%, 20%, 20%, and 50% respectively.

Table 6. Staining in two variety trials in the Geraldton region in 1992

Northampton 92GE33		**Allanooka** 92GE19	
Variety	Stained grain %	Variety	Stained grain %
Eradu	8.8	Millewa	11.8
Gutha	7.8	83Z107	6.9
Wilgoyne	4.6	82Y118	5.4
Excalibur	3.4	Eradu	3.9
Gamenya	3.2	Gutha	3.4
Amery (81Y971)	3.2	Gamenya	3.1
Kulin	2.9	Blade	2.9
83Z107	2.5	Excalibur	2.4
78Z976	1.3	78Z976	2.1
Blade	1.2	Amery (81Y971)	1.8
Aroona	1.1	Cadoux	1.6
82Y118	1.1	80Y111	1.5
Schomburgk	0.9	Aroona	1.4
80Y111	0.8	Spear	1.4
Spear	0.6	Kulin	1.1
Cadoux	0.6	Wilgoyne	1.1
Machete	0.3	Machete	0.9
		Schomburgk	0.9
lsd	2.0	lsd	2.4

6. Effects of location

Preponderance in the northern areas

This report mainly deals with the area around Geraldton, and little attempt has been made to analyse receival data other than that from the Geraldton Shipping Zone. Although fungal staining occurs throughout the Western Australian wheatbelt, most of the available data supports the commonly-held belief that it is a more severe problem in the northern than the southern areas. For example, Figure 2 shows data for three varieties from field trials in various medium-rainfall locations in 1988. Staining levels were higher in the M1 than the M2, and decreased further in the M3 zone. Data from the M4 and M5 zones were commonly nil. Data for other years and zones are not complete, but follow the same trends, with staining levels being worst in the northern areas. This may be owing to warmer weather during grain filling in the north, which allows black point to develop more extensively on the grains (see Section 7).

The major staining problem in the more southern areas of the state is with the soft wheat variety Corrigin, which is more liable to develop black point than the main alternative variety, Tincurrin. However, Corrigin has superior resistance to the leaf blotch disease caused by the fungus *Septoria tritici*, and is widely recommended for this reason.

Direct comparisons of different zones

In Appendix 3.1, tables are presented of data for receivals and downgrading in all four Western Australian port zones for the years 1987-91. Although downgrading can be significant in all zones, it is the Geraldton zone that has the most serious problem. In each of the years 1988, 1989, 1990 and 1991 the proportion of wheat downgraded was greatest in the Geraldton zone. In 1987 the worst problem was at Esperance, but considering the very dry season that year, most downgrading was probably the result of factors other than staining such as small grain.

Data for specific sites (Esperance, Avon and Geraldton) are given in Appendix 3.2. Dowgrading was usually greater at the Geraldton receival point than at the two more southerly sites. However, note that the data are variable, and there was considerable downgrading of Millewa and Spear, for example, at Northam in 1988 and 1989.

Also in Appendix 3.2 is a table showing the percentage of fungal stained grain for 1990 and 1991. If this is compared with the table on downgrading, it is clear that at Geraldton a much greater proportion of downgrading results from fungal staining than at the other two sites.

Effects of location within the Geraldton Shipping Zone

Examination of bin receivals shows that some locations are more likely than others to have grain downgraded because of staining (see tables and graphs in Appendices 1 and 2).

As with the comparison of varietal differences (Section 5), analysis of locational differences was made on a subset of data. In this case, data for four varieties (Eradu, Gutha, Millewa and Warimba), 10 bin locations (see below), and five years (1987-91) were used. The four varieties were all prone to staining and were used for the purposes of replication. Analysis of variation showed that there were significant differences both among locations and among years.

Table 7 shows mean data for each location, ranked in order of severity of staining. Northampton consistently had large amounts of grain downgraded as a result of staining and was given a ranking of "Very high", while

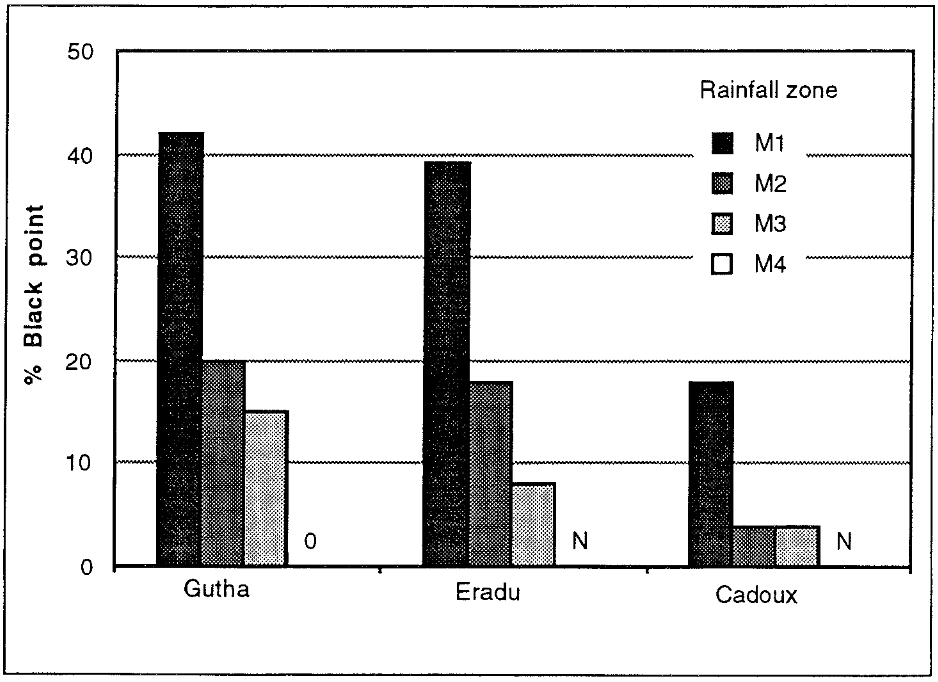


Figure 2. Effect of region on black point from variety trial data 1988

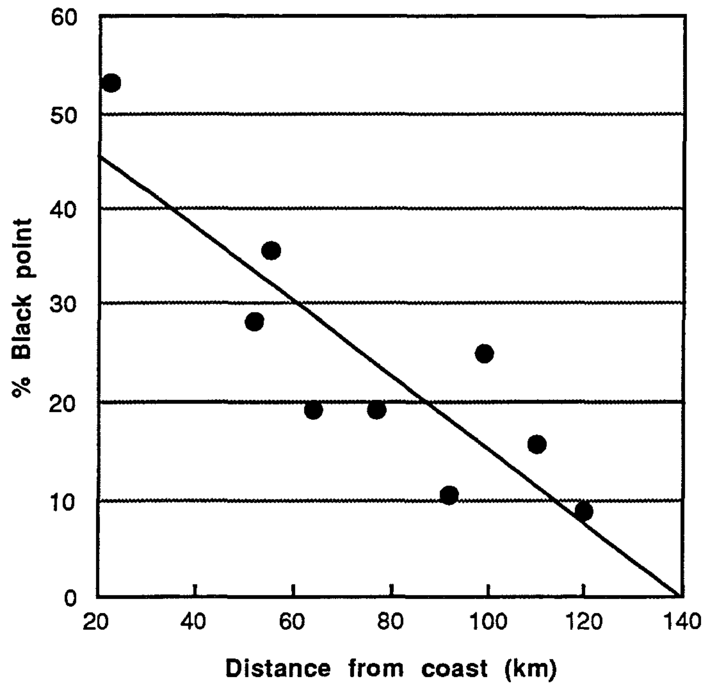


Figure3. Incidence of black point with distance from the coast

Table 7. Analysis of differences between sites. Data from four varieties at 10 bins over five years.

	% Stained grain	Statistical comparison	Ranking
Northampton	53	a	V. high
Geraldton	40	b	High
Binnu	35	bc	High
Mingenew	28	bcd	Moderate
Mullewa	25	bcd	Moderate
Three Springs	19	de	Moderate
Yuna	19	de	Moderate
Morawa	16	de	Moderate
Carnamah	11	e	Low
Canna	9	e	Low
lsd	13		

Data are for main effects of site, meaned across year and variety
Values with the same letter are statistically similar ($p \leq 0.05$).

Geraldton and Binnu were both ranked "High"; Carnamah and Canna "Low", and other sites "Moderate". As there was statistical overlap the rankings should be treated with caution.

In this analysis there was interaction between year and site, indicating that the relative incidence of black point at each site was not the same each year. The interactions were complex, and difficult to present, but a summary of the main points is as follows:

- For Canna, Carnamah, and Morawa differences between years were slight;
- For Binnu, Geraldton, Mingenew and Yuna, 1988 had significantly more black point than the other years; at Northampton both 1988 and 1991 had very high levels;
- Each year there were a few sites that had significantly lower levels of staining than the others. These were:

  1987 - Canna, Carnamah and Mingenew;

  1988 - Canna, Carnamah, Morawa and Three Springs;

  1989 - Canna, Carnamah and Yuna;

  1990 - Mullewa and Yuna;

  1991 - Canna, Carnamah, Mingenew, Mullewa, Morawa and Three Springs.

It is clear from the analysis that there are trends in the data with respect to the effect of location on the incidence of black point, but that there is also considerable variability. The rankings given in Table 7 indicate the relative risk of black point at the various locations. Growers should do careful calculations of potential returns before growing a variety prone to black point at locations such as Northampton, Binnu, and West Mingenew. Risk is discussed further in Section 9. Note that varieties prone to black point were used for the analysis, and the risk may be considerably lower with other varieties.

The data demonstrate an interesting relationship between distance from the coast and incidence of black point (Figure 3). Nine locations were used (Geraldton bin was excluded as its catchment area is very large), and the data are five year averages for four varieties, as in Table 7. The line shown in the figure has a linear regression coefficient (r) of -0.87, and the regression equation was $Y = 53.1 - 0.38X$, where Y represents percentage black point, and X distance from the coast. Thus the relationship was surprisingly good, and suggests that a factor related to either rainfall or relative humidity is involved.

7. Effects of climate, particularly rainfall

The reason for different sites being more at risk than others is probably complex. It has generally been attributed to a greater likelihood of rain between flowering and maturity. In this section, the results of analyses of rainfall and downgrading data are discussed.

Of the 10 bins in the Geraldton zone for which downgrading was analysed, eight were chosen for the rainfall analysis. Canna was excluded because rainfall records were not available. Geraldton bin was excluded because its catchment area is very large and the relationship between rainfall and downgrading was unlikely to be meaningful. For the other eight sites (Binnu, Carnamah, Mingenew, Morawa, Mullewa, Three Springs and Yuna) monthly rainfall data for the years 1987-1991 were compiled from reports of the Australian Bureau of Meteorology and compared with data on downgrading. Linear regression was the main statistical tool used in this analysis. Many combinations of the data were analysed; for instance, rainfall was examined for each month of the year separately, for various groups of months (e.g. July/August/September; September/October; October/November; April/October; May/December, etc.). The main parameters examined with relation to downgrading were percentage downgraded of Eradu or Gutha, or percentage of total receivals downgraded. Data for different bins were examined both as a complete set, and as individual or grouped sets; data from different years were also examined both separately and together.

The main question being examined with this analysis was whether rain at a particular time of the year could be clearly identified as being the cause of severe black point. Despite hundreds of regressions being performed, there was no clear answer to the question. The best fit for regression of downgrading with monthly rainfall was with May data, rather than with data for one of the later months(e.g. October), as was initially anticipated. In general, the most consistent fit across all subsets used was with total annual rainfall. Data for the relationship between percentage downgrading of Gutha and annual rainfall is given in Figure 4. The linear regression coefficient (r) was 0.70, and the relationship was: Y = 0.2X - 52.7, where Y was the percentage grain of Gutha downgraded, and X was the total annual rainfall for a particular site/year combination.

This analysis thus confirms that rainfall is probably a contributing factor, but has not clarified the situation with respect to the timing of rain. Attempts to find correlations between downgrading and data such as number of raindays or top daily record for each month were unsuccessful. It is possible that analysis of individual rainfall events might produce more useful results, but daily rainfall records were unfortunately not available at the time.

Because of the above difficulties, figures have been produced for two subsets of data so that readers can draw their own conclusions. Figure 5 describes the monthly rainfall for the years 1987-1991 at Northampton. This should be compared with Figure 1 which depicts downgrading data for Northampton for the same period. Data for Eradu is probably the most relevant. An extremely high proportion of Eradu was downgraded at Northampton in both 1988 and 1991 (89% and 98% respectively); moderate amounts in 1989 and 1990 (45% and 48% respectively); and very little in 1987 (5%). When regressions are done of these data, the linear correlation between annual rainfall and percentage grain downgraded of Eradu at Northampton

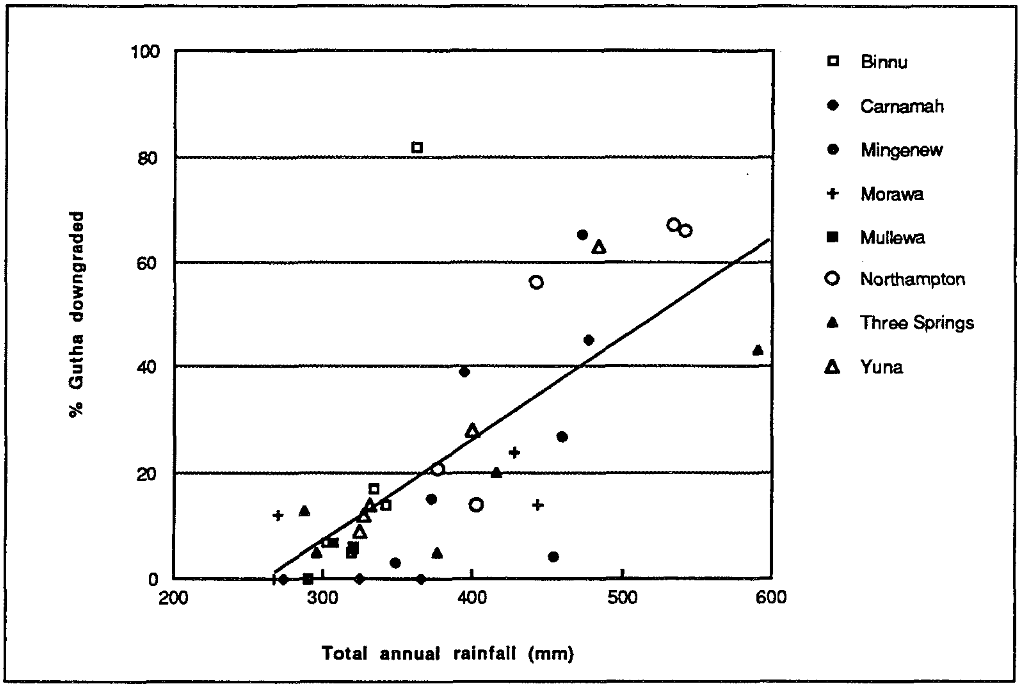


Figure 4. Downgrading of Gutha and annual rainfall

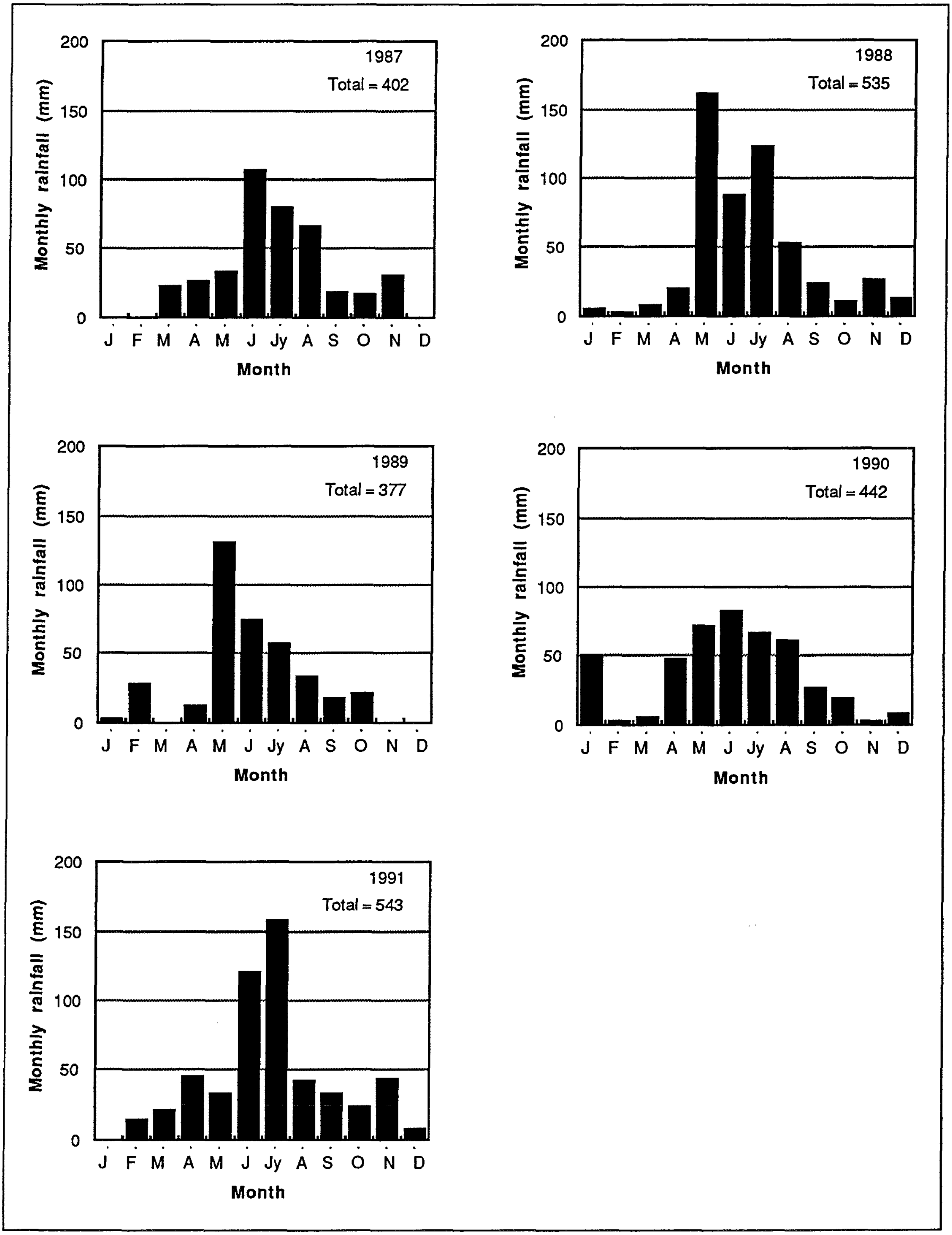


Figure 5. Monthly rainfall Northhampton 1987-91

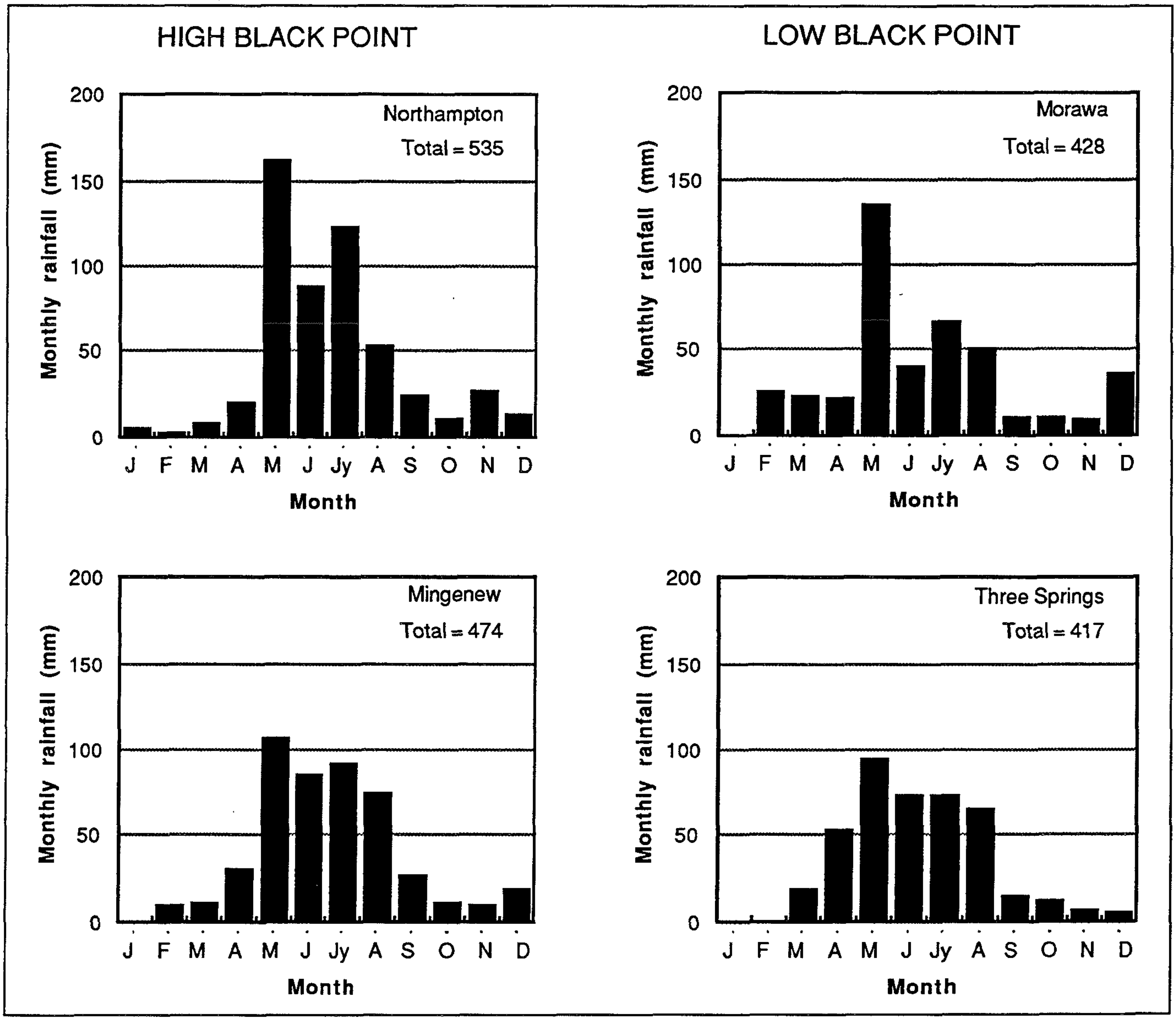
is 0.87. Apart from April to October rainfall, where the r value was marginally better (0.89), this was the best correlation obtained.

Rainfall records for four sites in 1988 are shown in Figure 6, to enable comparisons of data for sites with high staining (Northampton and Mingenew) and low staining (Morawa and Three Springs). The amount of grain of Eradu downgraded in 1988 at these sites was 89, 76, 15 and 11% respectively. (The relevant data on downgrading are tabulated in Appendix Table 1.2). As can be seen by examining the figure, it is very difficult to predict staining from the monthly rainfall data.

It is highly probable that rainfall is one of the significant factors in the development of black point. However, it is has not been possible to determine the timing of critical rainfall from the data examined here, nor to estimate the period over which heads would have remained moist. Data for the number of monthly rainfall events was examined but did not further explain the relationships. It is likely that the only method of satisfactorily proving cause and effect would be to conduct careful investigations of small but controlled data sets. This could be done by examining the rainfall, time of planting, varietal and staining records of individual farmers, or by conducting controlled environment experiments in which different regimes of watering and relative humidity are imposed on a set of plants.

Apart from rainfall, other environmental factors are likely to contribute to the development of black point. In Figure 3 it was shown that black point decreases with distance from the coast. It is highly likely that rainfall differences contribute to this relationship. However, other factors to consider are relative humidity, and the likelihood of drying winds, as black point is likely to be worse if the grains remain moist for a long period of time. Figure 7 shows comparative data for relative humidity at three sites: Geraldton, Mingenew and Carnamah. These were previously shown to be sites of high, moderate and low staining risk respectively (see Section 6). The relative humidity in the period August to December shows similar trends, with the sites having relatively high, medium and low relative humidity respectively. This is further evidence that relative humidity, rather than just rainfall, may be the most important environmental factor with respect to the development of black point. Data for Figures 7 to 10

Figure 6. Monthly rainfall 1988. Sites with high and low black point



were obtained from long term mean data (Australian Bureau of Meteorology 1988).

The air temperature during the period of development of black point may also be important, as the rates of fungal processes are often temperature-dependent, and for these types of infections the optima are often between 25 and 30° C. However, Figure 8 shows that differences in temperature between Geraldton, Mingenew and Carnamah are probably of little importance with respect to direct effects on fungal activity, as the three sites have very similar temperatures, particularly in August and September. In the later months of the year, the temperatures at Mingenew and Carnamah are higher than at Geraldton; this probably contributes to the lower relative humidities at the two easterly sites.

Nevertheless, air temperatures may contribute to State-wide differences in staining incidence. Figures 9 and 10 show data on relative humidity and temperature for Geraldton, Northam and Esperance. Differences in relative humidity cannot explain the low incidence of staining at Esperance in comparison with Geraldton, as Esperance is on the coast and the relative humidity is particularly high all year round. However, the temperatures at Geraldton are consistently warmer than at Esperance and this probably enhances fungal activity at the northern site. Northam is an inland site, and its more moderate staining incidence compared with Geraldton is probably related to low relative humidities at Northam between August and December, rather than to any differences in temperatures.

One of the problems with this type of analysis is that the process is complex and consists of more than one critical event. For example, it has been established experimentally that grains can be infected with the relevant fungi without developing the blackening associated with black point (see Section 3). Thus at least three events must occur:

i) there must be sufficiently abundant spores of the causal fungi present around the crop;

ii) conditions must be suitable for the spores to both enter the head, and infect the grains; and

iii) conditions must be suitable for blackening of the grains to develop.

Figure 7.Comparison of relative humidity Geraldton, Mingenew and Carnamah

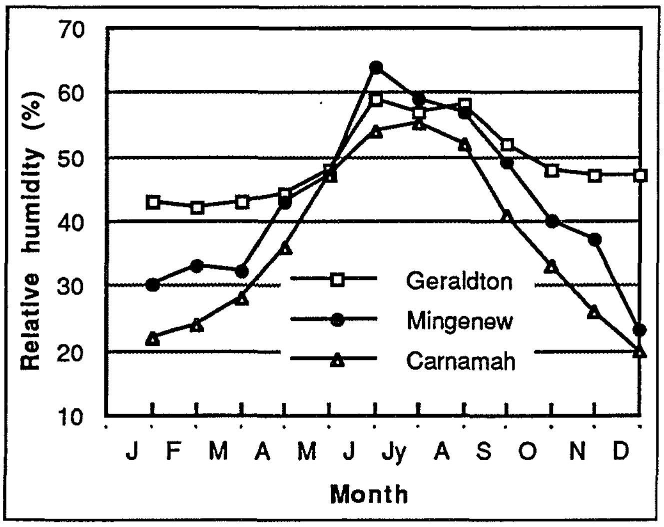


Figure 8.Comparison of temperatures Geraldton, Mingenew and Carnamah

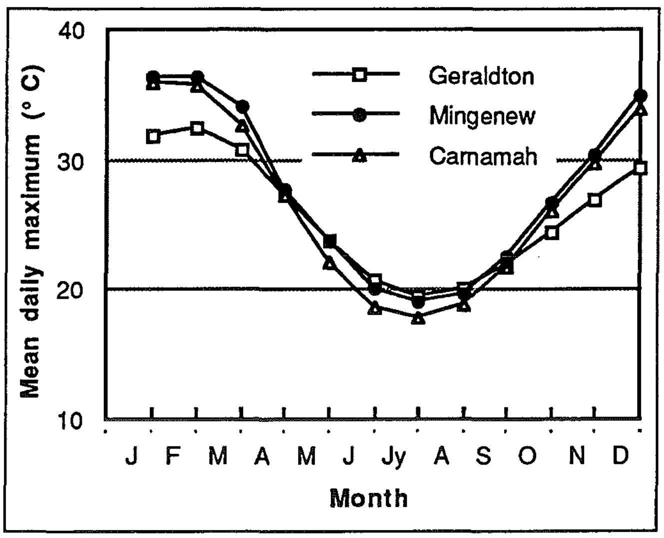


Figure 9.Comparison of relative humidity Geraldton, Northam and Esperance

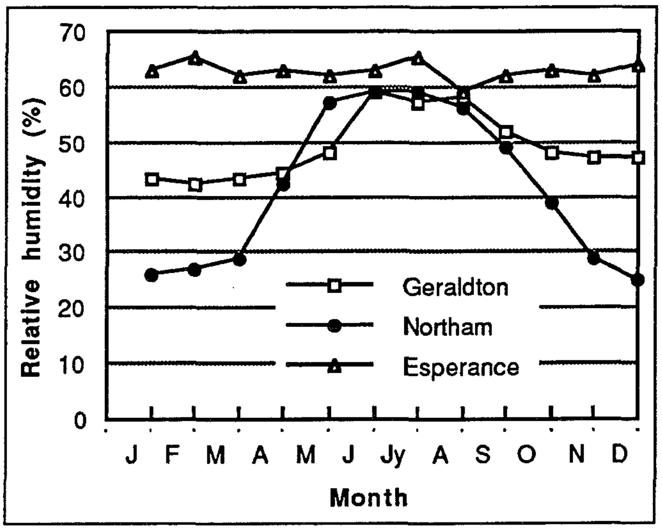
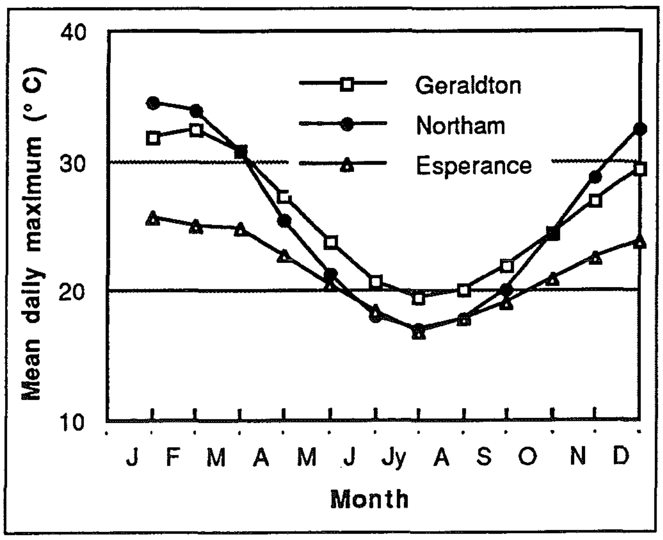


Figure 10. Comparison of temperatures Geraldton, Northam and Esperance



8. Results of field experiments - agronomic effects

Farmers and research workers frequently assert that a particular management factor contributes to increased staining of grain. Some of the factors implicated are soil type, topography (hollows *cf.* hills), fertilisers including both major and trace elements, and time of sowing. Unfortunately there are very little data to support or refute any such assertions, and often observations are complicated by the comparison of crops of different varieties, or with some other confounding factor. More measurements are required of staining on grain harvested from field trials, particularly those where some of the above factors are compared.

For the purposes of this report, fungal staining was measured on grain samples from five trials of Dr Wal Anderson. Full data and analyses are given in Appendix 4. The trials were located at Dowerin and Marchagee in 1989, and at Corrigin, Northam and Wongan Hills in 1990. Unfortunately no data were available from more northerly areas of the wheatbelt. All trials had the same design and involved the following factors:

- Two times of sowing
- Two rates of applied nitrogen fertiliser
- Six varieties (Aroona, Eradu, Gamenya, Kulin, Reeves and Spear)

There was considerable variation between the trials in both the level of staining, and the significance of the various factors. Significance levels for individual trials, and comments on these, are also given in Appendix 4. A summary of the effect of the factors across all five trials is as follows:

Variety

Eradu consistently had the worst staining, though sometimes Gamenya and Kulin had equally high levels (one trial each). For Kulin, the trial with especially bad staining (Northam 1990) had especially early times of sowing, thus contributing to increased staining of such a short season variety.

Reeves consistently had the least staining, though sometimes Spear and Aroona (three trials) or Kulin (one trial) had equally low levels.

Time of Sowing

The effect of this factor was variable, and was complicated by interactions with variety. For the overall data, earlier sowing produced more staining in two trials (Dowerin 1989 and Corrigin 1990), and later planting more staining in one trial (Marchagee 1989). In the other two trials time of sowing had no effect on staining. However, the sowing times were different between trials, making it quite difficult to make realistic comparisons. For instance, in the Northam trial, time of planting was not significant, but both times of planting were before mid-May, staining levels were very high, and all varieties would have been downgraded at both times of planting. Thus the evidence suggests that for most varieties, staining is worse at earlier plantings.

One of the most interesting results of the investigation, however, was the fact that there were some interactions between time of sowing and variety (see Appendix 4). The results were variable, but there was strong evidence that later planting of Kulin increases staining. Staining of Kulin was worse at the second planting in three trials (Marchagee, 1989, Northam and Wongan Hills, 1990). Of the other varieties, Aroona was most likely to be affected by time of planting, but it was worse at the earlier time. Figure 11 shows the effect of time of planting on staining of Kulin and Aroona in four of the trials. Data for Dowerin in 1989 are not shown as staining was negligible. The data are averages across nitrogen treatments.

Of the varieties used, Spear is late maturing, Kulin early maturing, and the others of medium maturity. While the results are not conclusive, they suggest that interactions occur between varieties and time of planting, and that they may be different for the different

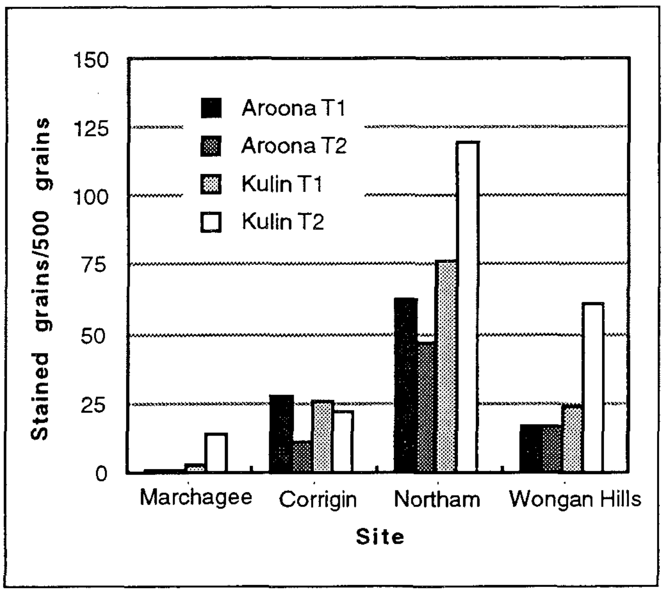


Figure11. Effect of sowing time on staining of Aroona and Kulin

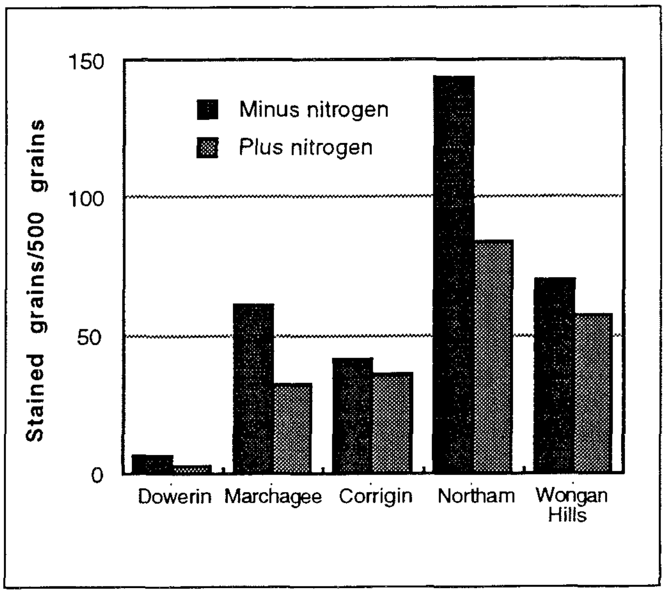


Figure 12. Effect of nitrogen on staining of Eradu

varieties. This is one factor that complicates the conclusions and certainly warrants further investigation.

Nitrogen

In three trials, staining was worse where no nitrogen fertiliser was applied, but it was only significant for the varieties with the highest staining levels (Eradu and Gamenya at Dowerin 1989, Eradu at Marchagee 1989, and Eradu and Kulin at Northam 1990). Figure 12 shows data for Eradu from all five trials, averaged across time of sowing.

Generally there was no interaction between time of sowing and nitrogen, except at Marchagee in 1989, where the nitrogen effect was only significant at the second time of sowing.

The fact that nitrogen application clearly reduced staining in three of the trials shows that claims of staining being affected by nutritional factors should not be dismissed. This is another factor that warrants further examination.

Additional data from 1992 trials

At the end of 1992, and after the initial draft of this document had been completed, several agronomic trials in the Geraldton area were assessed for black point. The factors investigated included seeding rate, phosphorus fertiliser rates, and trace element applications.

- **Seeding rate** was a factor in trials at both Northampton and Mullewa (92GE79 and 92GE67), which also included two varieties, Eradu and Wilgoyne. There was considerably more staining at Northampton than at Mullewa (average 18.1% compared with 0.6%), and at both sites Eradu was significantly more stained than Wilgoyne (25.9% for Eradu and 10.3% for Wilgoyne at Northampton, and 1.0% and 0.2% respectively at Mullewa). At both sites there was an increase in staining with increasing plant density up to approximately 140 plants/m^2. A summary of the results for Eradu is given in Table 8.

Table 8. The effect of plant density on the staining of Eradu in 1992

	Approximate plant density - plants /m^2					
	47	74	90	140	150	210
	% Stained grain of variety Eradu					
Northampton	-	20.9	26.6	29.2	28.0	24.8
Mullewa	0.50	0.85	1.05	1.30	1.20	-

- **Rates of superphosphate** were investigated in trials at Northampton (92GE71) and Allanooka (92GE72). Ten rates, ranging from 0 to 40 kg/ha applied P were used, but there was no effect on black point. Average staining was 14.4% at Northampton and 1.8% at Allanooka.
- **The effects of copper and zinc** were examined in a long term trial at Eradu (86GE38). This trial was in its seventh year in 1992, and was originally a virgin site with no fertiliser applications. The treatments assessed for staining were as follows: no copper, no zinc (treatment 4); no zinc, but plus copper (5), no copper, but plus zinc (7); and both copper and zinc applied (6). The variety Eradu was used, and staining was high, with an average of 23.8% stained grain. However, there were no significant differences between treatments.

The data on agronomic effects are incomplete, and there is a need for greater understanding of the effects of various management factors on staining. There are clearly several factors which warrant further attention. There is some evidence that black point is reduced by applications of nitrogen fertiliser, by delayed planting, and by lower plant densities. As the interaction with time of planting may be complicated by interactions with the maturity type of the variety, this also needs further investigation.

9. Costs of black point

Total losses

The total cost of black point to the wheat industry in the Geraldton Port Zone is usually less than 1% of total value, although it may be as high as 5% (Table 9). However, this varies considerably from site to site, and for different varieties. It is also significantly affected by the pricing regime applied. In this analysis, two pricing structures have been used: a low price (based on 1990/91 figures), and a relatively high price (based on 1991/92 figures). See Appendix 5 for details of prices.

As Table 9 shows, in 1988/89 a substantial amount of grain was downgraded; most of this was a result of fungal staining. Depending on the pricing structure applied, this would have resulted in between 2-5% of the total value of the crop being lost. Using the 1990/91 price structure, the loss estimation was almost $4.5 million. This loss was reduced to $3.9 million when the 1991/92 price structure was used. In reality, much less was lost in 1988/89 than we would expect, as most of the GP1A was sold as low-grade ASW in that year. Actual dollar losses are very dependent on the market conditions prevailing at the time; in some years the difference between ASW and lower grades is substantial, whereas at another time the difference may be marginal.

Losses at different sites

Although total losses to the local industry are usually less than 5%, losses at individual sites may be high. For comparison of different sites, data for 1988/89 and 1990/91 are shown in Figure 13. In 1988/89, losses were quite considerable at Binnu, Mingenew, and Northampton, at each of which downgrading estimates were approximately $400,000. At the Geraldton receival site, losses were estimated to be worth $1.7 million in 1988. As a percentage of the total value of the crop at each site, losses varied from 1.4% at Three Springs to 10.4% at Northampton in 1988/89 (Figure 14).

Losses in 1990/91 were slight in comparison with those in 1988/89, but there was still considerable variation among sites (Figures 13 and 14). At the Geraldton receival point, approximately $800,000 was lost owing to staining, but at other sites losses were all less than $100,000, with the greatest monetary losses occurring at Mingenew, Carnamah, Northampton and Three Springs. As a percentage of total crop value, monetary losses in 1990/91 varied from 0.02% at Mullewa to 1.6% at Carnamah and 2.6% at Geraldton.

Note that these calculations involved 10 key sites and 15 key varieties, and used the 1990/91 pricing structure (Appendix 5).

Losses for different varieties

Figure 15 compares monetary losses for different varieties in 1988/89, 1990/91 and 1991/92. The figures for Gutha and Eradu are startling, particularly in 1988/89 when estimated losses were over $1 million for each of these varieties. This reflects both the very large receivals of Gutha and Eradu in this region, and the fact that both varieties are prone to fungal staining. The proportion of these varieties has fallen since 1988, and they both now tend to be grown more in the drier areas of the region where staining is usually less of a problem.

Financial risks

The financial risks associated with growing a variety that is prone to downgrading is now a serious consideration for growers. Varieties such as Eradu and Gutha, which can attract premiums as either noodle or hard wheats respectively, and which are both prone to fungal staining present special problems.

Table 9. Receivals, downgrading, crop value and fungal staining costs for Geraldton Shipping Zone, 1987/91.

	1987/88	1988/89	1989/90	1990/91	1991/92
Receivals and downgrading					
Total receivals t	477,884	894,155	786,590	1,036,577	735,835
Grain downgraded t	4577	356,312	87,036	120,436	57,647
% Grain downgraded	1.0	39.9	11.1	11.6	7.8
Value and costs using 1990/91 prices					
Total value of receivals $	53,045,059	99,189,288	87,190,708	114,817,176	81,357,109
Cost of downgrading $	79,236	4,459,001	960,543	1,321,491	624,246
Cost of downgrading %	0.15	4.50	1.10	1.15	0.77
Value and costs using 1991/92prices					
Total value of receivals $	87,601,645	163,811,968	143,956,535	189,543,315	134,123,880
Cost of downgrading $	95,925	3,891,935	839,569	1,092,599	503,669
Cost of downgrading %	0.11	2.38	0.58	0.58	0.38

See Appendix 3 for explanation of prices used.

Note that the data in Table 9 take into account all receivals at all sites in the Geraldton Port Zone, whereas for comparison of separate sites or varieties (Sections 5 and 6), only selected sites and varieties are used (see Appendix 5).

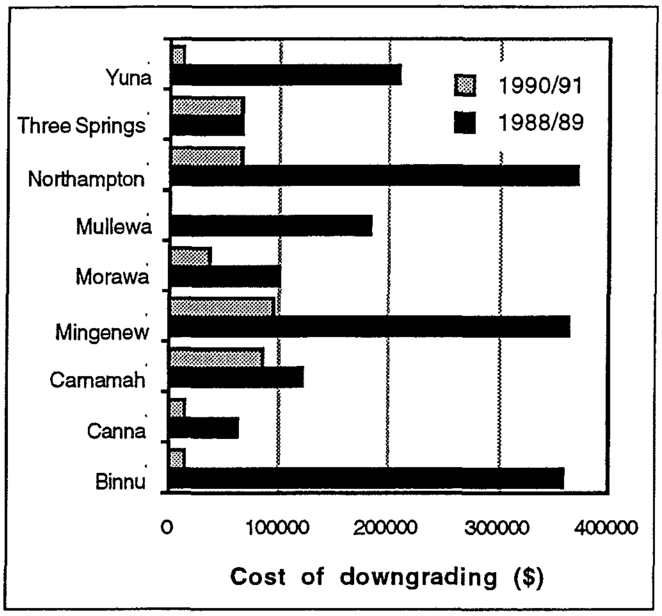


Figure 13. Cost of downgrading at different sites. 1988/89 and 1990/91 (1990/91 pricing structure) (Losses at Geraldton bin: $1,786,247(88/89),

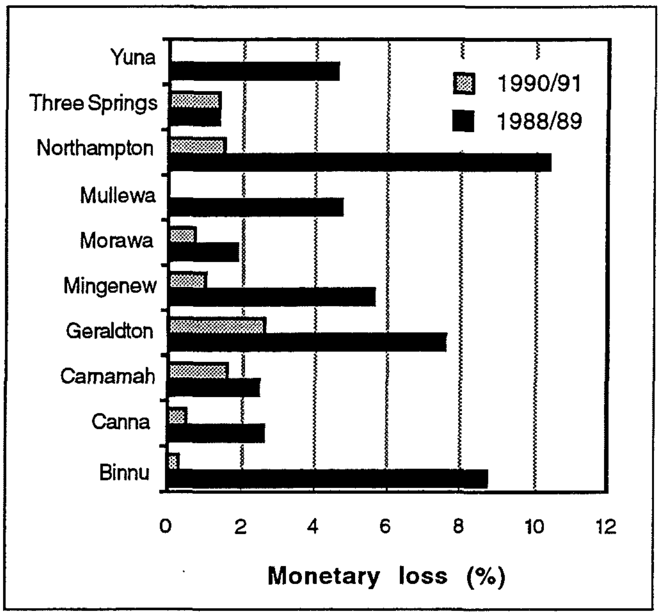


Figure 14. % monetary losses at different sites 1988/89 and 1990/91 (1990/91 pricing structure)

The financial risks will depend on the following factors:

- the value of the grain, and whether it could attract a premium (e.g. hard, noodle, soft). Currently the greatest risk is with Eradu which is received into the ASW Noodle Pool and attracts a variable premium above ASW ($10 to $30/t), but is also prone to fungal staining.
- whether the crop is likely to be within the required protein levels to attract any relevant premium
- the price difference between maximum value and the value of lower grades (i.e. the costs of dropping to GP1A or lower). This price differential can vary considerably from year to year, and tends to have more significance when the maximum price is low (e.g. in a year like 1990/91).

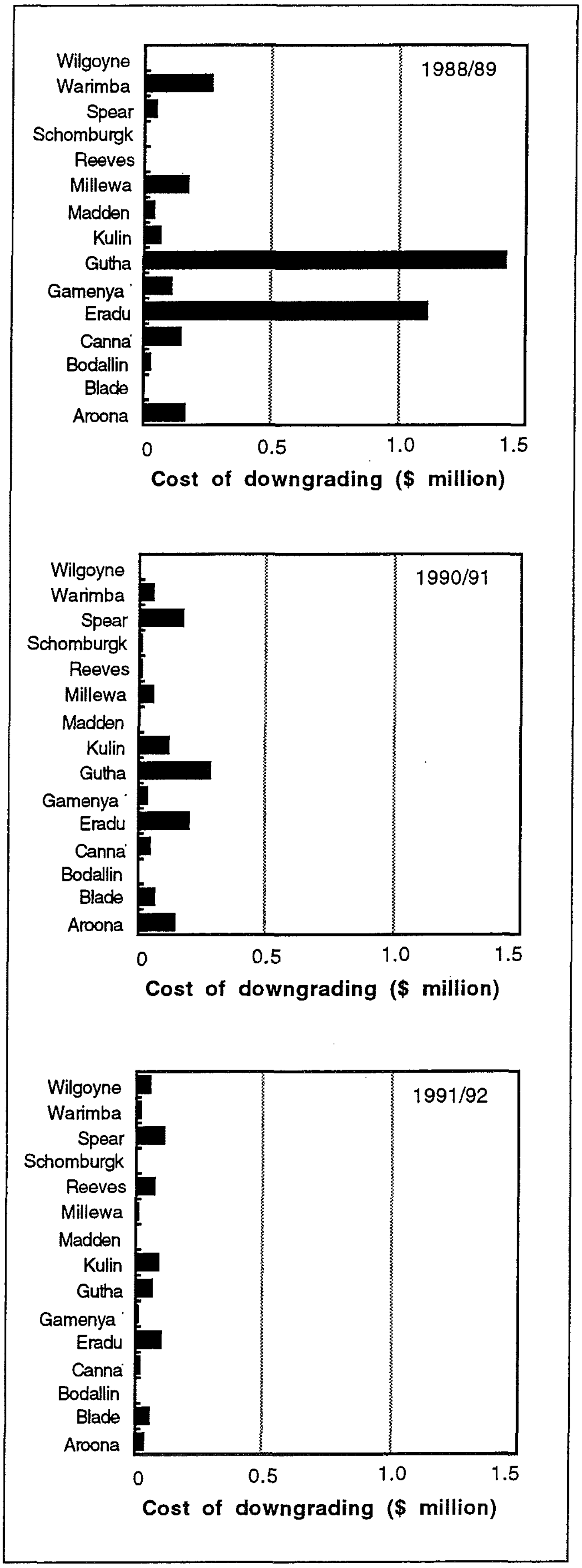


Figure 15. Cost of downgrading for different varieties (1990/91 pricing structure)

- the yield of the variety in comparison with other varieties. If a very high yield can be obtained, then this may reduce the effects of any risks associated with downgrading.

The computer program "Padrank", developed by Geraldton Regional Economist, Mark Stevens, can take into account all the above factors, and is very useful for estimating the potential for a variety in a particular situation. Figure 16 is an example of the type of analysis available. This shows the percentage downgrading of Eradu or Gutha needed before it is more profitable to grow an ASW variety in either the northern high (H1) or medium (M1) rainfall zone. Data for a low rainfall zone are not shown as the risk of downgrading in that environment is much lower; however, the principles would be the same. The different bars in the figure represent different planting times. At early plantings, ASW varieties (such as Spear) tend to be more profitable because their yield potential is higher than that of Eradu or Gutha; at later plantings, yield differences between the varieties tends to decrease and the relative profitability of higher quality varieties consequently increases. This analysis suggests that with a variety that attracts a premium such as Eradu or Gutha the percentage of downgrading required to reduce its profitability is quite high. At most sites the recorded incidence of downgrading is usually lower than that needed before an ASW variety would be a more profitable alternative. However, if the receival data presented in Appendices 1 and 2 are examined it is clear that Eradu and Gutha present considerable risks at sites such as Northampton, Binnu and West Mingenew in most years.

Farmers are advised to use the latest market information, together with a tool such as "Padrank" to assess the risks of growing different varieties.

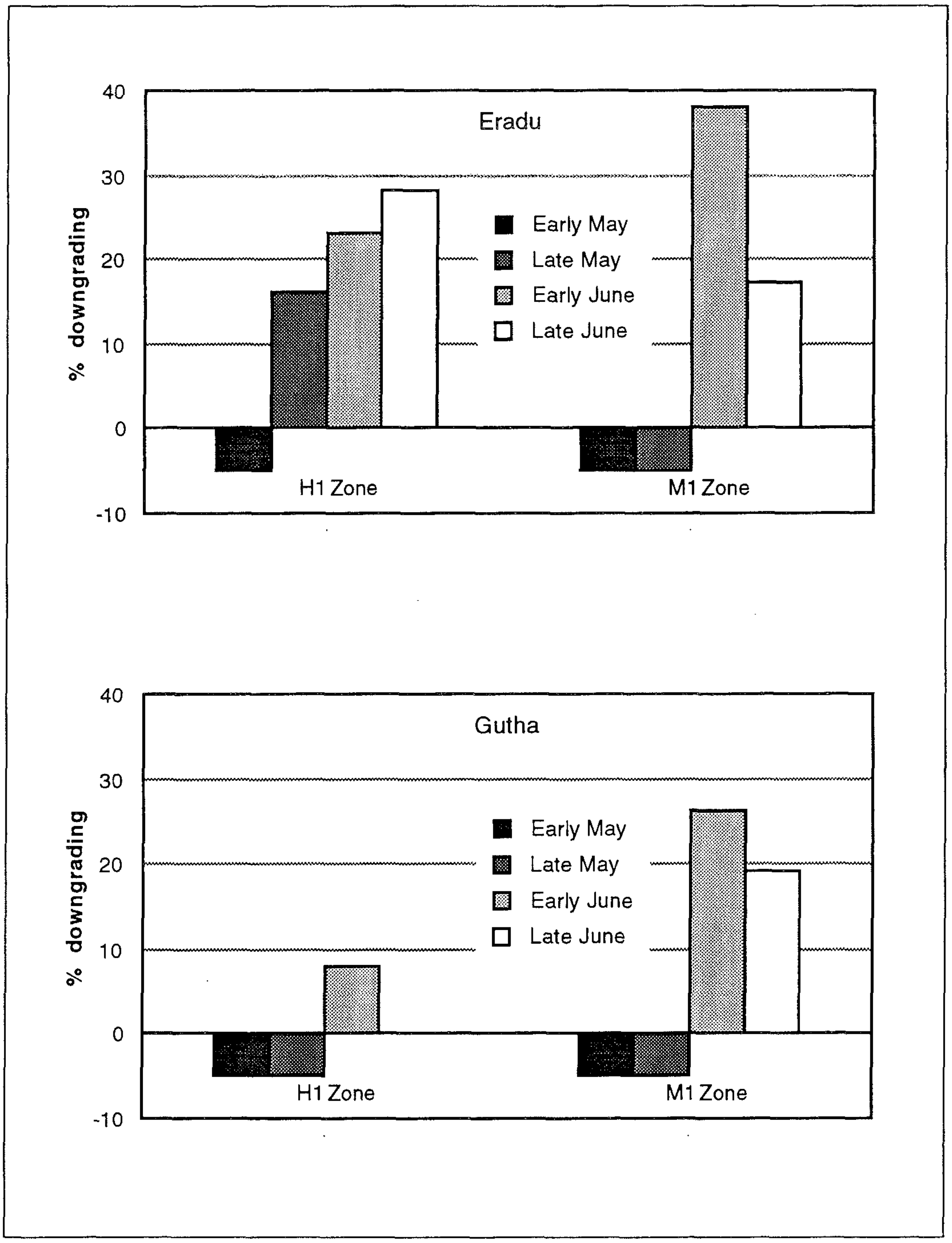


Figure 16. Downgrading for ASW to be more profitable than either Eradu or Gutha. Analysis by Mark Stevens. Prices at March 1992, 10% protein.

10. Conclusions

Black point is a difficult topic to analyse as the information available is rather limited. It appears that the problem is most significant in northern, rather than southern areas of Western Australia. This is partly because of the prominence in the north of varieties such as Eradu and Gutha which are more prone to staining than varieties commonly grown in southern parts. It is also probably a response to differences in climatic regimes; wheat-growing areas to the south are either inland sufficiently to have low relative humidities at the end of the season, or for those near the coast the temperatures are relatively low and thus less favourable for fungal development on the grain. In the northern wheatbelt, staining is most common in coastal locations, though in some seasons, notably 1988/89, significant black point also occurred at inland sites.

The cost of fungal staining to the industry varies for different sites and varieties. It is also dependent on the pricing structure used in the calculations. Using 1990/91 prices for comparison, the estimated loss to wheat returns in the Geraldton Shipping Zone varied between $80,000 (0.15%) in 1987, to $4.5 million (4.5%) in 1988/89. The greatest loss for an individual site (on a proportional basis) was at Northampton in 1988 when 10.4% of total monetary returns were lost because of downgrading. This reflected an overall average downgrading of approximately 78%.

Varieties differ in the extent and frequency that they become stained. Of the 16 varieties most commonly grown in the northern wheatbelt, those most prone to staining are Warimba, Eradu, Millewa and Gutha. Those least prone to staining are Wilgoyne, Schomburgk, Madden and Bodallin.

Farmers should critically examine the risks of growing any variety that is prone to staining. There is probably no good reason to be growing either Warimba or Millewa, as their yields are less than those of other varieties. However, both Eradu and Gutha attract premiums, (for noodle and hard classes respectively), and for these varieties the risks need to be assessed carefully against potential returns. This can be done relatively easily using the computer program Padrank, as long as good estimates are available of relative yields, expected proteins, and history of risk from staining. Eradu and Gutha are very risky varieties for locations such as Northampton, Binnu, West Mingenew, Dongara, Walkaway and Moonyoonooka, and western parts of the Chapman Valley.

Very little is known about the process of staining, or the factors that contribute to its severity. While head architecture may be important, further information is required before its relationship to staining could be confirmed. Management factors also probably play a part, and this report has presented evidence that both applications of nitrogen fertiliser, and delayed planting, may reduce the severity of staining. The interaction with time of planting may be complicated by the maturity type of the variety as in several trials the short season variety Kulin suffered worse staining at a later sowing time.

Considering the losses currently being faced by farmers, and that most current varieties are prone to at least moderate amounts of staining, there is justification for more research to be undertaken on the topic. Some of the aspects that deserve further attention are as follows:

- the biological processes of infection and blackening, including how and when they occur;
- the climatic conditions that increase staining severity;
- the plant structural attributes that affect staining severity;
- the management factors that reduce staining severity, with particular emphasis on nutritional factors;
- the possibility of successfully breeding for "resistance"; and
- cost structures, and management of financial risk.

11. Acknowledgements

This report would not have been possible without the provision of receival data by the Australian Wheat Board (AWB). I am grateful to Mr Bruce Watkins, Manager for Western Australia of the AWB for releasing the information, and to the AWB quality control officers in Western Australia, Mr Trevor Warburton and Mr Richard Williams, for their help in providing the data in a suitable form. Special thanks are owed to Trevor Warburton (now of the Melbourne office of the AWB), for his assistance in interpreting the data.

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The instigator of this project, Yuna farmer Mr Bill Creasy, deserves a special mention for his foresight and persistence in ensuring that an analysis of the problem of staining was undertaken. Mr Creasy and Dr Anderson were both members of the Wheat Research Committee of W.A. at the time of inception of the project, and both were instrumental in ensuring that funding was provided. I am of course very grateful to the Wheat Research Committee for the provision of operating funds.

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13. Appendices

1. Tables of receival data for selected sites

2. Graphs of receival data for selected sites

3. Tables of receival data for the four Western Australian zones

4. Summary of trial data used in Section 8

5. Pricing structures used in analysis of costs

Appendix 1. Tables of receival data and downgrading for selected sites in the Geraldton Shipping Zone, 1987-91

The data used in this report were supplied by the AWB, and consisted of receival data for the Geraldton Shipping Zone. This consists of 22 sites as follows:

- Arrino
- Binnu (BIN)*
- Bunjil
- Bowgada
- Buntine
- Canna (CAN)*
- Carnamah (CAR)*
- Geraldton (GER)*
- Gutha
- Latham
- Maya
- Mingenew (MIN)*
- Morawa (MOR)*
- Mullewa (MUL)*
- Northampton (NOR)*
- Perenjori
- Pindar
- Pintharuka
- Sullivan
- Three Springs (TS)*
- Wongoondy
- Yuna (YUN)*

Data for the 10 sites marked * are presented in the following tables, and in the graphs in Appendix 2. Abbreviations used are shown in brackets. Data for the other 12 sites are summed as "other" in the tables and are not presented in the graphs.

Data are for total grain received, and total grain downgraded (1987/88-89/90) or total grain fungal-stained (1990/91-91/92) for each variety at each site. For the sake of brevity, separate information for each grade (e.g. GP1A, 1B, GP2, FEED) is not shown in this report.

Data is shown for a selected 15 varieties for each site and year. The varieties are as follows:

- Aroona (AR)
- Blade (BL)
- Bodallin (BO)
- Canna (CA)
- Eradu (ER)
- Gamenya (GA)
- Gutha (GU)
- Kulin (KU)
- Madden (MA)*
- Machete (MC)*
- Millewa (MI)
- Reeves (RE)
- Schomburgk (SC)
- Spear (SP)
- Warimba (WA)
- Wilgoyne (WI)

Varieties marked * were not included every year. Madden was tabulated for four years: 1987-90, but was replaced by Machete in 1991. This was principally owing to an increasing interest in Machete throughout the region, but a significant decline in the receivals of Madden. Where receivals were zero at any site, the corresponding downgrading data is listed as N. Some varieties were not released during the early years; for example, Reeves, Schomburgk and Wilgoyne, and this accounts for the number of zeros for these varieties

Appendix 1.1

Receivals for selected sites and varieties in the Geraldton Zone.
Tonnes received 1987/88

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	622	0	4728	13999	6576	0	0	669	1237	1181	3924	32936
BL	22	0	0	0	0	0	0	0	0	0	0	22
BO	0	205	0	3015	2600	1755	596	0	307	120	12919	21517
CA	561	590	1877	5946	1321	36	344	215	40	3257	2951	17138
ER	5287	468	2927	19733	2154	411	3438	17385	2248	1616	21362	77029
GA	56	557	3030	8044	1687	441	559	88	5328	537	20992	41310
GU	9715	7550	10755	47248	14695	13676	12017	3267	17798	8390	63870	208981
KU	11	0	0	146	26	0	0	66	17	0	115	381
MA	879	216	1704	4178	1176	1683	845	396	2454	2827	6502	22860
MI	928	65	43	6623	3892	663	93	1463	158	766	2238	16932
RE	0	0	0	0	0	0	0	0	0	0	0	0
SC	0	0	0	0	0	0	0	0	0	0	0	0
SP	352	0	0	353	141	0	0	316	0	0	377	1539
WA	1375	0	1128	10289	4062	0	0	629	207	89	640	18419
WI	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	19808	9651	26192	119574	38321	18665	17892	24494	29794	18783	135890	459064

Downgrading at selected sites in the Geraldton Zone.
Percentage downgraded of selected varieties 1987/88

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	0	N	0	8	2	N	N	9	15	1	0	5
BL	0	N	N	N	N	N	N	N	N	N	0	0
BO	N	0	N	7	9	10	10	N	0	36	6	7
CA	3	0	0	15	2	67	10	24	60	18	9	11
ER	5	0	0	6	0	12	1	5	3	12	1	4
GA	0	0	0	17	7	30	3	66	3	17	3	7
GU	7	0	0	19	3	12	3	14	5	14	2	8
KU	18	N	N	0	54	N	N	0	0	N	28	13
MA	0	0	0	15	0	18	14	0	1	10	7	8
MI	8	0	0	17	6	15	100	35	36	26	1	14
RE	N	N	N	N	N	N	N	N	N	N	N	N
SC	N	N	N	N	N	N	N	N	N	N	N	N
SP	0	N	N	10	17	N	N	23	N	N	0	9
WA	24	N	0	22	4	N	N	20	0	21	0	16
WI	N	N	N	N	N	N	N	N	N	N	N	N
TOTAL	7	0	0	15	4	13	4	9	5	14	3	7

Appendix 1.2

Receivals for selected sites and varieties in the Geraldton Zone.
Tonnes received 1988/89

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	2647	0	9032	23991	13557	0	309	2198	2721	3294	8066	65815
BL	272	0	0	163	186	39	0	168	487	0	8	1323
BO	0	579	0	6229	6215	4943	2731	0	491	339	36690	58217
CA	913	1059	1670	12742	1495	222	1416	526	141	7100	6949	34233
ER	8710	1081	5687	35899	6081	1849	6501	19344	4926	5399	57680	153157
GA	158	1791	6638	8177	2205	1292	519	273	5641	276	36338	63308
GU	18134	15979	15835	74554	18585	33794	21718	3362	22376	16986	126396	367719
KU	1616	513	951	9418	1818	921	246	1764	1405	75	8006	26733
MA	653	54	1665	4208	1292	1434	1208	493	3850	4783	17633	37273
MI	1475	20	13	9100	5169	1333	165	1343	245	1102	4944	24909
RE	0	0	0	0	0	0	0	0	0	0	0	0
SC	64	0	0	0	99	0	0	91	0	0	0	254
SP	702	0	0	5289	12	372	13	750	5	229	2740	10112
WA	1760	0	2228	16298	2217	0	0	1386	0	1041	769	25699
WI	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	37104	21076	43179	206068	58931	46199	34826	31698	42288	40624	306219	868752

Downgrading at selected sites in the Geraldton Zone.
Percentage downgraded of selected varieties 1988/89.

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	50	N	5	32	29	N	3	48	14	35	6	25
BL	0	N	N	7	0	0	N	21	0	N	100	4
BO	N	12	N	17	8	3	38	N	24	0	11	12
CA	90	13	23	59	58	7	27	71	11	22	27	41
ER	80	7	29	83	76	15	34	89	11	52	23	52
GA	94	10	7	41	51	10	35	79	5	32	8	14
GU	82	31	39	69	65	24	55	67	20	63	30	45
KU	29	83	36	43	11	16	47	29	9	75	13	28
MA	58	0	22	25	11	16	38	14	2	22	3	12
MI	93	0	0	80	66	44	44	99	30	68	50	70
RE	N	N	N	N	N	N	N	N	N	N	N	N
SC	75	N	N	N	14	N	N	0	N	N	N	24
SP	57	N	N	62	0	5	0	64	0	14	14	46
WA	76	N	32	87	95	N	N	91	N	8	47	78
WI	N	N	N	N	N	N	N	N	N	N	N	N
TOTAL	76	28	24	63	49	21	47	78	14	45	21	40

Appendix 1.3

Receivals for selected sites and varieties in the Geraldton Zone.
Tonnes received 1989/90.

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	4161	0	10422	39862	18891	159	79	6724	3772	4393	11212	99675
BL	1001	96	0	8819	2228	207	436	768	1881	159	1981	17576
BO	0	1077	0	5197	6607	3352	1541	125	1001	235	31806	50941
CA	415	1040	560	10195	1036	511	99	427	78	5774	3830	23965
ER	8258	943	4071	33614	7309	881	7975	13691	5250	5126	45812	132930
GA	34	483	3655	8198	1713	98	937	144	4993	0	26995	47250
GU	14223	10592	6740	47060	12590	22166	11400	2914	13933	15546	74226	231390
KU	4102	1829	1010	26569	7745	1677	187	4869	3533	1063	10500	63084
MA	662	16	524	3488	805	1137	1479	196	2036	3577	11538	25458
MI	9	47	0	10277	3105	398	21	773	0	1177	1914	17721
RE	0	0	0	0	0	0	0	0	0	0	0	0
SC	600	0	116	287	594	0	0	474	0	0	667	2738
SP	736	0	1911	11153	840	709	536	1574	622	330	8830	27241
WA	972	0	318	12089	923	0	42	1113	46	319	261	16083
WI	0	0	0	110	50	50	0	9	41	0	376	636
TOTAL	35173	16123	29327	216918	64436	31345	24732	33801	37186	37699	229948	756688

Downgrading at selected sites in the Geraldton Zone.
Percentage downgraded of selected varieties 1989/90

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	21	N	0	14	2	0	0	14	19	2	0	9
BL	12	0	N	10	0	0	0	30	1	0	0	7
BO	N	0	N	2	0	3	8	12	5	0	1	2
CA	19	0	0	36	0	0	0	5	0	10	2	19
ER	14	0	0	30	1	49	5	45	4	4	0	14
GA	0	0	0	22	3	0	6	28	2	N	1	5
GU	14	0	0	25	15	5	7	21	13	12	1	10
KU	9	0	0	22	2	7	8	7	15	10	0	12
MA	2	0	0	6	0	0	2	6	3	4	3	3
MI	100	0	N	34	4	9	100	17	N	37	0	24
RE	N	N	N	N	N	N	N	N	N	N	N	N
SC	4	N	0	11	3	N	N	0	N	N	0	3
SP	23	N	0	21	3	1	24	4	2	0	0	10
WA	24	N	0	57	79	N	0	22	100	0	0	51
WI	N	N	N	0	0	0	N	0	0	N	0	0
TOTAL	14	0	0	24	5	6	6	26	9	9	1	11

Appendix 1.4

Receivals for selected sites and varieties in the Geraldton Zone.
Tonnes received 1990/91.

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	5341	0	13639	40717	23077	23	20	11410	3799	5954	13074	117054
BL	1295	559	81	26739	1467	464	1158	1717	4280	751	4515	43026
BO	0	4094	0	8440	10799	7812	3130	0	594	2019	42311	79199
CA	1559	1054	1699	12176	1094	10	800	565	125	8122	3966	31170
ER	8765	2922	6344	38859	8510	3455	19816	6821	4824	4011	74706	179033
GA	209	1816	4317	4870	1425	612	1590	27	5571	299	27366	48102
GU	11878	10459	10606	43553	6621	20278	7138	912	7925	13494	52290	185154
KU	10815	2454	2992	40822	20873	6661	897	11021	5483	2972	16110	121100
MA	118	22	814	994	185	136	249	0	1750	1817	13970	20109
MI	249	653	9	7248	2702	593	0	324	0	1553	1670	15001
RE	1405	249	985	11810	1249	774	314	1885	1705	210	6168	26754
SC	440	78	376	1389	1556	259	0	812	2151	172	3470	10703
SP	3280	1444	4559	29777	6949	3047	1032	4383	2047	1143	33200	90861
WA	273	223	687	9036	74	0	0	0	203	700	498	11694
WI	885	374	1966	3606	2663	1895	151	168	2287	771	9349	24115
TOTAL	46512	26401	49074	280036	89244	46019	36295	40045	42744	44042	302663	1003075

Fungal staining at selected sites in the Geraldton Zone.
Percentage fungal staining of selected varieties 1990/91.

	SITES											
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	0	N	2	26	13	0	0	3	5	0	2	12
BL	0	0	78	21	8	0	0	5	23	0	1	16
BO	N	1	N	0	0	0	0	N	0	0	0	0
CA	0	0	16	27	11	0	0	5	0	0	11	13
ER	3	1	13	22	4	17	0	48	5	0	1	8
GA	0	0	4	30	18	1	0	0	2	6	0	4
GU	5	10	45	26	27	14	0	56	43	9	7	17
KU	0	0	16	20	9	0	0	5	12	0	1	10
MA	0	0	1	8	0	0	0	N	4	0	0	1
MI	76	70	0	49	19	0	N	37	N	0	0	32
RE	1	0	0	9	5	0	0	0	3	0	0	4
SC	0	0	0	0	6	0	N	7	18	0	1	5
SP	8	0	11	50	18	0	0	10	4	1	0	19
WA	11	17	34	53	88	N	N	N	0	0	38	46
WI	0	20	0	0	0	0	0	0	0	0	0	8
TOTAL	3	6	15	26	11	12	0	14	14	3	2	11

Appendix 1.5

Receivals for selected sites and varieties in the Geraldton Zone.
Tonnes received 1991/92.

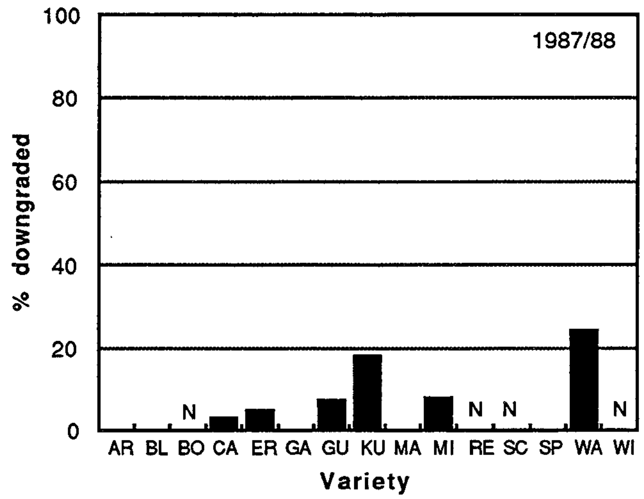
					SITES							
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	4117	0	5252	15434	7069	0	0	4426	1710	2338	3560	43906
BL	73	0	0	18320	127	0	331	979	592	488	1401	22311
BO	0	236	0	4349	4010	2309	815	0	892	1330	15060	29001
CA	122	162	489	2425	0	0	352	497	0	4678	656	9381
ER	4166	4367	2730	25202	4662	2441	16989	1053	4777	3970	42704	113061
GA	27	638	5468	3769	330	168	2320	0	2711	10	16836	32277
GU	7996	5958	1331	13635	1056	5041	2293	343	2337	7364	18141	65495
KU	7856	2586	2386	25806	14117	3439	646	5367	3053	3677	9241	78174
MC	471	0	2233	3042	3130	991	0	2982	1685	166	839	15539
MI	0	0	0	2563	133	75	0	0	0	287	349	3407
RE	15479	2637	8398	84743	15149	5774	4032	18739	8368	12393	29410	205122
SC	356	0	0	620	1250	48	233	454	721	0	1128	4810
SP	2199	158	3813	29253	8341	991	1785	6235	1493	808	10167	65243
WA	0	76	346	2346	0	10	0	0	53	0	98	2929
WI	1456	28	891	9836	1711	1915	800	494	1914	2239	6902	28186
TOTAL	44318	16846	33337	241343	61085	23202	30596	41569	30306	39748	156492	718842

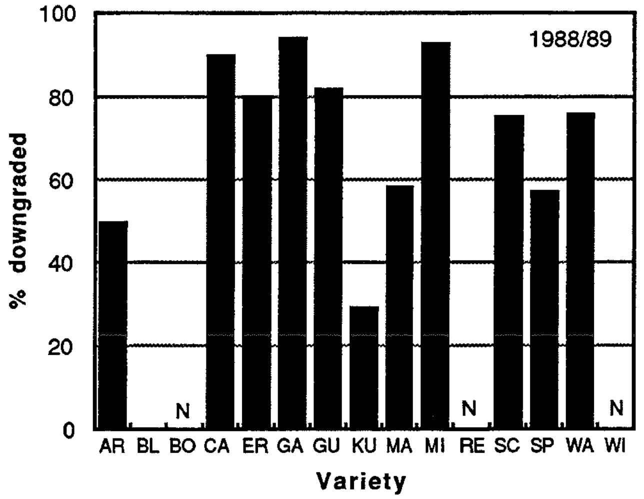
Fungal staining at selected sites in the Geraldton Zone.
Percentage fungal staining of selected varieties 1991/92.

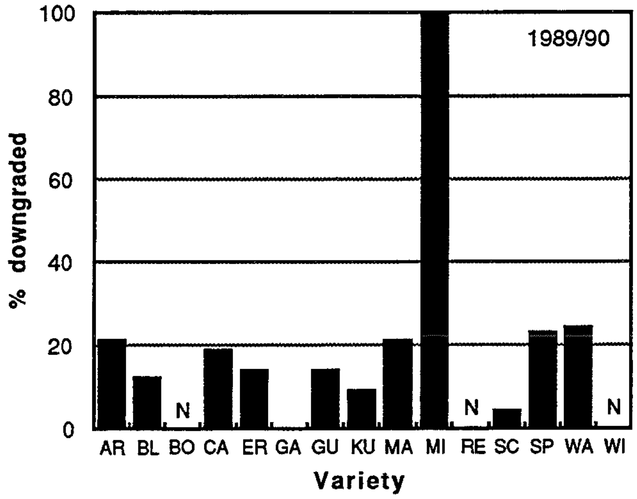
					SITES							
VAR	BIN	CAN	CAR	GER	MIN	MOR	MUL	NOR	TS	YUN	OTHER	TOTAL
AR	2	N	0	13	1	N	N	28	6	<1	N	8
BL	22	N	N	28	64	N	0	35	0	45	0	26
BO	N	0	N	4	0	0	0	N	0	0	0	<1
CA	0	0	0	42	N	N	0	40	N	19	0	22
ER	16	0	0	16	2	1	<1	98	3	14	0	6
GA	0	0	0	11	17	0	1	N	1	0	0	2
GU	17	0	0	19	4	0	6	66	5	28	0	10
KU	2	0	0	24	1	0	0	47	2	4	0	12
MC	5	N	N	4	0	0	N	8	0	0	0	3
MI	N	N	N	23	0	0	N	N	N	0	0	17
RE	2	0	0	6	0	0	<1	7	1	2	0	4
SC	0	N	N	0	0	0	12	38	0	N	N	4
SP	13	0	0	29	1	0	19	24	0	2	0	16
WA	N	0	0	62	N	0	N	N	0	N	0	50
WI	2	0	0	5	1	0	0	11	0	0	0	2
TOTAL	7	0	0	16	1	1	2	21	1	10	0	7

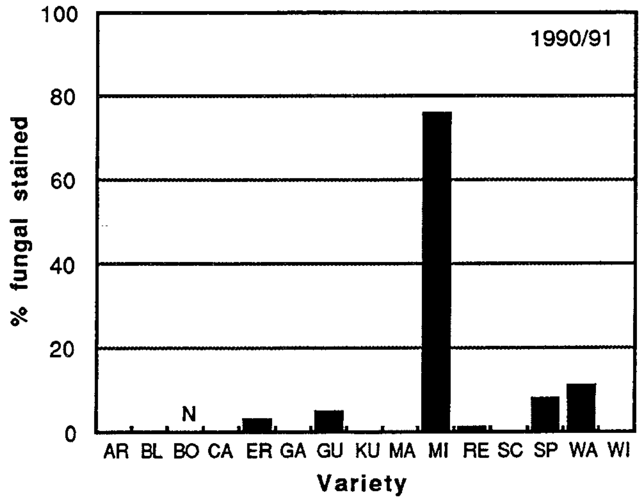
Appendix 2. Graphs of receival and downgrading data for selected sites

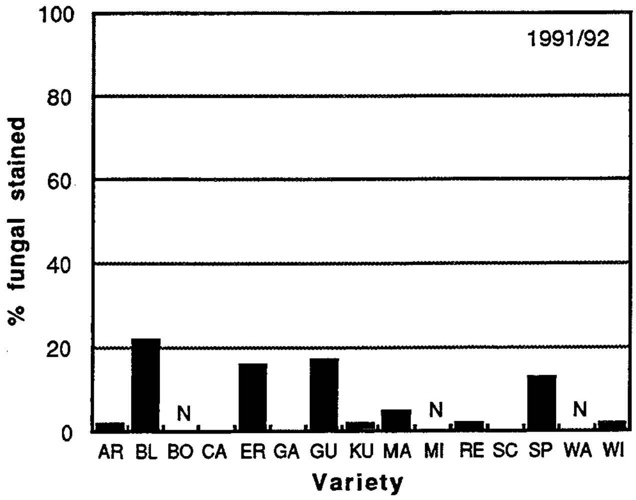
Binnu Grain Downgraded 1987-1991



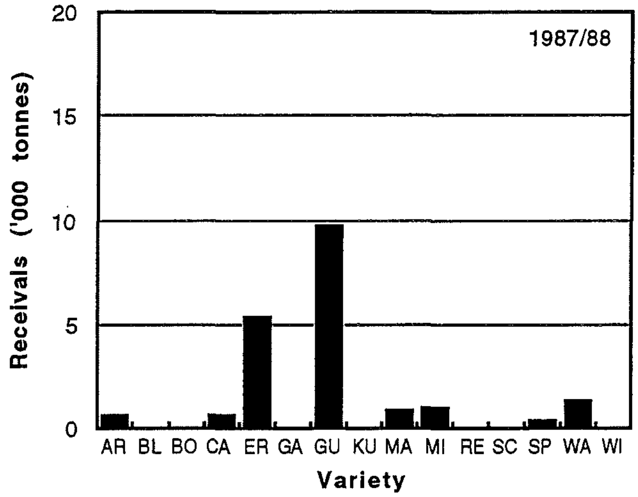


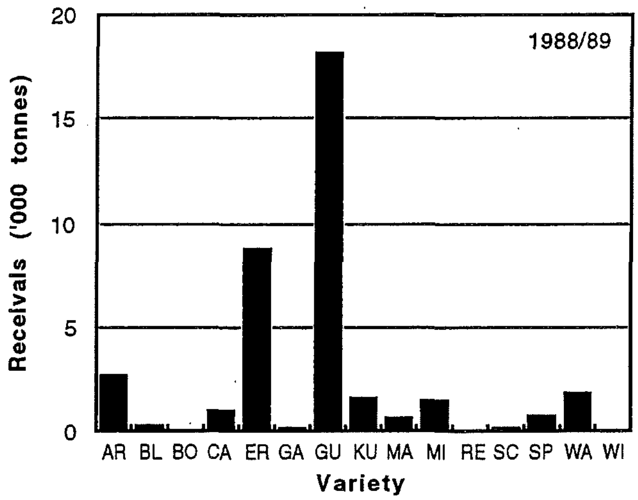


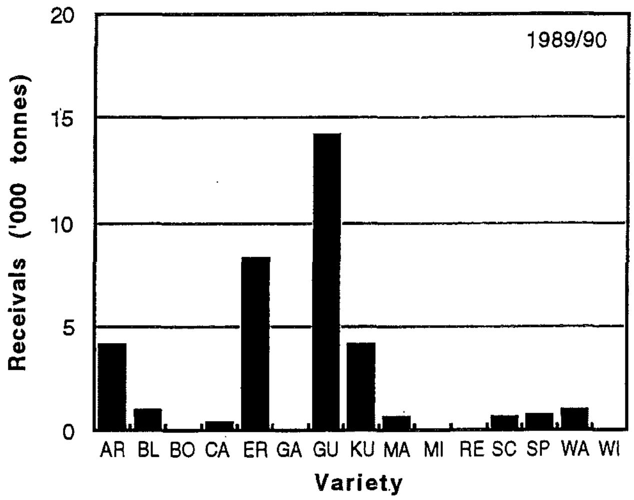


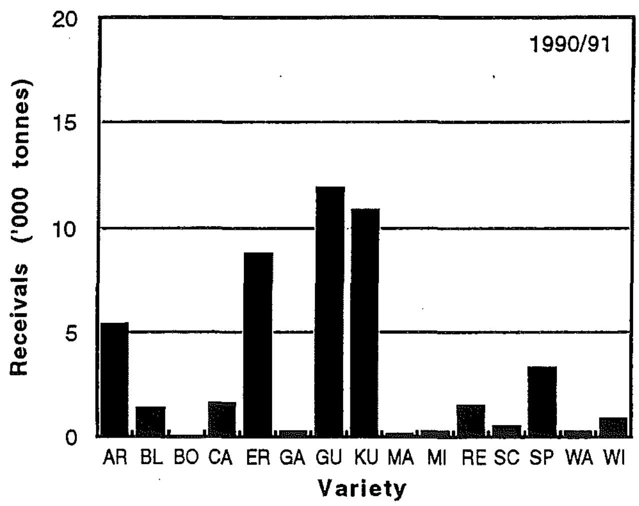


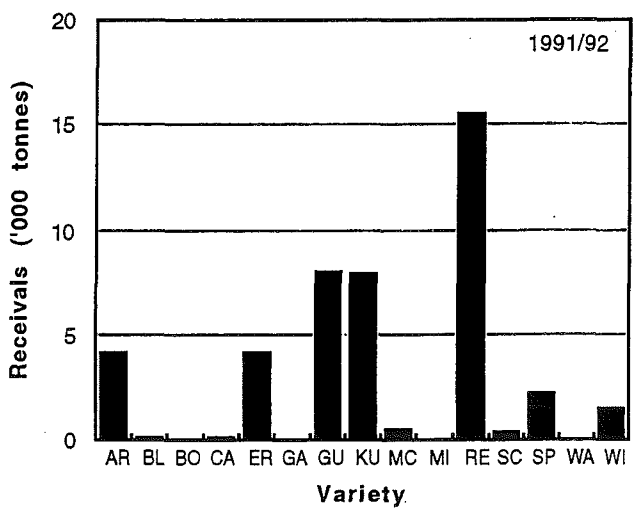
Binnu
Total Receivals
1987-1991



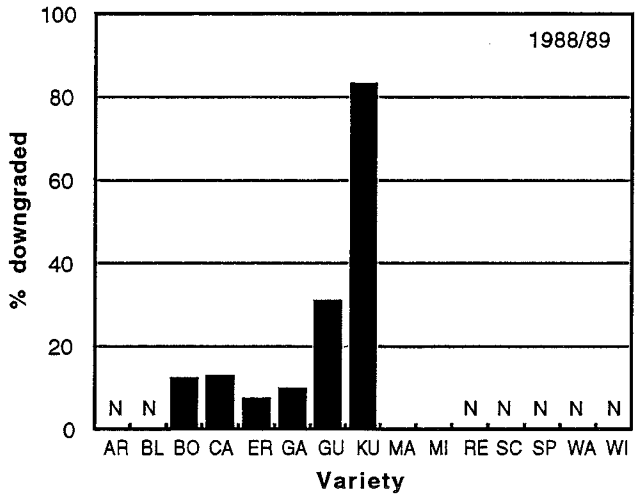


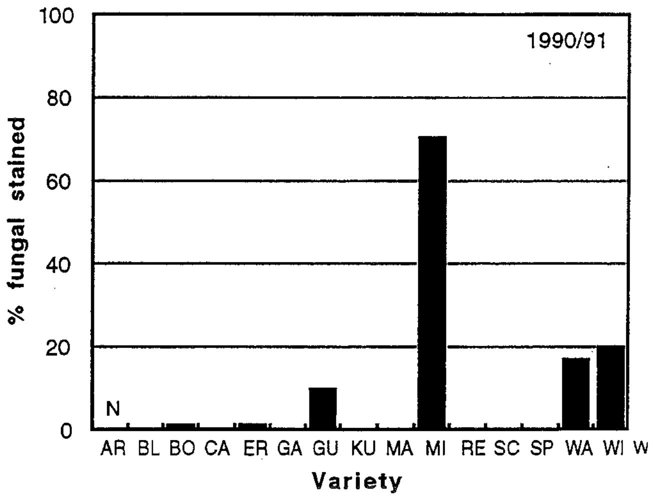






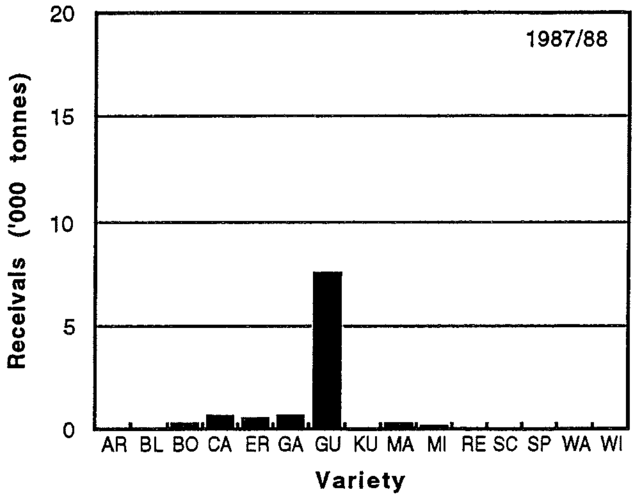
Canna
Grain Downgraded
1987-1991

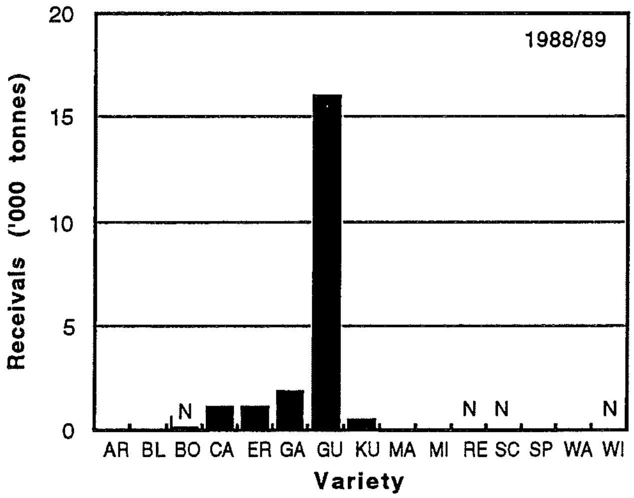


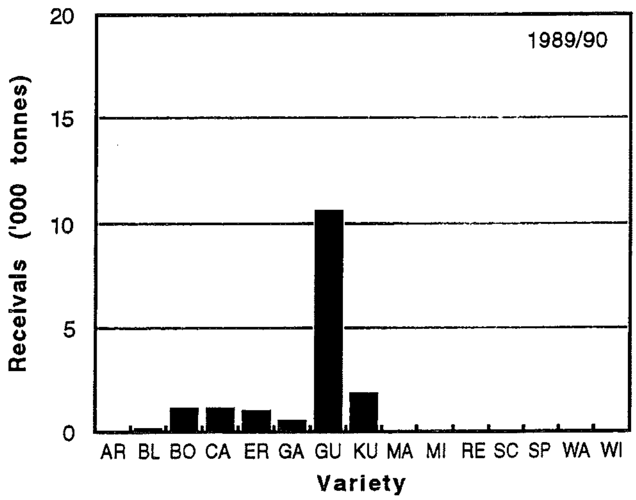


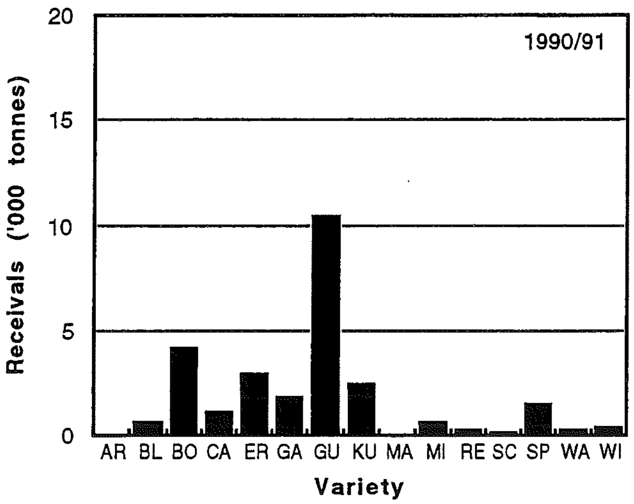
In 1987/88, 1989/90 & 1991/92 downgrading at Canna was negligible.

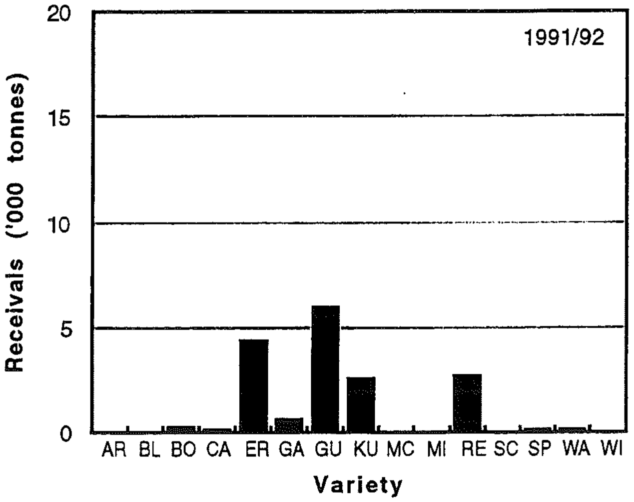
Canna
Total receivals
1987-1991



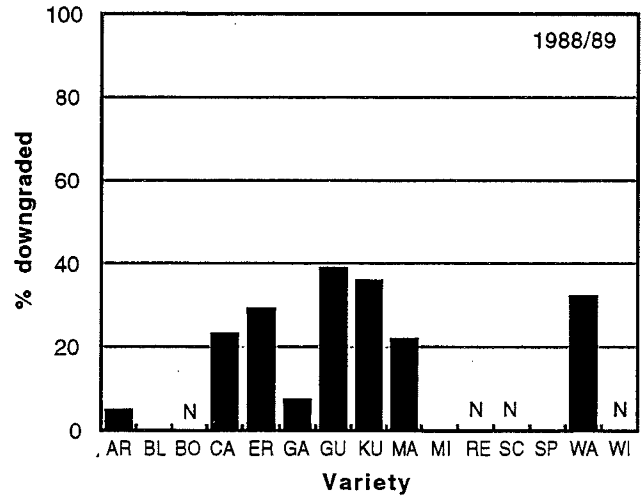


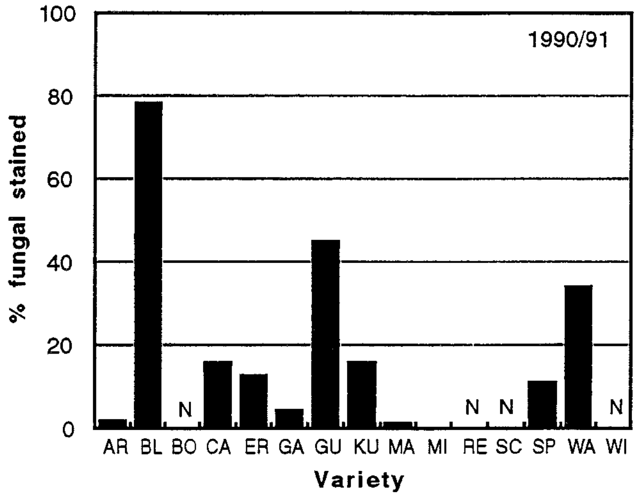






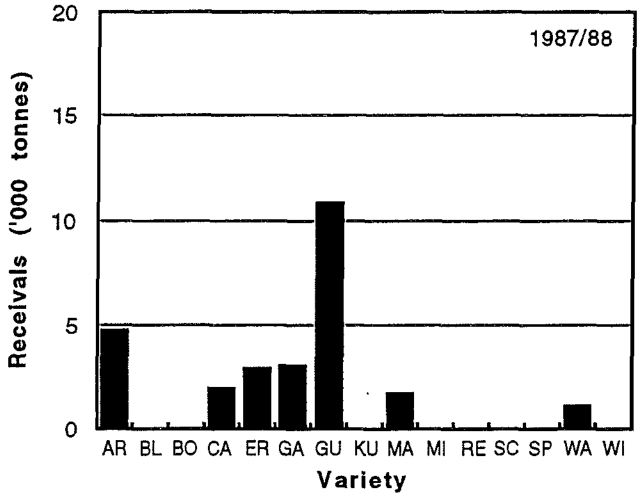
Carnarmah
Grain Downgraded
1988 and 1990

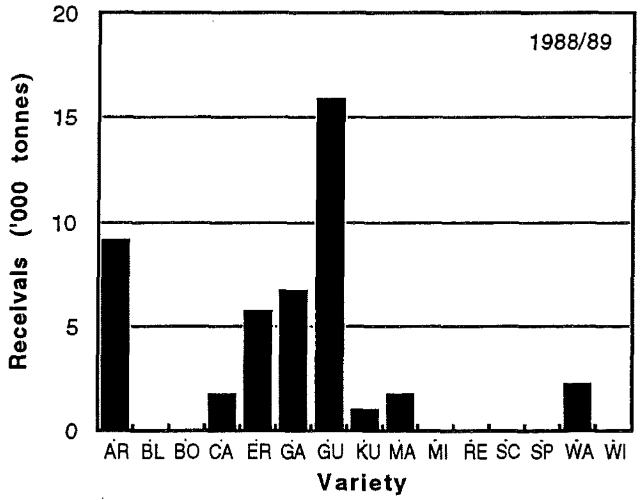


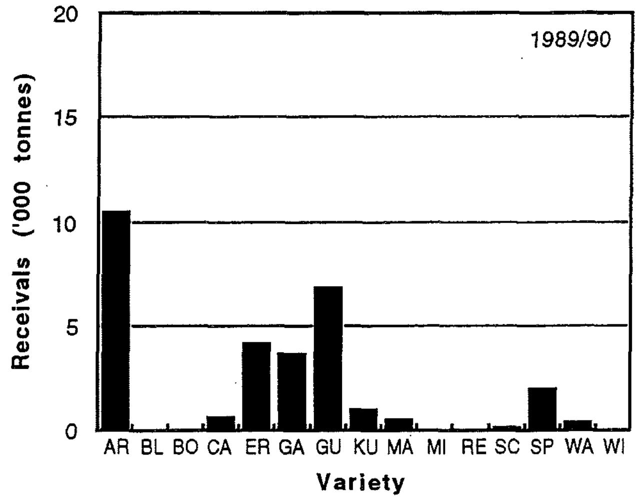


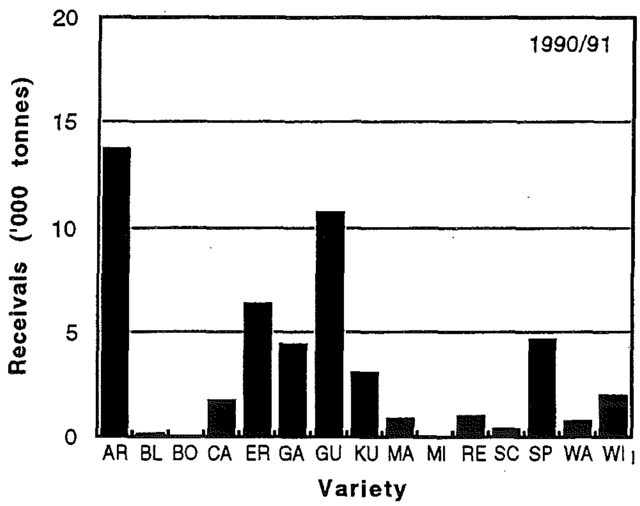
In 1987/88, 1989/90 & 1991/92 downgrading at Carnarmah was negligible.

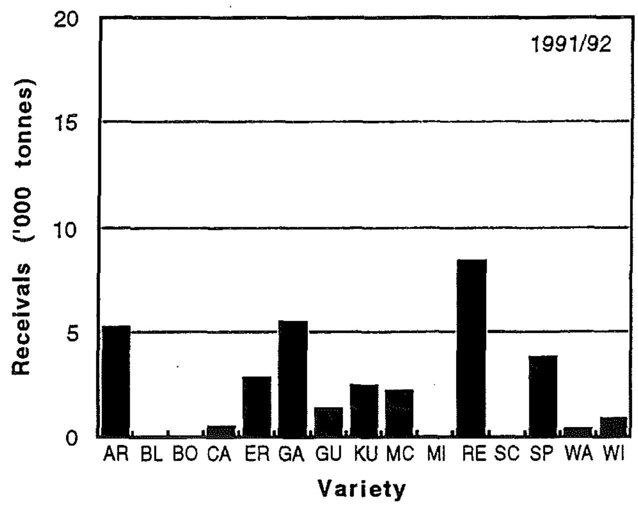
Carnarmah
Total receivals
1987-1991



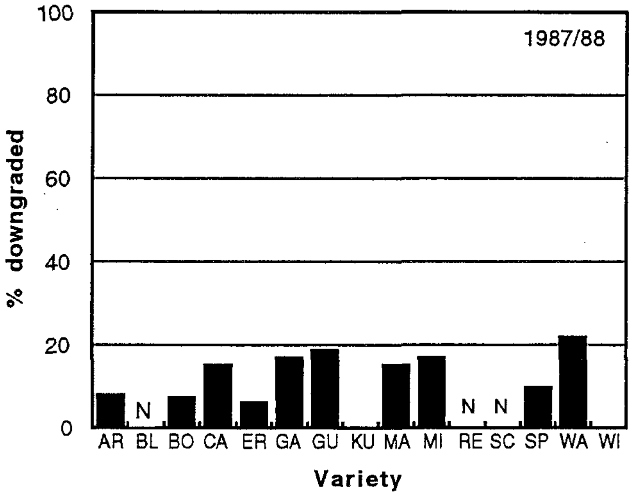


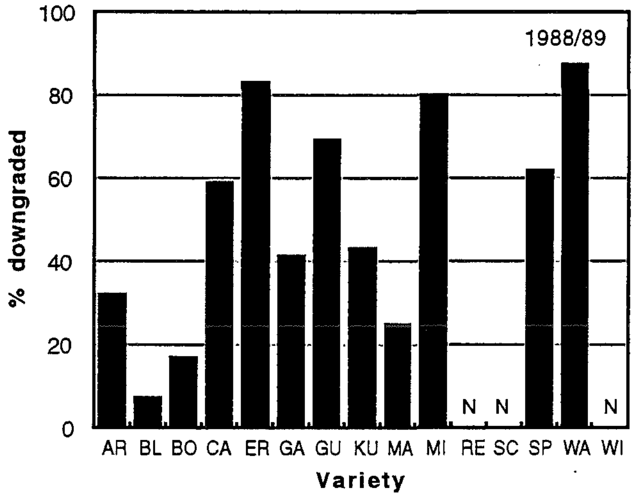


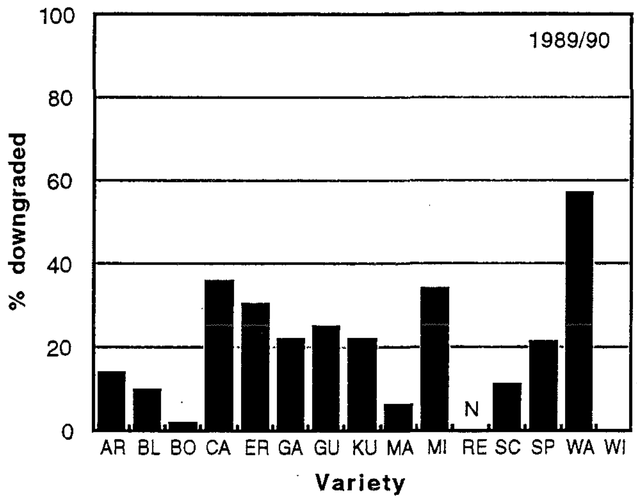


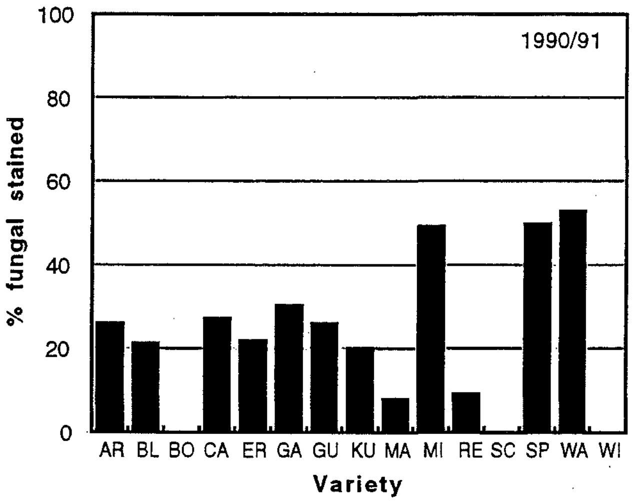


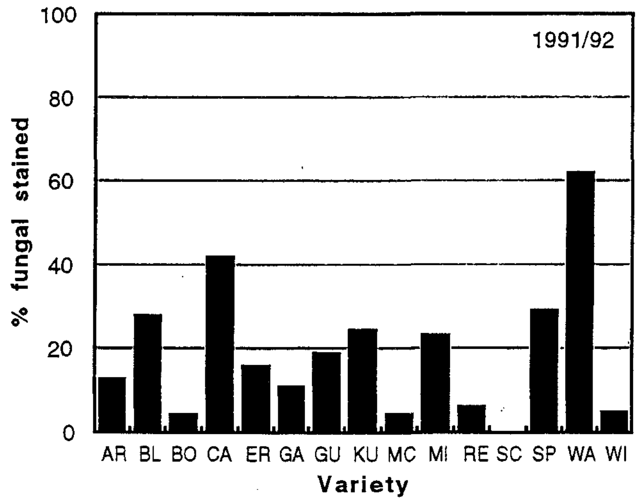
Geraldton
Grain Downgraded
1987-1991





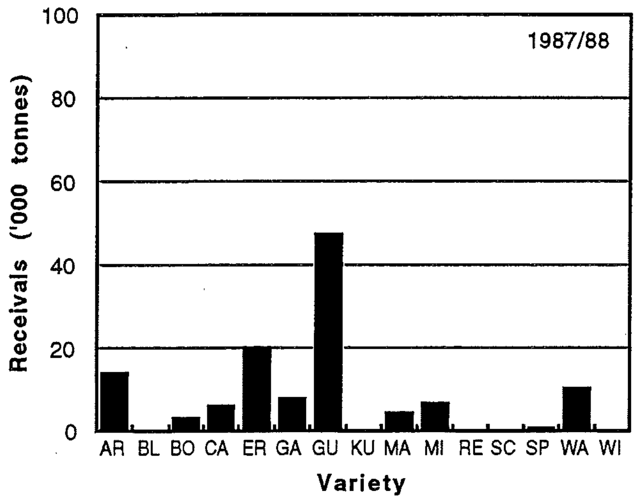


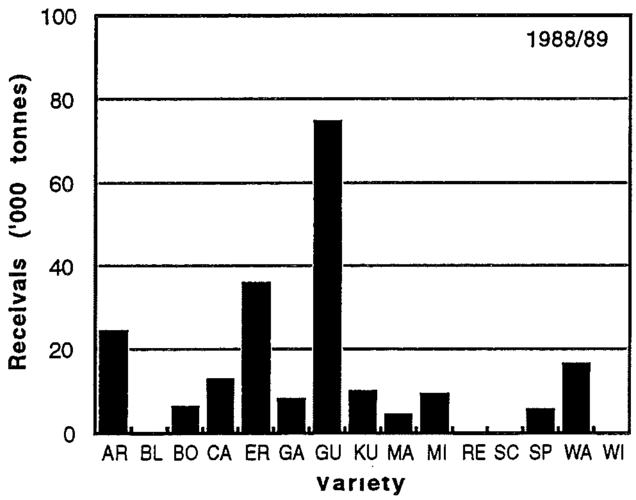


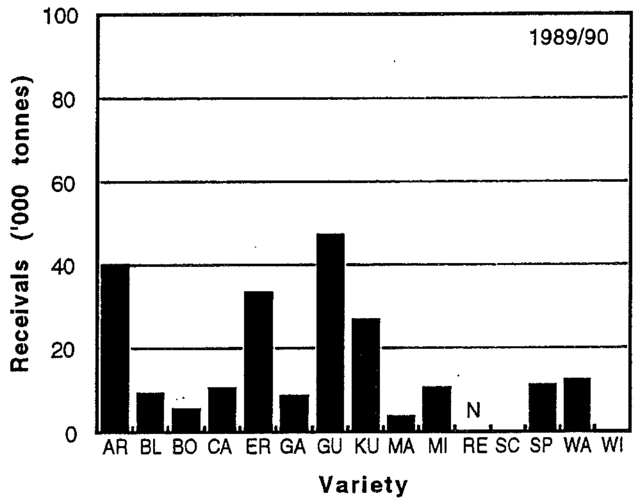


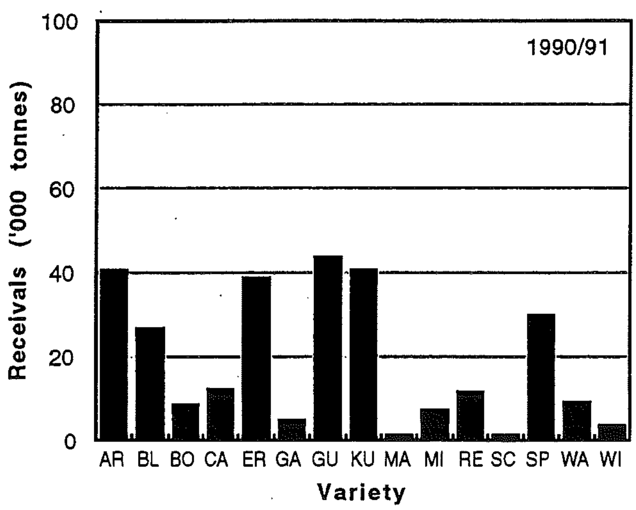
Geraldton Total Receivals 1987-1991

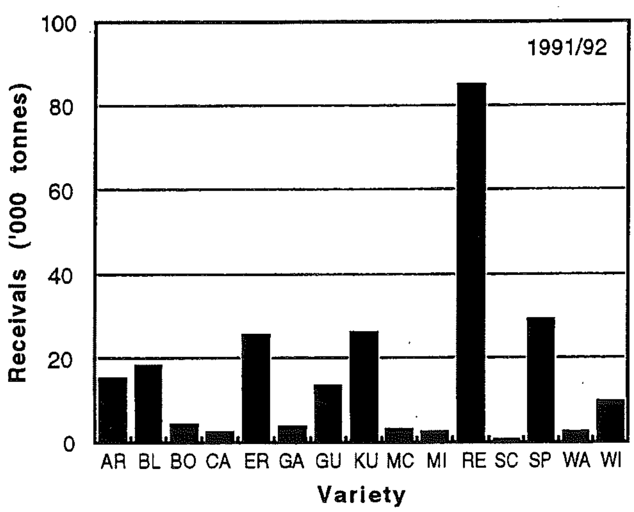
NOTE: Scale for Geraldton is greater than for other sites



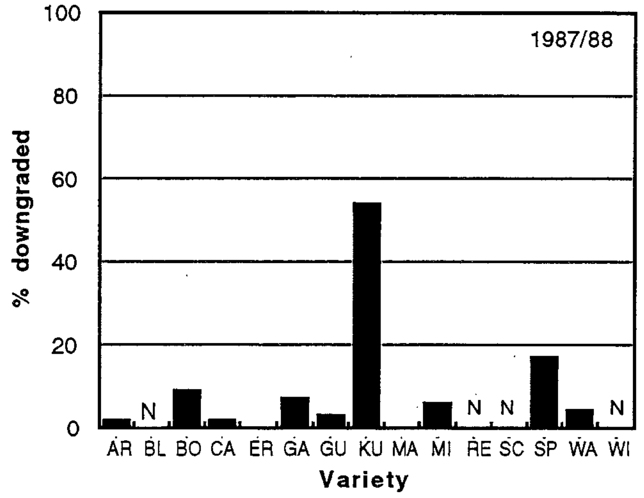


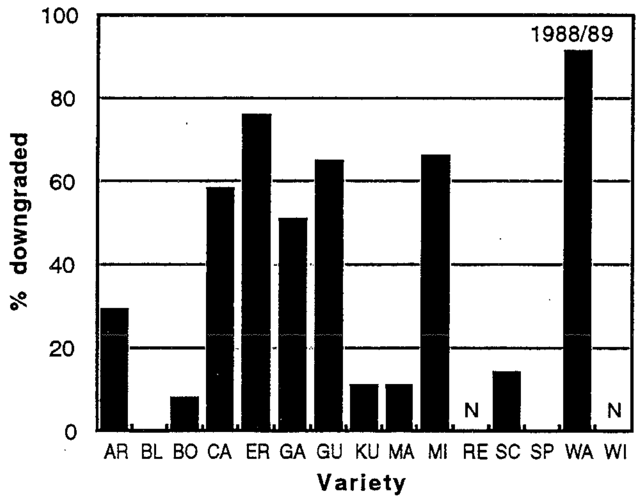


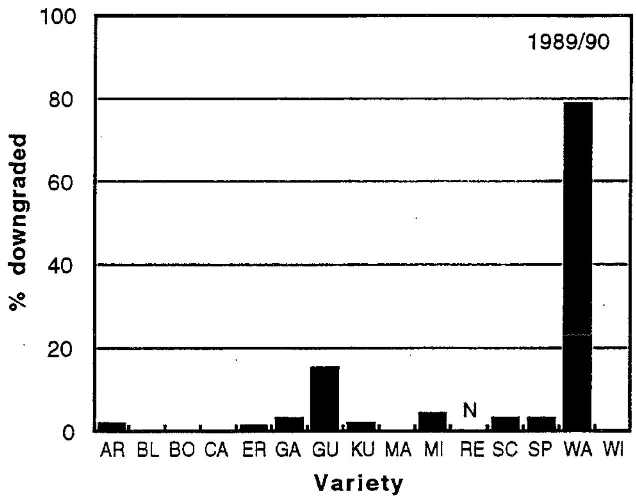


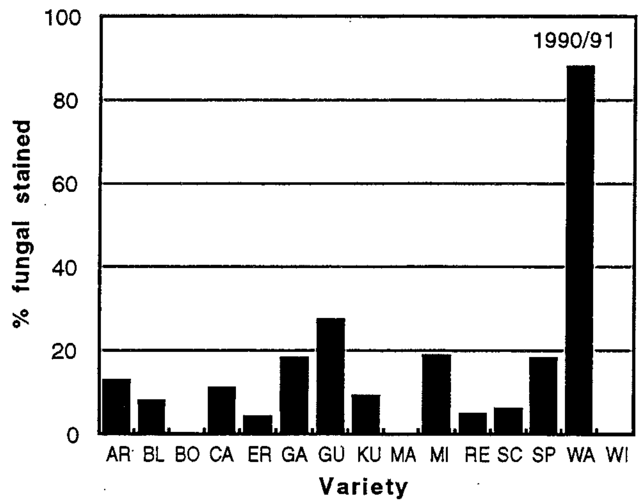


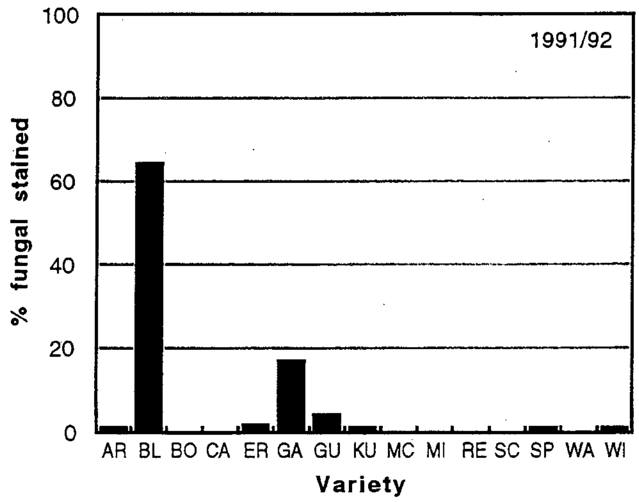
Mingenew
Grain Downgraded
1987-1991



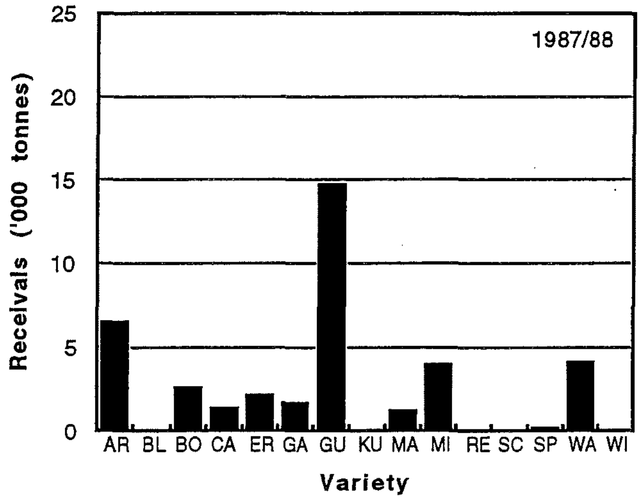


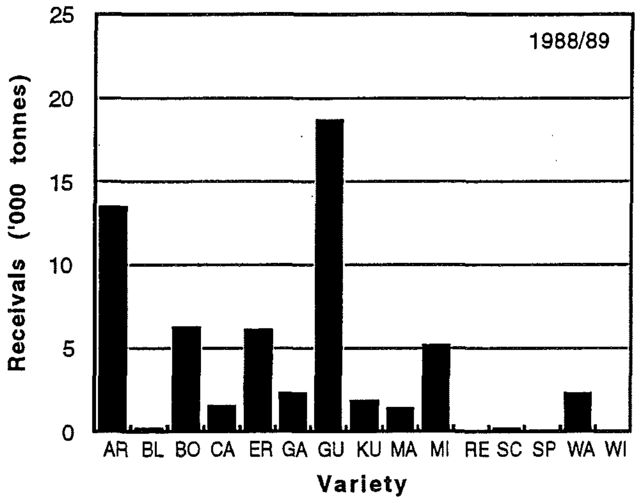


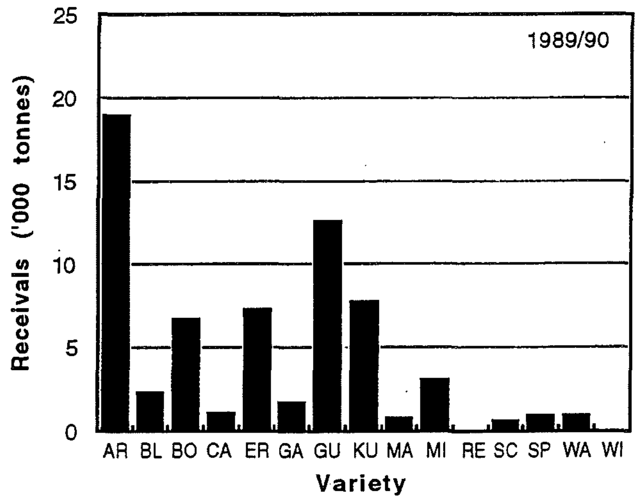


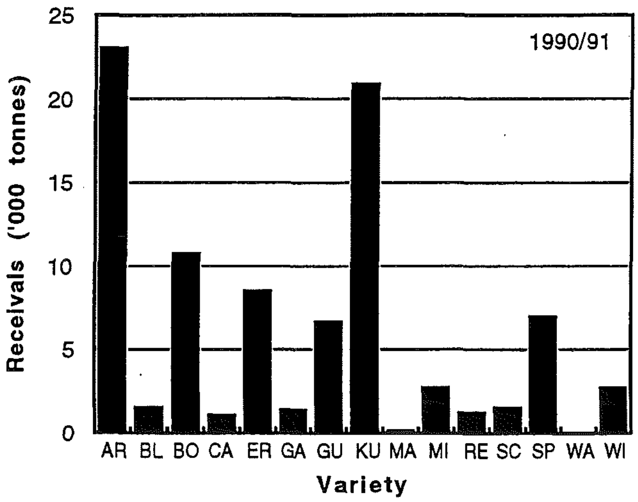


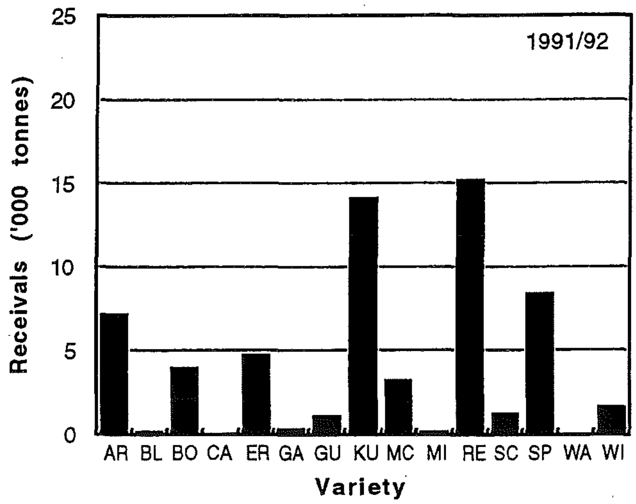
Mingenew
Total Receivals
1987-1991



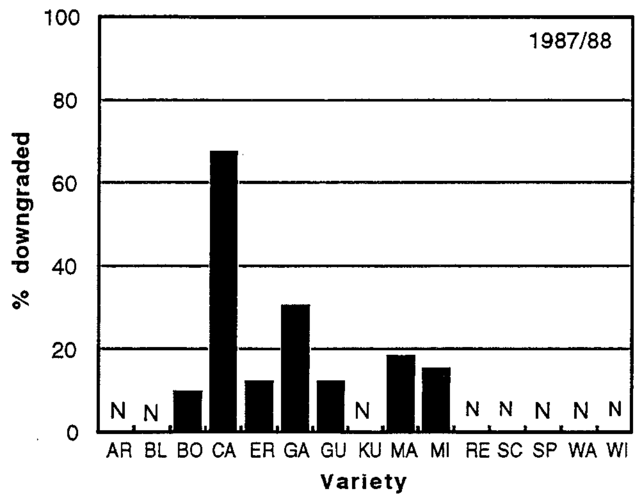


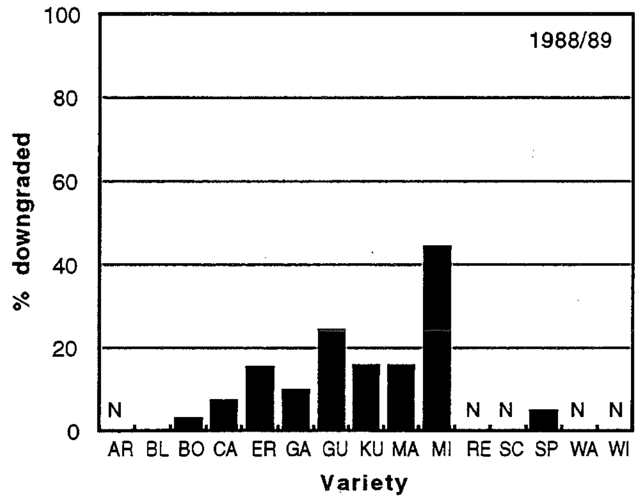


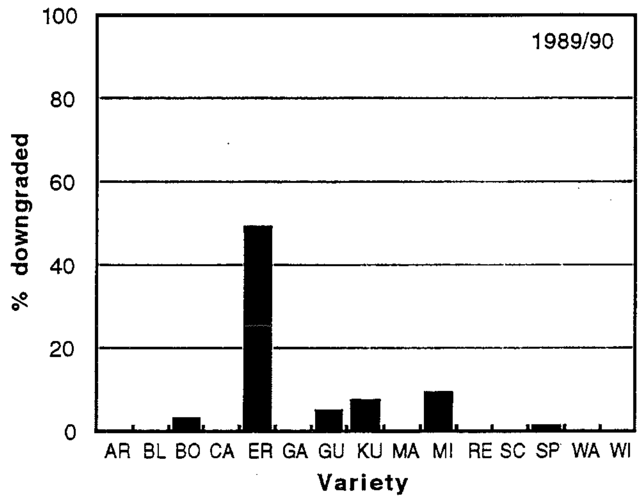




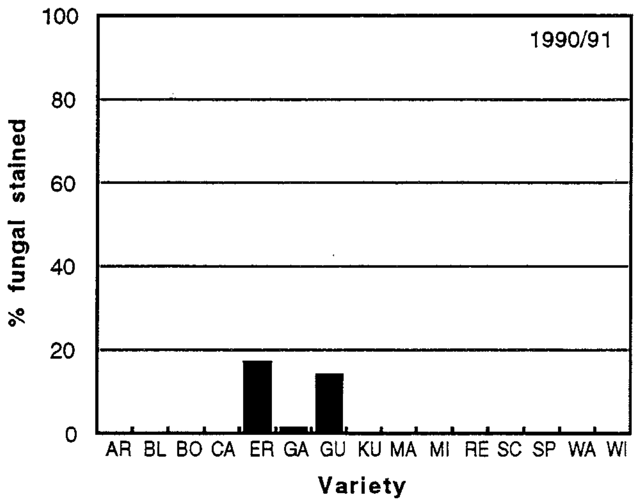
Morawa
Grain Downgraded
1987-1991



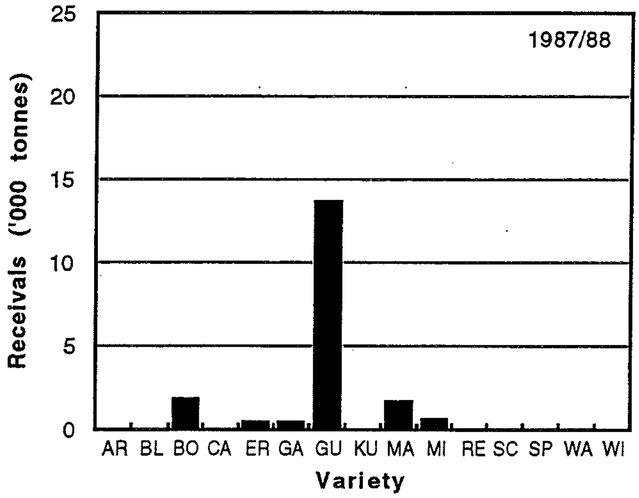


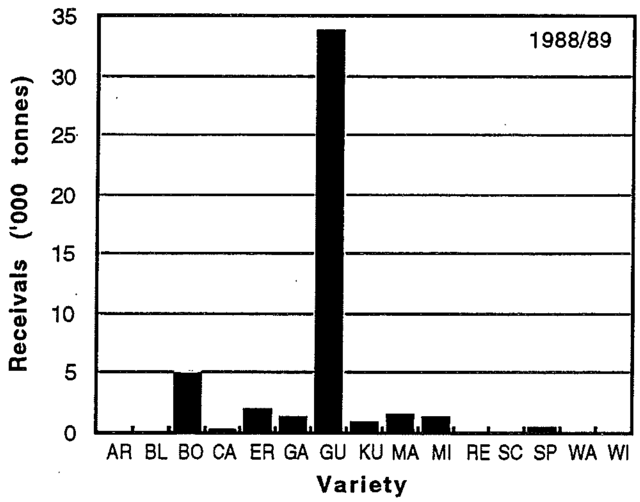


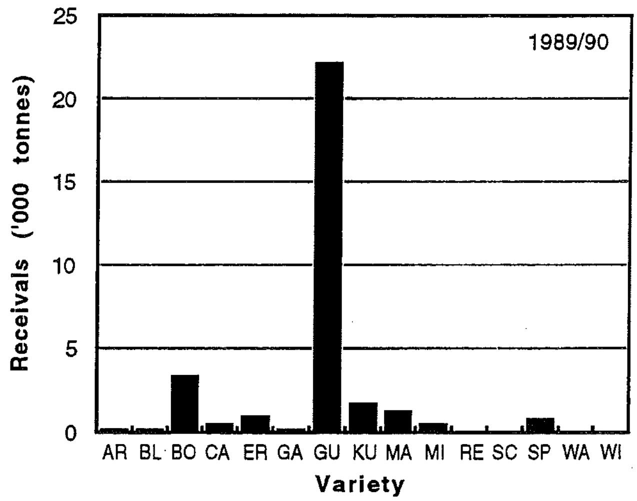
Fungal staining was negligible in 1991/92

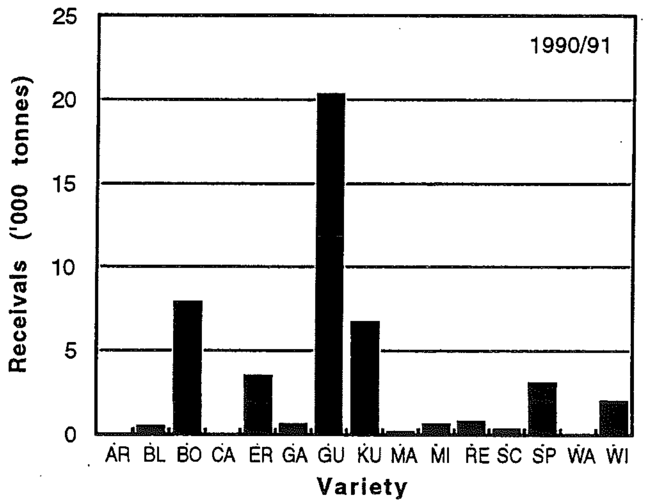


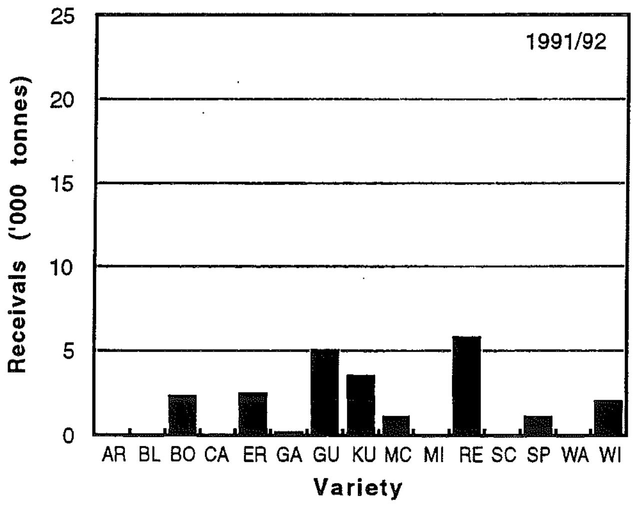
Morawa
Total receivals
1987-1991



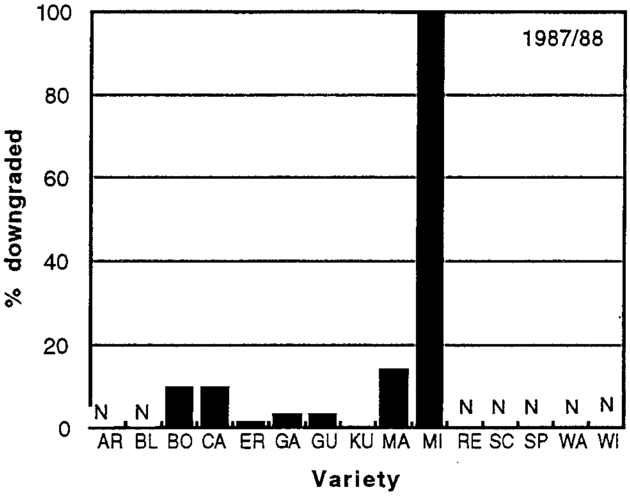


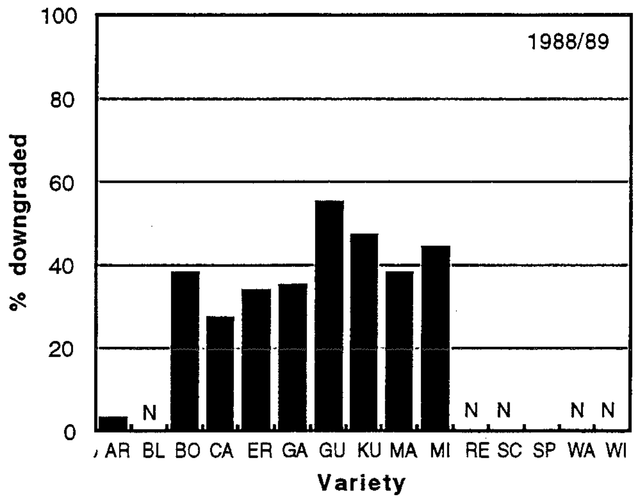


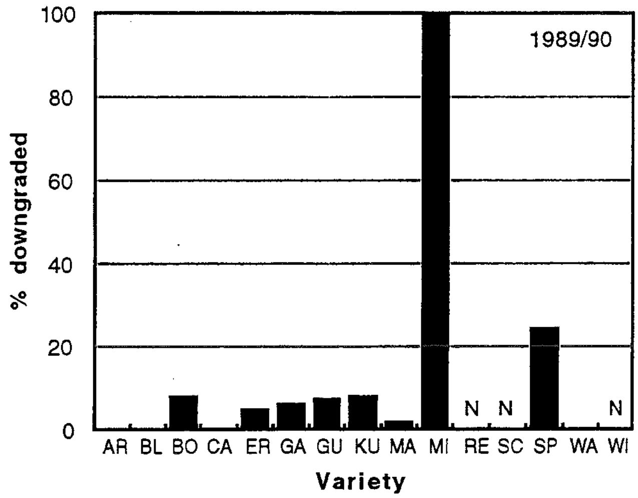




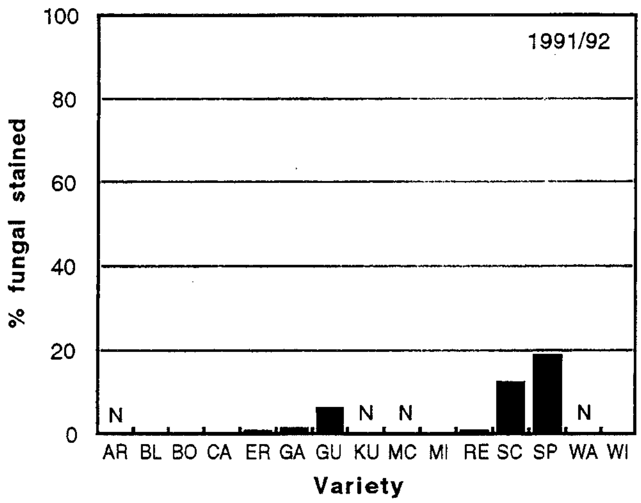
Mullewa
Grain Downgraded
1987-1991



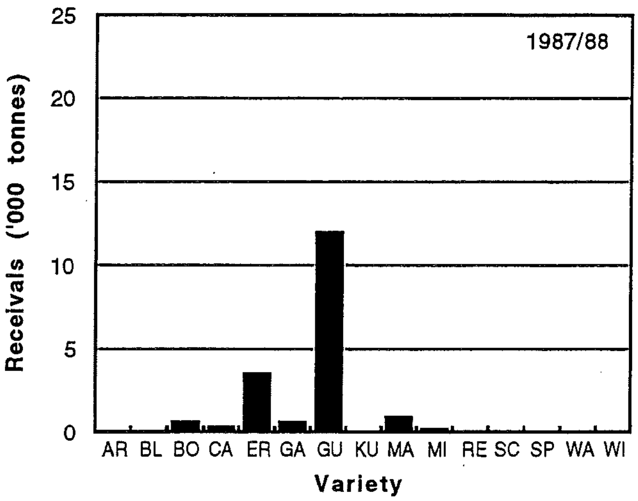


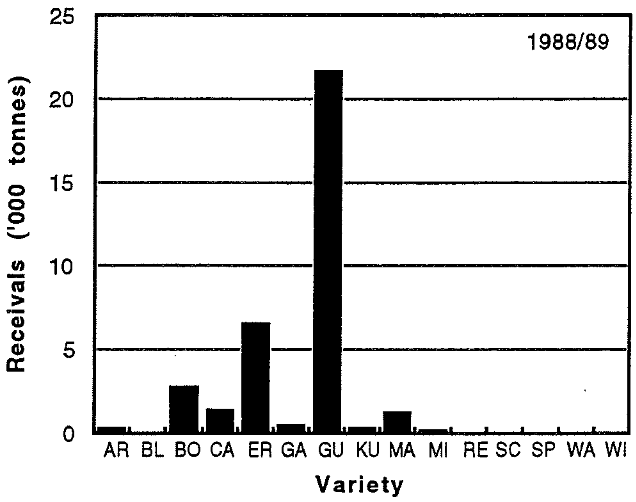


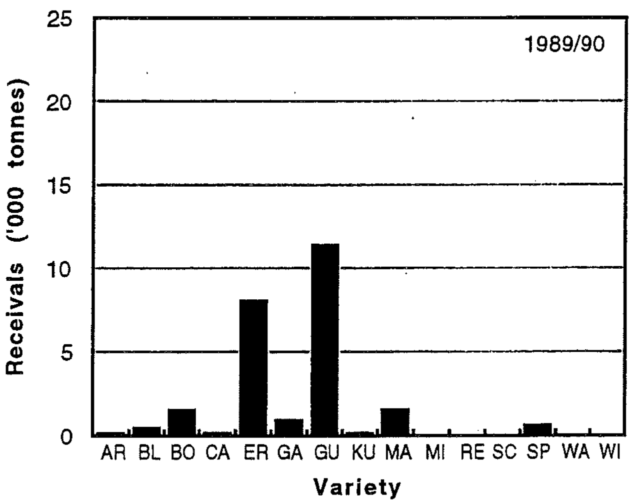
Fungal staining was negligible in 1990/91.

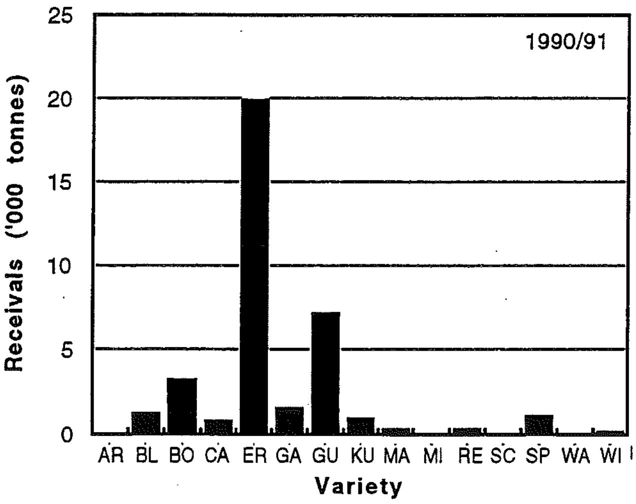


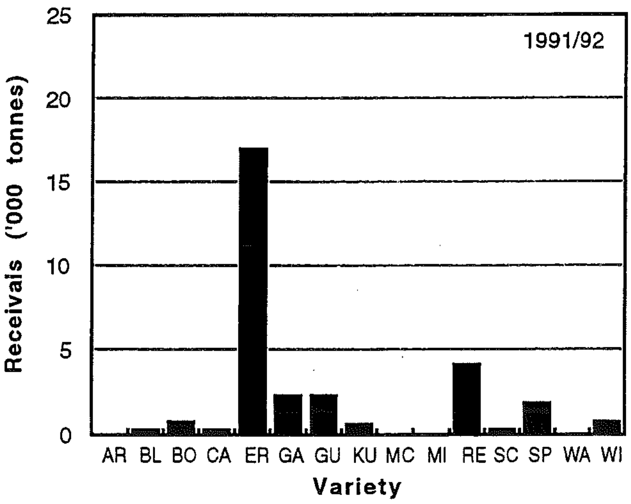
Mullewa
Total receivals
1987-1991



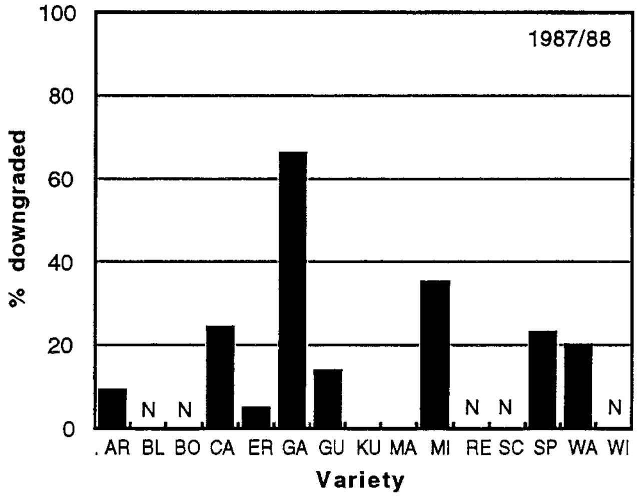


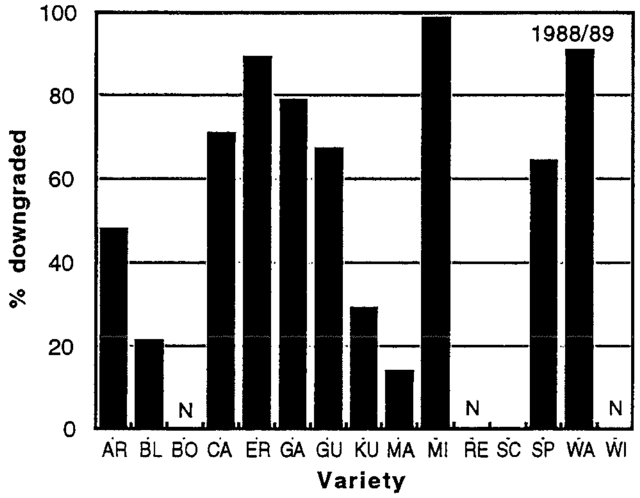


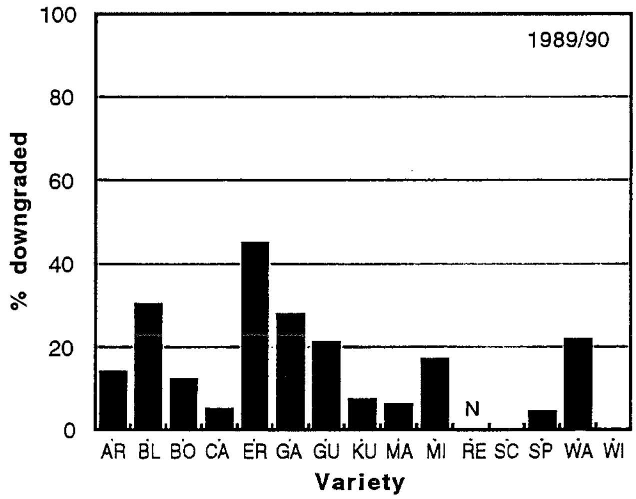


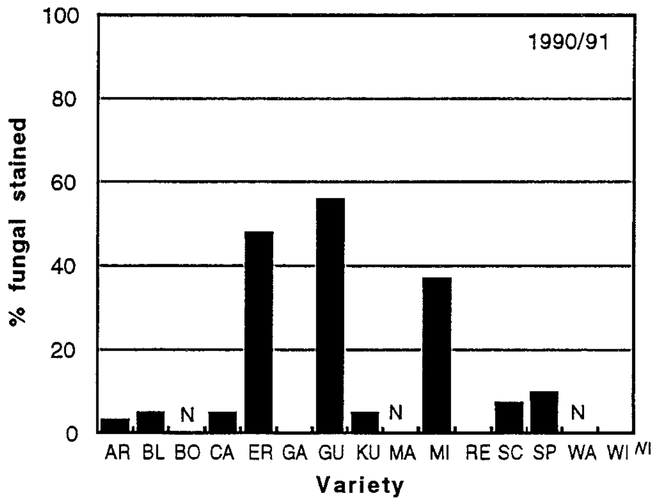


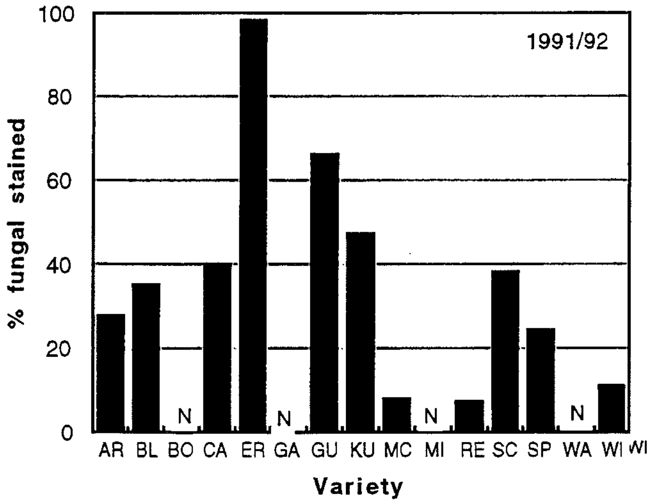
Northampton
Grain Downgraded
1987-1991



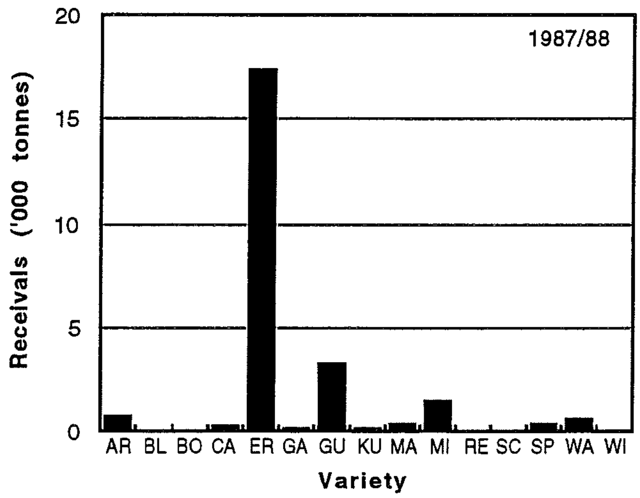


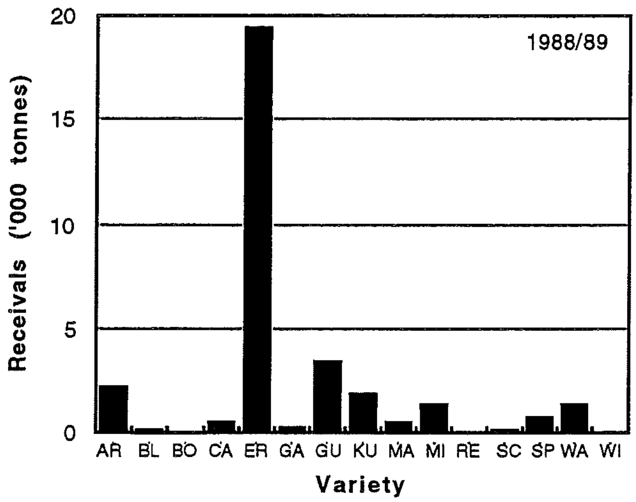


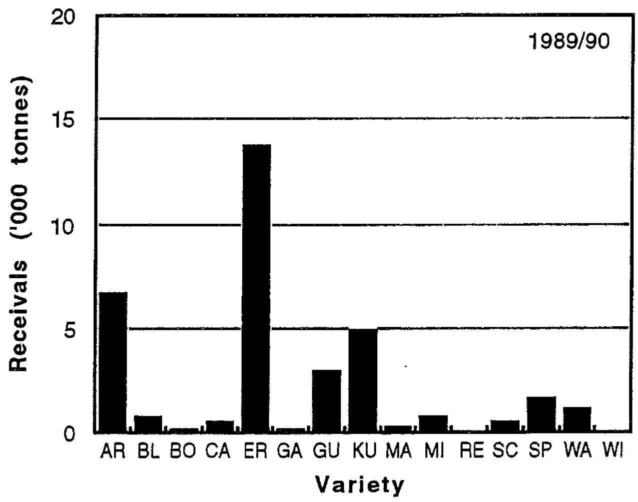


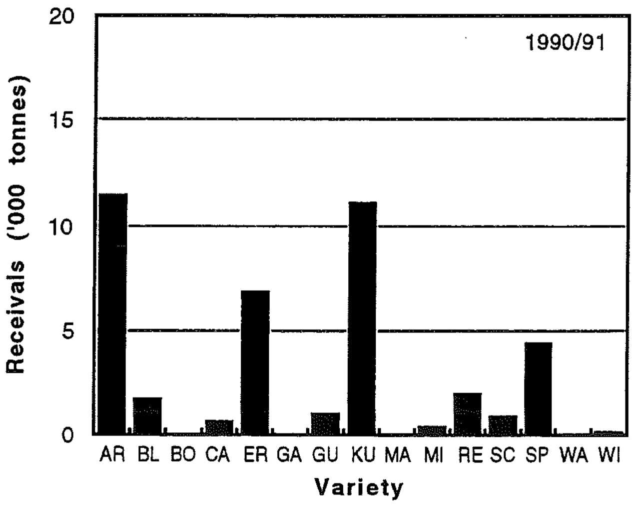


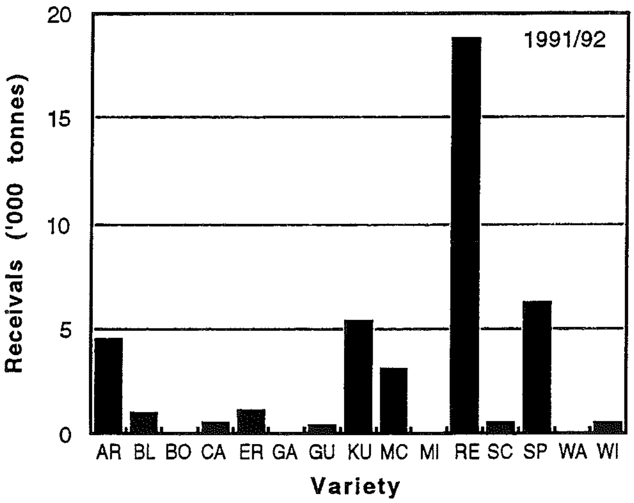
Northampton
Total receivals
1987-1991



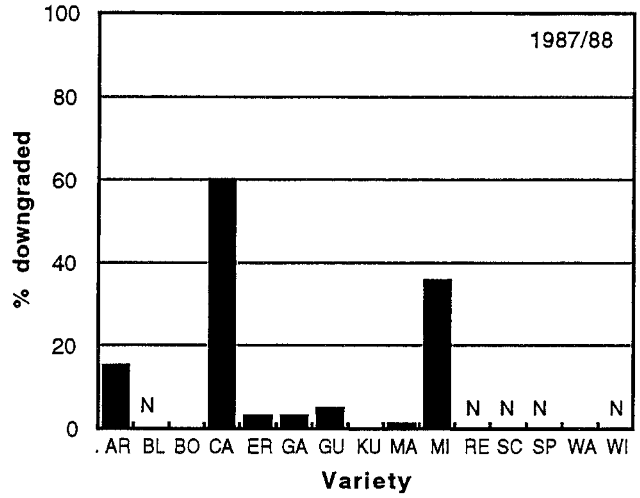


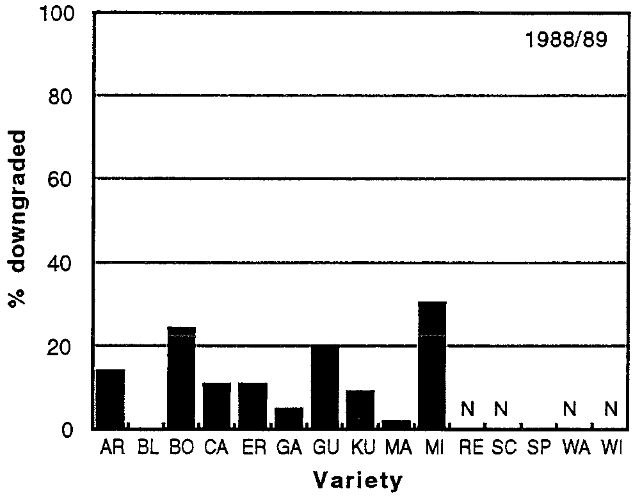


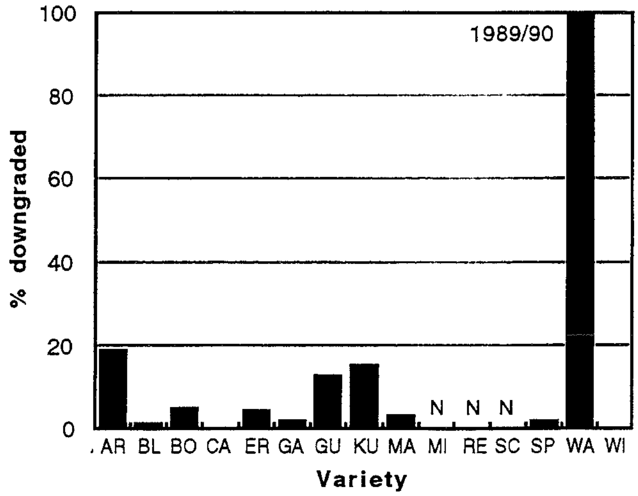


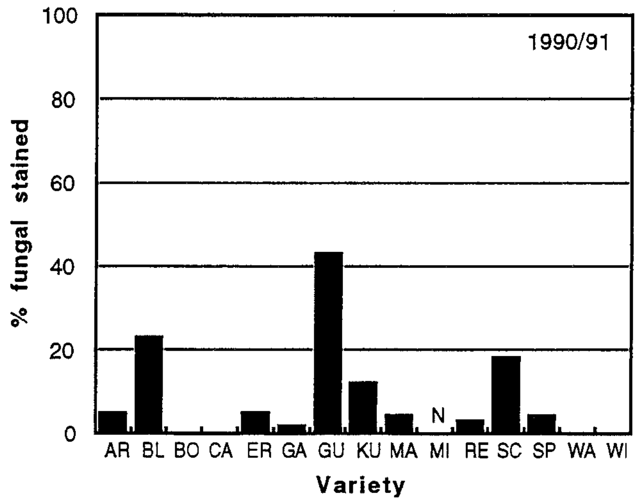


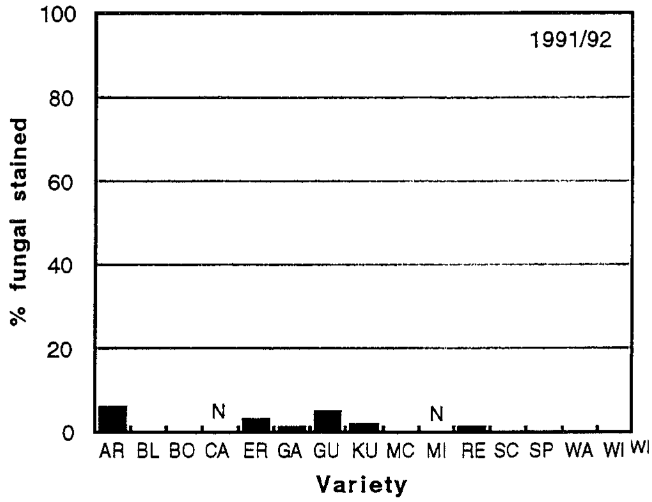
Three Springs Grain Downgraded 1987-1991



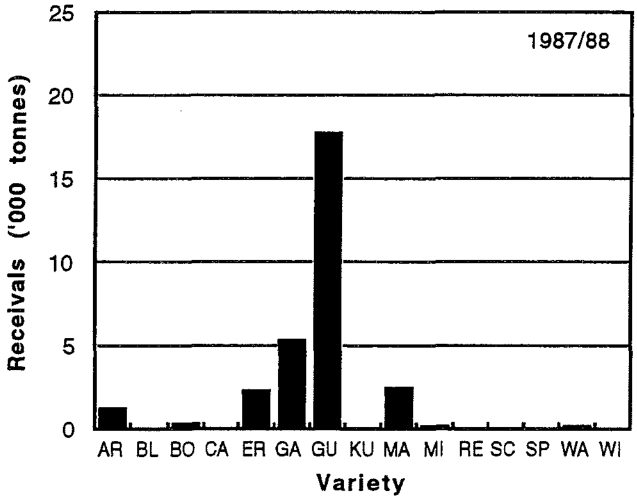


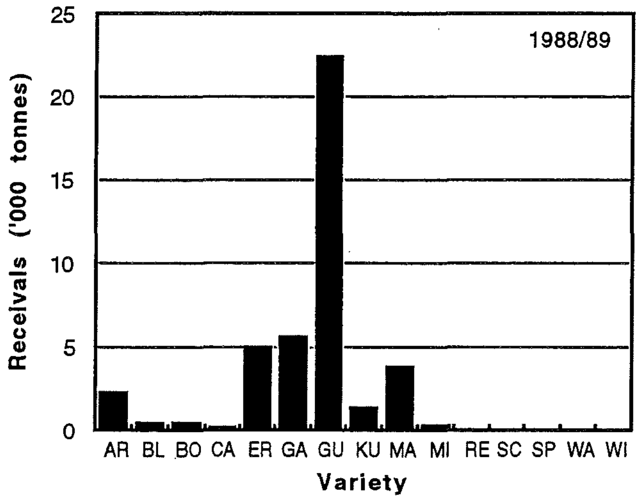


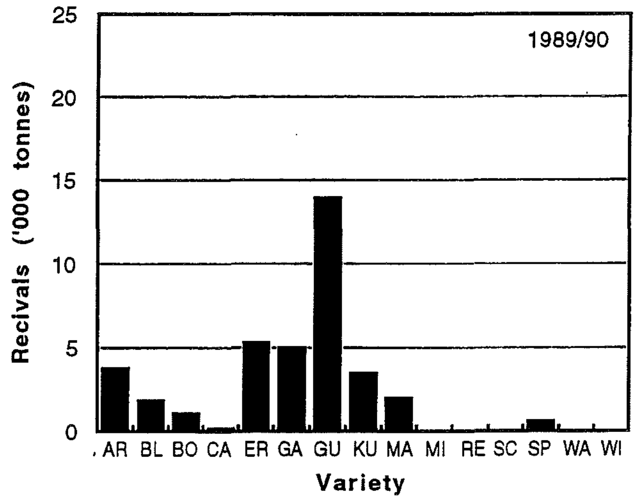


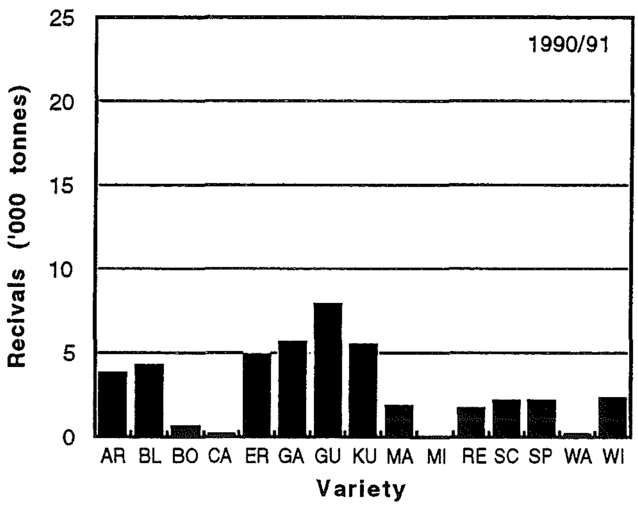


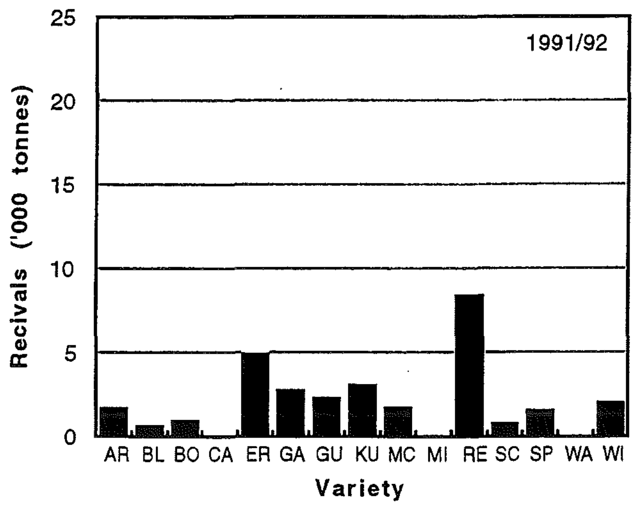
Three Springs Total Receivals 1987-1991



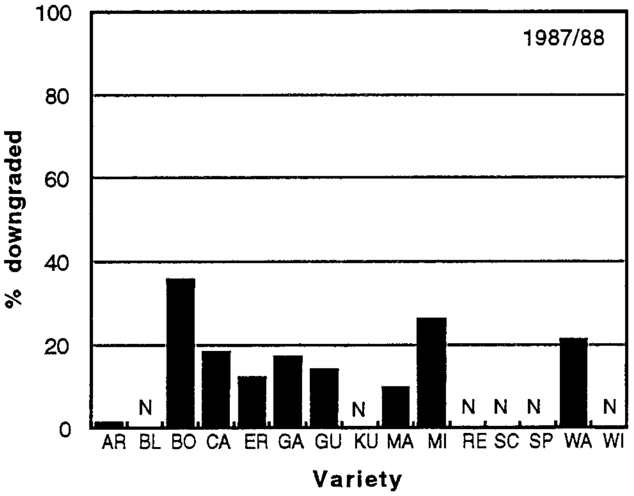


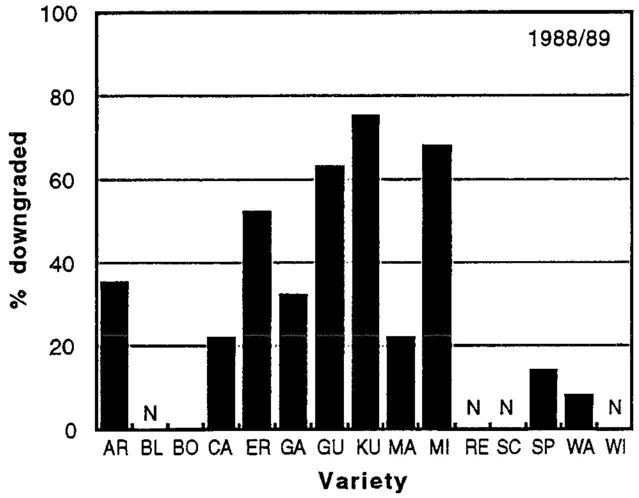


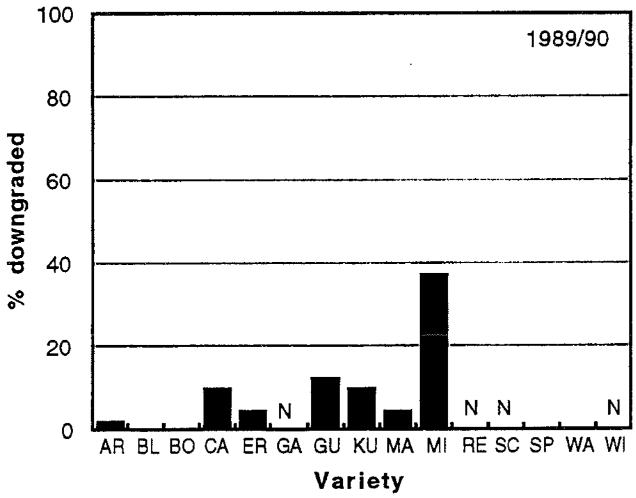


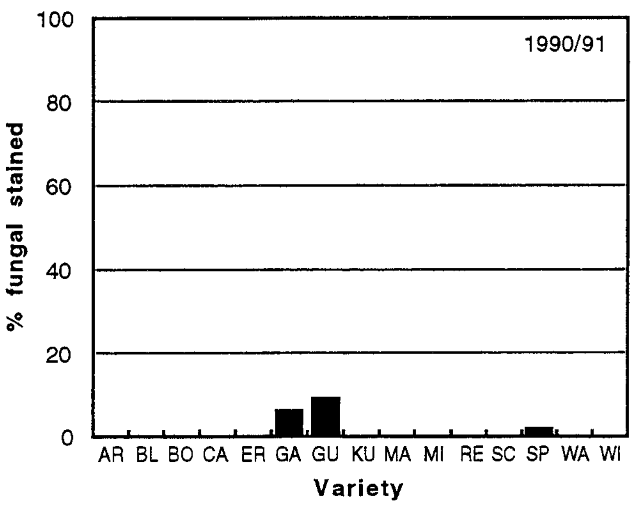


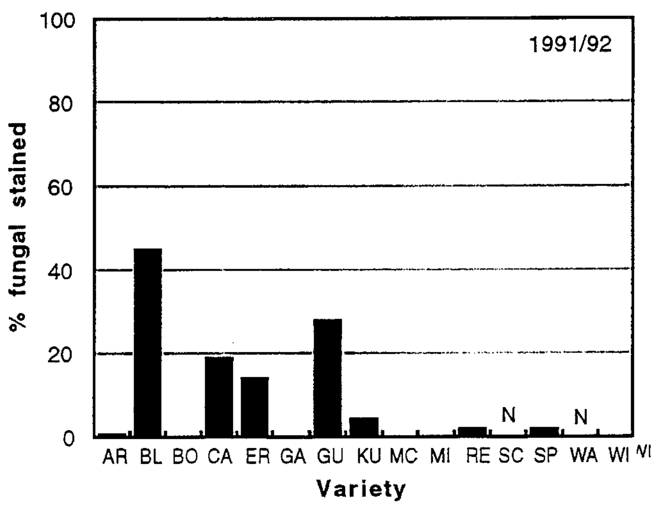
Yuna
Grain Downgraded
1987-1991



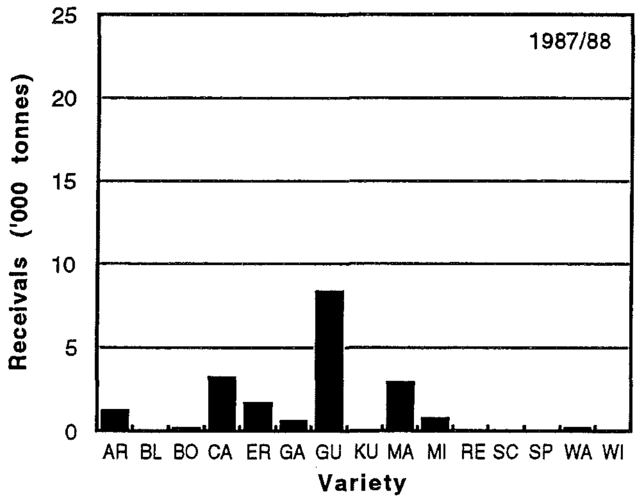


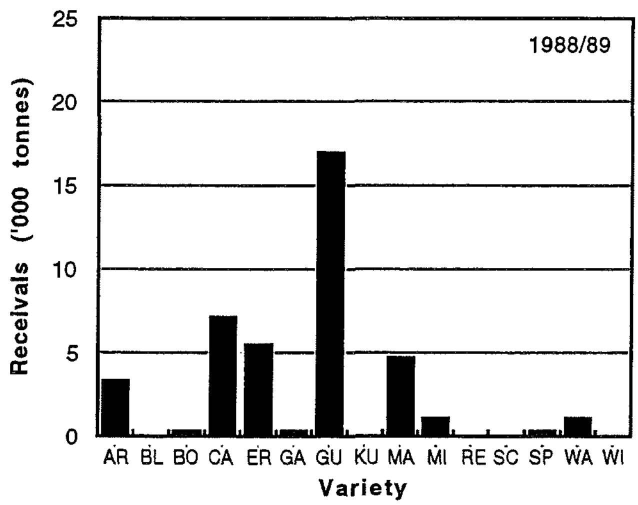


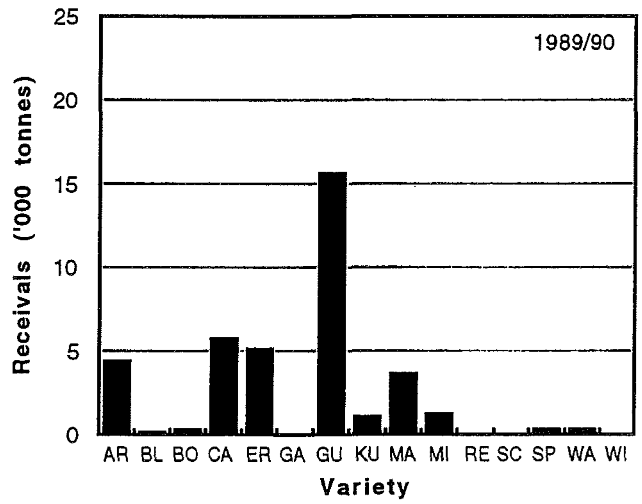


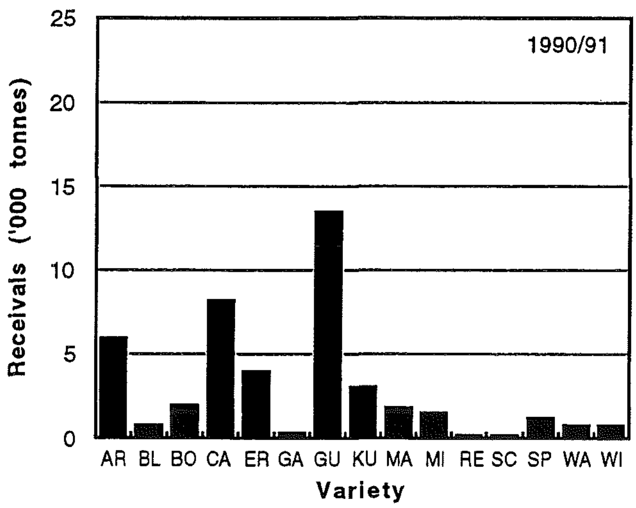


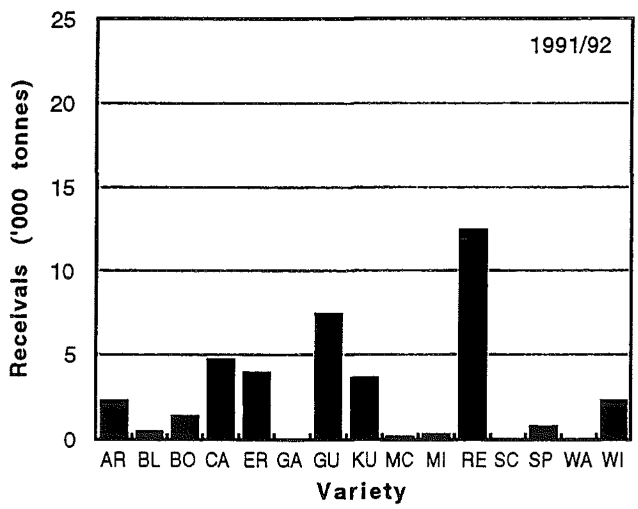
Yuna
Total receivals
1987-1991











Appendix 3. Tables of receival data for the four Western Australian port zones

In Western Australia there are four port zones: Albany, Esperance, Fremantle, and Geraldton. The following tables give data for wheat received in all four zones, and the proportion downgraded, for the years 1987-91 inclusive. Six selected varieties are given, so that comparisons can be made with confidence; these are, Aroona, Eradu, Gamenya, Gutha, Millewa and Spear.

Also included are data for the same varieties at three separate sites in southern, central, and northern parts of the wheatbelt. The sites are Esperance, Avon and Geraldton. As well as tonnes received and percentage downgraded, an additional table is included for 1990 & 1991 giving data for percentage fungal-stained. This is an important distinction, as grain can be downgraded for many reasons apart from staining. Unfortunately data for fungal staining was not tabulated separately before 1990.

Appendix 3.1
- Receivals of selected varieties in the four Western Australian port zones.
- Downgrading of selected varieties in the W.A. port zones

Appendix 3.2
- Receivals of selected varieties at three different sites
- Downgrading of selected varieties at three different sites
- Fungal staining of selected varieties at three different sites

Appendix 3.1

Receivals of selected varieties in the four Western Australian port zones.
Tonnes received 1987-1991.

Zone/year	Aroona	Eradu	Gamenya	Gutha	Millewa	Spear	All varieties
1987							
Albany	142840	5282	15905	29615	11925	27423	633971
Esperance	72890	12621	3072	33795	46115	8989	367430
Fremantle	402715	386312	192133	265316	26125	55764	2160575
Geraldton	32934	77030	41310	208978	16931	1539	477884
Total	651379	481245	252420	537704	101096	93715	3639860
1988							
Albany	118807	2812	6849	20793	6888	52868	621373
Esperance	65665	7645	3308	26978	34062	22424	338561
Fremantle	449440	552799	149249	394415	30112	216355	3281835
Geraldton	65816	153157	63307	367718	24908	10111	894155
Total	699728	716413	222713	809904	95970	301758	5135924
1989							
Albany	156335	3969	5084	17191	6255	100269	799304
Esperance	59924	5816	1851	19195	16610	36712	305546
Fremantle	424326	384146	77573	190895	12365	351136	2725518
Geraldton	99674	132928	47249	231390	17720	27241	786590
Total	740259	526859	131757	458671	52950	515358	4616958
1990							
Albany	111856	3149	2898	11545	1265	167761	781124
Esperance	56692	3692	2181	13501	8289	77771	344024
Fremantle	349610	449312	50961	150613	6761	669557	3114644
Geraldton	117054	179034	48102	185155	15002	90862	1036577
Total	635212	635187	104142	360814	31317	1005951	5276369
1991							
Albany	96550	1573	3570	8521	371	221660	881487
Esperance	39741	455	723	10282	2907	112643	330882
Fremantle	177956	241435	46097	68791	3353	534339	2464726
Geraldton	43931	113063	32277	65496	3407	65244	735835
Total	358178	356526	82667	153090	10038	933886	4412930

Downgrading of selected varieties in the four Western Australian port zones.
Percentage downgraded 1987-1991.

	Aroona	Eradu	Gamenya	Gutha	Millewa	Spear	All varieties
1987							
Albany	11.9	38.1	4.0	4.6	8.6	10.8	7.2
Esperance	19.2	23.4	13.2	10.0	17.4	14.9	14.5
Fremantle	3.5	3.7	1.8	2.8	8.5	1.8	3.2
Geraldton	4.5	3.9	6.5	7.7	14.0	8.6	7.5
Total	7.1	4.6	2.9	5.3	13.5	5.8	5.6
1988							
Albany	10.2	14.7	16.0	5.5	28.1	9.3	8.2
Esperance	9.6	4.8	1.9	3.2	18.9	8.7	8.7
Fremantle	6.6	7.9	10.6	6.0	30.8	3.2	6.3
Geraldton	25.1	52.0	14.0	44.9	69.6	45.5	39.9
Total	9.3	17.3	11.6	23.6	36.5	6.1	12.5
1989							
Albany	6.5	19.5	8.2	6.2	9.1	5.6	6.6
Esperance	7.1	22.4	2.4	8.4	8.4	6.1	5.7
Fremantle	3.2	1.8	4.1	1.1	3.1	1.5	2.3
Geraldton	8.5	14.0	4.9	9.8	23.9	10.2	11.1
Total	4.9	5.3	4.5	6.0	12.4	3.0	4.7
1990							
Albany	6.3	32.7	1.8	1.1	14.1	5.7	5.8
Esperance	3.2	40.7	4.5	29.2	10.9	3.7	5.4
Fremantle	5.7	18.4	5.7	3.6	18.6	3.7	7.1
Geraldton	16.2	10.9	5.4	23.0	43.6	23.1	16.4
Total	7.5	16.5	5.4	14.5	28.3	5.8	8.6
1991							
Albany	6.2	4.1	0.8	2.2	4.3	4.4	6.3
Esperance	7.6	24.2	17.4	19.7	17.1	9.2	8.6
Fremantle	4.6	3.8	4.2	2.9	0	3.9	6.1
Geraldton	16.7	7.7	4.6	20.6	57.0	24.9	15.8
Total	6.8	5.1	4.3	11.6	24.5	6.1	8.0

Appendix 3.2

Receivals of selected varieties at three different sites.
Tonnes received 1987-1991.

Zone/year	Aroona	Eradu	Gamenya	Gutha	Millewa	Spear	All varieties
1987							
Esperance	36774	5587	0	10103	30762	3677	137859
Avon	2651	4284	1923	59	757	12	12776
Geraldton	13999	19733	8044	47248	6623	353	132751
1988							
Esperance	33334	5287	116	7000	26117	8601	121938
Avon	2939	5180	1051	246	353	70	12789
Geraldton	23991	35899	8177	74775	9100	5289	221362
1989							
Esperance	27324	2197	106	4673	13217	13645	100940
Avon	4095	4967	1101	41	32	627	13862
Geraldton	39862	33614	8198	47060	10277	11153	235017
1990							
Esperance	26201	1895	117	4877	5274	25312	124932
Avon	3574	4963	655	0	0	1494	11739
Geraldton	40717	38859	4870	43553	7248	29777	294744
1991							
Esperance	17062	285	426	3705	2105	51347	136635
Avon	3178	4192	846	0	0	3474	18427
Geraldton	15434	25202	3769	13635	2563	29253	246187

Downgrading of selected varieties at three different sites.
Percentage downgraded 1987-1991.

	Aroona	Eradu	Gamenya	Gutha	Millewa	Spear	All varieties
1987							
Esperance	12.9	20.4	N	11.9	8.6	3.4	11.9
Avon	13.3	10.3	15.5	0	6.5	58.3	10.6
Geraldton	8.0	5.9	17.1	19.2	42.9	10.2	14.9
1988							
Esperance	9.5	2.9	0	4.9	13.9	6.1	11.2
Avon	23.9	25.6	46.2	83.3	83.0	100.0	33.8
Geraldton	32.2	82.7	40.7	68.8	79.5	62.4	63.0
1989							
Esperance	3.3	8.6	0	5.5	4.8	8.1	5.0
Avon	33.1	8.6	4.2	0	71.9	42.9	23.7
Geraldton	2.9	29.5	22.3	24.7	33.8	21.1	24.2
1990							
Esperance	4.1	67.6	0	24.8	5.1	7.3	7.8
Avon	5.5	4.3	5.5	N	N	1.9	5.8
Geraldton	33.1	27.3	34.1	38.6	67.0	57.3	36.2
1991							
Esperance	7.3	27.7	27.9	6.7	23.6	12.7	12.0
Avon	18.6	23.9	3.7	N	N	31.9	34.8
Geraldton	29.7	20.4	22.3	34.4	66.6	41.9	29.5

N: no data

Fungal staining of selected varieties at three different sites.
Percentage fungal stained 1990-1991.

	Aroona	Eradu	Gamenya	Gutha	Millewa	Spear	All varieties
1990							
Esperance	1.7	67.5	0	23.1	3.6	1.1	3.3
Avon	0.2	2.6	0	N	N	0.9	1.3
Geraldton	25.5	21.6	30.0	25.7	49.4	49.5	26.6
1991							
Esperance	1.0	0	0	0	2.7	1.6	1.2
Avon	0	12.3	0	N	N	1.2	3.1
Geraldton	14.2	15.9	10.9	18.8	23.3	29.6	16.5

NB: Fungal staining data is only available for 1990 & 1991; prior to this the causes of downgrading were not differentiated; N: no data.

Appendix 4. Summary of trial data used in Section 8

In Section 8 (on agronomic interactions) five trials of Dr Wal Anderson were discussed. These trials were part of an experimental program conducted in collaboration with Mr Graham Crosbie, and were located at Dowerin and Marchagee in 1989, and at Corrigin, Northam (Muresk) and Wongan Hills in 1990. All five trials had the same design, and involved the following factors:

- two times of sowing;
- two rates of applied nitrogen, 0 kg/ha or 50 kg./ha in 1989 or 40 kg /ha of nitrogen in 1990;
- six varieties: Aroona, Eradu, Gamenya, Kulin, Reeves and Spear;
- two replicate plots of each treatment.

Grain samples were analysed for black point after discussion of methods with operators from CBH. Data is presented as stained grains per 500 grains; for a discussion of the significance of the numbers, see Section 5. As different assessors were used in 1989 and 1990, and methods may have been slightly different, any comparisons between trials, and especially between years, should be made cautiously.

Full details of yield data, and other information, are available in the Experimental Summaries of the Crop Science Branch of the Division of Plant Industries for the respective years.

The data were analysed using analysis of variance, with time of sowing as a split factor. At the bottom of each table, asterisks indicate the level of significance of each factor, or factor interaction. The greater the number of stars, the more significant the factor (*p<.05, **p<.01, ***p<.001). "NS" means that the factor was not statistically significant.

For each trial, notes are given on the trends in each factor, or on interactions between factors.

A4.1. Fungal staining at Dowerin, 1989

TRIAL: 89NO4

		No. stained grains per 500 grains	
Sowing date	Variety	No applied nitrogen	Nitrogen applied
May 22	Aroona	0	0
	Eradu	10	4
	Gamenya	7	5
	Kulin	0	1
	Reeves	0	0
	Spear	0	0
June 8	Aroona	0	0
	Eradu	2	1
	Gamenya	2	1
	Kulin	0	0
	Reeves	0	0
	Spear	0	0

Analysis of variance - significance

Time of sowing:	**	Time x Var:	***
Variety:	***	Time x Nit:	NS
Nitrogen:	***	Var x Nit:	***
		Time x Var x Nit:	**

Summary of statistical differences:

Time of sowing: Staining was worse at the earlier planting time

Variety: Eradu stained worse than Gamenya, which was worse than the other four varieties. There was no difference between Aroona, Kulin, Reeves and Spear.

Applied nitrogen: Staining was reduced significantly by the application of fertiliser nitrogen

Interaction between time of sowing and variety: The time of sowing effect was only significant for Eradu and Gamenya. For the other varieties, time of sowing had no effect.

Interaction between time of sowing and nitrogen: This interaction was not statistically significant

Interaction between variety and nitrogen: The nitrogen effect was only significant for Eradu and Gamenya. For the other varieties, applied nitrogen had no effect.

Three-way interaction between factors: This was significant, but complex, and the main points are already covered above.

A4.2. Fungal staining at Marchagee, 1989

TRIAL: 89TS3

No. stained grains per 500 grains			
Sowing date	Variety	No applied nitrogen	Nitrogen applied
May 27	Aroona	0	1
	Eradu	14	20
	Gamenya	5	4
	Kulin	2	4
	Reeves	3	1
	Spear	4	2
June 26	Aroona	1	1
	Eradu	77	43
	Gamenya	24	18
	Kulin	14	13
	Reeves	4	3
	Spear	4	5

Analysis of variance - significance

Time of sowing:	*	Time x Var:	***
Variety:	***	Time x Nit:	**
Nitrogen:	*	Var x Nit:	*
		Time x Var x Nit:	**

Summary of statistical differences:

Time of sowing: Staining was worse at the second time of planting

Variety: Eradu stained worse than Gamenya and Kulin, which were similar, and in turn worse than Spear, Reeves and Aroona. The last three were statistically similar.

Applied nitrogen: Staining was reduced by the application of fertiliser nitrogen.

Interaction between time of sowing and variety: Eradu, Gamenya and Kulin were all significantly worse at the second time of sowing, but time had no effect on the other varieties.

Interaction between time of sowing and nitrogen: The nitrogen effect was only significant at the second time of sowing.

Interaction between variety and nitrogen: Only Eradu showed differences with nitrogen; all other varieties were unaffected.

Three-way interaction between factors: This was significant, but complex, and the main points are covered above.

A4.3. Fungal staining at Corrigin, 1990

TRIAL: 90ME62/63

No. stained grains per 500 grains			
Sowing date	Variety	No applied nitrogen	Nitrogen applied
May 1	Aroona	18	38
	Eradu	40	30
	Gamenya	34	26
	Kulin	28	24
	Reeves	15	11
	Spear	25	38
May 15	Aroona	12	10
	Eradu	41	42
	Gamenya	25	27
	Kulin	27	17
	Reeves	5	3
	Spear	7	6

Analysis of variance - significance

Time of sowing:	*	Time x Var:	*
Variety:	***	Time x Nit:	NS
Nitrogen:	NS	Var x Nit:	NS
		Time x Var x Nit:	NS

Summary of statistical differences:

Time of sowing: Staining was worse at the first time of sowing

Variety: Eradu was significantly worse than Aroona, Gamenya, Kulin and Spear. Reeves had significantly less staining than the other varieties

Applied nitrogen: Nitrogen was not significant

Interaction between time of sowing and variety: Most varieties were unaffected by time of sowing, but staining of Aroona and Spear was greater at the first time of sowing.

Interaction between time of sowing and nitrogen: Not significant

Interaction between variety and nitrogen: Not significant

Three-way interaction between factors: Not significant

A4.4. Fungal staining at Northam, 1990

TRIAL: 90NO97/98

Sowing date	Variety	No. stained grains per 500 grains: No applied nitrogen	Nitrogen applied
April 26	Aroona	63	63
	Eradu	140	78
	Gamenya	85	53
	Kulin	88	64
	Reeves	49	38
	Spear	69	59
May 14	Aroona	55	39
	Eradu	147	89
	Gamenya	75	66
	Kulin	165	74
	Reeves	34	44
	Spear	60	54

Analysis of variance - significance

Time of sowing:	NS	Time x Var:	*
Variety:	***	Time x Nit:	NS
Nitrogen:	***	Var x Nit:	**
		Time x Var x Nit:	NS

Summary of statistical differences:

Time of sowing: Not significant

Variety: Eradu and Kulin were similar, and greater than all other varieties. Gamenya was similar to Spear and Aroona. While Reeves was the least stained, it was not significantly different from Spear and Aroona. Note that overall staining levels in this trial were higher than in the other trials in 1990; in particular, Kulin had an unusually high amount of staining. This probably occurred because of the very early sowing times.

Applied nitrogen: Staining was reduced by nitrogen.

Interaction between time of sowing and variety: Staining of Kulin was significantly greater at the second time of planting. While the data for Aroona was not statistically significant at the chosen level of significance (p.05), there was strong evidence that staining of Aroona was worse at the first time of sowing.

Interaction between time of sowing and nitrogen: Not significant

Interaction between variety and nitrogen: Nitrogen application significantly reduced staining of Eradu and Kulin, but not the other varieties.

Three-way interaction between factors: Not significant

A4.5. Fungal staining at Wongan Hills, 1990

TRIAL: 90WH65/66

Sowing date	Variety	No. stained grains per 500 grains: No applied nitrogen	Nitrogen applied
May 23	Aroona	19	14
	Eradu	74	54
	Gamenya	57	62
	Kulin	25	22
	Reeves	24	14
	Spear	37	40
June 15	Aroona	19	14
	Eradu	65	59
	Gamenya	65	67
	Kulin	75	46
	Reeves	18	16
	Spear	37	44

Analysis of variance - significance

Time of sowing:	NS	Time x Var:	*
Variety:	***	Time x Nit:	NS
Nitrogen:	NS	Var x Nit:	NS
		Time x Var x Nit:	NS

Summary of statistical differences:

Time of sowing: Not significant (see below).

Variety: Eradu and Gamenya were similar, and had greater staining than the other varieties.

Applied nitrogen: Not significant.

Interaction between time of sowing and variety: Kulin had more staining at the second time of sowing. For the other varieties there was no effect of time of sowing.

Interaction between time of sowing and nitrogen: Not significant

Interaction between variety and nitrogen: Not significant

Three-way interaction between factors: Not significant

Appendix 5. Pricing structures used in analysis of costs

In the analysis of the cost of black point, two pricing structures were used. The first was based on 1990/91 figures, and was essentially the price received following harvest (1990) and March 1991 payments; i.e. no allowance was made for any equity remaining in the pools after March 1991. This pricing structure represents the low end of the scale of expected prices. Note that at the time that this project was commenced (April 1991), remaining equity was estimated to be negligible. Subsequent events, however, have significantly increased the expected total pool returns. For example, in these calculations a total return for ASW of $109.75 was used, whereas total returns at the time of writing (August 1992) are estimated to be $120.00

The second structure was based on 1991/92 figures, and represents the high end of the scale of expected prices. In this structure, the prices take into account the harvest (1991) payment, the March 1992 payment, and estimated equity remaining at the time of writing (August 1992).

Total value was calculated by multiplying the total receivals by the total pool return ("maximum return"). Total grain downgraded was a summation of the amounts of grain in each of the grades GP1A, GP1B, GP2, and FEED. Monetary losses due to downgrading were estimated by separately multiplying the losses for each grade by the receivals in that grade, then totalling the losses.

In calculating the total value of the receivals, it was assumed that the wheat was all at 10% protein. Thus no account has been made of the fact that some of the receivals would have been accepted into a hard grade (or on rare occasions in this region into a soft grade) and thus have received a higher price. It is also assumed that all Eradu and Gamenya were received into the noodle category. While these assumptions mean that the calculations were not strictly accurate, it considerably simplified the analysis and made comparisons between seasons much easier.

Table A5.1 shows the prices used in the calculations. Total return indicates the AWB return for the ASW pool; prices for Eradu and Gamenya include the noodle bonus. Loss columns indicate the total cost of downgrading to a lower grade.

Table A5.1. Prices and costs (per tonne) used in calculating losses, 10% protein was assumed

Grain type	Maximum return $	Losses incurred with downgrading GP1A $	GP1B $	GP2 $	FEED $
1990 Prices					
ASW	109.75	9.70	14.70	16.85	19.50
Eradu	113.75	13.70	18.70	20.85	23.50
Gamenya	116.75	16.70	21.70	23.85	26.50
1991 Prices					
ASW	180.00	6.00	9.00	20.00	25.00
Eradu	192.50	18.50	21.50	32.50	37.50
Gamenya	195.00	21.00	24.00	35.00	40.00