Integrated pest management in the GRAINCO, Queensland Australia, storage system

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Abstract

GRAINCO, the central bulk grain handling system in Queensland, Australia adopted a strategic plan for the implementation of integrated pest management, following unusually high levels of infestation in 1989–90 and 1990–91 harvest seasons. Several factors were found to have contributed to this increase, particularly insecticide resistance, requirements for nil or very low residues on grain and inadequate standards of hygiene.

The GRAINCO IPM plan is a multi-component integrated system which has been implemented as a total quality management package. The plan focused on several key initiatives aimed at ensuring that grain protection was both effective and economically viable in the future.

The strategies formulated from the initiatives included: improved storage hygiene; optimised pesticide application, population monitoring, extended use of sealed storages, controlled atmospheres, and cooling with aeration/refrigeration; review of receival standards; promotion of non-chemical control in the non-GRAINCO sectors of the industry; and development of operational tactics that promote IPM.

Progress reports have been encouraging. Since the GRAINCO plan was initiated, control failures and the general frequency of infestations have reduced significantly (60% in 1990 to 16% in 1992). No infestations were detected for the first four months of the 1992–93 and 1993–94 storage seasons. The percentage of storage capable of storing residue-free grain has increased from 30% to 90% and the cost of grain protection within GRAINCO reduced significantly.

Introduction

GRAINCO is the central bulk grain handling system based in Queensland. It operates as a grower-owned cooperative, handling a range of commodities. Hard wheat, barley, sorghum and soft wheat are the major crops while significant volumes of maize, sunflowers, and chickpea are also handled. The climate of GRAINCO's area of operations is essentially subtropical, that is, warm to hot—especially during the wheat harvest—and in some areas it can be very humid. These conditions are conducive to rapid multiplication of stored-product insect pests and mould growth. Stored-product protection therefore tends to be more challenging in this climate than in more temperate regions.

GRAINCO had previously embarked on integrated pest management in 1974 when resistance to malathion became a major issue (Bengston 1978). Some progress had been made in storage sealing and in alternative protection strategies, before the chemical grain protectant mixture bioresmethrin and fenitrothion was developed. However, this treatment was so effective that the emphasis on other control mechanisms and the principles of integrated pest management in general lost priority. The use of this grain protectant mixture became the major and in some storages the only control measure used and storage improvement programs stalled.

During the 1989/90 and 1990/91 harvest seasons, GRAINCO and some other central handling organisations experienced unusually high levels of infestations in their storages. During 1990/91 season approximately 60% of GRAINCO storages became infested. An investigation into the probable causes of the increase in the incidence of infestations was carried out in the form of audits of hygiene standards, resistance levels, storage suitability, procedures and a detailed analysis of each control failure.

The investigation highlighted several reasons for the increase in infestation. The relative effect and significance of each factor is indicated in Figure 1.

The most significant factor was residual protectant treatment failure. These failures were due to resistance in target insects, poor application of grain protectant, poor storage quality and the difficulties of storing untreated or low residue grain.

Almost as significant were the failures due to hygiene. The hygiene standards appeared to have degenerated gradually over a few seasons. The success of the grain protectants bioresmethrin and fenitrothion had resulted in some complacency. As the need for hygiene became less obvious, it became less of a priority. Field staff reductions, lack of experience and training in those doing the hygiene work, inadequate equipment and low morale also contributed.

The fumigation failures tended to be due to the unsuitability of the storages for this purpose. Failures due to grain movement logistics were caused by an incompatibility between the intake and outturn of grain and the requirement to seal the storage and maintain a lethal c/t product in the fumigation procedure.

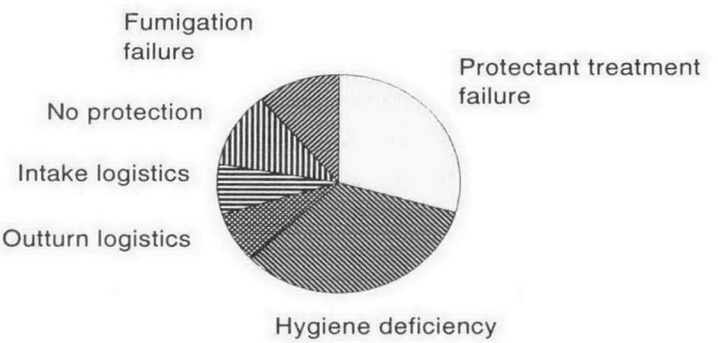

Fig. 1. Analysis of control failures, GRAINCO, 1990/91 season.

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The investigation also examined the requirements of grain protection in the future and identified several strategic issues. The most important of these were the increased sensitivity of markets to the presence of pesticide residues and the increasing demand for residue-free grain. While the problem of resistance of insects to contact pesticides is reaching crisis point, the use of fumigants (phosphine and methyl bromide) may be restricted due to concerns about the environment, health and safety of operators and chemical residues on food. Other areas noted were the economic downturn in the grain industry and poor seasonal conditions, the increased occurrence of late deliveries which are often heavily infested and/or contain pesticides, and the increased requirement for continuous domestic outturn of small quantities of grain that are both insect and residue free.

In response to the findings of this audit, a new integrated pest management plan (Collins and Bridgeman 1991) was devised and implemented as a total quality management initiative. It is a five-year plan containing several core strategies to be revised and updated annually. The plan incorporates resistance management as a major component.

Summary of Core Strategies

Criteria for development of GRAINCO integrated pest management

Before structuring the plan, the shortcomings of the previous pest management regime were examined. In addition the new integrated pest management plan not only had to be tailored to GRAINCO and the way it conducts business now, but it also had to be dynamic and flexible enough to cope with a rapidly changing external and internal environment. The plan had to consider the long-term future of the strategies used today, and in line with total quality management, the progress of the new plan had to be measurable.

Strategy 1: improvement of storage structure hygiene

Hygiene was targeted as a key success factor for each of the other strategies and the overall plan. The aims of this strategy were to approach the problem in several separate but related initiatives.

Procedures and standards: The first step was to establish appropriate standards and procedures required to clean storages. This was done in a series of staff workshops where those responsible for the hygiene formulated their own procedures and set the standards.

Staff training: Once written procedures were in place and actively maintained, a training program relating to all hygiene matters was implemented.

Supply of hygiene equipment: A program was implemented to improve the hygiene equipment with the intention of reducing the time spent on hygiene while increasing the standard achieved.

Hygiene audits: Self checking and periodic hygiene audits were implemented to establish a hygiene performance record as an indicator of compliance with the standard.

Strategy 2: insecticide resistance management

This strategy is designed to maximise the useful life of all grain protectants and fumigants as well as inhibiting the development of resistance in all major and minor insect pest species.

Resistance management tactics: The plan uses several recognised insecticide resistance management tactics including minimised chemical applications, emphasis on nonchemical controls, rotation of chemicals in time and space, mixtures of chemicals and use of chemicals with low magnitudes of resistance.

Strategy 3: optimising/rationalising application of insecticides

Chemical protection of grain is segregated into treatment of the storage and treatment of the grain and fumigation. The integrated pest management plan is designed to reduce reliance on chemical controls and residual grain protectants in particular.

Structural treatments: An important element in the integrated pest management plan is to phase out chemical treatments of storage structures and where appropriate to apply amorphous silica (as a slurry). Application methods for this material were devised and developed by GRAINCO and its effectiveness tested in a series of trials (Bridgeman 1992). Although the GRAINCO application methods (Bridgeman 1991), have been adapted in all states and by the grower community, there is a need to further investigate and optimise these techniques.

Residual grain protectants: Although the need to maintain the commodities residue free was a major issue in the analysis, the plan recognises the need for maintaining viable alternatives for future use. This is achieved through research on new and old pesticides and ensuring the best possible use of currently used chemicals.

Fumigants (nonresidual chemicals): Fumigation is the major chemical control used at GRAINCO. To optimise current and future fumigations, the plan ensures rigorous and continuous monitoring of current fumigations as well as the investigation and comparison of the efficacy and cost–benefit ratio of available fumigant application techniques in the range of GRAINCO storage types.

The plan actively supports research into new fumigants and considers the likely consequences on the development to resistance of various fumigation tactics and to use this as one criterion of acceptability.

Strategy 4: extended use of nonchemical controls (aeration, sealed storages, controlled atmosphere and high temperature disinfestation)

Compliance with the increasing demand by markets that grain should be residue free will require the extended use of nonchemical insect control methods and their integration with chemical methods.

Aeration: Aeration is primarily used to maintain grain quality during storage; however, a well designed aeration system is one of the most efficient way of dealing with grain that is being continuously outloaded for domestic markets. Domestic clients demand insect and residue-free grain to be available in small quantities over a long period of time. To cope with this market, the use of cooling by aeration has been introduced to as many storages as possible.

Sealed storages: The effectiveness of the physical barrier in pest control cannot be underestimated. The sealed bin not only ensures effective fumigation but also prevents reinfestation to some extent. GRAINCO has initiated a storage sealing program which, despite being affected by the poor seasonal conditions, has progressed with remarkable results.

Controlled atmospheres: Controlled atmospheres offer a method for maintaining grain free of insects without the problem of residues on the grain. This technology requires sealed storages and an inexpensive and practical gas supply. As a long-term goal the integrated pest management plan

outlines a program to develop controlled atmosphere techniques to a commercial operation scale, and once developed, to use controlled atmosphere in a rotation with fumigants.

Heat disinfestation: Disinfestation of grain using high temperatures has the benefits of being a very effective, rapid, no residue method. It offers no residual protection, however, its potential to be used to disinfest infested grain and dry moist grain at country silos, as well as for use at export terminals where markets demand nonchemical treatments, will continue to be investigated and implemented when appropriate.

Strategy 5: insect population monitoring

Insect trapping techniques: Insect population monitoring techniques have great potential to be used to detect incipient infestations and as an aid in disinfesting empty storages. A number of techniques using various types of traps have been developed. Early indications are that these methods are more sensitive and more cost effective than manual spear and sieve. Development of more accurate and less time consuming insect population monitorig systems will continue.

Data collection and recording: It is important that the progress of the integrated pest management be measurable, and that the significance of infestations between seasons can be compared. A computerised system to efficiently collate infestation data has been developed to ensure accurate recording and assessment.

Strategy 6: review receival and export standards

Three current standards relate to insect control. These include the 'nil tolerance for live insects', the limit of 12% moisture content and a requirement for no or low protectant residues. The nil tolerance is maintained by GRAINCO throughout the storage and it is also a requirement for export. The review examines the advantages and disadvantages of the nil tolerance of live insects in grain at intake and encourages payment of premiums to bulk handlers for the storage of residue-free, insect-free grain.

Strategy 7: promotion of nonchemical pest management in the non-GRAINCO sectors of the industry

GRAINCO prefers grain that is delivered insect-free and residue-free. This allows complete flexibility in how the grain is stored. The integrated pest management plan therefore seeks to promote and extend the use of alternatives to contact insecticides and fumigants to farmers and private grain traders and to demonstrate the efficacy and financial benefits of these alternatives. The aim is to minimise the use of contact insecticides and fumigants by growers and other grain handlers in order to maximise the amount of residue-free grain delivered to GRANCO storages.

Strategy 8: develop operational tactics that promote integrated pest management

As a significant percentage of control failures are due to the logistics involving intake and outturn, it is necessary to devise and promulgate a set of simple grain handling rules or operational tactics that will promote and facilitate integrated pest management and insecticide resistance management. Many of these may appear to be commonsense; however, in the event of control failure it is inevitable that one or more of these rules have been breached.

Strategic Controls for Integrated Pest Management

The strategic controls listed below are used to monitor the progress of the plan. This allows easy identification and quick response to any changes or deviations that may occur, as well as ensuring that any tactical and strategic decision-making is informed.

- Surveying for resistance to all protectants and fumigants in use in all major insect pest species.
- Monitoring numbers and locations of all insect infestations and comparing the cost/benefits of various insect control tactics.
- Investigations of all control failures to determine the cause.

Progress and Results of Integrated Pest Management to Date

Progress in general

Since the implementation of the GRAINCO integrated pest management plan, improvements have been recorded in most areas targeted. Not all the areas of note can be objectively measured. For example, although hygiene effort can now be audited and objective data collected, measurements of improvements gained by having better hygiene are still somewhat subjective. However, generally speaking, control failures due to hygiene deficiencies have decreased markedly (Fig. 2). This decrease is correlated to a better hygiene standard in the storages.

The decrease in control failures attributed to protectant treatment failure on the other hand are probably due more to the fact that only 10% of grain is now treated with protectant and the failures noted are due to problems in the application and the nature of IGR insecticides (methoprene), which only affects immature stages.

Although there has been a reduction in fumigation failures there has been a 300% increase in the number of storages

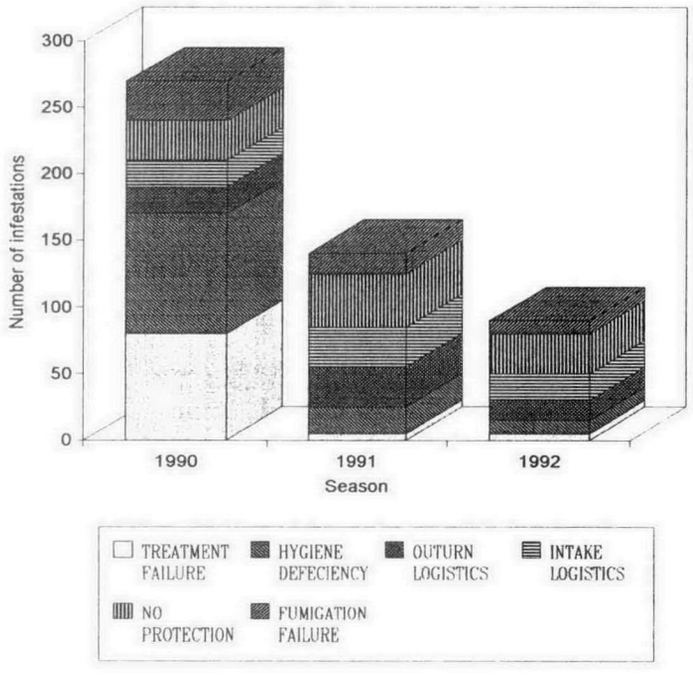

Fig. 2. Comparative analysis of control failures, GRAINCO, 1990/91, 1991/92, 1992/93 seasons.

under fumigation. These failures have all been due to unsuitable storages (poorly sealed without gas distribution systems in place). Continuing improvements in the area of bin sealing and gas distribution should ensure a gradual reduction in control failures due to fumigation failure over the next few seasons.

Reduction in insect detections

The most encouraging result has been the reduction in accumulated insect detections (Fig. 3). This reduction indicates that incidence of control failures is now acceptable and that there is a high level of control in place. The numbers of infestations experienced during the 1990/91 season (Fig. 3) indicates very little control as the incidence of insect population detection increased rapidly to almost 60% of storages infested. Improvements in the 1991/92 season indicate similar levels of detections as experienced in the 1988/89 season, prior to the problems of the 1990/91 season. The comparison with 1992/93 detections, where only 16% of storages used became infested is proof that the plan is achieving its goal. The rate of infestation has also fallen significantly, emphasising the greatly improved control the plan has allowed. Finally it should be noted that no infestations were detected during the first four months of 1992/93 and in 1993/94.

Reduced use of residual chemical treatment

The reductions in infestations achieved during the past three seasons are even more remarkable when it is considered that the use of residual grain protectants has been greatly reduced (Fig. 4). During 1990/1991 GRAINCO could store grain in approximately 30% of storages without residual chemical. By the 1993/94 season over 90% of storages had been modified to enable residue-free storage. The use of residual chemical to spray storage structures has been entirely replaced by Dryacide slurry. Plans in place will allow 100% nonresidual treatment by the year 2000.

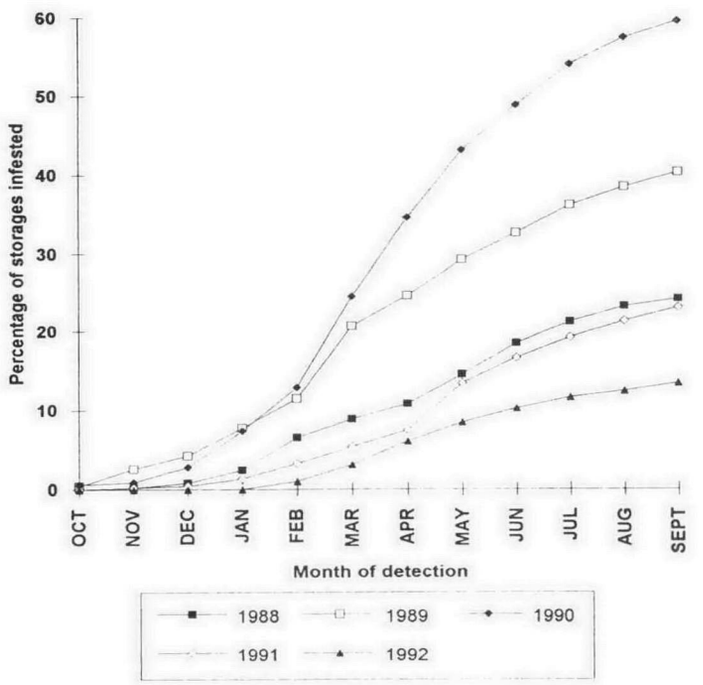

Fig. 3. Accumulated insect detections, GRAINCO, 1988 to 1992.

Reduced costs

The reductions in use of residual chemical and in control failures have led to a significant reduction in cost of grain protection. Thus the cost of residual chemical and fumigant has been reduced from over $1.50/t to approximately $0.60/t of grain handled since 1990 (Fig. 5).

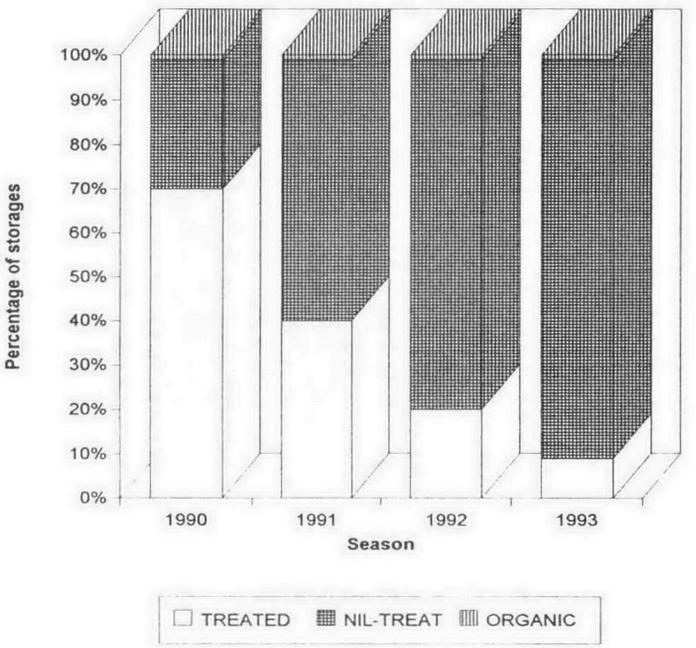

Fig. 4. Percentage of storages subject to each protection strategy, GRAINCO, 1990 to 1993.

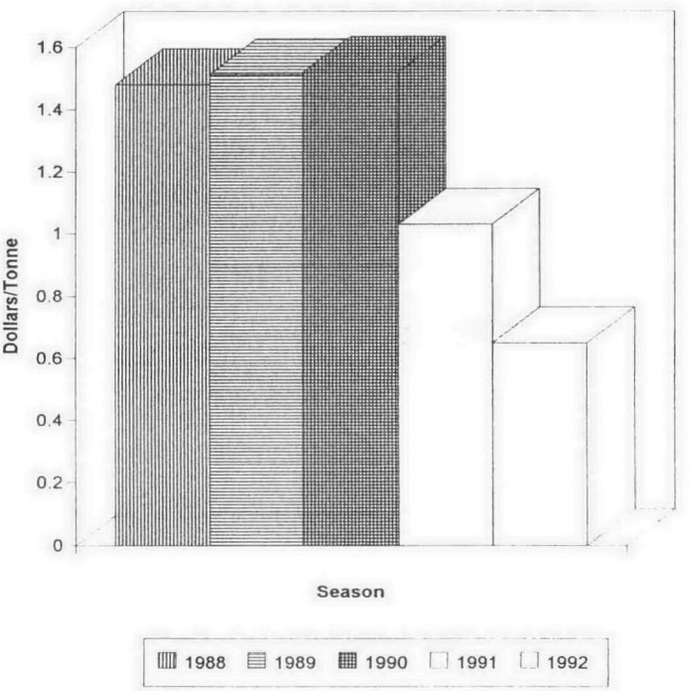

Fig. 5. Chemical cost comparison, GRAINCO, 1988 to 1992.

Concluding Discussion

Three years after the implementation of the GRAINCO integrated pest management plan, control failures are almost nonexistent. Insect infestations when they occur are usually the result of poor commodity management and grain movement logistics. Insect infestations due to these causes are not decreasing and will be the focus of future reviews of integrated pest management.

The review of intake standards is continuing. Moisture receival limits are continually under review and the insect receival standards are being challenged by novel fumigation systems. Deregulation of domestic marketing has seen an increase in delivery of protectant-treated and insect-infested grain, adding more pressure to the situation.

One of the most significant achievements of the plan has been the collection, recording and reporting of information. Data collection is continually improving and developing a high level of sophistication and accuracy. Monitoring techniques, although not perfect, are constantly under review, becoming more effective each season.

The reduction in insect infestations has been highly successful. This result was achieved by focusing on the several issues found to be contributing to the problem and increasing the effort in those areas. The most significant areas of treatment failure, hygiene deficiency and fumigation failure, were first to be addressed. The achievements in these areas are significant and will continue to improve in future seasons. The failures due to logistics and management issues have not yet been fully addressed. The infestations due to these problems are therefore at simular levels each season. Future plans to improve will focus on these areas more closely.

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