On farm

Viable Weed Seed Transfer in Feedlot Manure

Project number FLOT.212
Final Report prepared for MLA by:

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Feedlots

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1. SUMMARY AND KEY FINDINGS

Evan Powell Rural Consultants, Dalby Agricultural College and four feedlots have cooperated in a MLA (Feedlot Industry) funded project “FLOT 212” to examine feedlot manure as a possible source of viable weed seed transfer to cultivation land.

The project consisted of winter and summer phases utilising manure with various background treatments in weed seed germination observations in glasshouse pots, field plots and in nylon bags within manure stockpiles.

Results show that viable weed seeds of non-resident species were introduced to the observation site in manure from all feedlots.

Seed viability was destroyed when it was left in porous nylon bags placed in small observation stockpiles of manure.

In the winter glasshouse pot observations, germinations were observed in only one of six loose stockpile replicates. No germinations were seen in other treatments. In the summer phase of the glasshouse pot observation, germinations were observed in some replicates of the loose and composted piles at all three feedlots but not in the grain co-product or compacted treatments.

Germinations were recorded in all manure treatments in the winter and summer field plot observations. When control plot weed species were excluded, all bar the compacted manure pile treatment recorded some germinations in winter and all bar the grain co-product treatment recorded germinations in summer.

Temperatures in most of the background treatment manure piles exceeded those required for pathogen removal. However, the composting process was not considered complete in most treatments. Fusarium spores were not detected in any tests, which included freshly harvested pen manure and post storage summer treatments.

Irrespective of manure background treatment and stockpile temperatures recorded in this observation, viable weed seeds were introduced to cultivation land in feedlot manure. Incomplete heating of all manure in the storage, inadequate temperatures and re-contamination of manure stockpiles or windrows are thought to contribute to viable weed seed transfer. Lower weed counts are expected in commercial operations as in small observation piles thorough heating is less assured and there is more surface area to re-contaminate.

Some of the analytical data collected and information from reviewed previously unpublished observations relates to feedlot manure nutrient availability. Laboratory analyses of manure, from all treatments in winter and summer showed 60% of total phosphorus was present as Colwell phosphorus. A review of five field trials showed 72% of total manure phosphorus was either removed by the harvested crop or remained in the top 10 cm of soil.

There was some variation in duplicated laboratory tests. Most but not all of the difference was due to test methodology. This is an important point for licensing authorities, when specific laboratory methodology is not specified.

2. PROJECT CONTACT

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3. PROJECT BACKGROUND

Distribution of feedlot manure for use as a fertiliser is thought to be responsible for viable weed seed distribution. Feed processing, ruminant digestion, wetting and drying in the feed yard and heat generated during storage are thought to sterilise most plant seeds. However, there are observed situations where weed problems have increased following manure spreading.

Adverse publicity resulting from actual and perceived risk of introducing viable weed seeds threatens to reduce the saleability of feedlot manure. Inability for off-site disposal of manure can impact on the environmental sustainability of feedlots with limited manure utilisation areas. Manure sales generate significant income for feedlots in some districts.

More reliable heating and seed sterilisation is achieved in well managed, composting operations. However, significant costs associated with full composting are currently very difficult to recouped in bulk manure sales to broad acre agriculture. Other markets are constrained by excessive freight costs. Temperatures achieved in many manure stockpiles are believed to be sufficient to sterilise viable seeds but surface stockpile temperatures are much cooler. A limited number of effective turnings may be sufficient to achieve seed sterilisation.

4. PROJECT AIM

Measure viable weed seed transfer in feedlot manure of known backgrounds and establish risk management guidelines to reduce the chance of unwanted viable seeds being transferred in feedlot manure. Secondly, to increase knowledge of manure as an agricultural fertiliser.

5. METHODOLOGY

- Freshly harvested manure with known background from three feedlots with varying grain processing methods were placed in two to three unreplicated treatments on feedlot sites prior to winter and summer germination observations.
- Porous nylon bags containing seeds of known germination were placed at various positions in manure treatment piles. Germination was tested after the manure background treatment phase.
- Manure was analysed for drymatter, pH, conductivity, organic carbon, total nitrogen, ammonium nitrogen and nitrate nitrogen, Colwell phosphorus and total phosphorous at the commencement and end of the background treatment.
- Temperature and moisture were monitored in background treatments by feedlot staff.
- Following background treatment, the manure was transported to Dalby Agricultural College for inclusion in replicated field plot and glasshouse pot observations for weed germination. Methyl bromide treated soil was used to reduce the resident viable weed seed population in both the plot and pot observations.

6. TRIAL DESIGN

6.1. Manure Background Storage Pile Treatments

Feedlot 1	Feedlot 2	Feedlot 3&4
Reconstituted Grain	Steam Flaked Grain	Tempered Grain
Compacted (1P)	Loose (2L)	Loose (3L)
One turn (11)	Manure Compost (2C)	Manure Compost (3C)
Manure Compost (1C)	Manure+Grain Compost (2G)	

Compacted piles were rolled with a wheel tractor. It is possible some outer pile reinfestation of weed seed could have occurred during rolling of the small (6-12 tonnes) treatment piles. After rolling the compacted treatment was not disturbed until removal. No additional moisture was added.

Loose piles were left undisturbed with no additional water.

The one turn treatment was turned once with a front-end loader. No additional moisture was added.

Compost treatments consisted of manure only and were turned six to nine times with a front end loader. Manure turnings were based on feedlot procedures or temperature monitoring. Water was added on two to six occasions.

The grain treatment consisted of a manure and grain waste mix and was otherwise treated as the compost treatment.

6.2. Nylon Bag Inclusion

Porous nylon bags containing wheat, mungbean and lucerne seed were placed in manure storage treatments at two lots in the pre-winter phase and three lots in pre-summer phase.

The bags were located deep in the turned piles. They were removed and replaced at each turning. In the undisturbed treatments, bags were placed deep in the pile and just under the surface (3 cm.). Seed species were chosen for availability and hard seed. Germination tests were carried out in laboratory conditions at Dalby Agricultural College.

6.3. Field Plot Design

A random plot design was laid out with the following treatments and replicates ().

	Winter	Summer
FL1 – Compact (1P)	(3)	(3)
FL1 – One Turn (11)	(2)	(2)
FL1 – Compost (1C)	(3)	(3)
FL2 – Loose (2L)	(3)	(3)
FL2 – Grain and Manure (2G)	(2)	(2)
FL2 – Compost (2C)	(3)	(3)
FL3/4 – Loose (2L)	(3)	(2)
FL3/4 – Compost (3C)	(3)	(3)
Controls	(6)	(6)

$7m^2$ plots were separated by 0.5m of methyl bromide treated soil and surrounded by 0.5m of treated soil. A further minimum 2m of cultivated soil surrounded the plots. Winter and summer observations areas were treated with methyl bromide at the one time. The summer area was left covered during the winter observation.

A diagramatic representation of the field plot design is shown in Appendix Table 1, Field Plot Layout.

100 tonnes per hectare of manure drymatter was incorporated into the treatment plots by rotary hoe.

6.4. Glasshouse Observation

The field plots were duplicated in a glasshouse using 1.5 litre pots. Controls consisted of methyl bromide treated and untreated soil. Manure inclusion represented 25% of the soil-manure treatments. Ample treatment moisture was supplied by an automated misting system.

6.5. Manure History

Background treatment manure was freshly harvested from feed yards. Cattle feed ingredients at all yards that were considered a potential viable weed seed source were: grain, hay, silage and cottonseed. Hay and cottonseed are considered the most likely sources as there is no significant denaturing process prior to feeding. Commercially, most manure is left to dry in loose piles or windrows before inclusion in larger stockpiles. This procedure allows some heating of a moist product.

7. RESULTS

7.1. Drymatter Loss

It has previously been recorded, Kuhlman 1992, Powell 1994, Potts and Casey 1999, that manure loses dry matter mass during storage. Dry matter losses recorded in this observation are summarised below and detailed in Appendix Tables 2A, 2B and 2C, Drymatter Change. More frequently turned piles tended to lose more drymatter during storage. These background treatments were not replicated in either the pre-summer or pre-winter phases of the observation. Relative small un-replicated piles were stored on bare earth and weighed on truck scales or bagged and weighed on a spring balance.

Treatment	DM Loss
Loose	6.45%
Compact	5.46%
One Turn	6.51%
Compost	9.20%
Grain Co-Product	7.98%

Composted manure with more moisture and more turnings was more friable and easier to handle.

7.2. Drymatter Monitoring and Turning

Samples for drymatter analysis were periodically taken from manure treatments requiring turning. In most instances, drymatters were higher than the required 40%-50% WB, Potts and Casey 1999 or 40%-60% Sweeten 1989, for efficient composting. However, perfect composting is unlikely to be achieved in many commercial feedlot operations. Cooperating feedlots did not have established more desirable compost watering systems. Pre-winter and pre-summer drymatter are summarised in Appendix Tables 3A and 3B, Drymatter Monitoring.

In the pre-winter phase, FL1, FL2 and FL3 turned the compost piles 7, 9 and 4 times, respectively. Water was added on only two occasions at FL1 and FL2 and once at FL3. In the pre-summer phase, FL1, FL2 and FL4 turned the compost piles on six occasions. Water was added on 3 occasions at FL, 4 at FL2 and 6 at FL4. Turning intervals and water additions are summarised in Appendix Tables 4A and 4B.

7.3. Temperature Monitoring and Pathogen Transfer

Manure temperatures in pre treatment storage were monitored at all feedlots. Unfortunately, thermometer problems resulted in pre winter phase temperatures at Feedlot 3 being discarded. Temperatures were measured at five locations in each manure pile. Mean readings are presented in Appendix Table 5A and 5B.

In the pre winter phase at FL1, temperatures in the compost and one turn piles exceeded 60˚C for 39 and 65 days and 65˚C for 15 and 14 days, respectively. Maximum temperatures of 69˚C and 67˚C in these piles exceeded the desirable 65˚C maximum, Potts and Casey 1999, Pittaway 1999, for several days. In the pre summer phase, temperatures exceeded 60˚C for 14 days in both the composted and one-turn piles but did not exceed 65˚C. The compacted pile exceeded 50˚C for only 2 days in pre winter and not at all in pre summer.

This suggests that the practice of storing manure in compacted stockpiles is likely to be effective for fire control but temperatures may not be high enough to destroy some pathogens unless there is an uncompacted stage before the manure is put in the compacted stockpile. However, all seed germination was destroyed in porous nylon bags placed shallow and deep in the winter and summer compact treatments and there were no germinations in the glasshouse compacted manure treatment pots. In field plots, compacted had fewer germinations than composted treatments in winter but more in summer.

In the pre winter phase at FL2, the loose pile temperature exceeded 60˚C for 7 days and remained over 50˚C for the remainder of the 71 days storage. The grain co-product and manure only compost piles exceeded 60˚C for 65 and 58 days, and 65˚C for 19 and 28 days, respectively. In the pre summer phase, the loose pile temperature exceeded 60˚C for 45 days and 65˚C for 10 days. The grain co-product and manure only compost piles exceeded 60˚C for 45 and 57 days, and 65˚C for 4 and 10 days, respectively.

In the pre summer phase at FL4, temperatures exceeded 60˚C for only 2 days in both the loose and compost piles. The loose and compost piles exceeded 50˚C for 5 and 42 days, respectively.

According to Australian Standard AS 4454-1999, pasteurisation for turned compost piles is achieved with a composting period of at least six weeks with a minimum of three effective turns and temperatures exceeding 55˚C for at least three consecutive days prior to each turn. The standard also suggests that these best practice procedures are the best way of ensuring that there is minimal contamination with weed propagules. Feacham et al 1993 suggests 45-50˚C for 12 consecutive days should destroy all pathogens. US-EPA suggest temperatures of 55°C with five turns in 15 days is sufficient for pasteurisation.

Sweeten 89, states most weed seeds are inactivated at 65°C to 70°C. The higher level of this range conflicts with previously stated desirable maximum temperatures for composting.

Internal pile temperatures, in all bar the compacted piles and FL4 loose pile exceeded 55°C for greater than 25 days. Compost piles exceeded 65°C for more than 15 days pre-winter but no pile exceeded 65°C for 15 days pre-summer. The ability to ensure all parts of the stockpiles, especially the outer layer, achieve these temperatures is difficult with current turning machinery. A greater duration of higher temperatures may have been achieved with higher moisture and more frequent turning. The highest single reading was 75°C in the pre-summer loose pile at FL2.

Fusarium wilt is a major disease of the cotton industry. It is possible for the spores to be transferred on cottonseed from infected fields. Samples of freshly harvested and post background storage treatment manure for the summer observation, were screened for fusarium spores by the Queensland Department of Primary Industries. Cottonseed formed part of the rations at all feedlots. All samples tested negative for fusarium spores.

7.4. Manure Analytical Data

Ten sub-samples from each background manure treatments were composited into one laboratory sample for each treatment. Sampling was carried out at the commencement and end of the background treatment. Field samples were collected into ice slurry and transported in slurry or frozen. Laboratory results are presented in Appendix Tables 6A and 6B.

Ph: Mean pH across all treatments for winter and summer increased by 7% (7.05-7.53) during storage. Mean increase for loose and composted piles was 13% and 7%, respectively.

Conductivity: Mean conductivity across all treatments decreased by 24% (13.77-10.34 mS/cm) during storage. There was no trend between treatments.

Total Nitrogen: Mean TKN across all treatments decreased by 6% (2.60-2.44) during storage. No significant treatment differences were recorded due to variation between winter and summer treatments.

Nitrate Nitrogen: There was a mean trend for NO3-N to increase but there was trend reversal between summer and winter. Actual levels were low and variation high.

Ammonia Nitrogen: Across all treatments, there was a decreasing trend for mean NH4-N for winter and summer. However, actual levels were low in all treatments.

Organic Carbon: Mean organic carbon (furnace method) levels for all treatments dropped by 17% (40.5-33.7) during storage. Loose piles dropped by 14% and composted by 19%. Carbon:Nitrogen ratios averaged 14 : 1. This ratio is less than desirable for ideal composting, 15-30:1, Rynk 1992. Carbon sources suitable for co-composting are expensive to deliver to many feedlot sites. Hence, it is likely that addition carbon will not be added for manure sales to bulk broadacre users.

Total Phosphorus: Mean total phosphorus concentration increased by 2% (1.06-1.07). The proportion of manure phosphorus (45%) to total nitrogen is higher than the 20% desired for efficient composting, Sweeten 1989.

Bicarbonate (Colwell) Phosphorus: Mean Colwell phosphorus levels increased by 4% (0.63-0.64). It increased 2% as a proportion of total P. The proportion of Colwell P in the grain offal co-product treatment dropped by 33%. Excluding the grain co-product treatments Colwell P increased by 8%. Across all treatments in winter and summer, Colwell P as a measure of plant available P, was 60% of the Total P.

Composting with grain offal reduced the proportion of total P as Colwell P. Compost treatments had lower proportions of total P as Colwell P, than the loose stored piles. However, the composting process was considered to be incomplete at all sites. More complete composting and adequate curing period may have increased the proportion of available P in compost treatments. However, total storage times pre-winter and pre-summer were 78 to 85 days and 98 to 124 days, respectively. Testing was conducted on samples collected three to four weeks after the final turns.

Phosphorus availability was further determined by examining data from earlier industry funded research, Powell 1994. Comparing the amount of manure applied P, crop yields and residual soil Colwell P with control treatments in five crop response observations, showed 72% of the manure applied Total P was either removed in the harvested crop or remained as Colwell P in the top 10 cm of soil. Individual field observations are summarised in Appendix Table 7, Phosphorus Availability.

Homogeneous manure samples from all (8) post storage, pre summer treatments were submitted to two accredited laboratories for analysis. Significant result variation occurred especially with Total Nitrogen and Total Phosphorus. Much but not all of the variation is explained by varying methodology. Results are summarised Appendix Table 8, Laboratory Variation. The importance of this observation is in interpretation of laboratory reports by licensing authorities and legislators when laboratory methodology is not specified in licensing and reporting guidelines.

7.5. Nylon Bag Germinations

In the pre-winter phase, lucerne, celera mungbeans (hard seed) and wheat seeds were placed in porous nylon bags and located in manure treatments at FL1. Lucerne and mungbeans were observed at FL3. Control germinations for lucerne, mungbeans and wheat were 100%, 85% and 90% respectively.

Bags were placed deep in turned piles an shallow and deep in unturned piles. Results are summarised in Appendix Table 9A, Nylon Bag Germinations.

Irrespective of treatment, all seeds were sterilised at FL1. At FL3, there was significant germination at shallow depth in the loose pile and in the compost pile. The latter is possibly due to bags not being relocated in the piles after turning. All seed in undisturbed deep bags was sterilised at FL3.

In the pre-summer phase, germination percentage of lucerne, mungbean and wheat seed was again tested in porous nylon bags. Bags were placed deep in turned piles and shallow and deep in unturned piles at the three feedlot sites. Mean germinations for the lucerne, mungbean and wheat control seeds were 43%, 73% and 100%, respectively. Irrespective of treatment, all seed viability was destroyed in the manure piles. Results are summarised in Appendix Table 9B, Nylon Bag Germinations.

This results suggests weed seed can be sterilised by assuring all manure has the opportunity to reach sterilisation temperatures. One or two effective turns with adequate moisture could be sufficient. Irrespective of treatment, reinfestation of manure stockpiles with viable weed seed is indicated as a potential problem.

7.6. Glasshouse Germinations

In the winter phase, plots were established in May and germinations recorded on days 9, 17, 31 and 50 after treatment. After DAT 31, pots were placed in the sunlight to increase medium temperature. Two broadleaf weeds germinated in on of the 3 pots with manure from FL3's loose stockpile. No germinations were observed in the methyl bromide controls or other manure treatments. One and four germinations were observed in two of the three replicates of the untreated soil controls.

In the summer phase, pots were established in December and germinations recorded on days 10, 17, 24, 38 and 51 after treatment.

One and two broadleaf weeds germinated in one replicate of the one turn and compost treatments from FL1, respectively. There were no germinations in the compacted treatment. One broadleaf and five grasses germinated in one replicate of FL2's loose pile and five grasses in one replicate of FL2's compost treatment. Numerous grass germinations occurred in FL4's loose and compost treatments. One broadleaf was observed in one replicate of the methyl bromide control. There were broadleaf germinations in all untreated control soil and one grass germination of one replicate of these controls.

Excepting one broadleaf weed in each of one replicate of the FL1-1Turn and FL2-Loose treatments, all weed species observed in the manure treatments were also recorded in the untreated soil control pots.

Glasshouse pot observations are detailed in Appendix Table 10B and 10B, Glasshouse Pot Observations.

7.7. Field Plot Germinations

Winter field plots were established in May 2000. Germinations were identified and counted on DAT 16, 24, 38, 57 and 93.

Winter weed species and germinations by treatment and feedlot are summarised in Appendix Table 11B, 12B and 13.

Feedlot manure source average germinations per treated area were as follows: FL1/1.38; FL2/2.50; FL3/2.83 and Control/1.00. When seedling species identified in the control plots were removed average germinations were as follows: FL1/0.88; FL2/1.63; FL3/1.00 and Control/0.

Across all manure sources and manure treatments and excluding control or resident weeds, the following weed species were identified: canary, milk thistle, marshmallow, London rocket, blackberry nightshade, turnip, Argentine peppercress, wire weed, fat hen and Australian carrot.

Excluding control weed species, mean compost treatments had germinations of: FL1/0.33, FL2/2.00, FL3/1.67 and Combined/1.33. The grain co-product treatment had 0.5 mean germinations. Undisturbed stockpiles recorded FL1(compacted)/0, FL2 (loose)/2 and FL3 (loose)/0.33.

The lowest temperatures were recorded in FL1 compacted stockpile which had no germinations.

Summer field plots were established in December 2000. Germinations were identified and counted on DAT 15, 22, 29, 43 and 56. Following removal of established weeds, further observations were conducted in February and March 2001. Due to across treatment flooding these latter results were discarded.

Summer weed species and germinations by treatment and feedlot are summarised in Appendix Table 11B, 12B and 13. A glossary of weed species is presented in Appendix Table 14.

Feedlot manure source average germinations per treated area were as follows: FL1/9.63; FL2/7.14; FL4/25.00 and Control/11.38. When seedling species identified in the control plots were removed average germinations were as follows: FL1/2.00; FL2/1.02; FL4/8.20 and Control/0.

Across all manure sources and manure treatments and excluding control weeds, the following weed species were identified: black pigweed, barnyard grass, cotton, marshmallow, crowsfoot grass, rhynchosia and button grass.

Excluding control weed species, treatments had mean summer germinations of: loose/1.80, compact/2.67, one turn/4.88, compost/2.50 and grain/0.25.

Higher weed counts in FL4 treatments are possibly due to treatment reinfestation during stockpile break up and loading and/or lower stockpile temperatures. The tempering grain process was considered as a possible cause of higher counts but this was not supported in the winter phase by counts from FL3 with grain tempering processing.

Following the manure background storage treatments, grain processing method was not shown to impact on viable weed seeds in feedlot manure. All feedlots used a wet processing method.

Excluding control weed species, winter and summer mean plot germinations are summarised in Appendix Table 13 and as follows:

Feedlot 1 (W&S)	1.44
Feedlot 2 (W&S)	1.02
Feedlot 3 (W)	1.00
Feedlot 4 (S)	8.20
Loose	1.49
Compact	1.34
One Turn	3.94
Compost	1.92
Grain	0.25
All Treatments	2.91

In practice, most introduced weed species are destroyed by resident weed control management. However, there is possibility for introducing weed species that will increase farm weed control costs. A 7m^2 plot with 2.9 germinations of non-resident weed species equates to 291 introduced non-resident weeds per hectare, when 70% drymatter manure is applied at 10 tonnes a hectare.

Field plot moisture was maintained with a combination of rainfall and irrigation. Rainfall recordings and irrigation use are shown in Appendix Table 15. Supplementary irrigation was required in winter but there was sufficient rainfall in summer. Results from a second tillage and germination observation in summer were discarded as intense rainfall in early February caused flooding across the site.

8. TABLES AND FEEDLOT PROTOCOL

Protocol and recording forms for use by cooperating feedlots are presented in the Appendix.

9. RISK MANAGEMENT

It would be extremely difficult to guarantee manure as viable weed seed free. The risk of transferring weeds is reduced by attempting to ensure all manure is subject to temperatures of greater than 55°C for at least several days. This is difficult to achieve with one or two turn using front-end loaders or currently available windrowing machines. Developing a machine that ensures outside layers are turned to the inside of the windrow would enable more thorough heating.

Weed hygiene around manure storage areas and care when loading out will assist in reducing reinfestation.

Adding water to uncompacted storages will assist in breaking down larger manure particles.

Greater precautions should be taken with manure destined for the open market.

10. ACKNOWLEDGEMENTS

This project would not have been possible without the valued cooperation and assistance from the four feedlots that supplied the manure and conducted the background treatments. Dalby Agricultural College students and staff transported the manure, conducted the seed germination tests and glasshouse pot and field plot observations. The author gratefully acknowledges the financial support from Meat and Livestock Australia.

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12. APPENDIX

See Following pages.

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