Summary of the results of the investigation into the loss of canola seedlings from 2007-2011 in the Overberg

1. The problem of loss of seedlings overnight was first experienced following the change over from deep ploughing to conservation farming.
2. The key to determining what was responsible for the losses of seedlings was to link the organism to the losses and this required finding a trapping method which could be used to monitor most organisms that were present. Melthoid traps of 30 x30 cm placed on the ground and held down by two metal pegs were a cheap and effective device to accomplish this as virtually all organisms including legless lizards, geckos and slug eater snakes hid under the traps during the day.
3. Plots treated with different chemicals to eliminate different organisms could then be used to link seedling survival with the presence or absence of the various organisms so that a correlation could be determined and the culprit identified.
4. Only the cosmopolitan isopod *Armadillidium vulgare* and the three Mediterranean slug species *Milax gagates*, *Deroceras panormitanum* and *D. reticulatum* could be directly linked to the losses of seedlings.
5. Although there were 'explosions' in numbers in some years of crickets, millipedes, 'koffiepitte' (*Gonocephalum simplex*), earwigs and cockroaches, there were absolutely no correlations to link their numbers with the loss of seedlings. Neither were any of these organisms ever recorded feeding on canola seedlings.
6. The crucial period over which the seedlings must be protected is about 4 weeks from planting. After this period there is enough foliage on the plants that the damage caused by the feeding of slugs and isopods becomes negligible.
7. During the early trials various treatments, including covering of seeds with carbaryl, the burying of slug pellets in the soil during planting, doubling the number of canola seeds planted, disturbing the soil surface twice but planting only once, and combinations of these treatments were tested. Those treatments showing promise were then tested in full scale trails.
8. Trials showed conclusively that the most cost effective method of protecting canola seedlings was to broadcast slug pellets containing 30g/kg metaldehyde + 20g/kg carbaryl on the surface at planting.
9. There was found to be no significant advantage in broadcasting a second batch of slug pellets on the surface six days after the emergence of the canola seedlings.
10. Although very much less visible than slugs, isopods remain the main culprits in causing losses of seedlings. During most years they were found to be responsible for nearly all the losses of seedlings, in some years they may be found together with slugs.
11. Where canola seedlings in entire fields 'disappear', this is invariably due to isopods. Slugs cause bare patches to occur where the seedlings have been consumed and this is a consequence of their behaviour of congregating in the soil to conserve water. The slugs then feed at night while moving along the planting furrows which are both moist and in which the seedlings are growing. Several of these bare patches may coalesce and form larger areas of bare soil.

12. Both isopods and slugs consume the entire seedling as it emerges. Laboratory studies showed that isopods are even able to climb up seedlings to feed. Because seedlings grow from their apical point, once this is lost the seedling cannot re-sprout.
13. All locally available slug pellet products containing metaldehyde + carbaryl were found to be extremely effective in attracting and killing slugs and isopods. Metaldehyde alone will successfully kill the slugs but does not give the required control of isopods.
14. Carbaryl is toxic to most organisms and killed millipedes and beneficial predatory beetles but not crickets or earwigs which appeared not to feed on the slug pellets. Rarely were earthworms killed – only under melthoid traps when excessive dampness drove them onto the surface and in contact with the pellets would they be killed. So earthworms are not killed when slug pellets are broadcast onto the surface at planting. The indigenous slug *Oopelta polypunctata* is virtually unaffected by the slug pellets broadcast at planting because they only become active after the crucial 4 week period and do not venture far into canola fields but instead remain within the fynbos.
15. Laboratory studies have shown that isopods are immediately attracted to slug pellets and die within 15 minutes after feeding on them.
16. Although isopods need water to survive and may desiccate easily, there is an optimum moisture tolerance, above which excessive water becomes detrimental to the isopods. The years in which the slugs predominated, were years where the soil moisture was extremely high, which was favourable to slugs but detrimental to isopods whose numbers plummeted.
17. Isopods were found in the detritus on the surface (under the stubble), under rocks and clods, and so are able to respond rapidly to even slight moisture and immediately become active. This appears to be why the broadcasting of slug pellets on the surface at planting is so effective – they respond immediately and die within 15 minutes of feeding.
18. The slugs take a bit longer to emerge from the soil at the onset of the first rains – but instead steadily build up in numbers over the season, while laying eggs throughout this period. Of the entire slug population in a field over the season, less than 3% are present during the crucial 4 weeks from planting.
19. The outbreak of *Milax gagates* in the Swartland in 2009 and 2010 where it was virtually unknown before (and where isopods rarely occur) showed that slug numbers can increase rapidly if conditions are favourable. Thus the farmer cannot hope to exterminate the slugs by broadcasting slug pellets throughout the season. It is only cost effective to protect the seedlings during the crucial 4 weeks from planting. Nature (mainly weather) will cause more fluctuations in the numbers of isopods and slugs than that which can be caused by the farmer at great expense.
20. The literature states that these slugs, which spend most of their lives within the soil, may bury themselves up to 1.5 meters deep where they over-summer. From our experience this appears to be unlikely and they probably only occur within the first 12 cm or so – to the same depth that the tunnels of the earthworms extend into the ground.
21. As temperatures increase and the soil begins to dry at the end of the season, the slugs become concentrated wherever the last moisture is to be found and from here they enter the soil where there are cracks or they follow earthworm tunnels. Hence they automatically become clumped within certain areas,

which is advantageous to them. This explains why, with our limited sampling, we were unable to find them post-harvest because to do so would mean the sifting of sand over a large area in order to locate such a group of slugs. Deep ploughing in the past exposed these slugs to the elements and caused them to desiccate or be predated.

22. The three exotic slug species do not occur in the same ratios in different fields and rotation crops. *Deroceras panormitanum* was the dominant slug species in canola fields and appears to require a slightly moisture microclimate than *Milax gagates*. This is why *D. panormitanum* were shown to cluster significantly more on the underside of the traps where there is condensation, whereas *M. gagates* was more often found on the ground under the trap. *Milax gagates* was dominant in most wheat, lupin and lucern rotations. *Deroceras reticulatum* is enigmatic and no pattern can be discerned.
23. The micro-climate formed within a canola field when the canopy closes, giving both shade and conserving moisture, are especially favourable to *D. panormitanum* which results in an 'explosion' of newly hatched juveniles at the end of the season starting when the canola is in full flower.
24. We know that the slugs over-summer in the soil and that they enter the soil where it has cracked or where earthworm tunnels are exposed. We do not know to what depth they are found, whether they are able to widen tunnels, whether all three species may be found together, or how many slugs may be found in one clump.
25. Our trials have shown that the 10 permanent traps have a random distribution of isopods under all traps, but that the slugs are concentrated under certain traps only. Although some traps may be intrinsically slightly more attractive than others at a micro level, it is more probable that slugs follow the slime (mucus) trails of other slugs (and their own trails back to their daytime hiding place), and in which a pheromone may exist.
26. A parasitic nematode which enters the breathing hole on the side of the slug and eventually kills it is commercially available in Europe where it is broadcast from a helicopter on high value vegetable crops. This nematode is present in slugs in the Western Cape but is unlikely to be cost effective in dryland canola crops in South Africa but the expert in this field, Jenna Ross of the University of Aberdeen in Scotland will be researching such nematodes at Stellenbosch University under Prof Antoinette Malan for the next two years. Something of value may result from this research. Because the isopod is far more problematic than the slugs, slug pellets would still have to be broadcast to kill them.
27. The ecology of the isopods in the Overberg is unknown. An attempt was made to discover how far they moved and if this was directional or random. Four traps were laid out alongside each other in the centre and 8 traps were placed at a distance of 3 metres around them. Another 8 traps were then placed another 3m meters around them in turn. All the isopods in the centre 4 traps were marked with Tipp-Ex and at weekly intervals all traps were inspected. Of the more than 1000 isopods marked, only two moved 3 metres and the rest were not found again. Tipp-Ex had been shown in laboratory trials to remain attached to isopods for more than two months. It appears that the isopods are localized and that their movement is vertical into the soil rather than horizontal migration.

28. Initial 'capture-mark-release-recapture' trials which, using a mathematical formula, gives an accurate indication of the number of isopods in an area, varied widely but all indicated an extremely high population level per m^2.
29. From limited laboratory trials it appears that the slugs and isopods need variation in their food to complete their development – needing both green material as well as stubble (dry organic material).
30. The slugs in certain years when their numbers are large, will feed on wheat. Indications are longitudinal gaps in the leaves of wheat which are usually accompanied by slime trails. However, damage to wheat thus far has been minimal when compared to that of canola. Lupins are far more susceptible to slugs than wheat and bare patches throughout a field may occur, with 50% of the seedlings devoured.
31. Burning of stubble and weeds about a month before planting resulted in a significantly improved survival rate of seedlings. Burning combined with the broadcasting of slug pellets at planting gave full protection to the seedlings. The trial was not 100% conclusive, but the effect of fire appears to remove places of shelter for isopods and leave them exposed to desiccation. Burning is not part of conservation farming and is not recommended, but what this indicates is that suitable places for sheltering results in an increase in the numbers of isopods.
32. There is an indication from limited sampling carried out prior to planting that in those years when the juvenile isopods are as great in number as, or greater than the adult population, then the losses of seedlings were greatest. The converse appears true, that few juvenile isopods meant less damage from isopods. Fewer juveniles usually occurred during wetter years.
33. The slug outbreak in the Swartland where there had never before been a problem with slugs was quite extraordinary in that only one slug species was involved (*Milax gagates*) although all three exotic species had previously been recorded in towns thereabout. Unlike slug outbreaks in the Overberg, in the Swartland some fields were completely bare except for clumps of surviving seedlings. The heat and dryness of the soil (and perhaps some characteristic of the soil itself) in the Swartland in summer appears to limit the survival of isopods and slugs.
34. Weather appears to have had an influence, in that prior to the outbreak in the Swartland, out of season rainfall was experienced in November/December – very much like that experienced in the Overberg. Rainfall is crucial to the activity of both isopods and slugs, but it is not as simple as how much rain fell but when it fell and over what period. It is the wetness of the soil (i.e. the accumulation of moisture) that appears to be most important. Low temperatures are ideal for activity of both slugs and isopods.

G.D. Tribe, 13 February 2012