Stirlings to Coast Inc.

Impact of Stubble Management on Small Conical Snail Mortality.

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Harvest results

Plots were harvested on 23/12/2020.

The snail infestations were determined by counting snails in 166 grain samples of approximately 266g/sample and analysis of 3486 GrainCam images.

The number of snails per half litre of grain for the four treatments are shown in table 1.

Table 1: The number of snails per half litre of grain following various treatments.

Treatment	Snails per half litre
Cabling	2.93
Stubble Crunching	3.88
Speed Tiller	4.50
Nil (Control)	3.55

l.s.d. ($p<0.05$) =1.15

The data was analysed using Genstat and the output is shown in Appendix 1. The data was analysed initially as a one way anova using the 4 replicates and then re analysed using a spatial analysis taking account of the replicate position as well as the distance down the treatment plot. This improved the probability of treatment effects from p=0.063 to p=0.060. Based on the l.s.d. the speed tiller had greater snail infestation then the cabling treatments and all treatments were not significantly different to the control.

Genstat was used to create a map of the density of snails across the whole site and is shown in figure 1. This shows that the snails occurred in patches over the site but were not significantly influenced by the treatments applied.

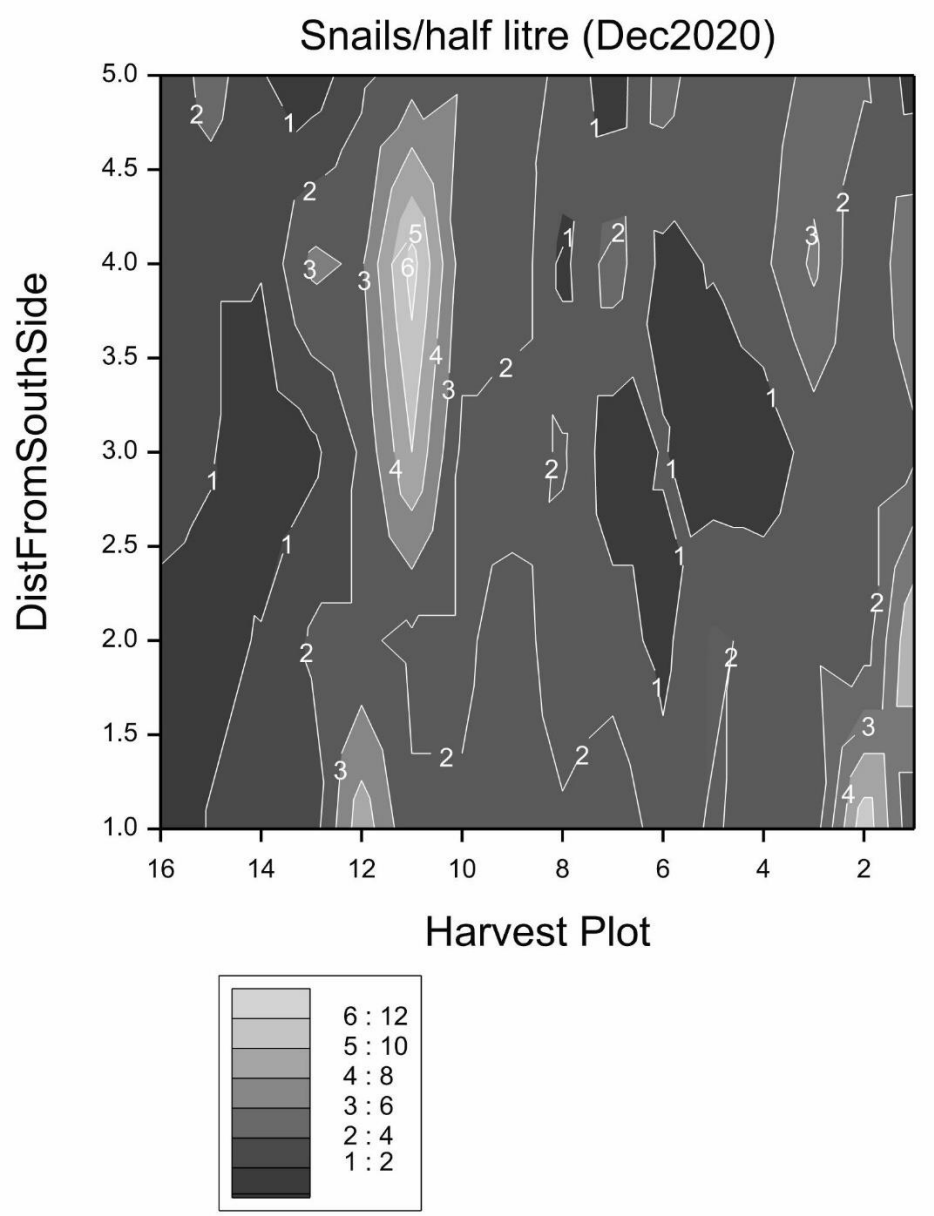

Figure 1: The numbers of snails present in the grain samples taken from the trial site.

Image analysis Results

The GrainCam is a device that is attached to the bubble auger on a harvester so that images of the grain may be taken during harvest. Images are then downloaded and passed through an artificial intelligence inference program. This scans the images and detects snails or snail like objects and records them.

The inference program is made by using images that have snails mapped in images of grain and these are passed through a neural network training program. In this case, we used YOLO3 as the training network. Training takes a long time and requires a large number of labelled images and significant computing power. Much of the data for training was taken from a previous DPIRD R4R project supervised by Micic and Moore in collaboration with UWA. The inference program produced is quite

small and runs very fast and the final goal is to have this running on a mobile phone on the GrainCam so snail detections may be made in real time.

The snails harvested in this project in 2020 were much smaller than snails in previous years and this resulted in some loss of accuracy. Some retraining with the small snails would improve the accuracy.

A typical image with a detect snails is shown in figure 2 together with a false positive. The numbers indicate the probability that the detection was really a snail. The fact that the false positive was 0.96 whereas the actual snail was 1.00 indicates that with further training of the model these can be eliminated. Increasing the threshold to 0.95 resulted in missing too many snails (e.g. those what were small, misshapen or partially covered).

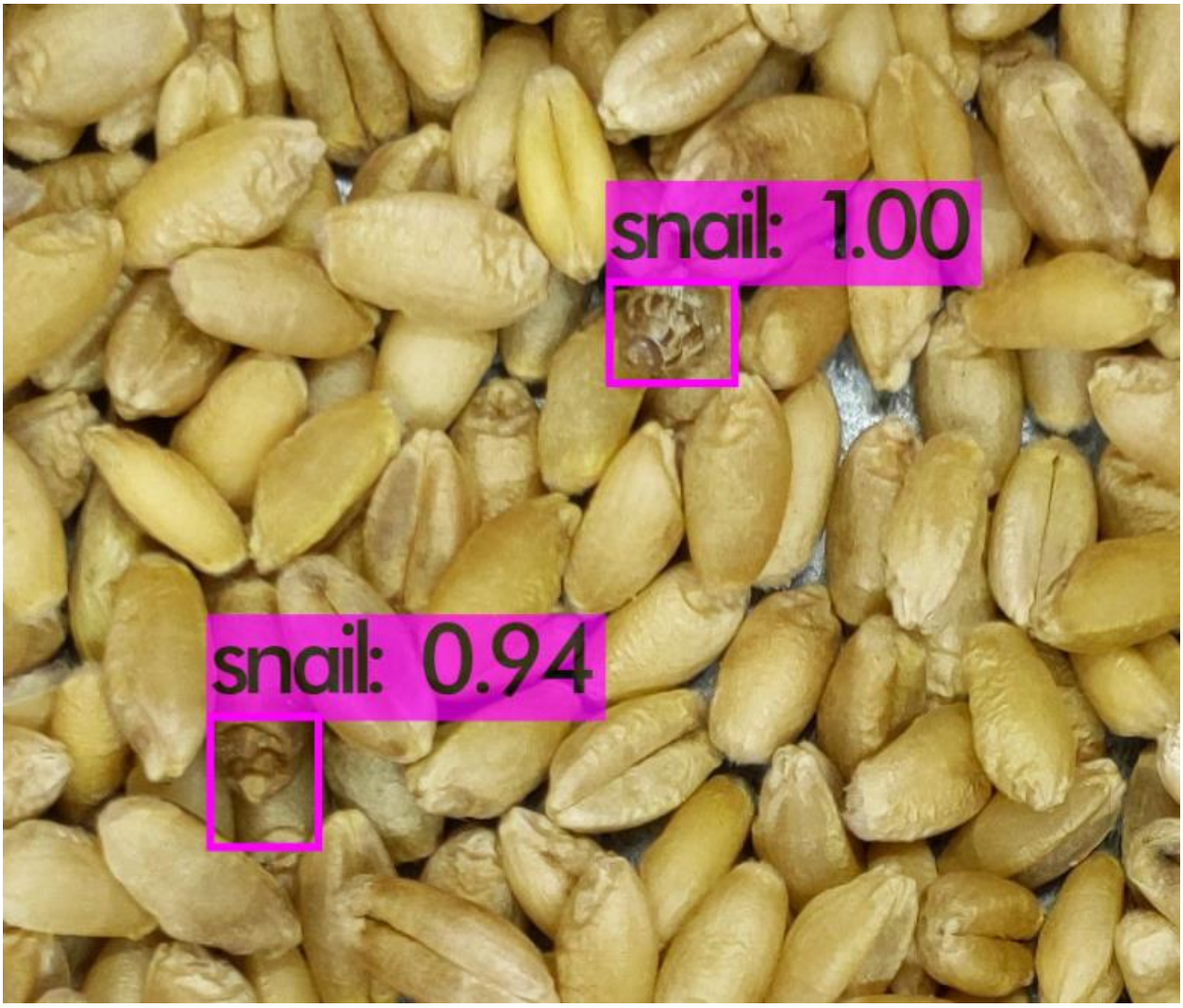

Figure 2: Typical snail detection and false positive with associated probabilities.

The grain at the site also had staining that resulted in some false positives as shown in Figure 3.

Figure 3: Grain defects that were misclassified as snails.

The correlation between the snails actually counted in samples compared to snails detected by AI was 0.55 which is actually significant at $p<0.05$. Retraining would improve this.

Table 2 versus Table 3 shows the numbers of snails counted compared to the number detected by artificial intelligence. In table 3 the high number in Rep3 result form more grain staining in these plots which was misinterpreted as snails. The overall larger numbers come from snails being counted more than once as the same snail may occur in an image and also in the subsequent image if the grain flow is slow.
There were no significant differences between treatments in the number of “snails” detected (see Appendix 2).

Table 2: The number of snails per half litre counted in samples.

Treatment	Rep1	Rep2	Rep3	Rep4	Average
Cabling	2.71	2.57	4.43	2.00	2.93
Crunching	4.93	3.29	4.71	2.57	3.88
Nil	4.07	2.71	5.43	2.00	3.55
Tiller	4.71	3.00	7.14	3.14	4.50
Average	**4.11**	**2.89**	**5.43**	**2.43**	**3.71**

Table 3: The number of "snails" detected by artificial intelligence and the GrainCam

Treatment	Rep1	Rep2	Rep3	Rep4	Average
Cabling	0.80	9.60	13.40	4.60	7.10
Crunching	5.08	13.80	12.90	4.80	9.15
Nil	0.82	0.20	18.20	8.50	6.93
Tiller	1.38	9.70	17.60	1.80	7.62
Average	**2.02**	**8.33**	**15.53**	**4.93**	**7.70**

Conclusions.

Cabling, crunching and tiller treatments had no significant effects on the number of snails that contaminated the grain at harvest. This season the snails were very small compared to last season indicating that they were younger and possibly less affected by treatments applied in autumn.

The GrainCam and artificial intelligence programs showed good potential for measuring snail contamination but require further development of the training algorithms to increase accuracy and reduce the number of false positives. These methods are much faster than counting snails in samples if large numbers of samples need or be processed or maps of contamination are required.

Appendix 1: Statistical analysis of snails counted in grain samples

Genstat 64-bit Release 20.1 (PC/Windows 8-10) 19 January 2021 10:21:43

Registered to: Agriculture Western Australia

Genstat Twentieth Edition
Genstat Procedure Library Release PL28.1

```
   1  SET [WORKINGDIRECTORY='C:/Users/moorej/Documents'; DIAGNOSTIC=messages]
   2  "Data taken from file: '\
  -3  C:/Users/moorej/Documents/SnailsSlugs/S2C/ImagesGrainCam/Mt Barker
grain samples imaging times.xlsx\
  -4  '"
   5  DELETE [REDEFINE=yes] _stitle_: TEXT _stitle_
   6  READ [PRINT=*; SETNVALUES=yes] _stitle_
  10  PRINT [IPRINT=*] _stitle_; JUST=left
```

Data imported from Excel file: C:\Users\moorej\Documents\SnailsSlugs\S2C\ImagesGrainCam\Mt Barker grain samples imaging times.xlsx
on: 19-Jan-2021 10:22:08
taken from sheet "GenstatSpatial", cells A2:I161

```
  11  DELETE [REDEFINE=yes]
Plot,Col,Rep,Treat,No_snails_found,Snail_HalfLitre,\
  12  Time_collected,RepCol
  13  UNITS [NVALUES=*]
  14  VARIATE [NVALUES=160] Plot
  15  READ Plot
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Plot	1.000	8.500	16.00	160	0

```
  22  FACTOR [MODIFY=no; NVALUES=160; LEVELS=5; LABELS=*; REFERENCE=1] Col
  23  READ Col; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Col	160	0	5

```
  29  FACTOR [MODIFY=no; NVALUES=160; LEVELS=4; LABELS=*; REFERENCE=1] Rep
  30  READ Rep; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Rep	160	0	4

```
  36  FACTOR [MODIFY=no; NVALUES=160; LEVELS=4;
LABELS=!t('Cabling','Crunching',\
  37  'Nil','Tiller'); REFERENCE=1] Treat
  38  READ Treat; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Treat	160	0	4

```
  44  VARIATE [NVALUES=160] No_snails_found
  45  READ No_snails_found
```

Identifier	Minimum	Mean	Maximum	Values	Missing	
No_snails_found	0.0000	2.600	12.00	160	0	Skew

```
  51  VARIATE [NVALUES=160] Snail_HalfLitre; DECIMALS=2
  52  READ Snail_HalfLitre
```

Identifier	Minimum	Mean	Maximum	Values	Missing	
Snail_HalfLitre	0.0000	3.714	17.14	160	0	Skew

```
  89  VARIATE [NVALUES=160] Time_collected; DREP=36
  90  READ Time_collected
```

Identifier	Minimum	Mean	Maximum	Values	Missing	
Time_collected	109513	109731	144315	160	0	Skew

```
 131  FACTOR [MODIFY=no; NVALUES=160; LEVELS=20; LABELS=*; REFERENCE=1]
RepCol
 132  READ RepCol; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
RepCol	160	0	20

```
 139  %PostMessage 1129; 0; 10000001 "Sheet update completed"
 140  "One-way design in randomized blocks"
 141  DELETE [REDEFINE=yes] _ibalance
 142  A2WAY [PRINT=aovtable,information,means; TREATMENTS=Treat; BLOCKS=Rep;
FPROB=yes;\
 143   PSE=diff,lsd; LSDLEVEL=5; PLOT=*; COMBINATIONS=present;
EXIT=_ibalance] Snail_HalfLitre;\
 144   SAVE=_a2save
```

Analysis of variance

Variate: Snail_HalfLitre

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	216.837	72.279	10.45	
Rep.*Units* stratum					
Treat	3	51.454	17.151	2.48	0.063
Residual	153	1058.036	6.915		
Total	159	1326.327			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Rep 1 *units* 7	8.59	s.e. 2.57
Rep 1 *units* 15	12.25	s.e. 2.57
Rep 3 *units* 22	9.50	s.e. 2.57
Rep 3 *units* 28	8.07	s.e. 2.57

Tables of means

Variate: Snail_HalfLitre

Grand mean 3.71

Treat	Cabling	Crunching	Nil	Tiller
	2.93	3.88	3.55	4.50

Standard errors of differences of means

Table	Treat
rep.	40
d.f.	153
s.e.d.	0.588

Least significant differences of means (5% level)

Table	Treat
rep.	40
d.f.	153
l.s.d.	1.162

```
 145
 146  SET [IN=*]
 152  "One-way design in randomized blocks"
 153  DELETE [REDEFINE=yes] _ibalance
 154  A2WAY [PRINT=aovtable,information,means; TREATMENTS=Treat;
BLOCKS=RepCol; FPROB=yes;\
 155   PSE=diff,lsd; LSDLEVEL=5; PLOT=*; COMBINATIONS=present;
EXIT=_ibalance] Snail_HalfLitre;\
 156   SAVE=_a2save
```

Appendix 2: GrainCam images.

The 3486 images are on the attached USB memory stick

Analysis of variance

Variate: Snail_HalfLitre

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
RepCol stratum	19	345.714	18.195	2.68	
RepCol.*Units* stratum					
Treat	3	51.454	17.151	2.53	0.060
Residual	137	929.158	6.782		
Total	159	1326.327			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

RepCol 14	3.61	s.e. 1.47
RepCol 1 *units* 3	11.00	s.e. 2.41
RepCol 2 *units* 2	7.70	s.e. 2.41
RepCol 13 *units* 6	8.32	s.e. 2.41
RepCol 14 *units* 5	7.61	s.e. 2.41

Tables of means

Variate: Snail_HalfLitre

Grand mean 3.71

Treat	Cabling	Crunching	Nil	Tiller
	2.93	3.88	3.55	4.50

Standard errors of differences of means

Table	Treat
rep.	40
d.f.	137
s.e.d.	0.582

Least significant differences of means (5% level)

Table	Treat
rep.	40

d.f.	137
l.s.d.	1.152

Appendix 2: Statistical analysis of snails detected by AI in grain samples

Genstat 64-bit Release 20.1 (PC/Windows 8-10) 18 March 2021 12:48:12

Registered to: Agriculture Western Australia

Genstat Twentieth Edition
Genstat Procedure Library Release PL28.1

```
  1  SET [WORKINGDIRECTORY='C:/Users/moorej/Documents'; DIAGNOSTIC=messages]
  2  "Data taken from file: '\
 -3  C:/Users/moorej/OneDrive - Department of Primary Industries and
Regional Development/Documents/SnailsSlugs/S2C/ImagesGrainCam/S2CMt Barker
grain samples.xlsx\
 -4  '"
  5  DELETE [REDEFINE=yes] _stitle_: TEXT _stitle_
  6  READ [PRINT=*; SETNVALUES=yes] _stitle_
 10  PRINT [IPRINT=*] _stitle_; JUST=left
```

Data imported from Excel file: C:\Users\moorej\OneDrive - Department of Primary Industries and Regional Development\Documents\SnailsSlugs\S2C\ImagesGrainCam\S2CMt Barker grain samp
on: 18-Mar-2021 12:50:45
taken from sheet "Genstat", cells A2:F17

```
 11  DELETE [REDEFINE=yes]
Plot,Rep,Treat,Snails_266gSample,Snails_HalfLitre,\
 12  AISnails
 13  UNITS [NVALUES=*]
 14  VARIATE [NVALUES=16] Plot
 15  READ Plot
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Plot	1.000	8.500	16.00	16	0

```
 17  FACTOR [MODIFY=no; NVALUES=16; LEVELS=4; LABELS=*; REFERENCE=1] Rep
 18  READ Rep; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Rep	16	0	4

```
 20  FACTOR [MODIFY=no; NVALUES=16; LEVELS=4;
LABELS=!t('Cabling','Crunching',\
 21  'Nil','Tiller'); REFERENCE=1] Treat
 22  READ Treat; FREPRESENTATION=ordinal
```

Identifier	Values	Missing	Levels
Treat	16	0	4

```
  24  VARIATE [NVALUES=16] Snails_266gSample; DECIMALS=2
  25  READ Snails_266gSample
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Snails_266gSample	1.400	2.567	5.000	16	0

```
  27  VARIATE [NVALUES=16] Snails_HalfLitre; DECIMALS=2
  28  READ Snails_HalfLitre
```

Identifier	Minimum	Mean	Maximum	Values	Missing
Snails_HalfLitre	2.000	3.668	7.143	16	0

```
  33  VARIATE [NVALUES=16] AISnails; DECIMALS=1
  34  READ AISnails
```

Identifier	Minimum	Mean	Maximum	Values	Missing
AISnails	0.2000	7.699	18.20	16	0

```
  37  %PostMessage 1129; 0; 10000001 "Sheet update completed"
  38  "One-way design in randomized blocks"
  39  DELETE [REDEFINE=yes] _ibalance
  40  A2WAY [PRINT=aovtable,information,means; TREATMENTS=Treat; BLOCKS=Rep;
FPROB=yes;\
  41   PSE=diff,lsd; LSDLEVEL=5; PLOT=*; COMBINATIONS=present;
EXIT=_ibalance] AISnails;\
  42   SAVE=_a2save
```

Analysis of variance

Variate: AISnails

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	406.27	135.42	8.37	
Rep.*Units* stratum					
Treat	3	12.20	4.07	0.25	0.858
Residual	9	145.56	16.17		
Total	15	564.03			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Rep 2 *units* 1	-7.4	s.e. 3.0

Tables of means

Variate: AISnails

Grand mean 7.7

Treat	Cabling	Crunching	Nil	Tiller
	7.1	9.1	6.9	7.6

Standard errors of differences of means

Table	Treat
rep.	4
d.f.	9
s.e.d.	2.84

Least significant differences of means (5% level)

Table	Treat
rep.	4
d.f.	9
l.s.d.	6.43

```
43
44  SET [IN=*]
```