3.3 CEREAL CANOPY MANIPULATION TRIALS

3.3.1 NITROGEN X SOWING RATE TRIAL IN BARLEY AND WHEAT (GNARWARRE)

Location:
Gnarwarre (Geelong) and Hamilton

Aim:
To determine the effect of sowing rate, nitrogen fertiliser rate and timing on wheat and barley crop establishment, tiller production, head counts at harvest, grain yield and grain quality.

Background:
It would appear that in most years, both barley and wheat particularly when grown on raised beds, can tend to become too vigorous in the early growth stages, producing too much vegetation (leaf and tillers) at the expense of grain fill during spring. Consequently, harvest index (ratio of grain to total plant dry matter) can be quite low. Potential grain yield is often not achieved because moisture is limiting during grain fill.

There is also some research that suggests the application of nitrogen to particularly wheat, can be delayed in order to better control the number of tillers and increase grain yield. Previous work also indicates that a delayed nitrogen application will increase grain protein, although screenings can also be increased, particularly in a dry finish.

Method:
A wheat trial was established at Gnarwarre (Geelong) and Hamilton, along with a barley trial at Gnarwarre. Two varieties of wheat were used, namely Kellalac (Spring wheat) and MacKellar (Winter wheat) and Gairdner was the barley variety selected. Each trial was fully replicated (4 reps) and randomized for statistical analysis.

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Funding Research:
Grains Research and Development Corporation

Conclusions:
- Delaying post sowing applications of nitrogen (92 kg/ha N) to the flag leaf stage for both Kellalac and MacKellar at the Gnarwarre site, resulted in the best grain yield and grain quality.
- Application of nitrogen (35 kg/ha N) to barley at the early jointing stage (GS32), gave the best grain yield and quality at Gnarwarre.
- Late nitrogen applications appeared to result in more flower sites (florets) filling with grain for both wheat and barley.
- Delaying the application of nitrogen to the later crop stage eg flag leaf for wheat, had a positive effect on grain quality and no adverse effect on screenings.
- Sowing rates had virtually no impact on grain yield and quality for wheat and barley at Gnarwarre and only minimal impact at Hamilton.
- There was excessive tiller production in wheat and barley resulting in significant wastage of moisture and nutrients. Restricting nitrogen at sowing and delaying until early jointing(GS32) for barley and flag leaf stage (GS39) for wheat, may reduce this tillering tendency.
- In the drier environments eg Gnarwarre, a reduction of seeding rate to 75 kg/ha for wheat and barley could be beneficial in most years.

Background Climatic, Soil and Rotation Data:
The results of the trials at both Gnarwarre and Hamilton are very encouraging, with excellent quality data having been achieved.

The season at Gnarwarre was slightly drier than average, with 333 mm occurring between May and November (Growing season rainfall), compared to the long term average of 341 mm. The spring grain filling period (Sep – Nov) for 2002 was 125.5 mm, compared to the long term average of 151 mm. This resulted in some moisture limitation during this critical phase, particularly for the wheat.

The rainfall received at the Hamilton site, whilst below average, was much more favourable than Gnarwarre, with 438 mm growing season (May – Nov) rainfall, compared to the long term average of 493 mm. The grain filling period (Sep – Nov) received 173 mm compared to the long term average of 196 mm.

The Gnarwarre site started with quite a low basal soil Nitrogen status, having been in wheat in 2001 and canola in 2000. This was reflected in quite low grain protein for both the barley and wheat for the control treatments. The Hamilton site however was much higher in soil nitrogen at the start of the trial, the rotation being wheat in 2000 and pasture in 2001, having come out of a long term pasture phase. The higher rainfall during the growing season would also have resulted in more mineralisation of organic nitrogen. This was reflected in much higher grain protein figures being achieved at the Hamilton site, compared to the Gnarwarre site. Testing of the sites for deep soil nitrogen (down to 60 cm) was not undertaken prior to the commencement of the trials, which was a serious oversight. This will be rectified in future trials.

SUMMARY OF FINDINGS

1. Effect of Planting Rate and Fertiliser Treatment on Crop Development at Gnarwarre

For both Kellalac and MacKellar, the number of heads/m^2 at harvest were approximately the same, regardless of planting rate. The higher seeding rate resulted in more plants being established, however tiller counts/m^2 were much the same. Kellalac produced between 750 and 850 tillers/m^2 and MacKellar up to 1300 tillers/m^2 The lower seeding rate for MacKellar resulted in significantly lower tiller numbers/m^2 (approx. 700/m^2).

Both Kellalac and MacKellar finished with approximately 450-500 heads/m^2 at harvest, regardless of sowing rate. Nitrogen applied at late tillering did increase head counts by approximately 50 heads/m^2.

For barley (variety Gairdner), the tiller counts were significantly greater than for wheat. Up to 3000 tillers/m^2 were grown under the higher seeding rates, resulting in approximately 500 heads/m^2 at harvest. Again nitrogen at late tillering resulted in approximately 50 more heads/m^2 at harvest.

These results indicate that there is a significant energy wastage by both wheat and barley through the production of excess tillers, only to lose these tillers at harvest.

2. Effect of Planting Rate on Yield and Grain Quality

For both the wheat and barley at the Gnarwarre site, planting rate had no effect on grain yield, protein %, screenings or test weight in all situations apart from MacKellar, where the higher seeding rate (120 kg/ha) produced grain of a higher test weight. At Hamilton, the higher seeding rates did result in higher wheat yields, reflecting the longer growing season. Grain test weight was also better at the Hamilton site for MacKellar under the higher seeding rates.

3. Effect of Fertiliser Treatment on Grain Yield and Quality

Nitrogen applied at late tillering, flag and flowering, did result in higher yields in both Kellalac and MacKellar at the Gnarwarre site. The best treatment appeared to be the high rate of nitrogen (92 kg/ha) applied at flag, giving approximately 600 kg/ha extra yield for Kellalac and 1000 kg/ha extra yield for MacKellar, compared to the control treatment (only 15 kg/ha nitrogen at sowing). Generally the later the application of nitrogen, the higher the protein %. Grain test weight also increased with the later nitrogen application compared to the control.

At Hamilton, the application of nitrogen at late tillering gave the worst yield for both Kellalac and MacKellar. There was only a marginal effect on yield with the other nitrogen treatments compared to the control. The later applications of nitrogen did give a significant increase in grain protein for both Kellalac and MacKellar, although the effect was not as pronounced as for the Gnarwarre site.

For barley at the Gnarwarre site, nitrogen application at early jointing (GS32) did result in a significant increase in yield compared to the control treatment. Grain protein was also higher with this treatment compared to the control, but not as high as when nitrogen was applied at early head emergence.

TREATMENTS
Barley

Sowing Date: 6th June 2002 (Gnarwarre)

Sowing Rate: S60 : 60 kg/ha
S90 : 90 kg/ha
S120 : 120 kg/ha

Fertiliser:
F1: 15 kg/ha Nitrogen at sowing
F2: 15 kg/ha Nitrogen at sowing + 35 kg/ha N at early jointing (GS32)*(28/08/02)*
F3: 15 kg/ha Nitrogen at sowing + 35 kg/ha N at early head emergence (GS42) *(11/10/02)*

TREATMENTS
Wheat

Sowing Date: 6th June 2002 (Gnarwarre), 20th June 2002 (Hamilton)

Sowing Rate: S60 : 60 kg/ha
S90 : 90 kg/ha
S120 : 120 kg/ha

Fertiliser:
F1: 15 kg/ha Nitrogen at sowing (Granulock 15 Gnarwarre, MAP Hamilton)
F2: 15 kg/ha N at sowing + 46 kg/ha N at late tillering (GS30) *(28/8 Kellalac Gnarwarre, 5/9 MacKellar Gnarwarre, 12/9 Kellalac Hamilton, 23/9 MacKellar Hamilton)*
F3:15 kg/ha N at sowing + 46 kg/ha N at flag (GS39) *(11/10 Kellalac & MacKellar Gnarwarre, 25/10 Kellalac & MacKellar Hamilton)*
F4: 15 kg/ha N at sowing + 46 kg/ha N at flowering (GS45) *(24/10 Kellalac & MacKellar Gnarwarre, 22/11 Kellalac & MacKellar Hamilton)*
F5: 15 kg/ha N at sowing + 46 kg/ha N at flag (GS39) + 46 kg/ha N at flowering (GS45)
F6: 15 kg/ha N at sowing + 92 kg/ha at flag (GS39)

Barley - Gnarwarre

Table 14: Effect of Planting Rate on Barley Yield and Grain Quality - Gnarwarre

Sowing Rate kg/ha	Yield kg/ha	Protein %	Test Weight kg/hl	Screenings (2.5mm)
S90	5,971	8.708	69.80	4.748
S60	5,867	8.817	67.15	4.607
S120	5,867	8.525	69.98	4.145
LSD	**414**	**0.422**	**4.204**	**0.982**
CV	**10.30**	**9.78**	**7.21**	**31.17**

- Planting rate had no effect on yield and grain quality

Table 15: Effect of Fertiliser Treatment on Barley Yield and Grain Quality - Gnarwarre

Fertiliser Rate kg/ha	Yield kg/ha	Protein %	Test Weight kg/hl	Screenings (2.5mm)	Grain Quality	Net Return $/ha[6]
F2	6,208	8.708	69.58	5.602	Feed	1,676
F3	6,117	9.533	70.27	3.685	Malt M1	2,080
F1	5,379	7.808	67.08	4.214	Feed	1,452
LSD	**414**	**0.422**	**4.204**	**0.982**		
CV	**10.30**	**9.78**	**7.21**	**31.17**		

[6] *Price based on $270/T Feed, $340/T Malt.*
Malt Protein criteria >9% and <12.5%, Malt Test Weight criteria >68 kg/hl.
Cost of extra N applied for F3 and F2 = $35/Ha

- There is a significant difference between treatments for yield, protein and screenings
- There was no significant difference between treatments for Test Weight

Wheat - Gnarwarre

Table 16: Effect of Planting Rate on KELLALAC Grain Yield and Quality - Gnarwarre

Sowing Rate kg/ha	Yield kg/ha	Protein %	Test Weight kg/hl	Screenings (2.5mm)
S60	4,578	9.071	77.55	4.280
S90	4,541	9.058	77.50	3.899
S120	4,502	9.029	77.66	3.814
LSD	**152**	**0.160**	**0.524**	**0.590**
CV	**7.41**	**7.73**	**1.41**	**28.04**

- There was no effect of planting rate on grain yield or quality for Kellalac at Gnarwarre

Table 17: Effect of Planting Rate on MACKELLAR Grain Yield and Quality - Gnarwarre

Sowing Rate kg/ha	Yield kg/ha	Protein %	Test Weight kg/hl	Screenings (2.5mm)
S90	4,920	8.625	76.68	5.479
S120	4,847	8.683	76.98	5.501
S60	4,769	8.721	76.34	5.900
LSD	**198**	**0.232**	**0.572**	**0.535**
CV	**9.77**	**9.70**	**1.54**	**17.12**

- There was no effect of planting rate on yield, protein and screenings for MacKellar at Gnarwarre
- S120 produced grain of higher test weight than S60 and S90

Table 18: Effect of Fertiliser Treatment on KELLALAC Grain Yield and Quality -Gnarwarre

Fertiliser Treatment	Yield kg/ha	Protein %	Test Weight kg/hl	Screenings (2.5mm)	Grain Quality	Net Return $/ha[7]
F6	4,769	9.650	78.00	3.311	ASW	1159.73
F2	4,689	8.608	77.57	3.611	ASW	1136.01
F5	4,608	9.883	77.88	3.955	ASW	1115.42
F3	4,551	9.117	77.92	4.028	ASW	1128.23
F4	4,457	9.125	77.80	4.448	ASW	1099.47
F1	4,167	7.933	76.25	4.633	ASW	1044.18
LSD	**215**	**2.262**	**0.741**	**0.834**		
CV	**7.41**	**7.73**	**1.41**	**28.04**		

[7] *Net return takes account of grain quality (protein, test weights and screenings) and is based on a basal pool price of $260/T. Cost of nitrogen application is $1 per kg applied.*

- There was a significant difference between fertiliser treatments for yield, protein, test weight and screenings for Kellalac at Gnarwarre

Table 19: Effect of Fertiliser Treatment on MACKELLAR Grain Yield and Quality- Gnarwarre

Fertiliser Treatment	Yield kg/ha	Protein %	Test Weight kg/hl	Screenings (2.5mm)	Grain Quality	Net Return $/ha[8]
F6	5,345	9.408	76.98	5.248	ASW	1278.56
F2	5,080	8.692	76.57	5.598	ASW	1233.98
F5	4,845	9.558	77.53	4.982	ASW	1157.21
F4	4,755	8.717	77.13	5.853	ASW	1149.56
F3	4,721	8.400	76.05	6.097	ASW	1130.74
F1	4,328	7.283	75.75	5.983	ASW	1009.85
LSD	**280**	**0.329**	**0.8096**	**0.757**		
CV	**9.77**	**9.70**	**1.54**	**17.12**		

[8] *Net return takes account of grain quality (protein, test weights and screenings) and is based on a basal pool price of $260/T. Cost of nitrogen application is $1 per kg applied.*

- There was a significant difference between fertiliser treatments for yield, protein, test weight and screenings

Table 20: Effect of Planting Rate on KELLALAC Grain Yield and Quality - Hamilton

Sowing Rate kg/ha	Yield kg/ha	Protein %	Test Weight kg/hl
S120	5,235	12.85	75.01
S90	4,818	12.76	74.92
S60	4,746	12.99	74.43
LSD	**181**	**0.411**	**0.757**
CV	**7.96**	**5.46**	**1.74**

- There was a significant difference between sowing rates for grain yield.
- There was no significant difference between sowing rates for grain protein and test weight.

Table 21: Effect of Planting Rate on MACKELLAR Grain Yield and Quality - Hamilton

Sowing Rate kg/ha	Yield kg/ha	Protein %	Test Weight kg/hl
S90	6,236	10.79	74.61
S120	6,208	10.88	74.18
S60	5,859	10.90	73.36
LSD	**232**	**0.270**	**0.805**
CV	**6.71**	**4.30**	**2.01**

- 90kg/ha and 120 kg/ha sowing rates were significantly higher yielding and had a higher test weight than the 60 kg/ha sowing rate
- Planting rate had no effect on grain protein

Table 22: Effect of Fertiliser Treatment on KELLALAC Grain Yield and Quality - Hamilton

Fertiliser Treatment	Yield kg/ha	Protein %	Test Weight kg/hl	Grain Quality	Net Return $/ha
F6	5,040	13.31	74.45	ASW	1301.81
F3	5,038	12.72	74.82	ASW	1332.40
F5	4,995	13.03	74.78	ASW	1282.37
F4	4,928	12.61	75.07	ASW	1299.59
F1	4,833	12.56	74.77	ASW	1318.44
F2	4,763	13.00	74.83	ASW	1263.83
LSD	256	0.5812	1.0713		
CV	7.96	5.46	1.74		

- There was a significant difference in yield and grain protein for the different fertiliser treatments
- The different fertiliser treatments had no effect on test weight

Table 23: Effect of Fertiliser Treatment on MACKELLAR Grain Yield and Quality- Hamilton

Fertiliser Treatment	Yield kg/ha	Protein %	Test Weight kg/hl	Grain Quality	Net Return $/ha
F5	6,253	10.88	75.05	ASW	1561.29
F3	6,175	10.86	74.40	ASW	1586.05
F1	6,146	10.49	74.17	ASW	1613.02
F6	6,123	11.09	73.53	GP	1377.52
F4	6,023	10.87	74.02	ASW	1546.18
F2	5,885	10.94	73.13	GP	1366.40
LSD	**328**	**0.381**	**1.1382**		
CV	**6.71**	**4.30**	**2.01**		

- Fertiliser treatments had a significant effect on grain yield, protein and test weight.

Table 24: Seed Counts

Variety	Seed wt grams/1000 seeds	Seeds/kg (Seed Count)
Kellalac	40.5	24,691
MacKellar	28.0	35,714

There is a significant difference between the seed weight and seed count between Kellalac and MacKellar.

The following Graphs (Figure 1 to Figure 6), show the effect of seeding rate and fertiliser treatment (F1 and F2) for both wheat and barley. The counts include seeds sown/m^2, plants established/m^2, tillers/m^2 and heads/m^2 at harvest. The results are for the Gnarwarre site. There are several interesting observations, namely:

- The higher the seeding rate the lower the percentage of viable seeds established.
- MacKellar established poorly by comparison to Kellalac (Figure 1, Figure 2, Figure 3 and Figure 4).
- Approximately 750 to 850 tillers/m^2 were established for Kellalac (Figure 1 and Figure 2) and up to 1300 tillers/m^2 for MacKellar (Figure 3 and Figure 4). There were significantly more tillers established at the high seeding rate for MacKellar (Figure 3 and Figure 4).
- Only approximately 350 – 400 heads/m^2 survived to harvest for Kellalac (Figure 1) with the F1 treatment, whereas the F2 fertiliser treatment maintained approximately 50 more heads/m^2 (Figure 2).
- More heads/m^2 were retained on the MacKellar compared to the Kellalac and the F2 treatment increased head count/m^2 by approximately 100 (Figure 3 and Figure 4).
- There was significantly more tillers/m^2 for the 90 and 120 kg/ha sowing rate compared to the 60 kg/ha sowing rate for Barley (Figure 5 and Figure 6)
- A large number of tillers were produced for Barley (approximately 3,000/m^2) (Figure 5 and Figure 6)
- A large number of tillers were shed by Barley between late tillering and harvest (Figure 5 and Figure 6).
- There was an insignificant effect of seeding rate and fertiliser treatment on the number of surviving Barley heads/m^2 (Figure 5 and Figure 6).

Figure 1: Effect of Sowing Rate and Fertiliser on Population - Kellalac F1

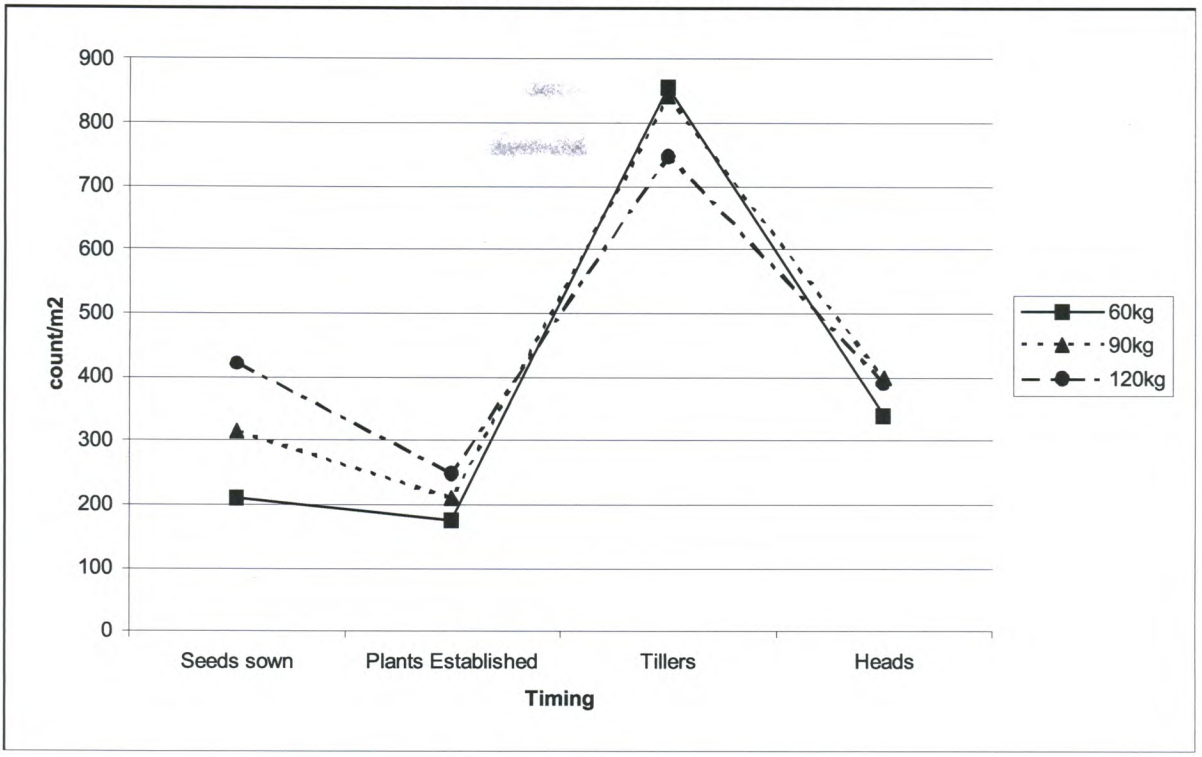

Figure 2: Effect of Sowing Rate and Fertiliser on Population - Kellalac F2

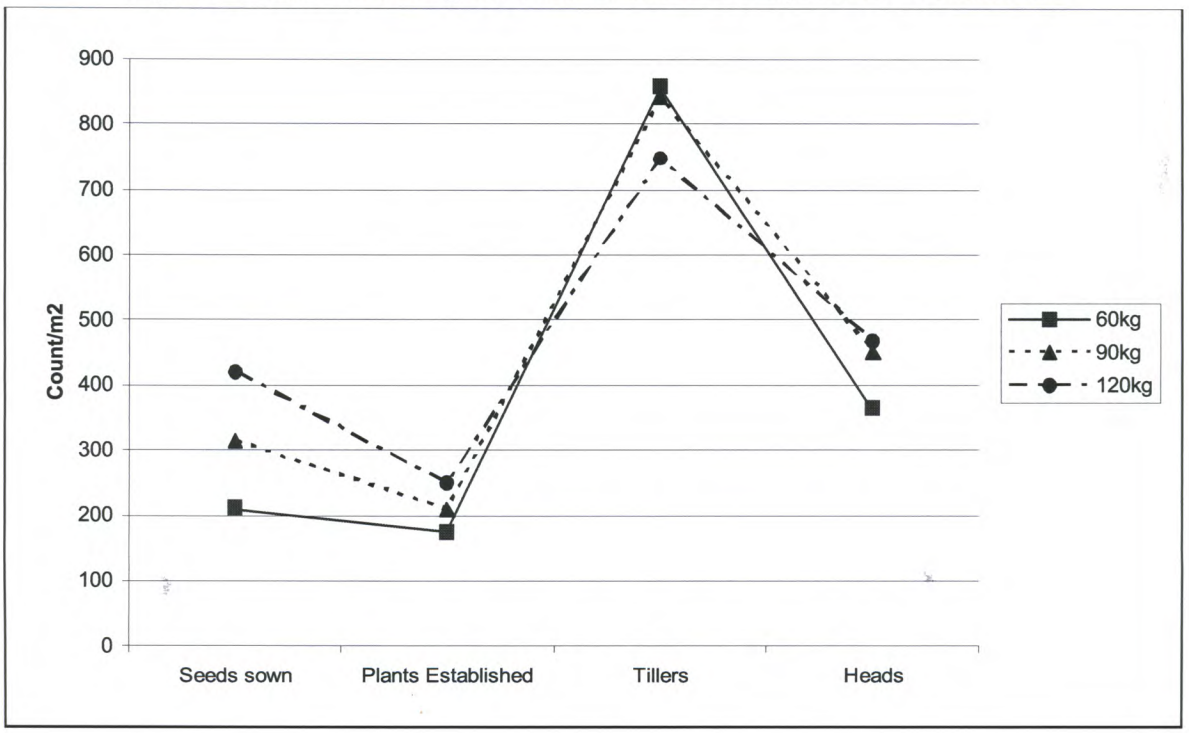

Figure 3: Effect of Sowing Rate on Population - MacKellar F1

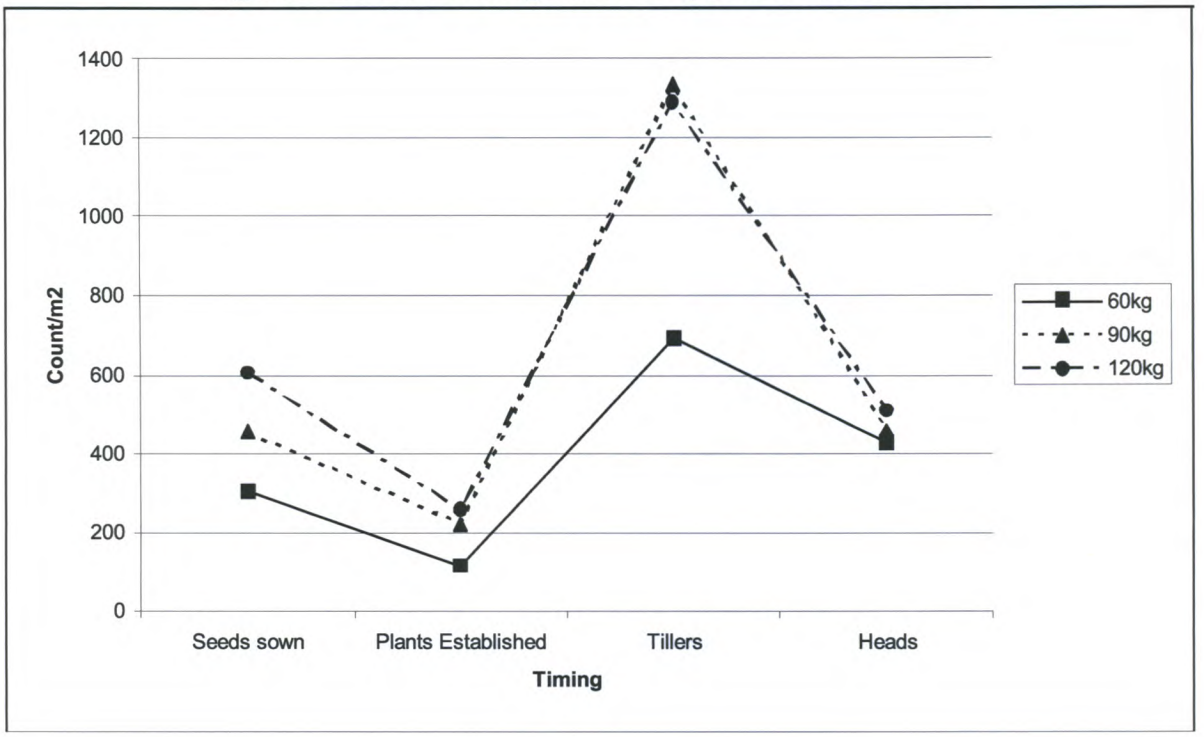

Figure 4: Effect of Sowing Rate and Fertiliser on Population - MacKellar F2

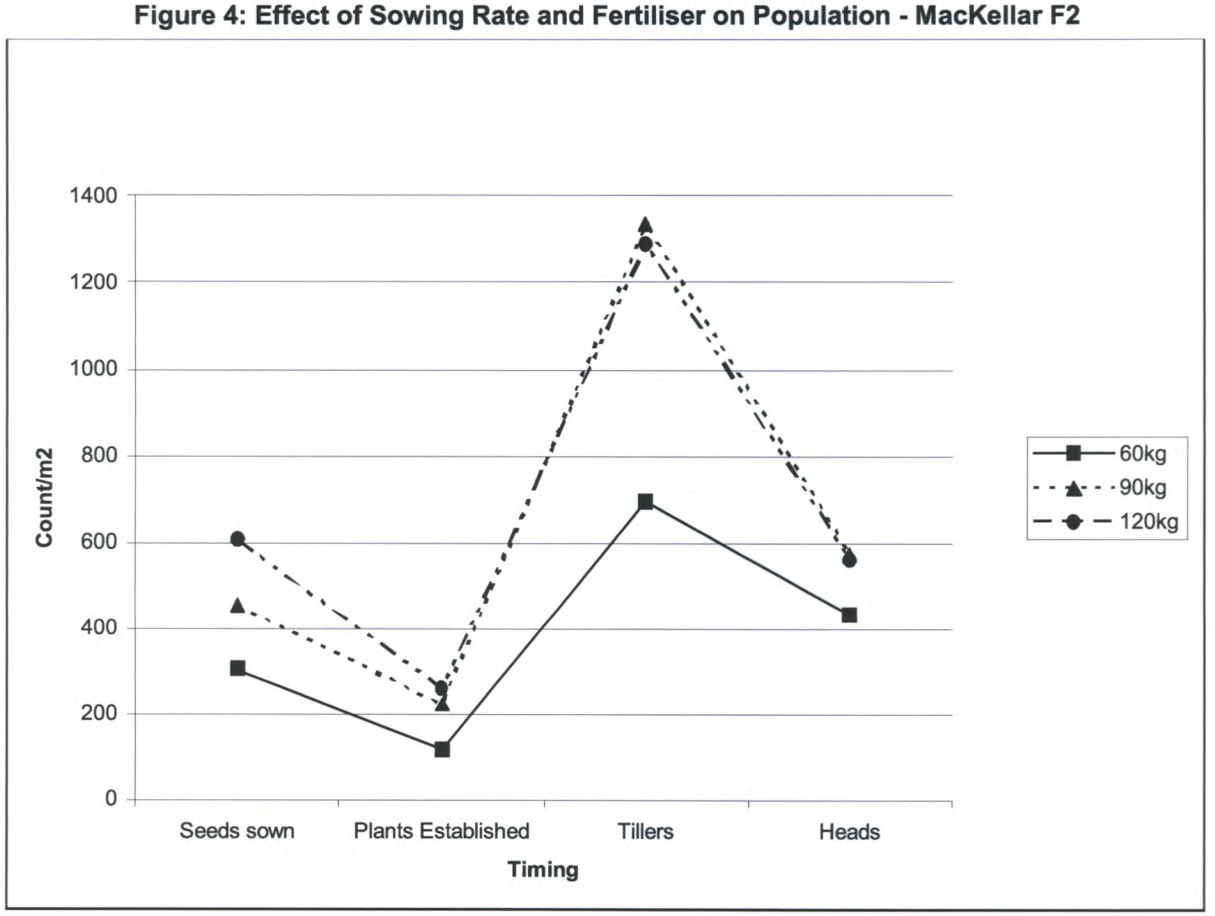

Figure 5: Effect of Sowing Rate and Fertiliser on Population - Gairdner F1

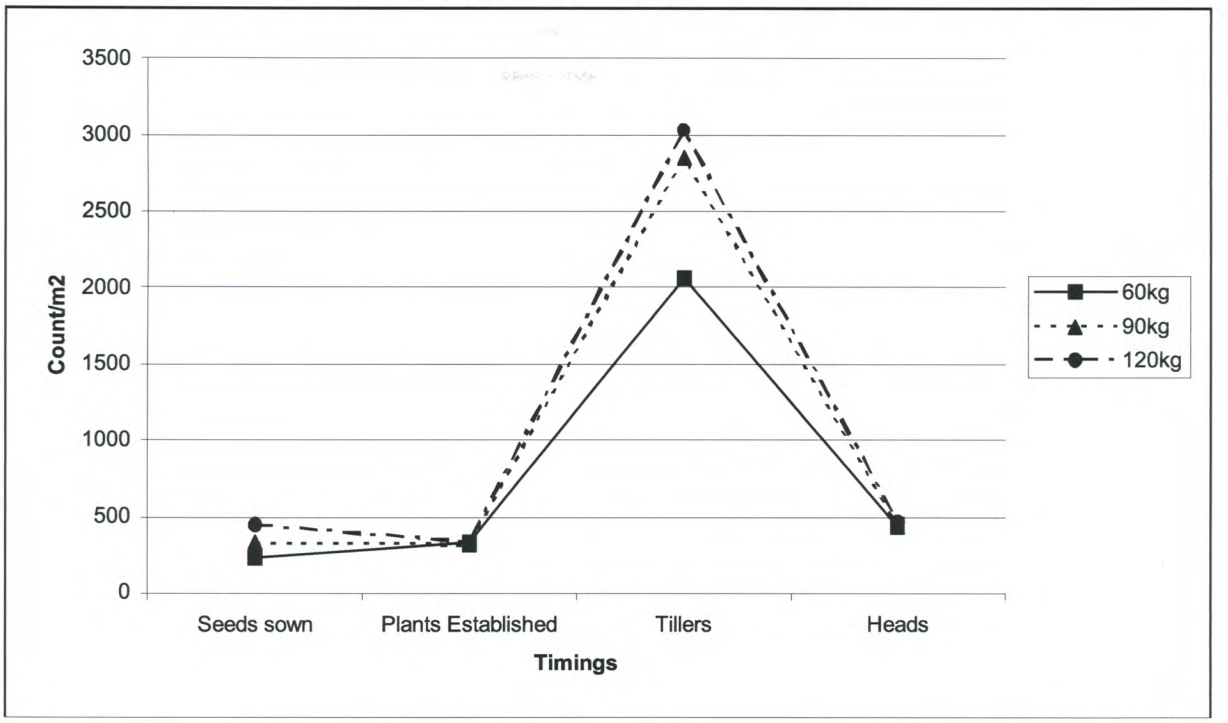

Figure 6: Effect of Sowing Rate and Fertiliser on Population - Gairdner F2