9818

Progress Reports A & B

A - Canola Yield Decline Analysis
B - 1999 Canola Field Monitoring Program

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REPORT A: Canola Yield Decline Analysis

Canola Yield Decline Problem: Is it real and what is causing it?

A) Is there a canola yield problem in Saskatchewan?

That is obviously the first question that needs to be answered before proceeding with an investigation to determine the causes. The answer to this question will vary depending on how you look at the data. If one only looks at provincial average yield data for the last 12 years, you will see a very healthy yield trend over that time period (Fig. 1a) and conclude that there is no yield problem.

On the other hand, if you look back 30 years or so, you get a different picture (Fig. 1b). We see a period of low yields (averaging 17.8 bu/ac) during the "rapeseed" years from the early 60's to the mid-70's followed by a substantial increase coinciding with the introduction of canola in the mid-70's. This higher plateau (averaging 23.4 bu/ac) is maintained, except for a couple of bad years in 1979 and 1984, until we reach 1988 when a severe drought resulted in poor yields. The yields recovered in 1990 but to a slightly lower plateau than the pre-88 drought period. If canola yields were progressing as you would expect with improved technology, cultural practices, etc., we would have expected the 90's plateau to be around the 25 bu/ac mark.

Another way to look at the canola yield problem is to compare it to other major crops in the prairies to see how the trends compare. Figure 2a compares the yield trends of wheat, barley, flax, and canola over the period from 1960 to 1998. If you compare the fitted regression lines of each crop, it is obvious that barley and flax are on a continuous path of increasing yields whereas wheat has apparently peaked in 1999 and canola would have peaked back in 1991 (bracketed numbers in the legend represent theoretical year when yields would peak according to the regression line). While the accuracy of the projected time of peak yields might be questionable due to the inherent variability of the data, this graph nevertheless serves to illustrate how canola yields have been losing pace relative to other major crops.

One useful way of analysing yield trends is to make comparisons with other provinces. Figure 2b compares the average canola yields in the last 4 decades between the 3 prairie provinces. It is quite evident from this chart that the problem of canola yield in Saskatchewan did not exist until the 90's when Saskatchewan yields stagnated while those of Alberta and Manitoba continued to increase. In particular, while canola yields in Manitoba increased by 27% from the 80's to the 90's, those in Saskatchewan decreased by 1%. That is not an insignificant difference in canola production, as it represents an annual loss of some $32M to Saskatchewan canola growers (@ $6/bu).

B) Is the problem general or localized?

Having reinforced the existence of a yield problem in Saskatchewan, the next step should be to determine whether the problem is general or localized in certain regions or crop districts. If the problem turns out to be localized, it will impel us to ask the question: why do certain areas or crop districts have high yields and others low yields?, what are the growers doing differently?, are the growing conditions different?, etc.

In order to dissect this yield problem, it is useful to analyse the data on a crop district basis for which there exists well documented historic yield data. In order to get some appreciation for how canola production is distributed across the province, figure 3a presents the canola acreage in all crop districts as of 1980 and 1998, depicting historically the changes in canola production over the last 19 years. It is noteworthy that the traditional canola growing areas such as crop districts 8 and 9 have been surpassed in acreage by the more southerly crop districts 5a, 5b and 6a. As is evident from this graph, there is little canola production in the south central and south western part of the province (crop districts 3 & 4), and so for simplification, these crop districts will not be considered in further analyses and discussions.

If we compare average yields in the 80's vs the 90's with respect to crop districts, we see quite a variation in how yields have changed in each district (Fig. 3b). For example, in crop districts 1 & 2, yields have increased from 19 to 45% whereas they have decreased by 6 and 12% in crop districts 9a & 9b, resp. The question can then be asked: why have yields increased significantly in the more non-traditional canola producing districts like 1,2,6 & 7a while the more traditional canola areas have seen either modest increases (8a & 8b) or decreases (9a & 9b).

C) <u>Why is yield declining in some crop districts and not others</u>?

1) Crop rotations and diseases:

It is difficult to find good historical data on disease incidence or crop rotations. The most reliable data set is a recent 3-yr canola disease survey from 1996 to 1998 coordinated by Dr. Robin Morrall at the University of Saskatchewan. However, with roughly 100 fields surveyed across Saskatchewan, there is usually not more than 10 fields to represent each crop district and so differences between crop districts may need to be quite large to be significant. For example, there was likely no significant difference in blackleg rating among crop districts in 1997 and 1998 (Fig. 4). As well, the sclerotinia infection level was almost nil in crop districts 9A and 9B, as was the case for the other districts except for crop districts 8A and 8B where levels were in the 10-20% range.

The crop rotation data do not reveal any significant differences among crop districts (Fig. 5a+b). However, the number of years between canola or other sclerotinia-susceptible crops appears to show a decreasing trend, the latter going from 3.3 to 3.0 years from one year to the next. This is less than the recommended 4 years or more to reduce the incidence of disease. In order to determine the long term trend in canola rotations, one can look at seeded acreages of canola as a percentage of total acres. A percentage approaching 33% would indicate a 1 in 3 crop rotation whereas a 25% canola acreage would suggest a 1 in 4 rotation. Figure 6 illustrates this trend over the last 18 years in all crop districts. Except for a couple of years in 1984, 88 and 94 for districts 8A, 9A and 9B, it would appear that most crop districts are well within the 25% limit for a 1 in 4 rotation. There is nevertheless a noticeable increasing trend in most districts from 1991 to 1994.

In general, there doesn't appear to be enough evidence to indicate that disease incidence is responsible for the decreased yield in crop districts 5B, 9A and 9B, nor for the general yield decrease in Saskatchewan during the 90's.

2) <u>Fertilizer use</u>:

According to information obtained from the prairie-wide canola disease survey, it appears that Saskatchewan canola growers are applying significantly less nitrogen than Manitoba (Fig. 7a) and slightly less phosphate and potassium, whereas sulphur use was intermediate between that of Alberta and Manitoba. Also, if we compare fertilizer use in our 1999 field monitoring sites in Saskatchewan with the average fertilizer rates in Manitoba (obtained from their Management Plus Program), we also find that Saskatchewan fertilizer rates were lower by 23%, 27% and 40% for N, P, and K, resp. (Fig. 7b). However, the S rate was 29% higher in Saskatchewan. Again, the Saskatchewan monitoring sites include only 20 fields in total and so this latter comparison may not be significant.

If we look at the average fertilizer use rates at each of the 5 monitoring regions in Saskatchewan, we find quite a bit of variability, with N use ranging from 50 to 77 lb/ac, P from 9 to 20 lb/ac, K from 0 to 6 lb/ac and S from 0 to 21 lb/ac (Fig. 8a). These variable rates among regions did not result in any significant differences in plant nutrient status among regions (Fig. 8b). It is obvious that we need to obtain more data on grower fertilizer practices in order to get an accurate assessment of the impact of fertility on canola yields in Saskatchewan.

3) <u>Weather</u>:

There doesn't appear to be any unfavorable trends in the weather which could explain a declining yield trend in the 90's. There are several weather related parameters that could be considered in the search for any correlations with yields. For example, if we look at the monthly average temperature trends for the past 25 years at Melfort and Waseca (c.d.'s 8A and 9B, resp.), we find no obvious trend in temperature that could explain a yield decline problem in the 90's (Fig. 9 &10). The bottom graph in each figure displays the average yields for the particular R.M. and the associated mean maximum temperatures in July. Since canola yields can be reduced by heat stress during flowering and early seed set in July, it is interesting to note that an increase in mean maximum July temperature to a level greater than 25-26 °C is often associated with a decrease in yield, e.g. 1984 & 1989 at both locations. Again, there is no indication that these temperature extremes have increased over the last decade.

Precipitation is usually the most critical weather variable affecting yields, and so it is important to look closely at precipitation trends over the last 2 decades to see if conditions have become unfavorable for canola yields in the 90's. Again, there are many types of analyses that can be done to look for correlations with yields. For example, figure 11 shows the May to August precipitation data for weather stations representing 8 crop districts (Data was only available for 1 or 2 stations per crop district. The analysis will be expanded to other stations as the data becomes available.) The graph displays the % change in monthly precipitation from the 80's to the 90's. In general, there is no indication that precipitation is a major problem in the 90's except for c.d. 9B which had reductions in precipitation in all 4 months (17% in May and July). Could it be that this lack of adequate rain in 9B could be responsible for that district having the largest decrease in yields during that period?

If we probe a bit further into c.d. 9B and look at some precipitation records on an R.M. basis (obtained from Sask Ag and Food), we see an interesting correlation between July precipitation and yields (Fig. 12 a+b). If we look at the change in precipitation over the last 5 years (1994-98) compared to the previous 5 year period and compare that to the change in yields corresponding to the same time period, we find that the only 2 R.M.'s that had significant increases in yield (R.M. 470 & 499) are the same ones that recorded an increase in July precipitation. This is consistent with the notion that adequate July precipitation is critical for optimum yield potential (due to the critical stages of flowering and seed set).

There remains a lot of weather data, both on a crop district and R.M. level, to be analysed for weather-yield associations. It is important to study this data very closely so that we can determine once and for all whether the apparent yield decline problem in Saskatchewan is or is not a result of unfavorable weather conditions. If it is, then this will exemplify the importance of considering heat and drought stress as high priorities in breeding and crop management strategies for the prairies.

4) <u>Agronomic factors</u>:

Using the Management Plus Program data from Sask Crop Insurance Corp as a good source of agronomic information on grower practices, we have looked at a number of agronomic factors such as seeding dates and rates, seeding implements, seeding on fallow vs stubble land, HT vs conventional varieties, etc. With only 3 years of data available from this source (1999 data not yet available at time of this report), we haven't seen any trends which might be linked to reduced canola yields. While the 97 and 98 data sets are not very extensive (less than 400 fields in each year), the 98 data set had close to 4,000 fields with good representation from all crop districts. This gave us some reliable information on present cultural practices by Saskatchewan farmers, and hopefully the 1999 data will be even more extensive and provide us with some indication of current trends in farming practices.

<u>Conclusion</u>

In summary, we feel that the exercise of gathering and analysing all of this data is well worth the effort and needs to be continued. The data presented in this report is just a small fraction of all the information and graphs that have been produced since the outset of this project. We haven't as yet been able to show any conclusive evidence as to the cause of the yield decline or stagnation, but an objective view of the production data appears to confirm the yield problem does in fact exist. There remains a considerable amount of agronomic and weather data to be analysed and it is important to continue this work so that we might inevitably get to the bottom of this nagging yield issue.

Figure 1a

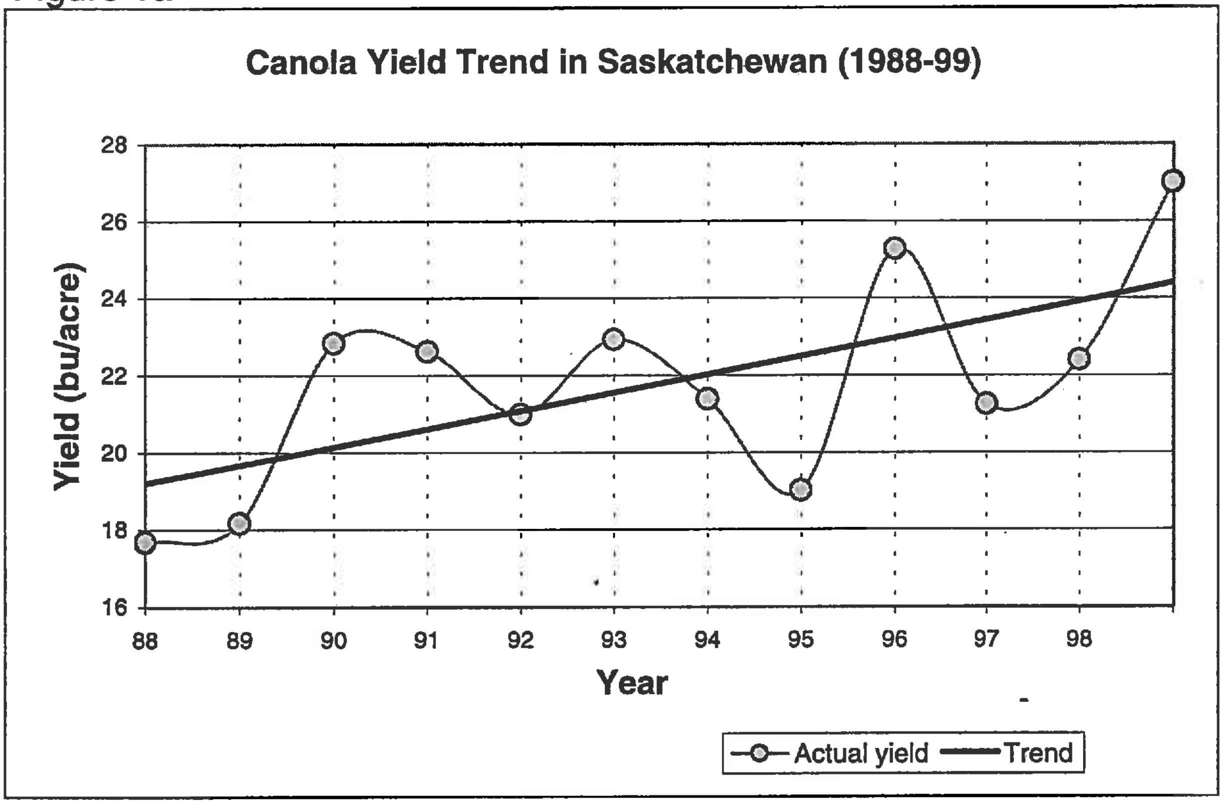


Figure 1b

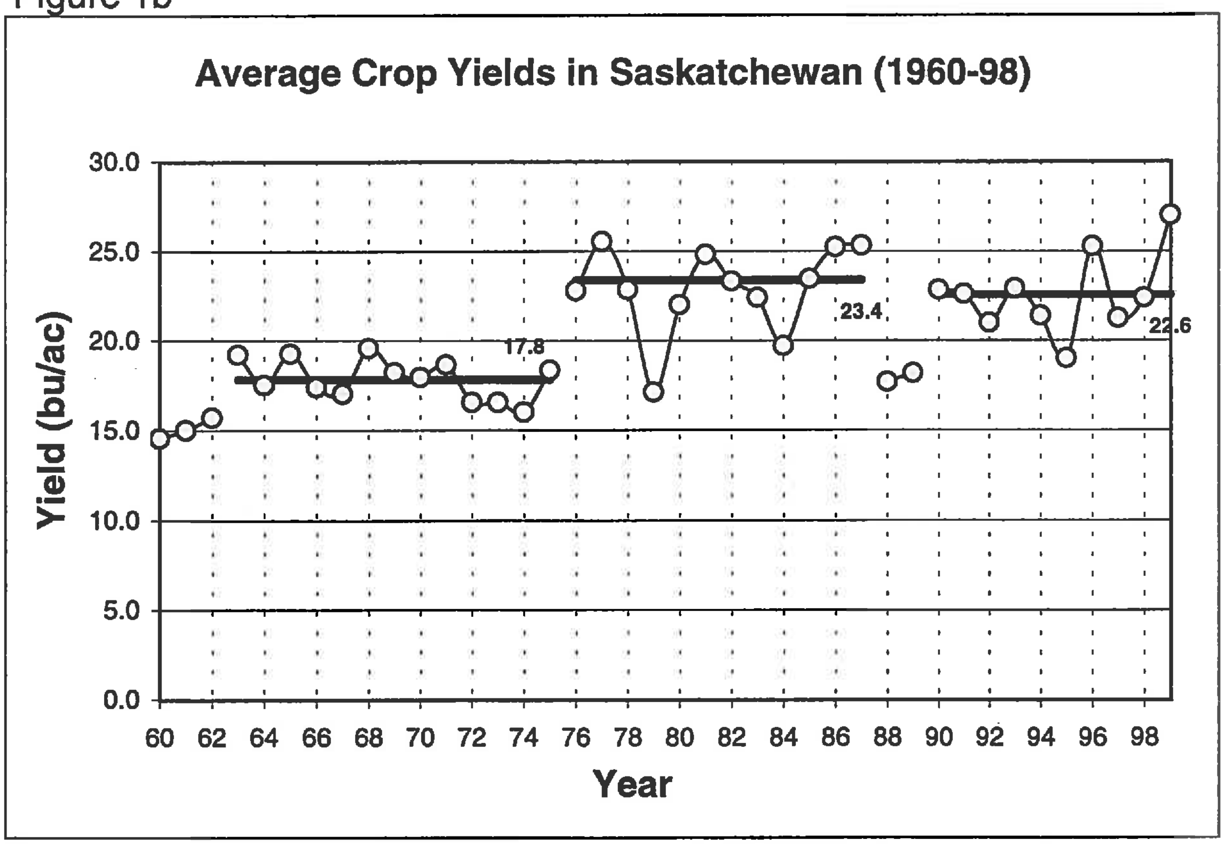


Figure 2a

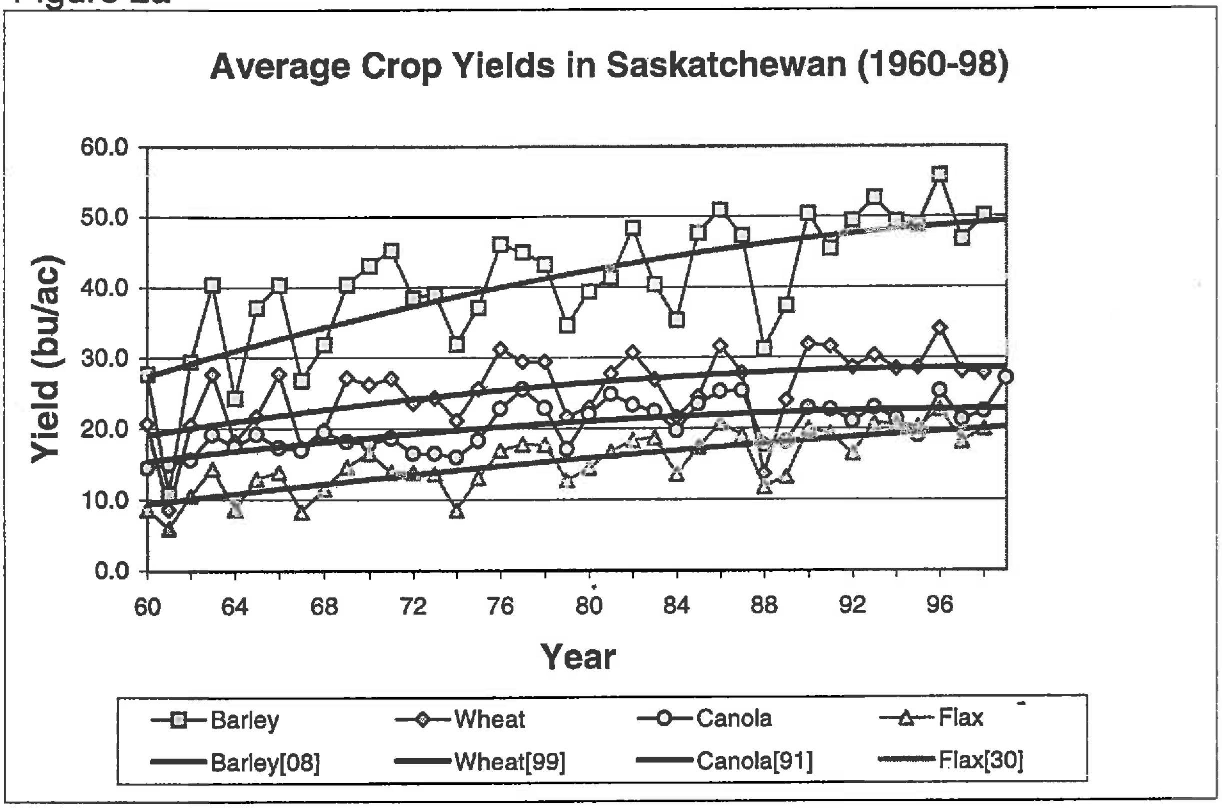


Figure 2b

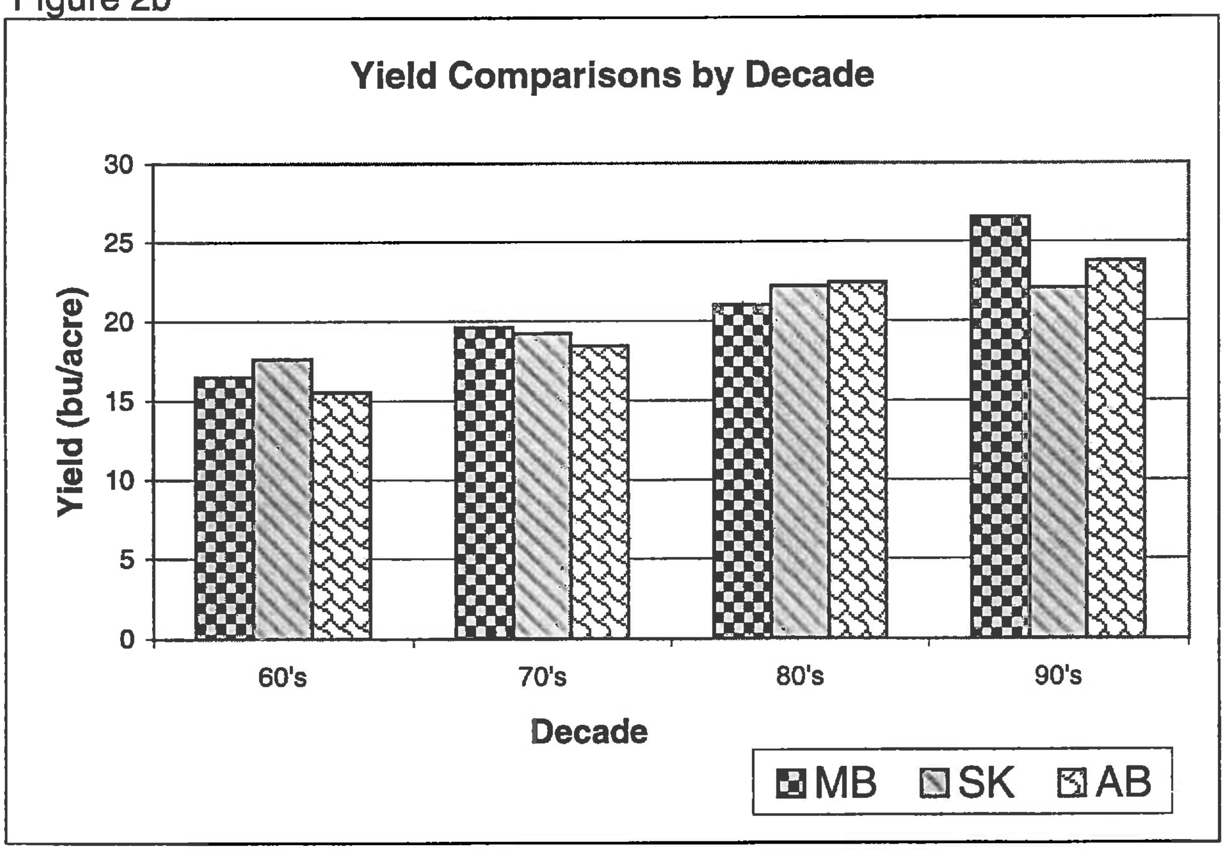


Figure 3a

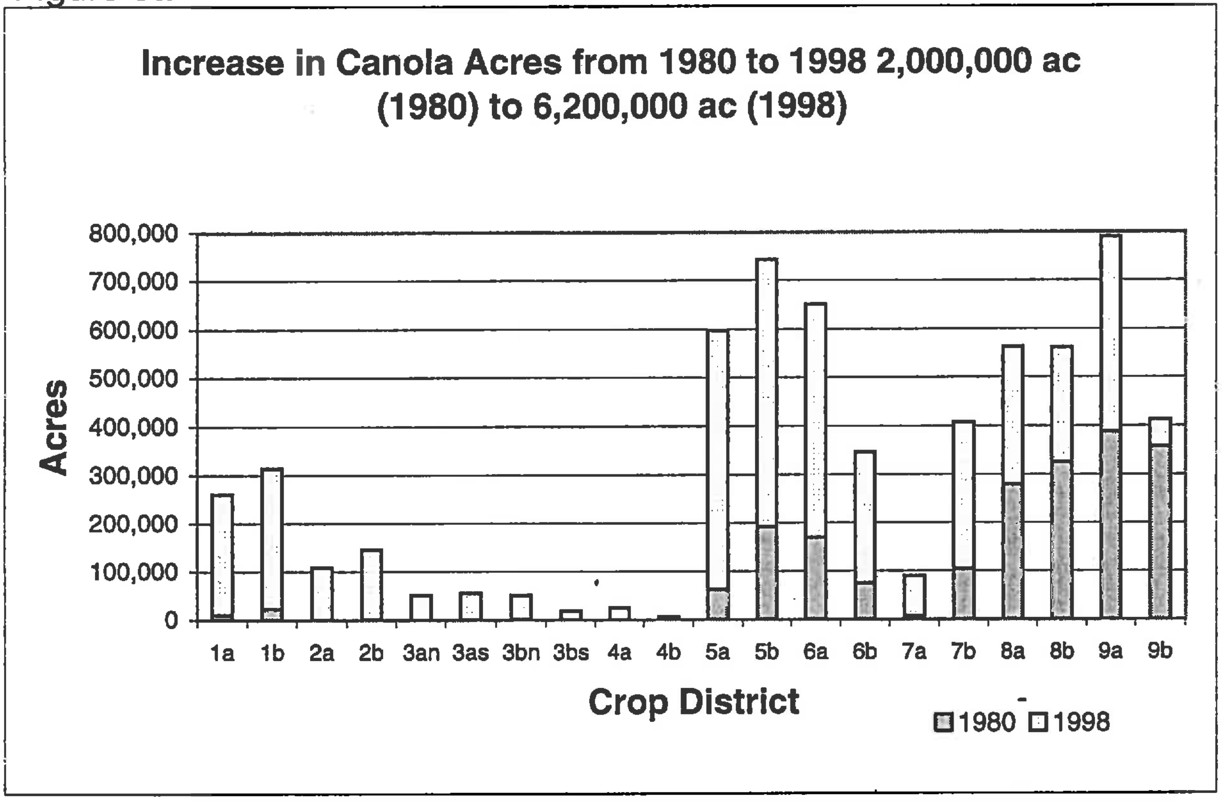


Figure 3b

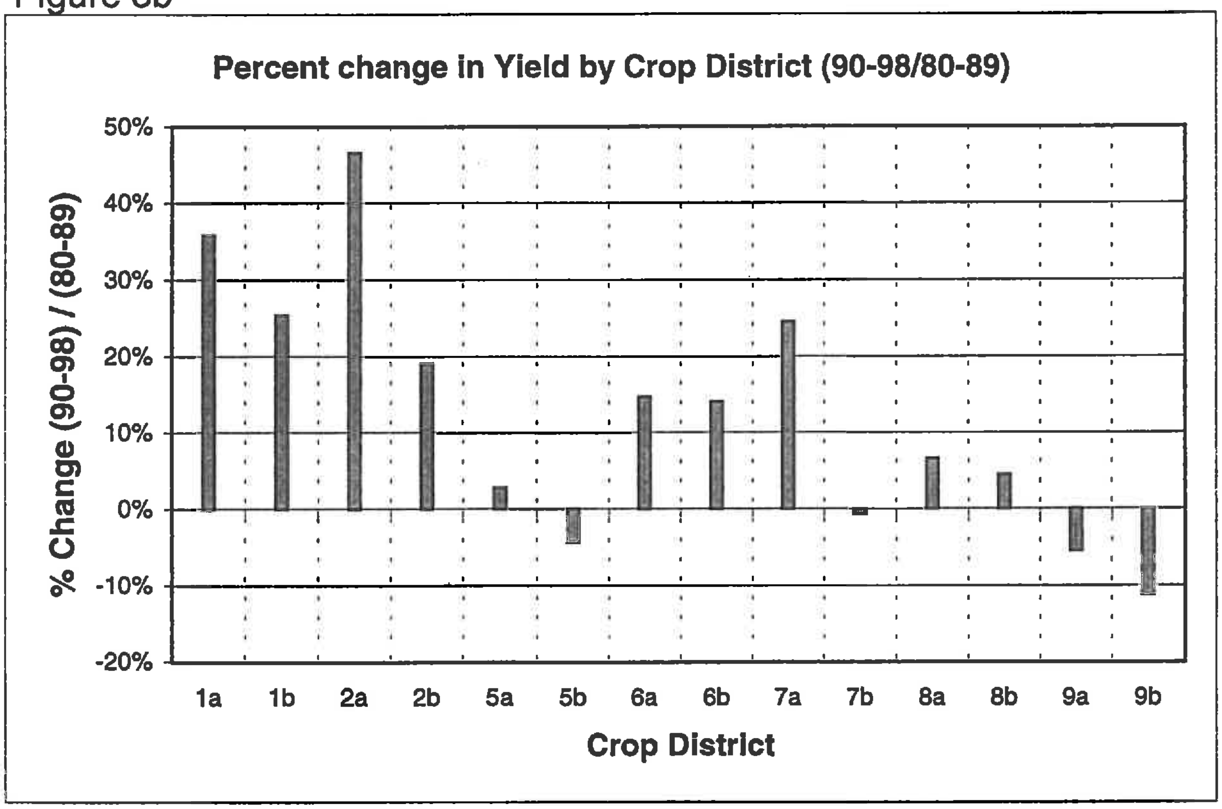
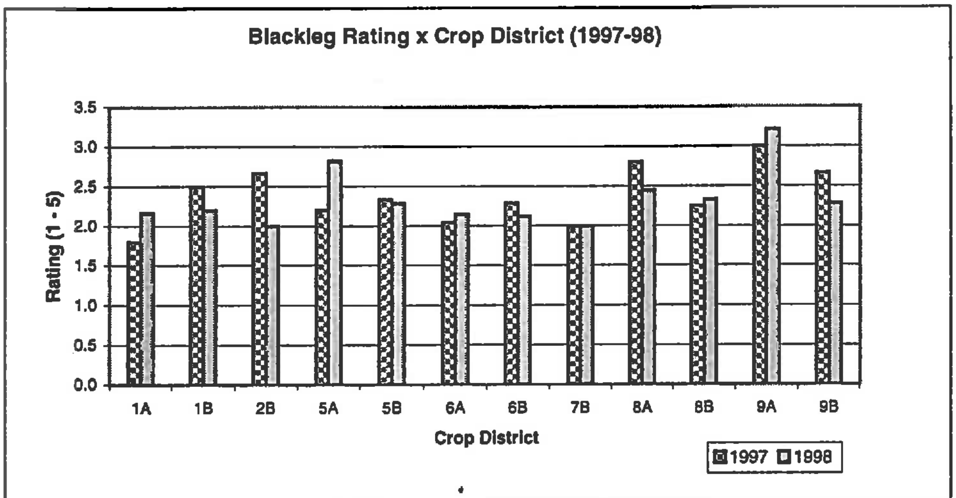
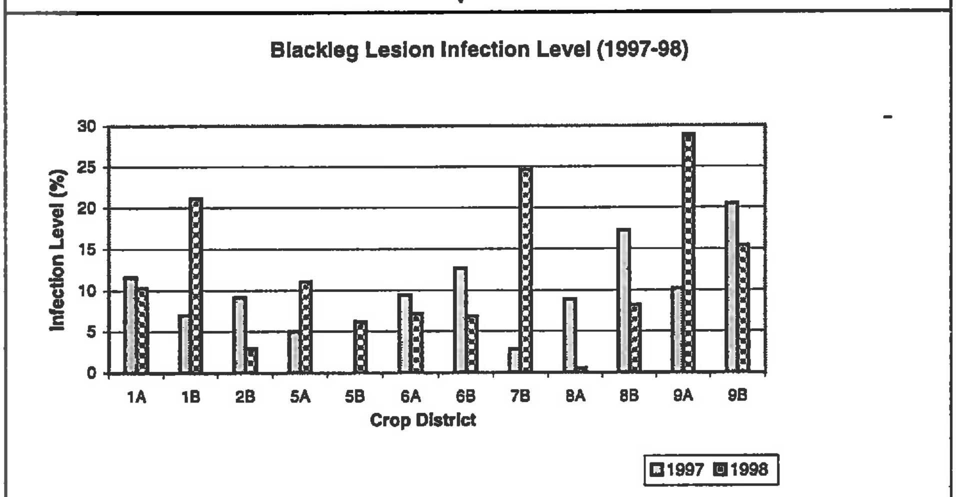


Figure 4.


Blackleg Rating x Crop District (1997-98)
Rating (1 - 5)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1A 1B 2B 5A 5B 6A 6B 7B 8A 8B 9A 9B
Crop District
1997 1998


Blackleg Lesion Infection Level (1997-98)
Infection Level (%)
30
25
20
15
10
5
0
1A 1B 2B 5A 5B 6A 6B 7B 8A 8B 9A 9B
Crop District
1997 1998

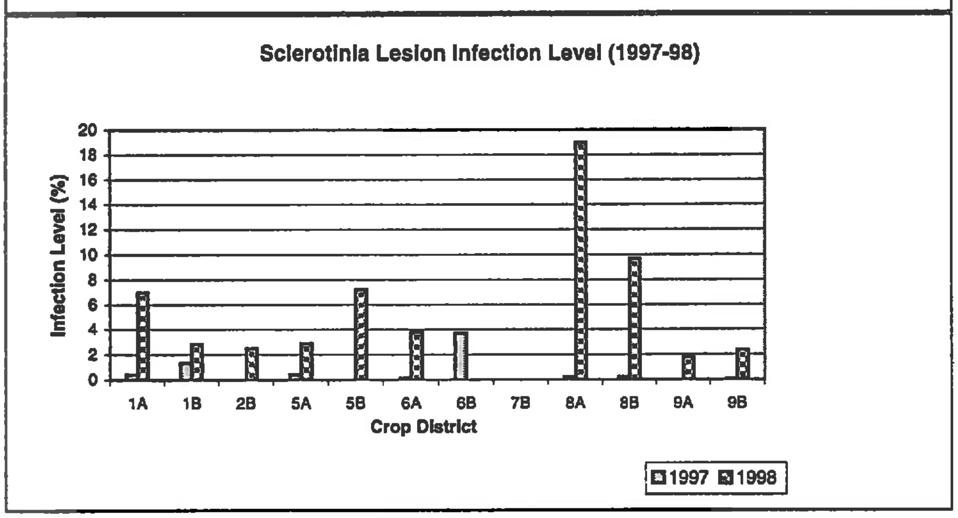

Sclerotinia Lesion Infection Level (1997-98)
Infection Level (%)
20
18
16
14
12
10
8
6
4
2
0
1A 1B 2B 5A 5B 6A 6B 7B 8A 8B 9A 9B
Crop District
1997 1998

Figure 5a.

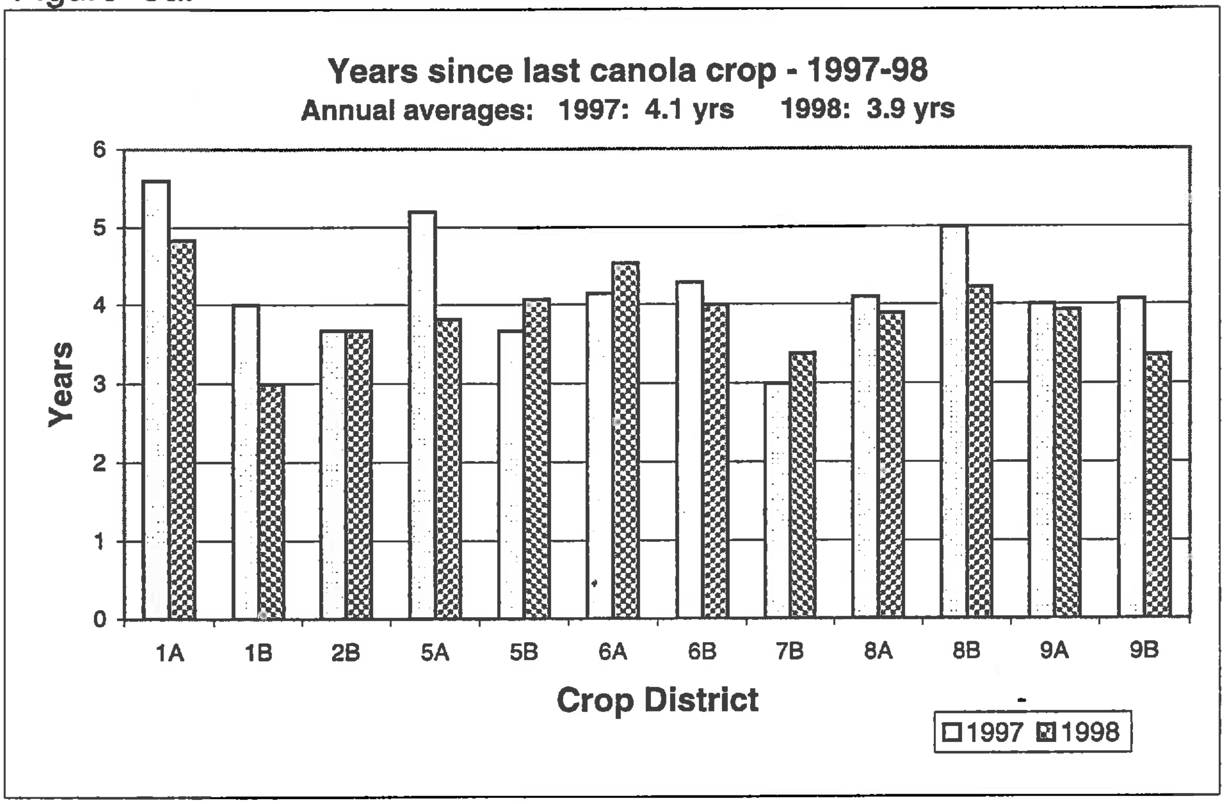


Figure 5b.

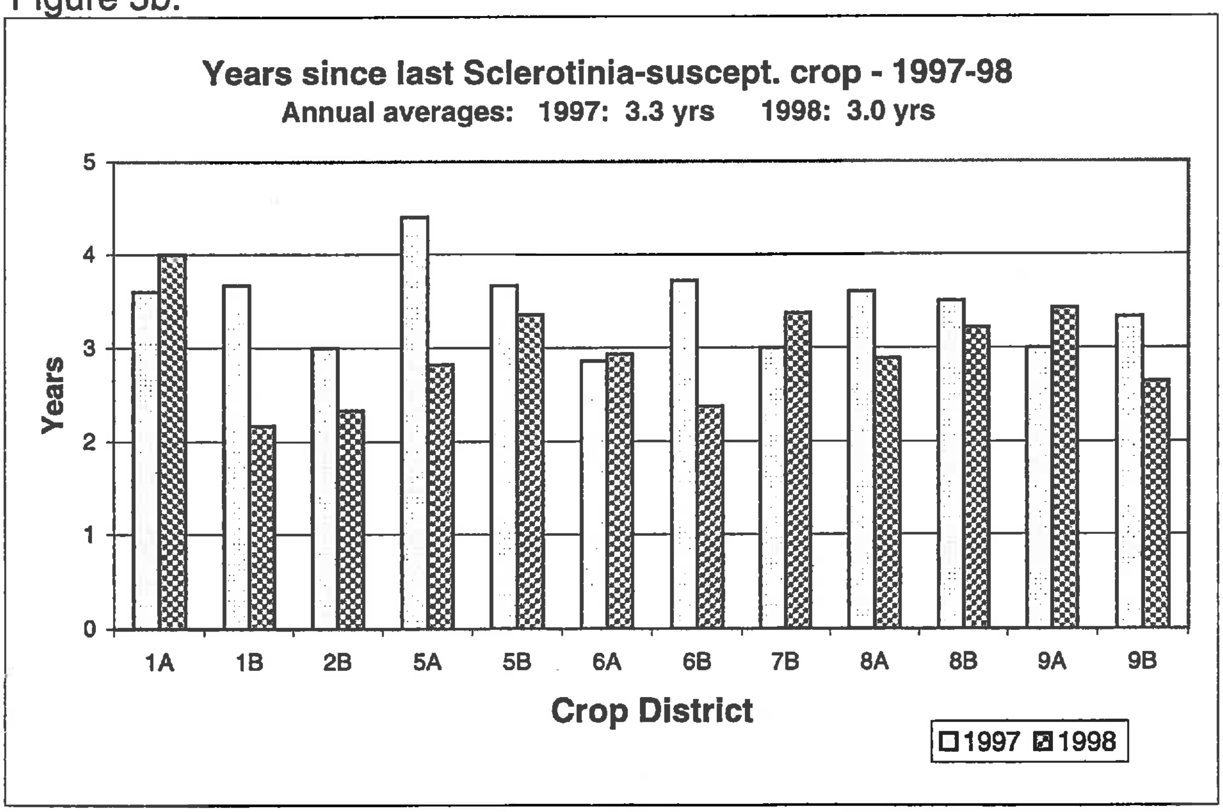


Figure 6a.

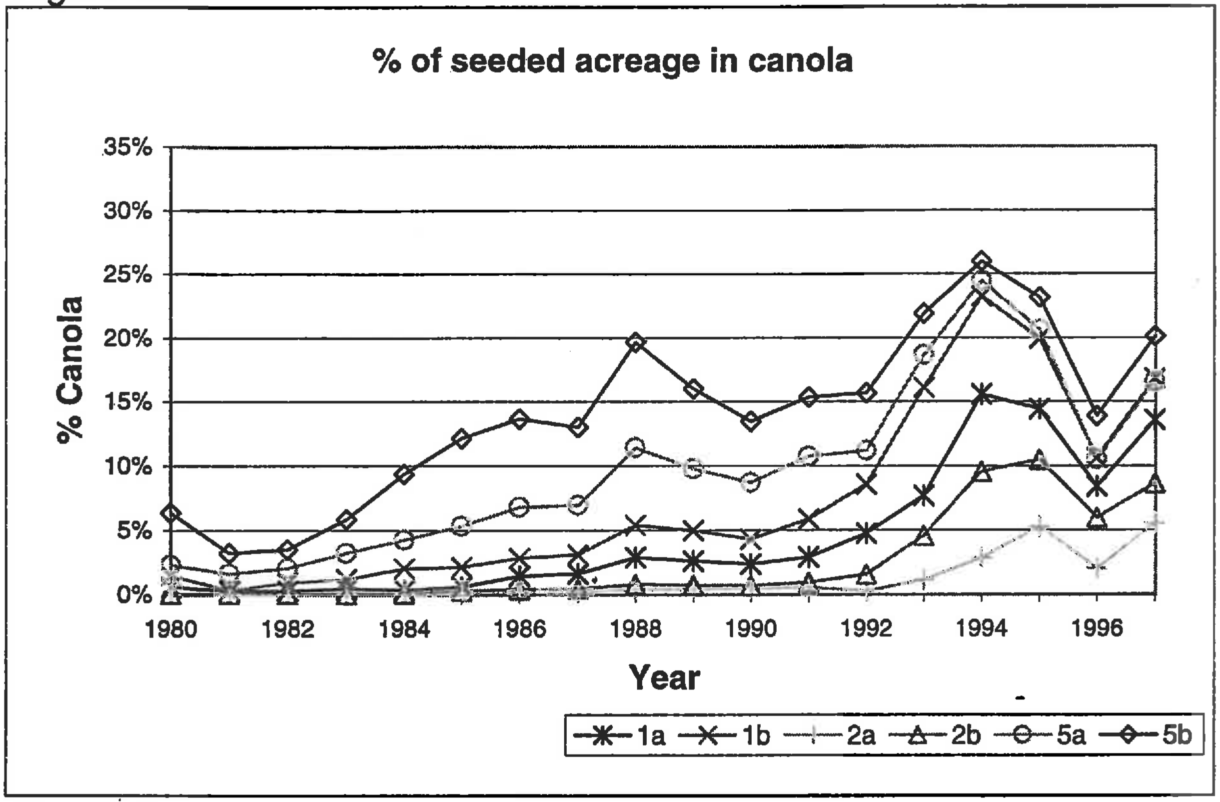


Figure 6b.

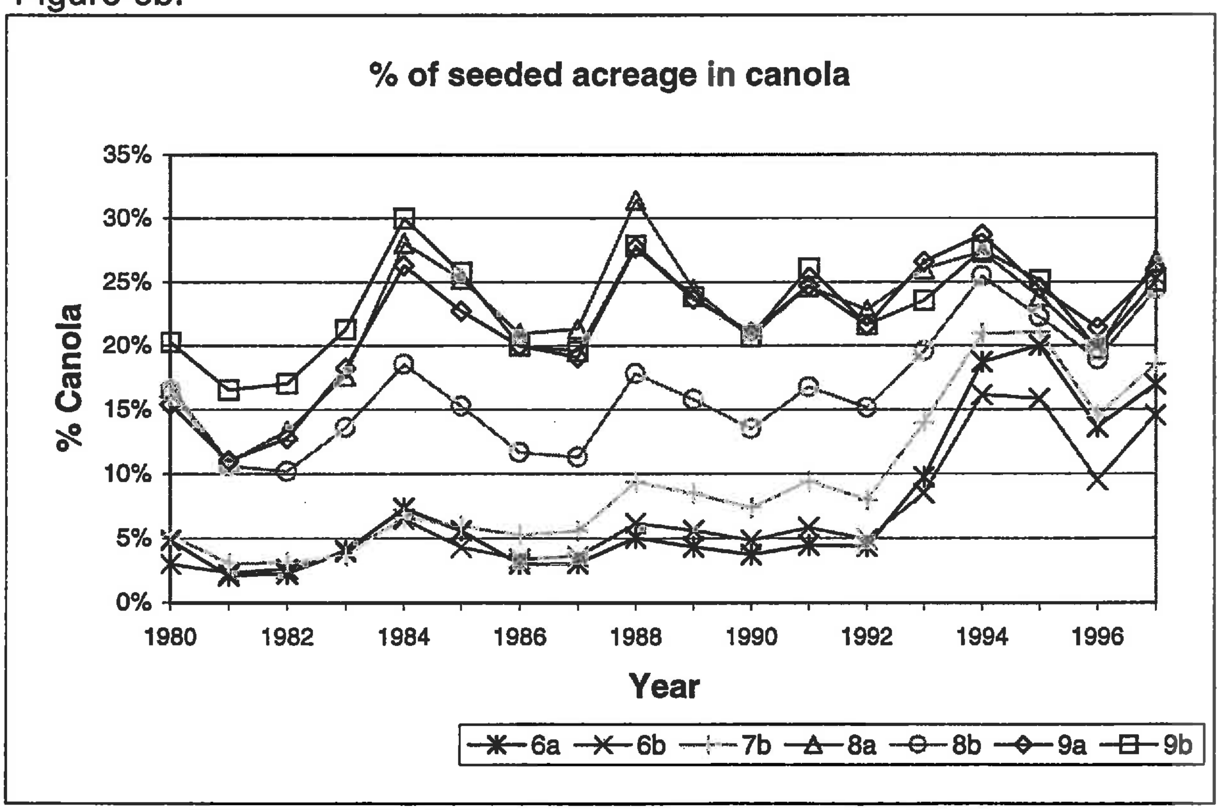


Figure 7a.

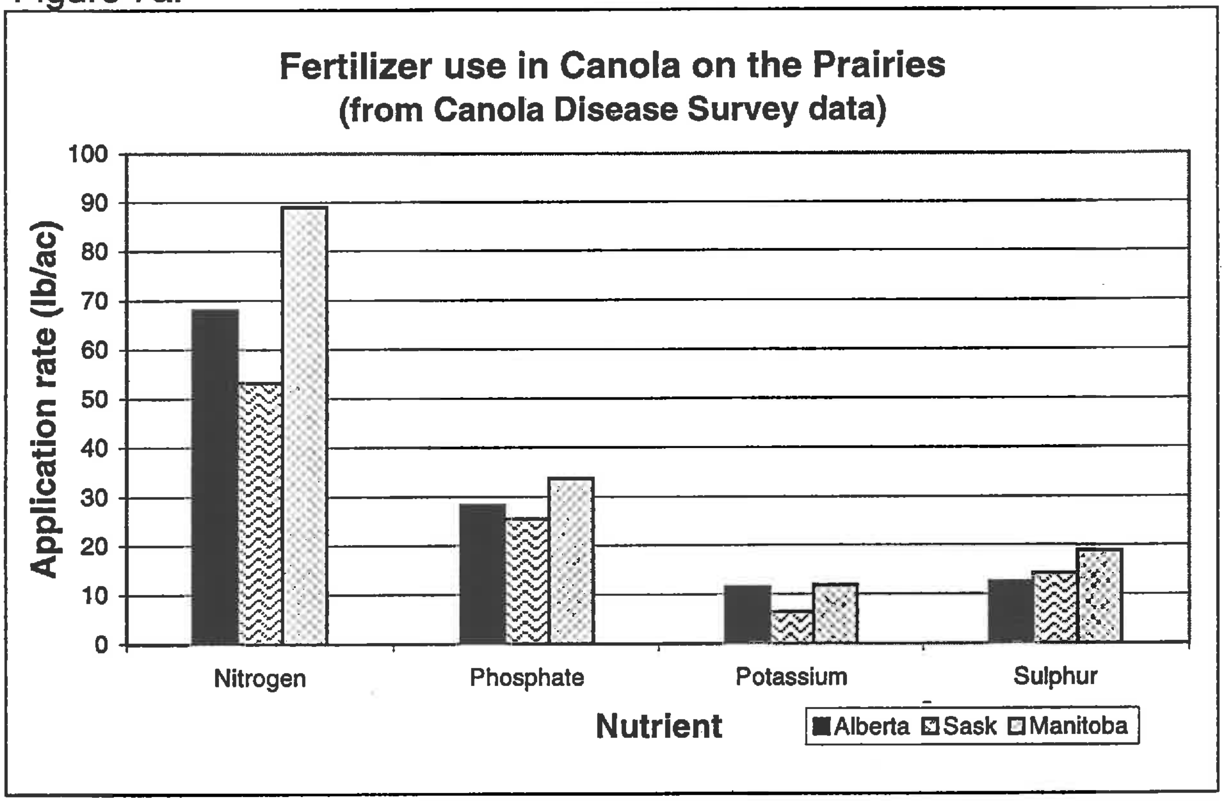


Figure 7b.

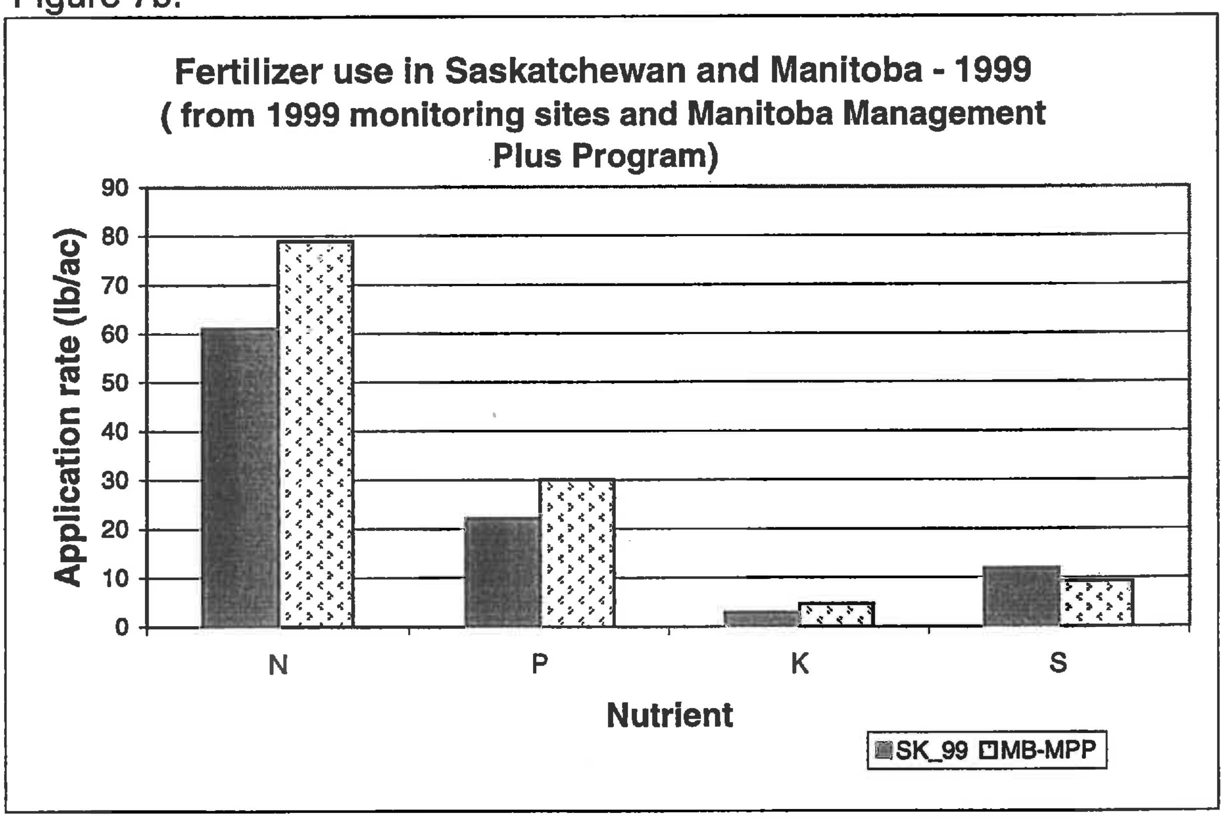


Figure 9a.

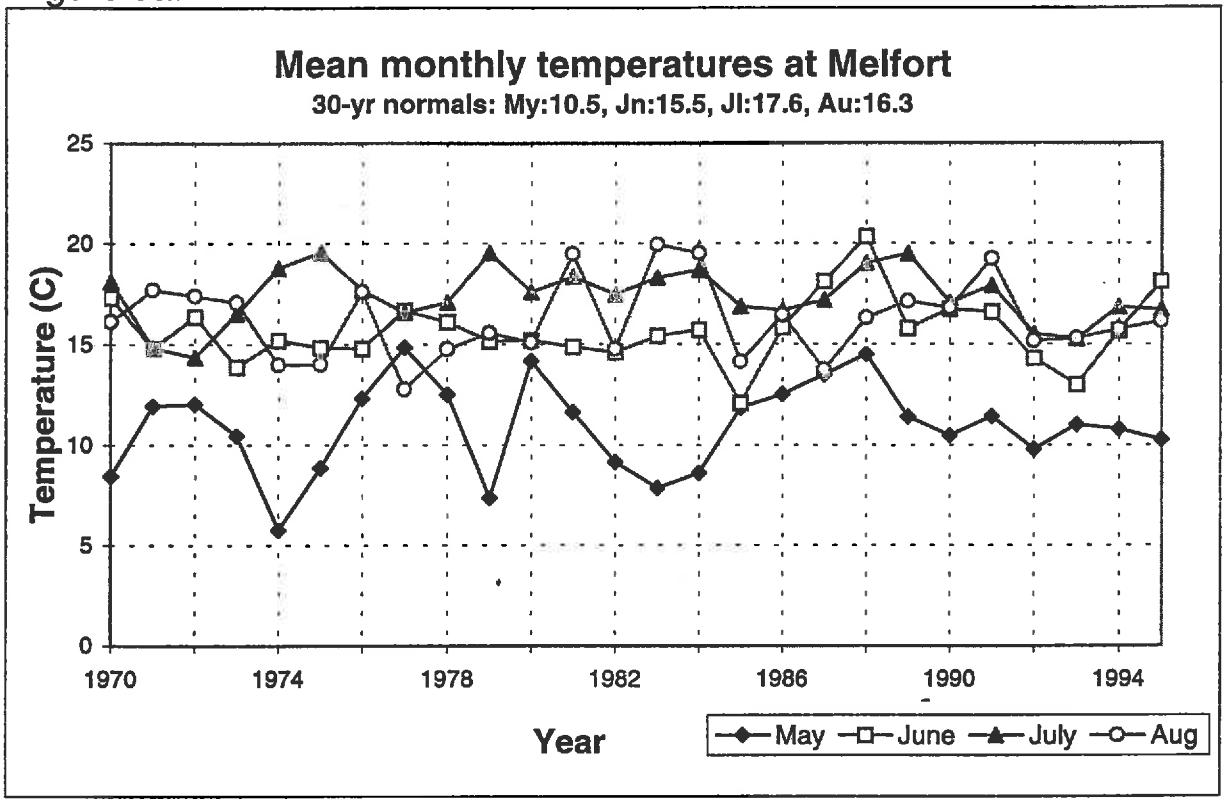


Figure 9b.

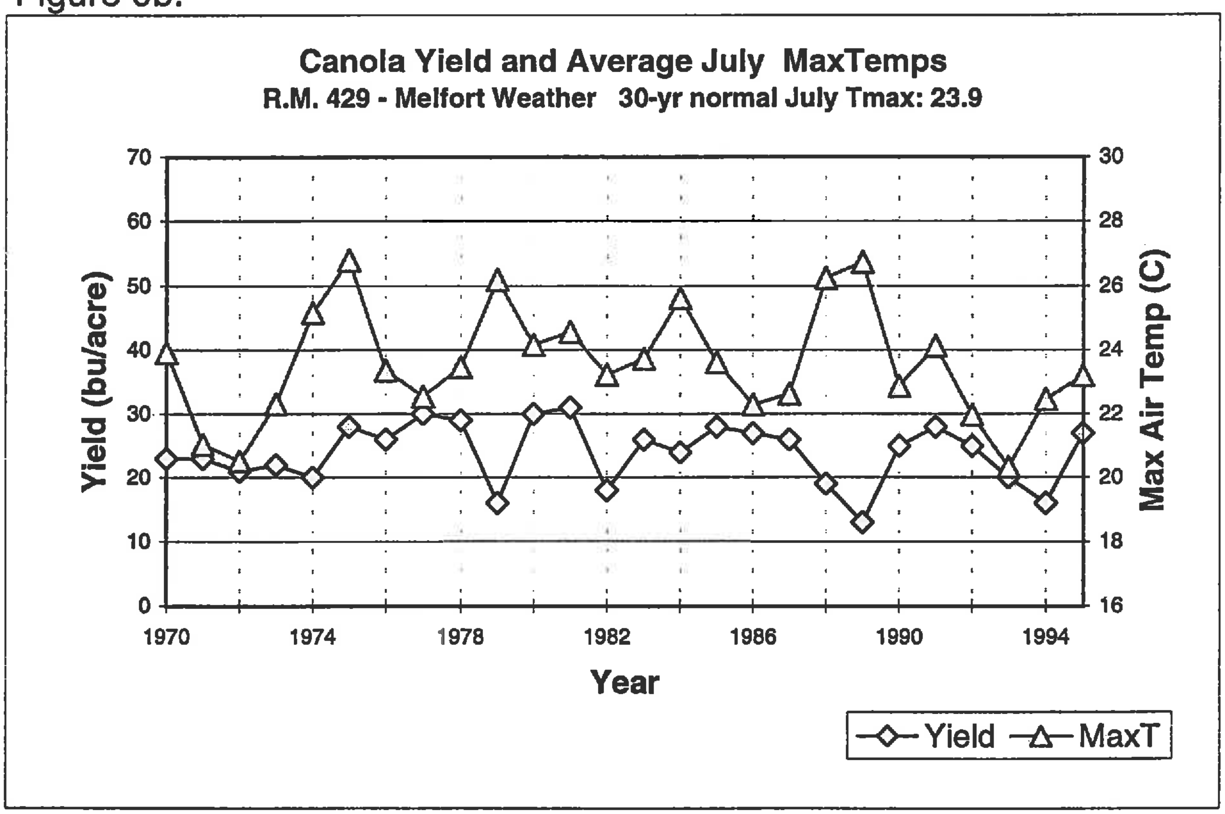


Figure 10a.

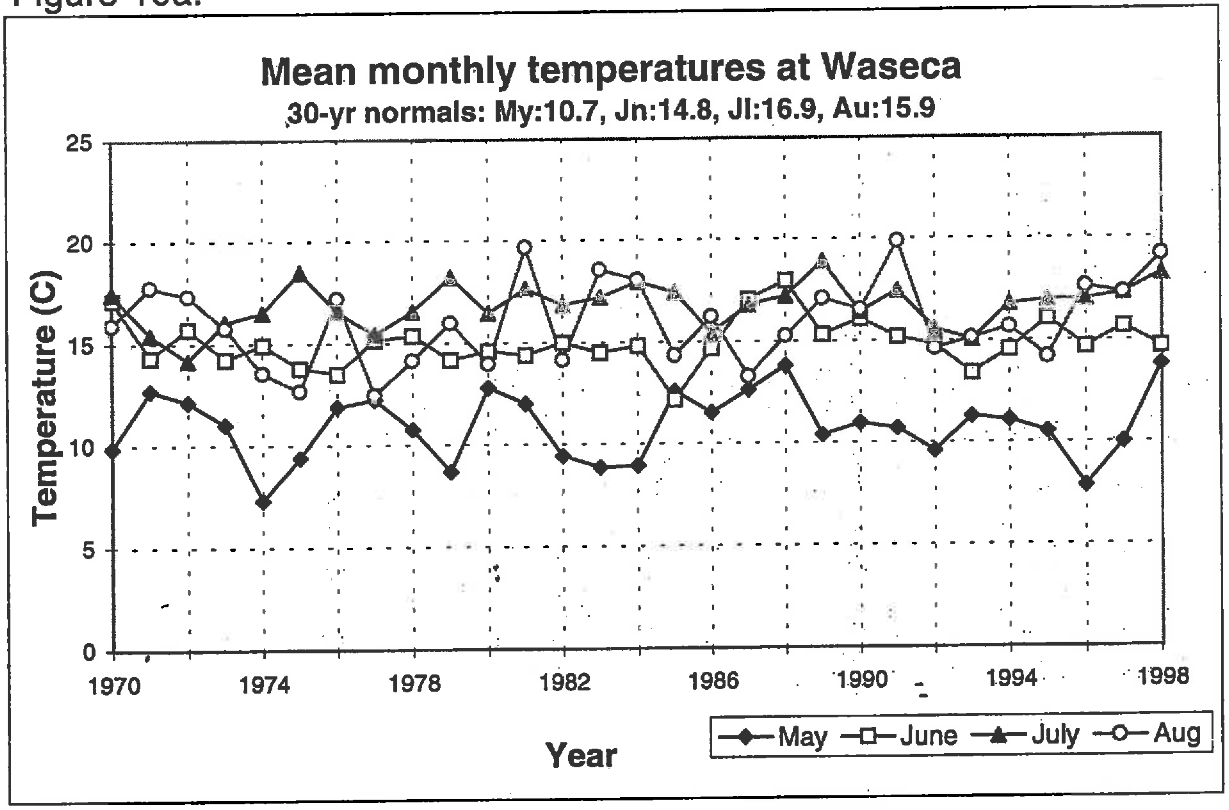
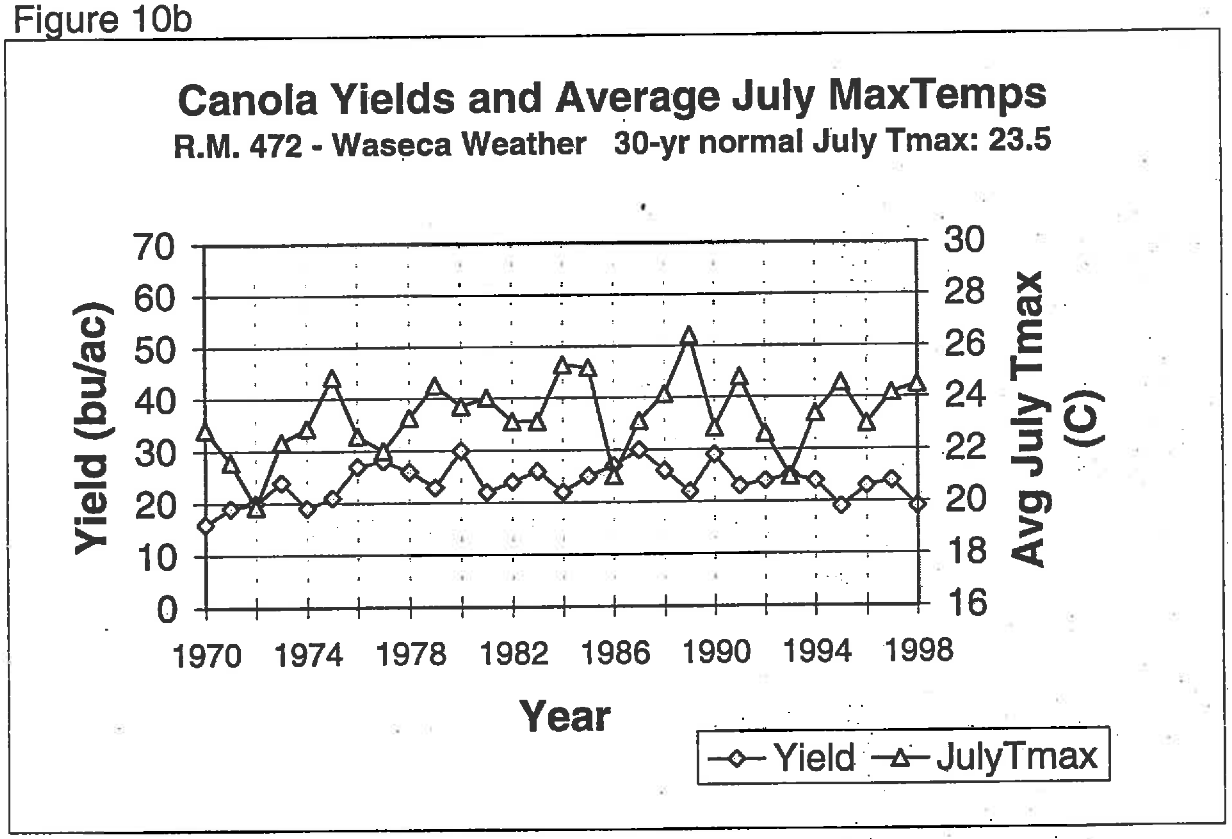


Figure 10b



REPORT B: 1999 Canola Field Monitoring Program

As part of the project to determine the cause(s) of stagnating canola yields in Saskatchewan, a field monitoring program was established across the Parkland region during the 1999 growing season. A total of 5 monitoring regions each containing 4 canola fields were selected to represent 5 crop districts whose the yield trends had been shown to be quite different (see Report A, fig. 3b) . The sites selected were all within 10 km of an Environment Canada weather station in order to have access to reliable meteorological data for weather/yield associations. At each field site, a 20 m x 20 m area within a grower's field was selected for measurements according to the protocol outlined in Appendix A. These measurements provided a continuous record, on a biweekly basis, of the growing conditions and development of the canola crops throughout the summer. A summary of the monitoring sites including the varieties, dates of field operations and final yields is presented in Table 1. An analysis of some of the factors considered in trying to explain yield differences among sites follows.

Weather

The general growing conditions during 1999 were quite favorable to canola production despite some seeding delays in certain areas due to a wet spring. Temperatures were cooler than normal and total precipitation ranged from 3% to 50% greater than normal depending on the region (Table 2 and Fig. 1a). The mean of July daily maximum temperatures, considered an important indicator of heat stress during the critical reproductive stage in canola, was 2 to 4°C lower than the 30-yr normals. These favorable conditions resulted in yields averaging 32 bu/ac (Fig.1b), 5 bu/ac greater than the provincial average of 27 bu/ac (the highest ever in Saskatchewan history). The relatively low variation in yields resulting from such favorable growing conditions will limit the monitoring program's ability to determine the cause of yield differences among the regions and field sites within the regions.

Soil moisture

Any differences in yield among fields did not appear to be caused by soil moisture contents which were generally greater than 20% (v/v) throughout June and July when moisture stress can have a large impact on yields. Only in Spiritwood did there appear to be a correlation between soil moisture and final yield, where fields 2 & 4 had soil moisture contents about 5% lower than fields 1 & 3 during the month of July with corresponding lower yields (Fig.2a). In contrast, field 1 at Kelliher had consistently lower moisture contents (5% to 10% lower) than the other 3 fields but ended up yielding the highest (Fig. 2b).

Biomass

Total above ground biomass accumulation varied between 800 and 1600 g/m^2 among all the field sites with some regions exhibiting more variability among fields than others (Fig.3a).

There was no obvious relationship between total crop biomass and final grain yield (Fig. 3b), nor between crop growth rates during any particular 2wk period and final yield (data not shown).

Fertilizer

There was a wide range of the four macro-nutrients (N,P,K,S) applied at all field sites, with N applications ranging from 7 to 95 lb/ac, P from 8 to 50 lb/ac, K from 0 to 15 lb/ac, and S from 0 to 42 lb/ac (Table 1). There was no relationship between the amount of any nutrient applied and total biomass accumulation. This lack of relationship was matched by a lack of relationship between fertilizer application and yield (Fig. 4). Soil test results from samples obtained after seeding also showed no relationship between any of the soil macro-nutrient levels and final yield.

Diseases

Sclerotinia was the dominant disease in canola in 1999 but did not appear to have a significant impact on yield. The Spiritwood area had the highest degree of infestation (Fig. 5), but this did not translate into decreased yields, as the average yield for the four fields was 31 bu/ac, just 1 bu/ac shy of the overall average.

Other analyses

A number of other factors derived from the field measurements, including crop growth rates, biomass production efficiency (i.e. amount of biomass produced per growing degree day), precipitation timing, water use rates, etc., were analyzed to try and explain yield differences among field sites (data too voluminous to present in this report). These analyses have failed to show any correlations with crop yields.

Conclusion

In view of the numerous factors interacting with one another and the inability of a monitoring program to control or isolate some of these factors, it appears that this approach in determining the cause of yield decline in canola may not be suitable. The idea of taking a "snapshot" of commercial canola production in a single season, even across a wide representative area of canola production, might give us some information on how the crops responded to a particular set of conditions during that year, but may not reveal any information regarding the long term trend of declining yields. It may be more appropriate to carry out extensive analyses of historic canola production, along with associated agronomic and weather data, in order to determine the cause(s) of this yield trend.

Table 1.

Site	Field	Variety	Yield	SeedDate	SwthDate	HarvDate	Actual nutrients applied			
							N	P	K	S
Kelliher	1	SW Arrow	23	25-May	30-Aug	20-Sep	58	14	0	11
Kelliher	2	LG 3295	30	29-May	07-Sep	01-Oct	55	18	0	14
Kelliher	3	Quest	33	19-May	28-Aug	29-Sep	68	10	0	8
Kelliher	4	Quantum	35	25-May	30-Aug	28-Sep	47	14	0	4
Lashburn	1	Magnum	34	19-May	10-Sep	28-Sep	7	8	0	6
Lashburn	2	Quantum	34	26-May	25-Aug	06-Sep	54	27	0	16
Lashburn	3	SW Arrow	38	10-May	22-Aug	05-Sep	60	20	15	20
Lashburn	4	Quantum	29	06-May	28-Aug	13-Sep	77	34	7	13
Melfort	1	46A72	27	30-May	20-Sep	10-Oct	78	20	0	18
Melfort	2	46A73	40	24-May	01-Sep	24-Sep	60	20	10	15
Melfort	3	45A71	29	28-May	10-Sep	01-Oct	70	20	0	8
Melfort	4	46A73	32	25-May	30-Aug	21-Sep	37	26	4	42
Spiritwood	1	Quest	33	11-May	01-Sep	25-Sep	60	25	0	20
Spiritwood	2	Quest	28	22-May	30-Aug	20-Sep	80	30	0	20
Spiritwood	3	Quest	34	17-May	05-Sep	09-Oct	95	17	9	13
Spiritwood	4	Quest	28	10-May	30-Aug	15-Sep	70	27	11	11
Watrous	1	Smart ?	30	06-May	15-Aug	06-Sep	56	18	0	0
Watrous	2	Quest	36	05-May	13-Aug	04-Sep	56	18	0	0
Watrous	3	46A65	32	28-May	04-Sep	23-Sep	71	26	0	0
Watrous	4	Quest	37	25-May	06-Sep	17-Sep	62	50	0	0
Overall avg			32.1	19-May	31-Aug	21-Sep	61	22	3	12

Site avgs:			Yield	SeedDate	SwthDate	HarvDate	Actual nutrients applied			
							N	P	K	S
Kelliher			30	24-May	31-Aug	27-Sep	57	14	0	9
Lashburn			34	15-May	29-Aug	13-Sep	50	22	6	14
Melfort			32	26-May	07-Sep	29-Sep	61	22	3	21
Spiritwood			31	15-May	01-Sep	24-Sep	76	25	5	16
Watrous			34	16-May	25-Aug	12-Sep	61	28	0	0

Table 2. Weather conditions during summer 1999 (May 1 to Aug 31) and 30-year normals for the 5 monitoring regions.

Region	Weather conditions for summer '99			30-yr normals		
	Precip	July Max Temp[3]	Mean Temp	Precip	July Max Temp	Mean Temp
Kelliher	261.4	22.5	14.6	233.8	24.3	14.9
Lashburn[1]	323.0	21.0	13.1	246.8	23.5	14.6
Melfort	229.5	21.0	14.2	223.0	23.9	15.0
Spiritwood[2]	247.8	20.4	13.0	204.8	24.4	13.9
Watrous	338.6	22.6	14.9	225.5	25.3	15.7

1. 30-yr normals for Lashburn obtained from Waseca AES weather station.
2. 30-yr normals for Spiritwood are for 30-yr period from 1941 to 1970.
3. Average of daily maximum temperatures in July.

Figure 1a.

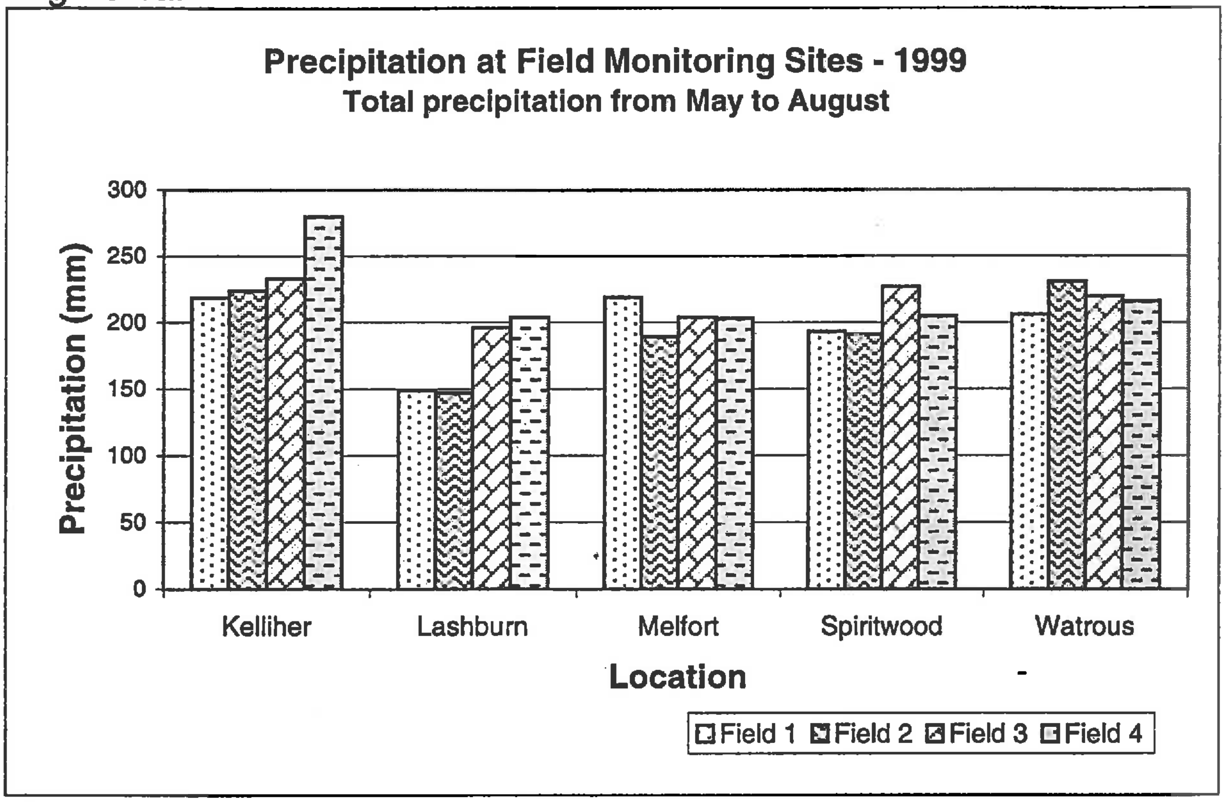


Figure 1b.

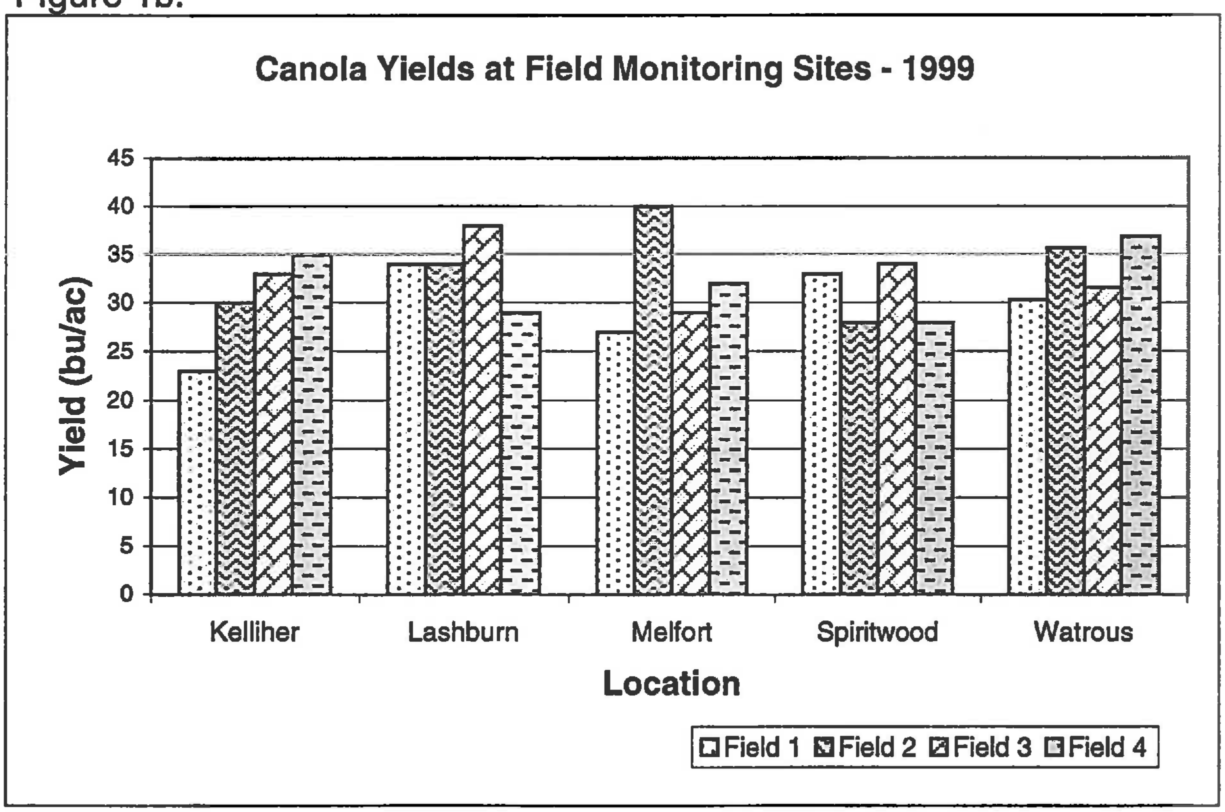


Figure 2a.

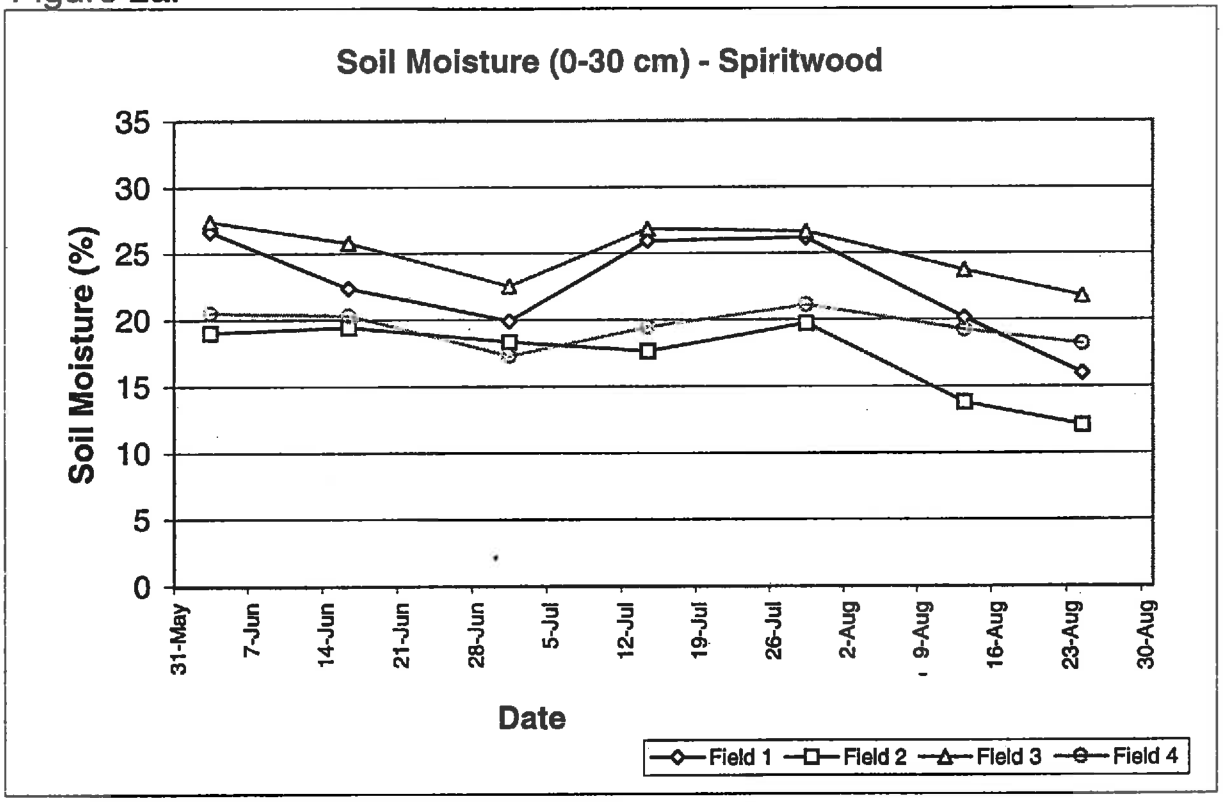


Figure 2b.

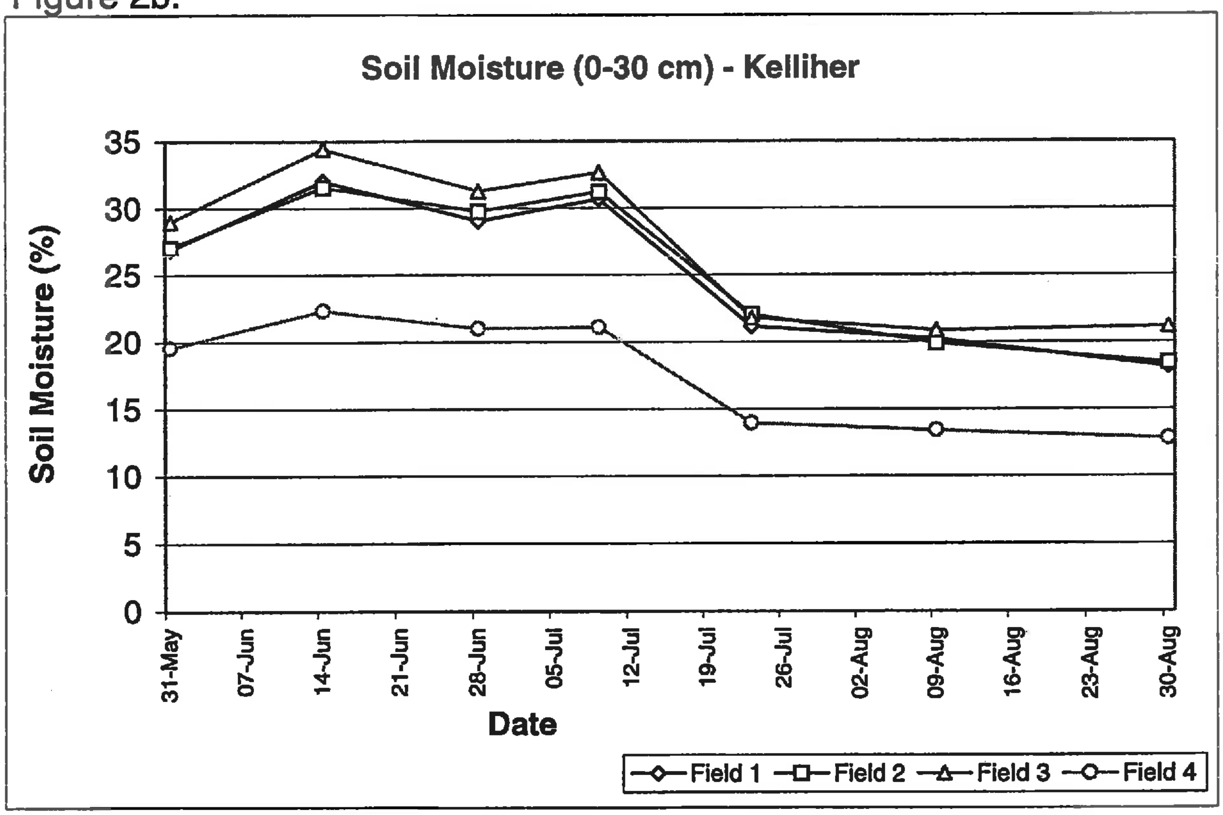


Figure 3a.

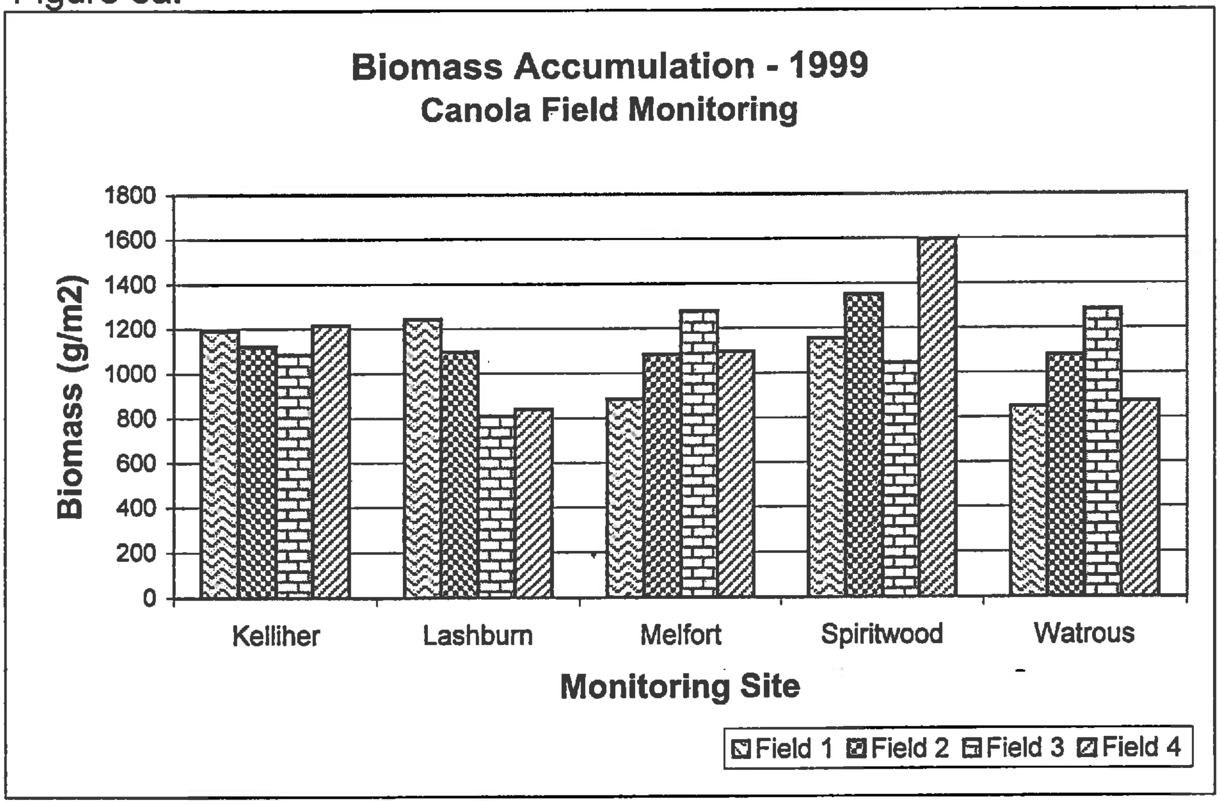


Figure 3b.

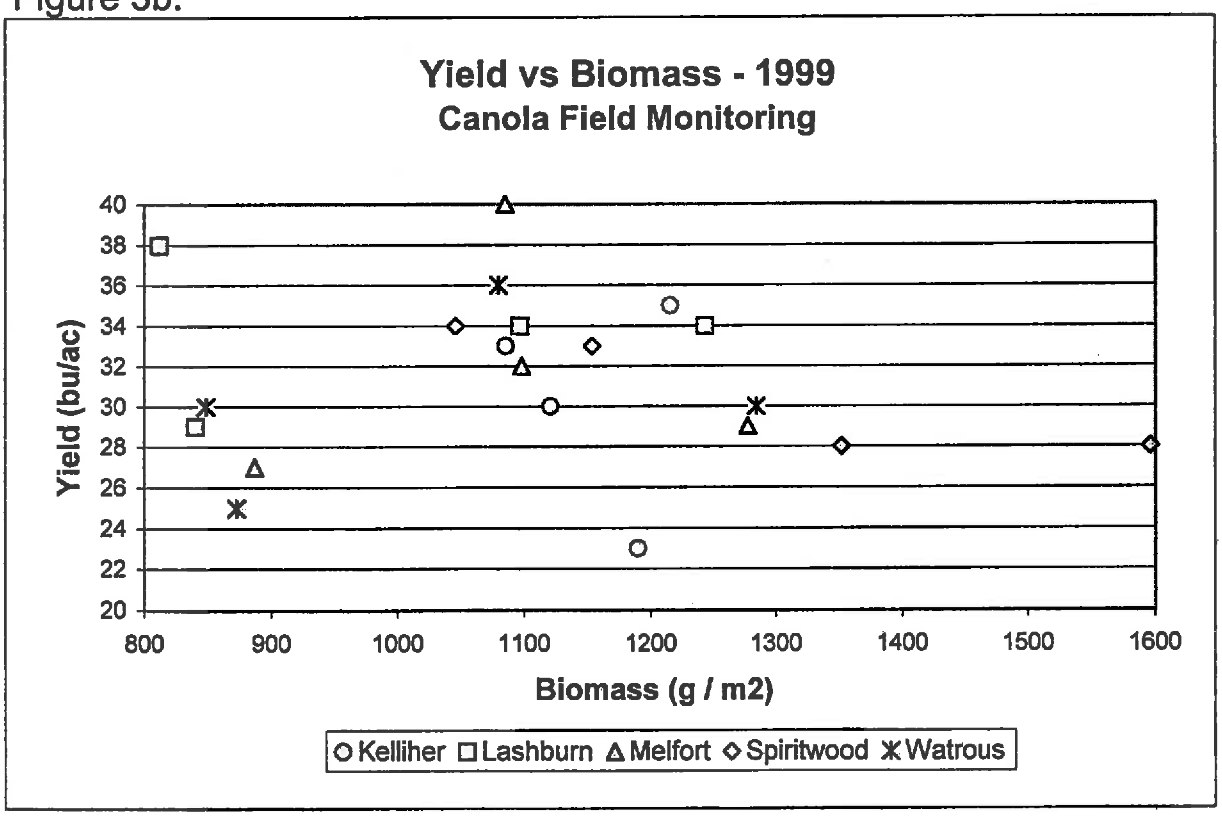
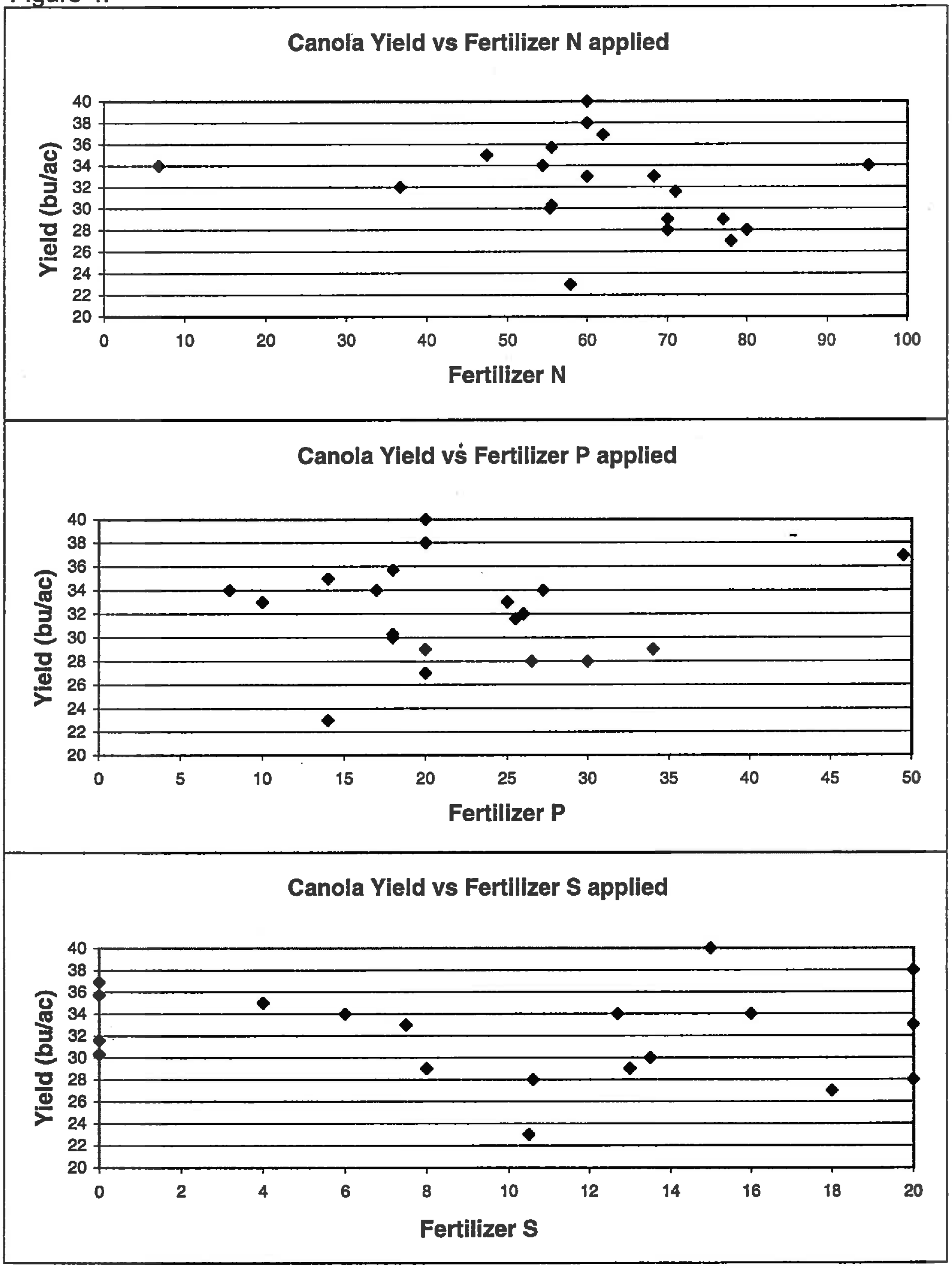
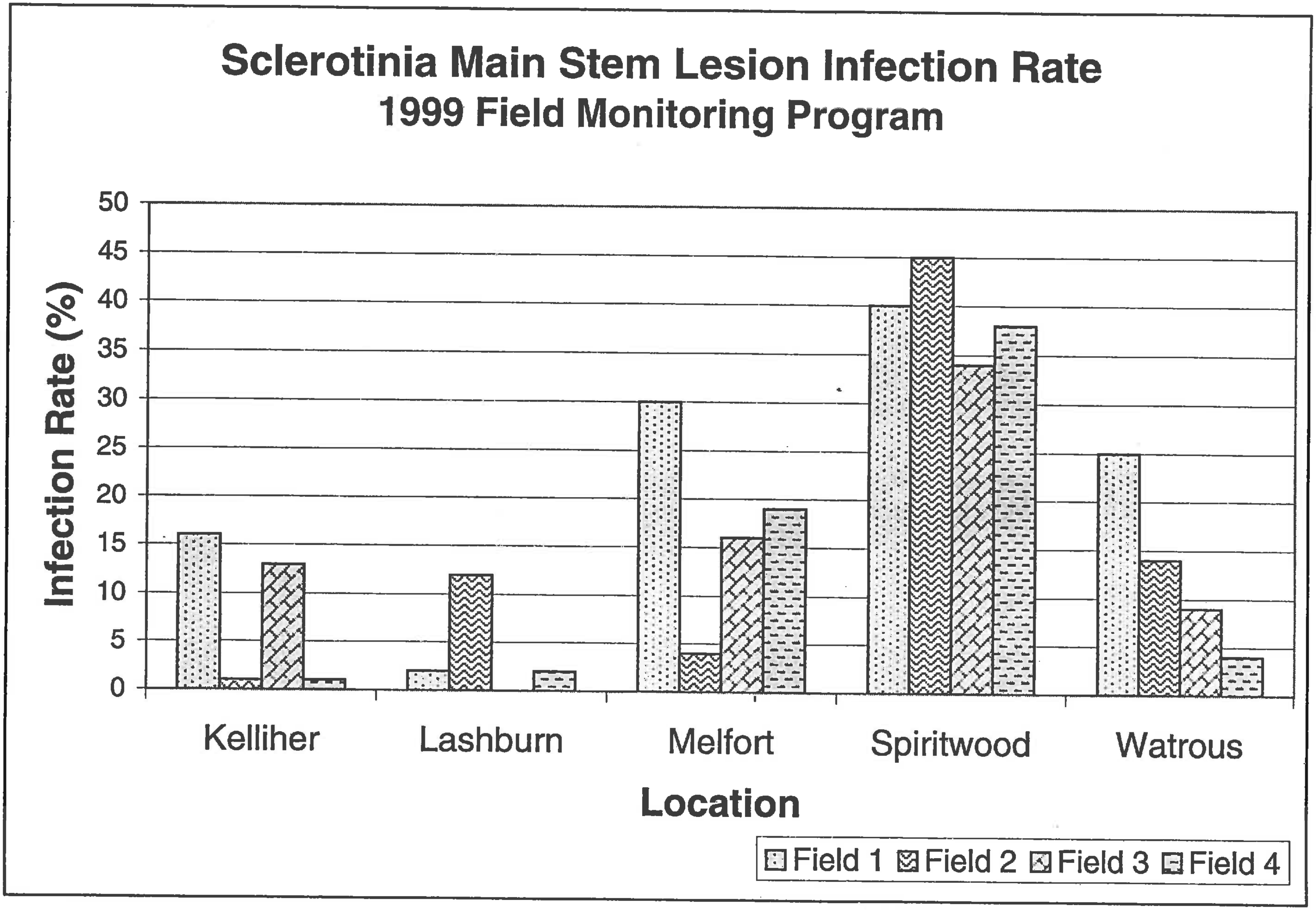


Figure 4.



Canola Yield vs Fertilizer N applied
Yield (bu/ac)
Fertilizer N
Canola Yield vs Fertilizer P applied
Yield (bu/ac)
Fertilizer P
Canola Yield vs Fertilizer S applied
Yield (bu/ac)
Fertilizer S

Figure 5.


Sclerotinia Main Stem Lesion Infection Rate
1999 Field Monitoring Program
Infection Rate (%)
50
45
40
35
30
25
20
15
10
5
0
Kelliher
Lashburn
Melfort
Spiritwood
Watrous
Location
Field 1
Field 2
Field 3
Field 4

Appendix A. Protocol for 1999 canola field monitoring program.

Site establishment:

- mark off 20 m x 20 m square where measurements will be made.
- soil tests: 10 locations composited x 2 depths, macro & micro-nutrients.
- install 2 sets of TDR probes for soil moisture measurement.
- install rain gauge.

One time measurements:

- emergence counts (2 weeks after emergence).
- stand density (4-6 weeks after emergence) and visual weed assessment.
- tissue analysis (at flowering - 4 to 5 plants).
- flowering dates

Measurements at 2-wk intervals:

- soil moisture
- photographs
- biomass sample (4 x ¼ m^2)
- rain gauge reading

Weather monitoring:

- daily min/max temperatures and precipitation from local Environ. Canada Weather Stn

Harvest:

- yield component determination (10 plants)
- grain yield at maturity (4 x ¼ m^2)
- disease rating