Agronomic Factors Associated with High Chlorophyll Levels in Rapeseed Grown in Western Canada

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Chlorophyll is extracted from rapeseed along with the oil and must be removed from the oil during processing in order that the end product have good stability and color (1,2). In recent years, the chlorophyll content of Canadian rapeseed has increased from less than 10 ppm (1976-1979) to 12 to 13 ppm (1980-1982).

Swedish studies (3) have indicated the following factors as influencing the chlorophyll content of rapeseed: species, cultivar, growing conditions - soil, weather, length of season, cultivation techniques, seeding time, seeding rate, row space, N fertilization, harvest time - swathing, length of time in swath, weather, and uneven stands. Variations in chlorophyll content were greatest in spring rape and were largely due to weather (4). In Western Canada, spring rapeseed is grown exclusively. The chlorophyll increase in Western Canada is most likely due to an increase in the utilization of higher chlorophyll *B. napus* varieties from about 40% in the early 1970's to 60% in recent years. *B. napus* varieties have been shown to have substantially higher levels of chlorophyll than *B. campestris* varieties (5,6).

The longer time required for *B. napus* varieties to mature (95 to 115 days compared with 75 to 100 days for *B. campestris*, coupled with the tendency of seed to shatter when mature might, induce farmers to harvest the crop when it is immature. Recommendations generally indicate that the crop should be swathed when 25-35% of the seeds in the pods have turned brown or black (usually about 35% moisture content) (7). Studies carried out by the Grain Research Laboratory and Agriculture Canada's Saskatoon Research Station have shown that rapeseed swathed at this stage will mature in 10 to 15 days.

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Certain areas of Western Canada, especially Southern Manitoba and Central Saskatchewan, have continually produced B. napus rapeseed with high average chlorophyll levels. Since crushing plants in Western Canada find the main source of seed in the immediate vicinity of the plant, some Western Canadian crushing plants produce oil with higher levels of chlorophyll than others.

The objective of this study was to investigate the relationship between chlorophyll content and agronomic practice using samples drawn from areas of Western Canada which have been producing rapeseed with high levels of chlorophyll. About one-third of the B. napus rapeseed samples from these high chlorophyll area contained less than 10 ppm chlorophyll. If relationships exist between agronomic practice and chlorophyll content, these should be considered in developing recommendations for farmers growing rapeseed in these "high chlorophyll" areas.

Methods

Samples and questionnaire collection was handled in conjunction with the contracting offices of the crushing plants in the areas sampled. This ensured a good response since some crushing plants required a sample and completed questionnaire prior to delivery of contracted seed. About 50% of the questionnaires returned had all questions answered. In 1981 and 1982, specific questions relating especially to harvesting techniques were added to the questionnaire. Agronomic factors investigated in the surveys are shown in Table 1. In 1982, an unusual severe frost in late August damaged much of the Western Canadian rapeseed crop making results from the questionnaire difficult to compare to other years. The data obtained in 1982 were not considered for this report.

Results and Discussion

Comparison of questionnaire responses with the chlorophyll levels in the seed for 1980 samples (Table 2) shows a significant negative correlation between chlorophyll and yield and a significant positive correlation between chlorophyll and planting date. Further analysis showed that samples with lower seeding rates (less than 4.5 kg/ha) and

later seed dates (later than June 1) had significant correlations between chlorophyll content and several other factors including fertilizer, area harvested and seeding date (in the case of low seeding rate). A late seeding date might be expected to give higher chlorophyll values because of the shorter period available for growing. Low seeding rates have resulted in higher chlorophyll values in plot studies (Grain Research Laboratory unpublished), probably because wider plant spacing allows more branching with more uneven flowering, ripening, especially for pods produced under the canopy.

In 1981, significant individual correlations were found between chlorophyll and seeding date, nitrogen fertilizer, spotty emergence, swathing date and combine date. Further analysis by stepwise multiple linear regression (Table 3) shows that, for all samples tested, swathing date, nitrogen fertilizer, time from seeding to swathing date, seeding rate, area harvested, and yield contributed in decreasing order, a total of 12% to the total reduction of sums of squares. A similar analysis for samples with high levels of chlorophyll shows that yield, area harvested, nitrogen fertilizer, total fertilizer, time from emergence, time from seeding to swathing and swath width contributed 26.0% to the total reduction in sums of squares. Since the samples were gathered from a wide area, it can be assumed that the factor accounting for the greatest variation in chlorophyll was the environment.

Swath rolling, which is carried out to prevent swaths from disintegrating in high winds, was found to significantly increase the chlorophyll content, particularly for samples with less than 20 ppm chlorophyll (Table 4). Although the differences were significant, these are small. Differences might be expected since swath rolling tends to compact the swath and thus slow the maturation rate for the material at the bottom of the swath by keeping it shaded and moist. The larger swath size created by newer and larger swathers further complicates this problem, particularly in the case of B. napus varieties where farmers must balance shattering loss from pods at the top of the swath with immaturity of seeds at the bottom of the swath.

Conclusions

Although weather patterns and species are the dominant factors controlling chlorophyll content of rapeseed, analysis of agronomic practices of Western Canadain farmers indicates that agronomic factors also influence chlorophyll. In the early part of the year, seeding date and seeding rate are important influences. For low chlorophyll levels, seeding dates should be as early as possible and seeding rates should exceed 4.5 kg/ha when economically feasible. High rates of nitrogen fertilizer and spotty emergence were also noted to cause high chlorophyll levels.

At harvest, the time of swathing and threshing, swath width and the use of a use of a swath roller influence the chlorophyll content of the seed. Before threshing, the maturity of the seed in all parts of the swath, particularly at the bottom, should be considered.

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Table 1
Agronomic factors investigated in farm surveys

Factor	Year Included in Survey		
	1980	1981	1982
Variety	X	X	X
Yield	X	X	X
Preceding Crop	X	X	X
Area Harvested	X	X	X
Location	X	X	X
Seeding Date	X	X	X
Seeding Rate	X	X	X
Emergence (even or spotty)	X	X	X
Emergence Date		X	X
Flowering Date		X	
Swathing Date		X	X
Swath Width		X	X
Swath Roller		X	X
Fertilizer	X	X	X
Pesticide	X	X	X

Table 2
Significant correlations between agronomic factors and seed chlorophyll for all samples with complete questionnaires (1980 and 1981)

Factor	Correlation Coefficient (r)	
	1980 (591 samples)	1981 (496 samples)
Seeding Date	0.32	0.25
Nitrogen	NS	0.21
Emergence	NS	0.23
Swathing Date	ND	0.25
Threshing Date	ND	0.20

NS - not significant
ND - not determined

Table 3
Contribution of factors to stepwise multiple linear regression with chlorophyll as the dependent variable

Factor	All Samples		High Chlorohyll Samples[3]	
	Order of stepwise selection[1]	Reduction in sums of squares (%)[2]	Order of stepwise selection	Reduction in sums of squares (%)
Swath Date	1	6.28	NS	NS
Nitrogen	2	4.23	3	3.75
Seeding Rate	4	0.20	8	1.91
Area Harvested	5	0.19	2	3.53
Yield	6	0.14	1	8.35
Total Ferilizer	NS	NS	4	NS
Time (emergence to swathing)	NS	NS	5	1.19
Emergence	NS	NS	7	1.24
Swath Width	NS	NS	9	1.94
Total Reduction in Sums of Squares		12.02		26.45
Multiple Regression Coefficient		0.345		0.524
Number of Samples		449		48

[1]forward stepwise selection.
[2]additional reduction of sums of squares is the increase in the total sum of squares over that of the previous stage of the selection procedure.
[3]chlorophyll 20-48 ppm

Table 4
Effect of swath rolling on chlorophyll level in rapeseeds (1981)

Range in Chorophyll (ppm)	Mean Cholorphyll (ppm)		Value of Students +
	With Swath Rolling	Without Swath Rolling	
0-56	13.0	11.7	2.95***
0-10	6.8	5.8	1.70*
11-20	14.9	14.3	2.44**
21-56	23.7	26.7	-0.03

*pr > .95 **pr > .99 ***pr > .995