RAPESEED RESPONSE TO SULPHUR, BORON, AND FERTILIZER PLACEMENT [1]

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Excellent marketing opportunities have spurred farmer interest in the production of rapeseed on the Canadian prairies to such an extent that in 1979, it was second only to wheat in terms of seeded acreage. Along with the dramatic increase in seeded acreage, large strides have been made in increasing the yield of rapeseed by plant breeding, fertilizers, and herbicides. However, in recent years, there have been increasingly frequent reports from farmer producers of erratic and unexplained poor rapeseed production. As a result, industry, university, and government research efforts were co-ordinated, providing a better understanding of the reasons for the inconsistent production of rapeseed on some soils.

A second area of concern was the problem of efficiently supplying phosphate fertilizer to rapeseed crops grown on deficient soils that required more phosphate than could effectively be applied in the seed row. A lack of equipment to side band fertilizer and a strong dislike by farmers for handling large amounts of fertilizer at the time of seeding had forced many farmers to turn to the only practical alternative available - broadcast and incorporate. Agronomists at WCFL felt there should be more effective alternatives available to farmers for applying the bulk of their fertilizer requirements prior to the seeding operation.

To provide a better insight into these problems, WCFL consequently concentrated a great deal of its research resources on rapeseed production in 1979. The bulk of this research was funded by the Pool/Co-op Agronomy Research Fund. The assistance of Agri-sul Canada in terms of helping to subsidize travel costs and the provision of a high analysis sulphur fertilizer for the sulphur trials is gratefully acknowledged. The assistance of provincial extension workers in the locating of possible sites for trials is also gratefully acknowledged.

POOR RAPESEED GROWTH

Extension agrologists in northeast Saskatchewan who attempted to assess the poor growth of rapeseed found that the problem was much more widespread than initially expected and suggested that a sulphur deficiency was the most likely problem.

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In 1979, WCFL established a total of 38 strip trials in the important rapeseed production area stretching from northeast Alberta to southern Manitoba. The location of the trials corresponded to the black, degraded black, and grey-wooded soils in fields that soil tests had suggested contained low to marginal levels of available sulphur.

A total of 27 trials are included in the results. A large number of trials were lost due to farmer misapplication of fertilizer, change in cropping plans, lack of proper weed control, poor crop growth, farmer harvesting of the plot area, and field crew inexperience in proper plot site selection.

<u>Strip Trial Design</u> The following diagram (Figure 1) illustrates the design selected for the strip plot trials. The strips were 15 feet wide and approximately 400-500 feet in length. Aside from a central check strip left for the purpose of easily locating the test strips, all the strips were treated with a blanket application of 27-27-0 at the rate of 250 or 500 lbs/acre. The higher rate was used on unfertilized stubble, whereas the lower rate was applied to fallow or stubble fields to which the farmer had applied a significant amount of nitrogen. The farmer was required to seed the plot area and could, if so desired, apply a drill-in fertilizer providing it did not contain significant amounts of sulphur. Weed control was also the responsibility of the farmer.

Figure 1: Strip Plot Design Utilized for Poor Rapeseed Growth Survey

Strip	Treatment Number
BORDER STRIP	-
27-27-0 + AGRI-SUL + 0-0-62 + BORON	(1)
27-27-0	(2)
27-27-0 + AGRI-SUL + 0-0-62	(3)
ABSOLUTE CHECK	(4)
27-27-0 + AGRI-SUL	(5)
27-27-0	(6)
27-27-0 + GYPSUM	(7)
BORDER STRIP	-

Note: 27-27-0 applied at 250 or 500 lbs/acre
0-0-62 applied at 100 lbs/acre
Agri-sul* (90% S) applied at 60 lbs/acre
Gypsum applied at 200 lbs/acre
Boron applied as Fertilizer Borate-68 at 5 lbs/acre.

* Registered trademark.

It was felt that the strip plot design was more suitable than replicated, completely randomized small plots for conducting a survey of the possible causes of poor rapeseed growth on a wide variety of soils scattered over a wide geographic area. The use of this plot design allowed the establishment of a large number of trials in a very short period of time while expending less resources but still providing the required information. It was felt that establishing a few detailed, time-consuming small plots increased the risk of obtaining little or no information due to improper site selection, drought, hail, or frost damage.

Summary of Survey Results The corrected average yield data (i.e. two check strips forced to equalize) are summarized in Table I. The need for sulphur for the production of rapeseed is clearly demonstrated on these problem soils. The data also suggest that the average response to Agri-sul (90% elemental sulphur suspended in bentonite clay) was only 1/3 of the response to gypsum. There also appeared to be a slight response to potash and boron (applied at the rate of one pound B per acre). The largest response was to the application of an N-P fertilizer.

Table I - Influence on Level of Available Sulphur on Yield of Rapeseed in Response to Fertilizer Treatment (WCFL, 1979)

		Average Yield of Rapeseed (Cwt/Acre) *							
		Treatment Number							
SO_4-S Range (0 - 24")	No. of Sites	1	2	3	4	5	6	7	Average SO_4-S
≤ 15	7	11.0	10.1	10.9	6.0	9.9	10.1	11.5	13.1
16-20	9	13.9	11.7	13.1	9.4	12.4	11.7	13.1	18.9
21-30	9	11.3	9.4	10.5	6.9	10.3	9.4	10.3	24.1
≥ 31	2	11.9	11.2	12.4	9.3	10.6	11.2	10.8	60+
Average	27	12.1	10.5	11.6	7.7	10.9	10.5	11.6	

* Based on corrected averages.
Note: Soil analysis conducted by Saskatchewan Soil Testing Laboratory, Saskatoon, Saskatchewan.

Sulphur Response The data presented in Table II are based on the actual uncorrected yield data and identify the need for sulphur to boost yields of rapeseed. Quite clearly, spring-applied Agri-sul was a much less effective source of sulphur for rapeseed than gypsum. Presumably, the sulphur in Agri-sul was not being mineralized rapidly enough to meet crop requirements.

The discrepancy between the two sources was greatest at the lowest category of soil available sulphur (i.e. 0 - 15 lbs/acre of SO_4-S in the 0 - 24" depth) where the average advantage for gypsum was equivalent to 3 extra bushels/acre. On the soils in which the sulphur deficiency was most severe, Agri-sul appeared to be of little or no value in the year of application and actually appeared to depress yields. The explanation of this phenomenon is not understood, but has previously been observed with very low rates of N and P.

The relative performance of Agri-sul improved somewhat at the next highest category of soil available sulphur (i.e. 16-20 lbs/ of SO_4-S in the 0 - 24" depth) but was still only 25% as effective as gypsum in the year of application. It would appear that on the more severely deficient soils, irreparable damage had been suffered by the crop due to sulphur stress before significant amounts of elemental sulphur could be oxidized to a plant available form.

For soils that contained between 21-30 lbs. of available sulphur in the 0 - 24" depth, Agri-sul and gypsum appeared to be equally effective, strongly suggesting that Agri-sul can be an effective source of sulphur for rapeseed providing that the soil test levels of available sulphur are not critically low (i.e. less than 21 pounds available S/acre). At the intermediate levels, it appears that there is sufficient sulphur available in the soil to meet crop needs until elemental sulphur is sufficiently oxidized to make a contribution to crop growth later in the year.

Table II - Influence of Level of Abailable Sulphur and Sulphur Source on Yield of Rapeseed (WCFL, 1979)

		Average Yield of Rapeseed (Cwt/Acre) *		
SO -S Range (0 - 24")	No. of Sites	N-P + Agri-sul	N-P	N-P + Gypsum
≤ 15	7	9.1	10.2	10.6
16-20	9	12.3	12.0	13.2
21-30	9	9.8	9.3	9.9
≥ 31	2	11.1	11.8	11.2
Average	27	10.6	10.6	11.3

* Based on actual, uncorrected yield data.

Plant Analysis for Sulphur in Manitoba At one site at which there was a strong visual response to sulphur, plant materials were collected for tissue analysis. At plot #1898 located near Mariapolis, Manitoba, whole plant samples were collected at the flowering stage (approximately July 12, 1979). The data obtained are summarized in Table III. Unfortunately, no corresponding yield data are available because the farmer spread 21-0-0 (24% S) over the entire field, including the plot area in an attempt to salvage a crop that was seriously suffering from a lack of sulphur. There was a very strong visual response to gypsum at the time the samples were collected.

Table III - Rapeseed Sulphur Content as Influenced by Sulphur Source

Plot #1898 Mariapolis, Manitoba

Treatment	% Sulphur *
Check	0.14
27-27-0 @ 500	0.19
27-27-0 @ 500 + Agri-sul @ 60	0.19
27-27-0 @ 500 + Gypsum @ 200	0.56

* Analysis conducted by Manitoba Soil Testing Laboratory.

Note: Analysis conducted on whole plant samples. Soil test available sulphur in the 0-24" depth prior to seeding was 14 pounds/acre.

The available SO_4-S in the 0 - 24" depth of soil prior to seeding at the Mariapolis site was 14 pounds per acre. An adequate level of sulphur in a plant should probably be in the range of 0.3-0.4%. Quite obviously, Agri-sul was not supplying adequate amounts of available sulphur at the time the samples were collected.

Plant Analysis for Sulphur in Alberta Plant samples were also collected at one site near Vermillion, Alberta, at the flowering stage when there was a very distinct visual response in favour of the gypsum source of sulphur. The results for this plot are summarized in Tables IV and V. In this case, tissue analyses were conducted on the youngest mature rapeseed leaf. As in the case of the Manitoba site, plant analysis clearly suggests the Agri-sul had minimal impact on plant uptake of sulphur at the early flowering stage of growth (July 20, 1979). Based on soil samples collected prior to planting, the available sulphur content in the 0 - 24" depth of soil was 11 pounds/acre.

Table IV - Rapeseed Sulphur Content as Influenced by Sulphur Source

Plot #1874 Vermillion, Alberta

Treatment	Percent Sulphur *		
	Total	Water Soluble	Organic
Check	0.12	0.08	0.04
27-27-0 @ 250	0.14	0.10	0.04
27-27-0 @ 250 + Agri-sul @ 60	0.14	0.09	0.05
27-27-0 @ 250 + Gypsum @ 200	0.42	0.16	0.26

* Analysis conducted by Alberta Soil and Feed Testing Laboratory.
Note: Analysis conducted on youngest mature leaf.

Yield samples were collected at the Vermillion site and are summarized in Table V. From the yield data, it is apparent that elemental sulphur mineralizing to sulphate-sulphur later in the growing season had a greater impact on yield than would have been suggested based on tissue analysis conducted in the mid-growing season.

Table V - Yield of Rapeseed as Influenced by Sulphur Source

Plot #1874 Vermillion, Alberta

Treatment	Yield of Rapeseed (Cwt/Acre)
Check	1.4
27-27-0 @ 250	2.0
27-27-0 @ 250 + Agri-sul @ 60	3.5
27-27-0 @ 250 + Gypsum @ 200	12.9

Note: Soil test available sulphur in 0 - 24" depth prior to seeding was 11 pounds/acre.

Potash Response on Sulphur Deficient Soils One of the concerns in studying the erratic growth of rapeseed in some regions was that factors other than sulphur could be involved. The data presented in Table VI appear to suggest lack of potash was a possible factor at many of the sites.

Unfortunately, the response to potash is likely influenced by the choice of material used as a sulphur source. A true picture of the need for potash could only be evaluated when sulphur was supplied in a readily available form. At the time the plots were being established, the choice was made to use Agri-sul as the sulphur source where other nutrients were being evaluated because of the much higher analysis of this material compared to gypsum and the impact of the fact on transporting large quantities of fertilizer materials to widely-scattered test trials. The availability of Agri-sul at many fertilizer dealerships within the test region was also a factor.

Because of the role of potash in helping plants to cope with stress, it is interesting to speculate whether the response to potash would have been greater or less if sulphur had been supplied in the form of gypsum.

Table VI - Influence of Available Soil Sulphur Category on Response of Rapeseed to Potash (WCFL, 1979)

	Yield of Rapeseed (Cwt/Acre)				
	Available Sulphur Category (0 - 24")				
	≤ 15	16-20	21-30	≥ 31	Average
Check	6.0	9.4	6.9	9.3	7.7
N P S *	9.1	12.3	9.8	11.1	10.6
N P S + K	10.6	11.9	10.4	11.6	10.8
Number of sites	7	9	9	2	27

* Sulphur supplied as Agri-sul.
Note: Potash applied as 0-0-62 at 100 lbs/acre.

Boron Response on Sulphur Deficient Soils The yield data related to boron are summarized in Table VII. As in the case of potash, there was concern that a lack of boron might be involved in some of the crops of rapeseed that had yielded erratically despite being adequately supplied with nitrogen and phosphorus. It is quite evident that there appears to be a response to boron. However, as in the case of potash, the true response picture is probably clouded by the unfortunate choice of Agri-sul rather than gypsum as the sulphur source.

In many of the fields where poor yields of rapeseed have been reported, a lack of pod and seed formation had also been observed. There was therefore good reason to expect the possible occurrence of boron deficiencies. This nutrient is essential to actively growing tissue in new growth areas and is required for pollen viability and good seed set.

Table VII - Influence of Available Soil Sulphur Category on Response of Rapeseed to Boron (WCFL, 1979)

	Yield of Rapeseed (Cwt/Acre)				
	Available Sulphur Category (0 - 24")				
	≤ 15	16-20	21-30	≥ 31	Average
N P	10.2	11.4	9.7	10.6	10.4
N P K S *	10.6	11.9	10.4	11.6	10.8
N P K S + B	11.0	12.0	11.0	11.0	11.3
Number of sites	7	9	9	2	27

* Sulphur supplied as Agri-sul.
Note: Boron applied at 1 pound/acre (i.e. 5 lbs. of Fertilizer Borate-68 obtained from U.S. Borax).

RAPESEED AND FERTILIZER PLACEMENT

Research conducted by WCFL has demonstrated that the benefits of placing nitrogen fertilizers in pre-planting, sub-surface bands should amount to an extra 1 - 5 bushels of grain per acre when compared to the usual approach of broadcasting and incorporating fertilizer into the top few inches of soil. Broadcast placement leaves the fertilizer in a layer of soil which is vulnerable to drying. Fertilizer located in dry soil is virtually stranded as far as the rooting system is concerned. Therefore, the drier the region and/or the drier the early growing season, the greater the potential benefits of deep band placement of fertilizer.

Drill-In Limited   The use of higher rates of fertilizer in recent years has made it less practical to apply a large proportion of the fertilizer in the seed row at the time of seeding. As a result, farmers turned with increasing frequency to applying larger proportions of fertilizer in a separate broadcast application. In the case of rapeseed, with higher rates of fertilizer being recommended, not even the total phosphate requirements could be placed in the seed row because of the susceptability of this small seeded crop to germination damage. Related research suggested that farmers were probably getting relatively poor returns from N-P fertilizers that were being broadcast.

Band Placement   Agronomists at WCFL have been encouraging the development of equipment that would enable the application of fertilizer in pre-planting, sub-surface bands in combination with a regular, required field cultivation in the interest of reducing field operations and reducing costs. The tillage implement utilized in all cases was a deep tillage field cultivator.

The data presented in Table VIII summarize the results obtained in some trials comparing pre-plant banded to broadcast and incorporated N-P fertilizers for wheat, rapeseed, and flax. The benefits of deep banding of nitrogen and phosphate in common bands were quite striking and the extra yield associated with a different method of placement of an equal amount of fertilizer were often enough to pay several times over, the total cost of the fertilizer applied.

The field in which plot #4 was located was subjected to some deep discing between the time the fertilizer was applied and the flax crop was seeded. It is obvious that the benefit of band placement of fertilizer is lost if the field is cultivated sufficiently deep to disturb the bands.

Table VIII - Yield of Grain Grown on Stubble as Influenced by Method of Fertilizer Placement (WCFL, 1979)

		Yield (Cwt/Acre)		
Site	Crop	Check	Broadcast	Band
#1	Wheat	14.3	21.6	24.5
#2	Wheat	16.5	18.5	25.3
#3	Rape	8.3	12.9	17.1
#4	Flax *	7.4	9.3	9.5
#5	Flax	3.7	4.7	6.8

* Bands disturbed due to excessive cultivation prior to the crop being seeded.

Note: Suspension based fertilizer (21-8-0) applied at the rate of 250 lbs/acre for wheat and flax, and 350 lbs/acre for rapeseed.

Placement and Rooting Pattern Field examination indicated that method of fertilizer placement had a distinct influence on the type of rooting system that developed. Moisture conditions at seeding were very favourable and were followed by some timely showers. As a result, in the broadcast treatments, the crop established the bulk of its rooting system in the nutrient-rich surface layer into which the broadcast fertilizer had been incorporated. In contrast, where the fertilizer had been banded, the crop developed a much deeper and stronger rooting system. This crop was therefore much better equipped to mine sub-soil moisture reserves and thus more effectively survived a dry spell in the latter part of the growing season.

Dual Application of N-P Fertilizer One trial was established in a phosphate-deficient fallow field in which various combinations of placement of nitrogen were compared for rapeseed. The data presented in Table IX illustrate a distinct benefit for applying nitrogen and phosphate in a common band rather than applying both by broadcasting or in separate operations. There is a great deal of research data available that suggest that nitrogen (particularly in the ammonium form) has a beneficial influence on the uptake of phosphate by plants if the nitrogen and phosphate are applied in a common band. The results obtained at this site confirm the benefits of this type of dual band application.

Table IX - Yield of Rapeseed Grown on Summerfallow as Influenced by Method of Nitrogen and Phosphate Placement (WCFL, 1979)

Yield (Cwt/Acre)

Placement	0	N (BC)	N (B)	Average
0	16.4	18.1	17.3	17.3
P_2O_5 (BC)	22.5	22.0	22.7	22.4
P_2O_5 (B)	23.0	23.7	24.7	23.8
Average	20.6	21.3	21.6	21.2

Nitrogen applied as 46-0-0 @ 50 lbs N/acre.
Phosphate applied as 0-45-0 @ 50 lbs P_2O_5/acre.
Note: Drill in (20 lbs P_2O_5/acre) applied to all plots.

OBSERVATIONS AND RECOMMENDATIONS

1) This research clearly demonstrates that spring-applied Agri-sul does not appear to mineralize rapidly enough to be of benefit for rapeseed grown on soils containing less than 20 lbs. of available SO_4-S/acre in the 0 - 24" depth of soil.

2) Spring-applied Agri-sul can be an effective sulphur source for rapeseed on soil containing between 20-30 lbs. of available SO_4-S/acre in the 0 - 24" depth of soil.

3) In very sulphur-deficient soils, Agri-sul should be applied in the fall, and if possible during the fallow period preceding the rapeseed crop to allow more time for mineralization to a plant-available form of sulphur.

4) The fertilizer industry needs a product similar to Agri-sul to meet the ever-increasing demand for sulphur. Therefore, there exists a need to conduct research on the performance of fall-applied Agri-sul (i.e. longer period for oxidizing elemental sulphur to sulphate).

5) Research should be initiated to determine the performance of Agri-sul in a farming programme where this material is applied annually compared to a "one-shot" application.

6) Research should be initiated to define the factors involved in determining the rate at which Agri-sul is mineralized to plant-available sulphate-sulphur.

7) Boron and potash as well as sulphur appear to be factors, at least in some fields, where rapeseed has yielded poorly due to lack of pod formation or seed set.

8) Rapeseed appears to respond much more strongly to N-P fertilizers that are placed in concentrated bands below the depth of seeding as compared to the usual approach of broadcasting and incorporating these nutrients.

9) Additional research is required to define the relationship of drill-in (i.e. starter) fertilizer to fertilizer placed in sub-surface bands in a pre-planting operation.

10) Application of N-P fertilizers can encourage deeper, stronger rooting systems whereas broadcast and incorporated fertilizers can encourage a shallow rooting system established in the nutrient-rich layer concentrated near the surface.