FIELD SALINITY STUDIES IN FLAX

Dr. Gordon G. Rowland
Crop Development Centre
University of Saskatchewan

With the production of a tissue-culture derived salt-tolerant selection (STS) of flax (Linum usitatissimum) cv. McGregor at the Crop Development Centre (McHughen and Swartz 1984) it was obvious that a field testing programme was going to be needed to determine if STS had any field salinity tolerence. Less obvious was exactly how this line should be tested in the field to determine whether the hypothesis that STS was more saline tolerant than McGregor was correct. The extreme variability of salinity in fields precluded using ordinary test plot designs as salinity levels change drastically both between and within normal sized plots. Sampling for yield, or other plant characters, and soil salinity would need to done within a small unit of land. Also a factor in designing experiments was a need to try to compensate for the difference in flowering and maturity between STS and McGregor (Table 1). Since STS flowered and matured so much earlier it might be possible that any difference between STS and McGregor could be explained on the basis of growth or vigour. A further confounding factor, and a very basic one, was what is salinity tolerance and how should it be measured?

MATERIALS AND METHODS

After much discussion it was decided that two experiments would be grown, one which would measure biological yield and

another that would look mainly at plant growth characters. It was hoped that one or some of these characters would respond to salinity. Experiment A compared seed and plant dry weight yield of STS with McGregor. Experiment B compared the differences in germination , plant growth, days to flowering, days to maturity, branching and seed yield per plant of STS, McGregor and Noralta. The experiments were grown at three locations in 1985 within an 80 km radius of Saskatoon. Three locations were chosen so as to minimize the probability that adverse weather conditions would badly damage all the plots and so that more than one soil type would be utilized. The three locations were Floral (Bradwell loam), Langham (Elstow clay loam) and Blaine Lake (Blaine Lake silty clay loam) on land that was known to have slainity problems. Floral and Langham are in the Dark Brown soil zone while Blaine Lake is a Black soil. The sowing dates were May 16 at Floral, May 21 at Langham and May 27 at Blaine Lake.

Table 1. A comparison of STS with five other flax cutivars grown on non-saline sites at three locations in Saskatchewan in 1984.

	Yield (kg.ha-1)	Oil (%)	1000 seed wt. (g)	Days+ to flower	Days+ to maturity	Height+ (cm)
STS	1100a*	36.1b	5.0	66.8a	92.7a	45.3ab
McGregor	1176a	36.8a	4.7	69.0b	95.3b	44.8ab
Linott	1099a	36.9a	4.9	66.5a	96.0b	45.7ab
Noralta	1010b	34.7d	4.7	66.7a	92.0a	45.5ab
NorLin	978b	35.4c	4.9	68.5b	92.7a	47.3a
NorMan	1170a	36.8a	4.9	66.7a	92.0a	43.0b

*Means followed by the same letter are not significantly different at the 1% level of significance as measured by the Duncan's Multiple Range Test.
+One location only.

In Experiment A McGregor and STS were sown in ten 30 m strips. Each strip was 1.4 m wide and contained 8 rows. Within each strip four randomly chosen m2 areas were marked out immediately after sowing and a 0-15 cm soil sample was taken. When the marked-off area ripened, all plants were pulled, counted and the bundle weighed for total dry matter. The plants were then threshed and the seed was cleaned and weighed. After harvest each m2 area was then soil sampled at 0-15, 15-30 and 30-60 cm depths.

For Experiment B a 10 m2 area was used and grid lines marked-out each 84 cm. At each grid intersection a paired plot was sown consisting of a 30 cm row (45 seeds per row) of each member of the pair spaced 15 cm apart. The three pairs used were McGregor-STS, Noralta-STS and McGregor-Noralta and these were arranged randomly throughout the grid. There were 48 plots of each pair. At each grid intersection a soil sample was taken at the 0-15 cm depth immediately after sowing. Records were kept on each pair as to number of seedlings and plant number at maturity. For five plants in each row notes were taken on weekly height beginning on the 12th day after planting , number of days to branch appearance, number of days to flowering, number of days to maturity and number of seeds per plant. The total seed yield of each row was also determined.

Soil conductivity (mS.cm-1) was estimated by the 1:1 soil:water method on all soil samples by the Saskatchewan Soil Testing Laboratory. The 1:1 conductivities were used for all analyses but for reporting purposes are converted, by use of regression equations, to saturated paste values (Hogg and Henry,

1984).

The data from Experiment A were analysed by calculating regression lines for each of the varieties with the mean salinity for 0-60 cm as the independent variable and the character under study as the dependent variable. The null hypothesis that B1-B2=0 was then tested for each character.

In Experiment B a paired t test was used to compare the differences between the variety pairs at non-(0-2 mS.cm-1), slightly (2-4 mS.cm-1) and moderate (4-8 mS.cm-1) saline levels for the characters under study at Langham, but only at moderate salinity levels at Floral and Blaine Lake. Regression equations for each character were compared by subtracting the McGregor or Noralta data from STS and regressing the difference against salinity level. A significant regression coefficient would then indicate a significant difference between the slope of the STS and the variety it was compared against. Furthermore, for each variety within a salinity level height was regressed against the day a measurement was taken in order to see if growth rates differed for the varieties.

RESULTS AND DISCUSSION

In Experiment A plant number, seed yield and straw yield of McGregor was greater than STS at all three locations. There was generally no significant difference between the regression coefficients of STS and McGregor for plant number, total dry weight, seed yield and straw yield. However, at Langham the total dry weight and straw yield of McGregor declined significantly ($p=0.01$) faster as salinity increased. There also was an

indication from Floral and Langham that in the highly saline areas (i.e. >8 $mS \cdot cm^{-1}$) McGregor was affected far more than STS.

In Experiment B there were usually significant diferences between the STS and McGregor or Noralta for days to flowering, days to maturity, seed yield and number of plants that survived over all salinity levels at all locations (Table 2). STS was much earlier in flowering and usually in maturity than McGregor and Noralta. This was the result of STS elongating much faster during the period 27 to 48 days after planting (Figure 1). This was so for all salinity levels and the differences in height between STS-McGregor and STS-Noralta were usually significant ($p=0.001$) at 33, 40 and 48 days after planting. There was no difference in the slopes between STS and McGregor and STS and Noralta at any of the sites and salinity levels. If the Langham site is examined one can see that the affect of increasing salinity is to delay the start of growth but the rate of growth remains the same. Thus, STS growing in moderately saline areas at Langham begins growth at the same time and with the same rate as McGregor in the non-saline areas giving the STS the appearance of salinity tolerance.

Although there were often significant differences between STS, McGregor and Noralta in flowering, maturity, plant survival and yield over the entire range of salinities found at the three sites, there was generally no difference in the slope of their regression lines. This indicates that the varieties were responding the same to salinity. The one exception to this was yield at Floral where the yield of McGregor declined significantly ($p=0.01$) faster as salinity increased than did STS.

The yield of McGregor was greater than STS until 8.6 mS.cm-1 at which point the lines intersect.

Table 2. Means for some characters of STS, McGregor and Noralta grown in Experiment B at Floral, Langham and Blaine Lake and the significance of the t tests between the the variety pairs.

Location, variety and variety pair	Conductivity range (mS.cm-1)	Days to flower	Days to maturity	Yield (g)	Number of plants surviving
Floral					
STS	4.1-8.6	52.5	109.5	15.3	24.4
McGregor	4.4-8.6	57.7	113.4	23.6	21.9
Noralta	4.1-8.6	56.1	110.8	19.9	21.5
S-M		***	***	***	NS
S-N		***	***	***	**
M-N		***	***	NS	NS
Langham					
STS	0.4-7.2	49.4	103.1	25.9	28.3
McGregor	0.4-7.2	54.5	107.3	34.0	25.7
Noralta	0.4-6.4	52.4	104.0	27.9	27.5
S-M		***	***	***	*
S-N		***	***	***	NS
M-N		***	***	***	NS
Blaine Lake					
STS	5.0-8.0	46.3	95.8	4.2	20.6
McGregor	5.0-8.0	50.3	98.4	5.1	25.4
Noralta	5.3-8.0	49.0	97.0	5.2	23.2
S-M		***	***	**	***
S-N		***	NS	*	NS
M-N		**	NS	NS	NS

*,**,*** significant at 5, 1 and 0.1 %, respectively.

In conclusion, there appears to be some evidence that STS possesses some level of salinity tolerance but further field testing is going to be needed to determine this level and its importance. The summer of 1985 had quite an influence on the varieties that were used in this study. July had near normal temperatures but the mean temperature for August and September at

Saskatoon were 2.1 and 2.9 oC below normal, respectively. This was an advantage to the later maturing McGregor which was able to continue flowering and producing bolls much longer than either STS or Noralta. Thus, a summer that would put a more equal heat stress on the varieties might change the way in which they respond to salinity.

ACKNOWLEDGEMENTS

The support of the Western Grain Research Fund and the technical assistance of Christine McOnie are very gratefully acknowledged.

REFERENCES

Hogg, T.J., and J.L. Henry. 1984. Comparison of 1:1 and 1:2 suspensions and extracts with the saturation extract in estimating salinity in Saskatchewan soils. Can. J. Soil Sci. 64: 699-704.

McHughen, A. and M. Swartz. 1984. A tissue-culture derived salt-tolerant line of flax (Linum usitatissimum). J. Plant Physiol. 117: 109-117.

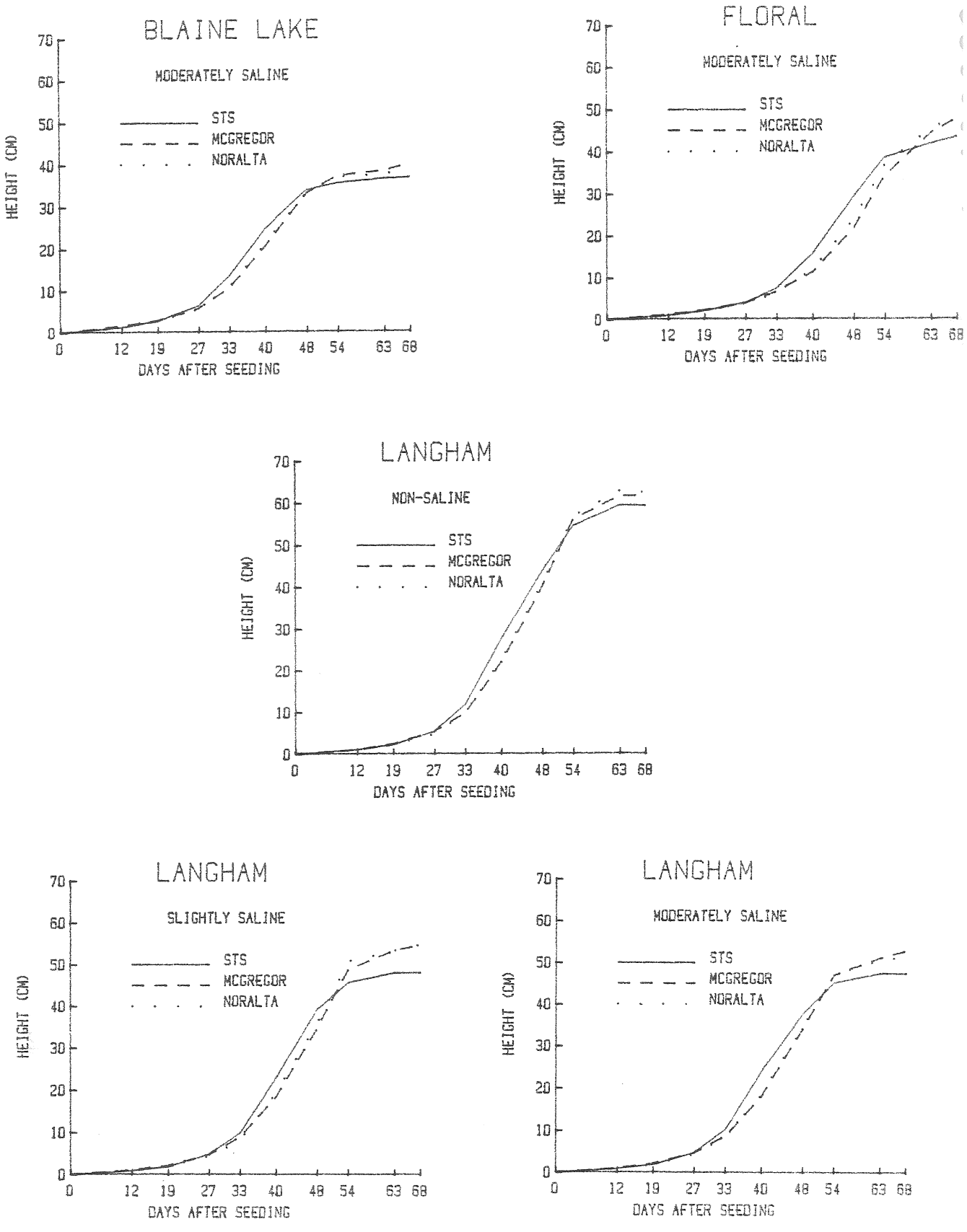

Figure 1. Growth of STS, McGregor and Noralta at three locations.