EFFECT OF PRODUCTION ENVIRONMENT ON YIELD AND QUALITY OF WINTER RAPESEED IN THE U.S.A.

K.A. Mahler(1), D.L. Auld(1), B. Shafii(1), W.J. Price(1)

(1) University of Idaho, College of Agriculture
Moscow, Idaho USA 83843

INTRODUCTION

During the 1986-87, 1987-88, and 1988-89 growing seasons, six cultivars of winter rapeseed were grown at 12, 16, and 17 locations across the U.S., respectively. Seed was harvested to determine seed yield and oil content. Self-pollinated seed was used to determine fatty acid composition and open-pollinated seed used to determine glucosinolate content. The objective of this study was to determine the influence of genotype and environment on seed yield, oil content, fatty acid composition, and total glucosinolate content.

MATERIALS AND METHODS

In the fall of 1986, 1987, and 1988 the National Winter Rapeseed Variety Trial was seeded at 12, 16, and 17 locations across the U.S., respectively (Mahler et al. 1986; Mahler, et al. 1987; Mahler et al. 1990) (Fig. 1). This trial contained six cultivars which were grown at each location to allow comparisons of seed yield, oil content, fatty acid composition, and glucosinolate content. Open-pollinated seed harvested in 1987, 1988, and 1989 was used to determine seed yield in kg ha^{-1}. Open-pollinated seed from these plots was used to measure both oil and glucosinolate content. Oil content was determined by standard NMR procedures. Glucosinolate concentrations were analyzed for six cultivars using the trimethylsilyl (TMS) procedure used by the Canadian Grain Commission (Daun and McGregor 1983). This gas chromatography procedure uses allyl-glucosinolate as the internal standard. Fatty acid composition was determined by using self-pollinated seed grown at each location. The average of each cultivar across locations was calculated. Analysis of variance was used to estimate the effect of cultivar, production environment, and their interaction.

RESULTS AND DISCUSSIONS

Average seed yield of the six cultivars of winter rapeseed grown at the 27 locations ranged from 728 to 6247 kg ha^{-1} (Table 1). Analysis of variance indicated that production environment and cultivar X environment significantly influenced seed yield while cultivar differences did not (Table 2). Generally greater differences were detected between cultivars in those environments producing seed yields greater than 3000 kg ha^{-1}.

Average oil contents of the six cultivars grown at 25 locations ranged from 33.6 to 45.5% (Table 1). Analysis of variance indicated that cultivar, environment, and the interaction of cultivars with production environments significantly influenced oil content (Table 2). The oil content of the six cultivars differed more in the production environments in the Southern U.S. where oil contents were often below 38.0%.

Average glucosinolate content of the six cultivars grown at 18 locations ranged from 56.8 to 113.5 μmoles g^{-1} (Table 1). Analysis of variance indicated that cultivars, production environment, and their interaction had significant effects on total glucosinolate concentration (Table 2). The glucosinolate concentrations of the cultivars averaged over all production environments ranged from 22.8 to 148.1 μmoles g^{-1} for Cascade and Jet Neuf, respectively. The cultivars selected for reduced levels of glucosinolates were less sensitive to environmental conditions.

The average oleic acid concentration of the Low Erucic Acid Rapeseed (LEAR) cultivars at 11 locations ranged from 50.1 to 57.6% of the methyl esters derived from extracted oil (Table 1). Cultivar, environment, and their interaction all had a significant influence on oleic acid concentration (Table 2). The oleic acid concentration of the LEAR cultivars ranged from 40.1 to 60.6%. Average oleic acid concentration of the two High Erucic Acid Rapeseed (HEAR) cultivars at these locations ranged from 5.8 to 17.9%.

The average erucic acid content of the two HEAR cultivars across the 11 locations ranged from 42.5 to 51.7% (Table 1). Cultivar and production environment did not statistically influence erucic acid concentration but their interaction was significant (Table 2). At those locations with low levels of erucic acid, Bridger had slightly higher levels of erucic acid than Dwarf Essex. The early maturing cultivar, Bridger, apparently was able to accumulate higher levels of erucic acid at the warmer locations.

CONCLUSIONS

Seed yield at the 27 location years analyzed ranged from 728 to 6247 kg ha^{-1} while oil content at 25 location years ranged from 33.6 to 45.5%. Fatty acid composition was determined at 11 location years for five of the cultivars. Oleic acid content of the LEAR cultivars ranged from 40.1 to 60.6% and erucic acid content for the HEAR cultivars ranged from 42.5 to 51.7%. Total glucosinolate content was analyzed for the six cultivars for 18 location years. Total glucosinolate content ranged from 9.0 μmoles g^{-1} for the cultivar Cascade at New York in 1989 to 190 μmoles g^{-1} for Dwarf Essex at Idaho in 1987.

The cultivars X environment interaction had a significant impact on the yield and quality of rapeseed grown across the United States. No single cultivar produced the highest yield, the highest oil content, or had the best quality factors across all of the production environments evaluated in this study. Optimum yield, oil content, and quality factors will require the development of specific cultivars adapted to individual production environments. Private industry and public researchers must work together in the development of these cultivars to ensure Canola and industrial rapeseed become a viable industry for United States agriculture.

REFERENCES

DAUN, J.K. and MCGREGOR, D.I. 1983. Glucosinolate analysis of rapeseed (Canola). Method of Canadian Grain Commission Grain Research Laboratory (2nd ed.). Agriculture Canada, Winnipeg. 32 p.

MAHLER, K.A., AULD, D.L., FIKE, W.T., HAIRSTON, J.E., HANG, A.N., HYERDAHL, R.H., JOHNSON, L., KARLEN, D.L., KAROW, R., MCBEE, G.G., RAYMER, P.L., STARNER, D.E. and WELTY, L. 1986. National winter rapeseed variety trial 1986-87. Idaho Ag. Exp. Stn. Misc. Ser. No. 113.

MAHLER, K.A., AULD, D.L., HAIRSTON, J.E., HANG, A.N., HYERDAHL, R.H., KAROW, R., LAWLESS, J., MCBEE, G.G., PUTNAM, D., RAYMER, P.L., STARNER, D.E., UNDERSANDER, D.L. and WELTY, L. 1987. National winter rapeseed variety trial 1987-88. Idaho Ag. Exp. Stn. Misc. Ser. No. 120.

MAHLER, K.A., AULD, D.L., CHRISTENSEN, N.L., FIKE, W.T., FRIBOURG, H., HAIRSTON, J.E., HANG, A.N., HILL, J., KAROW, R., MCBEE, G.G., RAYMER, P.L. and STARNER, D.E. 1990. National winter rapeseed variety trials 1988-89. Idaho Ag. Exp. Stn. Misc. Ser. No. 130.

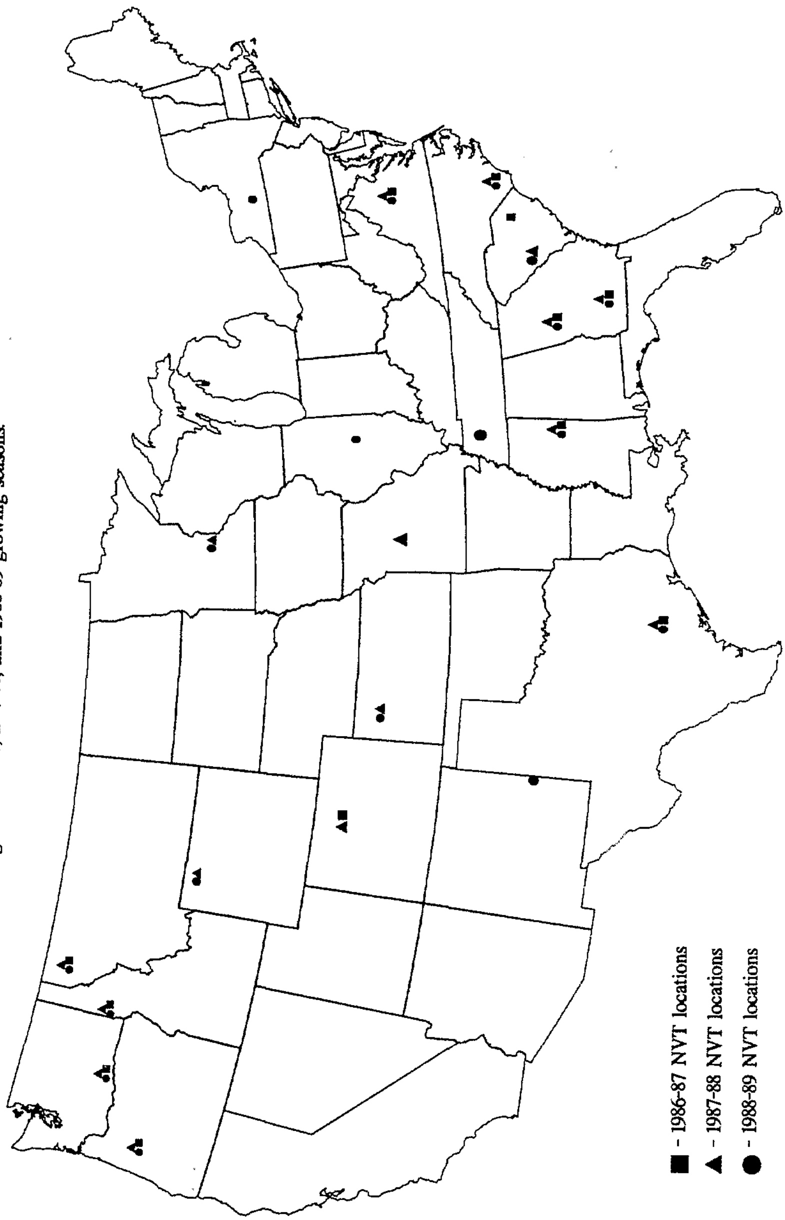

Figure 1. Forty-six locations of the National Winter Rapeseed Variety Trial across the U.S. during the 1986-87, 1987-88, and 1988-89 growing seasons.

Table 1. Average seed yield, oil content, glucosinolate levels, and selected fatty acid concentrations of six cultivars of winter rapeseed grown at 27 locations across the U.S. from 1987 to 1989.

Location	Year	Seed Yield	Oil Content	Total Glucosinolate	Four LEAR Oleic Acid Content	Two HEAR Erucic Acid Content
		kg ha^{-1}	--%--	-μmole g^{-1}-	---%---	---%---
Idaho	1988	6247	39.6	74.7	50.1	48.7
Idaho	1989	5393	39.3	65.1	57.6	49.6
Washington	1987	4417	45.5	----	----	45.7
Washington	1988	4045	42.8	----	----	47.3
Oregon	1987	3626	41.9	86.3	51.6	42.5
Montana	1987	3130	37.8	101.1	57.0	51.7
Washington	1989	3122	44.4	----	----	----
Virginia	1988	3087	39.3	77.0	54.1	49.6
New York	1989	3066	43.6	61.0	----	----
Oregon	1988	3030	42.7	90.0	52.8	45.2
Mississippi	1988	2485	40.6	----	----	----
Tennessee	1989	2471	39.8	71.2	----	----
South Carolina	1987	2461	41.2	96.2	54.5	43.6
South Carolina	1989	1813	35.2	56.9	----	----
Georgia (G[1])	1989	1687	38.8	70.5	----	----
Virginia	1989	1685	----	----	----	----
Kansas	1988	1401	39.3	----	----	----
Georgia (G)	1987	1396	34.2	85.3	----	----
Georgia (T[1])	1987	1352	37.6	98.7	----	----
North Carolina	1989	1254	---	----	----	----
South Carolina	1988	1183	37.6	73.2	----	----
North Carolina	1987	1121	41.0	84.9	----	----
Idaho	1987	1012	35.4	113.5	----	----
Texas	1987	998	33.6	----	51.8	44.2
Georgia (T)	1988	976	36.6	77.9	----	----
Georgia (T)	1989	757	33.7	56.8	----	----
Texas	1988	728	35.4	----	----	----
$LSD_{(0.05)}$		276	1.3	16.8	3.4	5.9

1 - Georgia (G) - Griffin, GA; Georgia (T) - Tifton, GA.

Table 2. Analysis of variance of six cultivars of winter rapeseed grown at 27 locations during the 1986-87, 1987-88, and 1988-89 growing seasons.

Source	Seed Yield		Oil Content		Glucosinolates		Oleic Acid		Erucic Acid	
	df	F Value	df	F Value	df	F Value	df	F Value	df	F Value
Cultivars	5	1.1ns	5	36.6**	5	211.3**	4	658.4**	1	2.3ns
Envir.	26	54.0**	24	49.9**	13	3.6**	10	6.0**	10	2.8ns
Cultivar X Envir.	130	4.0**	120	3.7**	65	5.1**	40	2.9**	10	2.6*
CV (%)		20.5		3.1		14.6		6.3		4.6

ns,*,** - Nonsignificant and significant at the 0.05 and 0.01 levels, respectively.