SOYBEAN CULTIVARS BETTER SUITED TO THE NEW ZEALAND CLIMATE

S.J. McCormick
Ruakura Soil and Plant Research Station,
Ministry of Agriculture and Fisheries, Hamilton
and
J.A.D. Anderson
Crop Research Division, DSIR, Pukekohe

ABSTRACT

Under the warm, variable summer temperatures of northern New Zealand soybean yields of 2 to 4 t/ha can be obtained with U.S.A. Group II maturity cultivars but yield is erratic. High yield requires a late spring sowing but results in an untimely mid autumn harvest.

Cool tolerant cultivars Fiskeby V (Sweden), Geiso (Germany) and BC-18-2-12 (Canada) which continue to set pods at lower temperatures than most U.S.A. cultivars were found to yield more consistently (mean c.v. = 13%) than the currently used U.S.A. cultivar Amsoy 71 (c.v. = 27%). Geiso and BC-18-2-12 matured 2 to 3 weeks earlier than Amsoy 71 and, at 3t/ha, gave similar yield but Fiskeby V which was 5 weeks earlier, yielded 20% less.

Seven of a further ten F_3 lines selected from the Canadian cool tolerant breeding programme showed low yield variability and appeared to be cool tolerant. Three of these yielded 103 to 113% of Amsoy 71 and matured 2 to 3 weeks earlier.

In one of two mid spring sowings which gave the desired early autumn harvest, four cool tolerant cultivars or lines yielded 30% more than Amsoy 71. Their yields at the early sowing were equal to, or only slightly less than, the yield of Amsoy 71 at the late spring sowing.

Cultivars with low temperature tolerance during flowering were considered better adapted to production in New Zealand. The Canadian breeding programme was seen to offer good prospects for developing consistently high yielding cultivars for early autumn harvest and improving on soybean production in New Zealand.

Additional Key Words: cool tolerance, seed yield, sowing date.

INTRODUCTION

In research and limited commercial production, soybeans have been found capable of yielding 2 to 4 t/ha in the northern area of New Zealand (McCormick, 1974, 1980). Agronomically, two problems prevent the general acceptance of the crop for commercial production. Currently, high yield is obtained by sowing Group II maturity cultivars in late November but seasonal variation in yield is high (McCormick, 1974). Secondly, with late November sowing, the crop matures in mid April when weather conditions for harvesting are likely to be unfavourable. Earlier sowing or the use of short season (Group OO-I) cultivars to achieve an earlier harvest date leads to reduced yield (McCormick, 1976). Both problems are seen as the consequence of inadequate summer temperatures during the flowering and, to a lesser extent, the pod filling periods (McCormick, 1975).

To date, cultivar selection has been based predominantely on U.S.A. commercial lines. Phytotron studies (Hume and Jackson, 1981) have recently shown the lower limits of temperature for pod setting in Group O-III, genotypes range from 13 to 18°C. Amsoy, the Group II cultivar which has given the highest yield most consistently in the field, proved to be one of the more low temperature tolerant of the U.S.A. cultivars tested. Fiskeby V, a cultivar bred by Holmberg (1973) for improved yield under the variable, low temperatures of the Swedish summer, was found to continue pod setting at temperatures down to 9°C.

The value of cool tolerant cultivars, those having the ability to continue to set pods at low temperatures, has been recognised for other regions. In Canada, Voldeng *et al.*(1978) have developed cultivars for use in the northern areas from crosses between the North American and Fiskeby V. genotypes.

Such cool tolerant cultivars could be expected to improve soybean productivity in New Zealand by allowing early sowing to give a late March harvest without loss in yield. Both full and short season cultivars could be expected to be more productive and show reduced seasonal yield variation.

The provision by the DSIR of off-season multiplication facilities for the Canadian bred lines has given access to a range of lines for evaluation in New Zealand.

MATERIALS AND METHODS

The Canadian lines were tested in Pukekohe (Lat. 36° 57'S) in 1977 and in Hamilton (Lat. 37° 47'S) and Pukekohe from 1978 to 1980 in a total of 11 trials over the four years. The lines and cultivars tested are listed in Table 1.

TABLE 1: Lines and cultivars tested.

Line/ Cultivar	No. Trials	Identification
Amsoy 71	11	U.S.A. commercial cultivars, not cool tolerant
Wayne	7	
Matsoy	5	
Amsoy X T19	5	U.S.A. early line ex Teweles Seed Co., not cool tolerant
Fiskeby V	9	Swedish, cool tolerant cultivar
Geiso	7	German, cool tolerant cultivar
BC-18-2-12	11	Pure line, ex Canada 1977, cool tolerant
DX-3-4	11	Ex Canada 1977, F4, cool tolerance unknown
X 249-25-1a	11	
X 249-34-2a	6	
X 451-1a	6	
K 618-5	5	Ex Canada 1979, F3, cool tolerance unknown
K 630-1	5	
K 731-1	5	
K 738-1	5	

Except for 1980, all trials were sown in late November. In 1980, sowings were made in late October and early December to evaluate the relative performance of the Canadian lines under earlier, cooler, flowering conditions.

Testing commenced with single row replicated plots and continued with four row plots as seed availability increased. In all trials, yields and harvest maturity dates were recorded with more detailed information on plant characteristics being taken on some trials. Where detailed crop development was recorded, growth stage were identified according to Fehr *et al.* (1971).

Performance assessment

Yield. Each entry was not present in all trials. Hence performance assessment by comparison of mean yields across trials may be biased by local and seasonal differences in trial yield levels. To avoid bias, within each trial, yield of an entry was expressed relative to the mean yield of the entries Amsoy 71, BC-18-2-12, DX-3-4 and X 249-25-1a as these four were common to all trials. The mean relative yields taken across trials were then adjusted to give Amosy 71 = 100.

Yield variability. The coefficient of variation of the mean yield of each entry across trials and the minimum yield expected one year in ten were calculated. These values were seen as measures of the tolerance of each entry to the variations in seasonal and local environments encountered.

Maturity ranking. Similarly to yield, maturity of an entry was assessed as days earlier (−ve) or later (+ve) than Amsoy 71 within each trial and the mean ranking across trials determined.

RESULTS AND DISCUSSION

Yield variability and cool tolerance

The three known cool tolerant entries, BC-18-2-12, Fiskeby V and Geiso, showed markedly less yield variability than Amsoy 71 (Table 2). With Amsoy 71 known to be less tolerant of low temperatures at flowering, this result supports the idea that cool tolerant cultivars would be better adapted to production under the warm, though variable, temperatures of the New Zealand summer. Conversely, the result implies that lines showing low yield variability compared to Amsoy 71 over a range of trials were likely to be cool tolerant. This initial identification of probable cool tolerance in early generation lines is significant because not all lines of cool tolerant parentage carry the trait. The trait may be tested for under controlled environment (Hume and Jackson, 1981) but the small number of plants used makes the test inconclusive when applied to early generation, segregating lines.

TABLE 2: Yield variability and yield and harvest maturity date compared to Amsoy 71.

Line/ Cultivar	Yield variation CV%	Yield low 1 yr in 10 t/ha	Relative yield Y*% Amsoy 71 = 3.01 t/ha	harvest maturity: days ± Amsoy 71
Amsoy 71	27	1.90	100	0**
Wayne	26	1.71	97	+2
Matsoy	17	2.45	116	+8
Amsoy x T19	31	1.23	74	−7
Fiskeby V	14	1.86	79	−34
Geiso	16	2.26	104	−13
BC-18-2-12	13	2.49	102	−19
DX-3-4	17	2.11	92	−21
X 249-25-1a	17	1.88	83	−14
X 249-34-2a	13	2.18	86	−18
X 451-1a	32	1.51	91	9
K 618-5	26	1.55	93	−3
K 630-1	9	2.63	113	−12
K 731-1	10	2.41	105	−15
K 738-1	16	2.09	103	−15

* Y = y (entry)/$\bar{y}$ (Amsoy 71, BC-18-2-12, DX-3-4 and X 249-25-1a).

** For December 1 sowing, harvest maturity date 0 = April 17.

Yield and maturity

Amongst the cool tolerant entries, Fiskeby V matured five weeks ahead of Amsoy 71 but was of too short a growth duration to compete favourably in yield. Mean yield of Amsoy 71 was 3.01 t/ha and Fiskeby V yielded 20% less (Table 2). However, both the Canadian line BC-18-2-12 and the German cultivar Geiso yielded as well as Amsoy 71 and showed the dual advantages of a more consistent yield and a harvest 2-3 weeks earlier.

Of the five Canadian lines tested from 1977, DX-3-4, X249-25-1a and X 249-34-2a showed low yield variability and like BC-18-2-12, appeared to be cool tolerant. Though more consistent in yield than Amsoy 71 and having the advantage of maturing 2-3 weeks earlier, the three lines yielded 8-17% less and were seen as inferior to BC-18-2-12 as replacements for Amsoy 71. The remaining line, X 451-1a, of similar maturity ranking to Amsoy 71, was not as consistent in yield and yielded less.

The K series of Canadian lines were tested only in 1979 and 1980. Over the five trials which included the U.S.A. cultivar Matsoy, the yield coefficient of variation for Amsoy 71 was 21%. Two of the K lines, 630-1 and 731-1, appeared to be cool tolerant having a lower yield variability than either U.S.A. cultivar but similar to that of the three known cool tolerant cultivars whose coefficient of variation for the five trials averaged 11%. These two K lines matured two weeks ahead of Amsoy 71 and were of similar yield level to Amsoy 71, BC-18-2-12 and Geiso.

Growth characteristcis

Agronomically, Amsoy 71 with its strong, upright growth habit, low susceptibility to lodging and disease and with pods borne well clear of the ground for good combine recovery, has been found most acceptable as a commercial cultivar (Table 3). The high yielding Canadian line, BC-18-2-12 showed many similar characteristics but, with shorter internodes, was not as tall and tended to set pods lower to the ground. The shorter stature could be advantageous under vigorous growth conditions but the lower podset needs to be considered in relation to likely combining losses. The equally high yielding German cultivar, Geiso, with a semi prostrate habit, vinelike growth and greater susceptibility to lodging, was judged far less suitable than BC-18-2-12 for commercial production.

TABLE 3: Plant characteristics of cultivars and lines tested.

Line/ Cultivar	Height cm	100 Bean wt g	Relative lodging*	Height 1st pods cm	Number nodes
Amsoy 71	86	19	2	16	15
Wayne	87	18	3	16	17
Matsoy	90	19	2	15	17
Amsoy X T19	61	17	2	-	13
Fiskeby V	50	17	1	8	10
Geiso	76	17	3	16	15
BC-18-2-12	66	20	2	11	14
DX-3-4	73	16	3	12	12
X 24a9-25-1a	83	19	4	20	15
X 249-34-2a	83	-	4	17	13
X 451-1a	103	-	5	22	15
K 618-5	84	20	1	13	16
K 630-1	81	19	3	14	15
K 731-1	69	20	2	12	15
K 738-1	78	18	3	14	13

*Ranking 1 = negligible to 5 = extensive.

All four remaining Canadian lines tested from 1977 were weaker in growth habit than Amsoy 71 or BC-18-2-12 and more susceptible to lodging. Line X 451-1a, with tall weak growth, was particularly prone to lodging and also highly susceptible to bacterial leaf blight (*Pseudomonas glycinea*). The K series of Canadian lines were of stronger growth habit, intermediate in height between BC-18-2-12 and Amsoy 71 and similar to Amsoy 71 in node number, bean weight and lodging susceptibility. Pods were borne closer to the ground than with Amsoy 71 but not as low as in the BC-18-2-12 line.

Response to sowing date

The yields obtained from late October and early December sowings made in 1980 are compared in Table 4. Typically, the yield of Amsoy 71 increased by around one third with the later sowing in Hamilton with the yield of the other USA cultivar Matsoy showing a substantial increase also. With the exception of K618-5 and K630-1, the Canadian lines and the two cool tolerant cultivars, Fiskeby V and Geiso, showed a relatively minor change in yield. At Pukekohe, however, cultivars Amsoy 71 and Matsoy yielded as well from the early as from the late sowing. Though there was no change in yield in the two U.S.A. cultivars, the two Canadian lines BC-18-2-12 and K630-1 and Fiskeby V increased in yield with the later sowing. Temperature records provided an explanation for the higher yield of the less cool tolerant U.S.A. cultivars at Pukekohe compared to Hamilton in 1980 and the lack of yield increase recorded for the late sowing at Pukekohe. Both early and late sowings at Pukekohe experiences some 70 hours of temperatures less than 15°C during the flowering period. At Hamilton, the early sowing experience 160 hours and the late sowing 100 hours. Whether the higher yields for the supposedly cool tolerant Canadian lines and Fiskeby V in the later sowing at Pukekohe were temperature related is not known.

TABLE 4: Yield response to sowing date in two localities (t/ha).

Line/ Cultivar	Hamilton			Pukekohe		
	Oct.	Dec.	% change	Oct.	Dec.	% change
Amsoy 71	2.04	2.84	+39	3.62	3.54	−2
Matsoy	2.46	3.01	+22	3.86	3.59	−7
Fiskeby V	2.11	1.99	−6	1.96	2.55	+30
Geiso	2.73	2.80	+3	3.23	3.16	−2
BC-18-2-12	2.40	2.66	+11	2.95	3.37	+14
X 249-25-1a	1.89	1.73*	−8	2.73	2.73	0
K 618-5	1.61	2.22	+38	3.20	2.89	−10
K630-1	2.69	3.14	+17	2.89	3.51	+21
K 731-1	2.56	2.50	−2	2.81	2.92	+4
K 738-1	2.44	2.26	−7	3.15	3.13	−1
LSD 5%	0.34	0.64		0.45	0.44	

* Crop 100% lodged.

At Hamilton, four of the seven Canadian lines and Geiso outyielded Amsoy 71 in the early sowing with their yields from the early sowing being equal to, or only slightly less than, the yield of Amsoy 71 in the late sowing. At Pukekohe, lines K618-5 and K738-1 showed a similar performance relative to Amsoy 71. Though one year's evidence is insufficient to categorise the response of the Canadian lines to early sowing it appeared that at least some of the lines might be used to advantage for early sowing The latest maturing of the current selection was ready for harvest in mid March.

CONCLUSIONS

Cultivars with a greater tolerance of low temperatures during flowering yield more consistently and appear better adapted to the warm, variable temperatures of the New Zealand summer than the currently best yielding cultivar, Amsoy 71. Lines available from the Canadian cool tolerance breeding programme offer good prospects for developing cultivars which would improve the level and consistency of soybean yield in the country.

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