SOYABEAN RESPONSES TO SOWING DATE IN THE WAIKATO AND THEIR IMPLICATIONS FOR PRODUCTION

S.J. McCormick
Soil and Field Research Organisation
Ministry of Agriculture and Fisheries
Ruakura Agricultural Research Centre,
Private Bag, Hamilton

ABSTRACT

The development and yield of soyabean cutlivars, Acme, Comet, Amsoy and Wayne, in the maturity groups 00, 0, 2 and 3 respectively, were studied in relation to sowing date in the two years 1973 and 1974 under irrigation.

As sowing date was delayed, from late October through to late December, the yield of each cultivar increased (though not significantly for Wayne), reached a maximum and declined. Maximum yield was greater according to cultivar maturity rating up to group 2, viz. 2.7, 3.0, 3.4 and 3.2 t/ha. Each cultivar gave maximum yield when flowering occurred in the period mid-late January. The range of sowing dates, for maximum yield, was successively earlier according to the increased maturity rating of the cultivar; viz. December 4-12 (Acme and Comet), November 26-December 4 (Amsoy) and October 25-November 26 (Wayne).

The increase in yield, with delay in sowing, was considered to be associated with improved temeratures for the preflowering growth and the increased coincidence of the reproductive period with the seasonal high temperatures.

Harvest date, for each cutlivar, was delayed progressively less as sowing date was delayed. Cultivar longevity was reduced by 5, 9, 16 and 30 days, for the groups 00-3 cultivars respectively, for a 58 day delay in sowing date. Dates of harvest, corresponding with maximum cultivar yield, fell in the period March 20-April 16. Unfavourable weather in mid to late April may necessitate earlier sowing for groups 2 and 3 cultivars to obtain maximum, harvestable yield. The greater flexibility in the sowing date for maxiumum yield expression in the group 3 cultivars was considered more likely to result in consistently high yield.

INTRODUCTION

In the soyabean both the rate and extent of plant development are sensitive to photoperiod and temperature, (Garner and Allard, 1930, Borthwick and Parker, 1938, Van Schaik and Probst, 1958, Johnson **et al.**, 1960). Decline in photoperiod hastens development but reduces its extent while increase in temperature enhances both the speed and extent of development. Cultivars are adapted to full season production within a narrow range of latitude, principally, on their photoperiod requirement for floral initiation. In the U.S.A. cultivars have been classified according to their latitude of adaptation into 10 maturity groups 00 to 8. Group 00 cultivars, which flower on a long photoperiod, are adapted to the northern latitudes while group 8 cultivars, which flower on a short photoperiod, are adapted to the southern latitudes. In New Zealand, however, because of the lower seasonal temperatures, the groups 0 to 3 cultivars, which are adapted to latitudes 39-47 North, are better suited to latitudes 37-41° South (Gerlach **et al.**, 1971).

In a given locality, cultivars from a range of maturity groups, sown at the same time in early season, mature on different dates and are classed, accordingly, as early, mid or full season cultivars for that locality. Generally, cultivars which take advantage of all or most of the growing season, outyield those which mature earlier though there are exceptions among the newer cultivars released (Scott and Aldrich, 1970). Adjustment in the date of sowing, because of changes in photoperiod and temperature with advancing season, alters the rate of development, growth characteristics and yield of cultivars (Feaster, 1948, Osler and Cartter, 1954, Torrie and Briggs, 1955). In the field the pattern of soil moisture availability also becomes involved in the sowing date response (Runge and Odell, 1960).

Clearly, an understanding of the responses of cultivars to sowing date, in a locality, is essential to the selection of the highest yielding cultivars for the conditions. This study investigated the sowing date response as determined by photoperiod and temperature in the Waikato.

MATERIALS AND METHODS

Soyabean cultivars Acme, Comet, Amsoy and Wayne, of maturity groups 00, 0, 2 and 3 respectively, were sown in 1973 and 1974 on Horotiu sandy loam soil at Rukuhia Research Station. In 1973 all cultivars were sown on the same six dates but in 1974 cultivars were sown on different dates, estimated from the 1973 results, to give six flowering dates common to all cultivars (Table 1). In both years a split plot, randomised block design, replicated 4 times, was used with varieties as sub plots. Sub plots comprised 6 rows (1973) and 4 rows (1974) 8 m long which were spaced at 61 m. Adequate levels of P and K were applied presowing and inoculated beans were sown at a rate of 35/m^2 with 110 kg/ha of N.P.K fertiliser (10.21.0).

	1973	1974		
	Acme Comet Amsoy Wayne	Acme Comet	Amsoy	Wayne
Oct. 25	•			
Nov. 1				•
6	•			
12			•	•
20	•			
22		•	•	•
27	•			
Dec. 2		•	•	•
6	•			
12		•	•	•
18	•			
22		•	•	•
31		•	•	
Jan. 10		•		

TABLE 1: Cultivars and dates sown 1973 and 1974.

Irrigation was applied in both years as required. In 1973, this to the whole trial on the same dates but, in 1974, to sub blocks according to stage of development.

Throughout the season weekly assessments of development were made using Fehr **et al.** (1971) system of classification and, after physiological maturity (stage R7), bean moisture was measured. At harvest, yield was determined from 5 m of the centre two rows.

RESULTS AND DISCUSSION

Available growing season.

The practical limits of the growing season for the Waikato were considered to be November 1 and April 14 (Fig.1). By November 1 soil temperature (10 cm, 0900 hr) normally reaches 15°C. In both years the soyabeans, sown at this time, germinated in 8 days with an emergence equal to that of later sowings. Earlier sowing than November 1 would not appear to be justified because slower germination, at the lower soil temperatures, would tend to lead to reduced emergence and greater weed competition (Scott and Aldrich, 1970). Harvesting of soyabean is done, by preference, at 13% moisture content to avoid the additional cost of drying before storage. After stage R7 bean moisture falls from 65% to 13% over a period of 7-14 days (Kato **el al.**, 1954) but, in the latter stages of drying, the rate of water loss depends on environmental conditions (Howell **et al.**, 1959). For the 1973 sowings, moisture content of the beans reached 13% on or soon after stage R8 and, for the 1974 sowings, 13% bean moisture was recorded between R7 and R8. However it was found that the beans absorbed moisture after rainfall and it was clear that a period of relatively dry weather would be required after R7 to allow for bean moisture to fall off and for the beans to be harvested as close to 13% moisture content as possible. Because of the decline in temperature, moving from March to April, and the increase in rainfall and the number of rain days, April 14 was set as the end of the growing season.

Phenology

The dates of attainment of stages R1 (commencement of flowering), R4 (commencement of bean filling), R7 (physiological maturity = maximum bean dry weight), R8 (harvest maturity = 95% brown pods) for each cultivar in relation to sowing date are shown in Fig. 1. Data from the two years were in close agreement and have been combined.

Characteristically, the intervals, sowing to first flower and sowing to harvest maturity, were longer according to the increased maturity grouping of the cultivar irrespective of sowing date. However, with delay in sowing, the length of successive periods of development was shortened for each cultivar but by an increasing amount for the group 3 compared to the group 00 cultivar. A delay in sowing of 58 days brought the harvest maturity date for the group 00, 0, 2 and 3 cultivars forward by 5, 19, 26 and 30 days respectively. The reduction in cultivar longevity, increasing with cultivar maturity ranking, is a common feature of sowing date trials (Cartter and Hartwig, 1963, Brown **et al.**, 1971). Contrary to the reports from the U.S.A. the major part of the reduction in longevity occurred in the post flowering rather than the pre flowering period.

The latest dates of sowing for the four cultivars, permitting stage R8 to be reached by April 14 were Acme December 31, Comet December 20, Amsoy December 2 and Wayne November 24. Seasonal temperatures for the two trial years were well above average. However, information from previous trials suggest that the harvest maturity dates would not be materially affected where seasonal temperatures were normal (1971-72) but that harvest maturity would probably be delayed by seasonal temperatures as low as those in 1968-69.

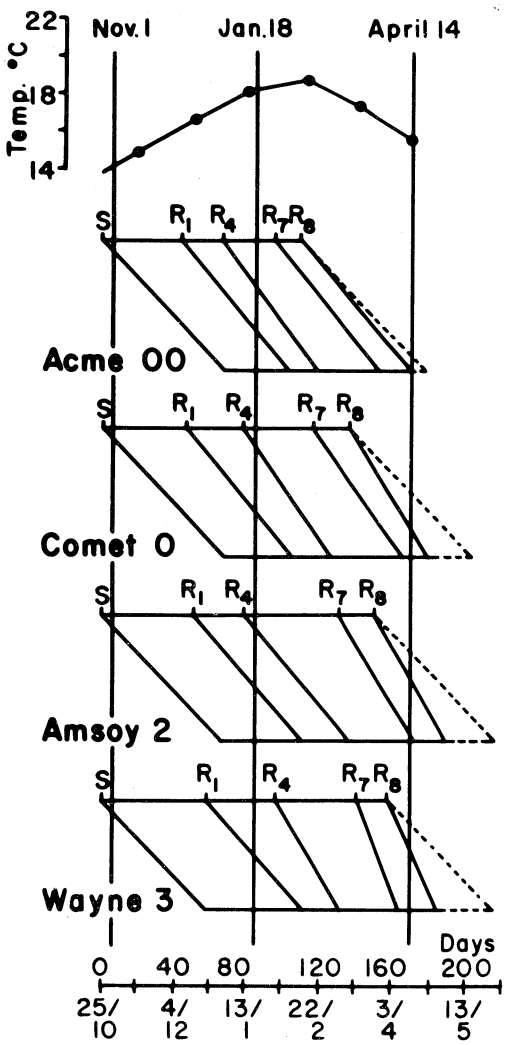

Figure 1: Stage of development for different sowing dates and cultivars in relation to time and seasonal temperature pattern.

The group 00 to 3 cultivars classify, then, from very early to full season for the Waikato.

Yield

Cultivar yields in relation to sowing date in 1973 are given in Fig. 2.

The importance of the yield sowing date response in soyabeans and the need to sow cultivars from different maturity groups on different dates, to attain maximum yield, was emphasised by the magnitude of the yield increase in Acme, Comet and Amsoy with delay in sowing and the yield decline in Wayne at the late sowing dates. When sown on more optimal dates maximum yield difference between cultivars was 300 kg/ha compared to 1600 kg/ha when all cultivars were sown in October 25.

The pattern of the yield sowing date response altered

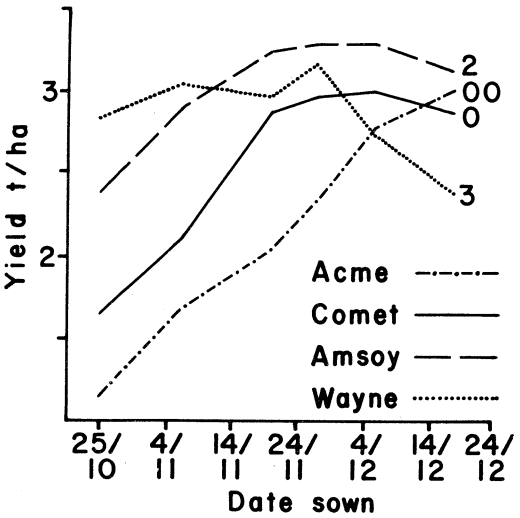

Figure 2: Yield in relation to sowing date and cultivar 1973.

in accordance with the maturity group rating of the cultivar. Group 3, Wayne, showed the least increase in yield and required the earliest sowing date to achieve maximum yield. As Wayne has a greater sowing to flowering interval than Acme a common link between flowering date and the attainment of maximum yield was suggested (Fig. 3). With the exception of Acme which did not reach a yield maximum, the cultivars showed a similar transition from rising yield (or for Wayne equal yield) to declining yield when flowering commenced in the period January 11-23.

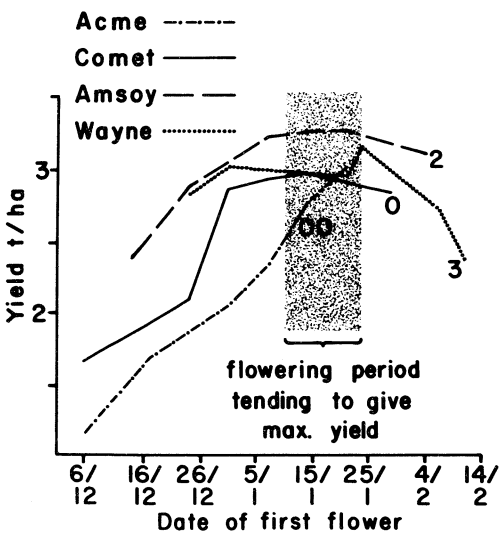

Figure 3: Yield in relation to flowering date and cultivar 1973.

The 1974 trial, through the adjustment of sowing dates to give a series of common flowering dates for the cultivars, examined the yield flowering date relationship more closely. Maximum yield of Amsoy was higher and the overall levels of yield of Acme and Comet were lower (Fig. 4). No reason for the lower yields was evident but the increased yield maximum for Amsoy appeared to come from improved timing of the irrigation. Despite the differences in yield between years, all cultivars moved from a phase of increasing (equal in Wayne) to declining yield when flowering commenced in the period January 21 to February 6. However the transitional phase occurred 10 days later than in the 1973 trial.

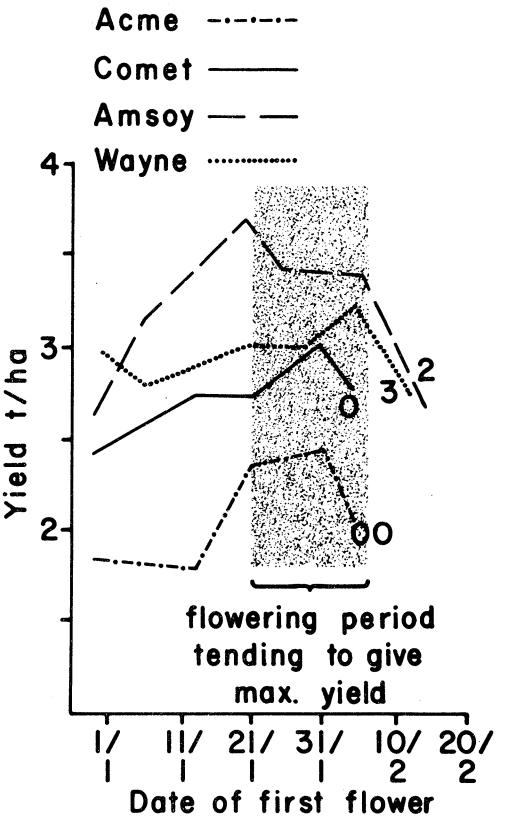

Figure 4: Yield in relation to flowering date and cultivar 1974.

The tendency for cultivars, regardless of maturity group, to give maximum yield with a common flowering date and the yield sowing date response **per se**, were considered to relate to the seasonal pattern of temperature. Temperature was considered to be the predominant factor affecting the yield response as seasonal temperatures in the Waikato rate as sufficient rather than optimum for soyabean growth. Temperature requirements for soyabean growth increase in successive stages of development (Enken, 1959) and it is during the post flowering period that yield is finally determined by the extent of pod set and bean fill. Therefore, though the level of temperature in the pre flowering period would affect the yielding capacity of the crop, through its effect on vegetative growth, the provision of high temperatures in the post flowering period would be more critical to yield. The yield sowing date response was seen as the expression of the extent to which the requirement for temperature, in each stage of development, was met by the seasonal temperature pattern. As sowing date was delayed, initially, cultivar yield increased as the total growth period and the flowering and bean filling period in particular, coincided, increasingly, with the warmer

part of the season. Yield declined, subsequently, as the bean filling period was subjected, increasingly, to the declining temperatures of late season.

The relationship between yield and flowering date indicated that, regardless of maturity group, the yield maximum of a cultivar would be achieved by scheduling flowering for the third week of January. If, as has been suggested, the yield response is closely linked with the pattern of seasonal temperature the critical flowering date period could be a factor common to other years and localities. While the level of seasonal temperature will change, the pattern of rising and falling temperature about a maximum in mid February is a feature of most North Island localities. However lower temperatures in March or a more rapid decline in temperature in late season would mean a restriction on bean filling at an earlier date. A higher yield would then be realised from an earlier flowering or sowing date than that predicted.

The sowing and harvest dates for each cultivar, corresponding to the flowering period January 14-21, are given in Table 2. For Amsoy and Wayne harvest dates fell at the extreme limit of the growing season defined. While, at present, there is insufficient information on the practicability of combing soyabeans in the latter half of April, experience in trial work indicates that a late March to early April harvest date would be preferable. To achieve an April 1 harvest date Amsoy would need to be sown about November 10 and Wayne about October 28. Flowering in both cultivars would then occur in late December and the yield of Amsoy, but not that of Wayne, would be reduced (Figs. 3 and 4). The superiority in yield of the group 2, Amsoy, over cultivars from other groups could then be lost.

Cultivar	Sowing period	Maturity period
Acme	Dec. 4 - 12	March 20 - 28
Comet	Dec. 4 - 12	April 3 - 11
Amsoy	Nov. 26 - Dec 4	April 12 - 16
Wayne	Nov. 16 - 24	April 12 - 16

TABLE 2: Sowing and maturity dates corresponding to flowering period January 13-21 for each cultivar.

The relative insensitivity of yield in the group 3 cultivar, Wayne to sowing date suggest that group 3 cultivars, in practice, may have a better chance of producing consistently high yield than groups 00-2 cultivars. That is, provided cultivar response to sowing date was typical of its maturity group. The systematic change in yield response amongst the cultivars according to their maturity groups would indicate that the cultivars tested responded characteristically. Also, the reaction of Wayne, as a full season cultivar for the locality, was in agreement with U.S.A. data on the yield response of full season cultivars to sowing date (Scott and Aldrich, 1970). It would appear logical, therefore, to look for improved yield performance in the newly developed group 3 cultivars, but in the meantime the group 2, Amsoy remains the most promising cultivar available.

CONCLUSION

Group 00-3 cultivars rate as early to full season for the Waikato. When sown in late October, yield is greater according to cultivar maturity group and harvest date is successively later over the period February 12 to April 1. When sown according to cultivar, so that flowering occurs in the period third week of January, the difference between cultivar yield is small but the harvest dates fall in the period March 24 to April 14. The yield sowing date response appears to be the expression of the relationship between the high temperature demand of the crop, particularly in the reproductive phase, and the extent to which the demand is met by the pattern of seasonal temperature with different sowing dates. The group 3 cultivars would appear to show a greater flexibility in the date of sowing for obtaining maximum yield and were considered to have a better chance for giving consistently high yields.

ACKNOWLEDGEMENTS

Messrs R.H. Kidd, J.T.K. Poll and D.L. Thomsen for their technical assistance in conducting the trial and in the collection and processing of the data. Mr C. Dyson for biometrical analysis.

REFERENCES

Borthwick, H.A. and Parker, M.W. 1938. Photoperiodic response of several varieties of soybeans. Botanical Gazette **101**: 341-365.

Brown, N.S. Watkin, B.R., Robinson, G.S. and Greenwood, R.M. 1971. Studies on soyabeans in the Manawatu. New Zealand Agricultural Science **5**: 5: 6-11.

Enken, V.D. 1959. Quoted by Holmberg, S.A. 1963. Soybeans for cool temperature climates. Agri Hortique Genetica XXXI: 1—20.

Feaster, C.V. 1949. Influence of planting date on yield and other characteristics of soybeans grown in South-east Missouri. Agronomy Journal **41**: 57-62.

Fehr, W.R. Caviness, C.E., Burmood, D.T. and Pennington, J.S. 1971. Stages of development descriptions for soybeans (Glycine max (L.) Merrill). Crop science **11**: 929-931.

Garner, W.W. and Allard, H.A. 1930. Photoperiod responses of soybeans in relation to temperature and other environmental factors. Journal Agricultural Research **41**: 719-735.

Gerlach, J.C. Cottier, K., Cumberland, G.L.B., Nixon, G., Bimler, K. and McCormick, S.J. 1971. Studies on the cultivation of soybean (Glycine max. (L) Merrill) in New Zealand. Proceedings Agronomy Society New Zealand **1**: 129-137.

Howell, R.W. 1963. "The Soybean". Ed Norman, A.G. Academic Press, New York, p. 105.

Johnson, H.W., Borthwick, H.A. and Leffell, R.C. 1960. Effects of photoperiod and time of planting on rates of development of the soybean in various stages of the life cycle. Botanical Gazette **122**: 77-95.

Kato, I., Sakaguchi, S. and Natio, Y. 1954. Quoted by Howell, R.W. 1963. "The Soybean". Ed. Norman, A.G. Academic Press, New York. p. 105.

Olser R.D. and Cartter, J.L. 1954. Effects of planting date on chemical composition and growth characteristics of soybeans. Agronomy Journal **46**: 267-269.

Runge, E.C.A.. and Odell, R.T. 1960. The relationships between precipitation, temperature and the yield of soybeans on the Agronomy South Farm, Urbana, Illinois. Agronomy Journal **52**: 245-247.

Scott, W.O. and Aldrich, S.R. 1970. "Modern Soybean Production". The Farm Quarterly, Cincinnati, Ohio. pp. 23-24 and 51.

Torrie, J.H. and Briggs, G.M. 1955. Effect on planting date on yield and other characteristics of soybeans. Agronomy Journal **47**: 210-212.

Van Schaik, P.H. and Probst. A.H. 1958. Effects of some environmental factors on flower production and productive efficiency in soybeans. Agronomy Journal **50**: 192-197.