

EFFECTS OF EXTENSION OF DAYS TO FLOWERING ON YIELD AND OTHER CHARACTERS OF EARLY MATURING SOYBEAN

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Abstract

Early maturing varieties of soybean are low yielding due to their small plant stature and short vegetative period. The objective of this research was to develop early varieties of soybean with extended days to flowering while keeping the days from flowering to maturity intact. Crosses were made between two early (CM2 and NS1) and two late (CB1 and LJ4) maturing varieties. Conventional and modified single seed descent methods were used to select for late flowering but early maturing relative to the early maturing parents. Eleven selected lines were tested for three seasons using two early maturing parents and SJ5, a medium maturing variety, as the standard check and it was found that four lines, C-3108, M-3213, M-3215, and M-3217, outyielded both early parents and the standard check, SJ5. These lines gave more days to flowering than the early maturing parental checks, but the days from flowering to maturity were similar to the early checks. The correlation between the yield with days to maturity was not important but with days to flowering it was significant. This experiment showed that the extension of days to flowering resulted in an increase of the yielding potential of early maturing soybean.

Keywords: soybean breeding, single seed descent, early maturing variety, correlation between characters

Introduction

In Thailand, early maturing soybean varieties which require less than 85 days to maturity are needed for sequential cropping after rice and other field crops. These varieties are useful for this crop production system to exploit residual moisture in the late rainy season and they can be harvested sooner to escape the incoming dry period. However, the present early maturing

varieties recommended to farmers are of small plant stature and low yielding potential. Therefore, it is important that higher yielding potential early maturing varieties should be developed for the late rainy season. Limits to productivity imposed by short crop duration are common in the tropics (Hartwig, 1970). The short photoperiods stimulate the precocious flowering of soybean

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genotypes before adequate biomass to sustain a high yield can be accumulated (Mayers *et al.*, 1991). In these conditions, biomass production can be increased by delay flowering.

Later flowering has been reported to be associated with higher soybean yield (Dunphy *et al.*, 1979). Therefore, the extension of days to flowering of early varieties may result in higher yielding varieties. Machikowa *et al.* (2007) were successful in attempting to increase days to flowering of early maturing varieties while trying to keep days from flowering to maturity (DF-DM) intact. The results showed that selected lines gave higher seed yield than their early parents. Many studies have shown that days to flowering (Niessl *et al.*, 1995) and days to maturity have relatively high heritability (Burton, 1987; Xu and Wilcox, 1992; Niessl *et al.*, 1995; Hasan *et al.*, 2008). The objective of this study was to evaluate the effects of an extension of days to flowering on yield and other characters of soybean.

Materials and Methods

The experiment was conducted at Suranaree University of Technology Experimental Farm (SUT Farm), Nakhon Ratchasima, in the northeast region of Thailand in 2006 and 2007. Eleven early maturing lines with long vegetative periods as described in Machikowa *et al.* (2007) and three checks, two early parents and SJ5, were evaluated in three seasons which were the late rainy season of 2006, and the early and late rainy seasons of 2007. The soil type at the experimental site was Chatturat clay loam (Typic Haplustals). Each plot consisted of four 5 m rows spaced 50 cm apart. Within each row, the hills were spaced 20 cm apart with two plants per hill (i.e. 20 plants m⁻²). Recommended herbicides were used to suppress weeds. Diseases and insects were controlled by regular application of fungicides and insecticides. Overhead sprinkler irrigation was used once a week as there was no rain in the planting season.

Eight characters were collected from the two central rows. Days to flowering (DF) was recorded when the first flower bloomed, and days to maturity (DM) was recorded when at

least 95% of the pods in each plot had turned brown. Ten plants per plot were selected at random from the interior portion of the two central rows for determination of plant height, number of pods per plant, and seeds per plant. The weight of 100 seeds was recorded as the average of three 100-seed samples. Days from flowering to maturity (DF-DM) was recorded as days from days to flowering to days to maturity. Two central rows were harvested for measuring seed yield. Analysis of variance was performed on the data with the SAS General Linear Models procedure (SAS, 1985). Duncan Multiple Range Test (DMRT) was used in the mean comparison. Phenotypic correlations were computed following the method outlined by Weber and Moorthy (1952).

Results and Discussion

Combined analyses of variance of soybean lines and varieties evaluated in the three seasons are shown in Table 1. Highly significant differences among lines/varieties were obtained for all characters including seed yield, days to flowering, days to maturity, plant height, etc. Similarly, significant interactions between seasons and lines/varieties were found for all characters except pods and seeds per plant. These variations revealed the genetic potentials of these materials to be used for selection for desired characters, especially for high yielding lines with a short duration from planting to maturity.

Means for yield, days to flowering, days to maturity, plant height and other characters are given in Table 2. In this study, NS1 and CM2 were two parental early checks and their yields were 2,463 and 2,338 kg ha⁻¹, respectively. SJ5, a well-known soybean variety which is grown widely in all planting areas of soybean in the country, was a medium maturing variety and the standard check. Its yield was 2,669 kg ha⁻¹. Four lines, including C-3108, M-3213, M-3215, and M-3217, when the C- and M- lines were the progenies of crosses selected using the conventional and modified single seed descent methods, respectively, outyielded the early maturing checks. They also outyielded the

medium maturing check, SJ5. Among these four lines, only M-3217 matured as early as the early checks. However, the other three lines should be retained for further tests as they gave higher seed yields and matured about 10 days earlier than SJ5, the medium check. These lines were

comparatively taller than their early maturing parents.

Correlations among characters are given in Table 3. It is important to note that the correlation between seed yield and DF was significant (0.327*) but that between yield and

Table 1. Mean squares from analyses of variance of characters of soybean genotypes tested in three seasons

Sources	df	Yield	Days to flowering	Days to maturity	Plant height ^{per}	Pods plant	Seeds per plant	100-seed weight	DF-DM ¹
Seasons (S)	2	7,366.89 ^{ns}	51.55 ^{**}	167.33 ^{**}	1,096.12 ^{**}	100.56 ^{**}	15,787.48 ^{**}	0.14 ^{ns}	115.71 ^{**}
Rep/seasons	3	417.67 ^{ns}	1.68 ^{**}	1.24 ^{ns}	127.06 ^{**}	71.53 ^{ns}	202.54 ^{ns}	0.71 ^{ns}	1.71 ^{ns}
Genotypes (G)	13	19,497.11 ^{**}	27.60 ^{**}	148.28 ^{**}	469.71 ^{**}	103.25 ^{**}	519.35 ^{**}	13.19 ^{**}	81.99 ^{**}
S * G	26	12,388.45 ^{**}	2.78 ^{**}	38.60 ^{**}	92.24 ^{**}	39.36 ^{ns}	245.62 ^{ns}	3.05 ^{**}	34.39 ^{**}
Error	81	4,258.09	0.39	1.34	22.50	31.08	189.27	0.58	1.73

** indicates significance at $p = 0.01$; ns = non significant

¹Days from flowering to maturity

Table 2. Means for yield and other characters of 11 promising lines and 3 checks varieties

Varieties/ Lines ²	Yield ¹ kg ha ⁻¹	DF ³ no.	DM no.	HT cm.	Pods —no./plant—	Seeds g.	100-seed wt. g.	DF-DM no.
NS1	2,463 ^{cd}	29 ^d	83 ^c	51 ^{cd}	36 ^c	82 ^e	18.87 ^{ab}	54 ^{bc}
CM2	2,338 ^{de}	29 ^d	82 ^c	42 ^e	36 ^c	83 ^e	16.44 ^{bc}	53 ^{bc}
SJ5	2,669 ^{cd}	35 ^a	98 ^a	59 ^{abc}	44 ^{ab}	100 ^b	16.82 ^{bc}	63 ^a
C-2101	2,188 ^e	34 ^{ab}	88 ^b	55 ^{bc}	41 ^{bc}	95 ^{bc}	18.35 ^{ab}	54 ^{bc}
C-2109	2,363 ^{de}	34 ^{ab}	87 ^b	52 ^{cd}	37 ^c	86 ^{de}	19.10 ^{ab}	53 ^{bc}
C-3105	2,438 ^{cd}	33 ^b	89 ^b	57 ^{bc}	41 ^{bc}	93 ^{cd}	15.63 ^{cd}	56 ^b
C-3108	3,175 ^a	33 ^b	89 ^b	63 ^{ab}	40 ^{bc}	89 ^{cd}	17.24 ^{bc}	56 ^b
C-3110	2,581 ^{cd}	34 ^{ab}	89 ^b	56 ^{bc}	44 ^{ab}	98 ^b	16.81 ^{bc}	55 ^{bc}
C-3117	2,225 ^{de}	33 ^b	88 ^b	48 ^{cd}	40 ^{bc}	85 ^{de}	16.59 ^{bc}	55 ^{bc}
M-2209	2,588 ^{cd}	33 ^b	83 ^c	45 ^{de}	39 ^c	83 ^{de}	16.91 ^{bc}	50 ^c
M-3202	2,525 ^{cd}	31 ^c	83 ^c	49 ^{cd}	42 ^{bc}	95 ^{bc}	16.62 ^{bc}	52 ^{bc}
M-3213	2,919 ^{bc}	33 ^b	89 ^b	67 ^a	46 ^a	107 ^a	14.97 ^d	56 ^b
M-3215	2,806 ^{bc}	33 ^b	88 ^b	59 ^{bc}	45 ^a	98 ^b	15.36 ^{cd}	55 ^{bc}
M-3217	2,988 ^{ab}	33 ^b	84 ^c	63 ^{ab}	37 ^c	85 ^{de}	16.98 ^{bc}	51 ^c

¹ Means in the same column that followed by the same letters are not significantly different at $p = 0.05$ according DMRT.

² C- and M- lines were progenies of crosses selected using the conventional and modified single seed descent, respectively.

³ DF = days to flowering, DM = days to maturity, HT = plant height, DF-DM = days from flowering to maturity

Table 3. Correlations among characters of soybean lines/varieties

Characters	Days to flowering	Days to maturity	Plant height	Pods per plant	Seeds per plant	100-seed weight	DF-DM ¹
Yield	0.327*	0.058	0.508*	0.172	0.154	-0.039	-0.104
Days to flowering		0.462*	0.627**	0.280*	0.224	0.023	0.001
Days to maturity			0.336*	0.648**	0.647**	-0.034	0.887**
Plant height				0.363*	0.351*	-0.064	0.053
Pods per plant					0.942**	-0.043	0.585**
Seeds per plant						-0.008	0.613**
100-seed weight							-0.050

*, ** indicate significant difference from zero at $p = 0.05$ and $p = 0.01$, respectively

¹ DF-DM = days from flowering to maturity

DM (0.058) was not important. This showed that the extended vegetative period resulted in the increase of seed yield of the early maturing soybean. However, other papers have shown that seed yield is associated with DM (Ishibashi *et al.*, 2003; Malik *et al.*, 2006). It was also found that most of the selected lines were taller than the early maturing check, especially CM2, and the correlation between DF and plant height was highly significant (0.627**). This showed that selection for late flowering gave taller plants which is associated with seed yield (0.508*).

Relationships between seed yield of lines and varieties of soybean with DF and DM are shown graphically in Figure 1. Most of the high yielding lines tended to be associated with late maturity. However, this might be due to late flowering instead of the total days from planting to maturity as it was found that most of the high yielding lines were of the late flowering selections. DF of the four high yielding lines (C-3108, M-3213, M-3215, and M-3217) were closed to SJ5, while DF-DM of SJ5 was quite distant. Moreover, the correlation between seed yield with DF-DM was not significant; this indicated that, for these materials, only the extension of DF, but not DF-DM, resulted in the increase of seed yield of soybean.

In this research, we attempted to increase DF and reduce DM of soybean, thus to increase the total photoperiod but so that the soybean can be harvested earlier than medium or late varieties. The increase of DF for one or more

days might result in the increase of seed yield. All the tested lines flowered later than the early checks by 2 to 5 days and four lines gave a lesser or the same DF-DM as the early checks. These responses to selection should provide an opportunity to develop a new plant type of the early maturing soybean with extended DF without the extension of DF-DM which enable the crop to accumulate biomass to sustain a high yielding potential.

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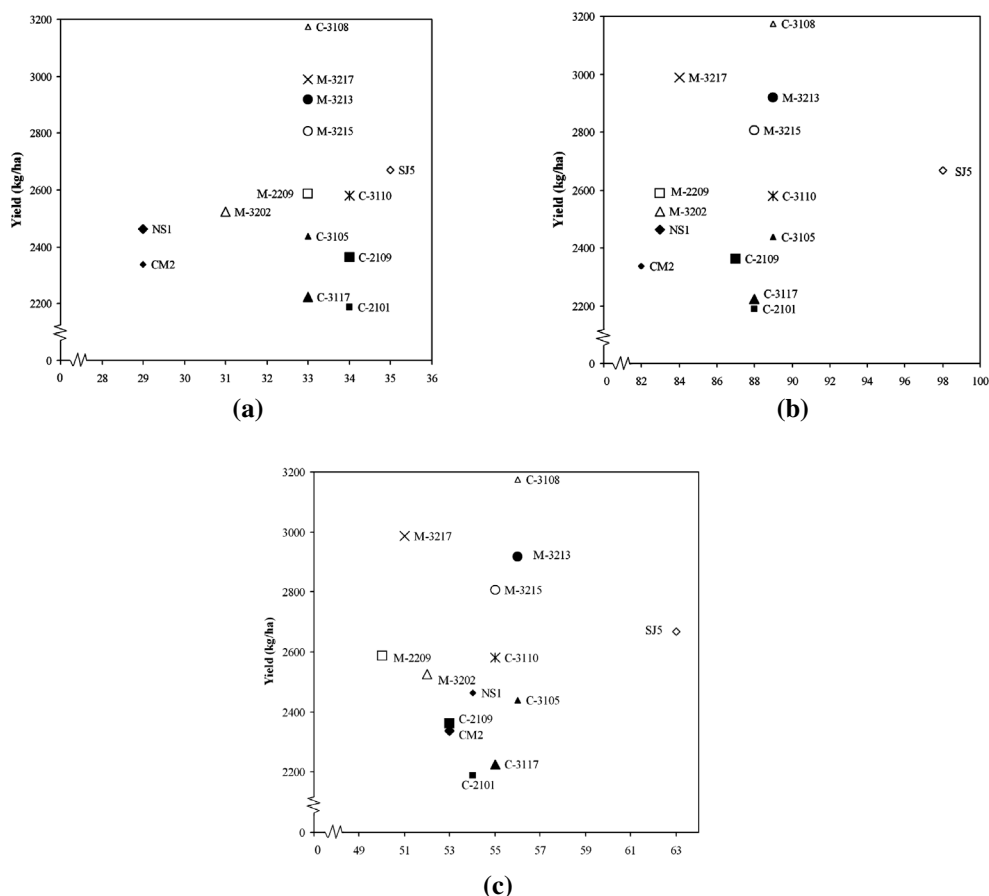


Figure 1. Relationships between seed yield of lines/varieties of soybean with (a) days to flowering, (b) days to maturity, and (c) days from flowering to maturity

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