Effects of genotype and sowing time on growth of soybean in the mountain region of Northern Vietnam

Truyen N Quach [1], Hanh T.M. Nguyen [1], Andrew T. James [2] and Long D Tran [1], Thang Q Ngo[1] and Truong T Tran[1]

[1] Vietnam Agricultural Science Institute, Van dien, Thanh tri, Hanoi, Vietnam,
Email: ngoc.quach@student.adelaide.edu.au
[2] CSIRO Plant Industry, Qld Bioscience Precinct, 306 Carmody Rd, St Lucia 4067, Brisbane, Australia

Abstract

Five soybean genotypes differing in growth duration (TN12 and M103 as early, and CM60, 95389 and MSBR20 as late maturity types) were sown on three different dates (July 12, July 27 and August 11 2002) to investigate the effects of genotype and sowing time on growth of soybean in rainfed mountain region of Northern Vietnam. Biomass and growth duration of early maturing genotypes were similar for three sowing dates, while late maturing ones had higher biomass and shorter growth duration for the 2 later sowing dates. Grain yield was not different for the three sowing dates but differed among genotypes. CM60 produced the highest yield of 2.4 t/ha. M103 and TN12 produced 1.67 and 1.6 t/ha while 95389 and MSBR20 yielded 1.47 and 1.29 t/ha, respectively. The results suggest that soybean could be sown from early July to early August in variable cropping systems and CM60 was the most promising variety for the region.

Media summary

Soybean grows well when it is sown from early July to early August in the mountain region of northern Vietnam

Keywords

Constraint, adaptation, stress, LAI, phenology

Introduction

From 1995 to 2001, the human population of Vietnam rose from 72 to 80 million with about 75% of the population depending on agriculture (Statistical year book 2002). Therefore, increasing the number of crops per year and exploiting rainfed mountainous areas for agricultural production are increasingly important issues. Soybean has the third highest priority for crop research in Vietnam after rice and maize (Thang *et al.* 1996), however, the yield of soybean in Vietnam is relatively low (Statistical year book 2002). In 2001, nationwide soybean yield was 1.24 t/ha, a 20% increase compared with the yield in 1995. Although a number of high yielding varieties have been released recently, which increased the productivity of soybean in irrigated areas, yield of soybean is still very low and variable in the rainfed mountain and non-irrigated regions. Water stress is a major constraint to soybean production in rainfed areas of Vietnam (Chinh *et al.* 2001). Yield of soybean in the rainfed areas can be improved either by avoiding stressful periods or by breeding for tolerance to stress (Wilcox 1987). Improved adaptation means matching the phenology of crop to the duration of favorable conditions. In Vietnam, phenology and sowing dates have been selected to avoid periods of stress, which is likely to reduce yields. A series of experiments in an ACIAR sponsored project selected a number of promising genotypes for summer production in the rainfed mountain regions of northern Vietnam. However, the sowing time varies depending on which other crops such as watermelon and maize are grown, and there has been no research on effects of sowing time on growth of soybean in this system (Long *et al*. 2001). This experiment aimed to study the effects of genotype and sowing time on the growth of soybean in rainfed summer-autumn conditions in the north mountain region of Vietnam.

Materials and methods

Five genotypes, differing in growth duration, and recommended for the mountain region of northern Vietnam (Long et al. 2001), were selected (Table 1). The genotypes were sown on 3 dates, 15 days apart (S1: July 12, S2: July 27 and S3: August 11) in the summer of 2002 at the College of Technology of Hatay, 30 km northwest of Hanoi. Seeds were sown in experimental beds in 4 rows with 50cm between rows. Fertilizers (40N: 60P: 60K) were applied at three times: at sowing, at the 2-leaf stage (V2) and the 5-leaf stage (V5). Water was supplied during the first week to establish the initial growth, but after this, the crops were grown under rainfed conditions. Plants were then thinned to a density of 25 plants m^{-2}. The experiment design was a split plot with 4 replications.

Table 1. Genotypes selected for the experiment

Genotype	Growth habit	Maturity
TN12	Determinate	Early
M103	Determinate	Early
CM60	Semi-determinate	Late
95389	Semi-determinate	Late
MSBR20	Semi-determinate	Late

Observations were taken every three days for growth, phenology and lodging. Phenology was determined as the length of time from sowing to the onset of flowering, end of flowering, and to maturity. The vegetative phase (V phase) is defined as the period from sowing to the end of new leaf appearance, and the reproductive phase (R phase) is the period from the start of flowering to maturity. Biomass and leaf area index (LAI) were measured every 10 days in an area of 1 m^2 each time. At harvest, 4 m^2 of each plot was cut and threshed for grain, and seed weight was taken after drying under sunlight. Five plants were randomly sampled for plant height and yield components. Correlations between agronomic characters and yield were performed using Excel. Analysis of variance was computed using IRRISTAT computer software (International Rice Research Institute, Philippines)

Results

Weather condition

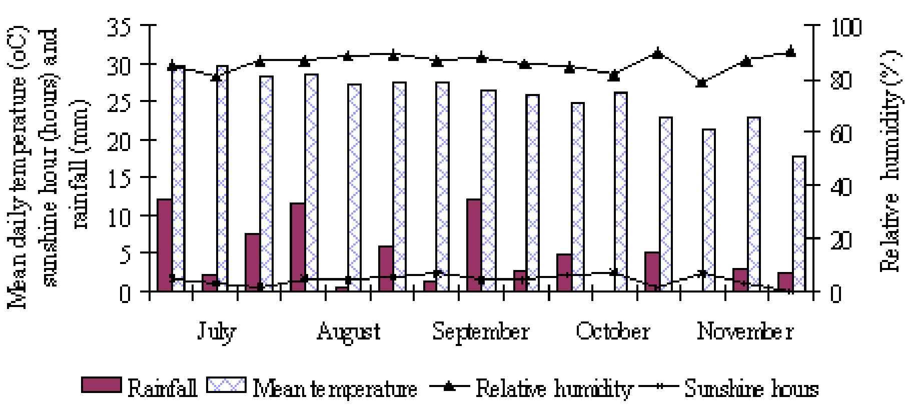


Figure 1. Weather conditions from July to November 2002 at Xuan Mai, Hatay. The data are the 10-day means (Data provided by the meteorological station Hatay-Hoabinh)

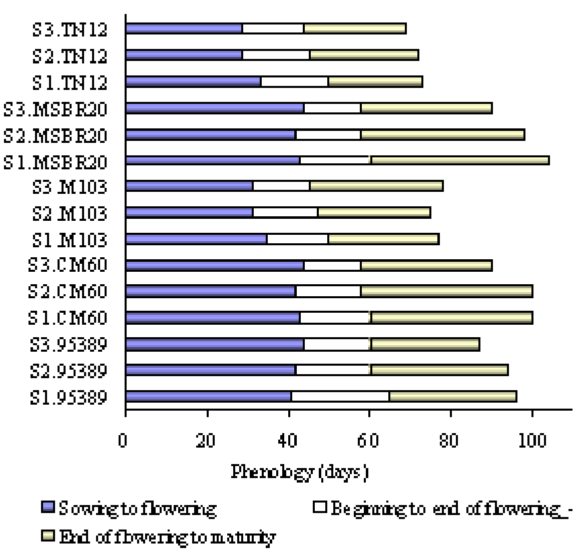
Mean daily temperature declined slightly from 30 ^{o}C in July to about 20 ^{o}C in the end of November (Figure 1). Rainfall varied unpredictably, sometimes continuing for several days and stopping for long time such as in the middle of October and the middle of November 2002. During October, rainfall declined sharply, with almost no rain in November. Relative atmospheric humidity was very high and mostly above 80%. Number of daily sunshine hours varied from 0 to 7 during the growing season

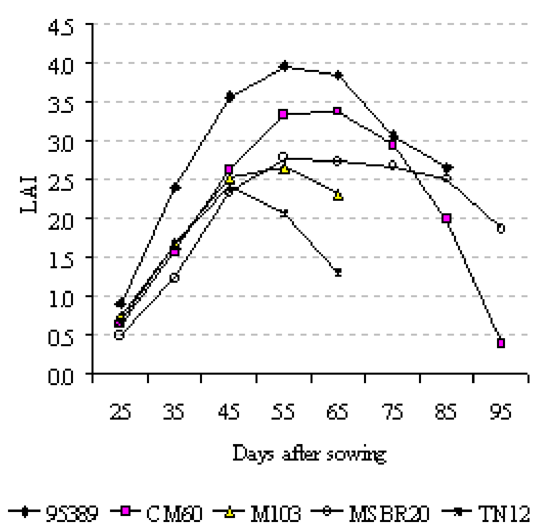
Phenology

Sowing date did not have an effect on the length of time to flowering (DTF) (Figure 2). Local genotypes, TN12 and M103, had short DTF with 31 and 33 days respectively, while the other 3 late maturing ones, MSBR20, 95389, and CM60, had DTF of over 40 days. The length of flowering was slightly shorter for later sowing dates and the difference was greater for late maturing genotypes. Genotype 95389 had the longest and most varied flowering duration. The duration of the reproductive period differed considerably, particularly in late maturing genotypes. TN12 and M103 (early maturing, local genotypes) had very short reproductive phases while late maturing genotypes had longer reproductive phases. The effects of sowing date on the total growth duration were only evident in late maturing genotypes.

LAI development

LAI of all the genotypes peaked at the end of flowering (Figure 3). Rate of LAI increase at early growth stage was highest in genotype 95389, with an LAI of 2 at 30 days after sowing while other genotypes had an LAI of about 1.5. LAI development of TN12 and M103 was not greatly affected by sowing time, but the LAI of the late maturing genotypes was increased by later sowing times (data not shown). At the end of flowering, LAI of TN12, M103 and MSBR20 were about 2.5, much lower than the optimum LAI of 3.5-4 for the tropical conditions (Whigham 1983). Genotypes CM60 and 95389 produced an optimum LAI.





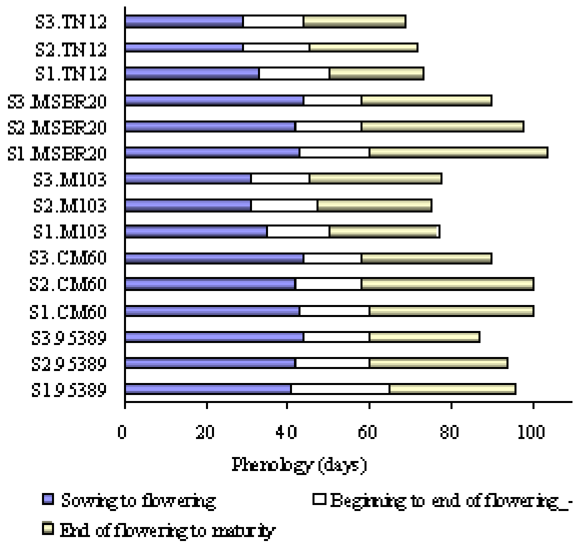


Figure 2. Phenology of 5 genotypes for three sowing dates. S1: July 12, 2002; S2: July 27, 2002 and S3: August 11, 2002

Figure 3. Development of LAI of 5 genotypes. Data are means of three sowing dates

Biomass accumulation, grain yield and harvest index

Mean grain yield of the genotypes across the sowing dates was 1.68 t/ha, ranging from 1.00 – 2.40 t/ha. Across genotypes, there was no significant difference in grain yield between sowing times (Table 2). Average yield across sowing dates ranged from 1.29 t/ha (MSBR 20) to 2.38 t/ha (CM60). Yields of two early maturing genotypes were 1.67 t/ha (M103) and 1.60 t/ha (TN12). The genotype, 93589, which yielded well in previous trials in the region, gave only 1.47 t/ha for a long growth period of 90-100 days.

Table 2. Seed yield, biomass and harvest index of 5 genotypes sown at three times (S1: 12/07/2002, S2: 27/07/2002 and S3: 11/08/2002) ** denotes a significant difference at the 1% level, * at 5%, and NS is non-significant difference

Genotype	Seed yield (t/ha)			Total biomass (t/ha)			Harvest index		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
95389	1.45	1.60	1.35	4.15	6.63	5.87	0.35	0.24	0.23
CM60	2.40	2.40	2.35	4.60	7.96	8.29	0.52	0.30	0.28
M103	1.60	1.90	1.50	2.98	3.30	2.94	0.54	0.58	0.51
MSBR20	1.00	1.40	1.48	4.20	5.46	5.90	0.24	0.26	0.25

TN12	1.50	1.70	1.60	2.96	2.69	2.94	0.51	0.63	0.54
LSD	Genotype (G): 0.27**			Genotype (G): 0.94**			Genotype (G): 0.08**		
	Sowing time (S): 0.21NS			Sowing time (S): 0.73**			Sowing time (S): 0.06NS		
	G x S: 0.46 NS			G x S: 1.63NS			G x S: 0.14*		

Total biomass at harvest was significantly different between sowing times (Table 2). The genotypes with early maturity and determinate growth habit showed a stable biomass at different sowing times. Late maturity and semi determinate growth habit genotypes produced higher biomass for later sowing dates even though their growth duration was shorter. CM 60 had the greatest average biomass of 6.95 t/ha while TN 12 produced the lowest biomass of 2.86 t/ha. Although 95389 had a high LAI, it had lower total biomass than CM60. Rate of biomass accumulation at early stage was higher in early maturity genotypes (data not shown). Mean harvest index (HI) of all 5 genotypes across three sowing dates was 0.40. HI was lower at the later sowing (0.36) while it was higher for the early sowing date (0.43). Across sowing times, short and determinate growth genotypes had the highest HI: TN12 (0.56) and M103 (0.54). HI was very low in long and semi-determinate growth genotypes such as: 95385 (0.27) and MSBR20 (0.25). CM60, the highest grain yielding genotype, produced a HI of 0.37.

Correlation between phenology, total biomass and grain yield

Total biomass for all treatments of genotypes and sowing times was significantly correlated with total growth duration ($r=0.64$, $p<0.05$) and the duration of pre-flowering growth ($r=0.82$, $p<0.01$) but not correlated with grain yield. Growth duration did not correlate with grain yield for all the three sowing times. HI was relatively high in early maturity genotypes, being negatively correlated with total biomass ($r=-0.71$, $p<0.05$).

Discussion

Although experiencing higher temperature, the late maturing genotypes sown early in the season (S1) had longer growth duration compared with the later sowing times (S2 and S3). The late maturing genotypes (95389 and MSBR20) produced low yields at all sowing times, while CM60, which had similar phenology, produced consistently high yields, indicating that fluctuations in weather conditions did not have much effect on yield of soybean during the growing period. Grain yield of soybean in the area varied with genotypes but not with sowing times. Therefore, soybean can be sown at different times in variable cropping systems during the summer-autumn growing season. Adaptation of early maturing genotypes proved better since their phenology, total biomass, LAI and yield were more stable at all three sowing dates. Because HIs of these genotypes were rather high compared with that of late maturing genotypes, yield of the former genotypes could be improved if they were grown at a higher density which would result in an optimum LAI of 3.5-4, which is common in Northern Vietnam. The result of this study reconfirmed the selection of CM60, TN12 and M103 for the summer-autumn growing season in the rainfed region of northern Vietnam.

Acknowledgement

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