Effects of Supra-Optimum Temperatures On Soybean Vegetative Growth and Development

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INTRODUCTION

Global climate changes would likely result in elevated temperatures that may negatively affect crop growth and development, resulting in impaired growth and lower crop seed yields. The study was conducted to investigate how the timing, duration and intensity of supra-optimum temperatures (SOT) affect vegetative growth of soybean . Three experiments (Exp. 1, 2, and 3) were conducted to investigate the effects of early, late, and transient SOT on soybean growth and development, respectively. Only results related to stem termination, plant height, internode length and node number are reported in this presentation.

MATERIALS AND METHODS

•The event dates and vegetative growth results of three experiments are provided in Table 1.

• Controlled greenhouse environment with CO_2 at 700 ppm and two O_2 levels (21% and 32%).

• Seed were sown in pots on 16 May, 15 Sept, 2011 and 28 Feb, 2012 for Exp 1, 2, and 3, respectively, and ended in different time (Table 1).

• Four day/night temperature regimes were established for the treatments to harvest maturity and duration study (Exp 3): 30/22 (control), 34/26 (except Exp 3), 38/30 and 42/34 ºC.

Table 1. Summary of final number of nodes and plant height under different treatments in three experiments. Exp = Experiment, TTR = temperature treatment.

Exp #	TTR ºC	Exp start date	Exp end date	Exp period days	TTR start date (DAS)	TTR end date	TTR start stage	Total nodes number	Mainstem length cm
Exp 1, 2011									
1	30/22 ºC	5/16	9/6	113	6/8 (23)	9/6	R1	22 f*	226 b
2	34/26 ºC	5/16	9/6	113	6/8 (23)	9/6	R1	25 e	268 a
3	38/30 ºC	5/16	9/22	129	6/8 (23)	9/22	R1	34 c	270 a
4	42/34 ºC	5/16	9/6	113	6/8 (23)	9/6	R1	37 b	206 bc
Exp 2, 2011									
1	30/22 ºC	9/15	12/21	97	11/2 (48)	12/21	R5+	18 g	194 c
2	34/26 ºC	9/15	12/21	97	11/2 (48)	12/21	R5+	19 g	193 c
3	38/30 ºC	9/15	12/21	97	11/2 (48)	12/21	R5+	18 g	180 cd
4	42/34 ºC	9/15	12/21	97	11/2 (48)	12/21	R5+	17 g	150 e
Exp 3, 2012									
1	30/22 ºC	2/28	5/29	91	3/8 (9)	5/29	VC+	19 g	200 c
2	38/30 ºC	2/28	5/29	91	3/8 (9)	5/29	VC+	30 d	162 de
3	42/34 ºC	2/28	5/29	91	3/8 (9)	5/29	VC+	42 a	172 d
4	38/30 ºC	2/28	5/29	91	3/14 (15)	3/24	V3	19 g	180 cd
5	42/34 ºC	2/28	5/29	91	3/14 (15)	3/24	V3	19 g	169 d
6	38/30 ºC	2/28	5/29	91	3/22 (23)	4/1	R2	19 g	156 e
7	42/34 ºC	2/28	5/29	91	3/22 (23)	4/1	R2	19 g	125 g
8	38/30 ºC	2/28	5/29	91	3/31 (32)	4/11	R3	19 g	156 e
9	42/34 ºC	2/28	5/29	91	3/31 (32)	4/11	R3	19 g	138 f
10	38/30 ºC	2/28	5/29	91	4/16 (48)	4/26	R5+	18 g	163 de
11	42/34 ºC	2/28	5/29	91	4/16 (48)	4/26	R5+	18 g	163 de

*: Values followed with the same alphabetic letters indicate no statistical difference at α=0.05 level.

RESULTS AND DISCUSSION

➢Flowering (R1) occurred at 22-24 days after sowing in three experiments.

➢Elevated oxygen had no significant effect on development rate and had a non-significant tendency to reduce biomass productivity.

➢Supra-optimal temperatures (SOT) accelerated soybean vegetative growth. Plants grown at higher temperatures had more nodes, but shorter internodes.

➢Excluding the 42/34 ºC treatment, SOT resulted in greater plant height, increased plant leaf area, increased leaf dry weight, and increased stem dry weight.

➢Supra-optimal temperature slowed reproductive development, as well as decreased pod number and pod weight per plant.

➢The highest temperature regime (42/34 ºC) inhibited both vegetative growth and reproductive development, leading to the formation of the smallest plants with the lowest leaf area with no pod formation.

➢Early timing of short-term SOT treatments caused more significant effects than later timings.

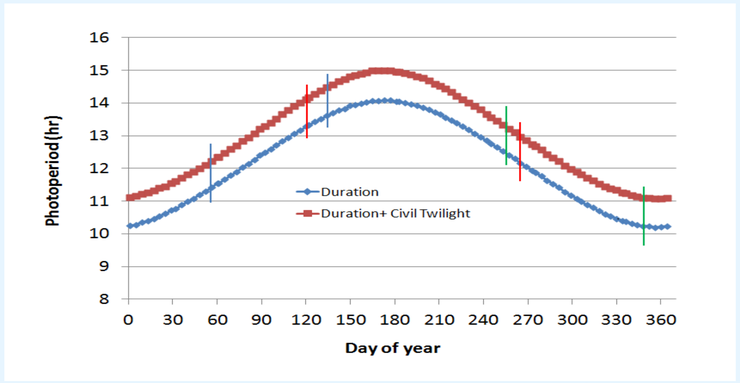

Fig.1 - Annual duration of daylight for Gainesville, FL (data for Lat: 30° N). Periods between the vertical red, green and blue lines are the period of Experiment (Exp) 1, 2, and 3, respectively. Period between red lines (Exp 1) experienced the longest photoperiod, periods (of the first half) between green lines (Exp 2) and blue lines (Exp 3) were similar to each other.

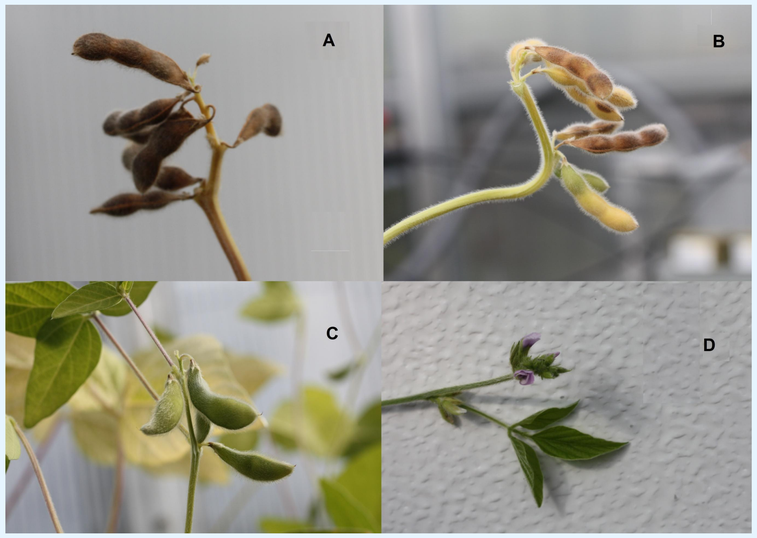

Fig. 2. Exp 1. Effect of supra-optimum temperatures on stem tip status at the end of experiment. A, B, C, and D show the stem termination status when the plant was grown at temperature regimes of 30/22, 34/26, 38/30 and 42/34 ºC, respectively. Plants in A and B showed no vegetative growth at the tips of stem, plants in C showed end of vegetative growth on the tip of stem but leaf retained , and plants in D showed continuous vegetative growth on the tip of the stem at the end of experiment period.

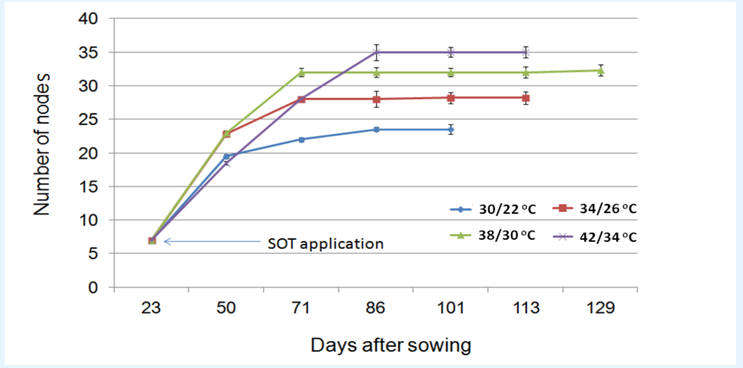

Fig. 3 Exp1. Effect of early application of super-optimum temperatures on soybean node appearance, compared with control temperature of 30/22 ° C. Super-optimum temperatures (SOTs) were applied at 23 days after sowing (approximately at R1 reproductive stage corresponding to V7 vegetative stage). Plants with different SOTs showed significant difference in number of nodes at maturity.

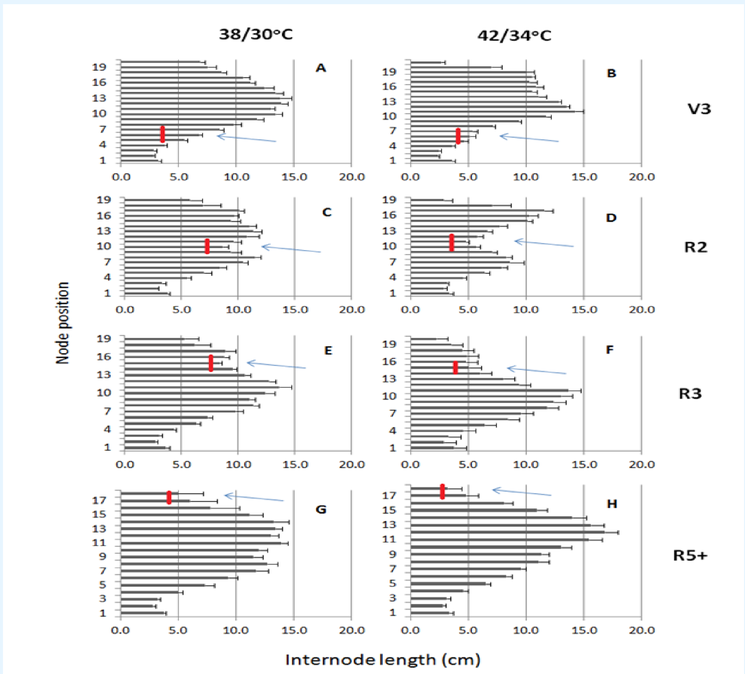

Fig. 4 Exp 3 Effect of supra-optimum temperature (SOT) on final patterns of soybean node number and internode elongation when treatments were imposed at the different growth stages. Seeds were sown on February 15, 2012 and data were collected on 29 May. Plants were grown under control temperature (30/22 ºC). At stages V3 (A and B), R2 (C and D), R3 (E and 8) and R5+ (G and 8), plants were transferred to rooms with moderate SOT (38/30 ºC: A, C, E, G) and high (42/34 ºC: B, D, F, H) treatment for 10 d, and then plants were returned to control temperature. Arrows and red bars indicate the node position where internode lengths were affected by elevated temperature, which was delayed by approximately three nodes. Error bars show the standard error of the mean of four plants.

SUMMARY

Supra-optimal temperature (SOT) affected soybean growth by shifting the balance from reproductive to vegetative development. Timing, duration and intensity of SOT are all important in affecting soybean growth and development. Extreme high temperature reduced internode elongation but increased number of nodes. Understanding the processes of impaired reproductive development and growth is important for ameliorating the effects of global climate change.