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High temperature stress response of agronomic traits in soybean and mungbean

BY

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FEBRUARY, 2016

MAJOR IN CROP SCIENCE AND BIOTECHNOLOGY

DEPARTMENT OF PLANT SCIENCE

THE GRADUATE SCHOOL OF SEOUL NATIONAL UNIVERSITY

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UNDER THE DIRECTION OF DR. SUK-HA LEE

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

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ABSTRACT

Climate change is an important factor for agricultural which is caused by the release of 'greenhouse gases' into the atmosphere. It causes global warming which is predicted to have a negative effect on plant growth generally and crop yield due to the damaging effect of high temperatures on plant development.

In this study, we conducted to investigate the response of phenotype of agronomic traits on high temperature in soybean [Glycine max] and mungbean [Vigna radiata] and finally to find the breeding material adaptive to high-temperature stress. We used nine soybean genotypes and two mungbean genotypes as planting materials. It was grown in four different temperature level plastic houses (normal field condition without plastic cover as the control (T1), T1+1.5℃(T2), T1+3.0℃(T3) and T1+5.0℃(T4)) to evaluate physiological response to high-temperature stress. Growth type traits such as plant height and the number of branches increased up to T3 treatment and decreased from T3 treatment in soybean. Flowering was faster with higher temperature and yield components like the number of pods and the number of seeds per pod continuously increased with increasing temperature. SS0404-T5-76 is one of the nine genotype we used, which was very highly significant on major agronomic traits at high temperature and was the increased production with increasing temperature. As a result, it is a promising breeding material to adaptive on high-temperature stress. Plant height and the number of pods consistently increased with increasing temperature in Sunhwanogdu and Gyunggijaerae and yield component like the number of pods and number of seed per pods also increased on high temperature in mungbean. Sunhwanogdu had a much pods number, and it had adaptability of high temperature than Gyunggijaerae.

Keywords: Climate change, High temperature, Agronomic traits, Stress-tolerance, Soybean, Mungbean

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INTRODUCTION

Climate change is a substantial factor in agricultural production. Agriculture is a part which is important to consider, in term of climate change. Climate-related parameters are temperature, precipitation, soil moisture, and sea level (Aydinalp and Cresser, 2008), which are expected to alter crop productivity. Many research studies have shown the impacts of climate variability on yield loss or the alteration of physiological mechanisms on cereal crop (Bainy et al., 2008). Increased air temperature is one of the significant climate change signs that cause heat stress on plants. Heat stress is a grave hazard to crop production all over the world.

Climatological extremes including very high temperature are predicted to have an extensive negative effect on plant growth and development and crop production (Craita E. Bita et al., 2013). Global average temperatures have risen by roughly 0.13℃ per decade since 1950, yet that this on agriculture has been not understood. An even faster pace of roughly 0.2℃ per decade of global warming is expected over the next two to three decades, with substantially larger trends likely for cultivated land areas. Identifying the particular crops and regions that have been most affected by recent trends would assist efforts to measure and analyze ongoing efforts to adapt. In Korea, measuring data during 1904 to 2000, mean air temperature increased above 1.5℃ and it shows a similar global warming trend in overall the world (NIMR, 2004). According to climate prediction using AIB data, Korea will become subtropical climate in 2100 (Kwon et al., 2007). Furthermore, the occurrence of severe high temperature (>35℃) increased during the day from 1.6 days/year to 2.3day/year in past 10 years (Heo and Kwon, 2007). Consequently, due to the global warming, the extremely high temperature is predicted to increase in the near future. Future crop yields will be influenced by complex interactions between the effects of increases in atmospheric concentrations of CO2 and trace gases such as ozone, methane, freon gas as well as the impact of increasing temperature brought about by climate change.

Legume crops such as soybean and mungbean have become the primary source of edible vegetable oils and high protein feed supplements for livestock in the world. As a leguminous plant is nodulated by rhizobia, causing the formation of nodules and establishing a nitrogen-fixing symbiosis (Dudeja et al., 2012). Among the environmental stresses limiting legume-Rhizobium associations, the temperature is the most influential especially in systems where tropical legumes are introduced into temperate regions (Sheokand et al., 2012).

Soybean [*Glycine max*] is one of the most important crops in the world and has a lot of high-quality protein and oil for food and industrial materials. Soybean production is 28,502 million ton in the world, but a recent study revealed that disadvantage environmental conditions (temperature and rainfall) during the reproductive growth stage can reduce seed yield of soybean (Thanacharoenchanaphas and Rugchati, 2011). Soybean yield is usually increased when temperature increases between 18-26℃, but adversely decreases at the temperature greater than 26℃ (Sionit et al., 1987). Also, the number of seeds per pod is the one of the seed yield components which is also affected by increasing temperature (Huxley et al., 1976; Baker et al., 1989).

Mungbean [*Vigna radiata*] is also known as a vital legume in Asia and a well-known economic crop in tropical and subtropical countries. Almost 90% of mungbean production comes from Asia and India. Yield is predetermined value by the potential of a given variety and the environment. The optimum temperature for the possible yield of mungbean lies 28℃ to 30℃

(Poehlman et al., 1991) and it also affected by high temperature (Khattak et al., 2009).

In the present, to investigate response of major agronomic traits on high temperature in soybean and mungbean and finally to find the breeding material adaptive to high-temperature stress.

LITERATURE REVIEWS

Climate change

The climate is a significant factor in agricultural productivity, and it has already caused significant impacts on water resources, food security, hydropower, human health, as well as all over the world. For last decade, regarding the probable effects of climate change on agriculture has motivated important change of research. Agriculture is an important part of the global economy, and it is highly dependent on climate conditions. Increasing in temperature and carbon dioxide (CO_2) can be beneficial for some crops in some places, but it also make difficult to grow crops. In a warming climate, extreme event like floods and droughts are likely to become more frequently. Rising temperatures will also heat surface waters, causing them to be more sensitive. Higher temperatures will cause more vaporization from soil and raising the atmosphere humidity, which can decrease crop water uptake. Increased temperature will reduce organic carbon levels in the soil, which can also reduce soil moisture levels and eventually impact on crop productivity.

Abiotic stress in plants

Abiotic stress cause extensive effect to agricultural production all over the world. Individually, stress conditions have been the subjected to a combination of different abiotic stresses. Abiotic stresses such as drought, salinity, high temperature, chemical toxicity and oxidative stress are great threats to agriculture and the environment. Abiotic stress is the primary cause of crop loss worldwide, reducing average yields for most major crop plants by more than 50% (Boyer, 1982).

Water stress is one of the most important factors affects various physiological processes associated with growth, development, survival and crop productivity (Begg and Turner, 1976). Plants periodically face increased temperature throughout their multi-seasonal life cycle. High temperature in the future will effect ecology and agriculture and heat stress is reported to have a direct negative effect on flower retention and eventually on pod formation (Kumari and Varma, 1983). Oxidative stress occurs accompanied drought, salinity and high temperature.

Analysis of variance (ANOVA)

Analysis of variance (ANOVA) is a statistical model, which used to analyze the differences and association between more than two groups. ANOVA evaluate the importance of one or more factors by comparing the response variable groups at the different levels. ANOVA also provides a statistical test of whether or not the means of several groups are equal and then, generalizes the t-test to more than two groups. ANOVA are effective model for comparing three of more groups for statistical significance.

Soybean and Mungbean

Soybean [*Glycine max*] is a legume crop, has been grown in Asia and, more recently, has been successfully cultivated around the world. Approximately 75% of the world's total soybean production was harvested from the United States, Brazil, Argentina, India and China. Soybean is one of the few plants that provides a complete protein as it contains all eight amino acids essential for human health. About 85% of the world's soybean processed into meal and vegetable oil, and virtually all of that meal used in animal feed. Soybean total productivity and quality are severely affected by various environmental stresses and drought are the most devastate factor. As one of the significant climate change, the temperature has a direct role on the protein and oil accumulation in soybean (Dornbos and Mullen, 1992; Rebetzke et al., 1996).

Mungbean [*Vigna radiata*] is also one of the most major legumes in the tropics and subtropics. India is the largest producer of pulses which contributes 35.7% to the global production (FAOSTAT, 2013). The optimum average temperature for the potential yield of mungbean lies between 28℃ and 30℃. Mungbean contains 51% carbohydrate, 24-26% protein, 4% mineral and 3% vitamins (Afzal MA, Murshad ANMMM et al., 2008). Besides providing protein, mungbean has the remarkable quality of helping the symbiotic root rhizobia to fix nitrogen (58-109 kg/ha) in an atmosphere. Despite the efforts for improving the mungbean, the yield of this crop remains low. A Recent study, mungbean encounters the cumulative adverse effects of other environmental factors as insects, pest, high temperature causing high yield loss (Sehrawat et al., 2013). Mungbean is reported to be more susceptible to drought stress than other grain legumes (Pandey et al., 1984), which is sensitive to varying photoperiod and temperature regimes.

MATERIALS AND METHODS

Plant materials

Nine soybean varieties, Daewon-kong, Pungsannamul-kong, Taekwang-kong, PI416937, Chungja 3, SS2-2, SS0404-T5-76, Buseok-kong and Gilyuk 69 were used as plant materials. Two mungbean varieties, Sunhwa nogdu and Gyunggi jaerae, were also used as plant materials. Three seed were sown in a pot in different temperature level plastic houses in June 26, 2014. The experiments conducted at the field farm of Seoul National University (37.27˚N, 126.99˚E), Suwon, and Korea in 2014.

Temperature treatments

Four plastic houses that were controlled by the target temperatures of ambient temperature (T_1), T_2 (T_1+1.5℃), T_3 (T_1+3.0℃) and T_4 (T_1+5.0℃) by automatic control of roof and side windows, ventilation fans, and hot-air blower. Air temperature of each house was monitored with date logger equipped with platinum resistor thermos-probe throughout the growing season (Figure 1).

Phenotyping of agronomic traits

Eight agronomic traits were measured such as flowering time(FT), plant height(PH), number of pods(PN), number of nodes(NN), length of pods(PL), length of nodes(NL), number of branches(BN), number of seeds per pod(SN).

PH was measured main stem height immediately after first flowering time. NN, NL and BN was measured after harvesting is completed. PN, PL and SN was measured three times after the completion of harvest every 10 days.

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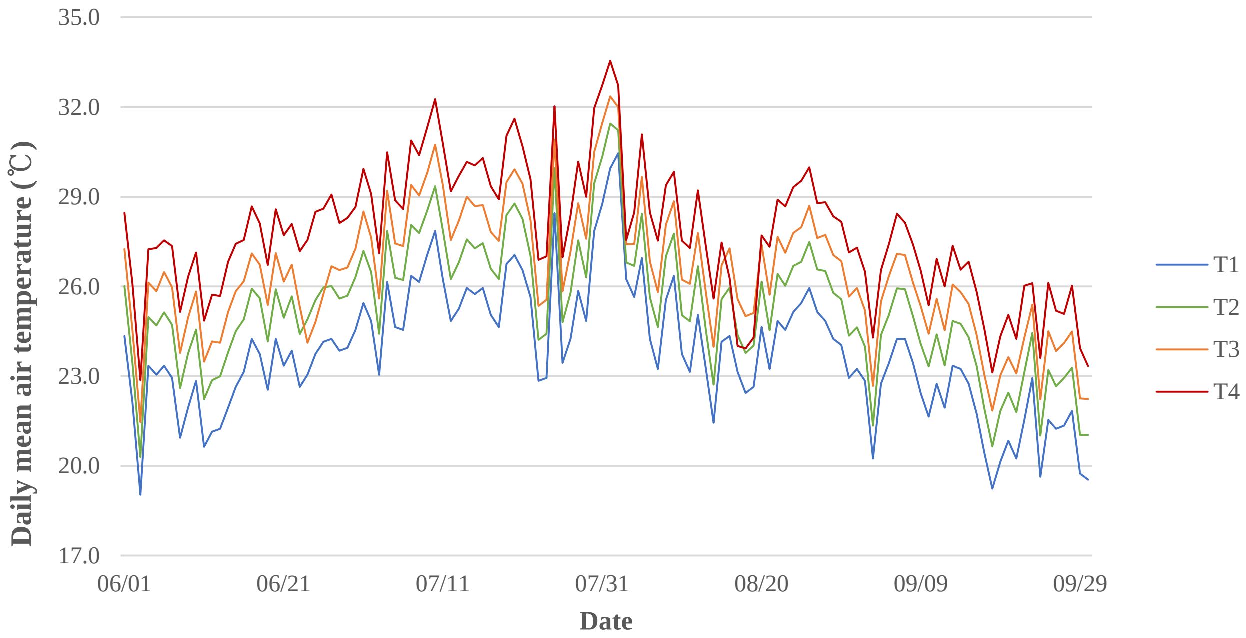


Figure 1. Mean daily air temperature each four different temperature plastic houses.

T_1 is ambient temperature (Suwon temperature). $T_2 = T_1 + 1.5$℃, $T_3 = T_1 + 3.0$℃ and $T_4 = T_1 + 5.0$℃

Statistical analysis

Plant height, flowering time, number of pod, number of node and number of branches value was the average of 3 measurements. Length of pod and number of seed per pod value was the average of 30 measurements, length of nod value was the average of 9 measurements.

All data were analyzed statistically as analysis of variance (ANOVA) that was used to test the significant between temperature variations, genotypes and eight major agronomic traits.

Pearson correlation analysis was used to identify the association between/among growth-related traits and temperature, yield-related traits and temperature.

The mean differences were adjusted with Duncan’s Multiple Range Test using the statistical computer program (SAS Institute, 2003, Cary, NC) and R package program was used for graphical presentation

RESULTS AND DISCUSSION

In this study, we observed response of major agronomic traits like plant height, flowering time, number of pods, number of nods, length of pods, length of nodes and number of seeds per pod on high temperature just in case global warming. We conducted experimental in plastic houses of different temperature level. Air temperature is increasing 0.2℃ per decade, now much faster, so we set temperature levels (1℃, 3℃, 5℃) higher than ambient temperature.

Interaction of temperature and genotype in soybean

The effect of temperature, soybean genotype and correlation (temperature x genotype) on agronomic traits in soybean was significant (Table 1). Results showed that growth type traits such as plant height and the number of branches and flowering time were influenced with the higher temperature. The number of pods is one of the yield type traits which was also influenced by temperature variation, however the number of seeds per pod was not too much significant with increasing

Table 1. Significant of temperature and genotype on traits in soybean

	Height	Branch number	Pod number	Seed number	Flowering time	Pod length	Node length	Node number
Temperature (T)	0.0013**	<.0001**	0.0478*	0.403	<.0001**	0.4143	<.0001**	<.0001**
Genotype (G)	<.0001**	<.0001**	0.2518	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
T * G	0.0529	<.0001**	<.0001**	0.0322*	<.0001**	0.0009**	<.0001**	<.0001**

temperature. Interaction of correlation of temperature and genotype also was meaningful relationship on all traits except plant height.

Effect of traits in soybean by genotype and temperature

The effect of genotype on agronomic traits was significant (Table 2). The highest plant height (63.65 cm) was recorded in Chungja 3 and the number of pods (50.10) was recorded in Daewonkong but less influenced compared with other genotypes. And the greatest number of branches (11.42) and number of seeds per pod (3.08) was recorded in SS0404-T5-76. Gilyuk69 had ealier flowering time (July7, 2014) than others.

The impact of increasing temperature on agronomic traits in soybean was also significant (Table 3). Result showed that flowering time became faster with increasing air temperature. Growth type such as plant height and the number of branches increased up to T_3 treatment and decreased from that. However, the number of seeds per pod is one of the yield component and the length of pods were not influenced with

Table 2. Effect of genotype on agronomic traits in soybean

	Height (cm)	**Branch number**	**Flowering time**	**Pod number**	**Seed number**	**Pod length (cm)**	**Node length (cm)**	**Node number**
SS0404-T5-76	49.42 e	11.42 a	20140723 cd	43.58 ab	3.08 a	4.23 de	4.22 g	16.25 a
Buseok	57.77 bc	6.50 c	20140722 d	45.50 ab	2.49 bc	4.04 e	6.44 cd	11.00 e
Chungja 3	63.65 a	8.09 b	20140726 a	33.64 b	2.14 d	5.42 a	7.42 b	13.91 b
Daewon	61.87 ab	4.50 d	20140722 d	50.10 a	2.26 cd	4.76 b	6.86 bc	12.10 ced
Gilyuk69	63.04 a	1.25 e	20140707 f	37.67 ab	2.92 a	5.50 a	8.26 a	14.33 b
PI416937	54.442 cd	7.00 c	20140724 bc	35.67 ab	2.36 bcd	4.59 bc	8.26 a	13.17 bc
Pungsannamul	50.117 de	-	20140724 ab	39.25 ab	2.60 b	3.34 f	5.26 f	-
SS2-2	56.192 c	5.20 d	20140716 e	40.70 ab	2.50 bc	4.83 b	6.07 de	12.90 bcd
Taekwang	46.136 e	4.27d	20140723 cd	36.82 ab	2.21 d	4.43 cd	5.58 ef	11.18 de

Table 3. Effect of temperature on agronomic traits in soybean

	Height (cm)	**Branch number**	**Flowering time**	**Pod number**	**Seed number**	**Pod length (cm)**	**Node length (cm)**	**Node number**
T_1	52.16 b	5.32 c	20140721 a	38.40 ab	2.43 a	4.52 a	6.06 c	12.09 b
T_2	56.60 a	4.75 c	20140721 a	34.33 b	2.51 a	4.65 a	7.49 a	11.75 b
T_3	58.60 a	8.00 a	20140720 b	43.52 a	2.57 a	4.59 a	6.88 b	14.13 a
T_4	55.81 a	6.20 b	20140719 b	45.26 a	2.51 a	4.51 a	5.51 d	14.80 a

increasing temperature. Another yield components, the number of pods increased with increasing air temperature. The highest plant height (58.60cm), the number of branches (8.00) and the number of seed per pod (2.57) was recorded at T_3 treatment. And the highest number of pods (45.26) and the number of nodes (14.80) was recorded at T_4 treatment. Also, the earliest flowering time (20140719) was recorded at that temperature treatment.

Significant of temperature on traits by genotypes in soybean

The interaction of genotype and agronomic traits with increasing temperature was significant. The result showed that plant height, the number of branches and flowering time were highly significant in almost genotypes (Table 4). SS2-2, Chungja 3 and especially SS0404-T5-76 were meaningful on the number of pods with increasing air temperature. The number of seeds per pod was high interaction in Pungsannamulkong, Gilyuk69, SS0404 and Taekwangkong. In particular, SS0404-T5-76 was highly significant on all agronomic traits except flowering time.

Table 4. Interaction of genotype and agronomic traits with increasing temperature.

		PI416937	Pungsan namul	Gilyuk69	SS2-2	Buseok	Chungja 3	Daewon	SS0404-T5-76	Taekwang
Height	R	0.9642	0.9854	0.8968	0.9321	0.9894	0.9689	0.9496	0.9919	0.986
	P	0.0061**	0.0001**	0.2193	0.0064**	0.8365	0.2414	0.0001**	0.0001**	0.0016**
Branch number	R	0.967	-	0.4931	0.9081	0.9671	0.8389	0.97	0.9765	0.7931
	P	0.0001**	-	0.125	0.0016**	0.0001**	0.0037**	0.0001**	0.0001**	0.0086**
Flowering time	R	0.8445	0.709	0.9416	0.2352	0.6688	0.3185	0.7058	0.4699	0.7494
	P	0.0013**	0.0154*	0.0001**	0.5183	0.0253*	0.4137	0.0491*	0.147	0.0164*
Pod number	R	0.2957	0.3724	0.3585	0.8511	0.5587	0.7446	0.3014	0.8333	0.2311
	P	0.3967	0.268	0.2891	0.0068**	0.0749	0.0175*	0.5096	0.0018**	0.5804
Seed number	R	0.058	0.1662	0.158	0.0386	0.0793	0.025	0.0801	0.1041	0.1756
	P	0.2061	0.003**	0.0043**	0.4542	0.0967	0.5853	0.1129	0.0383*	0.002**

Table 4. Continued

Pod length	R	0.108	0.3406	0.0698	0.5248	0.3037	0.0371	0.0593	0.5461	0.1387
	P	0.0912	0.0001**	0.2517	0.0001**	0.0001**	0.5441	0.3426	0.0001**	0.0378*
Node number	R	0.5804	-	0.4432	0.9434	0.5	0.853	0.6179	0.9861	0.5839
	P	0.0621	-	0.1755	0.0004**	0.1189	0.0027**	0.1029	0.0001**	0.0888
Node length	R	0.9844	0.1642	0.287	0.1578	0.1286	0.6372	0.5687	0.7099	0.6522
	P	0.0001**	0.1202	0.0118*	0.2081	0.2146	0.0001**	0.0001**	0.0001**	0.0001**

Interaction plot, only genotypes with high significance, showed change pattern by increasing air temperature (Figure 2). Five genotypes (SS0404-T5-76, Daewonkong, Pungsannamulkong, SS2-2 and Taekwangkong) showed that increased particular point after decreased pattern on plant height (a), all genotypes showed that increased specific point after decreased pattern such as plant height. Especially SS0404-T5-76 substantially increased from T_2 toT_3 (b). Gilyuk69 was the fastest flowering time genotype which showed that faster pattern with increasing temperature (c). In the case of the number of pods was only two genotypes, Chungja 3 and SS0404-T5-76, which showed different change pattern (d). Increased change pattern with increasing temperature in SS0404-T5-76 unlike Pungsannamulkong and Taewangkong (e).

In summary, flowering time was faster on higher temperature. Increased up to specific temperature and then, decreased again in growth type traits whereas different trend was observed in yield components such as number of pods and number of seeds per pod which steadily increased on high temperature. SS0404-T5-76 was influenced by increasing temperature on major agronomic traits especially yield components. That’s why that we determined SS0404-T5-76 is promising

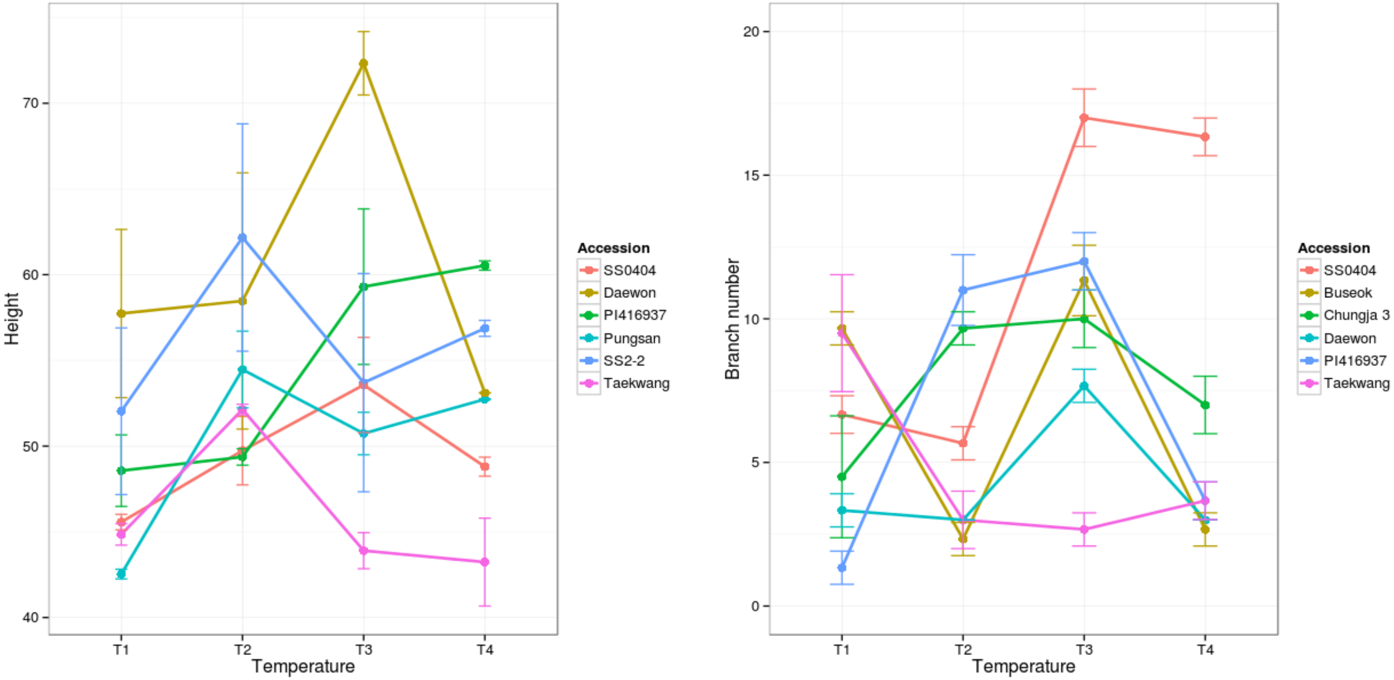
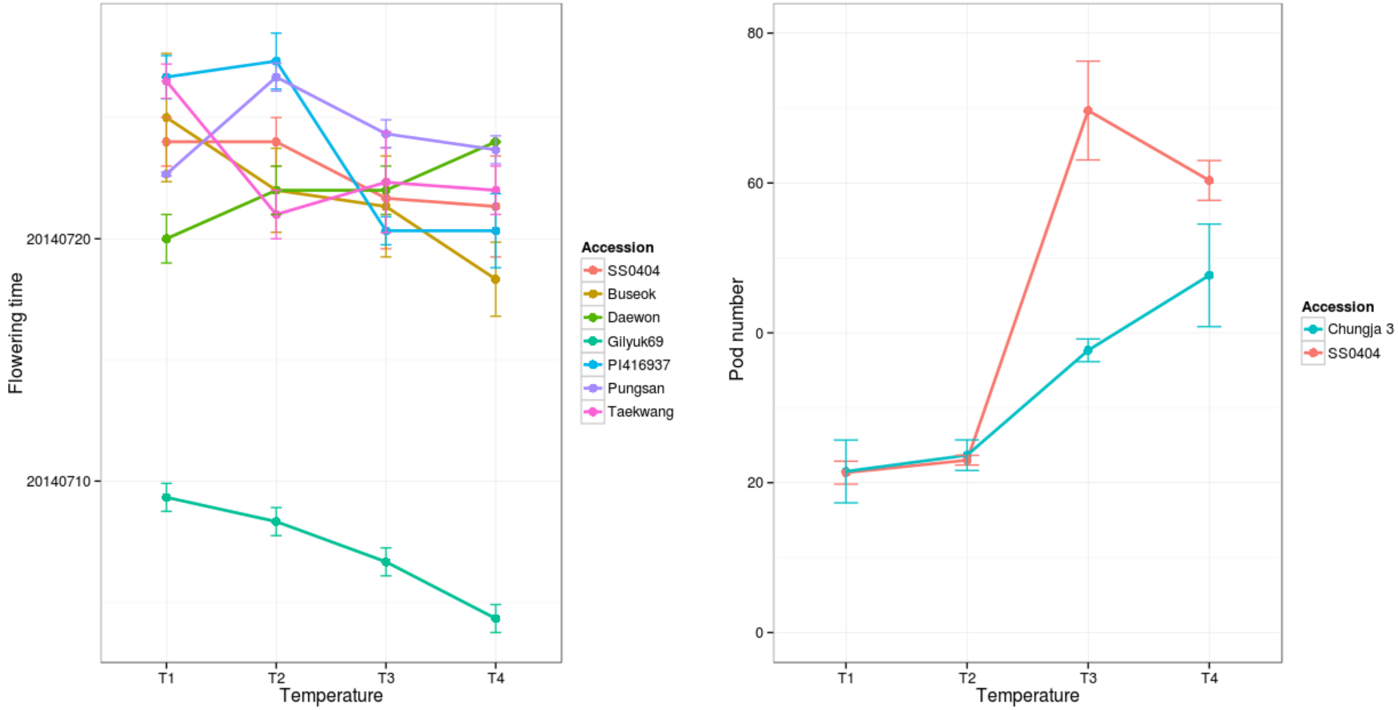


Figure 2. Interaction plot significant genotype in soybean for plant height (a), number of branch (b), flowering time (c), number of pods (d) and number of seed per pods (e)



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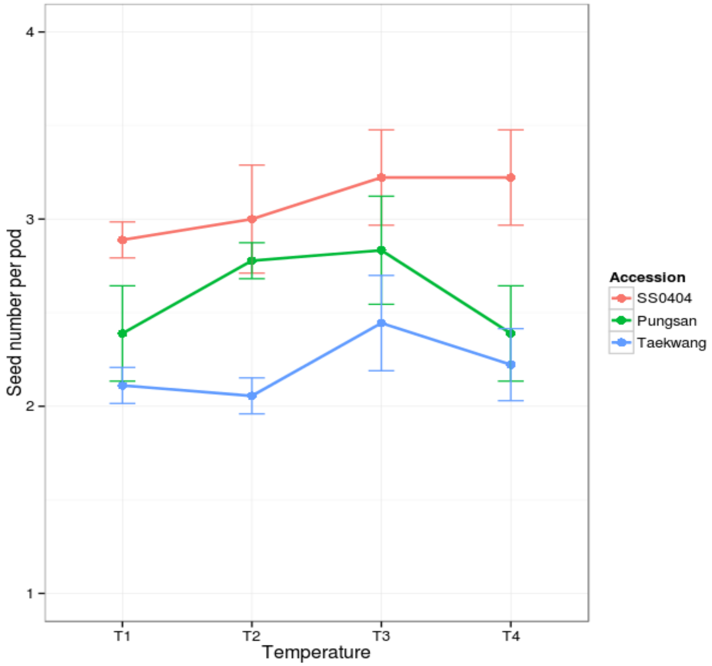

Figure 2. Interaction plot significant genotype in soybean for plant height (a), number of branch (b), flowering time (c), number of pods (d) and number of seed per pods (e)

breeding material on high temperature.

Interaction of temperature and genotype in mungbean

The interaction of temperature, genotype and correlation (temperature x genotype) on agronomic traits in Sunhwanogdu and Gyunggijaerae was significant (Table 5). Results showed that all measured agronomic traits had high meaningful relationship by different temperature except the number of branches. However, the number of branches was influenced included flowering time, the number of pods and the number of seed per pod by genotype. Only three traits, plant height, the length of pods and the length of node, were significant by temperature and genotype correlation. Yield components such as the number of pods and the number of seeds per pod were not influenced by correlation.

Table 5. Significant of temperature and genotype on agronomic traits in mungbean

	Height	Branch number	Flowering time	Pod number	Seed number	Pod length	Node number	Node length
Temperature (T)	<.0001**	0.1817	0.0002**	0.0035**	<.0001**	0.0004**	0.0098**	0.0002**
Genotype (G)	0.5492	<.0001**	0.0003**	0.0063**	<.0001**	0.5603	0.651	0.1009
T * G	0.0008**	0.1817	1	0.0654	0.2462	0.0073**	0.4992	0.0003**

Effect on traits in mungbean by genotype and temperature

The effect of genotypes on agronomic traits in Sunhwanogdu and Gyunggijaerae was significant (Table 6). Sunhwanogdu (49.71cm) was taller than Gyunggijaerae and Sunhwanogdu had a fast flowering time although both belong to the same group which was a result of Duncan's test. The noticeable difference is that Gyunggijaerae was the greatest in the number of pods, number of seed per pod and number of branches.

The impact of increasing temperature on major agronomic traits was also vital meaning (Table 6). Result showed that plant height and the number of seeds per pod increased up to T3 treatment and then decreased whereas the number of pods and number of branches increased steadily with increasing temperature. However, the flowering time was not greatly influenced by increasing temperature treatment, compared with T_1.

Table 6. Effect of genotype and temperature on agronomic traits in Sunhwanogdu and Gyunggijaerae

	Height	**Branch number**	**Flowering time**	**Pod number**	**Seed number**	**Pod length**	**Node length**	**Node number**
Genotype								
Sunhwanogdu	49.71 a	0 b	20140719 b	14.55 b	6.97 b	6.45 a	8.62 a	10.18 a
Gyunggijaerae	48.68 a	3.75 a	20140722 a	26.67 a	9.17 a	6.62 a	7.88 a	9.75 a
Temperature								
T_1	30.00 c	1.33 b	20140723 a	6.60 c	5.61 b	5.18 b	6.96 b	6.60 b
T_2	52.38 b	1.83 ab	20140719 b	18.00 bc	8.61 a	6.98 a	7.00 b	10.00 a
T_3	61.10 a	1.83 ab	20140721 b	26.33 ab	9.39 a	7.18 a	9.06 a	10.83 a
T_4	53.28 b	2.50 a	20140719 b	30.17 a	8.67 a	6.80 a	9.97 a	11.83 a

Significant of temperature on traits in mungbean

The interaction of genotype and agronomic traits with increasing temperature showed that plant height, the length of pod and the number of seeds per pod were highly significant in Sunhwanogdu and Gyunggijaerae (Table 7). Flowering time was significant in only Gyunggi jaerae instead of the number of pods and the length of node were a meaningful relationship in only Sunhwanogdu.

Interaction plot, only genotypes with high significance, showed change pattern by increasing air temperature (Figure 3). Both genotypes showed the same pattern that increased up to T_3 temperature and decreased from T_3. Gyunggi jaerae substantially increased from T_1 to T_2 temperature (a). The number of branches steadily increased pattern with increasing temperature but, no branch in Sunhwanogdu (b). Flowering time also showed that same pattern in both genotypes (c). Gyunggijaerae increased up to T_3 treatment after that decreased rather consequently increased in Sunhwanogdu (d) and the number of seeds per pod was the same pattern like pod number (e).

Table 7. Interaction of genotype and agronomic traits with increasing temperature.

		Height	Branch number	Flowering time	Pod number	Seed number	Pod length	Node length	Node number
Sunhwa nogdu	R	0.9796	-	0.5897	0.7869	0.5	0.6923	0.6802	0.7066
	P	0.0001**	-	0.0849	0.0095*	0.0001**	0.0001**	0.0001**	0.0279
Gyunggi jaerae	R	0.9862	0.4074	0.8857	0.6464	0.3547	0.4154	0.0181	0.4666
	P	0.0001**	0.2192	0.0004*	0.0326	0.0001**	0.0002*	0.8977	0.1504

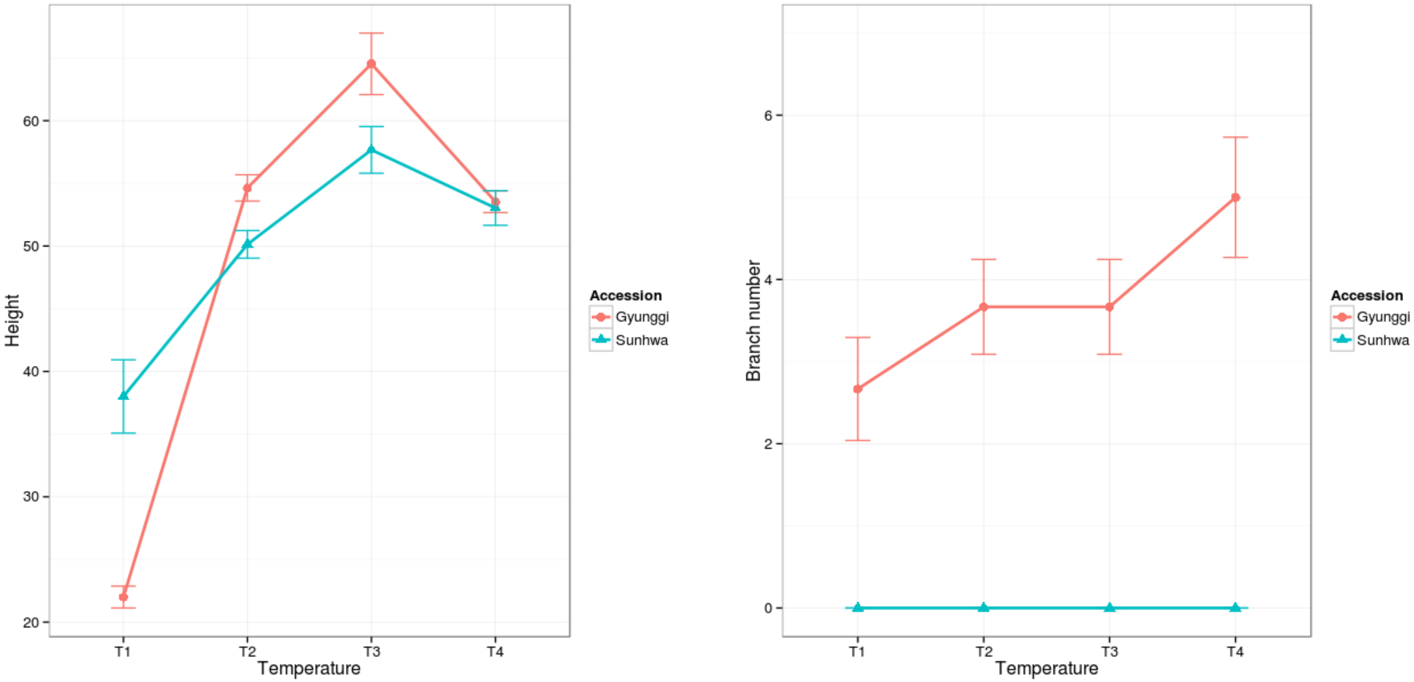

Figure 3. Interaction plot significant genotype in mungbean for plant height (a), number of branch (b), flowering time (c), number of pods (d) and number of seed per pods (e)

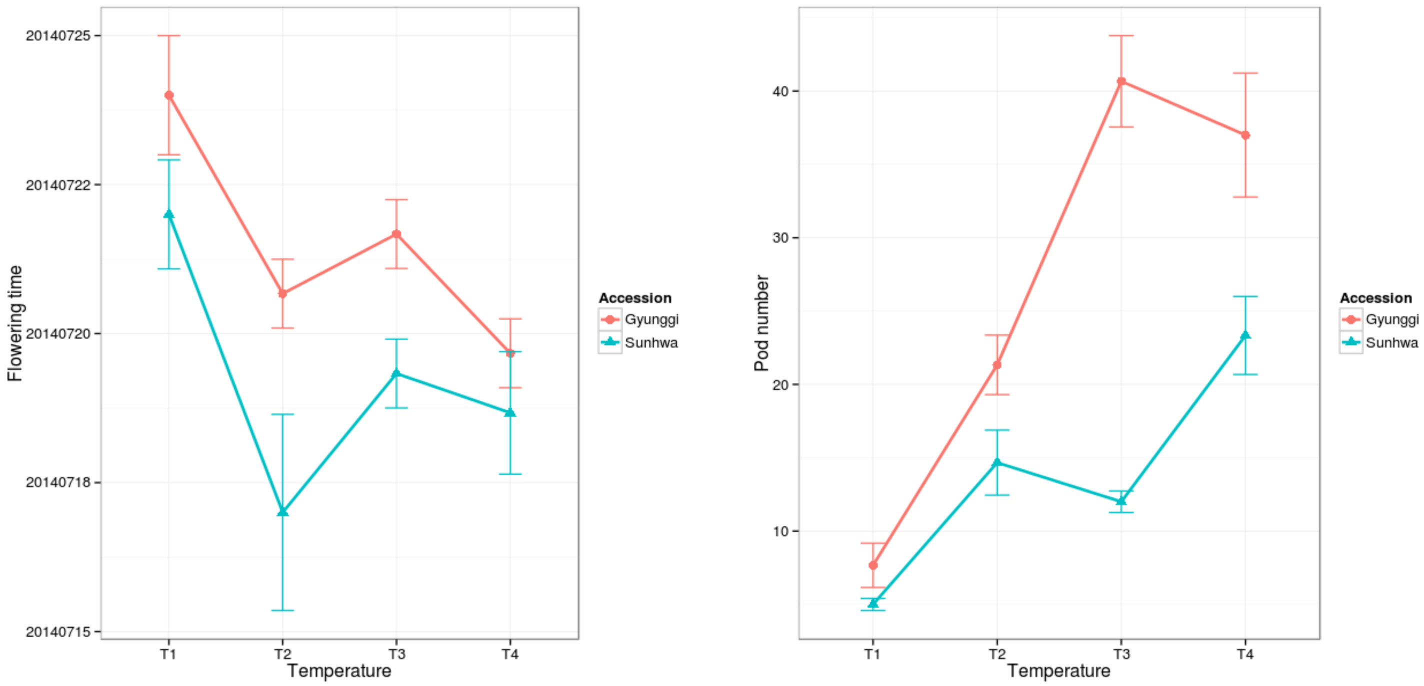

Figure 3. Interaction plot significant genotype in mungbean for plant height (a), number of branch (b), flowering time (c), number of pods (d) and number of seed per pods (e)

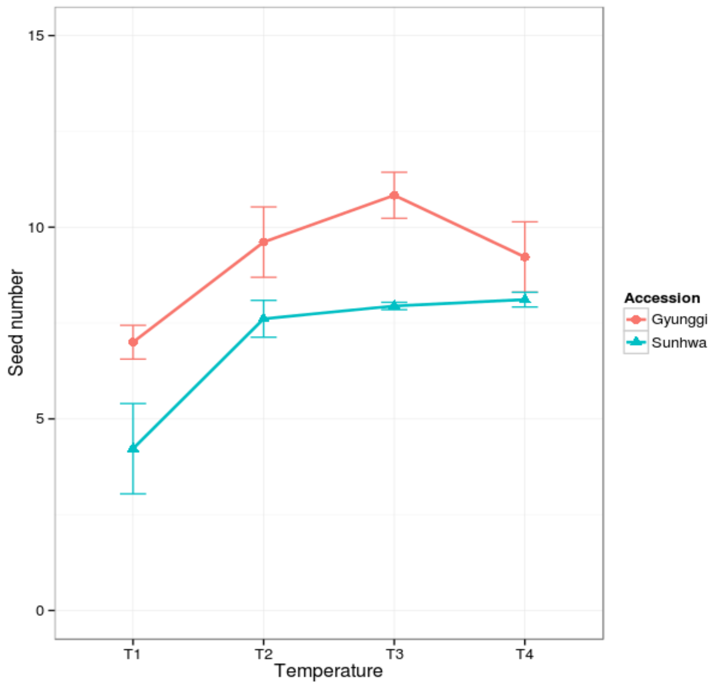

Figure 3. Interaction plot significant genotype in mungbean for plant height (a), number of branch (b), flowering time (c), number of pods (d) and number of seed per pods (e)

In summary, In Sunhwanogdu and Gyunggijaerae, major agronomic traits like growth type traits and yield components generally continuously increased with increasing temperature. In addition flowering time became faster compared to ambient temperature. Sunhwanogdu was the same as the other conditions, however, had a much pods number, and it had adaptability of high temperature than Gyunggijaerae. The origin of the soybean is known as Korea and China, and the mungbean has originated from the Indian subcontinent where it has tropical weather. So it can be easily adapted to high temperature than soybean. (Lambrides et al., 2006).

These results suggest that plant height is increased small degree of high temperature but, growth is limited to up 3 degree more than now ambient temperature. Using this plant materials can be conducted QTL mapping and as a result, can find heat tolerance genes in soybean and mungbean. With this, genomic selection for breeding should be possible more easily.

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ABSTRACT IN KOREAN

초록

기후변화에 따른 고온 스트레스에 대한 콩과 녹두의 반응 양상을 관찰하고 이에 적응력이 강한 품종을 찾고자 수행되었다. 콩은 총 9개의 품종을 사용하였고, 녹두는 2개의 품종으로 연구를 진행하였다. 고온 스트레스의 정도에 대한 생리적 반응을 평가하기 위해 온도처리는 외기온도를 기준으로, 1.5℃, 3.0℃, 5.0℃ 높은 온도를 처리해준 상태로 콩과 녹두를 생육하였다.

전체적으로 콩의 생육에 영향을 주는 표현형인 경장과 가지(branch)의 개수가 지속적으로 증가하다가 외기온도보다 5.0℃ 높은 처리 구에서는 생육이 다시 감소하는 추세를 관찰할 수 있었던 반면, 온도가 증가할수록 개화기는 점차 빨라졌으며 콩의 생산량에 영향을 미치는 꼬투리의 개수나 한 꼬투리 내 종자의 개수 역시 점점 증가하는 양상을 보였다. 콩은 9개의 품종 가운데 SS0404-T5-76 품종의 경우 온도변화와 그에 따라 주요 농업형질의 표현형이 모두 매우 높은 유의성을 가지고 있었으며, 온도가

증가함에도 수량의 증가 양상을 보였기에 다른 품종에 비해서 고온 스트레스에 적응력이 뛰어난 품종임을 확인 할 수 있었다.

녹두는 콩보다 열대기후에 좀 더 강한 작물이기에 공시한 2품종 모두에서 생육에 영향을 주는 경장과 가지의 개수가 꾸준히 증가하는 양상을 보이고 있었으며, 수량 구성요소인 꼬투리의 개수와 한 꼬투리 내 종자의 개수는 선화녹두의 경우 고온에 지속적으로 증가하는 추세를 보였으므로 고온적응성이 경기재래에 비해 더 우수한 것으로 판단되었다.

주요어: 지구온난화, 고온스트레스, ANOVA, 콩, 녹두

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