Effect of Temperature on Flower and Pod Abscission and Yield of Three Soybean Genotypes

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Abstract

A pot experiment was conducted at Soil Science Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during January to April 2014 to investigate the growth, abscission of flower and pod and yield performance of three soybean varieties (BINA Soybean-1, BINA Soybean-2, and Shohag) under three different temperature conditions. Flower abscission number and percentage were maximum in elevated temperature but the abscission of pods plant^{-1} was found to be the maximum in ambient temperature. In case of the performance of varieties, tallest plant and maximum node plant^{-1} were noted from the variety Shohag but number of nodules plant^{-1} , number of seeds pod^{-1}, weight of 100 seed and seed yield was highest in BINA soybean–2 while BINA soybean–1 had maximum flowers plant^{-1} and pods plant^{-1}. Abscission of flowers plant^{-1} was maximum in BINA soybean–1 under elevated temperature while similar variety grown under ambient temperature obtained the maximum abscission of pods plant^{-1} and the variety Shohag grown under elevated temperature noted the maximum abscission percentage of flower at all the data recording stages. These results suggested that ambient temperature and BINA soybean–2 singly or their interaction would be the most significant compared to others.

Key words: Morpho–physiological attributes, Temperature effect, Varietal effect, Yield attributes

Introduction

Soybean (*Glycine max* (L.) Merr) is one of the most important grain legume of the world and a new prospective crop for Bangladesh. Cultivation of soybean covered about 55,000 hectares of land and produced about 90,000 metric tons of seeds during the period of 2009-2010 in Bangladesh (Anonymous, 2011). Soybean is very sensitive to variation in photoperiod, temperature and water availability. The suitable temperature for soybean is 15-22°C at emergence, 20-25°C at flowering, and 15-22°C at maturity (Liu *et al.*, 2008). Soybean seed yield increased as the day/night temperature increased between 18/12°C and 26/20°C, but yield decreased when plants were grown at temperature greater than 26/20°C (Huxley *et al.*, 1976). Raising temperature from 29°C to 34°C during seed fill decreased soybean seed yield (Dornobos and Mullen, 1991).Temperature above 40°C causes severe pod abortion in soybean (Mann and Jaworski, 1970). High temperature accelerate the abscission process of developing the reproductive organs and affect in pod set and yield in soybean (Saito *et al.*, 1970; Ashley and Ethridge, 1978; Korte *et al.*, 1983). Flower set and retention in legumes is affected by high day-temperature and low available soil moisture (Davis, 1945; Stobbe *et al.*, 1966; Fisher and Weaver, 1974). Hot weather imposing temporary heat and /or drought stresses during reproductive development enhanced flower and pod abscission (Konsens, 1991). High temperature also enhanced the maturing of crop (Suppiah, 1997). Global temperature would increase 4°C by 2100 AD and it would probably decrease the production of most crops by about 25% (Lawlor, 1997). Jiwu and Hong (1997) also reported that ascending air temperature would influence soybean production in future. Photosynthesis and seed characteristics are the primary determinants of pod and seed number (Eglib, 2005), but recent research suggests that the temporal distribution of flower production may also play an important role. The present study was conducted to assess the effect of temperature on flower and pod abscission of soybean and their yield at the three temperature conditions (ambient, high, and cool).

Materials and Methods

The pot experiment was conducted in a controlled plant growth chamber and open field at the field laboratory of the Department of Soil Science, Bangladesh Institute of Nuclear Agriculture (BINA) during the period from January to May 2014. The experimental area was under the subtropical climate, which was characterized by moderately low temperature during *Rabi* season (October to March) and scanty rainfall associate with high temperature, high humidity and heavy precipitation with occasional gusty winds in *Kharif*-1 season (April to July) under Old Brahmaputra Flood Plain Agro-Ecological Zone. The soil was silty loam in texture having pH 6.7. Three soybean genotypes viz., BINA soybean-1, BINA soybean-2, Shohag (PB-1) were used as planting materials. Thirty six pots were prepared and their individual weight was recorded. Three seeds were sown by hand at a depth of 0.01m on 15 January 2014 in each pot with the aim of growing one plant up to maturity. After germination, one healthy seedling was kept in each pot at 20 DAS. The experiment was laid out in CRD with three temperature treatments as ambient, elevated and cool condition with four replication. Out of 36 pots, the 12 pots were placed in elevated condition and another 12 pots were in cool condition. The rest 12 pots were placed in ambient condition. Irrigation was done two times a day at morning (8.00 am) and afternoon (5.00 pm). Air temperature was recorded in a clear sunny day with Psychrometer (Testo 615, GM 295-14770, German) at one hour interval from 10 am to 4 pm on the month of March, 2014. Plant height, node number plant^{-1}, nodule number plant^{-1}, flower number plant^{-1}, pod number plant^{-1}, seed number plant^{-1}, seed weight plant^{-1}were recorded after final harvest. The data were analyzed

statistically and the means were adjusted by DMRT at 5% level of significance.

Results and Discussion

Interaction effect between various types of temperature and varieties on morpho–physiological, yield attributing characters and yield of soybean

The interaction effect of various temperatures and varieties on plant height, nodes plant^{-1}, nodules plant^{-1}, flowers plant^{-1}, pods plant^{-1}, seeds pod^{-1}, weight of 100 seed and seed yield are shown in Table 1. In Table 1, subscript a, b and c means values within a column followed by the same letter are not significantly different, LSD means least significant difference, LS means level of significance (1%) and NS means non–significant. The observed characteristics of plant in different temperature conditions are mentioned below.

Plant height

Interaction effect of various types of temperature and soybean varieties on plant height showed significant difference (varied from 0.405 to o.622 m) (Table 1).The significant tallest plant was found in variety Shohag grown under elevated temperature treatment followed by the similar variety grown under ambient temperature condition (0.522 m).On the other hand, the shortest plant was obtained from the variety BINA Soybean-2 at elevated temperature condition (0.405 m). Wang (2001) found that high temperature increased the plant height as well as the length of the nodes due to the increase of phenolic acid, flavonols, and antho-cyanins contents in plants.

Number of nodes plant^{-1}

The node development was faster in elevated temperature and significantly higher number of nodes per plant (9.06) was found in the variety Shohag (Table 1). The lowest number of nodes per plant was found in BINA soybean–2 (6.40) in cool temperature while statistically similar lower number of nodes per plant was also obtained by the rest of the soybean varieties in similar (cool condition) treatment (Table 1).

Number of nodules plant^{-1}

The maximum number of nodules per plant (96.40) was found in BINA Soybean–2 at ambient temperature (Table 1). On the other hand, opposite result was prevailed in cool condition at Shohag variety (33.80) (Table 1). Margesin and Schinner (1999) also reported that extreme lower temperature can drastically reduce the number of nodule in soybean plant.

Number of flowers plant^{-1}

The maximum number of flowers per plant (115.10) was found from the variety BINA Soybean-1 grown under elevated temperature treatment which was statistically differed from other interaction treatments (Table 1). On the other hand, the variety Shohag grown under cool temperature treatment showed significantly the minimum number of flowers per plant (85.30) which was also statistically differed from other interactions (Table 1). All three varieties of the present study showed reduced number of flowers per plant under cool temperature treatment than ambient and elevated temperature treatment. This finding was fully agreed to the findings of Fakir *et al.* (2000).

Number of pods plant^{-1}

The effect of varieties and temperature treatment on pod number per plant was significant (Table 1). At maturity, the highest pod number per plant was found (59.75) in BINA Soybean-1 under ambient temperature, on the contrary, the lower number of pod were shown in variety Shohag at elevated temperature, however, statistically similar pod per plant of BINA Soybean-2 was in ambient and cool temperature treatment. Ofier *et al*. (1993) reported that pod number of *phaseolus vulgaris* was significantly reduced by exposure to a high temperature of 32/27°C (day/night) for 5 days at anthesis, compared to 22/17°C. The reduction was caused by an increased abscission to flower buds, flowers and young pod and by the failure of fertilization and seed development.

Number of seeds pod^{-1}

Number of seed per pod was statistically identical among the whole interaction between temperature treatments and soybean varieties (Table 1).

Weight of 100 seed

Interaction effect of soybean varieties and various types of temperature treatments showed significant variation in respect of 100 seed weight (Table 1). The highest weight was found (13.20) in BINA Soybean-2 under ambient temperature, On the contrary, the lower number of pod were shown in variety Shohag at cool temperature, However, BINA Soybean-1 gave statistically similar pod per plant in ambient and elevated temperature treatment.

Seed yield

From the Table 1, it was evident that the highest seed yield (19.16 gm plant^{-1}) was found in BINA Soybean-2 under ambient temperature followed by the variety BINA soybean-1 under similar temperature treatments (18.55 gm plant^{-1}). Likewise, the lowest seed yield (8.61 gm plant^{-1}) was obtained from the variety Shohag grown under elevated temperature followed by the similar variety grown under cool temperature (9.47 gm plant^{-1}). The result indicated that the elevated and cool temperature decreased the seed yield regarding all varieties. Similar results were found by Terashima (2001), Shi *et al*. (2001), Morita. (2000), Robins and Domingo (1953). Imposing any kind of high temperature is expected to increase the process of abscission and thereby reduce the yield of soybean. Plant response to high temperature was most severe during the periods of rapid growth and development.

Table 1. Interaction effect between various types of temperature and varieties on morpho–physiological parameters, yield attributing characters and yield of soybean

Varieties	Plant height (m)	No. of nodes plant^{-1}	No. of nodules plant^{-1}	No. of flowers plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 seed weight (g)	Yield (gm plant^{-1})
Ambient x BINA Soyaben-1	0.484c	6.80cd	88.60b	110.60b	59.75a	2.43	12.80c	18.55b
Ambient x BINA Soyaben-2	0.422g	6.60de	96.40a	100.40e	55.80c	2.60	13.20a	19.16a
Ambient x Shohag	0.522b	7.25b	72.20c	88.40g	41.73g	2.33	11.80e	11.45f
Elevated x BINA Soyaben-1	0.523b	7.34b	54.31e	115.10a	55.48d	2.36	12.29d	16.09de
Elevated x BINA Soyaben-2	0.444f	6.94c	65.60d	102.40d	52.38e	2.54	12.94bc	17.21c
Elevated x Shohag	0.622a	9.06a	40.60g	98.40f	36.05h	2.30	10.38f	8.61h
Cool x BINA Soyaben-1	0.459e	6.50e	40.40g	105.80c	57.90b	2.30	12.32d	16.41d
Cool x BINA Soyaben-2	0.405h	6.40e	48.20f	98.40f	55.60cd	2.52	13.00b	18.22bc
Cool x Shohag	0.468d	6.50e	33.80h	85.30h	42.50f	2.16	10.30f	9.47g
$LSD_{(0.05)}$	0.993	0.370	0.763	0.756	0.375	0.165	0.198	1.067
LS	**	**	**	**	**	NS	**	*

**= significant at 1% level of probability

Interaction effect between various types of temperature and varieties on flower abscission percentage at reproductive stage

The interaction effect of temperatures and varieties on number of flowers plant^{-1}, number of pods plant^{-1} and flower abscission percentage are shown in Table 2. Interaction effect between temperature and varieties significantly influenced the abscission percentage of flowers (Table 2). Percentage of flower abscission was found to increase with the increase in temperature in respect of all varieties. It was the highest (63.25, 63.45 and 63.39%) in Shohag under elevated temperature treatment at 15–March, 20–March and 25–March, respectively indicating the susceptibility of high temperature. The second highest abscission percentage of flower (55.56, 55.64 and 55.60%) was obtained in BINA soybean–2 grown under cool temperature at those stages, respectively. The variety BINA Soybean-2 grown under ambient temperature appeared to have the lowest percentage of flower abscission (44.00, 44.80 and 45.68%) at 15–March, 20–March and 25–March, respectively. The results indicated that increasing temperature significantly increase the flower abscission in soybean. Similar study performed by Mann and Jaworski (1970) reported that flowers abscission of soybean cultivars in the polythene house was reduced due to higher temperature where air temperature above 40^{o}C caused severe pod abscission.

Table 2. Interaction effect between various types of temperature and varieties on number of flowers and pods plant^{-1}, and abscission percentage at reproductive stage

Treatments	No. of flowers plant^{-1}			No. of pods plant^{-1}			Flower abscission (%)		
	15–Mar	20–Mar	25–Mar	15–Mar	20–Mar	25–Mar	15–Mar	20–Mar	25–Mar
Ambient x BINA Soyaben-1	110.35b	110.90b	110.55b	59.58a	59.44a	59.47a	45.99g	46.40f	46.20e
Ambient x BINA Soyaben-2	99.80e	101.20d	102.73d	55.89c	55.86c	55.70c	44.00h	44.80g	45.68e
Ambient x Shohag	88.00g	88.80f	88.40f	41.71f	41.64f	41.81g	52.59c	53.10c	52.69c
Elevated x BINA Soyaben-1	115.10a	115.30a	114.90a	55.82c	55.33c	55.26c	51.50d	52.01c	51.90c
Elevated x BINA Soyaben-2	102.10d	102.60d	102.50d	52.35d	52.36d	52.43d	48.73f	48.96e	48.85d
Elevated x Shohag	98.10f	98.70e	98.40e	36.05g	36.07g	36.03h	63.25a	63.45a	63.39a
Cool x BINA Soyaben-1	105.65c	105.95c	105.80c	57.87b	57.93b	57.90b	45.23g	45.32fg	45.27e
Cool x BINA Soyaben-2	98.35f	98.45e	98.40e	43.71e	43.67e	43.68f	55.56b	55.64b	55.60b
Cool x Shohag	85.15e	85.40g	85.36g	42.53f	42.48f	45.52f	50.06e	50.25d	46.67e
$LSD_{(0.05)}$	**1.757**	**1.926**	**3.801**	**1.157**	**1.560**	**1.557**	**1.229**	**1.682**	**2.276**
LS	**	**	**	**	**	**	**	**	**

**= significant at 1% level of probability

Conclusions

This study clearly indicated that the ambient temperature and the variety BINA soybean–2 singly or their interaction would be the most significant than other studied temperature stress condition and varieties regarding growth, yield, contributing characters and yield of soybean.

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