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Influence of Temperature Regimes on Germination of Cotton (Gossypium hirsutum l.) Varieties

Abdul sattar khetran[1] Waseem Bashir[1] Sanaullah Baloch[1] Akram Saleh[1] Adnan Noor Shah[2]
Muhammad Yousaf[2] Salih A. I. Sabiel [2] Bilal hussain mastoe[3] Muzafar ahned lagove[3]
Shabeer Ahmed[3] Sheer Azam madokhail[3] Shahbaz Khan Baloch[1*]
1.Sindh Agriculture University, Tandojam Pakistan.
2.Huazhong Agricultural University, Hubei Wuhan, PR China.
3.Agriculture Research Institute (ARI) Sariab road Quetta, Balochistan, Pakistan
Corresponding author: E-mail: khanqamrani90@gmail.com

Abstract
The laboratory experiment was performed at the Seed Testing Laboratory, Department of Agronomy, Faculty of Crop Production, Sindh Agriculture University Tandojam.The experiment was replicated randomized complete design conducted during 2013. Cotton varieties Hari dost, Shahbaz and Sindh-1 were used. Seeds of cotton varieties are placed in a Petri dish having 13.5cm diameters (15 seeds in each Petri dish) on a double layer of Whatman filter paper and kept in seed germinator (Model-PL3) at various temperature regimes. The seeds were moistened whenever necessary. The seed germination % was recorded after 48 hours. The shoot, root length, including fresh and dry weights as well as root shoot ratio was further recorded after 12 days.The results for cotton varieties showed that maximum seed germination (79.78 %), root length (10.75 cm), shoot length (23.09 cm), root fresh weight (887.40 mg), shoot fresh weight (6434 mg), root dry weight (66.34 mg), shoot dry weight (482.2 mg), root shoot ratio (0.464) were observed in variety Sindh-1. However, the variety Shahbaz ranked second with seed germination (73.81 %), root length (6.99 cm), shoot length (15.81 cm), root fresh weight (618.6 mg), shoot fresh weight (4788 mg), root dry weight (48.27 mg), shoot dry weight (345.9 mg), root shoot ratio (0.432) were observed. On the other hand Hari dost had minimum (67.01 %) seed germination, root length (6.75 cm), shoot length (15.09 cm), root fresh weight (610.9 mg), shoot fresh weight (4650 mg), root dry weight (46.64 mg), shoot dry weight (342.0 mg), root shoot ratio (0.443) were observed. The 35oC temperature recorded maximum seed germination (79.73 %), shoot length (21.10 cm), root length (9.85 cm), shoot fresh weight (5858 mg), root fresh weight (765.4 mg), shoot dry weight (436.7 mg), root dry weight (58.25 mg) and root shoot ratio (0.447), whereas the 25oC temperature recorded maximum seed germination (76.83 %), shoot length (20.82 cm), root length (9.56 cm), shoot fresh weight (5543 mg), root fresh weight (756.5 mg), shoot dry weight (422.9 mg), root dry weight (56.96 mg) and root shoot ratio (0.459) were observed. However, the lowest seed germination (64.04 %), shoot length (12.07 cm), root length (5.08 cm), shoot fresh weight (4472 mg), root fresh weight (595.0 mg), shoot dry weight (310.5 mg), root dry weight (46.03 mg) and root shoot ratio (0.414) was recorded at 15oC temperature regimes.
Keywords: Cotton, Temperature, Germination, Varieties

Introduction

Cotton, (Gossypiumhirsutum L.) is the world's most important crop that produces a soft, fluffy staple fiber (Aiken, 2006). The thread from the fiber is often used to make a soft, breathable textile, which is the most widely used natural-fiber cloth in clothing today (Moseley and Gray, 2008). Mostly commercial production comes from varieties of upland cotton (Gossypiumhirsutum L.), but some requirements are also met from sea-island and American-Egyptian cotton (G. barbadense). G. arboreum and G. herbaceum are the chief cultivated species in Asia (CEE, 2003). In Pakistan, during 2011-2012, the cotton was cultivated on an area of 2835 thousand hectares, 5.4 percent more than the last year (2689 thousand hectares). The production is reported at 13.6 million bales, higher by 18.6 percent over the last year's production which was 11.5 million bales. The increase in cultivated area and production is attributed to the use of Bt. cotton and control over wide spread attack of insect pests and diseases (GOP, 2012).

Cotton development and production depend on many environmental factors affecting the plant itself, and its bolland fiber development. Germination of cotton seeds is sensitive to low temperatures (Baloch et al., 1999). Cotton producers face a problem in their planting schedule. If they plant seeds late in the season (e.g., mid to late May) when soil temperature is ideal for seedling emergence, they face reduced fiber and seed quality resulting from maturation under the cool fall temperatures. (Ahmad, 1999) If, however, producers plant seeds early in the season (e.g., mid to late April) so that crop maturation occurs under warmer fall conditions, seedling emergence and stand establishment are compromised due to the low early spring soil temperature (Gipson et al.,2006).

Global surface temperature has increased by approximately 0.6°C since the late 19th century and is projected to increase anywhere from 1.4 to 5.8°C by the end of the current century (Houghton et al., 2001) with a decrease in the diurnal temperature range (Dai et al., 2001). Environmental variables, especially temperature, are the key factor which affects plant growth, development and productivity (Kaleem et al., 2009).

Temperature is a primary environmental factor controlling growth and developmental rates of plants, yet little specific information is available regarding cotton (Gossypiumhirsutum L.) responses to temperature. Information covering a wide range of temperatures would be useful for predicting both developmental and growth rates in cotton (Reddy et al., 1992). Temperature is most important factors in irrigated, annual agro ecosystems at the beginning of the growth season where light, nutrients, and moisture don't limit growth typically (Garcia–Huidobro et al., 1982). In addition, temperature has a direct control on the rate of many chemical reactions, including respiration and photosynthesis (Munir et al., 2004). In recent years, a lot of studies have been done on invigoration of seeds to improve the germination rate and uniformity of growth and reduce the emergence time of many vegetables and some field crops (Basra et al., 2003).

Cool temperatures, below 20°C, may cause chilling injury to seedlings and reduce stand establishment (Cole and Wheeler 2006). Initial injury starting from the imbibition of cold water and water imbibition at 5°C for 12 h can kill cotton seeds. Secondary injury can occur 18 to 24 h after the initiation of germination when temperatures remain below 18°C. Therefore, cotton cultivars with enhanced cold tolerance are always desired (Duesterhaus et al., 2000). Low temperature is an important stress factor for germination and emergence of cultivated plants, especially tropical and subtropical plants such as cotton, soybeans, maize, and rice, which are known as cold-sensitive plants. These plants can exhibit significant physiological days function when they are exposed to low temperatures. (Lyons, 2005).

The research of various researcher suggested that there was genotypic variability in field-grown seedling establishment in response to cold temperatures, and they developed methods to distinguish differences in cold tolerance of cultivars in the laboratory using germination tests in both warm and cool conditions and validated under field conditions. Tuck et al. (2010) successfully used seedling length as an indicator of cultivar variation however; the approach needs to be validated with a wider range of genotypes and conditions.

Materials and methods

The laboratory experiment was conducted at Seed Testing Laboratory, Department of Agronomy, Faculty of Crop Production, Sindh Agriculture University Tandojam. Experiment was replicated randomized complete design conducted during 2013. Cotton varieties Hari dost, Shahbaz and Sindh-1 were used. Seeds of cotton varieties placed in Petri dish having 13.5 cm diameter (15 seeds in each Petri dish) on double layer of Whatman filter paper and kept in Seed Germinator (Model-PL3) at various temperatures regimes.The seed germination (%) was recorded after 48 hours. The shoot length (cm), root length (cm), shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg), root dry weight (mg)and root shoot ratio were also recorded.

Statistical analysis

The data was statistically analyzed through MSTATC computer software. The LSD value for mean comparison was calculated only if the general treatment F test was significant at a probability of ≤ 0.05 (Gomez and Gomez, 1984).

Results and discussion

The results revealed that upper limit seed germination % (79.73) was recorded @ 35^{0}C temperature and the lowest seed germination % (64.04) was observed @ lower temperature 15^{0}C. The higher seed germination % (79.78) was found in cotton variety sindh-1, the lower seed germination % (67.01) was recorded in variety Hari dost, respectively. It is seen from the results that maximum shoot length cm (20.82 and 21.10) was recorded @ 25 and 35^{0}C temperature regimes and the minimum shoot length cm (12.07) was observed @ lower temperature regime15^{0}C. Cool temperatures, below 20°C, may cause chilling injury to seedlings and reduce stand establishment (Cole and Wheeler 2006).

The maximum root length cm (9.56 and 9.85) was recorded @ 25 and 35^{0}C temperature regimes and the minimum root length cm (5.08) was recorded @ 15^{0}C lower temperature regime. The results further indicated that the higher root length cm (10.75) was found in variety sindh-1 and the lower root length cm (6.75) was recorded in variety Hari dost, respectively. Lyons (2005) reported that the low temperature is an important stress factor for germination and emergence of cultivated plants, especially tropical and subtropical plants such as cotton, soybeans, maize, and rice, which are known as cold-sensitive plants. These plants can exhibit significant physiological dysfunction when they are exposed to low temperatures.

The analyzed results for root shoot ratio showed significant response the maximum mean for temperature regimes (0.447) was observed @ 35^{0}C and the minimum (0.414) root shoot shootratio was observed @ 15^{0}C where as in case of varieties the maximum root shoot ratio (0.464) was found in variety Sindh-1 where as the lower root shoot ratio (0.432) was observed in variety Shahbaz, respectively. The research of various researcher suggested that there was genotypic variability in field-grown seedling establishment in response to cold temperatures, and they developed methods to distinguish differences in cold tolerance of cultivars in the laboratory using germination tests in both warm and cool conditions and validated under field conditions, Tuck et al. (2010).

Table I. Seed germination (%), shoot length (cm), root length (cm) and a root shoot ratio of different cotton varieties under the influence of different temperature regimes

Source of variation		Seed germination (%)	Shoot length (cm)	Root length (cm)	Root Shoot Ratio
Temperature x varieties					
15 ^{O}C	Hari Dost	60.45 h	10.11 d	4.14 d	0.410 d
	Shahbaz	62.85 g	11.11 d	4.12 d	0.370 e
	Sindh-1	68.8 f	14.99 c	6.99 c	0.463 abc
25^{0}C	Hari Dost	68.32 f	17.23 b	7.95 bc	0.467 abc
	Shahbaz	77.90 d	18.17 b	8.18 bc	0.450 c
	Sindh-1	84.27 b	27.04 a	12.5 a	0.463 bc
35^{o}C	Hari Dost	72.27 e	17.91 b	8.17 bc	0.457 bc
	Shahbaz	80.67 c	18.14 b	8.67 b	0.467 a
	Sindh-1	86.26 a	27.24 a	12.71 a	0.477 ab
	LSD 5%	1.716	1.356	1.106	0.0144

It is obvious from the results showed that the maximum shoot fresh weight mg (5543 and 5858) was recorded @ temperature regimes of 25 and 350C and the minimum shoot fresh weight mg (4472) was recorded @ lower temperature regime 150C. It is seen from the results higher shoot fresh weight mg (6434) was found in variety sindh-1 and the lower shoot fresh weight mg (4650) was recorded in variety Hari dost, respectively. The results further indicated that the maximum root fresh weight mg (756.5 and 765.4) was recorded @ temperature regimes of 25 and 350C and the minimum root fresh weight mg (595.0) was recorded @ lower temperature regime 150C. The results further revealed that highest root fresh weight mg (887.4) was recorded in variety sindh-1 and the lower root fresh weight mg (610.9) was recorded in variety Hari dost, respectively. Temperature is most important factors in irrigated, annual agro ecosystems at the beginning of the growth season where light, nutrients and moisture don't limit growth typically (Garcia–Huidobro et al., 1982).

The maximum shoot dry weight mg (422.9 and 436.7) was recorded @ temperature regimes of 25 and 350C and the minimum shoot dry weight mg (310.5) was recorded @ lower temperature regime 150C. The maximum shoot dry weight mg (482.2) was recorded in variety sindh-1 and the lower shoot dry weight mg (342.0) was observed in variety Hari dost, respectively. The interaction results showed that maximum root fresh weight mg (992.0) value was recorded @ 350C, in variety Sindh-1 and the lower root fresh weight mg (544.9) was observed @ 250C, in variety Hari dost. The results showed that the maximum root dry weight mg (56.96 and 58.25) was recorded @ temperature regimes of 25 and 350C and the minimum root dry weight mg (46.03) was observed @ 150C lower temperature regime. The maximum root dry weight mg (66.34) was observed in variety sindh-1 and the lower root dry weight mg (46.64) was observed in variety Hari dost, respectively. The temperature has a direct control on the rate of many chemical reactions, including respiration and photosynthesis (Munir et al., 2004).

Table II. Shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg), root dry weight (mg) of different cotton varieties under the influence of different temperature regimes

Source of variation		Freshshoot wt./5 seedlings (mg)	Freshroot wt./5 seedlings (mg)	Dryshoot wt./5 seedlings (mg)	Dryroot wt./5 seedlings (mg)
Temperature x varieties					
15^{O}C	Hari dost	3822d	544.9 c	266.5 c	41.05 e
	Shahbaz	3930 d	547.1 c	271.7 c	41.48 de
	Sindh-1	5663b	693.0 b	393.4 b	55.57 b
25^{O}C	Hari dost	4860c	641.1 b	373.4 b	47.49 cd
	Shahbaz	5065bc	651.2 b	378.6 b	50.99 bc
	Sindh-1	6705a	977.3 a	516.7 a	72.41 a
35^{O}C	Hari dost	5267bc	646.8 b	386.2 b	51.37 bc
	Shahbaz	5370bc	657.5 b	387.4 b	52.34bc
	Sindh-1	6936a	992.0 a	536.4 a	71.0 a
	LSD 5%	558.5	58.19	56.70	6.115

CONCLUSIONS

Regarding temperature effects on seed germination and related traits, the seeds of Hari dost, Shahbaz and Sindh-1 supplied with 15, 25 and 35^{o}C C responded well for seed germination (%), shoot length,root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, and root shoot ratio.It is concluded from the result that the higher temperature 35^0C gave superior results for various seedling growth traits of cotton. The variety Sindh-1 found better as ranked 1st , variety Shahbaz 2nd ranked and Hari dost found as ranked 3rd for germination and early growth traits of cotton crop. The interaction results indicate that 35^0C temperature x variety Sindh-1 found better for various seedlings growth traits of cotton.

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