

## Effect of Temperature Regimes on the Germination Testing of Cotton (*Gossypium hirsutum* L.) Germplasm

MUHAMMAD AMIR ZIA\*

SHAUKAT ALI

MUHAMMAD ANWAR

ARSHAD IQBAL

GHULAM MUHAMMAD ALI

National Institute for Genomics and Advanced Biotechnology  
(NIGAB)

National Agricultural Research Centre (NARC)

Islamabad, Pakistan

### Abstract:

*Cotton growth and production is affected by various environmental factors. Temperature is one of the factors that affect both germination power and germination speed of cotton. In the present study the effect of temperature regimes on the germination rate of 73 cotton germplasm seed was determined. The 50 seeds from each entry were germinated by using between paper towel methods of germination under lab conditions. Three different temperature treatments i.e. 25, 30 and 35 °C were applied separately on seeds of all 73 cotton entries. After seed germination at each temperature range their mean percentage was recorded for 20 randomly selected seedlings. Other parameters like mean fresh biomass, mean shoot and root lengths and finally mean dry biomass were studied at different temperature treatments. From the results it is clear that best germination 100% was recorded in A15 cotton genotype at 30°C. The best mean fresh biomass 0.588g seen in A7 genotype, mean shoot 10.5cm and mean root length 11cm and finally mean dry biomass 0.05g were recorded at 30°C temperature range followed by 25°C and 35°C respectively. It has been concluded from this study that 30°C is best suitable for the germination and post germination growth of cotton seed while seed germination rate is poor in case of both elevated*

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\* Corresponding author: amirzia\_narc@yahoo.com

and low temperatures.

**Key words:** Temperature, Germination Testing, Between Paper Towels, Cotton.

## Introduction

Cotton is the main cash crop and income source of Pakistan (Bakhsh et al. 2010). Pakistan occupies fourth position in the world cotton production by contributing 55% of the foreign exchange earnings of the country (Alam et al. 2000; Ali et al. 2010). Abiotic stresses are governed by various factors, the most prominent being the elevated temperatures and scarcity of water (Pena & Hughes 2007; Narusaka et al. 2003).

Cotton growth and production are affected by various environmental factors affecting the plant itself, its boll and fiber development. Out of these factors, temperature is one of them that affects both germination power and germination speed of cotton (Yılmaz 2008). Germination of cotton seeds is sensitive to low temperatures (Ahmad 1999; Baloch et al. 1999). Cotton growers face problems in their sowing time. If they plant seeds late in the season they face reduced fiber and seed quality resulting from maturation under the cool fall temperatures (Gipson et al. 1969). If, however, producers plant seeds early in the season so that crop maturation occurs under warmer fall conditions, seedling emergence and stand establishment are compromised due to the low early spring soil temperature (Christiansen 1964; Christiansen and Thomas 1969).

Low temperature has drastically reduced cotton germination under all tested conditions. For cotton germination it is obligatory that low temperature treatment should not be practiced (Pereira et al. 2005).

Poor fertilization efficiency under high temperature (Snider et al. 2009) likely accounts for the decline in seed set observed for cotton exposed to high temperature conditions in

both the field (Pettigrew 2008) and lab conditions (Bibi et al. 2010). The effects of high temperature on germination, seedling growth, vegetative growth and crop development have been well documented (e.g. Hodges et al. 1993; Reddy et al. 2002).

Many investigators have studied the influence of temperature on cotton seed germination under laboratory conditions (Filho et al. 2006). An optimum temperature range of 20 to 30C has been reported for cotton linted cotton seed (Reddy et al. 1991), but it has also been reported that there is no clear consensus about the optimum temperature for cotton, as plant response varies with plant developmental stage and plant organ (Burke and Wanjura 2009).

Although the factors affecting cotton seed germination are generally well known, interactions between temperature and their influence on germination require more investigation to provide results which could be used to compare the value of different cotton seed lots. The objective of the present study was to study the effect of cotton seed vigor on optimum germination temperatures.

## **Materials and Methods**

This study was conducted at National Institute for Genomics and Advanced Biotechnology (NIGAB), NARC, Islamabad during the year 2013.

### **Plant material:**

The seeds of all 73 cotton germplasm were obtained from the cotton fields of NIGAB to evaluate their germination testing at temperature regimes under lab conditions.

### **Procedure of germination testing**

Evaluation of temperature stress of cotton germplasm was performed under controlled conditions. For this purpose standard germination test was conducted using between paper

method of germination as per ISTA rules (Anon. 1993). Fifty cotton seeds of each line were grown on paper towels (22 cm x 23cm; Victory brand, Shinbashi Paper Company, Shizuoka, Japan). All treatments were repeated in triplicates. Cotton seeds were placed on the surface of paper towels which were moistened with distilled water. The same sheet was covered with another sheet of paper towel. After doing so, the paper sheets were rolled and placed vertically in plastic beaker, covered with polythene bag and placed at different temperature conditions i.e. 25°C, 30°C and 35°C in an illuminated germinator. After germination of cotton seeds the data was recorded.

#### **Germination Percentage:**

For each entry their germination percentage was calculated on the basis of number of normal seedlings.

#### **Root length and Shoot length (cm):**

Out of fifty seeds per entry the root lengths were measured from 20 randomly selected seedlings. Then after that the mean root length was calculated. Similarly the shoot lengths were also calculated from the same 20 selected seedlings of each cotton genotype.

#### **Seedlings fresh and dry biomass (g):**

Fresh weight in grams of the above mentioned randomly selected twenty normal seedlings was recorded by using electric balance. While for dry biomass, these seedlings were oven dried. For both fresh and dry biomass the mean weights were calculated.

### **Results**

Germination of all the 73 lines of cotton was tested on paper towels under lab conditions. Three distinct temperatures

ranges i.e. 25°C, 30°C and 35°C were applied to test the germination of all cotton entries. After applying the temperature regimes, the following parameters were checked thoroughly after germination of seedlings on paper towels.

- A. Germination percentage
- B. Mean fresh biomass (g)
- C. Mean shoot length (cm)
- D. Mean root length (cm)
- E. Mean dry biomass (g)

### **Germination Testing of cotton germplasm at 25°C:**

#### **A. Germination percentage**

At temperature of 25 °C all genotypes germination percentage were checked individually on the basis of normal seedlings. The results revealed that the highest germination percentage was obtained 84% in A15 genotype of cotton followed by 83% in A48 and A49 respectively. While third highest germination 82% was recorded in A40 and A71 genotypes. Similarly the lowest germination percentage was recorded in A58 (35%) followed by 41% in A60 respectively as shown in (Table 1).

#### **B. Mean fresh biomass (g)**

The results of fresh biomass from random 20 seedlings of all entries were recorded and their each genotype mean value was calculated. The maximum mean fresh biomass value at 25 °C was noted in A7 and A15 (0.52g) cotton genotypes. The minimum mean fresh biomass was observed 0.20 g in A1line. (Table 1).

#### **C. Mean shoot length**

Same like other parameters shoot lengths were studied in this experiment. The mean of 20 seedling shoots were recorded. From the results it has been cleared that optimum mean shoot length was seen in A18 (8.7cm) followed by 8.2cm in A15 lines. The minimum mean shoot length 4.1cm observed in A31 and A58 genotypes.

#### **D. Mean root length**

At the same temperature range i.e. 25 °C the highest mean root length was practiced in A38 (9.4cm) followed by 9.3cm in A27. Similarly the lowest mean root length among the tested genotypes was recorded for A60, A7 and A5 (3.9cm) respectively (table 1).

### E. Mean dry biomass

The dry biomass of 20 selected seedlings from each genotype was recorded and then their mean was taken. The mean of the selected dry biomass of seedlings revealed that high dry biomass was noticed in 0.052g in A15 and A18 genotypes while the lower mean of dry biomass 0.018 was seen in A2 genotype as shown in table 1.

S. No.	Genotype	Germination %age	Mean Fresh Biomass (g)	Mean Shoot Length (cm)	Mean Root Length (cm)	Mean Dry Biomass (g)
1	A1	76	0.20	5.4	4.9	0.020
2	A2	64	0.21	5.2	4.2	0.018
3	A3	77	0.34	6.1	5.2	0.023
4	A4	73	0.30	5.3	4.8	0.041
5	A5	69	0.41	5.3	3.9	0.036
6	A6	73	0.42	4.9	5.3	0.041
7	A7	70	0.52	4.3	3.9	0.032
8	A8	72	0.40	6.1	6.2	0.051
9	A9	77	0.41	7.0	7.9	0.032
10	A10	69	0.33	5.8	6.1	0.028
11	A11	81	0.31	4.3	5.4	0.037
12	A12	68	0.26	5.0	5.7	0.043
13	A13	73	0.41	4.9	5.7	0.039
14	A14	70	0.32	6.5	5.4	0.041
15	A15	84	0.52	8.2	7.9	0.052
16	A16	81	0.40	7.0	6.8	0.043
17	A17	66	0.38	7.2	6.4	0.039
18	A18	76	0.48	8.7	9.2	0.052
19	A19	77	0.41	6.2	6.4	0.039
20	A20	75	0.41	5.8	6.1	0.034
21	A21	70	0.38	6.6	6.1	0.042
22	A22	78	0.45	6.7	6.0	0.041
23	A23	80	0.35	6.1	7.7	0.038
24	A24	64	0.32	6.2	4.0	0.031
25	A25	81	0.44	6.3	9.1	0.037
26	A26	62	0.34	4.7	6.3	0.030
27	A27	81	0.35	5.7	9.3	0.038
28	A28	68	0.31	5.9	6.1	0.036
29	A29	79	0.43	5.4	7.7	0.046

30	A30	81	0.42	5.4	6.3	0.039
31	A31	51	0.31	4.1	6.0	0.028
32	A32	77	0.32	6.5	6.2	0.039
33	A33	72	0.41	6.0	7.1	0.037
34	A34	72	0.41	5.9	7.7	0.038
35	A35	79	0.40	7.4	6.6	0.036
36	A36	77	0.41	5.2	8.6	0.041
37	A37	81	0.42	6.7	7.2	0.042
38	A38	80	0.40	7.3	9.4	0.044
39	A39	70	0.42	6.4	7.1	0.031
40	A40	82	0.43	6.0	6.6	0.037
41	A41	77	0.42	7.1	7.2	0.040
42	A42	81	0.41	6.4	7.2	0.045
43	A43	65	0.31	5.1	5.0	0.038
44	A44	80	0.40	5.1	5.7	0.033
45	A45	62	0.30	6.0	5.0	0.029
46	A46	78	0.33	4.5	5.1	0.032
47	A47	50	0.30	5.0	4.7	0.027
48	A48	83	0.40	4.8	6.1	0.043
49	A49	83	0.43	6.3	7.0	0.044
50	A50	80	0.50	6.4	7.2	0.047
51	A51	77	0.41	6.3	5.4	0.038
52	A52	75	0.40	5.4	6.6	0.046
53	A53	76	0.41	6.0	4.4	0.038
54	A54	77	0.40	5.0	6.0	0.030
55	A55	62	0.31	7.0	5.4	0.037
56	A56	80	0.40	5.3	5.5	0.038
57	A57	81	0.39	5.0	5.3	0.033
58	A58	35	0.24	4.1	4.2	0.023
59	A59	69	0.41	6.3	5.3	0.033
60	A60	41	0.31	5.0	3.9	0.025
61	A61	59	0.38	4.6	4.2	0.033
62	A62	73	0.40	5.1	5.1	0.042
63	A63	52	0.30	5.0	4.3	0.039
64	A64	70	0.32	4.2	4.6	0.026
65	A65	81	0.41	4.3	6.0	0.029
66	A66	54	0.30	4.2	4.0	0.030
67	A67	73	0.39	6.0	5.5	0.044
68	A68	50	0.30	5.3	4.5	0.028
69	A69	73	0.45	7.4	7.0	0.040
70	A70	66	0.41	6.4	6.7	0.030
71	A71	82	0.35	6.4	5.6	0.029
72	A72	71	0.34	7.1	6.3	0.028
73	A73	81	0.53	7.4	6.8	0.039

**Table 1. Effect of temperature 25°C on germination testing of cotton**

## Germination testing of cotton germplasm at 30°C and 35°C

### A. Germination Percentage

To check the effect of temperature on the germination of cotton germplasms at 30°C and 35°C diverse data were recorded for different temperature treatments in controlled conditions. It is clear from the results that best germination %age was recorded 100% in A15 genotype at 30°C followed by 96% in A48, A49 and A71 while at 35°C the optimum germination %age was observed in A48 (79%). In the same fashion the minimum germination %age was recorded 44% in A60 at 30°C and 33% in

A85 genotype at 35°C. From the germination percentage it has been concluded that best results were observed at 30°C as compared to 25°C and 35°C as well. (Table 2 and 3).

#### **B. Mean fresh biomass (g)**

Mean fresh biomass was recorded at temperature of 30°C and the results illustrate that best value 0.588g seen in A7 genotype. Similarly at temperature of 35°C the optimum mean fresh biomass was reported 0.47g in A15 cotton genotype. While the lowest mean fresh biomasses recorded in 30°C and 35°C were 0.301g and 0.19g in A68 and A1 genotypes respectively as shown in table 2 and table 3.

#### **C. Mean shoot and root length**

Mean shoot and root lengths were observed at 30°C and 35°C temperature regimes. Best mean shoot length was noted in A18, 10.5cm and 8cm at temperature of 30°C and 35°C respectively. At the same time minimum shoot length at 30°C was practiced in 4.4cm in A7 and A65 genotypes. At 35 °C the lowest mean shoot length was recorded in A66 (3.5cm). Similarly the best mean root lengths at 30°C and 35°C were obtained 11cm and 8.5cm in A38 genotype as shown in table 2 and 3 respectively.

#### **D. Mean dry biomass**

Weight of dry biomass of the selected seedlings showed that best result was recorded 0.05g in A6, A11 and A18 at 30°C while at 35°C mean dry biomass 0.048g was recorded in A15 and 37 genotypes. The minimum mean value was noted 0.02g in A64, A71 and A72 at temperature range of 30°C while at 35°C A2 produced minimum 0.017g in A2 genotype (table 2 and 3).



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S. No.	Genotype	Germination %age	Mean Fresh Biomass (g)	Mean Shoot Length (cm)	Mean Root Length (cm)	Mean Dry Biomass (g)
1	A1	88	0.404	7.3	7.9	0.03
2	A2	80	0.462	7.4	6.92	0.02
3	A3	90	0.434	7.1	7.35	0.02
4	A4	90	0.402	7.3	6.86	0.04
5	A5	80	0.518	6.4	6.7	0.04
6	A6	82	0.428	6.9	5.46	0.05
7	A7	80	0.588	4.4	4.1	0.04
8	A8	82	0.438	7.2	6.4	0.03
9	A9	88	0.414	7.0	7.9	0.03
10	A10	78	0.438	7.3	7.3	0.04
11	A11	92	0.371	5.2	6.64	0.05
12	A12	84	0.416	6.2	6.9	0.04
13	A13	88	0.432	5.6	5.4	0.03
14	A14	82	0.382	6.5	5.2	0.03
15	A15	100	0.464	9.5	9.4	0.03
16	A16	94	0.360	7.9	8.2	0.04
17	A17	78	0.492	8.0	6.8	0.04
18	A18	88	0.391	10.5	10.0	0.05
19	A19	88	0.456	6.4	6.7	0.03
20	A20	88	0.428	6.3	6.9	0.03
21	A21	84	0.472	7.3	6.7	0.04
22	A22	88	0.458	6.7	6.0	0.04
23	A23	90	0.418	6.8	8.8	0.04
24	A24	76	0.372	7.0	4.4	0.03
25	A25	92	0.453	6.7	9.4	0.04
26	A26	74	0.367	5.6	8.08	0.03
27	A27	88	0.42	6.7	10.6	0.04
28	A28	82	0.41	7.9	7.2	0.04
29	A29	95	0.48	6.7	9.0	0.05
30	A30	94	0.46	5.6	6.8	0.04
31	A31	60	0.368	5.0	8.0	0.03
32	A32	92	0.376	7.2	6.6	0.03
33	A33	86	0.462	6.5	8.0	0.04
34	A34	90	0.44	7.0	9.4	0.04
35	A35	90	0.47	7.0	7.0	0.04
36	A36	90	0.45	5.9	10.6	0.04
37	A37	92	0.42	6.7	7.2	0.04
38	A38	92	0.444	7.0	11.0	0.04
39	A39	84	0.426	6.8	7.6	0.03
40	A40	92	0.474	6.2	7.2	0.03
41	A41	88	0.46	7.4	7.5	0.04
42	A42	94	0.47	7.1	8.6	0.05
43	A43	74	0.344	5.6	5.2	0.03
44	A44	92	0.44	5.4	6.2	0.03
45	A45	68	0.32	6.2	5.1	0.03
46	A46	80	0.39	4.6	5.0	0.03
47	A47	54	0.30	6.0	6.1	0.03
48	A48	96	0.44	5.0	6.67	0.04
49	A49	96	0.476	6.4	7.2	0.04
50	A50	94	0.518	7.4	8.82	0.05
51	A51	90	0.494	6.0	5.54	0.04
52	A52	90	0.4575	5.8	7.1	0.05
53	A53	88	0.456	6.1	4.8	0.04
54	A54	88	0.426	6.0	6.2	0.03
55	A55	70	0.313	7.1	5.4	0.03
56	A56	94	0.452	5.9	6.0	0.04
57	A57	94	0.394	5.2	5.7	0.03
58	A58	40	0.416	6.5	5.3	0.04
59	A59	80	0.433	6.9	5.8	0.04
60	A60	44	0.381	5.4	5.0	0.03
61	A61	64	0.422	5.8	4.8	0.04
62	A62	84	0.443	5.6	5.4	0.05
63	A63	58	0.326	5.2	4.9	0.04
64	A64	80	0.344	4.8	5.0	0.02

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65	A65	92	0.485	4.4	6.3	0.03
66	A66	60	0.322	4.7	4.0	0.03
67	A67	80	0.394	6.0	5.0	0.04
68	A68	52	0.301	5.0	4.0	0.02
69	A69	80	0.434	7.9	7.1	0.04
70	A70	70	0.432	6.6	6.6	0.03
71	A71	96	0.352	6.2	5.8	0.02
72	A72	80	0.388	7.4	6.4	0.02
73	A73	94	0.564	10.3	9.6	0.04

**Table 2. Effect of temperature 30°C on germination testing of cotton**

S. No.	Genotype	Germination %age	Mean Fresh Biomass (g)	Mean Shoot Length (cm)	Mean Root Length (cm)	Mean Dry Biomass (g)
1	A1	70	0.19	4.8	4.2	0.018
2	A2	61	0.20	5.0	4.0	0.017
3	A3	72	0.31	5.6	5.20	0.024
4	A4	70	0.28	5.1	4.72	0.038
5	A5	62	0.38	5.0	3.97	0.032
6	A6	71	0.40	4.6	5.30	0.029
7	A7	62	0.43	4.0	3.45	0.030
8	A8	66	0.36	5.4	5.4	0.043
9	A9	72	0.40	7.0	7.4	0.030
10	A10	63	0.30	5.4	6.0	0.026
11	A11	74	0.31	4.0	5.4	0.037
12	A12	64	0.23	5.0	5.3	0.040
13	A13	64	0.38	5.9	5.9	0.039
14	A14	60	0.30	6.0	5.0	0.038
15	A15	73	0.47	7.4	7.2	0.048
16	A16	74	0.43	7.4	6.3	0.040
17	A17	61	0.34	6.6	6.0	0.035
18	A18	70	0.42	8.0	7.5	0.047
19	A19	71	0.43	6.5	6.9	0.042
20	A20	70	0.40	5.9	6.0	0.032
21	A21	63	0.34	6.1	5.7	0.039
22	A22	72	0.40	6.2	6.4	0.039
23	A23	72	0.35	6.4	7.3	0.034
24	A24	61	0.30	6.1	4.1	0.030
25	A25	74	0.40	6.0	8.5	0.039
26	A26	58	0.30	4.1	5.2	0.027
27	A27	72	0.33	5.1	7.4	0.030
28	A28	63	0.27	5.4	6.0	0.033
29	A29	70	0.40	5.8	7.9	0.044
30	A30	77	0.38	5.1	6.0	0.034
31	A31	45	0.25	4.0	3.8	0.024
32	A32	69	0.30	6.1	6.5	0.039
33	A33	62	0.37	5.5	6.8	0.034
34	A34	66	0.35	5.3	7.5	0.039
35	A35	72	0.37	7.0	6.1	0.033
36	A36	70	0.38	5.0	8.2	0.037
37	A37	74	0.40	6.8	7.7	0.048
38	A38	77	0.44	7.2	8.5	0.041
39	A39	64	0.36	6.0	7.0	0.034
40	A40	73	0.41	6.4	5.4	0.034
41	A41	70	0.40	6.7	7.0	0.040
42	A42	74	0.41	6.4	7.0	0.043
43	A43	61	0.27	4.7	4.7	0.034
44	A44	69	0.37	4.4	5.2	0.031
45	A45	57	0.28	5.4	5.3	0.030
46	A46	71	0.30	4.0	5.0	0.031
47	A47	44	0.24	4.1	4.0	0.025
48	A48	79	0.35	4.4	6.0	0.040
49	A49	75	0.41	6.0	6.5	0.040

50	A50	77	0.46	6.0	7.0	0.040
51	A51	72	0.41	6.0	5.1	0.031
52	A52	71	0.37	5.3	6.2	0.045
53	A53	70	0.42	5.7	4.7	0.039
54	A54	71	0.37	5.6	6.7	0.034
55	A55	57	0.30	6.0	5.0	0.030
56	A56	70	0.34	5.0	5.1	0.034
57	A57	73	0.34	4.7	5.0	0.031
58	A58	33	0.22	43.1	2.4	0.020
59	A59	62	0.32	5.2	5.0	0.029
60	A60	36	0.28	4.5	3.3	0.023
61	A61	52	0.33	4.1	4.0	0.030
62	A62	66	0.38	4.2	5.0	0.038
63	A63	47	0.27	4.6	4.0	0.033
64	A64	65	0.28	4.0	4.3	0.027
65	A65	72	0.40	4.0	5.0	0.023
66	A66	50	0.26	3.5	4.4	0.027
67	A67	70	0.34	6.5	5.2	0.040
68	A68	43	0.27	5.0	4.0	0.025
69	A69	66	0.41	7.0	6.5	0.035
70	A70	62	0.37	6.1	6.3	0.027
71	A71	73	0.35	6.0	5.0	0.030
72	A72	65	0.31	6.3	6.1	0.031
73	A73	72	0.42	6.6	6.1	0.037

**Table 3. Effect of temperature 35°C on germination testing of cotton**

## Discussion

In the current study temperature effects on germination testing was tested in 73 different cotton germplasm. Three different temperatures i.e. 25°C, 30°C and 35°C were applied under lab conditions on wet paper towels having cotton seeds on it. At various stages of temperature each stage has performed its role on the cotton germination. In overall temperature range 30°C has showed best performance in all the tested parameters. The best germination 100% was recorded in A15 cotton genotype. As for as concerned other tested parameters like mean fresh biomass, mean shoot and root lengths and finally mean dry biomass have considerably higher at 30°C temperature range as compared to 25°C and 35 °C respectively.

Our findings are supportive to other researchers who stated that optimum temperature for stem and root growth was about 30°C in cotton (Hodges et al., 1993). Reddy et al, 1991 further stated that the ideal temperature range for cotton germination was from 20 to 30°C. Same to our results at 30 °C

it is parallel to Reddy et al (1991) but at 25°C there are reduction in germination and subsequently other tested parameters. These slight variations might be due to differences in genotypes and methodology used. Same to 25 °C results, there were reduction observed in the germination of cotton germplasm at temperature range of 35 °C. These results are in pipeline with the findings of Bibi et al. (2008, 2010) who mentioned that growth rate of cotton begins to decrease at temperature range of 35°C. High temperatures can have both direct inhibitory effects on growth and yield, and indirect effects due to high evaporative demand causing more intense water stress (Hall 2001). Further studies showed that high night temperature have adverse effects on cotton growth and development (Arevalo et al. 2008; Loka and Oosterhuis 2010).

In our results reduction in germination percentage has been observed at low temperature 25°C as compared to 30°C temperature treatment. Similar to our findings, Ahmad (1999) and Baloch et al. (1999) also reported that cotton germination rate decreases in low temperature than room temperature.

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