***Original Research Article***

# ~~Impact~~Influence of Heat units on Defoliation, Physiology and Yield of Cotton during Defoliants application


.**Abstract**

**Aims:** A study was conducted to determine the effect of temperature on defoliation process, physiology and yield of cotton during defoliants application.
**Study design:**The experiment was laid out in split-plot design with four replications.
**Place and Duration of Study:**Field experiment was conducted at Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore during 2018 to 2019.
**Methodology:**The main plot comprised of three stage of defoliants spray (120 DAS, 127 DAS and 134 DAS) and the sub-plots were seven defoliant treatments (Control, 2, 4 D (0.5 %), Ethephon (0.5 %), Ethephon (0.5%) + Triiodbenzoic acid (TIBA) (450 ppm), Sodium chlorate (0.9 %), 6 benzylaminopurine (BAP) (0.1%), Thidiazuron + Diuron (0.03 %) ).
**Results:**After 15 days after defoliants spray,Thidiazuron + Diuron (0.03 %) recorded highest defoliation percentage (99.3,98.1 and 96.8%) followed by Sodium chlorate (0.9 %)(91.9, 94.6 and 9.3%) at three different stage of defoliants spray. Although a significant effect was observed on chlorophyll index value (SPAD) due to the favorable weather condition like minimum temperature of 14.3, 16.9 and 19.3$^{o}$C and maximum average temperature 30.8, 31.8 and 33.23$^{o}$C (120, 127 and 134 DAS respectively) during defoliants spray to 15 days after defoliants spray. Sodium chlorate (0.9 %) and 6-BAP (0.1 %)recorded higher (95.8 and 95.4) per cent boll opening at 120 DAS when comparing to 127 DAS and 134 DAS. Heat units accumulated during defoliants spray to 15 days after defoliants spray was 113.54, 140.52 and 169.57$^{o}$C days (120, 127 and 134 DAS respectively).

**Conclusion:**Therefore, the minimum and maximum temperatures of 14.3 and 33.3 $^{o}$C, respectively conducive for inducing defoliation process and boll opening in cotton.



*Keywords: [Boll, cotton, defoliants, temperature, heat units}*


## 1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is perennial cropwith an indeterminate growth habit and serves as a significant source of fiber, feed, foodstuff, oil and bio-fuel. ~~Presently~~Currently, the Indian cotton industry and cotton growing farmers have moving towards mechanization by cotton harvester. In this regard, the farmers were facing a major problem at the time of harvesting due to more leaf vegetation in the cotton, which will disrupt the boll picking efficiency and fiber quality. Defoliation is induced in cotton as a natural physiological process which usually is not timely enough for a complete mechanical harvest of cotton. Therefore, defoliation before harvest is often induced by managing the plants so that senescence, abscission layer development and leaf drop are encouraged [1]. Many of the chemical defoliants and boll openers are in use today [2]to retard the production of auxin class hormones while stimulating the production of ethylene and abscisic acid (ABA) in the plant. This in turn results in the production of enzymes necessary for the degradation of cellular components and to the formation of the abscission layer and eventual leaf drop [3].

Selection of appropriate abscission chemicals is one of the critical decisions in cotton production. An abscission chemical with improved defoliation and boll opening properties is needed for cotton harvest practices. The effectiveness of defoliants depends upon crop maturity, uniformity of plant growth, weather conditions, spray coverage, absorption and translocation. Defoliation allows producers to harvest earlier than the crop matured naturally, but it can reduce yield and alter fibre quality if the application of the defoliants is premature. The producers attempt to optimize the timing of defoliant applications by maximizing the number of young bolls that are mature and harvestable without sacrificing the yield and quality of older bolls [4].The growth and development of cotton, like many other plants, is directly related to the amount of heat to which the plant is exposed. Heat units are a measurement of the amount of heat accumulated by a plant over a certain period of time and there are different methods for calculating heat units. Determining the optimal heat unit accumulation for cotton defoliation is important to maximize yield and fiber quality while minimizing costs of inputs. Minimum temperature of 16°C and a diurnal temperature of 24°C have been found critical for minimal leaf response to most defoliants. The Night temperature of 16°C has been found most suitable for defoliation [5].

Defoliation process usually completes in 7 to 10 days, but in some situations, it may be delayed for as long as 30 days. The success of defoliation process depends on the maturity of cotton crop and prevailing weather conditions at the time of application. Cotton defoliation is often practiced when 60% of bolls are opened to avoid loss in yield and fibre quality [6]. Therefore, it was intended to study the effect of different defoliants on defoliation process of cotton and to identify the ideal time of application based on temperature regimes prevalent during and after defoliant application to realize the leaf defoliation, physiology and yield of cotton.

## 2. MATERIAL AND METHODS

Cotton was sown on 5th September 2018;aresearch field located at Department of Cotton, Tamil Nadu Agricultural University, Coimbatore. Monthly maximum and mean temperatures, heat units and precipitation are given in (Table 1). In this study, high density cotton variety CO 17 was used as experimental material and it is medium duration variety with erect, compact plant architecture, also support much needed mechanization of various farm operations like sowing and picking. The experiment was laid out in a split-plot design with four replications. The main plot comprised of three stage of defoliant spray (Spray at 120 DAS, Spray at 127 DAS and Spray at 134 DAS) and the sub-plots were seven foliar treatments (Control, 2, 4 D (0.5 %), Ethephon (0.5 %), Ethephon (0.5%) + Triiodbenzoic acid (TIBA) (450 ppm), Sodium chlorate (0.9 %), 6 benzylaminopurine (BAP) (0.1%), Thidiazuron + Diuron (0.03 %). Control treatment was sprayed with water.Plots were arranged accordingly so that each plot could be mechanically harvested without affecting other plots. Recommended cultural practices and plant protection measures were followed throughout the crop growing season. Cumulative degree days were calculated using base temperature of cotton.

### 2.1.Plant Sampling and Measurements

There are many ways to determine proper defoliation timing, but the following have proven to be effective. Measuring percent open boll has been the standard defoliation technique for many years. The chemical defoliants were applied as a foliar spray as per treatments when cotton crop attained 60% of the bolls are open. However, this strategy may vary depends on weather conditions during crop period. Timing for the initial defoliant applications were determined using percent open boll. Defoliation process and open bolls were evaluated for the two-centered rows in the middle portion of the plot to avoid evaluation of the foliage in the control plots and defoliated plots were individually conducted. Prior to treatment application, five plants were randomly tagged from the two rows at the center of each plot for number of green leaves present. Treatment effects were detected by counting and recording the number of green leaves remaining on the same tagged plants 4 and 15 Days after Treatment.

### 2.2. Weather parameters and heat units

The weather conditions prevailed during the entire cropping period was collected from meteorological observatory at Department of Cotton, Tamil Nadu Agricultural University, Coimbatore. Growing Degree Day or heat units are calculated by taking the daily average temperature, (Max + Min)/2, and subtracting the base temperature, either 15.6 for Celsius from the daily average. Heat Units or (GDD) expressed in (°C day) (Table.1).

**Table 1. Crop calendar, temperature regimes and Heat units during crop season**

| S. No. | Parameters | Particulars |
|---|---|---|
| 1 | Date of sowing | 05.09.2018 |
| 2 | Date of defoliants spray | First stage of defoliants spray - 03.01.2019 (120 DAS) |
| | | Second stage of defoliants spray - 10.01.2019 (127 DAS) |
| | | Third stage of defoliants spray - 18.01.2019 (134 DAS) |
| 3 | Boll opening percentage (%) at defoliants spray | 60 % |
| 4 | Average maximum temperature during first defoliants spray ($^0$C) | 30.8 (03.01.2019 to 17.01.2019) |
| 5 | Average maximum temperature during second defoliants spray ($^0$C) | 31.8 (10.01.2019 to 25.01.2019) |
| 6 | Average maximum temperature during third defoliants spray ($^0$C) | 33.3(18.01.2019 to 02.02.2019) |
| 7 | Average minimum temperature during first defoliants spray ($^0$C) | 14.3 (03.01.2019 to 17.01.2019) |
| 8 | Average minimum temperature during second defoliants spray ($^0$C) | 16.9 (10.01.2019 to 25.01.2019) |
| 9 | Average minimum temperature during third defoliants spray ($^0$C) | 19.3 (18.01.2019 to 02.02.2019) |
| 10 | Base Temperature of Cotton | 15.6 $^0$C |
| 11 | Heat unit ($^0$C day)during defoliation process (15 | 113.5 (03.01.2019 to 17.01.2019) |

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| | days after first stage of defoliants spray) | |
| 12 | Heat unit ($^{0}$C day)during defoliation process (15 days after second stage of defoliants spray) | 140.5 (10.01.2019 to 25.01.2019) |
| 13 | Heat unit ($^{0}$C day)during defoliation process (15 days after third stage of defoliants spray) | 169.5 (18.01.2019 to 02.02.2019) |
| 14 | Heat units ($^{0}$C day)from sowing to first stage of defoliants spray | 1381.3 (05.09.2018 to 03.01.2019) |
| 15 | Heat units ($^{0}$ C day)from sowing to second stage of defoliants spray | 1432.8 (05.09.2018 to 10.01.2019) |
| 16 | Heat units ($^{0}$C day)from sowing to third stage of defoliants spray | 1497.89 (05.09.2018 to 18.01.2019) |

### 2.3. Defoliation and Boll Opening percentage

The defoliation percentage was recorded 4thand 15 days after defoliants spray. The number of leaves observed before day defoliants spray at randomly selected 5 plants for 3 replications and also observed the leaf numbers after spray was calculated by following equation,

Defoliation Percentage = La - Lb/La X 100%

Where, La = Number of leaves before treatment, Lb = Number of leaves after treatment.

Boll opening percentage was determined on the same tagged plants. Bolls on each plant were examined and recorded as either opened or closed and the boll opening percentage was calculated by following equation,

Boll Opening Percentage= OB/TB X100% where OB = Number of opened bolls, TB= Number of Total bolls. [6]

### 2.4. Chlorophyll Index (SPAD value)

Chlorophyll meter from Minolta (model 502 of Minolta, Japan) was used to measure chlorophyll index values for each defoliant treatment of Cotton. Chlorophyll meter determines the relative amount of chlorophyll present by measuring the absorbance of the leaf in two wavelength regions that chlorophyll has absorbance peaks in the blue (400 – 500 nm) and red (600 – 700 nm) regions, with no absorbance in the near-infrared region. The chlorophyll meter measures the absorbance; the meter calculates a numerical SPAD value which is proportional to the amount of chlorophyll present in the leaf.[7]

### 2.5. Yield

One week after application of the last defoliation treatments, seed cotton yield was determined in plots by manual harvesting of the center two rows of each plot and calculated g plant$^{-1}$.

### 2.6. Data processing and statistical analysis

The data collected were subjected to statistical analysis in split plot design [8].

## 3. RESULTS AND DISCUSSION

### 3.1. Heat Units

Defoliation in cotton by using different defoliants was influenced by various factors like type of chemical, rate of application, crop coverage, and maturity of the plant and weather conditions. The crop completed its defoliation in 15 days after treatment imposition indicating that the temperature prevailing at the time of defoliant application played a significant role in inducing defoliation. Efficacy of defoliation was affected strongly by temperature and heat units. In this experiment, changes occurred in all three time of defoliants application maximum (30.8°C) and minimum (14.3°C) temperatures in 120 days after sowing, maximum (31.8°C) and minimum (16.9°C) at 127 days after sowing and maximum (33.3°C) and minimum (19.3 °C) in 134 days after sowing (Table 1). This occurred during the fifteen days from date of defoliant application. Heat unit accumulated more than 100°C favors good defoliation in cotton. In the present study, heat units 113.5, 140.5 and 169.6 °C day (at 120,127 and 134 days after sowing respectively) days were received which hastened the defoliation process. This implies that warm temperatures played a dominant role to stimulate defoliation and boll opening processes. In this study, the defoliants [Thidiazuron + Diuron (0.03 %)] works better at 113.5°C days heat units and minimum temperature of 14.3°C in 120 DAS compared to 140.5°C heat units and 19.6°C minimum temperature in 127 DAS. The role of crop maturity was of lesser degree than that of temperatures not withstanding differences in crop ontogeny. [9] and[5]stated that condition of plant and prevailing weather at the time of application are the major factors that limit efficiency of defoliation process.

**3.2. Defoliation percentage**

Defoliation starts from 4 days after defoliant application, there was a significant increase in per cent defoliation (66.82, 33.02 and 61.90 %) in Thidiazuron + Diuron (0.03 %) at three different days (120 DAS, 127 DAS and 134 DAS) of applications and it was also significantly highest defoliation than remaining treatments. But interestingly, among the different day of defoliants application, defoliants spray at 120 DAS and 134 DAS recorded highest defoliation rate. The results indicated that, defoliation effect was influenced by time of defoliant application and some plant internal and environmental factors. Defoliants spray at 134 DAS registered highest defoliation than other stages of defoliants application and was coincided with higher heat units 169.6$^{0}$C days and low level of SPAD value. Among the treatments, application of Thidiazuron + Diuron (0.03 %) (99.3, 98.1 and 9.8 %) recorded highest defoliation rate followed by Sodium chlorate (0.9 %)(91.9, 94.6 and 94.3 %) was effective to induce defoliation at 15 days after defoliant spray (Figure 1). However higher defoliation percentage recorded at 120 days after sowing it may due to low level of SPAD value and leaf characters like leaf area, leaf area ratio and specific leaf weight. In interaction effect of application of Thidiazuron + Diuron (0.03 %) at 120 DAS and 134 DAS recorded higher defoliation. In this stage, the defoliants Thidiazuron + Diuron (0.03 %) worksbetter in both time of application. Under warmer conditions, physiological activity in cotton is higher, so defoliant effects may be more pronounced and rapid when compared with cooler conditions. Harvest aids like thidiazuron/diuron and ethephon/cyclanilide have optimal activity when maximum and minimum daily temperatures are above 27°C and 10°C, respectively [10].

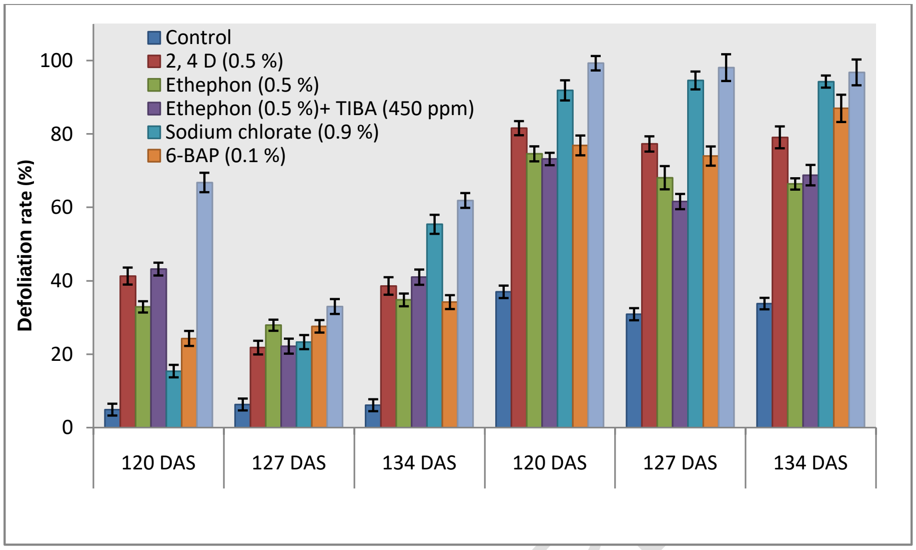


**Figure 1. Effect of defoliants on defoliation percentage of CO 17 Cotton variety**
*Significant from normal control, Mean ± S.E.M = Mean values ± Standard error of means of treatments*

### 3.3. Chlorophyll Index value

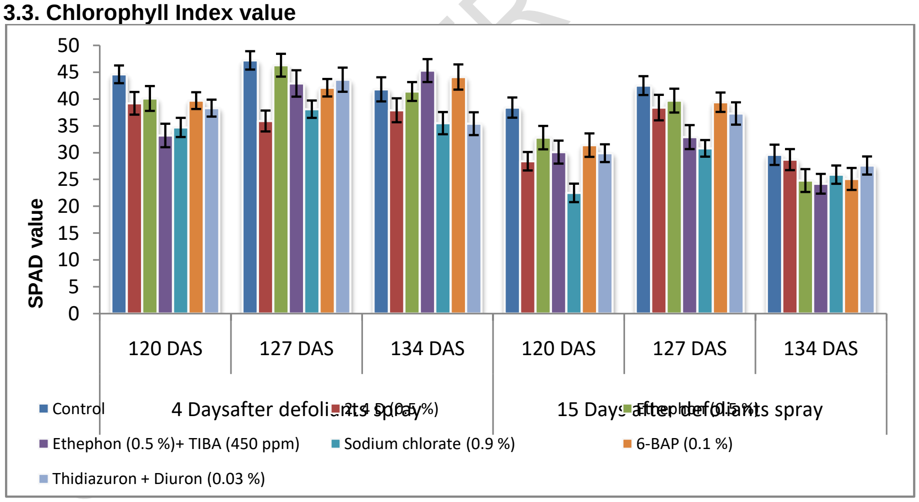


**Figure 2. Effect of defoliants on Chlorophyll index (SPAD unit) of CO 17 Cotton variety**
*Significant from normal control, Mean ± S.E.M = Mean values ± Standard error of means of treatments*

SPAD chlorophyll meter permits a rapid and non-destructive determination of leaf chlorophyll content by measuring leaf transmittance. The SPAD value decreased upon increases in the duration of defoliants spray from 4 to 15 days after defoliants spray. Lower the chlorophyll index is symptoms of degrading the chlorophyll leading to accelerating the defoliation. Among the different defoliants, highest chlorophyll index (SPAD value) was recorded in defoliants spray at 127 DAS followed by 134 DAS. Defoliant Sodium chlorate (0.9

%)recorded lowest SPAD value(34.70, 38.13 and 35.45) followed by 2, 4 D (0.5 %) (39.2, 35.9 and 37.9) at 4 Days after defoliants spray. At 120 DAS, the defoliant Ethephon (0.5 %) + TIBA (450 ppm)and Sodium chlorate (0.9 %)had lowest SPAD value which is accelerating the defoliation process. This trend was followed in 15 days after defoliants spray, the lowest SPAD value was recorded in defoliants spray at 127 DAS. (Figure 2).Similar result showed by [11] that the chlorophyll content decreased more in control plants when compare to thidiazuran defoliant treated plants.

### 3.4. Boll Opening Percentage and Seed cotton yield

Application timings and defoliants had differential effects on percent open boll. After 10 days spray of defoliants, Sodium chlorate (0.9 %) and 6-BAP (0.1 %)recorded 100per cent boll opening rate at 120 DAS. However, Thidiazuron + Diuron (0.03 %) showed 100 per cent boll opening in 127 and 134 DAS. This may be due to cytokinin like activity present in the defoliant. Part of these differences between times of application can be explained by the lower heat units accumulated in 120 DAS. Thidiazuron accelerates boll dehiscence by increasing ethylene level in cotton leaves. Light penetration is also improved by leaf removal. These crop conditions lead to early maturity and opening of bolls [12].Use of different defoliants and intervals of their application significantly affect seed cotton yield. Among the defoliants, Ethephon (0.5 %) and Ethephon (0.5 %) + TIBA (450 ppm) showed increment in seed cotton yield from 56.8 g plant$^{-1}$ to 54.0 g plant$^{-1}$ andon par with Thidiazuron + Diuron (0.03 %) (53.4) comparing to control (49.9) at 120 DAS (Table 2). To achieve consistent results, the heat-unit approach is suitable for use but only in conjunction with other traditional methods of defoliation timing. Dehiscence of boll requires dehydration of the entire boll and is acceleralated by ethylene. Defoliation and opening boll numbers were significantly increased by a defoliant-ethephon and thidiazuron it can be used effectively and safely in the field-grown cotton [13].[14]conducted a study on the effect of defoliants on number of bolls picked per plant and percent defoliation. The increase in boll opening percentage of 98.76 and 98.82 was recorded withethrel and Thidiazuron

**Table 2. Effect of defoliants on boll opening percentage and seed cotton yield of CO17**

| Treatments | Boll Opening Percentage (%) | | | | Seed cotton yield (g plant$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | 120 DAS | 127 DAS | 134 DAS | Mean | 120 DAS | 127 DAS | 134 DAS | Mean |
| Control | 70.0 | 92.3 | 80.0 | **80.8** | 49.9 | 46.5 | 59.0 | 51.8 |
| 2, 4 D (0.5 %) | 100.0 | 83.3 | 75.0 | **86.1** | 44.1 | 49.0 | 56.8 | 50.0 |
| Ethephon (0.5 %) | 94.1 | 64.3 | 81.8 | **80.1** | 56.8 | 64.8 | 53.9 | 58.5 |
| Ethephon (0.5 %)+ TIBA (450 ppm) | 69.2 | 94.7 | 77.8 | **80.6** | 54.0 | 54.9 | 57.6 | 55.5 |
| Sodium chlorate (0.9 %) | 100.0 | 90.9 | 92.3 | **94.4** | 46.4 | 48.1 | 54.3 | 49.6 |
| 6-BAP (0.1 %) | 100.0 | 88.9 | 82.9 | **90.6** | 52.9 | 53.2 | 55.6 | 53.9 |
| Thidiazuron + Diuron (0.3 %) | 94.4 | 100.0 | 100.0 | **98.1** | 53.4 | 54.7 | 59.5 | 55.9 |
| **Mean** | **89.7** | **87.8** | **84.3** | | **51.0** | **53.1** | **56.7** | |
| **Factors** | **M** | **S** | **M at S** | **S at M** | **M** | **S** | **M at S** | **S at M** |
| **SEd** | **0.353**** | **0.984**** | **1.617**** | **1.704**** | **0.29**** | **0.62**** | **1.04**** | **1.08**** |

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|---|---|---|---|---|---|---|---|---|
| **CD (0.05)** | **0.982** | **1.996** | **3.338** | **3.458** | **0.81** | **1.26** | **2.17** | **2.19** |

**Denotes significant at the 0.01 level of probability ** Denotes significant at the 0.05 level of probability*

## Conclusion

Use of different defoliants and intervals of their application significantly affect seed cotton yield. It can be concluded that cotton under high density planting 60-70 % open boll may be sprayed with defoliants without loss in boll opening and seed cotton yield. The ambient minimum and maximum temperatures of 14.3 and 33.3°C were found conducive for inducement of defoliation process. Therefore, heat unit can be used as an important tool along with defoliant application for inducing leaf defoliation in cotton.


## DISCLAIMER

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