Influence of Coloured LED Lights on the Occurrence of Fusarium Wilt in Pigeonpea

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Abstract

The present investigation was conducted in green house to study the effect of different coloured LEDs (Red, green, White, Blue and UV light) on the subsequent occurrence of Fusarium wilt in Pigeonpea seedlings whose the seeds were treated with different coloured lights prior to sowing. The seeds treated with red LEDs for 12 and 24 hrs and blue light for 24 hrs prior to sowing reduced the Fusarium wilt by upto 71 percent over control. The disease incidence was recorded after 45 days of inoculation with Fusarium udum culture was 14.58 per cent in Asha and 46.94 per cent in TAT-10 respectively.

Keywords

Light emitting diodes, Pigeonpea, Fusarium wilt, Asha, Tat-10.

Introduction

Pigeonpea production is greatly constrained by numerous biotic and abiotic stresses. The major biotic stresses affecting legumes are fungal diseases although insects, nematodes, viruses, bacteria and parasitic weeds can also drastically decrease pigeonpea production. Wilt caused by Fusarium udum Butler is the major constrain to pigeonpea production worldwide (Kannaiyan et al., 1984). The incidence of disease has been reported from 30 to 60 per cent at flowering and crop maturity stages (Kannaiyan and Nene, 1981), however it can cause yield losses up to 100 per cent in susceptible cultivars. In nature plants are exposed to light of different wavelengths from ultraviolet to far-red regions. Light of certain wavelengths (290-320 nm) may affect certain host-pathogen interactions (Honda, 2000; Kumagai, 1988). Induction of plant defence against pathogen attack is regulated by a complex network of different signals. Interaction between Fusarium udum and host plants was found to enhance defence responses against wilt disease in resistant cultivars of pigeonpea. Light was reported as one of the important factors affecting disease development by inactivating toxins of pathogens in certain plant-pathogen interactions (Kohmoto et al., 1989). The development of light-emitting diodes (LEDs) in the last few decades has introduced growers to a new source of lighting that provides many superior advantages. LEDs represent an innovative artificial lighting source for plants both as supplemental or sole-source lighting, not only
owing to their intensity, spectral and energy advances but also via the possibilities for targeted manipulation of metabolic responses in order to optimize plant productivity and quality. Plants have light receptors that detect visible light and generate a response. There are certain photoreceptors which get activated at specific wavelength of light. LED light is one of the sources which produce a constant source of light with specific wavelength. The hypothesis of this study is whether the wilt tolerance of pigeonpea seedlings could be improved with a light treatment.

**Materials and Methods**

**Seed material**

In this experiment, seed of two genotypes viz. Asha and TAT-10 were treated with fungicide solution for 5 minutes. Then washed with tap water for several times and were soaked in distilled water for 24 hours. Seeds were counted out in specific quantities (15 seeds for each treatment) and placed in standard sized (20 cm diameter) glass petri dishes lined with two layers of Whatman’s filter paper. Filter papers were moistened with distilled water and seeds were randomly dispersed over the triangles formed by partitions in Petridishes by thin layer of cardboard. The petri dishes containing seeds were then placed in box, 15 cm wide at the top 22 cm at the bottom with a distance of 25 cm from bottom to top internally covered with the appropriate plastic filter according to color. One LED light with specific colour was fitted at the top of each box which was 20 cm above the level of the petri dish. After 12, 24 and 36 hrs seeds were sown in pots.

**Light treatment**

For irradiation different coloured Light Emitting Diodes (LEDs) such as Red, Green, White, Blue and UV light were used. Light intensities for the various colored were measured by a Digital Lux Light Meter (LX-101, Lutron). The intensities of different coloured LEDs are given in Table 1.

**Fungus inoculation**

Seven days after sowing, the seedlings were inoculated with spore suspension culture of F. udum. The culture of Fungus *Fusarium udum* which affects the pigeon pea plant by causing *Fusarium* wilt disease was obtained from the Microbial Type Culture Collection and Gene Bank (MTCC) Chandigarh. The *Fusarium udum* culture was maintained on Potato Dextrose Agar (PDA) plates with timely sub-culturing. This culture was used for infection to the seedlings grown in plastic pots. Seedlings with no pathogen infection (un-inoculated plants) treated as control. The pathogenicity assays were conducted in triplicates. In one replication 5 plants were grown. Two discs of *F. udum* about five mm diameter were cut, and suspended in 20 ml distilled water and was shaken thoroughly to get good and uniform spore suspension. One drop of this spore suspension was placed on a haemocytometer and numbers of spores in 5 squares of haemocytometer at random were counted. The number of spores per ml was calculated with haemocytometer, using the formula given by Pathak (1984).

\[
\text{No. of spores per ml} = \frac{N \times 1000}{X}
\]

Where,

\[
N = \text{Total no. of spores counted/ no. of squares}
\]

\[
X = \text{Volume of mounting solution between the cover glass and above the squares counted}
\]
After irradiation with different coloured LEDs the seeds were sown in pots and diseases incidence was recorded after 45 days. Per cent Disease incidence (PDI) was calculated by using formula given by Anjaneyareddy and Saifullu, (2005)

\[
\text{PDI} = \frac{\text{Number of plants wilted}}{\text{Total number of plants}} \times 100
\]

**Statistical Analysis**

Statistical analysis for data was carried out in a FCRD (Factorial Completely Randomized Design). The analysis of sixteen treatments for assessing the different coloured lights effect on two pigeonpea genotypes was done taking \( V_1 \) and \( V_2 \) as main treatments and \( T_1 \) to \( T_{16} \) as sub treatments. The level of statistical significance to the experimental data was carried out as per procedure described by Gomez and Gomez (1984).

**Results and Discussion**

**Effect of genotypes**

Genotype Asha showed less wilt incidence as compared to susceptible genotype TAT-10 (Table 2). The disease incidence was 14.58 per cent in Asha whereas 46.94 per cent plants of TAT-10 were infected after 45 days of inoculation with *Fusarium udum* culture.

**Effect of light treatments**

Data regarding the effect of different coloured LEDs on wilt incidence is recorded in Table 2. From this data, it is observed that in red LEDs for 12 and 24 hrs and blue LEDs for 24 hrs, only 14.4 per cent plants infected with wilt and blue light for 36 hrs were found at par with the superior treatment red LEDs for 24 hrs. This decrease was 71 per cent over control and may be due to the red light irradiation that induces the production of antifungal substance(s) in plants.

Similar results were reported by various scientists while working on different plants. Certain wavelengths could be used to eliminate or maximize the abilities of fungi to proliferate or insects to navigate to host species (Mass *et al.*, 2008). Irradiation with red light induced the accumulation of an antifungal substance in leaf tissue of broad bean leaves. This substance prohibited germination of spores of several fungal pathogens including soil borne fungi as reported by Islam *et al.*, (1999). Islam and Gabadoost (2002) reported that the application of red light treatment induced disease resistance against *Phytophthora capsici* in pumpkin, pepper and tomato seedlings. Irradiation of *Nicotiana benthamiana* especially with blue and red wavelengths of light induced resistance against wildfire disease (Ahn *et al.*, 2013).

**Genotype x light interaction effects**

The data in respect of disease incidence is given in Table 2 and graphically represented in Figures 1. Treatment of red LEDs for 12 hrs and blue LEDs for 24 hrs showed significant reduction in the occurrence of *Fusarium* wilt in Asha (4.4 %) followed by red 24 hrs and blue LEDs for 36 hrs (6.6 %).

In Asha, red light treatment decrease disease incidence by 78 per cent over the control (20 %). The disease incidence percentage of TAT-10 genotype is presented in Table 2 and depicted in Figure 1. Red LEDs for 24 hrs treatment reduced the percentage of wilt in TAT-10. In this treatment 20 per cent plants were infected with wilt. Whereas in control in which the seeds were not irradiated with any light source 82.2 per cent plants showed wilt infection. This decrease in percentage in red LEDs treatment was 72 per cent over control.
**Table 1** Details of light emitting diodes used to illuminating seeds

| Sr. No. | Light Emitting Diodes     | Intensity of Light (μmol m⁻²s⁻¹) | Wavelength (nm) | Time duration          |
|---------|---------------------------|----------------------------------|-----------------|------------------------|
| 1       | Ultraviolet Light         | 2.5                              | 10-380          | 5, 10 and 20 mins     |
| 2       | Blue LEDs                 | 5                                | 450-495         | 12, 24 and 36 hrs     |
| 3       | Green LEDs                | 80                               | 495-570         | 12, 24 and 36 hrs     |
| 4       | Red LEDs                  | 25                               | 620-750         | 12, 24 and 36 hrs     |
| 5       | White LEDs                | 25                               | -               | 12, 24 and 36 hrs     |

**Table 2** Effect of different coloured LEDs on incidence of *Fusarium* wilt

| Genotypes | Disease Incidence (%) |
|-----------|-----------------------|
| Asha V1   | 14.58 (21.08)         |
| TAT-10 V2 | 46.94 (43.44)         |
| S. E. (m) ± | 0.62                  |
| C. D. at 5% | 1.75                  |

| Light treatments | Disease Incidence (%) |
|------------------|-----------------------|
| Control T1       | 51.11(45.75)          |
| UV 5 min T2      | 50.0(45.48)           |
| UV 10 min T3     | 42.0(39.83)           |
| UV 15 min T4     | 41.1(38.97)           |
| Red 12 hrs T5    | 14.4 (21.64)          |
| Red 24 hrs T6    | 14.4(19.50)           |
| Red 36 hrs T7    | 21.1(21.74)           |
| Green 12 hrs T8  | 30 (32.78)            |
| Green 24 hrs T9  | 28.8 (31.39)          |
| Green 36 hrs T10 | 26.8 (30.09)          |
| White 12 hrs T11 | 42.2(39.94)           |
| White 24 hrs T12 | 38.8(38.00)           |
| White 36 hrs T13 | 35.5(36.22)           |
| Blue 12 hrs T14  | 23.3 (28.82)          |
| Blue 24 hrs T15  | 14.4(22.34)           |
| Blue 36 hrs T16  | 17.7(23.72)           |
| S. E. (m) ±      | 1.76                  |
| C. D. at 5%      | 4.96                  |
| Control (Asha) V1T1 | 20.0(26.36)        |
| UV 5 min V1T2    | 17.78(24.85)          |
| UV 10 min V1T3   | 17.78(24.85)          |
| UV 15 min V1T4   | 15.56(23.13)          |
| Red 12 hrs V1T5  | 4.4(13.70)            |
| Red 24 hrs V1T6  | 6.6 (12.43)           |
| Red 36 hrs V1T7  | 22.2 (17.11)          |
| Green 12 hrs V1T8 | 20.0 (26.36)        |
| Green 24 hrs V1T9 | 13.3 (20.98)         |

2020
| Treatment               | LED Duration | V1T10  |
|-------------------------|--------------|--------|
| Green                   | 36 hrs       | 13.3 (20.98) |
| White                   | 12 hrs       | 20.0 (26.36) |
| White                   | 24 hrs       | 20.0 (26.36) |
| White                   | 36 hrs       | 22.2 (28.07) |
| Blue                    | 12 hrs       | 8.89 (17.11) |
| Blue                    | 24 hrs       | 4.44 (13.70) |
| Blue                    | 36 hrs       | 6.67 (14.96) |
| Control (TAT-10)        |              | 82.2 (65.15) |
| UV 5 min                |              | 82.2 (66.12) |
| UV 10 min               |              | 66.67 (54.80) |
| UV 15 min               |              | 66.67 (54.80) |
| Red                     | 12 hrs       | 24.4 (29.58) |
| Red                     | 24 hrs       | 20.0 (26.36) |
| Red                     | 36 hrs       | 22.2 (27.57) |
| Green                   | 12 hrs       | 40.0 (39.19) |
| Green                   | 24 hrs       | 44.4 (41.80) |
| Green                   | 36 hrs       | 40.0 (39.19) |
| White                   | 12 hrs       | 64.4 (53.52) |
| White                   | 24 hrs       | 57.7 (49.64) |
| White                   | 36 hrs       | 48.4 (44.36) |
| Blue                    | 12 hrs       | 37.7 (40.52) |
| Blue                    | 24 hrs       | 24.4 (30.97) |
| Blue                    | 36 hrs       | 28.8 (32.48) |
| S. E. (m) ±             |              | 2.48 |
| C. D. at 5%             |              | 7.02 |

**Fig.1** Effect of different coloured LEDs on incidence of *Fusarium* wilt
Furthermore, Wang et al., (2010) found that disease resistance to *Sphaerotheca fuliginea* in cucumber plants was induced by red light. Red light was also reported to suppress the lesion development of *P. capsici* on detached leaves of eggplant, pepper, pumpkin, and watermelon (Umezu et al., 1999). Induced resistance in plants by red light against *Alternaria tenuissima* has also been reported by Rahman et al., (2001). Khanam et al., (2005) reported that enhanced catalase activity under red light treatment contributes to the inhibition of lesion formation and fungal development on broad bean leaves infected with *Botrytis cinerea*. Kim et al., (2013) suggested that Blue LEDs suppresses the development of gray mold of *B. Cinerea* in tomato via enhanced accumulation of proline and antioxidative response. Thus numerous studies have suggested that physiological resistance of plants to environmental stresses including pathogen attack is closely connected with specific light treatments.

In conclusion, current study suggests that red and blue LEDs are highly efficient to protect crop plants from fungal attacks. This may be due to the increased production of osmoprotectants and antioxidants, including ROS scavenging enzymes.

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