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Effect of Different Fungicides Against the Boll Rot and Foliar Disease of Cotton under South Gujarat of India

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ABSTRACT: Cotton (*Gossypium* spp.) is one of the most important economic products of the group of fibers due to volume and value of production. It provides employment and sustenance to a population of nearly 42 Million people, who are involved directly or indirectly in cotton production, processing, textiles and related activities. Looking to the experiment, different fungicides were evaluated in cotton crop under field condition against the boll rot and different diseases. Total seven treatments including control were evaluated in this trial from which, treatment T_4 (25.17 PDI) and T_5 (28.83PDI) recorded minimum Bacterial leaf blight infection in comparison to the treatment T_7 *i.e.*, control (53.67PDI). The lowest boll rot incidence was observed in the treatment T_4 (13.67 PDI). The highest seed cotton yield was recorded in the treatment T_4 (2401.67 kg/ha), respectively.

Keywords: Cotton, *Gossypium* spp, Treatment, Disease, Fungicide, Control.

INTRODUCTION

Cotton (*Gossypium* spp.) is one of the most important economic products of the group of fibers due to volume and value of production. Its cultivation is also of great social importance, due to the number of jobs generated directly or indirectly. Cotton is a tropical and subtropical crop. For the successful germination of its seeds, a minimum temperature of 15ºC is required. The optimum temperature range for vegetative growth is 21 - 27ºC. It can tolerate temperatures as high as 43ºC, but does not do well if the temperature falls below 21ºC. During the period of fruiting, warm days and cool nights with large diurnal variations are conducive to good boll and fibre development. The fiber, the main product of cotton has many industrial applications. Examples are manufacturing of yarn for weaving of various kinds of fabrics, cotton batting for hospital use, felt clothing, blankets and upholstery, photographic films and plates for radiography among others (Richetti and Melo Filho 2001). The fibres can be made into a wide variety of fabrics ranging from lightweight voiles and laces to heavy sailcloths and thick-piled velveteens, suitable for a great variety of wearing apparel, home furnishings, and industrial uses. Cotton fabrics can be extremely durable and resistant to abrasion. Cotton accepts many dyes, is usually washable and can be ironed at relatively high temperatures. It is comfortable to wear because it absorbs and releases moisture quickly. When warmth is desired, it can be napped, a process giving the fabric a downy surface. Nonwoven cotton, made by fusing or bonding the fibres together is useful for making disposable products to be used as towels, polishing cloths, tea bags, tablecloths, bandages, and disposable uniforms and sheets for hospital and other medical uses Weigmann (2023).

Cotton, derived from the Arabic word ‘quotn’ (Lee and Fang 2014) belongs to *Gossypium* genus, which was also derived from the Arabic word ‘goz’, meaning a soft substance (Gledhill, 2008). Cotton is a unique natural fiber producing most common fiber crop of the world, which provides humanity with cloth and vegetable oil, medicinal compounds, meal and hull for livestock feed, energy sources, organic matter to enrich soil, and industrial lubricants (Abdurakhmonov, 2013). Cotton is grown worldwide for its natural fiber and oil. Cotton seed contain 30 per cent starch, 25 per cent oil and 16.20 per cent protein. It is also being used in the manufacture of medicinal supplies, tarpaulin, cordage and belting. The cotton hulls serve as roughage for livestock and the fuzz (short seed hair) is used in the manufacture of papers, plastics, carpets, rayon, explosives and cotton wool (Prasad, 2015). Based on archeological evidence, humans utilized cotton fiber from at least more than four to seven thousand years ago, and cotton started to be grown as a fiber crop around three thousand years ago (Lee and Fang 2014); (Fang and Percy 2015).

The cotton seed is rich in oil, with approximately 18 to 25 per cent, and contains 20 to 25 per cent of crude protein. The cotton seed meal is a by product of oil extraction, and is used in animal feed because of its high protein content, approximately 40 to 45 per cent. The seed coat is used to make certain types of plastics and synthetic rubber (Carvalho, 1996). The cotton seed after the removal of the plume, is commonly used as ruminant feed. It is considered a palatable food, with characteristics of dietary fiber with high levels of energy and protein (Savastano, 1999). Cotton, one of the world's leading agricultural crops is plentiful and economically produced, making cotton products relatively inexpensive.

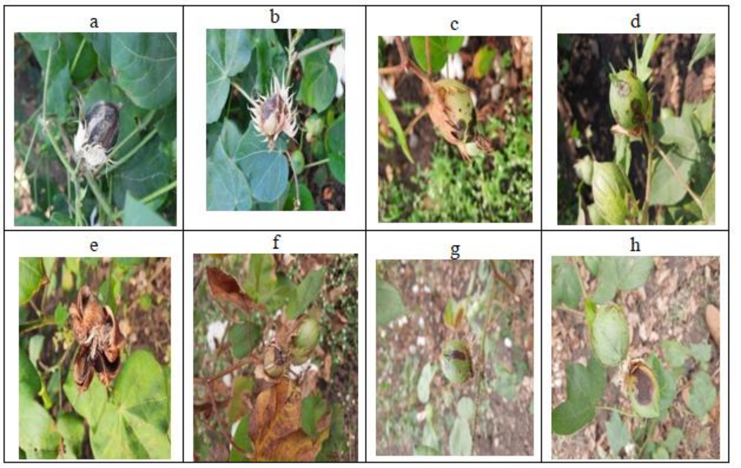
The genus Gossypium includes five 52 chromosome species (2n=4x=52) that arose some 1–2 million years ago (Cronn *et al*., 2002) through allotetraploidization between the extinct representatives of A and D cotton genomes. Cotton is grown on around 32–36 million-hectares area of tropical and northernmost agricultural latitudes in over 80 countries of the world (Abdurakhmonov *et al*., 2011) ; (Kumar *et al*., 2006) to fulfill the current global needs of humanity for the natural fiber.

In India, there are ten major cotton growing states which are divided into three zones *viz*., North zone, Central zone and South zone. North zone consists of Punjab, Haryana, and Rajasthan. Central zone includes Madhya Pradesh, Maharashtra and Gujarat. South zone comprises Andhra Pradesh, Telangana, Karnataka and Tamil Nadu. Besides these ten States, cotton cultivation has gained momentum in the Eastern State of Orissa. Cotton is also cultivated in small areas of non-traditional States such as Uttar Pradesh, West Bengal and Tripura.

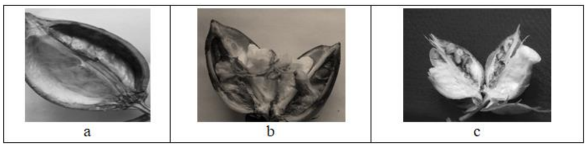
The most common cotton diseases reported in India are Wilt (*Fusarium oxysporum* f. sp. *vasinfectum* (G.F. Atk.) W.C. Snyder & H.N. Hansen), Root rots (*Rhizoctonia bataticola* (Taubenh.), Verticillium wilt (*Verticillium dahliae* Kleb.), Anthracnose (*Colletotrichum gossypii* Southworth. or *C. capsici* (Syd.) Butler & Bisby), Grey mildew (*Ramularia areola* G.F. Atk.), Blackarm (*Xanthomonas campestris* pv. *malvacearum* (Pammel) Dowson), Leaf blight (*Alternaria macrospora* Zimm), Leaf curl (Cotton leaf curl virus), Corynespora leaf blight (*Corynespora cassiicola* (Berk. & M. A. Curtis) C. T. Wei, Boll rot and physiological disorders as Para wilt, Leaf reddening and sometimes leaf elongation etc. The bacterial blight is the most wide spread and destructive disease reported to cause yield losses of about 10 to 30 per cent (Kalpana *et al*., 2004); (Sandipan *et al*., 2016). Losses due to Alternaria leaf spot (26.6%) however, *Alternaria alternata* has the potential to cause yield loss up to 30% under severe infection (Olmez *et al*., 2023), grey mildew (29.2%) and Myrothecium leaf spot (29.1 %) have been reported. Moreover, sometimes Myrothecium leaf spot, caused by the fungus *Myrothecium roridum* Tode, was responsible for losses of 50 per cent in the town of Balsas in Maranhão and also been reported in the state of Mato Grosso. The symptoms of the disease can appear on the leaves and cotton bolls (Suassuna *et al*., 2006). Cotton bolls rot can cause 20-30 per cent losses in productivity, (Iamamoto, 2007). Boll rot is considered as the most destructive one. In the USA, at least 170 microorganisms are capable of causing cotton boll rot (Guthrie *et al*., 1994). According to Hillocks (1992) a great number of microorganisms were isolated from cotton bolls rot and these pathogens can be divided into three groups: those capable of penetrating intact bolls, those which are introduced by insects and those are introduced after the bolls are damaged by insects or after the suture of the boll lobes are broken. Most of the agents that cause cotton bolls rot penetrate through wounds from insect or pests and / or rupture of the division through the lobes of the bolls. However, primary infection of boll, when the pathogen penetrates directly into the healthy boll is common in areas with high humidity or in those where the crop has dense vegetative growth.

According to Belot & Zambiasi (2007) there are many pathogens that can cause boll rot such as *Alternaria* spp., *Ascochyta gossypii*, *Aspergillus flavus*, *Aspergillus niger*, *Bacillus pumilus*, *Colletotrichum* spp., *Diplodia gossypina*, *Erwinia aroideae*, *Fusarium* spp., *Lasiodiplodia theobromae*, *Myrothecium roridum*, *Pantoea agglomerans*, *Phoma exigua*, *Phomopsis* sp., *Phytophthora* spp., *Rhizoctonia solani* and *Xanthomonas axonopodis* pv. *malvacearum*. And sometimes, saprophytic and/or opportunistic fungi detected and associated with cotton boll rots were *Botrytis* spp, *Cephalosporium* sp, *Cercospora* spp. , *Cladosporium* sp., *Curvularia* sp, *Epicoccum* sp, *Graphium* spp., *Mucor* sp, *Nigrospora* sp., *Periconia* sp., *Trichotecium* sp and *Rhizoctonia* sp. Zancan *et al*. (2013). Various symptoms may be due to the existence of a complex of pathogens. Commonly, the bolls are soft and blackened and in some cases, arise from lesions in both the apex and at its base. Fructifications in various colors, from white to purple are also verified. *Sclerotium rolfsii* is identified as one of the causes of boll rot in Bangladesh (Shamsi and Naher 2014). Hence systemic explorations by using different fungicides on cotton disease including boll rot were carried out. Keeping in view, an experiment based treatment is planned for the effectual management of the boll rot and cotton disease.

External boll rot: Generally, this external boll rot complex occurs during the boll maturity and bursting stages. It is caused by several fungal and bacterial pathogens and saprophytic fungi depending upon climatic conditions and insect-pest infestation (Mirzaee *et al*., 2013). Continuous cloudy weather, rain shower, warm weather and high relative humidity are conducive to external boll rots. (Photograph: a, b, c, d, e, f, g and h)



Internal boll rot: It can be caused single or a combination of bacteria and fungi. Bacterial seed and boll rot was first recorded in South Carolina, USA in 1999. In India, *Erwinia aroideae* was associated with boll rot of green bolls in cotton. *Pantoea ananatis*, *Pantoea anthophila* and *Pantoea agglomerans* causes disease symptoms in a wide range of economically important crops including plantation crops. Early disease diagnosis is very complicated, the boll seems to be healthy as no symptoms appear on the outer surface of the boll. The disease can only be observed when bolls are cross-sectioned or opened. The putative internal boll rots of green bolls are incited by opportunistic, facultative anaerobic bacterial phytopathogens of the family Enterobacteriaceae and some endophytic fungi. After flowering, disease organisms may invade the developing ovary (boll) via wounds associated with insect feeding, especially stink bugs and drizzling rains (Ehetisham-ul-Haq *et al*., 2014). However, the developing boll is susceptible to these piercing/sucking insects for only about the first 3 weeks. The immature seeds, fibers and lint in locules of immature unopened green bolls initially appear discolored, light yellow, pink-red to brown coloured with a slimy presence. The first report of occurrence and association of phytopathogenic bacteria *Pantoea dispersa*, a member of the Enterobacteriaceae family as a potential and principal pathogenic agent causing inner cotton (*G. hirsutum* L.) boll rots in Maharashtra state, India (Nagrale *et al.*, 2020; Photograph a, b and c).



MATERIAL AND METHODS

The experiment was laid by dibbling method with the following experimental details (Table 1 and 2). All the recommended agronomic practices were followed for raising the good crop. In each net plot of each treatment randomly tag 5 plants and score 4 lower, 4 middle leaves and 2 upper leaves of each plant/bolls in terms of 0-4 grade and work out PDI as mentioned below by using 0-4 scale as given by Sheo Raj and Verma (1988) and then these grades were converted into per cent disease incidence (PDI) by using the formula given by Wheeler (1969). (Bacterial leaf blight) and similar formula was used by Sandipan *et al*. (2022).

The fungicides were used as per the above treatment two foliar sprays were applied at 15 days interval, first from the initiation of the disease and second after the interval of 15 days from the first spray.

$$\text{Disease incidence (\%)} = \frac{\text{No. of infected plants/bolls (Numerical grades)}}{\text{No. of leaves/boll observed} \times \text{Max. Grade}} \times 100$$

Table 1: Experimental detail as below.

Objective	:	To find out the effective fungicides against the boll rot and foliar disease of cotton
Location	:	Main Cotton Research Station, Surat (Gujarat)
Year of commencement	:	2022
Experimental details		
Design	:	RBD
Treatment	:	Six (6) + 01 Control
Replication	:	Three (3)
Plot size in sq. meter	:	Gross: 6.0 × 4.5 Net: 3.6 × 3.6
Name of hybrid (Susceptible, if available)	:	Bt hybrid (RCH 2 BG II)
No. of rows/plot	:	5
No. of dibbles/row	:	10
Plot size in sq. Meter (1 plot)	:	27.0
Expt. area in ha.	:	1458 (0.14 ha)

Spacing	:	120 × 45 cm
FYM t/ha	:	-
Fertilizer dose NPK kg/ha	:	240:40:00
Previous crop	:	-
Date of sowing	:	22.06.22
Date of germination	:	27.06.22
Date of gap filling	:	04.07.22, 22.07.22, 04.08.22
No. of plant protection	:	As per the treatments
No. of irrigation	:	As & when required

Table: 2 Treatment details.

Trt No.	Treatment details	Dose	Application Time	Observations to be taken
T_1	Kresoxim methyl 44.3% SC @ 0.044 %	1ml/ litre of water	Foliar spray at the time of disease initiation and second after 15 days of first spray.	Per cent Incidence (PDI) and seed cotton yield
T_2	Propiconazole 25% EC @ 0.025 %	1ml/ litre of water		
T_3	Propineb 70% WP @ 0.175%	2.5g/ litre of water		
T_4	Fluxapyroxad 167g/ litre + Pyroclostrobin 333g/ litre SC @ 0.3%	0.6g/ litre of water		
T_5	Metiram 55% + Pyroclostrobin 5% WG @ 0.12 %	2g/ litre of water		
T_6	Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 0.029%	1ml/ litre of water		
T_7	Control (Water spray)	—	—	

For, Boll rot disease

Scale	PDI	Grade	Symptoms
0	0.0	Immune	Without any fungal or bacterial spot, no disease symptoms
1	0.1-25%	R	Minute spots not spreading on the surface of the bolls 1-24% boll area
2	25.5-50%	MR	Spots increasing in size but not penetrating and also not affecting the lint and seed, 25-49% boll area
3	50.5-75%	MS	Infection spreading to one or two locules and causing damage to lint and seed, 50-74% boll area
4	>75.5%	S	More than two locules affected by fungal/ bacterial infection causing damage to lint and seed, more than 75.5 boll area

For, Bacterial leaf blight (BLB) disease

Scale	PDI	Grade	Symptoms
0	0.0	Immune	No Infection
1	1-25%	R	Few spots, scattered, 1mm in dia, no coalescing, reddish, no angular, veins free, around 5% leaf area covered
2	26-50%	MR	Spots initially wet but rapidly drying, several, larger 2 mm in dia, no coalescing, reddish brown, veins and veinlets free or with dry lesions, 10% leaf area covered
3	51-75%	MS	>2mm dia lesions, angular, turning brown and black, coalescing, spreading linearly along the small viens, or water soaked vien infection along the main veins, 11-20% leaf area cover
4	>75%	S	Larger lesions, water soaked, coalesing, or veins infected and extended up to pulvinus and petioles, larger lesions turning to brown black, in severe cases branches and stem also attacked and covering more than 20% leaf area

For, Alternaria (ALS), Cercospora, Corynespora leaf spot (CoLS), Myrothecium (MLS), Grey mildew and Rust disease

Scale	PDI	Grade	Symptoms
0	0.0	Immune	No Infection
1	1-25%	R	A few small spots, less than 2mm, scattered, which over less than 5% leaf area
2	26-50%	MR	Spots bigger in size up to 3mm and cover 6-20% leaf area covered
3	51-75%	MS	Spots increasing in size 3-5mm, irregular in shape, coalesing and 21-40% leaf area cover
4	>75%	S	Many spots coalesce to make bigger lesion, irregular in shape and size and covering more than 40% leaf area

It is the standard methodology of AICRP on Cotton and similar disease scale was used by Sandipan *et al.* (2022).

Phytotoxicity Test. Observations on leaf injury, vein clearing, necrosis, epinasty and hyponasty is taken after 7 days of first spray and second observation after 7 days of second spray of application of the fungicides.

Scale	Phytotoxicity/ Injury Per cent (%)
0	0 (No phytotoxicity)
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

RESULT AND DISCUSSION

The field experiment was conducted during *Kharif* 2022 at Main Cotton Research Station (MCRS), Surat (Gujarat). The results presented in the Table 3 and Graph 1 revealed that the out of seven treatments including control, treatment T_4 (25.17 PDI) and T_5 (28.83PDI) recorded minimum Bacterial leaf blight infection in comparison to the treatment T_7 *i.e.* control (53.67PDI) in RCH 2 BG II hybrid but in comparison to bactericide it is less effective to control Bacterial leaf blight disease (Table 3 and Graph 1).

The lowest boll rot incidence was observed in the treatment T_4 (13.67 PDI) and T_5 (14.67 PDI) treatment as compared to the control T_7 (26.83 PDI) Table 3 and Graph 2.

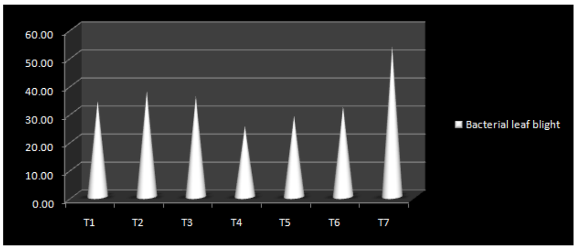
The highest seed cotton yield was recorded in the treatment T_4 (2401.67 kg/ha) and treatment T_5 (2223.67 kg/ha), respectively (Table 3 and Graph 3).

Comparison of the efficacy between the fungicides used in different treatments at Surat centre indicated that treatment T_4: Fluxapyroxad 167g/ litre + Pyraclostrobin 333g/ litre SC @ 0.6g/ litre of water first spray at the time of initiation of the disease and second after 15 days was found little bit effective in reducing the Bacterial leaf blight infection in comparison to other fungicides and boll rot infection effectively and increases the seed cotton yield in RCH 2 BG II hybrid cotton followed by treatment T_5: Metiram 55% + Pyraclostrobin 5% WG @ 2g/ litre of water.

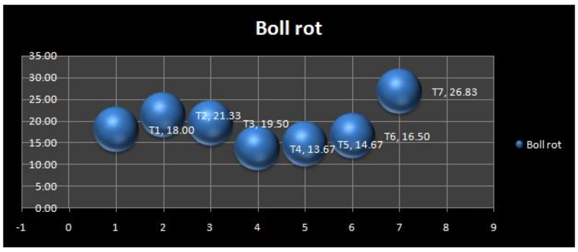
Table: 3 Statement showing the per cent disease intensity of Bacterial leaf blight (BLB), Boll rot and seed cotton yield in different fungicides against cotton disease 2022-23.

-	Treatment	Bacterial leaf blight (PDI)	Control (%)	Boll rot (PDI)	Control (%)	Seed cotton yield (Kg/ha)
T_1	Kresoxim methyl 44.3% SC @ 1ml/ litre of water	34.17 (35.71) *	36.34	18.00 (25.01) *	32.92	1950.00
T_2	Propiconazole 25% EC @ 1ml/ litre of water	37.67 (37.75)	29.81	21.33 (27.38)	20.50	1728.33
T_3	Propineb 70% WP @ 2.5g /litre of water	35.83 (36.66)	33.23	19.50 (26.07)	27.33	1844.33
T_4	Fluxapyroxad 167 g/ litre + Pyraclostrobin 333g/ litre SC @ 0.6g/ litre of water	**25.17 (29.93)**	**53.11**	**13.67 (21.64)**	**49.07**	**2401.67**
T_5	Metiram 55% + Pyraclostrobin 5% WG @ 2g/ litre of water	28.83 (32.36)	46.27	14.67 (22.50)	45.34	2223.67
T_6	Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 1ml/ litre of water	32.17 (34.37)	40.06	16.50 (23.88)	38.51	2094.33
T_7	Control (Water spray)	53.67 (47.10)	0.00	26.83 (31.17)	0.00	1502.33
S. Em.± (T)		1.89	-	1.52	-	158.88
C.D.at 5% (T)		5.82	-	4.68	-	489.60
C.D. (Y x T)		-	-	-	-	-
C.V. %		9.02	-	10.36	-	14.01

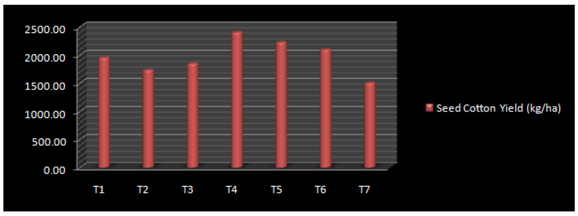
* Figure in the parenthesis are Arc sine transformed values



Graph 1: Per cent Disease Intensity (PDI) of Bacterial leaf blight (BLB).



Graph 2: Per cent Disease Intensity (PDI) of Boll rot.



Graph 3: Seed cotton yield.

Table 4: Phytotoxicity effect of fungicides on cotton during *Kharif*, 2022 (7 days after 1st spray).

Sr. No.	Treatment	Phytotoxicity/ Injury Per cent (%)				
		Leaf injury	Vein clearing	Necrosis	Epinasty	Hyponasty
T_1	Kresoxim methyl 44.3% SC @ 1ml/ litre of water	0.0	0.0	0.0	0.0	0.0
T_2	Propiconazole 25% EC @ 1ml/ litre of water	0.0	0.0	0.0	0.0	0.0
T_3	Propineb 70% WP @ 2.5g /litre of water	0.0	0.0	0.0	0.0	0.0
T_4	Fluxapyroxad 167 g/ litre + Pyraclostrobin 333g/ litre SC @ 0.6g/ litre of water	0.0	0.0	0.0	0.0	0.0
T_5	Metiram 55% + Pyraclostrobin 5% WG @ 2g/ litre of water	0.0	0.0	0.0	0.0	0.0
T_6	Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 1ml/ litre of water	0.0	0.0	0.0	0.0	0.0
T_7	Control (Water spray)	0.0	0.0	0.0	0.0	0.0

Table 5: Phytotoxicity effect of fungicides on cotton during *Kharif*, 2022 (7 days after I1st spray).

Sr. No.	Treatment	Phytotoxicity/ Injury Per cent (%)				
		Leaf injury	Vein clearing	Necrosis	Epinasty	Hyponasty
T_1	Kresoxim methyl 44.3% SC @ 1ml/ litre of water	0.0	0.0	0.0	0.0	0.0
T_2	Propiconazole 25% EC @ 1ml/ litre of water	0.0	0.0	0.0	0.0	0.0
T_3	Propineb 70% WP @ 2.5g /litre of water	0.0	0.0	0.0	0.0	0.0
T_4	Fluxapyroxad 167 g/ litre + Pyraclostrobin 333g/ litre SC @ 0.6g/ litre of water	0.0	0.0	0.0	0.0	0.0
T_5	Metiram 55% + Pyraclostrobin 5% WG @ 2g/ litre of water	0.0	0.0	0.0	0.0	0.0
T_6	Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 1ml/ litre of water	0.0	0.0	0.0	0.0	0.0
T_7	Control (Water spray)	0.0	0.0	0.0	0.0	0.0

Phytotoxicity Test Result. It is evident from the test result that the phytotoxicity of various fungicides as given in the Table 2 and 3 did not observe any phytotoxicity symptoms/ injury on the leaves of the cotton plant after 7 days of first spray and second observation after 7 days of second spray of application of the fungicides (Table 4 and 5).

CONCLUSIONS

It is found from the result that the Treatment T_4 (Fluxapyroxad 167g/ litre + Pyraclostrobin 333g/ litre SC @ 0.6g/ litre of water) with two sprays first from the initiation of the disease and second after the interval of 15 days recorded the lowest incidence of boll rot and recorded the highest seed cotton yield (2401.67 kg/ha).

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