

INTEGRATED MANAGEMENT OF STEM ROT DISEASE (*Sclerotium rolfsii*) IN GROUNDNUT UNDER RICE-BASED CROPPING SYSTEMS

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ABSTRACT

Stem rot of groundnut caused by *Sclerotium rolfsii* Sacc. is a major constraint to productivity under rice-based cropping systems. The pathogen was isolated from diseased groundnut stems and evaluated against seven fungicides at 50, 100, 150, 250 and 500 ppm and six bio-control agents under *in vitro* conditions. Among the fungicides, trifloxystrobin + tebuconazole (50 ppm), tebuconazole (250 ppm), azoxystrobin (150 ppm) and azoxystrobin + difenoconazole (100 ppm) were most effective, inhibiting mycelial growth of *S. rolfsii* by up to 89.69%. Among the bio-control agents, *Trichoderma harzianum* showed the highest antagonistic activity, suppressing mycelial growth by 60.97% three days after inoculation. Based on *in vitro* efficacy, a field experiment was conducted during the summer seasons of 2018-2020 under a rice-based cropping system. The results revealed that the integrated treatment comprising seed treatment with azoxystrobin 23 SC @ 1 ml kg⁻¹ along with soil application of *T. harzianum* 1.5% WP @ 2.5 kg ha⁻¹ at sowing recorded the lowest plant mortality (15.24%). This treatment also significantly reduced pod rot (1.79 pods plant⁻¹) and improved plant height (50.37 cm), number of pods per plant (12.93), pod yield (1983 kg ha⁻¹) and haulm yield (5845 kg ha⁻¹). The study demonstrates that integrated use of fungicide and bio-control agent is an effective and sustainable strategy for managing stem rot of groundnut.

Keywords: *Arachis hypogaea*, Bioagents, Fungicides, Management, *Sclerotium rolfsii*

The word groundnut (*Arachis hypogaea* L.) has its origin from Greek word, 'Arachis' meaning a legume and 'hypogaea' meaning below ground referring to the formation of pods in the soil. It has been reported that South America was the place from where cultivation of groundnut originated and spread to Brazil, Southern Bolivia and North Western Argentina. Groundnut was introduced by the Portuguese from Brazil to West Africa and then to South-Western India in 16th century (Thamaraikannan *et al.*, 2009). Groundnut is used for various purposes food (raw, roasted, boiled, cooking oil), animal feed (pressings, seeds, green material, straw), and industrial raw material (Nwokolo, 1996). It is a very important oilseed crop in India, cultivated widely throughout the country in both *kharif* and *rabi*-summer seasons. India is one of the leading producers of groundnut worldwide. The country ranks second in the world after China in groundnut production (FAO, 2023). In India, groundnut is cultivated on 4.71 million ha area producing 10.18 million tons with a productivity of 2163 kg/ha (Anonymous, 2024a). Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Madhya Pradesh, Orissa, and Uttar Pradesh are major groundnut producing states in India. Among these Gujarat ranks first and accounts for more than 50 per cent of country's

total groundnut production from an area of 1.968 million ha with a production of 5.218 million tons and yield of 2650.56 kg/ha during 2023-24 (Anonymous, 2024b).

Groundnut is susceptible to both biotic and abiotic stresses leading to significant yield losses. The protective measures implemented during their cultivation are often limited, particularly since they are primarily grown under rainfed conditions. Various diseases, including late leaf spot, early leaf spot, rust, stem rot and collar rot (fungal) as well as bud necrosis and stem necrosis (viral) pose significant challenges to groundnut production nationwide. Among these issues, stem rot disease caused by *Sclerotium rolfsii* (Sacc.) is the most significant constraint leading to considerable yield losses in groundnut-growing regions across the country (Rodriguez Kabana *et al.*, 1975). *Sclerotium rolfsii* Sacc. (Teleomorph stage=*Athelia rolfsii*, Curzi Tu and Kimbrough) has been reported to cause stem rot, root rot and sclerotial wilt (Chohan, 1974) and stem and pod rot (Mehan *et al.*, 1995). Stem rot also known as white mold or southern blight, is a devastating soil borne disease in India. This disease is more likely to develop in dense plantings, high soil moisture content and frequent irrigation conditions at all growth stages (Coley-Smith and Cook, 1971; Sconyers *et al.*, 2005). Stem rot of groundnut is able to spread more between plants when these conditions are present. Stem rot, root rot, sclerotial wilt and pod rot were all symptoms

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Date of receipt: 17.02.2025, Date of acceptance: 18.12.2025

that appeared on groundnut plants that had been infected with *S. rolfsii*. In India, a severe soil-borne disease known as stem rot, sometimes known as white mould or southern blight, can be seen in some crops. According to Pande and Rao (2000), the disease presents primarily during the seedling stage, as well as during the flowering, pod formation and maturity stages. Recently, *S. rolfsii* was able to infect groundnut plants at every stage of their growth, including the stage in which the seeds were germinating which resulted in pre-emergence rot. Additionally, immature plants exhibited indications of stem rot and pod rot. High stem rot disease incidence and economic yield loss in groundnut have been reported from India and abroad. Aycock (1966) reported peanut pod yield losses ranging from 25 - 50 per cent in USA. In India, pod yield losses in groundnut vary from 10-59 per cent (Singh and Mathur 1953; Mayee and Datar 1988; Ray 1994; Mehan *et al.*, 1995; Rakholiya, 2019) and it can extent up to 80 per cent in heavily infested fields. In the South Gujarat region, the stem and pod rot caused by *S. rolfsii* Sacc. is one of the significant restrictions and it has the potential to reduce summer groundnut production. Keeping these facts in view along with economic importance of groundnut and yield losses due to *Sclerotium rolfsii* in groundnut, the present study was planned with the aim to minimize pod yield loss due to stem rot disease in groundnut.

MATERIALS AND METHODS

Isolation of the pathogen and purification

The *S. rolfsii* pathogen was isolated by collecting sclerotia from infected groundnut plants at the Regional Rice Research Station N.A.U., Vyara farm and farmers' fields. Sclerotia were surface sterilized by immersing them in 0.1% HgCl₂ for 5-10 seconds followed by 3-4 rinses with sterile distilled water. The sclerotia were placed in a Petri plate with potato dextrose agar media and incubated at 27±2°C for germination and mycelial growth. The pathogen was purified and kept in a PDA slant. The pathogenicity of *S. rolfsii* was proved to satisfy Koch's postulates. The pathogen's pathogenicity was also tested in pots using the stem inoculation approach reported by Patil *et al.* (1977).

Laboratory bioassay of fungicides

Seven fungicides i.e. trifloxystrobin 25% + tebuconazole 50% (Nativo), mancozeb 63%+cabendazim 12% (SAAF), azoxystrobin 23% SC (Amistar), azoxystrobin 18.2%+ difenconazole 11.4% SC (Amistar Top), carbendazim 50 % WP (Bavistin), thiram 75 WP (Devithiram) and tebuconazole 2% DS (Raxil) were evaluated at five concentrations against the pathogen under laboratory conditions. Efficacy of

the fungicides was based upon their inhibitory effect on the growth of the fungus (*S. rolfsii*). The experiment for the evaluation of *in vitro* fungicides against *S. rolfsii* was set up using Poison Food Techniques (Schmitz 1930; Nene and Thapliyal, 1993) on PDA based medium in a CRD design with three replications. Stock solution of each fungicide was prepared by dissolving 500 mg/μl of the active ingredient in sterilized distilled water following the method of Borum and Sinclair (1968). After 3 days of the inoculation, the fungal growth was recorded in each Petri-dish and per cent growth inhibition of pathogen was calculated by using the following formula (Vincent, 1947).

$$I = \frac{C - T}{C} \times 100$$

where, I = Per cent inhibition, C = Radial growth in control, T = Radial growth in treatment

Evaluation of bio-agents against the pathogen *in vitro*

For the study, *Sclerotium rolfsii* was grown on potato dextrose agar media. Bio-agents i.e. *Trichoderma viride*, *Trichoderma harzianum*, *Trichoderma longibrachiatum*, *Trichoderma koningii*, *Psuedomonas fleuroscense* and *Bacillus subtilis* were brought from Department of Plant Pathology, Navinchandra Mafatlal College of Agriculture, Navsari Agricultural University, Navsari. The anti-pathogen activity of these bio-agents was assessed using the 'Dual Culture Technique' (Dennis and Webster, 1971). After 3 days of incubation, antagonist and pathogen growth were measured and per cent mycelial growth inhibition was calculated using Vincent's formula (Vincent, 1947).

Effective fungicides and bio-agents under field conditions

The trials were conducted in randomized block design with three replications using the groundnut variety TG-37A during three subsequent years to determine the efficacy of fungicides and bio-agents in different treatments viz. T₁: seed treatment with trifloxystrobin 25% + tebuconazole 50% @ 0.5g/kg seed; T₂: seed treatment with tebuconazole 2DS @ 1.25g/kg seed; T₃: seed treatment with azoxystrobin 23SC @ 1ml/kg seed; T₄: seed treatment with azoxystrobin 18.2% + difenconazole 11.4%SC @ 1ml/kg seed; T₅: seed treatment with *T. harzianum* @ 10 g/kg seed; T₆: seed treatment with azoxystrobin 23SC @ 1ml/kg seed + soil application with *T. harzianum* 1.5% WP (2x10⁶ cfu/gm) @ 2.5 kg/ha at the time of sowing and T₇: Control.

For uniform coating of the seeds, a dose of each treatment was mixed in 25 ml of water. The following formula was used to calculate plant mortality.

Plant height, no of pods/plant and rotted pods/plant were recorded from 5 randomly selected plants from each replication of each treatment. Pod and haulm yield was recorded from each plot and converted in to kg per hectares.

$$\text{Plant mortality (\%)} = \frac{\text{Initial plant population} - \text{Final plant population}}{\text{Initial plant population}} \times 100$$

Statistical analysis

All data related to *in vitro* evaluation of fungicides were transformed into square root transformation for analysis. In field trials, per cent plant mortality data were transformed into angular transformation for statistical analysis. OPSTAT software (<http://14.139.232.166/opstat/>) was used to do statistical analysis with Duncan's New Multiple Range Test (DMRT) as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The current study on bioagents found that *Sclerotium rolfsii* grew the most slowly in *Trichoderma harzianum* by 35.13 mm, followed by *Bacillus subtilis* (36.75 mm), *T. viride* (40.00 mm) and *Pseudomonas fluorescens* (43.00 mm). *T. harzianum* suppressed highest mycelium growth by 51.36% followed by *Bacillus subtilis* (50.29% at 4 days after incubation) and proved to be superior over all the bio-agents tested (Table 1). The most recent finding demonstrated that *T. harzianum* inhibited mycelial growth by the greatest amount (58.05%). *T. koningii* had the lowest percentage of inhibition against *S. rolfsii*. Biswas and Sen (2000), Pant and Mukupadhyay (2001), Manjula *et al.* (2004) and Karthikeyan *et al.* (2006) reported similar results. Darvin and Prasanna (2013) and Darvin *et al.* (2013) found that *T. harzianum* has considerable antagonistic activity against *S. rolfsii* *in vitro*. *T. harzianum* was

reported to be more growth inhibitory than *T. viride* against *S. rolfsii* by Madhavi and Bhattiprolu (2011), Bhuiyan *et al.* (2012) and Manu *et al.* (2012).

In vitro investigation on fungicides found that all seven fungicides greatly inhibited the growth of *S. rolfsii* when compared to the control; however, the fungicides and their concentrations were significantly different among themselves. At 50 ppm concentration, trifloxystrobin + tebuconazole suppressed the mycelial growth of *S. rolfsii* by 89.69 per cent. While, azoxystrobin + difenconazole inhibited mycelial growth by 89.69 per cent at 100 ppm concentration. Whereas, both azoxystrobin and tebuconazole inhibited the mycelial growth by 89.69 per cent at 150 ppm and 250 ppm concentrations, respectively (Table 2). Carbendazim was found to be the least effective even at high concentrations (500 ppm). Compared to other fungicides, carbendazim failed to inhibit the mycelial growth at 50, 100 and 150 ppm and at 250 ppm, hence, it was shown to be the least effective at all concentrations.

Moreover, trifloxystrobin + tebuconazole, tebuconazole, azoxystrobin and azoxystrobin + difenconazole were found to be the most effective in inhibiting mycelial growth of *S. rolfsii*. Similar results were obtained by Manu *et al.* (2012) who determined that Nativo gave 100% inhibition of *S. rolfsii* at 1000 ppm concentration. Patel (2015) recorded that tebuconazole + trifloxystrobin were most effective and provided 100% inhibition at 1000, 1500 and 2000 ppm concentration, whereas, Bhat *et al.* (2015) found tebuconazole + trifloxystrobin to be highly inhibitory with ED₅₀ value of 0.131 µg/ml. Bhuiyan *et al.* (2012) reported that carbendazim was least effective at all concentrations.

According to Manu *et al.* (2012), carbendazim was ineffective against *S. rolfsii*. Deepthi and Reddy (2013) revealed that carbendazim was ineffective

Table 1. Antifungal activity of different bio-agents against *Sclerotium rolfsii* under *in vitro* conditions

Sr. No.	Bioagent	Mycelial growth (mm)	Growth inhibition (%)*
1	<i>Trichoderma viride</i> Navsari isolate	40.00	48.21 ^{ab}
2	<i>Trichoderma harzianum</i> Navsari isolate	35.13	51.36 ^a
3	<i>Trichoderma longibrachiatum</i> Navsari isolate	52.13	40.41 ^c
4	<i>Trichoderma koningii</i> Navsari isolate	59.25	35.74 ^d
5	<i>Pseudomonas fluorescens</i> Navsari isolate	43.00	46.28 ^b
6	<i>Bacillus subtilis</i> Navsari isolate	36.75	50.29 ^a
7	Control	90.00	0.30 ^e
SEm±			1.21
CD (<i>p</i> ≤0.05)			3.58
CV (%)			6.21

* Arc sine transformed value of four repetition means. Value 0% substituted by 0.30

Table 2. Effect of different fungicides on mycelial growth of *Sclerotium rolfsii* under *in vitro* conditions

Fungicide	Concentration				
	50 ppm	100 ppm	150 ppm	250 ppm	500 ppm
Mycelial growth inhibition (%)					
Carbendazim 50%WP	0.30	0.30	0.30	22.78	27.30
Thiram 75% WS	71.43	80.42	68.32	89.69	89.69
Carbendazim 37.5% + Thiram 37.5% SD	41.79	63.04	89.69	83.30	89.69
Tebuconazole 2SD	67.81	71.79	75.94	89.69	89.69
Azoxystrobin 23SC	53.06	68.43	89.69	89.69	89.69
Trifloxystrobin 25% + Tebuconazole 50% WG	89.69	89.69	89.69	89.69	89.69
Azoxystrobin 18.2% + Difenconazole 11.4%SC	76.26	89.69	89.69	89.69	89.69
Control	0.30	0.30	0.30	0.30	0.30
Factors	SE(m)	CD ($p<0.05$)	SE(d)		
Fungicide (A)	1.068	3.011	1.510		
Concentration (B)	0.844	2.380	1.194		
Fung. x Conc. (A x B)	2.388	6.732	3.377		
CV (%)		6.65			

* Arc sine transformed values of four replication means.

The value 0% substituted by $1/4n$ and 100% substituted by $100-1/4n$ where n is 90

against *S. rolfsii*, while Mahato *et al.* (2014) observed that carbendazim was less effective at 0.1 per cent concentration. Vamshi *et al.* (2022) reported that 100 per cent inhibition of *S. rolfsii* was observed with thiram and tebuconazole, while in carbendazim and azoxystrobin was 76.29%, 34.29% and 89.07%, 83.14%, respectively at both recommended and half the recommended dosages.

The most effective bio-control agents and new molecules of fungicides were chosen for field testing to manage groundnut stem rot disease through seed treatment. Experiments were conducted over three years, from 2018 to 2020, during the summer seasons in a rice-based cropping system.

In summer-2018, the results revealed that all treatments were significantly superior compared to the control. Minimum plant mortality by 14.54% was recorded in seeds treated with azoxystrobin 23SC @ 1ml/kg seed along with soil application with *T. harzianum* @ 2.5 kg/ha at the time of sowing (T_6) which was at par with seeds treated with azoxystrobin 23SC @ 1ml/kg seed (T_3) and seeds treated with trifloxystrobin 25% + tebuconazole 50% @ 0.5g/kg seed (T_1) by 16.00 and 18.39%, respectively. Maximum plant mortality by 45.65% was recorded in treatment T_7 (Fig. 1). Similarly, rotted pods per plant (Fig. 2), minimum (0.40) was recorded in treatment T_6 , it was at par with treatment T_3 and treatment T_4 by 0.73 and 0.87, respectively. Highest, 4.20 rotted pods/plant was recorded in

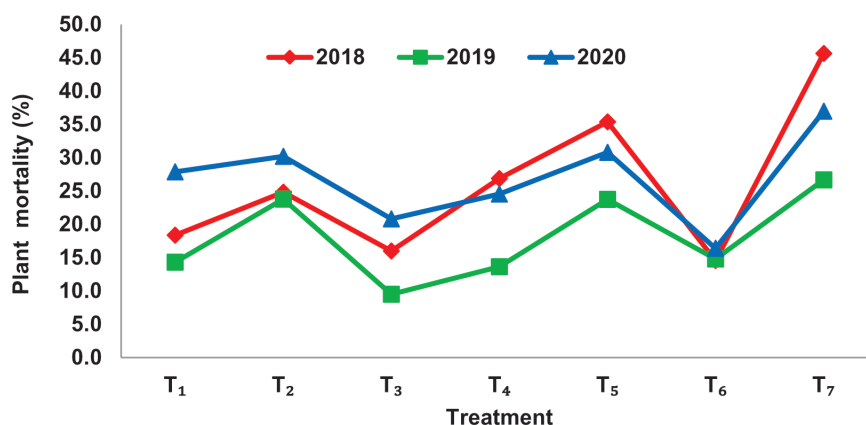


Fig. 1. Year-wise effect of different fungicides and bio-agents on stem rot disease incidence of groundnut during summer season

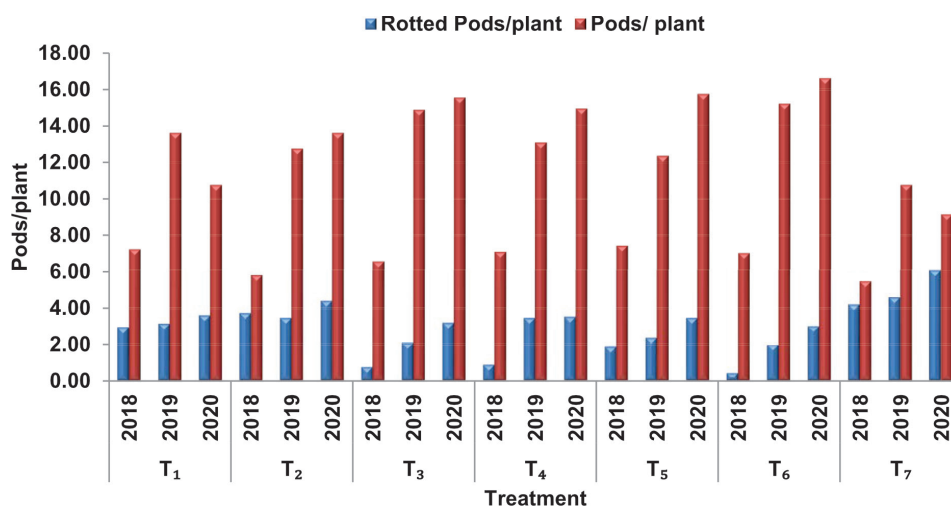


Fig. 2. Year-wise effect of different fungicides and bio-agent on pods of groundnut during summer season

treatment T₇ (control). In case of healthy pods/ plant (Fig. 2), maximum (7.40) was recorded in treatment T₅ which was at par with treatment T₁, T₆ and T₃ with 7.20, 7.00 and 6.53 pods/plant, respectively. In terms of pod and haulm yield (Fig. 3), significant differences among treatments were recorded. Highest pod yield (1904 kg/ha) was harvested from treatment T₆ which was at par with seeds treated with treatment T₃ with 1880kg/ha. The highest haulm yield (4331 kg/ha) was recorded in treatment T₃, which was par with treatment T₄.

In summer-2019, all treatments were significantly better than control. Minimum plant mortality (9.50%) was observed in treatment T₃ which was at par with T₄, T₁, T₆ with 13.64, 14.34 and 14.79 per cent, respectively, while it was maximum (26.68%) in treatment T₇ (Fig. 1).

Highest, 15.20 pods/ plant were recorded in treatment T₆ at par with treatment T₃ (14.87) (Fig. 2). Minimum rotted pods (1.97/plant) were recorded in treatment T₆ which was at par with treatment T₃ and T₅ (2.07 and 2.33 per plant, respectively). In case of pod and haulm yield, maximum pod yield (1995 kg/ha) was recorded in treatment T₃ which was at par with treatment T₄ (1661 kg/ha) and T₆ (1509 kg/ha). While, haulm yield was maximum (7808 kg/ha) in treatment T₆ (Fig. 3) which was at par with T₃ and T₅ treatment (7110 and 6456 kg/ha, respectively).

In summer-2020, the results revealed that all treatments were found significantly superior over the control. Minimum plant mortality (16.39%) was observed in treatment T₆, it was at par with T₃ and T₄

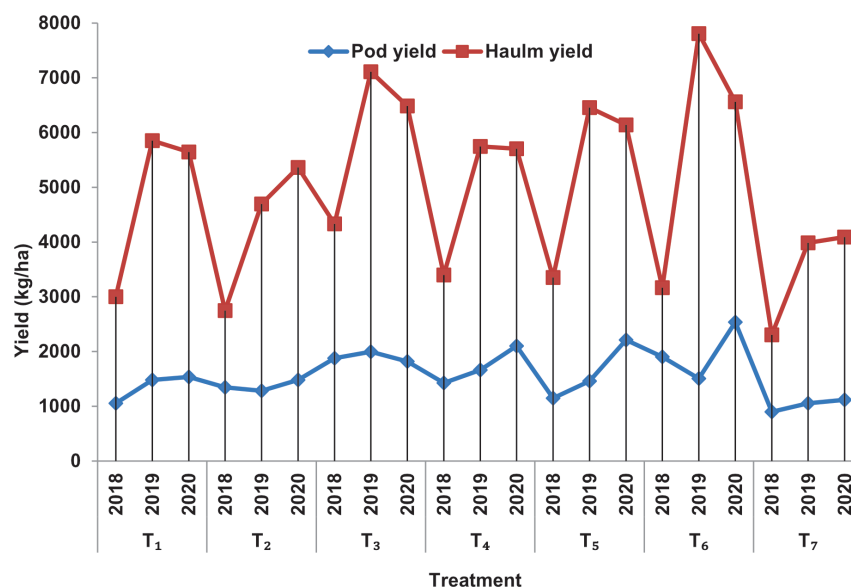


Fig. 3. Year-wise effect of different fungicides and bio-agent on pods and haulm yield of groundnut during summer season

with 20.81 and 24.54 per cent respectively. In control treatment, it was observed to be 36.97 per cent (Fig. 1). Highest pods/ plant (16.60) was recorded in treatment T₆ at par with treatment T₅ (15.73), T₃ (15.53), T₄ (14.93) and T₂ (13.60). Minimum rotted pods/plant (3.00) was recorded in treatment T₆ which was at par with the treatment T₃, T₅, T₄, T₁ and T₂ (3.20, 3.47, 3.53, 3.60 and 4.40, respectively) (Fig. 2). Highest pod yield) 2538 kg/ha) was recorded in treatment T₆ (Fig. 3), it was at par with treatment T₅ and T₄ (2212 and 2102 kg/ha, respectively). Maximum haulm yield (6563 kg/ha) was recorded in T₆ treatment followed by T₃ and T₅ treatment (6486 and 6141 kg/ha, respectively).

Pooled results

During the summer seasons of 2018-2020, a field experiment was conducted to manage stem rot disease of groundnut under a rice-based cropping system. The results indicated that all treatments were significantly

superior to the control (Table 3). The minimum plant mortality (15.24%) was recorded in treatment T₆, which was statistically at par with T₃ (15.44%), T₁ (20.20%) and T₄ (21.68%). In contrast, the highest plant mortality (36.44%) was observed in the control treatment (T₇).

The greatest reduction in plant mortality over the control was recorded in treatment T₆ (58.17%) followed by T₃ (57.63%) and T₁ (44.55%). The lowest reduction in plant mortality was observed in treatments T₅ (17.71%) and T₂ (27.88%) (Table 3). Similar findings were reported by Grichar *et al.* (2000), who observed that azoxystrobin application in peanut fields provided control of southern stem rot caused by *Sclerotium rolfsii* comparable to tebuconazole.

The highest plant height (50.35 cm) was recorded in treatment T₆, which was statistically at par with T₅ (49.16 cm), T₁ (48.19 cm) and T₃ (47.60 cm). No significant differences were observed among treatments T₃, T₄, T₅

Table 3. Performance of different fungicides against stem rot disease, yield and yield attributes of groundnut during summer season

Tr. No.	Treatment	Plant mortality (%)	Plant mortality reduction (%)	*Plant Height (cm)	*No. of pods/ plant	*No. of rotted pods/ plant	Pod yield (kg/ha)	Halm yield (kg/ha)
T ₁	Trifloxystrobin 25% + tebuconazole 50% @ 0.5g/kg seed	20.2 ^{bc}	44.55	48.19 ^{ab}	10.51 ^{ab}	3.22 ^{bc}	1357 ^f	4833 ^e
T ₂	Tebuconazole 2SD @ 1.25g/ kg seed	26.28 ^{abc}	27.88	46.88 ^{bc}	10.71 ^{ab}	3.87 ^{ab}	1371 ^e	4268 ^f
T ₃	Azoxystrobin 23SC @ 1ml/kg seed	15.44 ^c	57.63	47.6 ^{ab}	12.31 ^a	2 ^{cd}	1898 ^b	5976 ^a
T ₄	Azoxystrobin 18.2%+ difenconazole 11.4%SC @ 1ml/ kg seed	21.68 ^{bc}	40.50	47.26 ^{ab}	11.69 ^a	2.62 ^{bcd}	1730 ^c	4951 ^d
T ₅	<i>T. harzianum</i> @ 10 g /kg	29.98 ^{ab}	17.71	49.16 ^{ab}	11.82 ^a	2.56 ^{bcd}	1607 ^d	5317 ^c
T ₆	Azoxystrobin 23SC @ 1ml/kg seed + soil application with <i>T. harzianum</i> @ 2.5 kg/ha	15.24 ^c	58.17	50.35 ^a	12.93 ^a	1.79 ^d	1983 ^a	5845 ^b
T ₇	Control	36.44 ^a	-	43.8 ^c	8.44 ^b	4.96 ^a	1024 ^g	3462 ^g
Treatment (T)								
	SEm±	2.19		1.47	0.83	0.25	149.64	294.89
	CD ($p \leq 0.05$)	6.28		NS	2.56	0.72	461.88	908.65
	CV (%)	27.81		5.83	15.30	25.07	15.68	12.34
Year (Y)								
	SEm±	1.43		0.96	0.54	0.16	97.96	193.05
	CD ($p \leq 0.05$)	4.11		2.96	1.68	0.47	301.87	594.90
Y×T								
	SEm±	3.79		1.60	0.99	0.43	141.88	352.55
	CD ($p \leq 0.05$)	NS		4.60	2.84	NS	407.29	1012.03

Mean of three replications in each treatment of three years' pooled data

*Mean of five plants in each treatment

and T_6 with respect to the number of pods per plant. The maximum number of pods per plant (12.93) was recorded in T_6 followed by T_3 (12.31), T_5 (11.82) and T_4 (11.69), all of which were statistically at par with T_2 (10.71) and T_1 (10.51).

The minimum number of rotted pods per plant (1.79) was observed in treatment T_6 , which was statistically at par with T_3 (2.00), T_5 (2.56) and T_4 (2.62). Pod yield and haulm yield differed significantly among treatments (Table 3). The highest pod yield (1983 kg ha⁻¹) was recorded in treatment T_6 followed by T_3 (1898 kg ha⁻¹) and T_4 (1730 kg ha⁻¹), whereas the control treatment yielded only 1024 kg ha⁻¹.

Regarding haulm yield, the maximum yield (5976 kg ha⁻¹) was recorded in treatment T_3 , followed by T_6 (5845 kg ha⁻¹), T_5 (5317 kg ha⁻¹) and T_4 (4951 kg ha⁻¹). These results are in agreement with Solorzano and Malvick (2011) who reported that maize seed treatment with azoxystrobin and fludioxonil significantly improved germination, growth, plant population and yield by protecting plants from soil-borne pathogens. Similarly, Grichar *et al.* (2000) observed that consistent application of azoxystrobin increased peanut yields by up to 43% over untreated plots when southern stem rot was the predominant soil-borne disease. Rideout *et al.* (2002) also reported that in-furrow application of azoxystrobin suppressed *Sclerotium rolfsii* activity in the peanut rhizosphere, resulting in less than 5% disease incidence at 21 days after planting.

CONCLUSION

From the present study, it can be concluded that seed treatment of groundnut with azoxystrobin 23 SC @ 1 ml kg⁻¹, along with soil application of *Trichoderma harzianum* 1.5% WP @ 2.5 kg ha⁻¹ at the time of sowing, effectively reduced stem rot disease incidence and significantly increased pod and haulm yields.

Acknowledgements

Authors would like to extend our gratitude to Dr. V A Solanki, Ex. Professor and Head, Department of Plant Pathology, N M College of Agriculture in Navsari, for the technical guidance.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Ethical approval

This article does not contain any studies on human beings or animals by any of the authors.

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