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Evaluation of pea germplasm and management strategies for stem rot of pea caused by *Sclerotinia sclerotiorum* (Lib.) de Bary

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Abstract
Pea (*Pisum sativum* L.) an annual herbaceous legume grown for its edible seeds and seed pods suffers from a number of diseases. *Sclerotinia* stem rot, caused by the fungus *Sclerotinia sclerotiorum* is a devastating disease affecting pea crops worldwide. 68 germplasm of pea were screened against stem rot by two methods i.e., by field screening and by detached leaf method (based on lesion length in cm). Out of 68 germplasm, none of the germplasm was found immune and resistant, 31 germplasm were found moderately resistant, 30 germplasm were found to moderately susceptible, 6 germplasms were found susceptible and 1 germplasm was found highly susceptible in field screening. Screening by detached leaf method showed that among 68 germplasm, 5 germplasm were found to resistant, 59 germplasm were found to moderately resistant and 4 germplasm were founded susceptible to stem rot. The disease can be managed by integrated approaches viz., cultural practices, biological control, botanicals, varietal resistance and chemical control. Nine treatments were undertaken in the study in which the disease first appeared in the untreated plot (56 DAS) and lately in the fungicides treated plots (65 DAS). After seed treatment and two sprays, maximum disease control was recorded in the plot treated with Tabuconazole 50% + Trifloxystrobin 25% WG (66.69%) and minimum disease control was recorded in mulching with neem leaves (28.68%) treated plots as compared to untreated check with maximum percent Disease Intensity (44.0%).

Keywords: *Sclerotinia sclerotiorum*, management, stem rot, *Pisum sativum*, germplasm

Introduction
One of the common diseases affecting pea crops is stem rot, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary. Initially a minor disease, it gradually became serious and resulted in yield losses. *Sclerotinia sclerotiorum* (Lib.) de Bary is a fungus that is known to infect over 500 plant species and is considered to be one of the most cosmopolitan one. (Purdy, 1979; Steadman, 1983; Ziqin *et al.*, 2008; Sharma, 2014) [18, 21, 22, 19]. This fungus can live for a very long time in the form of sclerotia and has a wide host range. Although the fungus affects every portion of the plant that is above ground, the stem is where the most damage is seen. *S. sclerotiorum* causes stem rot and it spreads in the air by ascospores or through soil-borne sclerotia that germinate to generate hyphae that infect neighbouring plants' roots.

Cultural practices, biological control and chemical control are some of the integrated techniques that can be used to manage *Sclerotinia* rot. Sclerotia-free seedlings, three-to five-year rotations with non-host crops, open canopy, tillage, controlling host weeds, late sowing, etc. are examples of cultural practices. Fungicides are used in the early stages of disease symptoms or blossoming as a means of chemical control. *Pseudomonas fluorescens*, *Bacillus liquifaciens* and *Trichoderma* sp. are used in biological control techniques such as soil drenching and seed treatment. Application of *Trichoderma* spp. minimizes the severity of disease by 27-29% (Khan *et al.* 2022) [9]. The disease can also be managed with the use of botanicals like neem oil, garlic extract and neem leaf mulching.

Therefore, the goal of the current research is to find out the germplasms of pea that can be incorporated in pea breeding programs for resistant variety development and to screen most effective biocontrol agent, botanical and chemical against the disease.

Materials and Methods

Evaluation of pea germplasm for resistance against *Sclerotinia* rot of pea

All pea varieties were screened against *Sclerotinia sclerotiorum* using 0-6 scale (Sharma 1992) [20] in field conditions and also screened by detached leaf method based on lesion length (cm) (Kull, 2003) [10]. Percent disease intensity was calculated using formula given by Mckinney (1923) [12]:

$$\text{PDI} = \frac{\text{Summation of numerical ratings observed}}{\text{Number of plants observed} \times \text{Maximum rating}} \times 100$$

All pea varieties were screened against *Sclerotinia sclerotiorum* in the field condition by the following disease rating scale:

Table 1: Disease Rating scale for stem rot of pea (Sharma 1992) [20]

Rating scale	Percent area infected	Disease reaction
0	No infection	Immune
1	Very small lesions or up to 5% green area infected	Resistant
2	Very small, individual water-soaked lesions or up to 20% green area infected	Moderately resistant
3	Well-defined brown to dark lesions on the stem/pod or up to 40% green area infected	Moderately susceptible
4	Enlarged dark-brown lesions, sometimes covered by white cottony mass or up to 60% green area infected	Susceptible
5	Severe stem and pod rot infections, in most cases death of the plant or more than 60% green area infected	Highly susceptible

Pea germplasm were also screened by detached leaf method by the scale given by Kull (2003) [10]:

Table 2: Disease rating scale given by Kull (2003) [10]

Reaction of host plant	Lesion length (cm)
Resistant	0.4-0.8
Moderately resistant	0.8-3.5
Susceptible	3.5-4.3

Management of *Sclerotinia* rot of pea under field conditions

Evaluation of the efficacy of various bioagents (T_1-Seed treatment with *Trichoderma harzianum* @ 4g/kg seed and foliar spray of *T. harzianum* @ 0.5% at 75 and 90 DAS,) T_2-Seed treatment with *Pseudomonas fluorescens* @ 10g/kg seed and foliar spray of *P. fluorescens* @ 0.5%), fungicides (T_3.Seed treatment with Thifluzamide 15% + Difenoconazole 20% @ 0.04% and foliar spray of Thifluzamide 15% + Difenoconazole 20% @ 250ml/ha, T_8-Seed treatment with Tabuconazole 50% + Trifloxystrobin 25% WG @ 0.08% and foliar spray of Tabuconazole 50% + Trifloxystrobin 25% WG @ 400g/ha), botanicals (T_4-Seed treatment garlic bulb extract @ 15% and foliar spray of garlic bulb extract @ 15%, T_5-Seed treatment neem oil @ 4% + and foliar spray of neem oil @ 4%), mulching (T_6-Soil mulching with neem leaves (3cm) and T_7-Seed treatment with Bijamrit and foliar spray with Jivamrit along with T_9-As Untreated check was applied with two sprays of water and assessed against the stem rot disease. All the treatments were more or less effective and they reduced the disease incidence and disease intensity.

The foliar sprays including botanicals, fungicides, bioagents and Jivamrit were administered at 15-day intervals. The first spray was given after 15 days following the onset of the disease (75 DAS) and the second spray was given at 15 days following the first spray (90 DAS). Plant Disease Intensity was recorded in all the treatments and Percent Disease Control was calculated.

Results and Discussion

Field screening

Among 68 germplasms, none of the germplasm was founded immune and resistant while 30 germplasms viz., SKNP 04-09, HUDP 15, IPFD 19-1, HFP 4, Pant P 462, IPFD 21-4, Pant P 517, KPMR 907, RFP 2010-21, VL 42, RFP 2011-1, IPF 16-13, Azad Pea-2, Azad Pea-4, Kashi Samriddhi, Kashi Udai, Kashi Udai×NDVP-4, Kashi Mukti× Azad Pea-3, Kashi Mukti×NDVP-2, Kashi Nandini× Azad Pea-3, Kashi Nandini × NDVP-2, Kashi Nandini × Kashi Udai, Kashi Samriddhi × NDVP-2, Azad Pea-3 × Azad Pea-4, Azad Pea-1 × NDVP-4, Azad Pea-2 × Azad Pea-3, Azad Pea-4 × Kashi Udai, Kashi Nandini × Azad Pea-2, Kashi Mukti × Kashi Udai, NDVP-4× Azad Pea-3 were found moderately resistant with percent Disease Intensity in the range of 6.66-20.00%, 30 germplasm viz., IPFD 19-3, HFP 1426, Pant P 455, Pant P 514, Pant P 508, HUDP 1802, Pant P 480, Pant P 484, IPFD 18-3, HUDP 15(ch.), IPFD 20-2, HFP 1709 IPFD 21-7, IPF 21-16, SKNP 04-09, HFP 1811, SKAU P-17, Pant P 523, Pant P 516, IPF 21-13, HUTP 1705, IPF 21-21NM, NDVP-2, Kashi Nandini, Kashi Samriddhi × Azad Pea-3, Kashi Samriddhi × NDVP-4, Azad Pea-1 × Azad Pea-4, Kashi Samriddhi × Kashi Mukti, Kashi Udai × Azad Pea-3, FPD 21-138 were found to be moderately susceptible with percent Disease Intensity in the range of 20.66-37.5%, 6 germplasms viz., KPMR 954, Pant P 479, IPFD 21-5, HFP 4 (ch.), SKNP 04-09 and HFP 1809 were found susceptible with percent Disease Intensity in the range of 41.66-48.66% and two germplasm viz., Azad Pea-3 and HFP 1817 were found to be highly susceptible with percent Disease intensity of 61.33% in field screening to stem rot. (Table no. 3 and 4)

Table 3: Pea germplasm field screening against stem rot

S. No	Germplasm	Per cent Disease Intensity (PDI)	S. No	Germplasm	Per cent Disease Intensity (PDI)
1.	IPFD 19-3	29.66	35.	RFP 2011-1	7.66
2.	HFP 1426	20.66	36.	Pant P 523	30.66
3.	SKNP 04-09	12.33	37.	HFP 1809	42.00
4.	HUDP 15	15.00	38.	Pant P 516	27.66
5.	IPFD 19-1	11.66	39.	IPF 21-13	20.66
6.	HFP 4	16.66	40.	IPF 16-13	19.00
7.	Pant P 462	9.33	41.	HUTP 1705	25.00
8.	Pant P 455	23.33	42.	IPF 21-21NM	23.33
9.	Pant P 514	26.00	43.	Azad Pea-2	10.66
10.	KPMR 954	46.33	44.	Azad Pea-4	15.00
11.	Pant P 479	48.66	45.	Kashi Samriddhi	19.00
12.	IPFD 21-5	46.66	46.	NDVP 2	23.66
13.	HFP 4(ch.)	41.66	47.	Azad Pea-3	63.33
14.	Pant P 508	36.66	48.	Kashi Nandini	33.66
15.	HUDP 1802	22.66	49.	Kashi Udai	20.00
16.	Pant P 480	25.00	50.	Kashi Udai × NDVP 4	9.33
17.	Pant P 509	36.33	51.	Kashi Mukti × Azad Pea-3	11.33
18.	SKNP 04-09	48.66	52.	Kashi Mukti × NDVP 2	9.66
19.	IPFD 21-4	20.00	53.	Kashi Nandini × Azad Pea-3	10.33
20.	Pant P 484	23.66	54.	Kashi Nandini × NDVP 2	17.00
21.	IPFD 18-3	36.33	55.	Kashi Nandini × Kashi Udai	19.33
22.	HUDP 15(ch.)	26.00	56.	Kashi Samriddhi × AP-3	26.00
23.	IPFD 20-2	23.00	57.	Kashi Samriddhi × NDVP 4	19.66
24.	HFP 1709	30.66	58.	Kashi Samriddhi × NDVP 2	35.66
25.	IPFD 21-7	22.33	59.	AP-3 × AP-4	12.33
26.	HFP 1817	61.33	60.	AP-1 × AP-4	27.66
27.	IPF 21-16	25.00	61.	AP-1 × NDVP 4	12.66
28.	Pant P 517	19.33	62.	AP-2 × AP-3	6.66
29.	SKNP 04-09	34.33	63.	AP-4 × Kashi Udai	10.00
30.	KPMR 907	15.33	64.	Kashi Samriddhi×Kashi Mukti	27.66
31.	RFP 2010-21	19.33	65.	Kashi Nandini × AP-2	18.66
32.	HFP 1811	37.5	66.	Kashi Mukti × Kashi Udai	13.33
33.	VL 42	16.00	67.	Kashi Udai × AP-3	28.66
34.	SKAU P-17	21.66	68.	NDVP 4 × AP-3	17.66

Table 4: Disease reaction and grade of Pea germplasms against stem rot on the basis of field screening

Number of Germplasms	Grade	Name of the Germplasms	Disease reaction
0	0	Nil	Immune
0	1	Nil	Resistant
30	2	SKNP 04-09, HUDP 15, IPFD 19-1, HFP 4, Pant P 462, IPFD 21-4, Pant P 517, KPMR 907, RFP 2010-21, VL 42, RFP 2011-1, IPF 16-13, Azad Pea-2, Azad Pea-4, Kashi Samriddhi, Kashi Udai, Kashi Udai×NDVP-4, Kashi Mukti× Azad Pea-3, Kashi Mukti×NDVP-2, Kashi Nandini× Azad Pea-3, Kashi Nandini × NDVP-2, Kashi Nandin × Kashi Udai, Kashi Samriddhi × NDVP-2, Azad Pea-3 × Azad Pea-4, Azad Pea-1 × NDVP-4, Azad Pea-2 × Azad Pea-3, Azad Pea-4 × Kashi Udai, Kashi Nandin × Azad Pea-2, Kashi Mukti × Kashi Udai, NDVP-4× Azad Pea-3	Moderately resistant
30	3	IPFD 19-3, HFP 1426, Pant P 455, Pant P 514, Pant P 508, HUDP 1802, Pant P 480, Pant P 484, IPFD 18-3, HUDP 15(ch.), IPFD 20-2, HFP 1709 IPFD 21-7, IPF 21-16, SKNP 04-09, HFP 1811, SKAU P-17, Pant P 523, Pant P 516, IPF 21-13, HUTP 1705, IPF 21-21NM, NDVP-2, Kashi Nandini, Kashi Samriddhi × Azad Pea-3, Kashi Samriddhi × NDVP-4, Azad Pea-1 × Azad Pea-4, Kashi Samriddhi × Kashi Mukti, Kashi Udai × Azad Pea-3, FPD 21-138	Moderately susceptible
6	4	KPMR 954, Pant P 479, IPFD 21-5, HFP 4(ch.), SKNP 04-09 and HFP 1809	Susceptible
2	5	HFP 1817 and Azad Pea-3	Highly susceptible

4.3.2 Germplasm screening by detached leaf method

Among 68 germplasm, 5 germplasm viz., Pant P 462, RFP 2011-1, Kashi Udai × NDVP-4, Kashi Mukti × NDVP-2, Azad Pea-2 × Azad Pea-3 were found to be resistant with lesion length of 0.6-0.7 cm, 59 germplasm viz., IPFD 19-3, HFP 1426, SKNP 04-09, HUDP 15, IPFD 19-1, HFP 4, Pant P 455, Pant P 514, KPMR 954, IPFD 21-5, HFP 4(ch.), Pant P 508, HUDP 1802, Pant P 480, Pant P 509, IPFD 21-4, Pant P 484, IPFD 18-3, HUDP 15(ch.), IPFD 20-2, HFP 1709, HFP 1709, IPF 21-16, Pant P 517, SKNP 04-09, KPMR 907, RFP 2010-21, HFP 1811, VL 42, SKAU P-17, Pant P 523, Pant P 516, IPF 21-13, IPF 16-13, HUTP 1705, IPF 21-21NM, Azad Pea-2, Azad Pea-4, Kashi Samriddhi, NDVP-2, Azad Pea-3, Kashi Udai, Kashi Mukti × Azad Pea-3, Kashi Nandini × Azad Pea-3, Kashi Nandini × NDVP-2, Kashi Nandini × Kashi Udai, Kashi Samriddhi × Azad Pea-3, Kashi Samriddhi × NDVP-2, Kashi Samriddhi × NDVP-4, Azad Pea-3 × Azad Pea-4, Azad Pea-1 × Azad Pea-4, Azad Pea-4 × Kashi Udai, Kashi Samriddhi × Kashi Mukti, Kashi Nandini × Azad Pea-2, Kashi Mukti × Kashi Udai, NDVP 4 × Azad pea-3, Kashi Udai × Azad Pea-3 were found to be moderately resistant with lesion length between 1.0-3.2 cm and 4 germplasm Pant P 479, SKNP 04-09, HFP 1817, HFP 1809 were founded susceptible with lesion length 3.6-3.8 cm and one germplasm HFP 1817 among the four susceptible germplasm had a lesion length of more than 4.3 cm in screening by detached leaf method to stem rot. (Table No. 5 and 6)

Table 5: Pea germplasm reaction against stem rot by detached leaf method

S. No	Germplasm	Lesion Length (cm)	S. No	Germplasm	Lesion Length (cm)
1.	IPFD 19-3	1.8	35.	RFP 2011-1	0.6
2.	HFP 1426	1.5	36.	Pant P 523	1.9
3.	SKNP 04-09	1.0	37.	HFP 1809	3.8
4.	HUDP 15	1.4	38.	Pant P 516	1.9
5.	IPFD 19-1	1.0	39.	IPF 21-13	1.4
6.	HFP 4	1.2	40.	IPF 16-13	1.4
7.	Pant P 462	0.6	41.	HUTP 1705	1.8
8.	Pant P 455	1.8	42.	IPF 21-21NM	1.6
9.	Pant P 514	1.9	43.	Azad Pea-2	1.0
10.	KPMR 954	3.06	44.	Azad Pea-4	1.2
11.	Pant P 479	3.6	45.	Kashi Samriddhi	1.4
12.	IPFD 21-5	3.2	46.	NDVP 2	1.8
13.	HFP 4(ch.)	3.2	47.	Azad Pea-3	1.2
14.	Pant P 508	2.8	48.	Kashi Nandini	2.3
15.	HUDP 1802	1.6	49.	Kashi Udai	1.9
16.	Pant P 480	1.6	50.	Kashi Udai × NDVP 4	0.7
17.	Pant P 509	2.9	51.	Kashi Mukti × Azad Pea-3	1.1
18.	SKNP 04-09	3.6	52.	Kashi Mukti × NDVP 2	0.6
19.	IPFD 21-4	1.5	53.	Kashi Nandini × Azad Pea-3	1.0
20.	Pant P 484	1.8	54.	Kashi Nandini × NDVP 2	1.4
21.	IPFD 18-3	2.2	55.	Kashi Nandini × Kashi Udai	1.5
22.	HUDP 15(ch.)	1.8	56.	Kashi Samriddhi × AP-3	1.9
23.	IPFD 20-2	1.8	57.	Kashi Samriddhi × NDVP 4	1.6
24.	HFP 1709	2.1	58.	Kashi Samriddhi × NDVP 2	3.2
25.	IPFD 21-7	1.4	59.	AP-3 × AP-4	1.2
26.	HFP 1817	>4.3	60.	AP-1 × AP-4	2.1
27.	IPF 21-16	1.8	61.	AP-1 × NDVP 4	1.2
28.	Pant P 517	1.4	62.	AP-2 × AP-3	0.6
29.	SKNP 04-09	2.5	63.	AP-4 × Kashi Udai	1.0
30.	KPMR 907	1.0	64.	Kashi Samriddhi×Kashi Mukti	2.2
31.	RFP 2010-21	1.6	65.	Kashi Nandini × AP-2	1.5
32.	HFP 1811	2.9	66.	Kashi Mukti × Kashi Udai	1.1
33.	VL 42	1.2	67.	Kashi Udai × AP-3	2.3
34.	SKAU P-17	1.5	68.	NDVP 4 × AP-3	1.4

Table 6: Reaction of Pea germplasms against stem rot based on lesion length

Lesion Length (cm)	No. of germplasm	Name of the germplasms	Disease reaction
0.4-0.8	5	Pant P 462, RFP 2011-1, Kashi Udai × NDVP-4, Kashi Mukti × NDVP-2, Azad Pea-2 × Azad Pea-3	Resistant
0.8-3.5	59	IPFD 19-3, HFP 1426, SKNP 04-09, HUDP 15, IPFD 19-1, HFP 4, Pant P 455, Pant P 514, KPMR 954, IPFD 21-5, HFP 4(ch.), Pant P 508, HUDP 1802, Pant P 480, Pant P 509, IPFD 21-4, Pant P 484, IPFD 18-3, HUDP 15(ch.), IPFD 20-2, HFP 1709, HFP 1709, IPF 21-16, Pant P 517, SKNP 04-09, KPMR 907, RFP 2010-21, HFP 1811, VL 42, SKAU P-17, Pant P 523, Pant P 516, IPF 21-13, IPF 16-13, HUTP 1705, IPF 21-21NM, Azad Pea-2, Azad Pea-4, Kashi Samriddhi, NDVP-2, Azad Pea-3, Kashi Udai, Kashi Mukti × Azad Pea-3, Kashi Nandini × Azad Pea-3, Kashi Nandini × NDVP-2, Kashi Nandini × Kashi Udai, Kashi Samriddhi × Azad Pea-3, Kashi Samriddhi × NDVP-2, Kashi Samriddhi × NDVP-4, Azad Pea-3 × Azad Pea-4, Azad Pea-1 × Azad Pea-4, Azad Pea-4 × Kashi Udai, Kashi Samriddhi × Kashi Mukti, Kashi Nandini × Azad Pea-2, Kashi Mukti × Kashi Udai, NDVP 4 × Azad pea-3, Kashi Udai × Azad Pea-3	Moderately resistant
3.5-4.3	4	Pant P 479, SKNP 04-09, HFP 1817, HFP 1809	Susceptible

Numerous studies have assessed *Pisum sp*. germplasm to search for resistance to *S. sclerotiorum*. Porter (2012) [16] evaluated pea genotypes with partial resistance to *Sclerotinia sclerotiorum* in growth chambers under controlled conditions. The genotypes were incubated at five temperatures (15.6, 18.3, 21.1, 23.9, and 29.4 °C) and at four incubation periods (12, 24, 48, and 72 hours) with 90-100% relative humidity. Significant differences in lesion expansion among genotypes were observed only after 48 and 72 hours of incubation. Pathak *et al.* (2017) [15] screened 48 pea accessions for resistance to *Sclerotinia sclerotiorum* using two different methods: the cut stem method and the detached leaf method. 5 accessions (EC-329569, EC-296176, ET-45189, P-107-2-1, and IPF-5-19) were found to be resistant to the pathogen, producing leaf lesions between 0.4 and 0.8 cm in length. 40 pea accessions were reported to be moderately resistant, producing leaf lesions between 0.8 and 3.5 cm in length.

Management of Stem rot of Pea

The disease was first observed in untreated plot (56 DAS), then in the plots treated with neem oil (60 DAS), Jivamrit (62 DAS), mulching with neem leaves (62 DAS), *T. harzianum* and *P. fluorescens* (63 DAS) and garlic bulb extract (64 DAS) and observed lately in the plots treated with fungicides Tabuconazole 50% + Trifloxystrobin 25% and Thifluzamide 15% + Difenoconazole 20% (65 DAS).

Effect of first spray at 75 DAS

All the treatments were found to be significantly effective against stem rot after the first spray at 75 days of sowing (DAS) as compared with the untreated check. Minimum PDI was recorded in the plot treated with Tabuconazole 50% + Trifloxystrobin 25% (12.66%), followed by the plot treated with Thifluzamide 15% + Difenoconazole 20% (14.66%), garlic bulb extract (18.00%), *T. harzianum* (20.00%), *Pseudomonas fluorescens* (20.66%), neem oil (22.66%), Jivamrit (26.00%) and maximum PDI was recorded in the plot in which mulching with neem leaves was done (27.33%) as compared to untreated check (36.00%). Maximum PDC (64.52%) was found in the plot treated with Tabuconazole 50% + Trifloxystrobin 25%, followed by the plot treated with Thifluzamide 15% + Difenoconazole 20% (59.48), garlic bulb extract (49.57%), *Trichoderma harzianum* (44.53%), *Pseudomonas fluorescence* (42.47%), neem oil (31.23%), Jivamrit (27.73%) and minimum PDC (24.01%) was recorded in the plot in which mulching with neem leaves was done.

Effect of second spray at 90 DAS

Minimum PDI (14.66%) was recorded in the plot treated with the fungicide Tabuconazole 50% + Trifloxystrobin 25%, followed by the plot treated with the fungicide Thifluzamide 15% + Difenoconazole 20% (17.33%), garlic bulb extract (22.00%), *Trichoderma harzianum* (24.00%), *Pseudomonas fluorescens* (24.66%), neem oil (28.00%), Bijamrit + Jivamrit (30.00%) and maximum PDI (31.33%) was recorded in the plot in which mulching with neem leaves was done (30.00%) as compared to untreated check (44.00%). Maximum PDC was found in the plot treated with the fungicide Tabuconazole 50% + Trifloxystrobin 25% (66.69%), followed by the plot treated with the fungicide Thifluzamide 15% + Difenoconazole 20% (60.68%), garlic bulb extract (51.72%), *Trichoderma harzianum* (45.50%), *Pseudomonas fluorescence* (43.85%), neem oil (36.20%), Bijamrit + Jivamrit (31.64%) and minimum PDC was recorded in the plot in which mulching with neem leaves was done (28.68).

Similar findings were reported by Fatehpuria *et al.* (2017) [5] in which they evaluated 3 botanicals namely *Zingiber officinale, Curcuma longa and Allium sativum* against *Sclerotinia sclerotiorum* and all the botanicals effectively inhibited the growth of the fungus. However their effectiveness gradually increased with the increase in their concentration. Garlic crude extract had the maximum inhibition, followed by turmeric and zinger. Similar results were also observed by Bairwa *et al.* (2020) [3] in their investigation into the effectiveness of six indigenous materials—cow urine, heeng powder, turmeric powder, neem oil, castor oil and garlic extract—against the *Sclerotinia* rot of brinjal in both *in vivo* and *in vitro* conditions. They showed that among all, garlic extract was the most effective in preventing mycelial growth followed by neem oil and cow urine.

Table 7: Effect of treatments on management of stem rot of pea after second spray

Treatments	First appearance of disease (Days After Sowing)	Percent Diseases Intensity (PDI)	Percent disease control (PDC)
T_1 (*Trichoderma harzianum*)	63 DAS	24.00 (29.28)	45.50 (42.40)
T_2 (*Pseudomonas fluorescens*)	63 DAS	24.66 (29.76)	43.85 (41.45)
T_3 (Thifluzamide 15% + Difenoconazole 20%)	65 DAS	17.33 (24.57)	60.68 (51.18)
T_4 (Garlic bulb extract)	64 DAS	22.00 (27.92)	51.72 (46.00)
T_5 (Neem oil)	60 DAS	28.00 (31.93)	36.20 (36.94)
T_6 (Mulching)	62 DAS	31.33 (34.03)	28.68 (32.33)
T_7 (Bijamrit + Jivamrit)	62 DAS	30.00 (33.20)	31.64 (34.14)
T_8 (Tabuconazole 50% + Trifloxystrobin 25%)	65 DAS	14.66 (22.44)	66.69 (54.81)
T_9 (Control)	56 DAS	44.00 (41.55)	0.00
SEm±		7.27	43.16
CD 5%		4.67	11.37

Conclusion

After the second spray, maximum disease control was recorded in the plot treated with the fungicides Tabuconazole 50% + Trifloxystrobin 25% (66.69%), followed by the plot treated with the fungicides Thifluzamide 15% + Difenoconazole 20% (51.72%) and minimum disease control was recorded in the plots having mulching with neem leaves (28.68%) as compared to untreated check with maximum percent Disease Intensity (44.00%).

In conclusion, our study has clarified that integration of seed treatment with Tabuconazole 50% + Trifloxystrobin 25% WG and its two foliar spray gave best disease management of stem rot of pea (66.69%) as compared to check. Also germplasm of pea that are moderately resistant to the

Sclerotinia rot disease can be used in breeding programs to develop resistant varieties.

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