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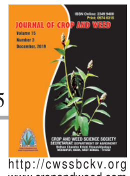

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Soil borne disease dynamics on lentil (*Lens culinaris*) and their correlation with weather factors under Conservation Agriculture

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ABSTRACT

The major challenge of today's agriculture is to provide food security for a growing population while remaining sustainable. As a result, a paradigm shift toward conservation agriculture (CA) is urgently required. Lentil is one of the major pulse crops in West Bengal and its incorporation into the cropping system through CA will ensure soil health and production sustainability. The goal of this study was to find the dynamics of soil-borne disease development on two lentil cultivars in three different tillage systems (conventional tillage, reduced tillage and zero tillage) with five different doses of fertilizer and organic residue treatments: T_1= (0% Residue + 100% NPK), T_2=(0% Residue + 50% NPK), T_3=(100% Residue + 75% NPK), T_4=(50% Residue + 100% NPK) & T_5=(50% Residue + 75% NPK). Regardless of treatment, it was discovered that among the three different tillage practices, zero tillage and reduced tillage had the lowest disease incidence (%) and severity (%). Whereas, irrespective of tillage, the lowest disease incidence (%) and severity (%) were observed when residue and NPK were used at (100% +75%) and (50% +100%), respectively, indicating that disease suppression could be achieved through minimal soil disturbance and residue retention. Through correlation and regression analysis it was also found that weekly average of two weather factors viz., maximum and minimum temperatures and bright sunshine hour had the significant effect on both disease incidence and severity. The isolated pathogens from collar rot and wilt infected plants were confirmed as Sclerotium rolfsii & Fusarium oxysporum f.sp. *lentis by studying its morphological characteristics.*

Keywords*:* Conservation agriculture, disease incidence, disease severity, soil borne disease, *Sclerotium rolfsii*.

In India, lentil is the second most important winter pulse crop due to its high nutritional values (rich in protein, calcium, phosphorus, iron & lysine). The amount of nitrogen fixed by the crop in soil varies greatly from 0 to 192 kg total N ha^{-1} around a mean of 80 kg total N ha^{-1} (Erskine *et al*., 2009), which also helps in improving soil physical structure. Herein lie it's importance for adoption in conservation agriculture (CA) practices. CA includes the use of minimum or no-tillage along with crop residue retention to address soil physical degradation problems (Sayre and Hobbs, 2004). Earlier it was observed that residue retention also increases soil carbon sequestration in the soil, thus indicating several beneficial roles of conservation agriculture (Das *et al.*, 2014). Soil aggregation and aggregate stability was found to be improved in CA practices dominated by residue retention (Li *et al*., 2011). CA also known to increase water infiltration rate in soil due to minimum soil disturbance as reported by Mrabet (2007).

Lentil is found affected by several fungal, bacterial and viral diseases among which *Fusarium* wilt and Collar rot are most destructive (Mondal *et al.*, 2020; 2021). CA practices having crop residue on soil surfaces favors soil borne microorganisms including plant pathogens with a comfortable habitat, so disease severity (%) may increase. On the other hand several diseases were reduced due to an increase~~s~~ population of antagonistic microorganisms in soil as reported by Chakraborty *et al.* (2021). In another instance, rice blast disease severity (%) was significantly lower in zero tillage cropping system than conventional tillage systems was found by Sester *et al.* (2014). Foot rot and root rot pathogen *Fusaium culmorum* survive as hyphae in stubble as well as chlamydospore in soil was also reported by Burgess (2011). Thus due to less tillage in CA practices, a more favourable environment is created for plant pathogens to cause persistent diseases (Bockus and Shroyer, 1998). However, rice sheath blight and spot blotch of wheat disease incidence was found to be lower in conservation agricultural practices than in conventional tillage for some varieties from third year onwards of continuous cultivation (Chowdhury *et al*., 2017). So amid different findings, this experiment was designed to obtain a greater insight with the objective to examine the dynamics of

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soil borne disease development on two lentil varieties under three different tillage systems with five different treatments.

MATERIALS AND METHODS

Measurement of disease severity (%) and disease incidence (%) data under field conditions and statistical analysis of data:

The disease severity (%) (DS) and Disease incidence (%) (DI) data were collected from the disease affected lentil plants at seven day interval period. The field of investigation was Balindi farm, BCKV, West Bengal (during rabi season 2020- 2021). The data was taken from the following two cultivars namely-IPL-316 and Asha. In the Balindi farm, three different tillage practices were followed under conservation agriculture systems *i.e*. Conventional tillage, Reduced tillage and Zero tillage. Five different treatments followed for research were- T_1= (0% Residue + 100% NPK), T_2= (0% Residue + 50% NPK), T_3=(100% Residue + 75% NPK), T_4=(50% Residue + 100% NPK) & T_5=(50% Residue + 75% NPK).

In each tillage systems, there were five treatments. With the help of measuring scale (100cm/1m), an area of one square meter was marked in each treatment block. This particular $1m^2$ area was tagged using a wooden stick. In each $1m^2$ block, plants were observed & disease data were taken in terms of DS & DI at seven-day interval up to harvesting. In the same way data was taken in three replications from each of the five treatments of three different tillage systems. Then data was calculated by using the standard formula given below-

$$\text{DS}(\%) = \frac{\text{Summation of all the ratings}}{\text{Total plants} \times \text{Maximum disease grade}} \times 100$$

The disease rating scale (scale 1-9) was followed by the rating method proposed by Meena *et al.*(2017) (for the evaluation of resistant lentil genotypes against *Fusarium* wilt of lentil). The rating scale referred is mentioned below-

Rating scale	Reaction
1- Plants wilted 1% or less	Resistant
3- Plants wilted 2-10%	Moderately resistant
5- Plants wilted 11-20%	Moderately susceptible
7- Plants wilted 21-50%	Susceptible
9- Plants wilted above 50%	Highly susceptible

For DI(%) calculation, observation of the whole plant in terms of wilting, drooping, yellowing was observed carefully. The method followed here was proposed by Bayaa and Erskine (1990).

$$\text{DI}(\%) = \frac{\text{Number of inf ected plants}}{\text{Total plants examined}} \times 100$$

The layout of the experiment was Split plot design. Three tillage systems *i.e.* conventional tillage, zero tillage and reduced tillage were randomly distributed among the main plots and again five different doses of fertilisers and organic residues were randomly assigned among the five subplots. The data of the different parameters *i.e*., Disease severity and Disease incidence percentage were therefore analysed using split plot analysis of variance method. To compare the means of treatments, Duncan's multiple range test (DMRT) was used at 5% level of significance using CRAN-R software. Similarly, Pearson's correlation coefficient between disease incidence (%), disease severity (%) and weekly average weather parameters (minimum and maximum temperature, maximum and minimum relative humidity, bright sunshine hours and soil temperature measured at 5cm depth) was performed to know the potential weather factor (s) affecting DI (%) and DS (%). Again, multiple regression analysis was entertained to find out the key weather variable (s) impacting DI (%) and DS (%).

Procedures followed in laboratory for pathogen isolation

Lentil plants which showed typical symptoms of collar rot and wilting were collected from Balindi farm research plot. The part of the collar region showing white hyphal mass were cut into small pieces along with some healthy portion. In case of wilt symptoms, the wilted plants were collected and vascular portion showing typical reddening symptoms was sectioned vertically. Then they were surface sterilized with 0.1% Mercuric chloride solution for one minute. To remove any traces of Mercuric chloride solution, such cut pieces were washed thoroughly with sterile distilled water. Then they were aseptically transferred to sterilized potato dextrose agar (PDA) plates. These plates were incubated at 27±1 °C for three days for growth of the fungus. After few days when growth was observed in plates, loopful of fungal mycelia was transferred into fresh sterilized PDA media with the help of cork borer. Thus pure culture of the fungus was obtained and maintained by regular periodic transfer. Later on their morphological characteristics were studied accordingly.

RESULTS AND DISCUSSION

Morphological study for identification of the pathogens

The collar region affecting pathogen produced fan like white fluffy colonies on the PDA Plates. The colonies appeared as pure white mycelial growth which was much in abundance. Sclerotia were small, mustard shaped, white, round bodies with clamp in the beginning, later (after 15days) became light to dark brown in colour with shiny appearance. The isolated pathogen was identified as *Sclerotium rolfsii*, according to their morphological studies.

While the wilt causing pathogen produced hyaline, septate and much branched mycelium. On media the colony varies from fluffy to appressed and also vary in colour (pink or violet tinge). The pathogen produced three kinds of asexual spores; micro conidia, macro conidia and chlamydospores. Microconidia are usually single celled, ovoid and hyaline. Macroconidia are usually two to seven celled, appeared in clusters. While the Chlamydospores are single celled, spherical shaped, formed singly or intercalary in the hyphae. The isolated pathogen was identified as *Fusarium oxysporum* f.sp. *lentis*, according to their morphological studies.

Disease dynamics of soil borne pathogen in field

The two cultivars of lentil were sown on 9th November, 2020 in five different treatments (T1= 0% residue + 100% NPK; T2= 100% residue + 50% NPK; T3= 100% residue + 75% NPK; T4= 50% residue + 100% NPK and T5= 50% residue + 75% NPK) with three conservation tillage practices. The cultivar IPL 316 showed that, with increase in date of observation or age of the plant there was a significant increase in disease incidence. In every date of observation, it was observed that maximum Disease incidence (%) of IPL 316 was recorded in T1 treatment followed by T5 treatment whereas, minimum in T2 and T3 treatment (2.27% & 2.48% in 69 DAS; 3.17% & 3.34% in 76 DAS, 3.49% & 2.74% in 83 DAS & 2.89% & 3.97% in 90 DAS) up to early stage of incidence. Whereas with increase in age, the minimum disease incidence was noticed in T3 treatment (4.99%; 5.40% & 5.97% at 97 DAS, 104 DAS & 111 DAS respectively). Thus higher crop residue effecting less disease development can be supported by the findings of lupin leaves being less infected by brown leaf spot fungi when grown with high rate of stubble mulching in soil, as reported by Sweetingham *et al.* (1993).

Among the three tillage practices conventional, reduced and zero tillage, it was observed that in earlier stage, infection was minimum in reduced tillage (2.55% in 69 DAS, 2.97% in 76 DAS & 2.82% in 83 DAS), whereas with increase in age the disease incidence was minimum in zero tillage (3.53% in 90 DAS 4.25% in 97 DAS; 4.69% in 104 DAS & 5.00% in 111 DAS) and in all the cases the disease incidence was maximum in conventional tillage practices and these differences in disease incidence was statistically significant (Table-1). Similar findings of inoculum density of root rot pathogen *Cochliobolus sativus* being higher in conventional tillage causing more disease than in zero tillage was also observed by Tinline and Spurr (1991).

In case of Disease severity (%) of IPL 316, the different treatments and three different tillage practices were statistically significant. Among the treatments maximum disease severity was noticed in T1 (2.34% in 69 DAS; 2.39% in 76 DAS; 3.00% in 83 DAS; 3.20% in 90 DAS; 4.10% in 97 DAS, 4.35% in 104 DAS & 4.84% in 111 DAS). Treatments are significantly at par with T5 (1.47% in 69 DAS, 2.40% in 76 DAS; 2.99% in 83 DAS; 3.45% in 90 DAS; 3.80% in 97 DAS; 4.08% in 104 DAS & 4.76% in 111 DAS). This finding of T_5 treatment having higher disease occurrence is similar with previous studies like, left-over residues at or below soil surface harboring pathogen propagules can cause more disease in CA practices (Watkins and Boosalis, 1994). However, T3 and T4 treatments showed minimum disease severity irrespective of tillage practices used. (1.04 % & 1.38% in 69 DAS; 1.96% & 1.82% in 76 DAS, 1.95% & 2.16% in 83 DAS; 2.44% & 2.50% in 90 DAS; 2.93% & 3.22% in 97 DAS; 3.38% & 3.43% in 104 DAS and 4.18% & 4.04% in 111 DAS).

Among the three tillage practices zero tillage showed minimum disease severity (1.06% in 69 DAS; 1.67% in 76 DAS; 2.10% in 83 DAS; 2.55% in 90 DAS; 2.92% in 97 DAS; 3.50% in 104 DAS; and 3.81% in 111 DAS) (Table 2). However, it was also noticed that in reduced tillage the disease severity level at each age of the plants were statistically at par with zero tillage and maximum infection was noticed in conventional tillage practices. Similar findings of the prevalence of soil borne diseases being less in zero tillage compared to conventional tillage was also reported by Workneh and Yang (2000) in soybean.

In case of Asha cultivar, among the three tillage systems, the disease incidence (%) was maximum in conventional tillage systems. (2.84%, 3.64%, 3.76 %, 4.19 %, 5.35%, 6.33% and 7.24% in 69 DAS,76 DAS, 83 DAS, 90 DAS, 97 DAS, 104 DAS, 111 DAS respectively) and minimum in zero tillage system (1.79% in 69 DAS, 2.01 % in 76 DAS, 2.33% in 83 DAS, 2.41% in 90 DAS, 4.29% in 97 DAS, 4.98% in 104 DAS, and 5.34% in 111 DAS) followed by reduced tillage irrespective of different treatments.

When different treatments were considered, it was observed that in every date of observation, disease incidence (%) was maximum in T1 followed by T5-, Whereas minimum was noticed in T4 followed by T3

Table 1: Disease incidence (%) on IPL 316 cultivar of lentil on different days after sowing (DAS) on conservation agriculture

	69DAS				76DAS				83DAS				90DAS				97DAS				104DAS				111DAS			
Treatment	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean
T1	4.25	3.18	2.76	3.39^{a}	4.67	4.05	2.95	3.89^{a}	5.3	4.06	2.94	4.10^{a}	5.46	4.3	3.3	4.35^{a}	6.34	4.76	4.02	5.04^{a}	7.37	4.9	4.77	5.68^{a}	8.76	5.5	4.99	6.42^{a}
T2	3.39	1.2	2.23	2.27^{b}	4.49	1.2	3.82	3.17^{b}	4.73	1.99	3.74	3.49^{b}	5.12	2.58	0.97	2.89^{b}	6.14	4.38	4.69	5.07^{a}	6.7	4.52	4.87	5.36^{b}	7.87	5.86	5.12	6.28^{a}
T3	2.96	1.85	2.63	2.48^{b}	3.6	2.66	3.75	3.34^{b}	4.12	1.03	3.08	2.74^{c}	4.52	3.63	3.75	3.97^{c}	5.67	5.08	4.23	4.99^{b}	6.64	5.09	4.47	5.40^{b}	7	6.07	4.84	5.97^{c}
T4	3.04	3.71	2.63	3.13^{a}	3.04	393	2.73	3.23^{b}	3.04	2.94	2.94	2.97^{c}	3.82	4.1	2.73	3.55^{c}	5.52	4.47	4.04	4.68^{b}	6.53	5.3	4.51	5.45^{b}	7.98	5.88	4.64	6.17^{b}
T5	4.72	2.83	3.06	3.54^{a}	5.69	2.99	3.68	4.12^{a}	5.83	4.03	3.68	4.51^{c}	5.83	4.39	3.86	4.69^{a}	6.8	5.27	4.23	5.43^{a}	7.49	5.38	4.82	5.89^{a}	8.26	6.15	5.37	6.59^{a}
	3.67^{a}	**2.55^{b}**	**2.66^{b}**		**4.29^{a}**	**2.97^{b}**	**3.39^{b}**		**4.61^{a}**	**2.82^{b}**	**3.28^{b}**		**4.96^{a}**	**3.80^{b}**	**3.53^{b}**		**5.95^{a}**	**4.80^{b}**	**4.25^{b}**		**6.95^{a}**	**5.04^{b}**	**4.69^{b}**		**7.98^{a}**	**5.89^{b}**	**5.00^{c}**	
										SE=1.83				SE=1.50				SE=0.95				SE=0.49				SE=0.51		

Note: T1= Residue 0% + NPK 100%, T2= Residue 100% + NPK 50%, T3= Residue 100% + NPK 75%, T4= Residue 50% + NPK 100%, T5= Residue 50% + NPK 75%, SE= Standard Error, DAS= Days After Sowing.

Table 2: Disease severity (%) on IPL 316 cultivar of lentil on different days after sowing(DAS) on conservation agriculture

	69DAS				76DAS				83DAS				90DAS				97DAS				104DAS				111DAS			
Treatment	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean
T1	2.32	1.52	1.16	2.34^{a}	3.36	2.25	1.57	2.39^{a}	4.18	3.18	1.64	3.00^{a}	4.29	3.16	2.16	3.20^{a}	5.41	3.63	3.26	4.10^{a}	4.86	4.02	4.18	4.35^{a}	5.88	4.29	4.26	4.84^{a}
T2	1.89	0.5	0.97	1.12^{c}	3.04	0.76	1.88	1.89^{b}	2.94	1.16	2.3	2.13^{b}	3.9	1.47	2.85	2.74^{b}	4.64	2.76	3.22	3.54^{b}	4.59	2.98	3.72	3.76^{b}	5.51	3.59	4.19	4.43^{b}
T3	1.38	0.68	1.07	1.04^{c}	2.89	1.24	1.74	1.96^{b}	2.31	1.68	1.85	1.95^{c}	2.78	1.93	2.6	2.44^{c}	3.64	2.56	2.58	2.93^{c}	4.12	3.22	2.80	3.38^{b}	5.43	3.71	3.4	4.18^{c}
T4	1.34	1.81	0.99	1.38^{b}	1.56	261	1.3	1.82^{c}	1.87	283	1.78	2.16^{b}	2.38	2.96	2.17	2.50^{b}	4.96	2.29	2.41	3.22^{b}	4.08	3.11	3.09	3.43^{b}	5.27	3.81	3.04	4.04^{c}
T5	2.18	1.12	1.11	1.47^{b}	3.68	1.71	1.82	2.40^{c}	3.68	2.35	2.93	2.99^{a}	4.49	2.88	2.99	3.45^{a}	5	3.3	3.1	3.8^{a}	5.56	3.31	3.37	4.08^{c}	6.73	3.4	4.15	4.76^{a}
	1.82^{a}	**1.13^{b}**	**1.06^{b}**		**2.91^{a}**	**1.72^{b}**	**1.67^{b}**		**2.99^{a}**	**2.24^{b}**	**2.10^{b}**		**3.57^{a}**	**2.49^{b}**	**2.55^{b}**		**4.73^{a}**	**2.91^{b}**	**2.92^{b}**		**4.65^{a}**	**3.33^{b}**	**3.50^{b}**		**5.76^{a}**	**3.75^{b}**	**3.81^{b}**	**3.81^{b}**
						SE=0.31								SE=0.69				SE=0.37				SE=0.22				SE=0.54		

Note: T1= Residue 0% + NPK 100%, T2= Residue 100% + NPK 50%, T3= Residue 100% + NPK 75%, T4= Residue 50% + NPK 100%, T5= Residue 50% + NPK 75%, SE= Standard Error, DAS= Days After Sowing.

Table 3: Disease incidence (%) on Asha cultivar of lentil on different days after sowing(DAS) on conservation agriculture

	69DAS				76DAS				83DAS				90DAS				97DAS				104DAS				111DAS			
Treatment	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean
T1	3.91	1.84	2.7	2.82^{a}	4.38	2.16	3.12	3.22^{a}	4.61	2.16	3.35	3.37^{a}	4.82	2.15	3.35	3.44^{a}	5.77	3.75	4.76	4.76^{a}	6.71	4.19	5.62	5.57^{a}	7.91	5.13	5.75	6.26^{a}
T2	2.34	2.39	1.04	1.92^{c}	3.47	2.97	1.24	2.56^{b}	3.88	3.22	2.34	3.15^{b}	4.42	3.41	2.34	3.39^{a}	5.33	3.89	4.17	4.46^{b}	6.4	4.44	4.59	5.14^{b}	7.42	4.74	4.96	5.71^{b}
T3	1.87	2.91	2.38	2.39^{b}	3.54	3.36	2.37	3.09^{a}	3.54	3.55	2.35^{b}	3.15^{b}	3.54	3.36	2.61^{b}	3.17^{b}	4.82	5.33	3.9	4.68^{a}	5.83	5.83	4.98	5.55^{a}	6.89	56.56	5.61	6.02^{a}
T4	2.55	2.55	1.15	12.07^{b}	2.56	2.54	1.15	2.08^{c}	2.48	3.4	1.15	2.34^{c}	3.54	3.4	1.15	2.69^{c}	5.07	4.28	3.9	4.41^{b}	5.64	4.48	4.79	4.97^{c}	6.28	4.97	5.03	5.43^{c}
T5	3.55	2.54	1.66	2.58^{a}	4.25	3.44	2.18	3.29^{a}	4.28	3.44	2.43	3.38^{a}	4.63	3.44	2.6	3.56^{a}	5.75	4.07	4.73	4.85^{a}	7.07	4.81	4.91	5.59^{a}	7.71	5.65	5.33	6.23^{a}
	2.84^{a}	**2.45^{a}**	**1.79^{b}**		**3.64^{a}**	**2.89^{ab}**	**2.01^{b}**		**3.76^{a}**	**3.12^{ab}**	**2.33^{b}**	**2.33^{b}**	**4.19^{a}**	**3.15^{b}**	**2.41^{b}**		**5.35^{a}**	**4.26^{b}**	**4.29^{b}**		**6.33^{a}**	**4.75^{b}**	**4.98^{b}**		**7.24^{a}**	**5.21^{c}**	**5.34^{b}**	
	SE=1014				SE=0.67				SE=0.63																			

Note: T1= Residue 0% + NPK 100%, T2= Residue 100% + NPK 50%, T3= Residue 100% + NPK 75%, T4= Residue 50% + NPK 100%, T5= Residue 50% + NPK 75%,
SE= Standard Error, DAS= Days After Sowing.

Table 4: Disease severity (%) on Asha cultivar of lentil on different days after sowing (DAS) on conservation agriculture

	69DAS				76DAS				83DAS				90DAS				97DAS				104DAS				111DAS			
Treatment	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean	Conventional	Reduced	Zero	Mean
T1	1.83	0.68	1.25	1.25^{a}	2.67	1.04	1.77	1.83^{a}	3.31	1.07	2.3	2.23^{a}	3.62	1.45	2.22	2.43^{a}	4.63	2.0	2.68	3.10^{a}	5.0	2.65	3.61	3.75^{a}	5.53	3.0	3.76	4.09^{a}
T2	1.2	1.24	0.45	0.96^{b}	2.41	2.45	0.78	1.88^{a}	2.49	2.27	1.28	2.01^{b}	3.03	2.19	1.48	2.23^{a}	3.95	2.27	3.32	3.18^{a}	4.25	2.54	3.61	3.47^{b}	5.6	2.89	4.11	4.20^{a}
T3	1.11	1.52	0.89	1.17^{a}	1.98	2.26	1.37	1.87^{a}	2.28	2.44	1.37	2.03^{b}	2.76	2.33	1.43	2.17^{b}	3.8	3.32	1.89	3.00^{b}	3.2	3.05	2.67	2.97^{c}	4.94	3.86	4.15	4.32^{a}
T4	1.63	1.41	0.58	1.21^{a}	2.02	1.41	0.73	1.39^{b}	2.22	1.8	0.79	1.60^{c}	2.41	1.89	0.87	1.72^{c}	2.39	2.37	1.62	2.13^{c}	3.12	2.4	2.57	2.69^{c}	4.62	3.44	3.25	3.77^{b}
T5	2.03	1.02	0.8	1.28^{a}	2.82	1.84	1.15	1.94^{a}	3.07	2.23	1.09	2.13^{a}	3.16	2.29	1.37	2.27^{a}	4.47	2.58	2.29	3.11^{a}	4.85	2.94	2.97	3.59^{a}	5.69	3.85	3.45	4.33^{a}
	1.57^{a}	**1.18^{ab}**	**0.80^{b}**		**2.39^{a}**	**1.72^{ab}**	**1.17^{b}**		**2.68^{a}**	**1.96^{ab}**	**1.37^{b}**		**3.00^{a}**	**2.04^{b}**	**1.47^{b}**		**3.85^{a}**	**2.51^{b}**	**2.38^{b}**		**4.09^{a}**	**2.72^{b}**	**3.09^{b}**		**5.28^{a}**	**3.41^{b}**	**3.75^{b}**	
	SE=0.55				SE=1.04				SE=1.21				SE=1.13				SE=0.82				SE=0.79				SE=1.32			

Note: T1= Residue 0% + NPK 100%, T2= Residue 100% + NPK 50%, T3= Residue 100% + NPK 75%, T4= Residue 50% + NPK 100%, T5= Residue 50% + NPK 75%,
SE= Standard Error, DAS= Days After Sowing.

Table 5: Pearson's correlation coefficient between DI and DS of wilt, collar rot pathogen complex of two lentil cultivars and weekly average weather parameters (*Rabi* season, 2020-2021).

Weather factors	Asha		IPL316	
	DI (%)	DS (%)	DI (%)	DS (%)
Tmax	.972**	.956**	.962**	.922**
Tmin	.931**	.907**	.931**	.885**
RH-I	-0.120	-0.187	-0.175	-0.286
RH-II	-0.715	-.764*	-0.746	-.818*
Bright Sunshine Hour	0.508	0.608	0.553	0.670
Soil Temperature (at 5cm depth)	.944**	.917**	.943**	.893**

**. Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level (2-tailed). Note: Tmax= Maximum temperature(^{0}C), Tmin= Minimum temperature(^{0}C), RH-I= Maximum relative humidity(%), RH-II= Minimum relative humidity(%).

Table 6: Predictive equations for DI (%) and DS (%) of wilt, collar rot disease complex of two lentil cultivars (*Rabi* season 2020-2021)

Cultivars with DI (%) & DS (%)	Prediction equations
Asha DI (%)	-51.59+2.59Tmax.Std. error: 0.27, R^2 Value: 0.945
Asha DS (%)	-26.55+1.13Tmax+0.686BSH.Std. error: 0.12, R^2 Value: 0.989
IPL 316 DS (%)	-27.47+1.18Tmax+1.00BSH.Std. error: 0.21, R^2 Value: 0.976
IPL316 DI (%)	-44.98+2.48Tmax.Std. error: 0.31, R^2 Value: 0.925

except in first observation date (69 DAS) where minimum was noticed in T2 (1.92%) (Table 3), which may be supported by the fact that higher left-over residues get decomposed to produce several phytotoxins, which in turn may suppress the occurrence of disease (Boosalis *et al*., 1981).

Similarly in Disease severity (%) of Asha cultivar, with increase in the age of the plant, disease severity also increased and among the three tillage practices Conventional tillage showed maximum severity in all the observations (1.57 % In 69 DAS, 2.39% in 76 DAS, 2.68% in 83 DAS, 3.00% in 90 DAS, 3.85% in 97 DAS, 4.09% in 104 DAS, and 5.28% in 111 DAS). The similar findings of greater charcoal rot disease incidence of soybean under conventional tillage than zero tillage was also obtained by Almeida *et al*. (2003). In the last two date of observation, lowest disease severity was found in reduced tillage (2.72% in 104 DAS, & 3.41% in 111 DAS), though the disease severity data of reduced & zero tillage showed no significant difference in between them.

In different treatments it was observed that T4 treatment showed minimum disease severity (1.21% in 69 DAS, 1.39% in 76 DAS, 1.60% in 83 DAS, 1.72% in 90 DAS, 2.13% in 97 DAS, 2.69% in 104 DAS and 3.77% in 111 DAS) and maximum was noticed in T1 and T5 (1.25% & 1.28% in 69 DAS, 1.83% & 1.94% in 76 DAS, 2.23% & 2.13% in 83 DAS, 2.43% & 2.27% in 90 DAS, 3.10% & 3.11% in 97 DAS, 3.75% & 3.59% in 104 DAS & 4.09% & 4.33% in 111 DAS) treatments (Table 4).

The Pearson's correlation coefficients (r) were calculated using disease severity (%) and disease incidence (%) of each of the two cultivars and five weather parameters *i.e*., average seven days temperature (min and max), RH-I, RH-II, soil temperature and bright sunshine hours (Table 5). The results show that the RH-I did not have significant correlation with both DI (%) & DS (%). On the other hand, it was observed that both the disease incidence (%) and severity (%) with its relative progress on both the two cultivars depended upon max and min temperature and soil temperature, positively and significantly. The high correlation coefficient value (r) supports the fact strongly. But RH-II had a significant negative *correlation* (-.764*, -.818) with DS (%) of both the cultivars (Table 5) respectively.

The multiple regression analysis was performed for both the cultivars considering DI (%) and DS (%) as dependent variable and the weekly weather parameters as independent variables. The predictive equations were obtained for both DI (%) & DS (%) in terms of both the cultivars (Table 6).

It was found that, for both Asha and IPL 316, maximum temperature was positively and significantly correlated the DI (%) with R^2 value of 0.945 & 0.925 respectively, suggesting that around 94.5% & 92.5% change in DI (%) was caused by maximum temperature. While both maximum temperature and bright sunshine hours were correlated with DS (%) of both the cultivars with R^2 value of 0.989 & 0.976 respectively, indicating that around 98.9% & 97.6% change in DS (%) were caused by both maximum temperature & bright sunshine hours and they were highly significant statistically.

Thus the results were obtained from both the cultivars showed that irrespective of treatments, minimum disease incidence and severity were observed in zero tillage followed by reduced tillage while the maximum disease occurrence was in conventional tillage practices. Apart from this when the treatments were considered, minimum disease incidence and severity were observed on the treatment where (100% residue + 75% NPK) (T_3) was in use, followed by (50% residue + 100% NPK) treatment (T_4). Whereas, maximum incidence and severity was observed on (0% residue + 100% NPK) (T_1) followed by (50% residue + 75% NPK) (T_5) treatment. It indicated that, minimum soil disturbance allows maximum residue decomposition, which increased the organic base in soil, thus contributing to root growth and development while providing a food shelter to the beneficial microorganisms in soil which may reduce the disease caused by soil borne pathogens. Similar findings of higher microbial biomass activity in the uppermost soil helping in higher plants root growth was observed by Carter and Rennie (1984). The increased microbial activity in CA practices can lessen soil borne diseases was also reported by Bailey and Lazarovits, (2003). So to conclude it can be said that the significant findings of this study shows the way by which different treatments (%Residue+%NPK) & tillage practices influence the dynamics disease development from sowing to harvesting stage of the crop, thus justifying the unique nature of the research.

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