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Evaluation of different dates of sowing on PDI of *Sclerotinia* stem rot of lentil

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Abstract
Pulse crops play an important role in Indian agriculture and economy and they are the major source of protein and complementary to cereals both in production and consumption. The fungus *Sclerotinia sclerotiorum* is one of the most destructive pathogens of lentils. Yield losses can be attributed to fungal growth within stems and resulting lodging, which leads to smaller and fewer seeds, premature ripening, shattered pods, loss of smaller, shrunken seeds during harvesting. The stem rot fungus overwinters as sclerotia in the soil, in stubble at the soil surface and mixed with seed. Sclerotia can remain viable in the field for five years or more. Each year some sclerotia will germinate when conditions are suitable but others will remain dormant. Germination is either myceliogenically which directly infect plants or may be carpogenic (spore-producing apothecia) heavy infections result from airborne spores produced by apothecia at the soil surface. The present investigation experiments were conducted to find out the effect of different dates of sowing on Sclerotinia stem rot incidence in lentil, starting form 05 October to 15 November at 10 days interval, irrespective of the year.

Keywords: Sclerotinia, PDI, correlation, yield loss, date of sowing

Introduction
Cereals, pulses and oilseeds are the three main contributors of our food; pulses are the major source of protein. Pulses improve soil fertility, requires less water and their rotation with cereals help in controlling diseases and pests. On the other hand, pulses are relatively cheaper source of protein (Joshi & Saxena, 2002) [7]. The Latin name of lentil is *Lens culinaris*, the genus name *Lens* meaning 'lens' in English, suggestive of the lens-like shape of the lentil seed. Lentil (*Lens culinaris* L.) is an important legume crop. It belongs to the family "Leguminoceae" sub family "Papilionaceae". The per capita net availability of pulses, unfortunately, has been declining continuously and has reached a low level of 26.4 gms/day in 2001 from a much higher level of 61.6 gm/day in 1965, due to increase in population and stagnation in production of pulses. India is the largest producer, consumer and importer of pulses in the world. India accounts for about 33 percent of world area and about 22 percent of world production. About 90 percent of the total global area under pigeon-pea, 65 percent under chickpea and 37 percent under lentil is contributed by India (Reddy, 2004) [10]. The state of Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra and Andhra Pradesh are major contributor in pulse growing states. It is one of the most important multipurpose pulse crops, native of Southwest Asia (Turkey-Cyprus). This crop is a global importance and grown particularly in India, Pakistan, Bangladesh, Nepal, Iran. The worldwide lentil production during year 2016-17 was 6.71 million tones with 5.45 million hectares of area and productivity was 1105 kg/ha while in India, total area under lentil crop is about 1.276 million hectares, with production 0.976 million tones which contributes 6.18% share of total pulse production and productivity 764.9 kg/ha (Sources: FAOSTATS, 2016-17). In Uttar Pradesh, total area under lentil crop is about 0.44 mha. With production 0.24 mt. and productivity 537 kg/ha (Sources: Agriculture statistics & crop insurance, 2014–2015).
Lentil is an annual and bushy herb, adapted to cool temperate steppe through sub-tropical dry to moist ambience, usually sown in areas where temperature ranges 20-30 ºC. Lentils are sensitive to water logging and are able to withstand 4-12 week drought.

The lentil production is greatly affected by many biotic and abiotic factors, among which diseases are the main constraints. Various fungal as well as bacterial pathogens threatens lentil crop. Among the fungal diseases e.g. Sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) de Bary) collar rot (*Sclerotium rolfsii* Sacc.), anthracnose (*Colletotrichum lindemuthianum*), ascochyta blight (*Ascochyta fabae* f.sp. *lentis*), botrytis gray mold (*Botrytris cinerea*), fusarium wilt (*Fusarium oxysporum* f.sp. *lentis*), and rust (*Uromyces fabae*).and Alternaria blight of lentil caused by *Alternaria alternata* (Fr.) keissl are important.

Infections of lower main stem or branch tissue initiated soon after early bloom will result in more severe symptoms. Yield losses reflect reduced seed filling per infected plant, the amount of preharvest shattering, and the percentage of infected plants in a crop. In general, when conditions for the disease are favorable and infections are initiated during early flowering, yield reduction per infected plant can equal 50% or more. This pathogen of sclerotinia stem rot in lentil, leads to serious losses in yield due to lodging and premature shattering of seedpods (Gugel and Morrall, 1986) [5]. Yield losses can be attributed to fungal growth within stems and resulting lodging, which leads to smaller and fewer seeds, premature ripening, shattered pods, loss of smaller, shrunken seeds during harvesting. *Sclerotinia sclerotiorum* (Lib.) de Bary is a cosmopolitan necrotrophic fungal pathogen with a wide host range, including over 400 different plant species (Boland and Hall, 1994; Purdy, 1979) [1, 9]. Most of the plants susceptible to the necrotrophic pathogen belong to Solanaceae, Cruciferae, Umbelliferae, Compositae, Chenopodiaceae and Leguminosae (Willets and Wong, 1980) [13]. Increase in host range of *S. sclerotiorum* narrows down the opportunity for disease management using either crop rotation or resistant varieties. The stem rot fungus overwinters as sclerotia in the soil, in stubble at the soil surface and mixed with seed. Sclerotia can remain viable in the field for five years or more. The level of sclerotia in the soil will largely reflect the disease severity. Each year some sclerotia will germinate when conditions are suitable, germination is either myceliogenic which directly infect plants or may be carpogenic (spore-producing apothecia) infections result from airborne spores produced by apothecia at the soil surface.

The fungus *Sclerotinia sclerotiorum* occurs in all the lentil growing areas, causing stem rot, one of the most destructive diseases of lentils. When right combination of inoculum load, crop density and weather conditions or irrigation coincide, heavy infections can develop almost anywhere. Early sowing will increase the height and size of the plant at first bloom, while late sowing can result in lower quality and diminished seed yield. Even after plants are infected, the severity of stem rot symptoms and the resulting effect on yield will vary according to where the infections occur, crop density, lodging potential and especially the stage of crop growth at the time of infection.

Methods and Materials

A field experiment was carried out to study the incidence of Sclerotinia stem rot in different dates sown lentil crops during *Rabi* season 2015-16 and 2016-17 at Crop Research Centre, SVPUA&T Meerut. HUL-57 variety was used in this study. Lentil seeds were sown in 4 x 3 meter plots in different dates of sowing from October to November with 10 days interval both years. Each treatment was replicated thrice and the disease incidence was recorded before harvesting by counting the healthy and diseased plant through random selection and the per cent disease incidence was calculated for each sowing date. Disease incidence was recorded from forty randomly selected plants in each plot at different growth stages of the plant *viz*., 60 and 90 DAS as per the formula devised by Mathur *et al*. 1972 [8] as given below.

$$\mathrm{PDI} = \frac{\text{Infected Plants}}{\text{Total No. of plants observed}} \times 100$$

To assess the effects of different weather factors associated with development of the disease, data on weather parameter, *viz.*, maximum and minimum temperatures, sun shine hours and relative humidity were recorded during the crop growth period for each sowing dates at each stage. The observations were recorded for-

- Disease incidence
- Yield (q/ha)
- Yield loss percent

Results

The experiments were conducted to find out the effect of different dates of sowing on Sclerotinia stem rot incidence in lentil, starting form 05 October to 15 November at 10 days interval, irrespective of the year.

Effect of dates of sowing on the disease incidence and yield of lentil: Data in Table – 1, indicate that per cent disease incidence significantly increased with advancement of crop growth stages and sowing dates during both the years. Among the different date sown crops In 60 DAS, disease incidence was lowest (7.50%) in 15th October sown crop during 2015-16 followed by 15.0% and 18.32% in 5th and 25th October sown crop. While maximum disease incidence percent 29.17% was recorded in crop sown on 15th November followed by 22.50% in 5th November sown crop. In case of 90 DAS crop maximum disease incidence (48.32%) was recorded in 15th November sown crop followed by 39.17% and 31.67% in 5th November and 25th October sown crop while least disease incidence was recorded in 15th October sown crop (15.00%) followed by crop sown on 5th October (25.82%). Maximum grain yield 10.17 qntl/ha was recorded in 15th October followed by 8.97 qntl/ha and 7.77 qntl/ha in 5th Oct and 25th October sown crop. While minimum yield 6.53 qntl/ha was recorded in 15th November sown crop followed by 5th November sown crop (7.12 qntl/ha).

Second experiment was conducted during crop season 2016-17. Maximum disease incidence (30.0% and 52.50%) was reported in 15th November sown crop both at 60 DAS and 90 DAS observation. While 25.82%, 20.82% and 15.82% disease incidence were recorded in 5th November, 25th Oct and 5th October sown crop whereas minimum disease incidence (8.32%) was recorded in 15th October sown crop after 30 days of sowing. In case of 90 DAS, 42.50%, 32.50% and 26.75% disease incidence were recorded in 5th November, 25th Oct and 5th October crop while least disease incidence (14.17%) was recorded in 15th October sown crop. Highest grain yield 10.09qntl/ha was recorded in 15th October sown crop followed by 8.74, 7.25 and 7.15qntl/ha in 5th Oct, 25th October and 5th November sown crop whereas least grain yield 6.41q/ha was recorded in 15th November sown crop.

During year 2015-16 maximum yield loss (35.8%) was recorded in crop sown on 15 November followed by 30.00%, 23.60% and 11.80% in crops sown on date 5 Nov, 25 oct and 5 oct respectively. Similarly in 2016-17 maximum yield loss (36.48%) was recorded in crop sown on 15 November followed by percent yield loss 29.14%, 28.15% and 13.38% in the crops sown on date 5 Nov, 25 oct and 5 October respectively. The loss in yield was increased with the advancement in date of sowing.

Table 1: Effect of dates of sowing on the disease incidence and yield of lentil

Date of sowing	2015-16				2016-17			
	% Disease incidence		Yield q/ha	% Yield loss	% Disease incidence		Yield q/ha	% Yield loss
	60 DAS	90 DAS			60 DAS	90 DAS		
5-Oct	15.00	25.82	8.97	11.80	15.82	26.75	8.74	13.38
15-Oct	7.50	15.00	10.17	0.00	8.32	14.17	10.09	0.00
25-Oct	18.32	31.67	7.77	23.60	20.82	32.50	7.25	28.15
5-Nov	22.50	39.17	7.12	30.00	25.82	42.50	7.15	29.14
15-Nov	29.17	48.32	6.53	35.8	30.00	52.50	6.41	36.48
C.D. (0.05)	1.619	2.123	2.92		1.439	1.710	2.86	
S.E. (m)	0.489	0.641	8.844		0.435	0.516	8.653	

Correlation of PDI with yield of lentil on different date sown crop

The PDI at 60 DAS and 90 DAS was correlated with grain yield. The data are presented in Table-4.6 and Fig. -4.6, The data from the Table reveal that, during 2015-16, there was negative correlation between PDI and yield at 60 DAS (-0.978) and 90 DAS (-0.983). However, during 2016-17 there was also a negative correlation observed at all the stages of crop growth between PDI and yield (-0.977 at 60 DAS and -0.951 at 90 DAS respectively).

Table 2: Correlation of PDI with yield of lentil on different date sown crop

Date of sowing	2015-16				2016-17			
	60 DAS		90 DAS		60 DAS		90 DAS	
	PDI	Yield	PDI	Yield	PDI	Yield	PDI	Yield
05-Oct	15.00	8.97	25.82	8.97	15.82	8.74	26.75	8.74
15-Oct	7.50	10.17	15.00	10.17	8.32	10.09	14.17	10.09
25-Oct	18.32	7.77	31.67	7.77	20.82	7.25	32.50	7.25
05-Nov	22.50	7.12	39.17	7.12	25.82	7.15	42.50	7.15
15-Nov	29.17	6.53	48.32	6.53	30.00	6.41	52.50	6.41
Correlation	-0.978		-0.983		-0.977		-0.951	

Correlation of PDI with different weather parameters in 2015-16

The PDI at 90 DAS and 60 DAS was correlated with the weather parameters prevailed during crop season 2015-16 and presented in Table 4.7 and figure-4.7. The data revealed that, there was significant negative correlation between average temperature and PDI at 60 DAS (-0.618) and 90 DAS (-0.199), it means whenever, temperature decreases than PDI increases relatively. While there was a significant positive correlation between percent disease incidence and percent relative humidity. Where correlation was recorded 60 DAS (0.999) and 90 DAS (0.406). It showed that whenever RH increases, PDI also increases relatively.

Table 3: Correlation of PDI with different weather parameters in 2015-16

Date of sowing	60 DAS			90 DAS		
	Avg. temp.	% RH	% Disease incidence	Avg. temp.	% RH	% Disease incidence
05 Oct 2015	18.10	67.50	15.00	10.10	73.40	25.82
15 Oct 2015	13.00	62.50	7.50	9.20	78.50	15.00
25 Oct 2015	12.00	70.60	18.32	8.20	68.40	31.67
05 Nov 2015	10.10	73.40	22.50	8.00	79.10	39.17
15 Nov 2015	9.20	78.50	29.17	9.50	83.40	48.32
Correlation	-0.618	0.999		-0.199	0.406	

Correlation of PDI with different weather parameters in 2016-17: The PDI at 60 DAS and 90 DAS was correlated with the weather parameters prevailed during crop season 2016-17 and presented in Table 4.8 and Fig. -4.8. The data revealed that there was significant negative correlation between average temperature and PDI at 60 DAS (-0.513) and 90 DAS (-0.244), it means whenever, temperature decreases than PDI increases relatively. Whereas there was a significant positive correlation between percent disease incidence and relative humidity. Where, correlation was recorded 60 DAS (0.935) and 90 DAS (0.906). It showed that whenever RH increases, PDI also increases relatively.

Table 4: Correlation of PDI with different weather parameters in 2016-17

Date of sowing	60 DAS			90 DAS		
	Avg. temp.	% RH	% Disease incidence	Avg. temp.	% RH	% Disease incidence
05 Oct 2016	11.00	54.40	15.82	11.60	54.30	26.75
15 Oct 2016	10.00	48.50	8.12	9.60	53.50	14.17
25 Oct 2016	10.10	53.20	20.82	10.60	55.20	32.50
05 Nov 2016	10.60	64.30	25.82	10.10	67.30	42.70
15 Nov 2016	8.10	68.50	30	9.50	79.10	52.00
Correlation	-0.513	0.935		-0.244	0.906	

Discussion

The effect of different dates of sowing on Sclerotinia stem rot incidence was evaluated; per cent disease incidence significantly increased with advancement of crop growth stages and sowing dates during both the years except the date of sowing 15th October where percent disease incidence was minimum at both 60 DAS and 90 DAS. Among the different date sown crops in 60 DAS, disease incidence was lowest (7.50%) in 15th October sown crop during 2015-16 followed by 15.0% in 5th October sown crop. While maximum disease incidence percent 29.17% was recorded in crop sown on 15th November. In case of observation at 90 DAS maximum disease incidence (48.32%) was recorded in 15th November sown crop, while least disease incidence was recorded in 15th October sown crop(15.0%) followed by 5th October sown crop (25.82%). Maximum grain yield 10.17 qntl/ha was recorded in 15th October sown crop followed by 8.97 qntl/ha in 5th October sown crop. While minimum yield 6.53 qntl/ha was recorded in 15th November sown crop. In the experiment, conducted in crop growing season 2016-17, maximum disease incidence (30.0%) was recorded in 15th November sown crop at 60 DAS observation, whereas minimum disease incidence 8.32% was recorded 60 DAS in 15th October sown crop followed by 15.82% disease incidence in 5th October sown crop. Whereas in case of 90 DAS observations maximum disease incidence was recorded in 15th Nov sown crop and lowest disease incidence 14.17% was recorded in 15th Oct sown crop followed by 26.75% disease incidence in 5th October sown crop. Highest grain yield 10.09qntl/ha was recorded in 15th October sown crop whereas least grain yield 6.41 was recorded in 15th November sown crop. The PDI at 60 DAS and 90 DAS was correlated with grain yield. During 2015-16, there was negative correlation between yield and PDI at 60 DAS (-0.978) and 90 DAS (-0.983). However, during 2016-17 there was also a negative correlation between yield and PDI (-0.977 at 60 DAS and -0.951 at 90 DAS respectively). Studies conducted by Singh and Singh (1984) [8, 11, 12] on *Cicer arietinum* in *Sclerotinia sclerotiorum* sick field sown crop at weekly interval on 15th October to 10th December, it was noted that yield was higher in early November sown crop. Clark *et al.,* (1993) [2] evaluated the same effect of different date of sowing on incidence of stem rot in two sunflower cultivars sown on five different dates at approximately 14 day intervals between mid-October and early January. Crops sown during October and early November had a lower incidence of stem rot at an early growth stage, and greater yields than plants sown after late November. Similarly Gupta *et al.* (2004) [6, 8] studied the effects of dates (21st October, 5th Nov, 5 Dec., 20 Dec., and 5 Jan.) of sowing on disease incidence and crop yield of rapeseed mustard. Early sowing (5th November) resulted greatest disease incidence (10.5% on average), disease incidence decreased with the delay in sowing. Sowing on 21st October gave the highest yield (1585.7 Kg/ha*)* further delay in sowing significantly reduced the yield. Singh and Tripathi (1995) [8, 11, 12] observed a significant reduction in disease severity caused by *Sclerotinia sclerotiorum* in late sown crop of sunflower. It suggested that a sudden increase in temperature might be responsible for the increase in disease.

Correlation of PDI with different weather parameters in 2015-16

The PDI at 90 DAS and 60 DAS was correlated with the weather parameters prevailed during crop season 2015-16. There was significant negative correlation between avg temperature and PDI at 60 DAS (-0.618) and 90 DAS (-0.199). While there was a significant positive correlation between relative humidity and percent disease incidence at 60 DAS (+0.999) and 90 DAS (+0.406).

Correlation of PDI with different weather parameters in 2016-17

The PDI at 90 DAS and 60 DAS was correlated with the avg. temperature and relative humidity data revealed that, there was significant negative correlation between avg temperature and PDI at 60 DAS (-0.513) and 90 DAS (-0.244). While there was a significant positive correlation between relative humidity and percent disease incidence after 60 DAS (+0.935) and 90 DAS (+0.906).

Conclusion

The effect of different dates of sowing on Sclerotinia stem rot incidence was evaluated; percent disease incidence significantly increased with advancement of crop growth stages and sowing dates during both the years except the date of sowing 15th October where percent disease incidence was minimum at both 60 DAS and 90 DAS. Among the different date sown crops in 60 DAS, disease incidence was lowest (7.50%) in 15th October sown crop during 2015-16 followed by 15.0% in 5th October sown crop. While maximum disease incidence percent 29.17% was recorded in crop sown on 15th November. In case of 90 DAS crop maximum disease incidence (48.32%) was recorded in 15th November sown crop, while least disease incidence was recorded in 15th October sown crop (15.0%) followed by 15th October sown crop (25.82%). Maximum grain yield 10.17 q/ha was recorded in 15th October sown crop followed by 8.97 q/ha in 5th October sown crop. While minimum yield 6.53 q/ha was recorded in 15th November sown crop. Second experiment was conducted in crop season 2016-17. Maximum disease incidence 30.0% was reported in 15th November sown crop at 60 DAS observation, followed by 25.82% in 5th Nov sown crop. Whereas minimum disease incidence 8.32% was recorded in 15th October sown in 60 DAS. In case of 90 DAS observation maximum percent disease incidence 52.50% was recorded in 15th nov sown crop followed by 42.50% in 5th November sown crop while minimum percent disease incidence 14.17% was recorded from 15th October sown crop. Highest grain yield 10.09 q/ha was recorded in 15th October sown crop whereas least grain yield 6.41 q/ha was recorded in 15th November sown crop. The PDI at 60 DAS and 90 DAS was correlated with grain yield. During 2015-16, there was negative correlation between yield and PDI at 60 DAS (-0.978) and 90 DAS (-0.983). However, during 2016-17 there was also a negative correlation between yield and PDI (-0.977 at 60 DAS and -0.951 at 90 DAS respectively). The PDI at 90 DAS and 60 DAS was correlated with the weather parameters prevailed during crop season 2015-16. There was significant negative correlation between avg. temperature and PDI at 60 DAS (-0.618) and 90 DAS (-0.199). While there was a significant positive correlation between relative humidity and percent disease incidence at 60 DAS (+0.999) and 90 DAS (+0.406). The PDI at 90 DAS and 60 DAS was correlated with the avg. temperature and reactive humidity data revealed that, there was significant negative correlation between avg. temperature and PDI at 60 DAS (-0.513) and 90 DAS (-0.244). While there was a significant positive correlation between relative humidity and percent disease incidence after 60 DAS (+0.935) and 90 DAS (+0.906).

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