The Pharma Innovation Journal 2022; SP-11(8): 31-34

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(8): 31-34

www.thepharmajournal.com
Received: 07-06-2022
Accepted: 12-07-2022

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Effect of different dates of sowing on incidence of Sclerotinia rot disease of Indian mustard in Bihar

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Abstract
Amongst the fungal diseases of oilseed *Brassica* crops, Sclerotinia rot incited by *Sclerotinia sclerotiorum* (Lib.) de Bary, which was earlier considered to be a minor problem in India has now became a serious problem of rapeseed-mustard growing areas of country including Bihar. This disease is becoming major constraints to cultivation of this oilseed *Brassica* crops in present conditions. Infection of pathogen occurs on the leaves, stems and pods at different developmental stages of plant causing losses in seed yield of up to 80% as well as significant reductions in oil content and quality also. Management of Sclerotinia rot with chemical fungicides though remains successful, accumulation of pesticide residues in the edible parts threatens its quality for consumers, as well as the scope for export of the commodities to other countries. Most of the conventional methods are not effective in management of the disease. Hence, to meet the challenge, the integration of various IPM measure may be the best approach. Connecting with this, a field trial on effect of different dates of sowing on disease development had been carried out during Rabi 2016-17 and 2017-18. The crop sown on November 30th, recorded lowest per cent Sclerotinia rot disease incidence. A relatively higher disease incidence (37.42% & 40.12% respectively and 38.78% on pooled basis) was recorded in the crop sown on November 10th, and corresponding lower incidence was observed with delayed or earlier dates of sowing during both the years of experimentations and on pooled basis also. Highest seed yield of 1290 kg/ha & 1260 kg/ha respectively and 1275 kg/ha on pooled basis was recorded when crop was timely sown on 30th October during both the years. Highest seed yield was not recorded with early and late sown crop (October, 20th and November, 30th respectively), despite comparatively less disease incidence. This might be attributed to crop phenology and meteorological parameters (Env^{n}.) during these sowing dates. Multiple Regression Equation between per cent disease incidence and weather variables i.e. R^2=0.6554, 0.6751 & 0.6653 In pooled indicated that the combined effect of these weather variables favoured the disease development causing upto 65 to 67 per cent variation in the Sclerotinia rot incidence.

Keywords: Indian mustard, sclerotinia rot, dates of sowing, weather parameters

Introduction
Rapeseed-mustard is an economically prodigious and utile oilseed crop of the world. Contributing to 32% of the total oilseed production in the country, it is the main source of edible oil in India after groundnut. Out of 59.93 mt of rapeseed produced over 30.74 m ha in the world, India produces 7.67 mt from an acreage of 6.51 m ha with a productivity of 1179 kg/ha (GOI 2011). India is ranked 3rd largest producer of Rapeseed Mustard in the world accounting 11.3% of production (7.0 million tons) after Canada and China. Indian mustard having potential upto3.5 ton per hectare with bold seeded and up to 42% oil content. It holds a premium position in Rapeseed Mustard economy of the world with 2nd and 3rd rank in area and production, respectively. The development of high yielding varieties coupled with improved production technologies has lead to a considerable increase in the productivity of rapeseed- mustard in India during past decade. But despite this increase, the yields of oilseed brassicas in India are much below the global average. A huge sum of money (8000-10000 crores/ annum) is being spent on import to meet the current edible oil demand. The wide gap between the potential and realized yields is largely because of the biotic and abiotic stresses. Among the biotic factors, fungal diseases alone are responsible for severe damages to the crop resulting in yield losses up to 70% on a world wide scale. The severe attack of many fungal diseases not only deteriorates the quality of the seed but reduces the oil content considerably in different oil-yielding Brassica species. Amongst the diseases, stem rot caused by *Sclerotinia sclerotiorum* (Lib.) de Bary is next only to Alternaria blight in importance. Stem rot caused by *Sclerotinia sclerotiorum* was considered to be the disease of minor importance of rapeseed and

mustard but due to newer agriculture technology and extensive cultivation of new susceptible varieties, the disease is appearing in epidemic form. The disease was observed in severe form in Gujarat during 1987-88 and 1988-89 causing losses up to 50 per cent (Dang *et al.*, 1992) [2]. Chauhan *et al.* (1992) [1] reported that stem rot of mustard caused yield loss up to 72 per cent in severe cases in Uttar Pradesh. Yield losses in susceptible crops due to stem rot may be as high as 100 per cent (Purday, 1979). Plants infected at or before flower initiation resulted in 100 per cent yield loss, whereas, infection after flowering stage caused more than 50 per cent yield loss (Shukla, 2005) [7]. The present paper discusses the Sclerotinia rot disease incited by *Sclerotinia sclerotiorum* (Lib.) de Bary with respect to different dates of sowing along with weather parameters so that prediction may be given from which farmers of this region may be benefitted.

Materials and Methods

To determine the effect of different dates of sowing on disease development, field trials were carried out in Randomized Block Design. Seeds of mustard variety, Rohini were sown at 5 different dates *viz.* 20th October, 30th October, 10th November, 20th November and 30th November during *Rabi* 2016-17 and 2017-18. Four replications were made for each date of sowing. The plot size was 3x1.5 m^2. Seeds were sown in each plot at 30 cm x 10 cm spacing. Artificial inoculation was carried out by spraying mycelial suspension of *Sclerotinia sclerotiorum*. Development of disease in terms of incidence was recorded at 100 days after sowing (DAS) on the basis of 100 plants selected randomly from each replication. Cumulative weather parameter like temperature, relative humidity, rainfall and number of rainy days upto 100 days corresponding to the disease observations were recorded from weather observatory, Department of Agril. Meteorology, Tirhut College Agriculture, Dholi. Step wise multiple regression analysis (MRA) was calculated to determine the effect of individual as well as combined weather factors on disease development. Disease prediction analysis equation viz. $Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6$ was derived. Significance of coefficient of multiple determination (R^2) and partial regression coefficient (b) value was followed at 5 per cent level of probability. Total seed yield were recorded after harvest of the crop.

Results and Discussion

As evident from the data presented in Table 1, the crop sown during *Rabi* 2016-17 on November 30, recorded lowest per cent Sclerotinia rot incidence. A relatively higher disease incidence was recorded in the crop sown on November 10, and corresponding lower incidence was observed with delayed.e.20th Nov. (28.14%) and 30th Nov. (8.83%) or earlier dates of sowing i.e. 20th Oct. (13.83%) and 30th Oct. (17.92%). The crop sown on November 10 favoured quick Sclerotinia rot development and recorded highest (37.42%) disease incidence. The max^m $temp^r$ from 23.84 to 25.44 ^{0}C, min^m $temp^r$ from 10.06 to 12.21 ^{0}C, the max^m RH from 89.36% to 90.92% and min^m RH from 55.785 to 61.10% and the average mean temperature 17.03 to 18.82ºC and average mean relative humidity 73.97 to 76.01% apparently favoured disease development. Highest seed yield of 1290 kg/ha was recorded in timely sown crop (30th October). Significantly higher seed yield was not recorded with early i.e. October, 20th sown crop and late sown crop i.e. November, 30th during 2016-17.

Per cent disease incidence was negatively correlated with max^m temperature while positively correlated with min^m $temp^r$, RH (morning) and RH (evening) during *Rabi*, 2016-17 (Table 1a). Table 1b. Indicates that multiple regression equation between per cent disease incidence and weather variables (independent variables) exhibites strong relationship among the different components of epiphytotics. Average max^m temperature, average min^m temperature and average max^m relative humidity and average min^m relative humidity indicates that the combined effect of different weather variables favoured the disease development causing upto 65 per cent variation in the Sclerotinia rot disease incidence.

Similarly the crop sown during *Rabi* 2017-18 on November 30, recorded lowest per cent Sclerotinia rot incidence. A relatively higher disease incidence was recorded in the crop sown on November 10, and corresponding lower incidence was observed with delayed or earlier dates of sowing. The crop sown on November 10 favoured quick Sclerotinia rot development and recorded highest (40.14%) disease incidence. The average mean temperature 15.84 to 17.74ºC and average mean relative humidity 91.66 to 92.58% apparently favoured disease development. Highest seed yield of 1,260 kg/ha was recorded in timely sown crop (30th October). Significantly higher seed yield was not recorded with early and late sown crop on October, 20th and late sown crop on November, 30th, 2017-18 (Table 2).

Per cent disease incidence was positively correlated with max^m $temp^r$, min^m $temp^r$, RH (morning) and RH (evening) during *Rabi*, 2017-18 (Table 2a). Similarly the multiple regression equation between per cent disease incidence and weather variables exhibites strong relationship among the different components of epiphytotics i.e. Average max^m temperature, average min^m temperature and average max^m relative humidity and average min^m relative humidity collectively favoured the disease development causing upto 67 per cent variation in the Sclerotinia rot incidence (Table 2b).

The pooled data from Table 3, also reveals that the crop sown on November 30 in both the years recorded lowest per cent Sclerotinia rot incidence. A relatively higher disease incidence was recorded in the crop sown on November 10, and corresponding lower incidence was observed with delayed or earlier dates of sowing. The crop sown on November 10 favoured quick Sclerotinia rot development and recorded highest (38.78%) disease incidence. Over all, the minimum temperature from 9.86 to 11.93ºC, maximum temperature from 23.02 to 24.64ºC, morning relative humidity from 89.36 to 90.92% and evening relative humidity from 55.78 to 61.10% apparently favoured disease development. Highest seed yield of 1,275 kg/ha was recorded in timely sown crop (30th October). Significantly higher seed yield was not recorded with early and late sown crop (October, 20th and November, 30th respectively), despite of comparatively low disease incidence. Gupta *et al*. (2004) [3] also observed that the sowing on 21 October resulted in the greatest disease incidence (10.5% on average); and disease incidence decreased with the delay in sowing. The maximum (20.5-25.4 ^{0}C) and minimum (3.9-10.7 ^{0}C) temperatures at the flowering stage of crops established through sowing on 21 October were negatively correlated with the development of Sclerotinia blight. The minimum disease incidence was recorded where sowing was done in the last week of October. The growth of the fungus was significantly increased by the increasing RH%.

Per cent disease incidence was positively correlated with max^m temp^r, min^m temp^r, RH (morning) and RH (evening) on the basis of pooled data (Table 3a). Multiple regression equation between per cent disease incidence and weather variables exhibites strong relationship among the different components of epiphytotics i.e. Max^m temperature, Min^m temperature, relative humidity morning and relative humidity evening, indicates that the combined effect of different weather variables favoured the disease development causing upto 66 per cent variation in the Sclerotinia rot incidence. (Table 3b). Mehta (2014) [5] also reported that the white stem rot or Sclerotinia rot disease progression is favoured by high in relative humidity (>80%), maximum temperature up to 25^0 C and minimum temperature of 5-12^0 C. Bhattacharya and Chattopadhyay (2013) also reported that persistent spell of temperature lower than normal in second fortnight of January driven by snowfall in the neighbouring Himalayas triggered Sclerotinia outbreak. Husain and Choudhary (2018) [4] concluded that the temperature 20- 25ºC and pH 4.5 to 5.5 was most suitable for the growth and sclerotial formation by the pathogen in laboratory condition.

Table 1: Effect of dates of sowing on Sclerotinia rot development during *Rabi* 2016-17

Date of sowing	*Disease incidence (%)	*Yield (kg/ha)	**Mean Temperature (ºC)			**Mean Relative humidity (%)		
			Max. (X_1)	Min. (X_2)	Avg.	Max. (X_3)	Min. (X_4)	Avg.
20-10-2016	13.83 (21.8)	1037	25.44	12.21	18.82	89.36	55.78	72.57
30-10-2016	17.92 (24.9)	1290	24.53	11.44	17.98	90.04	57.91	73.97
10-11-2016	37.42 (37.6)	1174	23.84	10.24	17.04	90.70	59.60	75.15
20-11-2016	28.14 (31.8)	1085	23.91	10.16	17.03	90.92	61.10	76.01
30-11-2016	8.83 (17.2)	932	24.14	10.06	17.10	90.37	60.43	75.4
SEm±	1.90	13.29	-	-	-	-	-	-
CD at 5%	5.91	39.71	-	-	-	-	-	-

* Average of Four replications ** Average of 100 days
Figures in parentheses are transformed angular value

Table 1a: Correlation matrix of weather parameters on Sclerotinia rot disease of Indian Mustard

Incidence (%)	Temperature (°C)		Relative Humidity (%)	
	Maximum (X_1)	Minimum (X_2)	7 hrs (X_3)	14 hrs (X_4)
Incidence (Y)	-0.594^{NS}	0.975^{**}	0.941^{*}	-0.957^{*}

*Significant at 5% probability level.
** Significant at 1% probability level

Table 1b: Multiple linear regression models for weather parameters and Sclerotinia rot disease incidence of Indian Mustard

Incidence (%)	Pure constant	Temperature (°C)		Relative Humidity (%)		R2
		Maximum (X_1)	Minimum (X_2)	7 hrs (X_3)	14 hrs (X_4)	
Incidence (Y)	-5047.006	+ 15.285	– 13.507	+ 64.820	– 17.127	0.6554

Multiple Linear Regression equation (Y) = -5047.006 + 15.285 X_1 – 13.507 X_2 + 64.820 X_3 – 17.127 X_4

Table 2: Effect of dates of sowing on Sclerotinia rot development during Rabi 2017-18

Date of sowing	*Disease incidence (%)	*Yield (kg/ha)	**Mean Temperature (ºC)			**Mean Relative humidity (%)		
			Max. (X_1)	Min. (X_2)	Avg.	Max. (X_3)	Min. (X_4)	Avg.
20-10-2017	16.09 (23.6)	1,010	23.83	11.64	17.74	99.73	83.59	91.66
30-10-2017	21.89 (27.9)	1,260	23.06	10.83	16.95	99.75	84.18	91.97
10-11-2017	40.14 (39.3)	1,145	22.27	9.84	16.06	99.49	84.53	92.01
20-11-2017	30.54 (33.5)	1,051	22.12	9.56	15.84	99.33	85.82	92.58
30-11-2017	11.66 (19.9)	901	22.59	10.01	16.30	99.36	85.16	92.26
SEm±	0.91	6.07	-	-	-	-	-	-
CD at 5%	3.00	20.12	-	-	-	-	-	-

* Average of Four replications ** Average of 100 days
Figures in parentheses are transformed angular value

Table 2a: Correlation matrix of weather parameters on Sclerotinia rot disease of Indian Mustard

Incidence (%)	Temperature (°C)		Relative Humidity (%)	
	Maximum (X_1)	Minimum (X_2)	7 hrs (X_3)	14 hrs (X_4)
Incidence (Y)	0.997^{**}	0.979^{**}	0.994^{**}	0.981^{**}

*Significant at 5% probability level.
** Significant at 1% probability level

Table 2b: Multiple linear regression models for weather parameters and Sclerotinia rot disease incidence of Indian Mustard

Incidence (%)	Pure constant	Temperature (°C)		Relative Humidity (%)		R2
		Maximum (X_1)	Minimum (X_2)	7 hrs (X_3)	14 hrs (X_4)	
Incidence (Y)	-21429.431	+ 268.934	– 238.252	+ 171.343	– 8.251	0.6751

Multiple Linear Regression equation (Y) = -21429.431 + 268.934 X_1 – 238.252 X_2 + 171.343 X_3 – 8.251 X_4

Table 3: Effect of dates of sowing on Sclerotinia rot development during Rabi 2016-17 and 2017-18 (Pooled)

Date of sowing	*Disease incidence (%)	*Yield (kg/ha)	** Temperature (ºC)		** Relative humidity (%)	
			Max. (X_1)	Min. (X_2)	Max. (X_3)	Min. (X_4)
20-10-2017	14.96 (22.6)	1023.5	24.64	11.93	89.36	55.78
30-10-2017	19.905 (25.3)	1275.0	23.80	11.14	90.04	57.91
10-11-2017	38.78 (37.93)	1159.5	23.06	10.04	90.70	59.6
20-11-2017	29.34 (31.4)	1068.0	23.02	9.86	90.92	61.1
30-11-2017	10.24 (17.4)	916.5	23.37	10.04	90.37	60.43
SEm±	1.48	9.17	-	-	-	-
CD at 5%	4.60	29.21	-	-	-	-

* Pooled of Two Years ** Pooled of two years from 100 days
Figures in parentheses are transformed angular value

Table 3a: Correlation matrix of weather parameters on Sclerotinia rot disease of Indian Mustard

Incidence (%)	Temperature (°C)		Relative Humidity (%)	
	Maximum (X_1)	Minimum (X_2)	7 hrs (X_3)	14 hrs (X_4)
Incidence (Y)	0.993^{**}	0.972^{**}	0.992^{**}	0.977^{**}

Table 3b: Multiple linear regression models for weather parameters and Sclerotinia rot disease incidence of Indian Mustard

Incidence (%)	Pure constant	Temperature (°C)		Relative Humidity (%)		R2
		Maximum (X_1)	Minimum (X_2)	7 hrs (X_3)	14 hrs (X_4)	
Incidence (Y)	-32423.95	+198.728	– 113.783	+ 322.395	-22.684	0.6653

Multiple Linear Regression equation (Y) = $-32423.95+198.728\ X_1 - 113.783\ X_2 + 322.395\ X_3 - 22.684\ X_4$

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