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Study on the Occurrence and Epidemic Model of Rape Sclerotinia Stem Rot of 'Zheyou 50'

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Abstract: In order to investigate invading and epidemic rules of rape sclerotinia stem rot of 'Zheyou 50' and promote the development of brassica campestris industry, this paper studied the outbreak regularity and epidemic model of rape sclerotinia stem rot according to field investigation and infection. The result showed that machinery direct seeding rape was good for the occurrence of sclerotinia stem rot for the reason of late seeding and high density. The period from water damage appeared to wilting death was about 15 days only, when latent period from nature mycelium to invade to total was about 8-17 days with a infected rate up to 13.2%. The epidemic dynamic showed to be linear-rise trend. Flowering stage was the main epidemic period of disease. Diffusion of rape sclerotinia stem rot fitted a logistic function model.

Keywords: Artificial inoculation, infect rate, latent period, logistic model, rape sclerotinia stem rot

INTRODUCTION

Rape was not only an important oil crop in agricultural production, but also an important economic forage crop today. Sclerotinia stem rot, caused by Sclerotinia sclerotiorum, was an important disease on rape, which occurred in 25 provinces (cities, districts) in China. The Yangtze River Basin was the most serious area. The disease can cause a general production loss of 10-20%, when severe plots more than 50%. It had become a major obstacle for rape industry, which seriously hampered the economic benefits and enthusiasm of farmers (Zhang*et al*., 2007; Du*et al*., 2009; Zhuand Chen, 2010). With the innovation of traditional nursery cultivation to fully mechanized cultivation, rape industry had a rapid development, and cultivated area had expanded each year. In usual case, sclerotinia stem rot mainly showed damage symptom since flower period or soon after that (Zuo *et al*., 2011; Zhao *et al*., 2010; Li *et al*., 2007). Recent years, with the development of mechanical seeding and area of a rape variety 'Zheyou 50' continued to expand, the occurrence of Sclerotinia sclerotiorum infestation period appeared obvious changes, and the production loss becoming larger (Chen *et al*., 2006; Wang*et al*., 2010; Chen *et al*., 2010). On the other hand, researches on 'Zheyou 50' were still in blank field. Therefore, in order to explore the intrusion, diffusion and epidemic rule of sclerotinia stem rot of 'Zheyou 50' and promote the rape industry, a survey on occurrence rule and epidemic model of sclerotinia stem rot was executed through artificial inoculation and field incidence survey in 2009-2011, It was found out the appearance character, lesion formed process, timing variation, disease invasion and popular rule of sclerotinia stem rot according, the aim of which is to provide references for forecasting and comprehensive prevention of rape sclerotinia stem rot.

MATERIALS AND METHODS

'Zheyou 50', which was cultured by rape research center, institute of crops and nuclear technology utilization ademy of Agricultural Sciences, Zhejiang agriculral sciences.

Sowing and cultivation: Machinery direct sowing with a seeding quantity of 2700 g/hm^2 on Nov. 18, 2010. Conventionally manage after sowing.

Choosing 200 healthy, high-viability and consistent seedings and transplanting into the bowls when seeding age was about 60 days on Jan 18, 2011. Arranging 4 treatments labeled A, B, C, and D (Fig. 1), each treatment had 50 seedings.

Spreading fresh hyphae of *Sclerotinia sclerotiorum* collected from the diseased field of natural on lower part of rape stem in bowls on Mar. 3, 2011 (Ran *et al*., 2007; Song and Guan, 2008; Du *et al*., 2008). Treatments A and C was inoculated when seedings were in 6-10 leaves stage: Spraying water mist every day in 20 days after inoculation to keep a damp environment, Recording temperature and humidity.

Observing and recording disease infectious status in each bowl and collecting meteorological datas every day until plant died.

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A_1	A_2	A_3	A_4	.....	A_{49}	A_{50}
B_1	B_2	B_3	B_4	.....	B_{49}	B_{50}
C_1	C_2	C_3	C_4	.....	C_{49}	C_{50}
D_1	D_2	D_3	D_4	.....	D_{49}	D_{50}

Fig. 1: Each treatment field arrangement diagram

Different types of rape fields were investigated in 2009-2011. Recording the growth period, plantingdensity, plantheight, the effective number of branches, the number of pods per branch and grains per pod, and other biological-economic traits.

RESULTS AND DISCUSSION

The biological characteristics performance of 'Zheyou 50': Based on the field observation, 'Zheyou 50' was mechanically direct sowed on Nov. 18, 2010. Single leave emerged every 15-20 days in seedling stage. On Mar. 11, rape entered into bolting stage from vegetative growth. The flowering period was about 10 days, and pod period was 45-50 days. Bio-economic traits showed the average planting density of 49.6 plants/m^2 (45~107 plants/m^2), average plant height of 142.6 cm (136-144 cm), 6.7 (6 to 10) effective branches, 16.6 pods/branch (11.6 to 24.4 pods), 22.6 grains/pod (19.0-31.0 grains). The theoretical yield was 5310 kg/hm^2.

Pathogenetic regularity of sclerotiniastem rot: As Table 1 showed, treatments A and C which inoculated fresh hyphae performed disease symbol. Combining inoculation test in field, 'Zheyou 50' showed disease symbol in 8 days after natural inoculation. The early susceptible parts were water-soaked lesion. Hyphae intrusion latent period lasted 8 to 17 days, its natural mycelium inoculation incidence could up to 13.0% (4.0 to 22.0%)

Lesion formation process and timing variation of sclerotinia stem rot. Lesion was water-soaked circular shape or irregular-shaped in stem base at the beginning, gradually changed into a grey white lesion around the stem. White flocculent mycelium formed, which spread

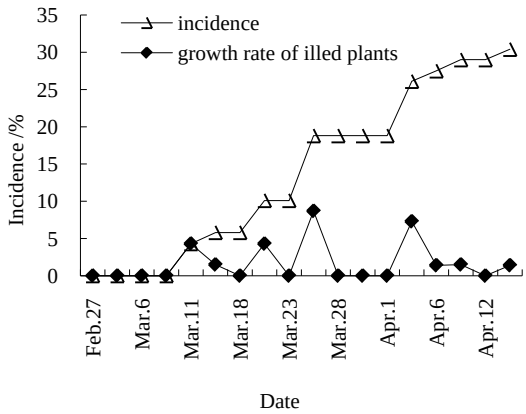

Fig. 2: Epidemic trends and timing growth rate of sclerotinia sclerotiorum of 'Zheyou 50'

to a big fusiform, long and narrow lesion around the stemfrom the bottom up when under a high humidity condition. There were black sclerotia like mouse droppings inside the stem at the laterstage.

Intrusion and popular rule of sclerotinia stem rot on 'Zheyou 50'. According to system monitoring for diseased plants, results were shown in Fig. 2. Plants were inoculation on March 3 (at 6-10 leaf stage), lesions appeared on March 11 (10-13 leaf stage). Then the lesion expanded until inflection point appeared on March 20 (at early flowering stage), when disease exploded. On April 4 (at podding stage), the disease entered an stable period. Disease diffusion basically presented an linear rise law. Throughout the process of rape growth period and the disease prevalence relations, there were 3 popular peaks, when rape entered bolting stage, full-bloom stage and final flowering stage. That means flowering stage of rape was the popular period for sclerotinia stem rot.

Main factors affecting the epidemic of sclerotinia stem rot. Statistical analysis based on the incidence and related factors of sclerotinia stem rot showed the main factors affecting the epidemic of sclerotinia stem rot in machinery direct seeding rape field were bacteria source, the amount of bacteria, growth period of rape and climatic conditions, etc.

Table 1: Disease incidence test of 'Zheyou 50'

				Mar. 11		Mar. 15		Mar. 20	
Treatments	Date	Growth period when inoculation	Amount of plants inoculated	Amount of plants appeared symptom	Incidence /%	Amount of plants appeared symptom	Incidence /%	Amount of plants appeared symptom	Incidence /%
Group A	Mar. 3	6~10 leaves	50	4	8.0	4	8.0	11	22.0
Group C	Mar. 3	6~10 leaves	50	2	4.0	2	4.0	2	4.0
Total			100	6	6.0	6	6.0	13	13.0
Group B	Mar. 3	6~10 leaves	50	3	6.0	7	14.0	7	14.0
Group D	Mar. 3	6~10 leaves	50	0	0.0	0	0.0	2	4.0
Total			100	3	3.0	7	7.0	9	9.0
Average			50.0	2.3	4.5	3.3	6.5	5.5	11.0

Table 2: Relationship between status of Sclerotinia stem rot and climate condition on 'Zheyou 50'

Date	Growth period	Average temperature in previousday /°C	Relative humidity in previousday/%	Incidence/%
Mar. 3	6~10 leaves	7.0	38.0	0
Mar. 6	6~10 leaves	6.9	37.7	0
Mar. 9	6~10 leaves	9.0	37.7	0
Mar. 11	10~13 leaves	8.9	34.0	4.3
Mar. 15	Bolting	12.2	33.3	5.8
Mar. 18	Bolting	9.4	36.7	5.8
Mar. 20	First flowering	11.2	40.5	10.1
Mar. 23	Early flowering	11.8	52.0	10.1
Mar. 25	Interim flowering	9.9	42.0	18.8
Mar. 28	Later flowering	10.0	37.3	18.8
Mar. 30	Blossom fall	10.4	33.0	18.8
Apr. 1	Blossom fall	11.2	33.5	18.8
Apr. 4	Early podding	14.7	49.7	26.1
Apr. 6	Early podding	10.2	42.0	27.5
Apr. 8	Early podding	14.8	56.0	29.0
Apr. 12	Podding	15.3	59.3	29.0
Apr. 14	Podding	13.2	44.5	30.4

Table 3: Digitized epidemic trends of sclerotinia stem rot

					$y = 46/(1 + 21.3e^{-0.099t})$	
Date of survey	t*	Incidence y/%	ln (K/y - 1)	K value	Predicted value	Predicting accuracy/%
Mar. 11	8	4.3	2.2719	46.0	4.32	99.53
Mar. 15	12	5.8	1.9360	46.0	6.14	94.15
Mar. 18	15	5.8	1.9360	46.0	7.90	63.83
Mar. 20	17	10.1	1.2682	46.0	9.28	91.86
Mar. 23	20	10.1	1.2682	46.0	11.67	84.43
Mar. 25	22	18.8	0.3694	46.0	13.48	71.70
Mar. 28	25	18.8	0.3694	46.0	16.47	87.62
Mar. 30	27	18.8	0.3694	46.0	18.62	99.03
Apr. 1	29	18.8	0.3694	46.0	20.85	89.11
Apr. 4	32	26.1	-0.2712	46.0	24.26	92.93
Apr. 6	34	27.5	-0.3964	46.0	26.51	96.39
Apr. 8	36	29.0	-0.5341	46.0	28.69	98.93
Apr. 12	40	29.0	-0.5341	46.0	32.72	87.19
Apr. 14	42	30.4	-1.1527	46.0	34.51	86.49

*t means quantized date which represent the days after pathogen inoculation

Bacteria source and the amount of bacteria: The result of inoculation experiment showed that disease occurred early and more popular in machinery direct seeding rape field, that's because of the sufficiency of bacteria amount. According to statistical analysis based on disease base (incidence rate between Feb. and Mar., N) and disease status during stable period (incidence rate on April), the two appeared significant correlation M = 3.7194N + 11.0437（n = 6, r = 0.8859*>0.05 = 0.8114）

Growth period disease growth rate: The entire growth period showed disease increment during flowering stage contributes 66.7% among the whole growth period. That indicated petalage was susceptible to Sclerotinia sclerotiorum. Pathogen infected petalage, anthers and old leaves at first, followed by stems, branches and siliques, among which stems contributed the most loss caused by sclerotinia stem rot.

As Table 2 showed,Disease incidence M (%), average temperature T (°C) and relative humidity W (%) of the previous day Were analyzed (Sun *et al*., 2010; Qi *et al*., 2011; Qi *et al*., 2006), which indicated average temperature and relative humidity affected disease diffusion significantly. Temperature model: M = 3.3831T-22.0969（n = 18, r = 0.7624**）showed disease occurred when average temperature above 8°C, accelerated above 10°C, and entered high-incidence season if temperature over 10°C. Therefore, sclerotinia stem rot developed with temperature rise in Spring; humidity model: M = 0.7955W-18.1832 (n = 18, r = 0.5819**) showed sclerotinia stem rot developed with humidity rise when relative humidity exceeded 40%.

Epidemic track and logistic model of sclerotinia stem rot on 'Zheyou 50'. State changes of disease during Mar. 11 and Apr. 14 were digitized (Table 3). Growth rate increased faster and faster between Mar. 11 and Apr. 1; Later, Growth rate increased slowly. Tipping point for growth appeared 8 days after disease intrusion, Disease severity was half of the maximum value 30 days after intrusion. Then it grew slowly. Epidemic track presented an logistic function curve.

Setting *y* as incidence of disease, *t* as quantized date which represent the days after pathogen inoculation (*t* = 1, 2, 3, …, n), then working out the

parameter of saturation (K value) by Microsoft Excel. The largest correlation coefficient of the linear pattern worth K = 46 (incidence of disease was 46%) was saturation value, thereby creating a logistic function model:

$$Y = 46/ (1 + 21.3e^{-0.099t}),\ t = (1, 2, 3, \ldots, n),\ (n = 14;\ r = 0.9762^{**};\ r_{0.01} = 0.6614)$$

The model fits well with an predicting accuracy up to 90% in data back testing. A predicting accuracy = [(predicted value-actual value) /actual value] ×100%. That means epidemic track of Sclerotinia sclerotiorum appeared to be a logistic function mode.

CONCLUSION

The research had found out the appearance character, lesion formed process, timing variation, disease invasion and popular rule of sclerotinia stem rot according to artificial inoculation test of 'Zheyou 50' and also clearly elaborated the main epidemic factors of the disease. This research established a Logistic model for diffusion of sclerotinia stem rot for the first time which could be used for disease forecasting. Flowering stage of rape was the popular period for sclerotinia stem rot. The achievements helped to formulate a prevention and control technology operation procedures of sclerotinia stem rot and promote current rape industry more healthy developed.

Fresh hyphae of Sclerotinia sclerotiorum collected from the diseased plant in natural field be used when inoculation, therefore virulence and inoculation dose of strain probably had unexpected impact on disease diffusion. In addition, prevention indicators, as well as active pharmaceutical screening test of Sclerotinia sclerotiorum remains to be further studied according to the test. Through incidence survey of different types of locally grown rape field, late seeding and high density of machinery direct seeding rape made for the outbreak of disease. So we suggested early seeding, and seeding quantity not too much, in order to enhance the rape resistance and reduce the incidence of disease.

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