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Assessment of yield losses in *Brassica juncea* due to downy mildew (*Hyaloperonospora brassicae*)

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Abstract

Susceptibility of cultivated varieties of Indian mustard (*Brassica juncea* L.) to downy mildew (DM), [*Hyaloperonospora brassicae* (Gaum.) Gçker; formerly *Peronospora parasitica*] is one of the major constraints in increasing crop productivity. This study reports the effect of DM on yield of three important Indian mustard cultivars as affected by several yield parameters. Compared to the healthy plants, DM-infected plants reduced yield by 42.6, 46.8 and 66.7 percent in cvs. Rohini, Varuna and NRCDR-2, respectively. DM infection significantly reduced average plant height, 1000-seed weight and oil content of seeds. Number of primary branches per plant however, was significantly higher in infected than in healthy plants. Generally, the number of siliquae on main shoot, as well as, on primary branches was also significantly lower in infected than in healthy plants. Quantification of economic impact showed that the yearly expected loss in India due to DM was about 683.1 million Indian rupees, depending upon the disease severity.

Key words: *Brassica juncea, Downy mildew, Hyloperonospora brassicae, yield loss*

Introduction

Rapeseed-mustard is the most important *post-rainy* (winter, October-March) oilseed crop in India. In 2010-11, the cultivated area and production were 6.7 million hectares with 8.2 million tonnes respectively, contributing about 25 per cent of the total oilseed production in the country (GoI, 2011). The edible oil imports have increased consistently during the last two decades. Therefore, increasing the production of edible oil by growing higher yielding, disease and pest resistant cultivars has been the main focus of agricultural research nationally. Downy mildew is one of the most important biotic stresses causing a significant yield loss in rapeseed-mustard.

Downy mildew (DM) caused by *Hyloperonospora brassicae* (Gaum.) Gçker, Voglmayr, Reithm. Weiss & Oberw; [formerly *Peronospora parasitica* (Pers) de Bary] (Goker *et al.*, 2004) has been recorded as early as 1918 by E.J. Butler, and since then the disease has been reported on cultivated *Brassica* species and other cruciferous host species in widely separated areas in numerous countries throughout the world (Channon, 1981; Saharan *et al*., 1997; Verma *et al.*, 1994). Downy mildew is known to occur in all major rapeseed-mustard growing states in India (Saharan, 1995). The disease mainly affects all above ground parts of young plants, the plants become stunted and in the severe cases the plants dies. Infection at later stage results in the debilitation and reduction in yield performance.

Hypertrophied host tissues (stagheads) are often bserved in association with a mixed infection of *Albugo candida* and *H. brassicae*, particularly at the flowering stage. Yield losses in *B. rapa* spp. Toria due to such combined infections is estimated to be 34 per cent (Kolte, 1985), in *B. juncea* 37.5 per cent (Bains and Jhooty, 1979) and 23-55 per cent (Saharan *et al*., 1997).

The main objectives of the present research were to compare and identify the most susceptible cultivar (=higher yield loss), and determine most affected yield parameters by DM. This will help

Brassica breeders to search and direct their DM resistance studies towards improving physical nature of those specific yield parameters.

Materials and Methods

During 2010-11 crop season, quantitative data on several yield parameters, and oil content, were collected from 10 randomly selected healthy and infected plants/ plots of each of the three Indian mustard (*Brassica juncea*) cultivars, *viz.* Varuna, Rohini and NRCDR-2, seeded in irrigated conditions at the Directorate of Rapeseed-Mustard Research, Bharatpur, India. Since there were 4 replicated plots (size 5x5m) for each of the three cultivars, each value in Table 1 represents average of 40 plants.The different yield parameters examined were: plant height, number of primary and secondary branches /plant, length of main shoot, number of siliquae on main shoot, number of seeds/ siliquae, and 1000 seed weight. The difference in mean values was tested for their statistical significance using t-test. Formula for estimation of the yield loss (%) = (mean yield of healthy plants – mean yield of diseased plants)/ mean yield of healthy plants X 100 was used as suggested by Saharan *et al.* (1997).

For collecting information on probability of disease occurrence, expected yield loss and extent of area affected by DM, and total area under mustard cultivation, a survey was conducted in the state of Rajasthan, where more than 50 per cent of the total rapeseed-mustard produced in India is grown. The different districts in the state were classified into three zones on the basis of area under irrigation. One district out of each zone was selected at random, and following the method of multistage random sampling 18 villages was selected. Ten rapeseed-mustard farmers were randomly selected from each village, and the responses on the question regarding disease incidence, frequency and severity were collected using a pre-tested schedule. Thus, each value in Table 2 represents the average of survey data from 180 rapeseed-mustard farmers. The data from the primary survey were used to calculate the impact of DM on rapeseed-mustard production and profitability.

The economic impact of a disease over large cultivated areas depends both on incidence and severity of the disease. Using primary survey data, the economic impact on yield loss due to DM was calculated following the method reported by Joshi *et al*. (2005).

$$D = \{(YL * A * p) TMA\}P_{rm}$$

Where, D = Total expected damage in Indian rupees

YL = Yield loss in Indian mustard due to downy mildew

A = Proportion of area under Indian mustard having the disease

p = Probability of occurrence of the disease

TMA = Total area under rapeseed mustard in the state (Rajasthan)

P_{rm} = Market price of mustard during the assessment year

Results and Discussion

Result showed that *H. brassicae* infection significantly reduced both 1000-seed weight and per cent oil content. Although, DM-infected plants were significantly shorter than the healthy plants, the number of primary branches per plant were significantly higher in diseased than healthy plants (Table 1). Generally, the number of siliquae on the main shoot as well as on the primary branches was also significantly reduced due to DM-infection (Meena *et al*., 2012). Length of main shoot, primary and secondary branches, number of seeds per siliquae and number of siliquae on secondary branches were also reduced in the infected plants, but the reduction were not significant. Based on the 1000-seed weight, the per cent yield reductions were 46.8, 42.6 and 66.7 in cvs. Varuna, Rohini and NRCDR-2, respectively. Bains and Jhooty (1979) reported losses in *B. juncea* from 37-47% and 17-32% reduction in siliquae formation and seed production respectively due to mixed infection of DM and white rust. Others workers have also reported 23-55% yield loss in *B. juncea* due to mixed infection with both pathogens (Saharan, 1992). Yield losses in *B. rapa* spp. Toria due to mixed infection is estimated to be about 34%, when the average

Table 1. Effect of downy mildew on different cultivars of Indian mustard (*Brassica juncea*)

Yield parameters	Varuna			Rohini			NRCDR-2		
	Healthy	Infected	Difference (%)	Healthy	Infected	Difference (%)	Healthy	Infected	Difference (%)
Plant height (cm)	203.3	187.0	-8.0**	202.6	191. 0	-5.7^{NS}	158.6	139.8	-11.9*
No. of primary branches/ plant	8.2	10.0	22.0**	6.4	9.8	53.1*	5.2	8.8	69.2***
No. of secondary branches/ plant	25.2	27.8	10.3NS	15.5	24.8	60.0^{NS}	13.2	31.4	137.9***
Length of main shoot (cm)	83.3	68.2	-18.1**	78.8	77.4	-1.8^{NS}	54.6	53.6	-1.8^{NS}
Length of primary branch (cm)	60.1	50.4	-16.1^{NS}	66.4	64.0	-3.6^{NS}	40.6	42.0	3.4^{NS}
Length of secondary branch (cm)	38.5	34.7	-9.9^{NS}	38.0	39.6	4.2^{NS}	26.6	23.2	-12.8^{NS}
Length of siliquae (cm)	3.9	3.8	-2.6^{NS}	4.0	3.9	-2.5^{NS}	3. 8	4.0	5.3^{NS}
No. of siliquae on main shoot	63.7	41.8	-34.4***	63.4	57.8	-8.8^{NS}	53.4	37.0	-30.7**
No. of siliquae on primary branch	45.1	30.6	-32.2***	47.4	44.6	-5.9^{NS}	40.0	27.0	-32.5**
No. of siliquae secondary branch	23.7	19.0	-19.8^{NS}	28.0	24.2	-13.6^{NS}	24.2	11.4	-52.9***
No. of seeds per siliquae	14.2	11.8	-16.9***	16.6	15.8	-4.8^{NS}	16.4	15.4	-6.1^{NS}
1000 seed weight (g)	6.2	3.3	-46.8***	5.4	3.1	-42.6***	5.1	1.7	-66.7***
% oil content	38.8	38.0	-2.1*	43.7	40.1	-8.2***	41.6	37.2	-10.6***
% Yield Reduction		46.8$^{\#}$			42.6$^{\#}$			66.7$^{\#}$	

Note: ^{NS} = Not significant, The asterix indicates that the difference in mean values is significant at 0.10 (*), 0.05(**) and 0.01(***) per cent level of significance, $^{\#}$per cent yield loss based on difference in 1000-seed weight between healthy and infected plants.

Table 2. Estimation of economic loss due to downy mildew in 2010-11 crop season in India

Parameters	Value
Average actual yield loss (Kg/ha)	143.2
Area affected by downy mildew infection (%) [a]	11.0
Probability of disease occurrence [a]	0.45
Total area under mustard (m ha)[b]	5.2
Price of output (INR / kg)[c]	18.5
Expected yield loss (mt)	0.75
Expected value of damage due to disease(Million INR)	683.1
Loss of edible oil @ 42 per cent oil recovery rate (mt)	0.31

[a]Calculated from primary survey data. [b] Calculated as 80 per cent of the total area under rapeseed-mustard in India during 2010-11 (GoI, 2011). [c] The price of output was taken as the minimum support price announced for the produce by the Government.

length of individual hypertrophied racemes was 10 cm (Kolte, 1985). The relationship of host pathogen interaction in case of downy mildew of crucifers is a complex phenomenon which determines the disease development (Saharan *et al.*, 1997). Differences in response to *Pernospora parasitica* isolated from *B. rapa* in seedlings at the cotyledon stage was reported earlier in accessions of different cultivars of *B. juncea* cultivars (Nashaat and Awasthi, 1995). During the study, an additional information by identifying the most susceptible cultivar (=higher yield loss), and most affected yield parameters were also reported.

Impact Assessment of Downy mildew

Results of the field survey indicate that the average yield reduction of 143.2 kg/ha was lower than the potential yield loss observed in the experimental field. The potential yield reduction due to downy mildew was 52 per cent in the experimental field whereas the yield reduction reported by farmers was only 12.2 per cent. About 11.0 per cent of the total area under Indian mustard cultivation was found to be affected by the disease. The probability of occurrence was calculated based on the reported occurrence of the disease during the last 5 cropping seasons. The incidence of DM, results in an estimated loss of 0.75 million tonnes, valued at 683 million Indian Rupees. The economic impact due to DM could be higher since the reduction in per cent oil content, and cost of chemical control is not taken in to consideration. The difference in yield reduction due to DM observed in the experimental plot, and farmer's field, could be attributed to the control measures adopted by the farmers. Since, the data on cost of plant protection measures adopted by the farmers is not available; the cost of disease management was not included. However, available evidence shows that the incidence of DM could reduce edible oil amount by at least 0.31 million tonnes which translate to about 4 per cent of the edible oil imports in 2009-10. Based on the gross unit value of import of edible oil, this will result in an additional expenditure of 10219 million INR on edible oil import.

The potential yield loss from DM in the three widely-grown Indian mustard cultivars indicates that the mechanism of disease establishment and progress may vary between cultivars. Further studies on the bio-chemical and physiological basis of the differences in yield parameters need to be undertaken. This information is required for developing plant breeding strategies aimed at evolving cultivars that are resistant to downy mildew infection. Though, the area affected by the disease is relatively low (11 per cent), the presence of the disease across wide geographical locations, and the average expected yield reduction of more than 50 per cent make it important to have appropriate management strategies for the disease. The probability of disease occurrence is also very high ($p = 0.45$) indicating the need for continuous monitoring and identification of the disease to take timely chemical control measures for disease management. The information about changes in the yield parameters

due to DM infection could help in the efforts undertaken to develop varieties with resistance to the disease.

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