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Management of collar rot of pea through resistant germplasm and chemicals application

Muhammad Ehetisham-ul-Haq[1], Muhammad Kamran[*1], Shaukat Ali[1], Muhammad Idrees[1], Muhammad Iqbal[1], Huma Abbas[2], Abdul Rashid[2], Saleem Il Yasin[3], Mudassar Iqbal[4]

[1]*Plant Pathology Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan*

[2]*Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan*

[3]*Fodder Research Institute, Sargodha, Pakistan*

[4]*Vegetable Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan*

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Abstract

Collar rot is a devastating disease of pea lowers the yield significantly. The present research was aimed to find the resistant pea germplasm against collar rot disease and to evaluate the fungicides efficacy under field conditions for disease management. Fourty-four pea varieties and lines were evaluated against collar rot disease of pea under field conditions. No variety and line was found immune. Three varieties/lines (1300-8, No. 267, Rondo) exhibited highly resistant response. Samrinazard, 2001-40, Ambassador, Robina, Pea-09, Strike and Isprit were resistant against the pathogen's virulence. Fifteen varieties/lines (FS 21-87, MID No.8, 2001-40, LINA Pak, 9800-10, 1300-8, Green Arrow, PAF-400, 92001, Sprinter, Tere-2, Winner, Parker, Kinglit, Italian-680) responded moderately susceptible against collar rot disease. 9800-5, Climax, No. 380, PTL-1, 9805, Olympia, IT-96, GRW-45, Knight, Chinese, FS 23-87, Mayfair, Headline. G. Feast, AM-1, Verdo and Bounting were found susceptible while 2001-60 and Meteor were found highly susceptible to the disease. Five different fungicides {(Acrobat (Dimethomorph), Revus (mandipropamid), Success (Chlorothalonil + Metalaxy), Curzate (Cymoxanil 8% + Mancozeb 64%) and Ridomil Gold (64% w/w Mancozeb + 4% w/w Metalaxyl-M) were evaluated against collar rot disease @ 2.5g/L, 2.4 ml/L, 2g/L,6g/L and 2g/L respectively in field conditions. Ridomil Gold (64% w/w Mancozeb + 4% w/w Metalaxyl-M) was found the most effective to manage the disease.

* **Corresponding Author:** Muhammad Kamran ✉ mkamran.uaf.pk@gmail.com

Introduction

Pea (*Pisum sativum*)an unique vegetable crop grown for its seed and pods(Thompson and Kell, 1923, Maxted and Ambrose, 2001)around the globe belongs to the family "Fabaceae" (Sharma and Gupta, 1982, Baldev, 1988). It is an important vegetable due to its dietary importance. It is a rich source of carbohydrates (14.45 g/100g), proteins (5.42 g/100g), vitamins (45.84mg/100g), fats and the minerals (418.12mg/100g)(Rodriguez *et al.*, 2006). Not only for its dietary importance, it is a crop of agronomic value and also grown to improve the soil fertility for successive planting in the field. It is a crop of cold regions; more than eighty-five countries in the world are the pea producers. Annually, more than 17.430.767 tons of pea were produced on 2297.767thousand hectares around the globe(FAO, 2013).

Pea plant is vulnerable to several diseases; collar rot, downy mildew, powdery mildew, wilt and leaf spots disease annually reduce the biologically yield considerably (Kraft and Pfleger, 2001). *Phytophtora megasperma* causing collar rot disease is a devastating pathogen of the pea plant. Symptoms with the varying intensity are more visible in all pea fields at the end of flowering stage(Podger, 1978). Slowing down of growth, which appears in patches throughout the fields, is a result of the very weak root systems. On the root and collar regions of the plant, the disease is seen as variable blackening effect. New infections are mostly detected at the point where cotyledons are attached. Progressively developing necrosis towards the collars and roots can also be detected. Degradation of the root system was greater when the infection was detected at the earlier stages of diseased plants (Soylu and Dervis, 2011).

The disease management approach through growing resistant germplasm is a cost effective practice biologically and economically (McGee, 1995). The strategy is beneficial for all poly-cyclic, mono-cyclic and polyetic pathogens. The resistant plant interferes with the pathogen's establishment, colonization and multiplication, hence, interferes with the pathogen's life cycle process and attritions pathogen's population pressure. Economically, this approach dramatically reduces the inputs of the grower to counter the disease. The cost for cultural and chemical practices to debacle the disease progression is too high comparing to this approach (Meynard *et al.*, 2003).

Economic Threshold Level (ETL) directs to adopt the appropriate disease management strategies. Fungicides application is a reliable approach to manage the disease, however, is not an eco friendly as the use of chemicals have defiled our terrestrial and hydral environment (Crathorne *et al.*, 1990). However, by adopting prescribed safety measures, the environmental pollution hazards can be minimized(Waxman, 1998). To meet the challenge of food security, the strategy is the best against the yield robbers.

The present research was aimed to find the resistant pea germplasm against collar rot disease by screening of pea varieties/lines. Fungicide's efficacy was evaluated under field conditions for disease management.

Materials and methods

Screening of germplasm

Field trials were conducted at sick filed already prepared by adding culture of *Phytophtora megasperma* repeatedly in experimental area of Plant Pathology Research Institute, Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan on 2016. Certified seeds of fourty-four pea varieties and lines (Samrinazard, Ambassador, Rohina, Pea-09, Strike, ISPRIT, 1300-8, No. 267, Rondo, 2001-40, FS 21-87, MID No.8, 2001-40, LINA Pak, 9800-10, 1300-8, Green Arrow, PAF-400, 92001, Sprinter, Tere-2, Winner, Parker, Kinglit, Italian-680, 9800-5, Climax, No. 380, PTL-1, 9805, Olympia, IT-96, GRW-45, Knight, Chinese, FS 23-87, Mayfair, Headline. G. Feast, AM-1, Verdo, Bounting, 2001-60, Meteor) were taken from Vegetable Research Institute, AARI, Faisalabad, Pakistan. Prior to sowing, seeds were soaked in sterile water overnight to increase the germination rate.

Seeds were sown on beds by keeping row to row and plant to plant distance 60 and 30 cm respectively. Augmented design was adopted with two repeats. In each repeat, eight seeds of each variety/line were sown. All agronomic practices were adopted. Disease incidence was recorded and varieties/lines were evaluated using Mayee and Datar, disease rating scale (Mayee and Datar, 1986)after the appearance of the disease.

Evaluation of fungicides in field conditions

For field evaluation of different fungicides against the disease, certified seeds of "meteor" variety were taken from Vegetable Research Institute, AARI, Faisalabad. Trial was conducted in sick plot of experimental area of Plant Pathology Research Institute, Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan. Five different fungicides {(Acrobat (Dimethomorph), Revus (mandipropamid), Success (Chlorothalonil + Metalaxy), Curzate (cymoxanil 8% + mancozeb 64%) and Ridomil Gold (64% w/w mancozeb + 4% w/w metalaxyl-M)} were evaluated against collar rot disease at 2.5g/L, 2.4 ml/L, 2g/L,6g/L and 2g/L respectively in field conditions. In control treatment, nothing was applied. Randomized Complete Block Design (RCBD) was used with five repeats. In each replication, nine seeds of pea were sown in a sick plot keeping row to row and plant to plant distance 60 and 30 cm respectively. Chemicals were applied foliar at 4:00 pm after two weeks of emergence of plants by knapsack sprayer. Disease data was recorded after 10 days of application.

Statistical analysis

Recorded disease incidence data was analysed using Analysis of Variance (ANOVA). Efficacy of different treatments were compared by using Fisher's Least Significant Difference (LSD) test(Steel *et al.*, 1997).

Data was analysed using SAS software (SAS, 2011-2012)and data representation was accessed through "Microsoft Office-2013" software(Wilson, 2014).

Results and discussion

Screening of germplasm against the collar rot of pea

Out of fourty-four pea varieties/ lines, no one variety/line was found immune against collar rot disease.

Table 1. Reaction of different Peas germplasm to collar rot disease.

Disease %	Reaction	Varieties/line	No. of Varieties/line
0%*	Immune	None	-
1 or less	Highly resistant	1300-8, No. 267, Rondo	03
1-10 %	Resistant	2001-40, Samrinazard, Ambassador, Rohina, Pea-09, Strike, ISPRIT,	07
11-20 %	Moderately resistant	FS 21-87, MID No.8, 2001-40, LINA Pak, 9800-10, 1300-8, Green Arrow, PAF-400, 92001, Sprinter, Tere-2, Winner, Parker, Kinglit, Italian-680	15
21-50 %	Susceptible	9800-5, Climax, No. 380, PTL-1, 9805, Olympia, IT-96, GRW-45, Knight, Chinese, FS 23-87, Mayfair, Headline. G. Feast, AM-1, Verdo, Bounting,	17
51 % or more	Highly susceptible	2001-60, Meteor	02
Total			44

*Reaction based on percent plant mortality.

Three varieties/lines (1300-8, No. 267, Rondo) exhibited highly resistant response. Samrinazard, 2001-40, Ambassador, Rohina, Pea-09, Strike and Isprit were resistant against the pathogen's virulence. Fifteen varieties/lines (FS 21-87, MID No.8, 2001-40, LINA Pak, 9800-10, 1300-8, Green Arrow, PAF-400, 92001, Sprinter, Tere-2, Winner, Parker, Kinglit, Italian-680) responded as moderately susceptible against the disease. 9800-5, Climax, No. 380, PTL-1, 9805, Olympia, IT-96, GRW-45, Knight, Chinese, FS

23-87, Mayfair, Headline. G. Feast, AM-1, Verdo and Bounting were susceptible while 2001-60 and Meteor were found highly susceptible to the disease (Table 1).

The disease management approach through growing resistant germplasm is a cost effective practice biologically and economically.

Resistance/susceptibility primarily depends on the genome inheritance(Biffen, 1905), mainly controlled by one (vertical resistance) or many genes (horizontal resistance) (Vanderplank, 1984). Often, in the presence of susceptible host and virulent pathogen, it happens that infection may not be established due to unfavorable weather condition(Agrios, 2005). Field resistance mainly depends on the genomic properties of the germplasm or by environmental factors (Govindaraj *et al.*, 2015). True resistance phenomenon comes when a plant resists against the pathogen infection under favorable environmental condition by the genomic property (vertical or horizontal resistance.

Table 2. Efficacy of different treatments against collar rot disease of pea (Analysis of Variance).

Source of Variation	DF	SS	MS	F	P
Treatments	5	8652.62	1730.52	65.63	0.0000
Replications	4	65.86	16.47		
Error	20	527.33	26.37		
Total	29	9245.81			

α = 0.05.

In the above-performed experiment, it is clear that infection was established under favorable environmental conditions, which supports the idea that the variation among varieties/lines is due to genomic characterization. To evaluate whether the resistance is horizontal or vertical, molecular study is needed to identify the target genes responsible for inducing resistance.

Mustafa *et al.* (2017) screened twenty three pea varieties against collar rot disease. Out of twenty-three varieties/lines, 4 lines/varieties i.e. No.2001-40, Isprit, 2001-60 and Green arrow were categorized as resistant. Twelve test entries exhibited moderately resistant while remaining germplasm was rated as moderately susceptible.

Efficacy of different fungicides against the disease in filed conditions

Significant difference in fungicides efficacy was seen against the collar rot disease of pea (Table 2). Among six fungicides, Ridomil Gold (64% w/w Mancozeb + 4% w/w Metalaxyl-M) was found the most effectiveto manage the disease. Revus (Mandipropamid) was found more significant as compared to the Success (Chlorothalonil + Metalaxy), Curzate (Cymoxanil 8% + Mancozeb 64%), Acrobat (Dimethomorph) and Control treatments except Ridomil Gold (64% w/w Mancozeb+4% w/w Metalaxyl-M). Acrobat (Dimethomorph) was recorded more effective as compared to Curzate (Cymoxanil) however both were statistically same to manage the disease. Success (Chlorothalonil + Metalaxy) was seen least effective to manage the disease among other fungicides but was significant comparing to control. In control, maximum disease incidence was noted (Figure 1).

To manage the disease thorough chemicals applications is a reliable approach, however, environmental hazards are serious concerns which maybe minimized by adopting suitable safety measures. *Phytophthora megasperma* is a soil invader and attacks to the collar part of the plant. Five fungicides having basipetal systemic mode of action were selected to manage the disease. Systemic fungicides enter in the plant system through stomata, travel to the distal plant parts and reach to the target sites through plant sap (BASF, 2017, DuPont, 2017b, Syngenta, 2017a, b). Among five evaluated fungicides, Ridomil Gold (64% w/w Mancozeb + 4% w/w

Metalaxyl-M) was found the most effective against the pathogen. Having translaminar property, it moves through plant sap and eliminates the infection. The Ridomil-Gold fungicide is a combination of two fungicides (64% w/w Mancozeb + 4% w/w Metalaxyl-M) both act as curative and protectant. Mancozeb produce the protective film on plant parts which inhibits spore germination. Metalaxyl-M having a systemic mode of action, inhibits fungal growth and reproduction, and protects new growth produced after application (Syngenta, 2017c).

Revus (Mandipropamid) and Acrobat (Dimethomorph) are systemic fungicides, both inhibit spore's germination, however, Revus (Mandipropamid) was found more effective to manage the collar rot disease as compared to the Acrobat (Dimethomorph). Curzate (Cymoxanil 8%+Mancozeb 64%) was launched by DuPont company has a unique mode of action, induces the plant's natural defence mechanism. The plant then works against the disease arresting further fungal growth, the result is death of infected cells and the pathogen (DuPont, 2017a).

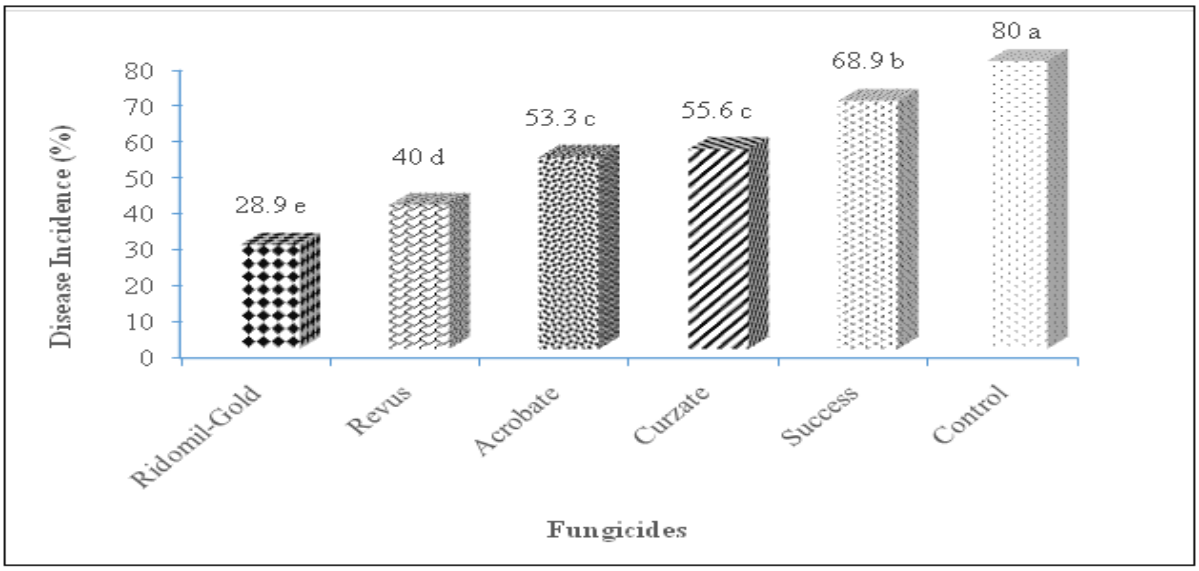

Fig. 1. Relative efficacy of different fungicides against collar rot disease of pea (LSD = 9.99).

The fungicides effectiveness directly relates to the inert material/adjuvants added with active ingredient (Steurbaut, 1993), adsorption capability of active ingredient in plant system(Barak *et al.*, 1983) and persistence to the a-biotic environment (Sigler *et al.*, 2000).

The inert material/adjuvant facilitates the dispersal and attachment of the active ingredient of the fungicide (Gent *et al.*, 2003, Ryckaert *et al.*, 2007). The effectiveness of the fungicide may decrease if a chemical may fails to reach its target site. The absorbance of chemical in the plant part is also an important property of a fungicide. The success of an effective fungicide may reduce if it doesn't absorb well to the plant. The fate of the fungicide highly depends on the temperature(Munnecke, 1972, Sigler *et al.*, 2000).

The rate of volatility and dissociation of active chemical in fungicide may vary at different air temperatures. So, the time of application is also a factor of concern. Furthermore, the efficacy of the tested fungicides may vary region to region because of the different temperature ranges. So, the relative efficacy of these tested fungicides may change at different regions of the world.

Conclusion

Present study revealed that the "1300-8 and No. 267"lines were found highly resistant against the disease, plant breeders may use these germplasms for their future varietal development trials.

The variety "Rondo" may be used by the farmers where the collar is a serious problem in the field.

Application of Ridomil Gold (64% w/w Mancozeb + 4% w/w Metalaxyl-M) may be used for the collar disease management.

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