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Monitoring of epidemiological factors promotive for the expansion of downy mildew of onion and its chemotherapeutic management under field conditions

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Abstract

Downy mildew of onion is the most damaging disease of onion and is the major cause of reduction in yield in Pakistan. In current study for management purpose ten varieties of onion and five fungicides namely Shincar, Tilt, Ridomil gold, Rally and Curzate M at three concentrations (1,1.5 and 2g/liter of water) were evaluated under Randomized Complete Block Design. Among ten varieties only two varieties (1122F1hyb, SV.0748NP) expressed resistant response towards Downy mildew with 7.5-8.5% incidence. Among fungicides Shincar exhibited maximum reduction in incidence of disease (30, 55, and 85%) at three concentrations respectively. As environmental factors play a critical role in disease development and disease dispersal. So, in the current study their relationship with varieties in disease development was monitored. It was found that environmental factors have significant positive correlation at 5% (*P*) level. Characterization of epidemiological factors indicated that with increase in max temperature (20-26^{o}C), minimum temperature (10-15^{o}C), Relative humidity (64-80 %) and wind speed (3-6Km/h), disease also increased. These results are helpful for farmers, researchers and scientists for timely management of Downy mildew to save their onion crop from the harms of Downy mildew.

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Introduction

Onion is the most important vegetable crop cultivated all over the world. South west Asia and Mediterranean are the native regions of onion cultivation (Wani, 2011). It plays a significant role in food and pharmaceutical industries. Onion contains crude protein (24.8%), potassium (10mg), sodium (11.2mg), and calcium (175mg). Cardiovascular diseases and cancers (colorectal cancer) in humans are treated with onion. It is well known due to the presence of sulfenic acid which exhibit pungent taste. Onion plays a crucial role in different industries including food and medicine (Dini *et al.,* 2008). In ancient times, onion was compared to pearl just not only because of its shape and high nutritional importance (Shigyo *et al*., 2008).

Onion is vulnerable to numerous fungal bacterial and viral diseases which are responsible for causing heavy losses worldwide. Among all diseases downy mildew (DM) disease of onion which is caused by *Perenospora destructor*is very destructive in temperate as well as humid regions (Fujiwara *et al*., 2019). First time Downy mildew was observed by Berkly in 1841. An imbalance fertilizer and irrigation application leads to the development of downy mildew disease (Mishra *et al.,* 2014).It affects onion seed and bulbs production (Schwartz and Mohan 2008).Pathogen affects seed stalk and as a result nutrient and water supply towards umbel is affected badly (Schwartz and Mohan, 2008). Downy mildew disease initially appears on seed stalks and leaves in the form of pale green to yellowish regions with ovate to cylindrical shape. Infected regions are covered with the mass of fruiting bodies. Symptoms appear as frost like growth in inner side of leaves while the upper surface of leaves exhibit yellowing. Pathogen growth becomes clear on both upper and lower side of leaves under favorable conditions. Relative humidity up to 95% and temperature (22 to 25°C) is required for pathogen sporulation (Hildebrand and Sutton, 1982). Sporulation starts when favorable conditions prevail at night for 6 hours and stopped with rainfall. Sporangia released at daytime when relative humidity is low. Infection starts when temperature is 3 to 14℃ and water film exists on leaves for 2 to 6 hours. About 9 to 16 days are required for the development of new sporulation (Schwartz and Mohan, 2008). As epidemiological factors play a vital role in the multiplication, perpetuation of pathogen and enhancement of disease significantly. That is why in present study effect of epidemiological factors was monitored and relationship between environmental factors and disease was studied and most suitable environmental factors were determined through regression analysis. Different management strategies are adopted by various researchers and farmers toward DM but the most economical and environment friendly is the use of resistant varieties. That is why in present study available germplasm was evaluated under field conditions. DM can be minimized through the use of fungicides, bio-control agents and crop rotation. Bio-control agents like *T. harzianum, T. pseudokoningi, T. virens* exhibit inhibitory effect against pathogen spore germination but unfortunately farmer needs a quick response while these agents are slow in response (Imtiaz and Lee, 2008). Use of botanical extracts is another useful method for the management of downy mildew disease because of their antibacterial and antifungal characteristics. Extracts of neem (*Azadirachta indica*), *Eucalyptus globules* and *Cydonia oblonga* exhibits best results by causing reduction in bacterial and fungal diseases (Hanaa *et al.* 2011; Gurjar*et al.* 2012; Zahid *et al.,* 2012) but unluckily botanical extracts are not available in markets. Resistant germplasm can minimize the disease incidence and severity (Koike *et al.,* 2001) and it is usually preferred but unfortunately resistant germplasm is not always available up to desirable level (Tripathy *et al.,* 2013). Among all of these management methods, application of fungicides is preferred by farmers because when disease appears in epidemic form then farmers forced to use fungicides to overcome DM. According to IPM (Integrated Pest Management) fungicides should be applied at the appearance of first disease sign (Wright *et al.,* 2002). Best potential average yield and high crop quality can be maintained by spraying with 7 to 10 days interval (DeVisser, 1998). Therefore, current experiment was designed to evaluated fungicides at

different concentration to select most effective fungicide with least toxicity to environment and is effective toward DM.

Materials and methods

Evaluation of onion germplasm against Downy mildew of onion under field conditions

Nursery of available germplasm of onion was established in research area, Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan in 2019 under Randomized Complete Block Design. Land was prepared with the help of agriculture machinery (plough, planker and rotavotator). Onion varieties/cultivars were cultivated following P×P and R×R distance of 10 cm and 30 cm respectively. Agronomic practices were maintained during experiment to keep field healthy. Characteristic symptoms of downy mildew symptoms (violet grayish lesions) were observed on the seed stalk. Data regarding disease was recorded by following rating scale of Sharma (1997) as expressed in table1 While disease incidence data was calculated by using following formula.

$$\text{Disease incidence \%} = \frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$

Correlation and characterization of environmental conditions on development of

Downy mildew disease of onion

Environmental data was obtained from Department of Agronomy, Agro metrological Bulletin, and University of Agriculture Faisalabad (UAF). The data was based on minimum, maximum temperature (^{o}C), rainfall (mm), wind speed (Km/h) and relative humidity (%). Downy mildew disease of onion was correlated to these environmental factors by studying and recoding disease incidence data on weekly basis. The most favorable conditions for the development of Downy mildew disease of onion was determined through regression analysis.

Assessment of chemicals against Downy mildew disease under field conditions

Five fungicides i.e. Tilt, Shincar, Ridomil Gold, Chlorostrobin and Copper oxychloride were evaluated for the management of *Perenospora destructor* causing DM at three concentrations (1.00, 1.5, 2.00g/liter of water). Application of first spray was done after the appearance of characteristic symptoms of Downy mildew disease.

Three sprays of five fungicides were applied against DM under field conditions.

Data analysis

Statistical tests were performed by using SAS / STAT statistical software (SAS institute, 1990). Means were separated using Fisher's protected least significant difference (LSD) procedure at 5 % probability level.

Significant treatments and their combinations were identified for the control of Downy mildew disease of onion.

Results

Evaluation of onion germplasm against downy mildew disease of onion under field conditions

Among ten varieties, five varieties namely Onion14121, Vrio5, Husri, Phulkara, F1 Zeous showed highly susceptible response with 64 to 78% disease incidence while one Variety GHL132 expressed moderately susceptible response (26%) and two varieties Rubi F2 and Desi large exhibited susceptible response (55.50 -57%) while remaining two varieties showed resistant response (7.50 -8.50%) against downy mildew disease of onion (Fig.1).

Evaluation of chemicals against downy mildew disease under field conditions

Among all fungicides Shincar was proved themost effective causing (56.66%) disease reduction followed by Tilt (48.33), Rally (36.66), CurzateM (13.33), and Ridomil Gold (4%) respectively as compared to control (Table2, Fig.2). While in interaction between treatment and concentration, shincar showed maximum disease reduction (30, 55, 85.%) at all concentrations followed by Tilt (25.00, 45.00, 75.00%), Rally(20.00, 35.00, 55.00%), Curzate M (0.00, 15.00, 25.00%) and Ridomil Gold (0.00, 0.00, 12.00%) as compared to control (Table 2).

Table 1. Rating scale for assessment of onion germplasm against Downy mildew.

Description	Rating Scale	Response
Disease symptoms are not present	0	I
Few spots present on the tip, covers less than 10% leaf area	1	R
Dark purplish brown patches are covering less than 20% leaf area	2	MR
Patches along with paler outer region, covering up to 40% leaf area	3	MS
long lines are present covering up to 75% leaf area	4	S
Complete leave dried or its breakdown occur from stalk	5	HS

I= Immune R= Resistant MR= Moderately Resistant MS= Moderately Susceptible.

S= Susceptible HS= Highly Susceptible.

Table 2. Assessment of interaction b/w treatments and concentrations against Downy mildew of onion under field conditions.

Treatments	Disease reduction (%)			
		Concentrations		
	Active ingredients	1.00g/liter of water	1.5g/liter of water	2.00g/liter of water
Shincar	Carbendazin	30.00f	55.00c	85.00a
Tilt	Prpinazoloe	25.00g	45.00d	75.00b
Rally	Myclobutanill	20.00h	35.00e	55.00c
Curzate M	Mancozeb + cymoxanil	0.00k	15.00i	25.00g
Ridomil Gold	Metalaxyl M + S-Isomer	0.00k	0.00k	12.00j
Control	Distilled water	0.00k	0.00k	0.00k
LSD		0.056		

Correlation of environmental factors with incidence of DM of onion under field condition

Maximum temperature expressed positive significant relationship with nine varieties (onion 14121, Rubi F2, Vrio 5, Husri, SV.0748NP, Phulkara, 1122F1hyb, F1 zeous, Desi large) while GHL132 expressed non-significant correlation. Minimum temperature expressed positive correlation with nine varieties (Rubi F2, Vrio 5, Husri, SV.0748NP, Phulkara, 1122F1hyb, F1 zeous, Desi large) Relative Humidity expressed significant correlation with ten onion varieties (onion 14121, GHL132, Rubi F2, Vrio 5, Husri, SV.0748NP, Phulkara, 1122F1hyb, F1 zeous, Desi large). Rainfall expressed positive significant correlation with nine varieties (onion 14121, Rubi F2, Vrio 5, Husri, SV.0748NP, Phulkara, 1122F1hyb, F1 zeous, Desi large) while varietyGHL132 did not expressed significant correlation. Wind speed expressed positive significant correlation with nine varieties (onion 14121, Rubi F2, Vrio 5, Husri, SV.0748NP, Phulkara, 1122F1hyb, F1 zeous, Desi large) while GHL132 expressed did not expressed positive correlation (Table 3).

Table 3. Correlation of epidemiological factors with Downy mildew of onion under field conditions.

Varieties	Max T (℃)	Mini T (℃)	Relative humidity (%)	Rain fall (mm)	Wind speed(km/hour)
Onion 14121	0.957 0.00*	0.659 0.076^{NS}	0.889 0.003*	0.988 0.000*	0.760 0.029*
GHL132	0.685 0.061^{NS}	0.798 0.018*	0.792 0.019*	0.683 0.062^{NS}	0.633 0.092^{NS}
Rubi F2	0.993 0.000*	0.758 0.029*	0.990 0.000*	0.922 0.001*	0.768 0.026*
Vrio 5	0.993 0.000*	0.746 0.033*	0.976 0.000*	0.903 0.002*	0.749 0.032*
Husri	0.993 0.000*	0.746 0.033*	0.976 0.000*	0.903 0.002*	0.749 0.032*
SV.0748NP	0.997 0.000*	0.754 0.031*	0.973 0.000*	0.945 0.000*	0.730 0.040*
Phulkara	1.000 0.031*	0.736 0.037*	0.970 0.000*	0.942 0.000*	0.750 0.032*
1122F1hyb	0.978 0.000*	0.728 0.041*	0.957 0.000*	0.958 0.000*	0.705 0.051*
F1 Zeous	0.991 0.000*	0.728 0.041*	0.975 0.000*	0.935 0.001*	0.808 0.015*
Desi large	0.996 0.000*	0.788 0.020*	0.982 0.000*	0.934 0.001*	0.747 0.033*

Characterization of environmental factors conducive for the development of Downy mildew of onion under field conditions

Maximum disease incidence was recorded on Vrio 5 (65.00%) with r value 0.9924 followed by Desi large 0.90 and Rubi F2 0.99 at maximum temperature ranges between 20 to 26 °C (Fig.3) While at minimum temperature ranges between 10 to 15 °C, maximum disease incidence was recorded on Vrio 5 (65.00%) with r value 0.73 followed by Desi large 0.74 and Rubi F2 0. (Fig.4) while in case of rainfall disease incidence was observed at ranges 0 to 1 mm on Vrio 5 (65.00%) with r value 0. 28 followed by Desi large 0.23 and Rubi F2 0. 25 (Fig.5) while in case of relative humidity maximum disease incidence was observed at ranges 64 to 80 % Vrio 5 (65.00%) with r value 0.90 followed by Desi large 0.9093 and Rubi F2 0. 9893 (Fig.6) In case of wind speed maximum disease incidence was observed at ranges 3 to 6 km/h on Vrio 5 (65.00%) with r value 0.50 followed by Desi large 0.68 and Rubi F2 0. 53 (Fig.7).

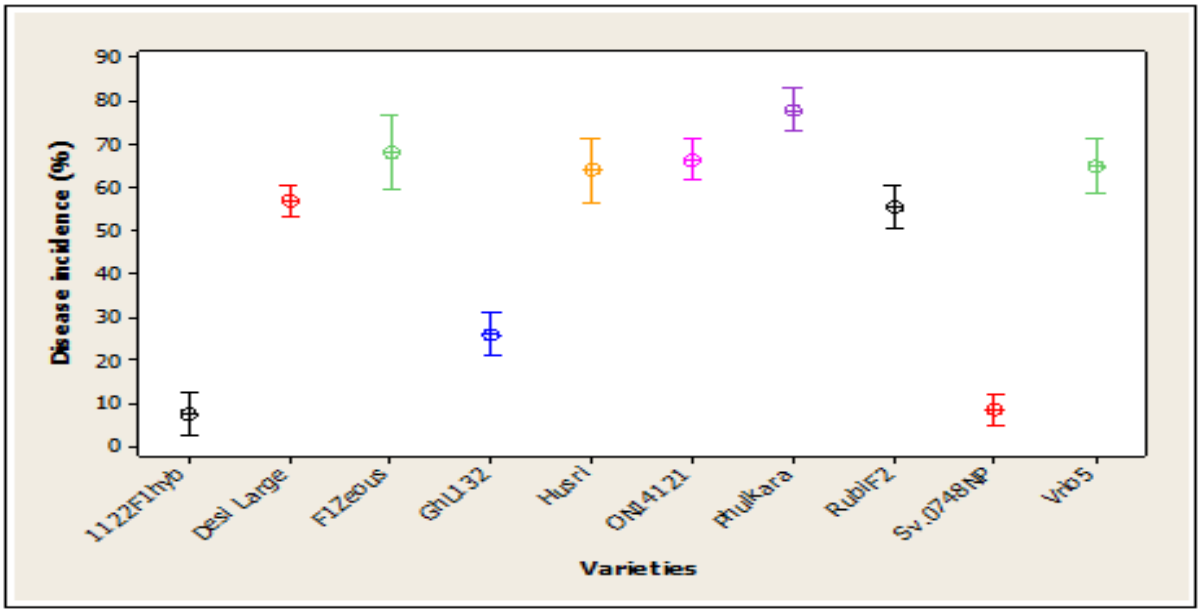

Fig. 1. Evaluation of onion germplasm against downy mildew disease of onion under field conditions.

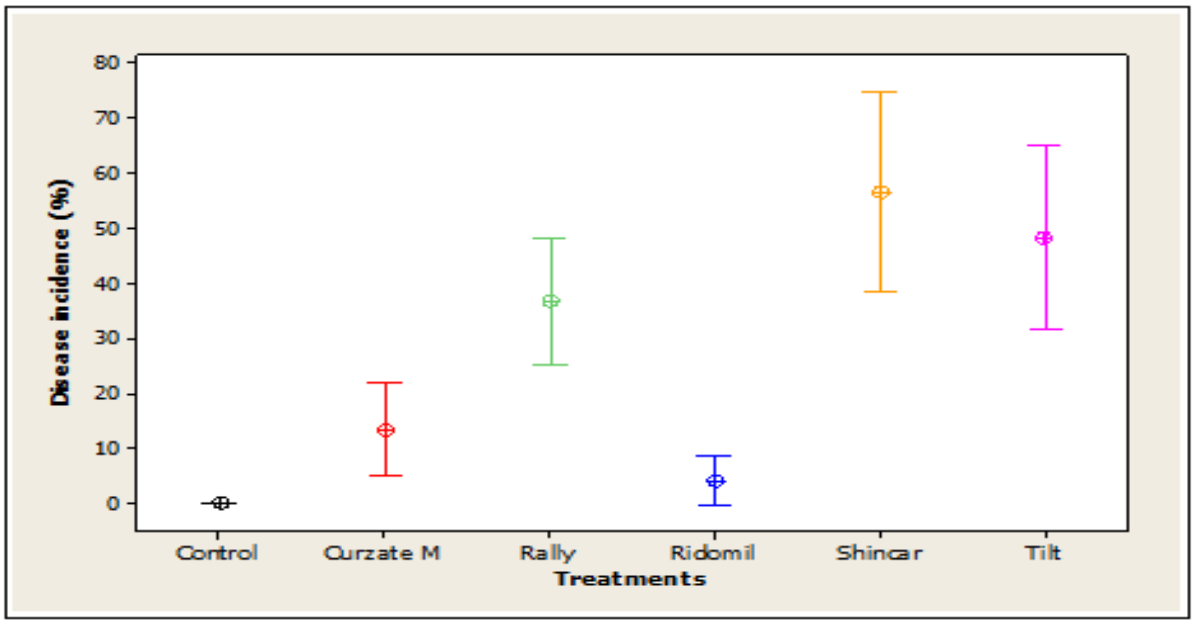

Fig. 2. Evaluation of chemicals against Downy mildew of onion under field conditions.

Discussion

Numerous diseases are the cause of reduction in yield of onion but the most important one is the Downy mildew (DM) which is the potential threat to the successful production of onion. A number of management approaches are adopted by farmers and researchers towards DM but the most economical and suitable one is the use of resistant source. For this purpose, screening of the available germplasm is pre-requisite.

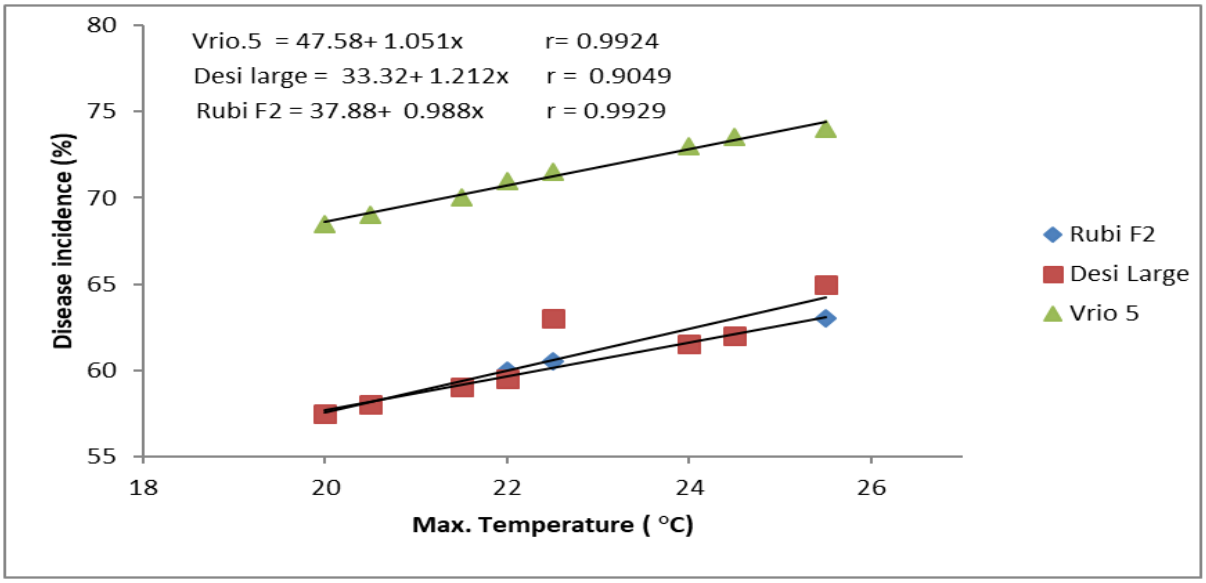

Fig. 3. Relationship between maximum temperature and disease incidence during 2018- 019 recorded on varieties/lines (y1=Desi large; y2=Vrio.5; y3=Rubi F2).

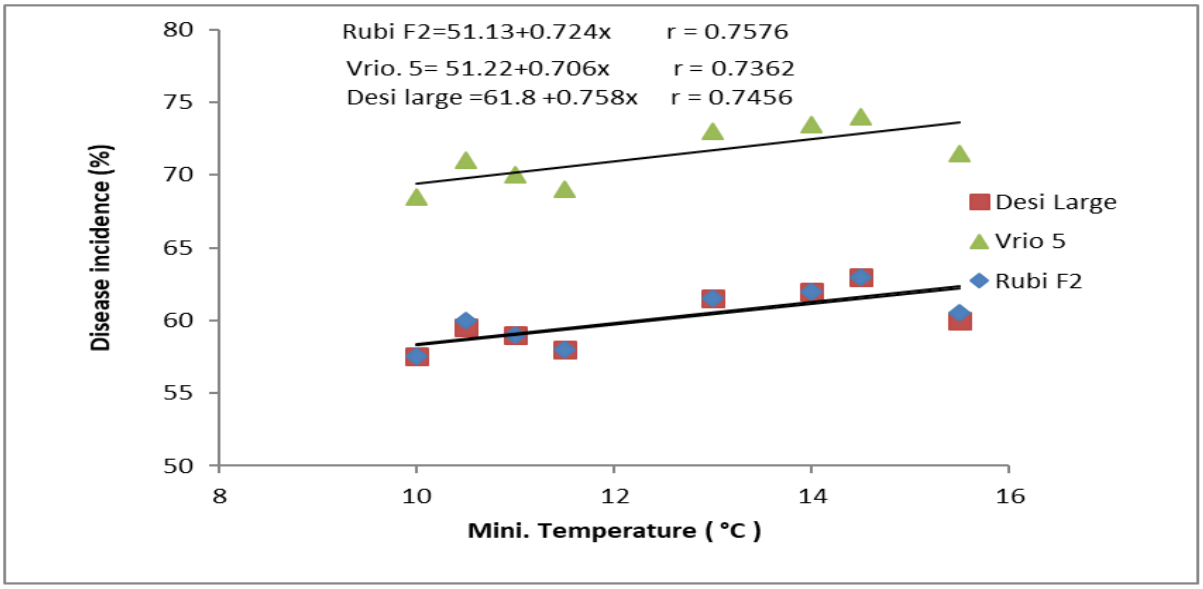

Fig. 4. Relationship between minimum temperature and disease incidence during 2018- 019 recorded on varieties/lines (y1=Desi large; y2=Vrio.5; y3=Rubi F2).

That is why in present study ten varieties were evaluated towards DM. Among ten only two varieties (1122F1hyb, SV.0748NP) expressed resistant response which can be used by researchers in breeding program to incorporate resistant genes in the advanced lines of onion with good genetic and horticultural attributes which enable the researchers and scientist to release new resistant cultivar of onion with in short time with good yield potential. Outcomes of the contemporary study is supported by

the work of Krauthausen *et al.,* (2001) who reported that only the use of resistant varieties is the eco-friendly and most suitable way towards DM. Results of the present study are also in line with the findings of Khan(2001) and Goncalves *et al.,*(2004).

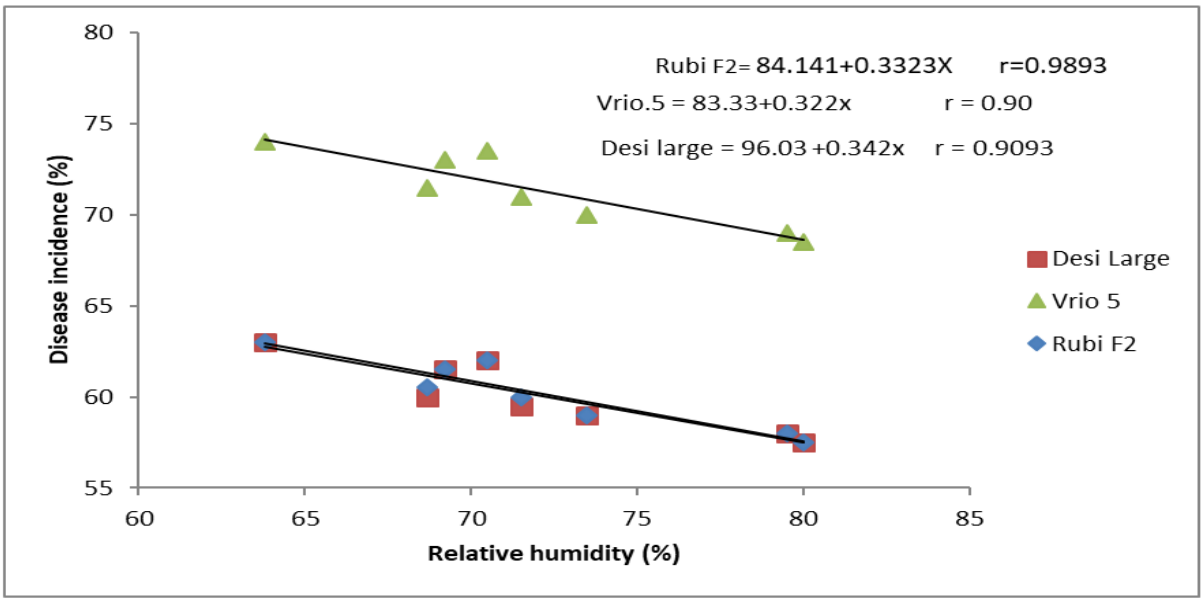

Fig. 5. Relationship between Relative humidity and disease incidence during 2018- 019 recorded on varieties/lines (y1=Desi large; y2=Vrio.5; y3=Rubi F2).

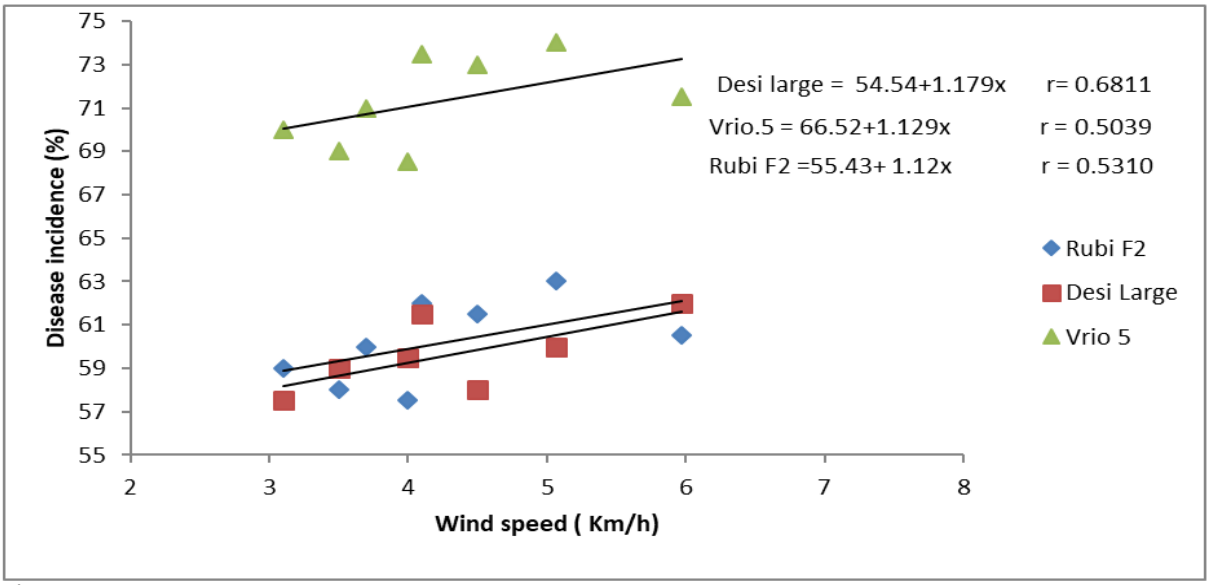

Fig. 6. Relationship between wind speed and disease incidence during 2018- 019 recorded on varieties/lines (y1=Desi large; y2=Vrio.5; y3=Rubi F2).

No doubt, the most appropriate way towards DM is the use of resistant varieties but if disease appeared suddenly in epidemic form then farmers are bound to use fungicides against DM which are quick in action towards pathogen of DM but inappropriate use of chemicals cause health hazardous and environmental pollution issues.

That is why in current study five fungicides at three concentrations were screened towards DM. Among five chemicals shincar (Carbendazin) expressed significant results against Downy mildew and caused 56.66 (%) reduction in disease. Results of the present study are supported by the work of Surviliene *et al.,* (2008); Araujo *et al.,* (2017); Araujo *et al.,* (2020)

who evaluated different chemicals towards DM and concluded that the only way to manage downy mildew of onion is the use of fungicide when disease appeared in field in the epidemic form to save production and increase production of onion. Current study is also in agreement with the work of Raziq (2008) who also used Derosal (Carbendazin) for management of DM in his study.

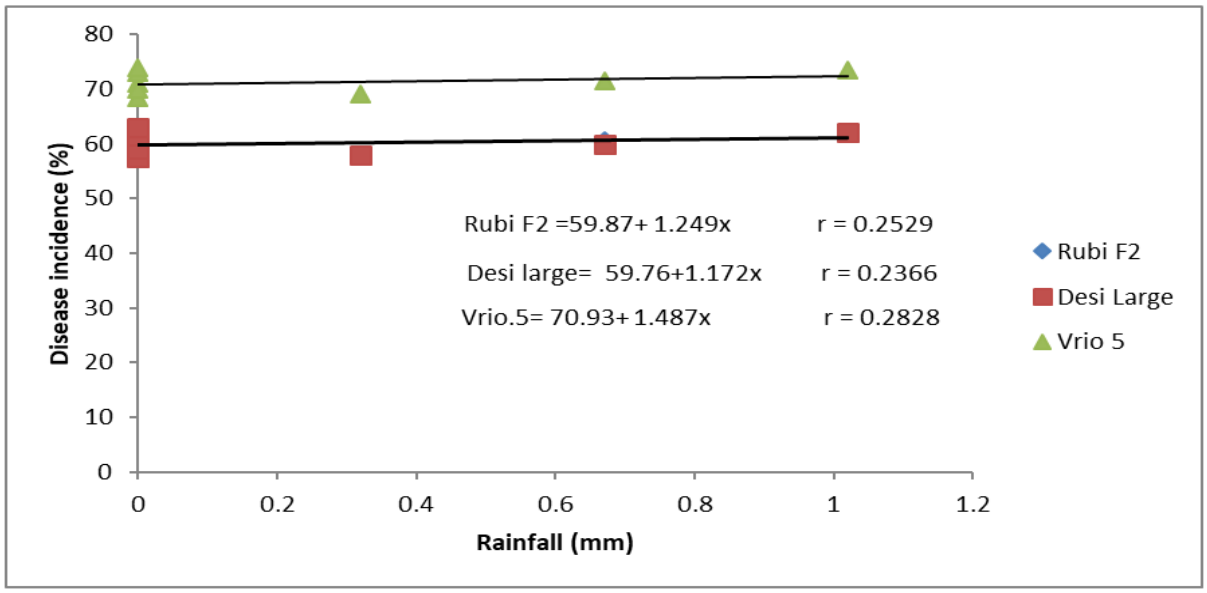

Fig. 7. Relationship between Rainfall and disease incidence during 2018- 019 recorded on varieties/lines (y1=Desi large; y2=Vrio.5; y3=Rubi F2).

For successful infection of *Perenospora destructor,* environmental factors, age of host plant, degree of resistance/ susceptibility of the host plants played a vital role. So, in current study correlation of environmental factors with disease development and characterization of epidemiological factors was done which is helpful for researchers and farmers for adopting in time management strategies towards DM to save their onion yield and uplift their profit and social status. In contemporary study, it was concluded that increase in maximum, minimum temperature, relative humidity and wind speed results in intensification of disease severity and incidence. These results are in line with the findings of Premila and Sophiarani (2015) who observed the impact of temperature and relative humidity on the sporulation of *Perenospora destructor* and found increase in DM disease intensity with increase in temperature (max. mini) and relative humidity because temperature and relative humidity uplift the process of sporulation which is responsible for increase in disease severity while wind speed is the cause of spread of spores of *P. destructor* (Gilles *et al.,* 2004).

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