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PLANT PATHOLOGY

Downy Mildew Disease Severity on Different Dates of Sowing Under Variable Weather Conditions in Different Varieties of Isabgol

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ABSTRACT

The downy mildew incited by *Peronospora plantaginis* Underwood is one of the economically important diseases of Isabgol. It is important to study and understand the role of different dates of sowing on the development of diseases and their eco-friendly management. The downy mildew symptoms appeared in four different varieties viz. GI-2, Niharika, H1-5, and HI-2009 sown on 28th October (1st DOS) on 74-76 DAS whereas it was 52-54 days when sown on 12th November (2nd DOS) and 51-52 days on the crop sown on 28th November (3rd DOS). The maximum disease intensity of 62.77% was observed during the second date of sowing and the least disease intensity was recorded on the third date of sowing (27.77%). The maximum average disease progression (7.50 cm) was observed on the first date of sowing and a minimum of 6.49 cm on the third date of sowing. As the disease intensity increased AUDPC values also increased and these values were almost similar for all four varieties with the date of sowing. The apparent infection rate increased to a greater extent from the first date of sowing to the second date of sowing thereafter, decreased during the third date of sowing.

HIGHLIGHTS

- Isabgol (*Plantago ovata*) is the most important and commercially grown medicinal crop in India for its dietary fiber.
- The seed husk is having great medicinal properties and is used to cure inflammation of the mucus membrane of gastrointestinal and genito-urinary tracts, chronic constipation, dysentery, duodenal ulcers, gonorrhea, and piles.
- It is also being used in the food industry especially in ice creams, biscuits, candies, and calico printing and setting lotions.
- The crop is affected by various biotic and abiotic factors. Downy mildew caused by *Peronospora plantaginis* is one of the major limiting factors for its production and quality.
- The growth of the fungal mycelium and disease development is highly influenced by the predisposition factors viz. temperature, relative humidity, and precipitation of dew on leaves during night hours.
- The sporangiospores germination take place early in the morning when leaves remain wet by the dew precipitation, positively correlated with the incidence and severity of the disease. Early sowing significantly reduces the disease incidence and losses in the crop.

Keywords: Isabgol, downy mildew, date of sowing, disease intensity, varieties

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The Isabgol crop is mainly distributed under commercial cultivation in Gujarat, Madhya Pradesh, Rajasthan, and Haryana in India. However, the crop is spreading to other parts of the country such as Uttar Pradesh and Karnataka. Anonymous, (2013-14). At present, the Isabgol grown as a winter season crop has acquired the place "Dollar earner" in North Gujrat and South West Rajasthan. The botanical name of Isabgol is *Plantago ovata* Forsk, and in English, it is called "Blonde Psyllium". In Sanskrit, it is known as "*Shlakshnajira Snigdhabya*". About 200 species of Psyllium are available in the world, out of which, 10 are commonly found in India. *Plantago ovata* Forsk known for superior quality husk is preferred over others. It is an annual herb belonging to the family Plantaginaceae. India is the largest producer and exporter of Isabgol in the world. Since more than 90 percent of the total production is exported all over the world through which about rupees 300 crores are earned annually. The total production of Isabgol in India is around 90,000 tonnes, however, Gujarat has maximum productivity of 632 to 672 kg/ha. Isabgol is cultivated in an area of 2000 ha in Haryana. Experiments have been conducted to explore the possibilities of successful cultivation of this crop in countries, like Australia (McNeil 1991) and the USA (Russel 1975). However, commercial cultivation has not been successful. Therefore, India enjoys a monopoly in the international trade of this plant product**.**

Isabgol has larger demands and is traded in major medicinal drug markets of the world. The use of *Plantago* species as sources of pharmaceutical drugs is reported by Shyren (1985). The husk and seeds of Isabgol are mild laxatives, emollient and demulcent. It is considered a safe laxative particularly beneficial in case of habitual constipation, chronic diarrhea, and dysentery. The seed and husk are also used to cure inflammation of the mucous membrane of gastro-intestinal and genio-urinary tracts, duodenal ulcer, gonorrhea, and piles. It can also be used as a cervical dilator for the termination of pregnancy (Anonymous 1979). Isabgol mucilage has a remarkable property as a thickener and is therefore also used for making ice cream in the west. Seeds after removal of husk are by-products of Isabgol industry are now used as a supplement in various diversified food products such as bread, cookies, and ice-cream stabilizer (Pflaumer *et al.* 1990; Trautwein *et al***.** 2000). Seeds without husk are rich in protein and used as cattle feed. Kanitkar and Pandse (1969) found its seed oil possessing the property of reducing cholesterol levels of serum in rabbits.

MATERIALS AND METHODS

The investigations were carried out on downy mildew of Isabgol (*Plantago ovate Forsk*) caused by *P. plantaginis* at MA&UUP Research farm, Department of Genetics & Plant Breeding, CCSHAU, Hisar. Four Isabgol varieties HI-5, HI-2009, GI-2, and Niharika were sown in randomized block design with four replications in a plot size of 1.5m × 2.1m on three dates viz. October 27th, November 12th and November 28th. The time of disease appearance was recorded in each variety sown at three different dates by observing the first appearance of symptoms.

Symptomatology

Symptoms were observed as chlorotic patches accompanied with ashy-white downy growth on the lower surface on these patches. Later, the infected leaves become brownish, shriveled, and distorted. At last, the whole plant becomes dry, and such infected plant produced very few ear heads.

Effect of date of sowing on the development and progression of downy mildew

Four Isabgol varieties HI-5, HI-2009, GI-2, and Niharika were sown in randomized block design with four replications in a plot size of 1.5m × 2.1m on three dates viz. October 27th, November 12th and November 28th.

Disease appearance

The time of disease appearance was recorded in each variety sown at three different dates by observing the first appearance of symptoms.

Disease intensity

The disease intensity was recorded by selecting ten random leaves from each variety sown at three staggering dates. The percent disease intensity was calculated by using the following formulae & the scale was developed which is as follows:

$$\text{Percent disease intensity (PDI)} = \frac{\text{Sum of all numerical rating}}{\text{No of leaves assessed} \times \text{Maximum disease rating}} \times 100$$

Grade	Description
0	Healthy
1	1 to 10% of leaf area infected
2	11 to 20% of leaf area infected
3	21 to 40% of leaf area infected
4	41 to 80% of leaf area infected
5	More than 80% of leaf area infected

Apparent infection rate (*r*)

Apparent infection rate (r) was calculated by disease intensity using the formula given by Vander Plank (1963):

$$r = \frac{2.3}{t_2 - t_1} \left\{ \log \frac{X_2}{1 - X_2} - \log \frac{X_1}{1 - X_1} \right\}$$

Where,

r = Apparent infection rate

t_1 = First date of recording disease intensity

t_2 = Second date of recording disease intensity

X_1 = Disease intensity at time t_1

X_2 = Disease intensity at time t_2

2.3 = Constant value

Area under disease progress curve

Area under disease progress curve (AUDPC) was calculated by disease intensity using the formula given by Wilcoxon *et al.* (1975):

$$\text{Accordingly } A = {}^{k}\sum_{i=1} \tfrac{1}{2} (Si + Si - 1) \times d$$

Where A = AUDPC value

Si = Disease severity at the end of the week

K = Number of successive evaluation of disease

d = Interval between two evaluations

RESULTS AND DISCUSSION

Pathogen

The *Peronospora plantaginis* belongs to the family *Peronosporaceae* of order *Peronosporales* of class *Oomycetes* of phylum *Oomycota*. The important characteristics of the *Peronospora plantaginis* are; the mycelial hyphae aseptate, thin-walled, sporangiophores long, hyaline, unbranched 2/3rd at the base and upper third dichotomously branched several times and each branch terminates into acute stigmata bearing single sporangium which was thin-walled smooth and ovoid to ellipsoidal. Similar types of characteristics were earlier reported by Thind, K.S. (1942) and Sharma and Pushpendra 1997).

Symptomatology

Downy mildew of Isabgol caused by *P. plantaginis* appeared as chlorotic patches accompanied with ashy-white downy growth on the lower surface on these patches. Later on, infected leaves become brown followed by curling, crinkling, and drying of leaves, which resulted in poor growth of the plant and flowering. At last, the whole plant becomes dry, and such infected plant produced very few ear heads. These types of symptoms were earlier reported by Desai and Desai (1969).

Disease appearance

The perusal of data in Table 1 revealed that the first appearance of disease was observed on 75 days on the first date of sowing whereas it was 53 days on the second date of sowing and 52 days on the third date of sowing. The disease appeared earlier during the second date of sowing however, it was late on the first and second date of sowing. The disease intensity was also calculated and data presented in Table 1 revealed that maximum disease intensity (65.55%) was observed during the second date of sowing in the variety HI-2009 followed by the first date of sowing (49.99%) in variety HI-2009 and least disease intensity was recorded in the third date of sowing (30.55%) in the same variety. The varietal behavior of downy mildew was also recorded and revealed that all four varieties were susceptible to downy mildew and there was no variation in the development of downy mildew.

Disease intensity on different dates of sowing

The results presented in Table 2 revealed that the intensity of downy mildew during the first date of sowing varied from 60-64 percent being maximum on variety GI-2 (64.44%) followed by variety Niharika (63.33%). Whereas minimum

Table 1: Effect of sowing dates on downy mildew appearance in different varieties of Isabgol under field conditions

Treatments (Date of sowing)	First appearance of disease (Days after sowing)				Mean	Disease Intensity (%)				Mean
	GI-2	Niharika	HI-5	HI-2009		GI-2	Niharika	HI-5	HI-2009	
27th October	75	76	76	74	75	48.32 (44.02)	44.99 (44.97)	49.44 (42.10)	49.99 (44.66)	48.18 (43.93)
12th November	53	53	54	54	53	61.11 (51.40)	59.99 (50.75)	64.44 (53.37)	65.55 (54.04)	62.77 (52.39)
28th November	51	52	52	52	52	26.66 (31.06)	24.99 (29.98)	28.88 (32.48)	30.55 (33.53)	27.77 (31.76)
Mean (%)						45.36 (42.16)	43.32 (41.9)	47.58 (42.65)	48.69 (44.07)	
CD at 5%						1.30				
SE(m)						0.45				
CV						2.10				

Figures in the parentheses are angular transformed values.

Table 2: Downy mildew intensity, AUDPC and apparent infection rate on different Isabgol varieties under first date of sowing

Date of observations	Varieties											
	Disease intensity (%)											
	GI-2			Niharika			HI-5			HI-2009		
	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)
11th January	4.99 (12.85)	13.47	—	7.21 (15.44)	20.13	—	6.66 (14.84)	18.48	—	5.55 (13.55)	15.15	—
14th January	8.32 (16.73)	23.46	0.38	8.88 (17.26)	25.14	0.19	9.44 (17.80)	26.82	0.25	8.32 (16.73)	23.46	0.23
17th January	14.99 (22.73)	43.47	0.41	16.66 (24.06)	48.48	0.44	16.1 (23.59)	46.8	0.37	13.33 (21.37)	38.49	0.33
20th January	25.55 (30.34)	75.15	0.37	26.66 (31.06)	78.48	0.32	23.88 (29.22)	70.14	0.27	23.88 (29.22)	70.14	0.4
23rd January	35.55 (36.56)	105.15	0.22	36.1 (36.87)	106.8	0.21	34.44 (35.90)	101.82	0.25	33.33 (35.24)	98.49	0.23
26th January	52.21 (46.25)	155.13	0.26	52.22 (46.25)	155.16	0.25	49.99 (44.97)	148.47	0.25	49.43 (44.66)	146.79	0.27
29th January	55.55 (48.16)	165.15	0.04	54.99 (47.85)	163.47	0.03	53.33 (46.89)	158.49	0.04	52.22 (46.25)	155.16	0.04
1st February	60 (50.75)	178.5	0.05	58.32 (49.77)	173.46	0.04	57.77 (49.45)	171.81	0.05	56.66 (48.80)	168.48	0.05
4th February	63.33 (52.71)	188.49	0.03	62.22 (52.06)	185.16	0.04	60 (50.75)	178.5	0.03	59.44 (50.42)	176.82	0.03
7th February	64.44 (53.37)	191.82	0.01	63.33 (52.72)	188.49	0.01	61.66 (51.72)	183.48	0.02	60.55 (51.07)	180.15	0.01
CD at 5%	1.90			2.15			2.30			1.28		

AUDPC = Area under disease progress curve, AIR = Apparent infection rate, figures in the parentheses are angular transformed values.

disease intensity was recorded on the variety HI-2009 (60.55%).

On the second date of sowing, data presented in Table 3 revealed that disease intensity varied from 72 – 75 percent being maximum on the variety Niharika (74.99%) followed by the variety GI-2 (74.44%). Whereas minimum disease intensity was recorded on the variety HI-2009 (72.22%).

On the third date of sowing, data presented in Table 4 revealed that disease intensity varied from 51 – 53 percent being maximum on the variety Niharika (53.33%) and minimum on HI-2009 (51.11%). The results revealed that the downy mildew intensity was increased from 64 – 75 percent when a crop is sown in the first fortnight of November. However, disease intensity decreased from 74 - 53 percent when the crop is sown in the second fortnight of November. The varietal behavior on the development/progression of downy mildew was also recorded and revealed that all four varieties were susceptible to downy mildew and there was no variation in the development of downy mildew concerning the varietal behavior.

The development of disease in any crop under field conditions is critically influenced by the variation in sowing time. In the present studies, the sowing done at different periods had a profound effect on the development of downy mildew of Isabgol. The first appearance of the downy mildew disease in four different varieties namely viz; GI-2, Niharika, HI-2009 and HI-2009 (Patel J.G. and Desai M.V. 1987) of Isabgol sown on 28th October appeared on 74 – 76 DAS whereas, it was 52 – 54 DAS in 2nd date of sowing (12th November) and 51 – 52 DAS in 3rd

Table 3: Downy mildew intensity, AUDPC and apparent infection rate on different Isabgol varieties under second date of sowing

Date of observations	Varieties											
	Disease intensity (%)											
	GI-2			Niharika			HI-5			HI-2009		
	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)
05th January	6.66 (14.84)*	18.48	—	6.1 (14.15)	16.8	—	5.55 (13.55)	15.15	—	4.99 (12.85)	13.47	—
08th January	17.21 (24.47)	50.13	0.67	16.66 (24.06)	48.48	0.71	16.1 (23.61)	46.8	0.75	15.55 (23.18)	45.15	0.80
11th January	23.33 (28.86)	68.49	0.20	22.22 (28.09)	65.16	0.20	21.11 (27.33)	61.83	0.19	20 (26.53)	58.5	0.17
14th January	27.77 (31.78)	81.81	0.12	27.21 (31.41)	80.13	0.14	25.55 (30.34)	75.15	0.13	24.44 (29.60)	71.82	0.13
17th January	31.66 (34.21)	93.48	0.09	32.22 (34.56)	95.16	0.11	31.1 (33.86)	91.8	0.13	29.99 (33.19)	88.47	0.14
20th January	48.32 (44.02)	143.46	0.29	47.77 (43.70)	141.81	0.26	47.21 (43.38)	140.13	0.28	45.55 (42.42)	135.15	0.28
23rd January	53.33 (46.89)	158.49	0.06	51.66 (45.93)	153.48	0.08	51.1 (45.61)	151.8	0.05	49.99 (44.97)	148.47	0.06
26th January	68.88 (56.08)	205.14	0.17	69.99 (56.76)	208.47	0.18	68.32 (55.73)	203.46	0.19	66.66 (54.79)	198.48	0.19
29th January	73.33 (58.89)	218.49	0.04	73.88 (59.25)	220.14	0.03	72.77 (58.52)	216.81	0.04	71.66 (57.81)	213.48	0.05
01st February	74.44 (59.61)	221.82	0.01	74.99 (59.97)	223.47	0.01	73.88 (59.24)	220.14	0.01	72.22 (58.17)	215.16	0.004
CD at 5%	1.97			2.01			1.86			1.56		

AUDPC = Area under disease progress curve, AIR = Apparent infection rate, figures in the parentheses are angular transformed values.

Table 4: Downy mildew intensity, AUDPC and apparent infection rate on different Isabgol varieties under third date of sowing

Date of observations	Varieties											
	Disease intensity (%)											
	GI-2			Niharika			HI-5			HI-2009		
	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)	Disease intensity (%)	AUDPC	AIR (*r*)
19th January	4.99 (12.85)*	13.47	—	5.55 (13.45)	15.15	—	5.55 (13.45)	15.15	—	4.99 (12.85)	13.47	—
22nd January	8.88 (17.26)	25.14	0.41	8.32 (16.67)	23.46	0.23	7.77 (16.14)	21.81	0.24	8.32 (16.73)	23.46	0.37
25th January	18.88 (25.73)	55.14	0.52	17.77 (24.90)	51.81	0.53	16.66 (24.06)	48.48	0.53	15.55 (23.18)	45.15	0.43
28th January	30.55 (33.53)	90.15	0.32	29.99 (33.19)	88.47	0.36	28.88 (32.48)	85.14	0.38	27.77 (31.78)	81.81	0.40
31st January	32.77 (34.90)	96.81	0.05	33.33 (35.24)	98.49	0.07	32.77 (34.90)	96.81	0.08	32.22 (34.56)	95.16	0.10
3rd February	35.55 (36.58)	105.15	0.05	36.1 (36.91)	106.8	0.05	34.99 (36.25)	103.47	0.04	34.44 (35.91)	101.82	0.04
6th February	38.88 (38.56)	115.14	0.06	39.44 (38.88)	116.82	0.06	38.32 (38.23)	113.46	0.06	37.77 (37.90)	111.81	0.06
9th February	48.88 (44.34)	145.14	0.15	49.43 (44.66)	146.79	0.15	47.77 (43.70)	141.81	0.15	46.66 (43.06)	138.48	0.14
12th February	51.11 (45.61)	151.83	0.02	51.66 (45.93)	153.48	0.03	49.99 (44.97)	148.47	0.03	50.55 (45.29)	150.15	0.05
15th February	52.22 (46.25)	155.16	0.01	53.33 (46.89)	158.49	0.02	51.66 (45.93)	153.48	0.02	51.11 (45.61)	151.83	0.01
CD at 5%	1.36			1.76			1.74			1.57		

AUDPC = Area under disease progress curve, AIR = Apparent infection rate, figures in the parentheses are angular transformed values.

date of sowing (28th November). The results further revealed that maximum disease intensity (62.77%) was observed during the 2nd date of sowing by the 1st date of sowing (48.16%) and the least disease intensity was recorded on the 3rd date of sowing (27.70%). This indicates that there was a role of hostage in occurrence and that with an increase in yield, the Isabgol plant becomes susceptible to the disease. The relation of tissues to a pathogen may change with maturity and many factors are probably involved. Younger tissues may produce more phytoalexins or produce it more quickly or biochemical changes in the maturity tissues may make it a more or less suitable substrate for the pathogen (Tar 1972). In the present investigation age of Isabgol plants affected the downy mildew initiation as disease did not appear till the plant had attained plant age of 74 – 76 days on 1st date of sowing, 52 – 54 days on the 2nd date of sowing, and 51 – 52 day in 3rd date of sowing. Plant age of 51-76 days was found the most susceptible stage for the infection and development of disease. This might

be due to the presence of phenolic compounds and other inhibitors in the plant. Rajpurohit (2001) has reported that total and ortho- dihydric phenols in the healthy tissues of the Isabgol plant reduced with the increase in age of the plant. It was also observed that the total phenolics declined rapidly during the development of the plant to a relatively low concentration than *P. plantaginis* attacked the leaves (Anonymous, 1981). These basic data can help in deciding the sowing date and preparing a timely schedule for a fungicidal spray for their effective control. The role of hostage in the development of downy mildew has been reported in the case of corn (Sun *et al.* 1966) and mustard (Singh 1998). Gandhi *et al*. (1996) reported that ridge gourd downy mildew (*Pseudoperonospora cubensis*) did not develop in a young crop of fewer than 30 days of age even under the congenial weather conditions for disease development.

An early and late sown crop had less severity of disease whereas normal sowing crop (last week of October to 20th November.) suffered greater damage in the crop i.e. an average of 62.77% disease intensity in different varieties of Isabgol. Similar observations had already been made by Kumawat and Sharma (2000) from Rajasthan. At Hisar conditions, the maximum disease appeared in November. Sown crop as by that time, early sown crop almost complete the most susceptible stage which may defer sufficient inoculum build-up at early crop stage and thus, severe damage to the crop is avoided. In late sown crops the reason for less severity of disease seems to be that the prime growth period for infection of the late sown plant falls in a period of high minimum and maximum temperature and low humidity. Present investigations indicated that Isabgol sown by mid-October was good for protecting the crop from downy mildew under present conditions. Rathore and Pathak (2002) have, however, demonstrated that the downy mildew of Isabgol in Rajasthan can be effectively managed by early sowing of the crop.

The higher disease intensity, value of AUDPC, and Apparent infection rate were observed particularly in the first fortnight of January in all four varieties with dates of sowing. Our results are in agreement with the earlier reports of Sun, M.H., Chang, S.C. and Chen N.C. (1966), Kumawat and Sharma (2000) and Rathore (2008). The results revealed that as the disease intensity increased, the AUDPC value was increased and their value was almost similar in all four varieties. Similarly, the Apparent infection rate also increased to a greater extent from 1st date of sowing to 2nd date of sowing and then decreased during 3rd date of sowing.

Isabgol (*Plantagoovata* Forsk) is an important medicinal plant. The crops suffer a lot due to fungal diseases. Among all diseases, downy mildew caused by *P. plantaginis* Underwood is the most important and widespread disease, which appears in severe form every year and causes extensive damage to the crop. The disease causes up to 32.1 % and 37.1% reduction in seed and straw yield (Rathore and Rathore 1996; Kumawat and Sharma 2000).

Studies were therefore conducted to know the role of environmental factors responsible for downy mildew progression, development, and management of disease through eco-friendly approaches. The fungus produced pale brown chlorotic spots on the leaf blade accompanied with characteristics of ash-colored downy growth on the lower surface on these patches. As the disease progressed, leaves turned yellowish due to the loss of chlorophyll. Later, the infected leaves became brownish, shriveled, wrinkled, and distorted. At last, the whole plant becomes dry & such infected plants produced very few ear head. In diseased plants, plant height and the number of tillers also decreased.

CONCLUSION

Isabgol crop sown in different dates revealed that downy mildew usually appeared in the first fortnight of January and continued to progress up to the first week of February and stabilize thereafter on all four varieties under natural field conditions. The different dates had a profound effect on the development of downy mildew and all three dates showed non-systemically infected plants in all four varieties. Furthermore, as the disease intensity increased, AUDPC values also increased as well and these values were almost similar for all four varieties with the date of sowing. The maximum apparent infection rate was observed during mid of January on all the varieties. Its rate increased to a greater extent from 1st date of sowing to 2nd date of sowing then decreased during 3rd date of sowing.

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