IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
ISSN-0973-1547 Volume 17 | Issue 1 | January, 2022 | 76-81

DOI: 10.15740/HAS/IJPS/17.1/76-81
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**RESEARCH ARTICLE**

# Effect of different inoculum levels of *P. arborescens* in disease development and yield losses of opium poppy

■ **Roop Singh, Pokhar Rawal and Irfan Khan**

## SUMMARY

Downy mildew (DM) caused by *Peronospora arborescens* is the most alarming disease of opium poppy which hampered the production of opium crop in major growing areas of India. The pooled data taken from *Rabi* 2016-17 and 2017-18 demonstrated that chemical protected un-inoculated plot had a minimum per cent disease severity (9.83) with maximum dry latex yield (31.25 kg $ha^{-1}$), seed yield (801.31 kg $ha^{-1}$) and husk yield (889.66 kg $ha^{-1}$). However, plots inoculated with *Peronospora arborescens* at high inoculum density of $9\times10^5$ spores $ml^{-1}$ had considerably higher per cent disease severity (67.00) and minimum dry latex yield (6.94 kg $ha^{-1}$), seed yield (548.42 kg $ha^{-1}$) and husk yield (590.86 kg $ha^{-1}$) with maximum 77.79,31.56 and 33.58 per cent loss as compared to un-inoculated chemical protected plot, respectively. The severity of the downy mildew disease was found to rise in direct conflict with the level of inoculum concentration with significant reduction in dry latex yield, seed yield and husk yield.

**Key Words :** Opium poppy, Yield losses, *P. arborescens*

**How to cite this article :** Singh, Roop, Rawal, Pokhar and Khan, Irfan (2022). Effect of different inoculum levels of *P. arborescens* in disease development and yield losses of opium poppy. *Internat. J. Plant Sci.*, **17** (1): 76-81, **DOI: 10.15740/HAS/IJPS/17.1/76-81,** Copyright@ 2022:Hind Agri-Horticultural Society.

**Article chronicle : Received :** 02.08.2021; **Revised :** 25.10.2021; **Accepted :** 27.11.2021

Opium poppy (*Papaver somniferum* L.) is a member of the *Papaveraceae* family and one of the earliest known medicinal plants (Kapoor, 1995). Around 80 annual, biennial, and perennial herbs in the genus *Papaver* are found in Central and South Western Asia, Central and Southern Europe and North Africa (Carolan *et al.,* 2006). Opium or oilseed poppy (*P. somniferum* L.), the most well-known species, is an ancient medicinal plant grown for both its edible seed and opium production (Kapoor, 1995; Cotterill and Pascoe, 1998; Williams and Ellis, 1989; Facchini and Park, 2003 and Ozcan and Atalay, 2006). The capsule is the plant's most important part, supplying raw opium and edible seeds. About 70% of the total morphine generated by the plant is contained in the capsule (Mishra, 2021). The seeds of the opium poppy are extremely nutritious, containing upto 24% protein and other essential minerals

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for human health. In some parts of the world, the plant's leaves are consumed as a vegetable. Poppy seed oil is also beneficial to human health because it contains a high percentage of linoleic acid (68%) that aids in the reduction of blood cholesterol levels and is also utilized in the treatment of cardiovascular diseases (Vos and Cunnne, 2003 and Sacks and Campos, 2006). Furthermore, the opium poppy is grown for its seeds and seed oil, both of which are high in unsaturated fatty acids (Mishra *et al.,*2013). It is grown in India for the production of edible seeds, oil, and opium latex under narcotic control in places like Uttar Pradesh, Rajasthan, and Madhya Pradesh. In Rajasthan, it is cultivated among the districts of Chittorgarh, Kota, Udaipur, Jhalawar, Baran, Bhilwara and Pratapgarh (Patel *et al.,* 2020).

India is a leading opium supplier on the world market, and it must always strive to maintain its top position by improving productivity. Downy mildew, caused by *Peronospora* spp., is one of the most serious diseases of the opium poppy and is responsible for preventable crop losses around the world (Cotterill and Pascoe, 1998; Yossifovitch, 1929; Scott *et al.,* 2003; Scott *et al.,* 2004 and Landa *et al.,* 2007). The disease severity was observed to be 25 per cent with the infection progressing upwards from lower leaves and affecting the flower and capsule at plant maturity (Gupta *et al.,* 2016). The incidence of disease occurs in between 20 to 30 per cent of plant population in the districts of Barabanki, Rampur, Lucknow and their adjoining areas of Uttar Pradesh (Alam *et al.,* 2014). Due to a massive systemic infection of downy mildew, capsule formation is hampered. As a result, the opium output is drastically reduced, resulting in economic losses.

Hence, the present investigation was planned with major emphasis on disease development and estimation of losses at different inoculum levels of *P. arborescens* which causes DM in opium poppy.

## MATERIAL AND METHODS

The field experiment has been carried out during two consecutive years 2016-17 and 2017-18 at research farm, RCA, Udaipur to assess the disease development and reduction in dry latex yield, seed yield and husk yield of opium poppy under different inoculum levels of pathogen at $1\times10^5$, $3\times10^5$, $5\times10^5$, $7\times10^5$ and $9\times10^5$ spore $ml^{-1}$ and un-inoculated chemical protected with seed treatment with Metalaxyl @ 8g/kg seed plus three foliar sprays of (Mancozeb 64% + Metalaxyl 8%) 72 WP @ 0.25 % at 30, 45 and 60 DAS and un-inoculated unprotected served as check. Opium poppy cultivar 'Chetak Aphim' were sown in 3×2 sqm plot size with 30×10 cm crop geometry. Each treatment with three replications were planned in Randomized Block Design (RBD). The crop was raised as per recommended package of practices and protective irrigation was given as and when required. The virulent pathogen inoculum (Udrca1) was used for inoculation with spray inoculation technique. Fifty days old plants were used for inoculation and sprayed with sterile water before inoculation. For preparation of aqueous spore suspension undersurface of infected leaves gently scrapped with the help of brush in sterile water. This spore suspension was filtered through two layer of cheese cloth to remove debris. Before inoculation conidial concentration was adjusted to different inoculum level of pathogen with the help of hemocytometer (Sattar *et al.,* 1995). Fifty days old plants were inoculated with spore suspension of pathogen by spraying using hand atomizer during early morning. High humidity and canopy temperature was maintained throughout disease development period by frequent irrigation and spraying of water.

Observations of 5 randomly selected plants of each plot for disease severity were recorded by using standard downy mildew disease rating 0-9 scale (Kim *et al.,* 1999) and per cent disease severity was observed by using following formula:

$$\text{PDS} = \frac{\sum(\text{rating of each plant})}{\text{Numbers of plant rated x Maximum disease grade}} \text{ x } 100$$

The yield of seed and capsule of each plot was recorded at the time of harvest. The latex yield of each plot was collected and dried in hot air oven after that dry latex yield were recorded. The per cent loss in yield was observed by following formula:

$$\text{\% loss in yield} = \frac{\text{Yield in control} - \text{Yield in treatment}}{\text{Yield in control}} \text{ x } 100$$

### Data analysis :

Data were subjected to analysis of variance determined at 5 and 1 per cent probability. Treatment means were compared using RBD to determine efficacy of the different treatments.

## RESULTS AND DISCUSSION

In two consecutive years, 2016-17 and 2017-18, experiments were conducted to assess the disease severity and yield losses caused by downy mildew of the opium poppy. The disease emerged eight days after inoculation and the severity of the disease increases in lockstep with the plant's growth until capsule formation. The data taken from *Rabi* 2016-17 and 2017-18 demonstrated that chemical protected un-inoculated plot had a minimum PDS (9.83). Plots inoculated *Peronospora arborescens* at high inoculum density of $9\times10^5$ spores $ml^{-1}$ had considerably higher PDS (67.00) which subsequently decreased at density levels of $7\times10^5$, $5\times10^5$, $3\times10^5$, $1\times10^5$ and un-inoculated un-protected check with PDS of 55.17, 50.00, 37.50, 33.00 and 28.63, respectively (Table 1 and Fig. 1).

The severity of the disease on the plants resulted in a significant reduction in dry latex, seed and husk yield.

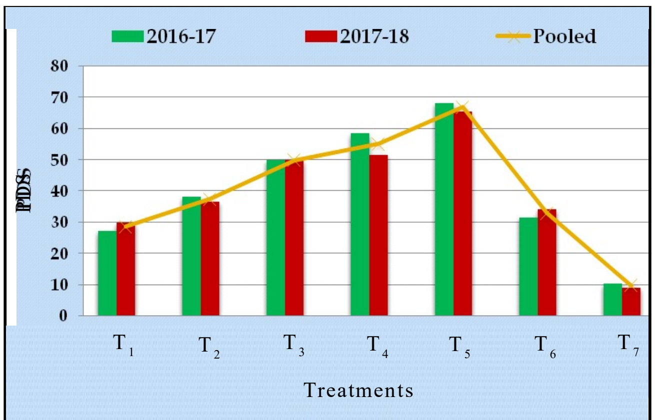


**Fig. 1: Effect of different inoculum levels of *Peronospora arborescens* on disease development during *Rabi* 2016-17 and 2017-18**

The pooled data analysis of the year *Rabi* 2016-17 and 2017-18 pointed out that the maximum dry latex yield found in chemical protected un-inoculated plot was 31.25 kg $ha^{-1}$. Whereas the minimum dry latex yield 6.94 kg $ha^{-1}$ was found in plot inoculated *Peronospora arborescens* at high inoculum density of $9\times10^5$ spores $ml^{-1}$with maximum 77.79 per cent loss in dry latex yield as compared to un-inoculated chemical protected plot. However, the plots inoculated with higher to lower inoculum density levels as $7\times10^5$, $5\times10^5$, $3\times10^5$, $1\times10^5$ and un-inoculated un-protected check the dry latex yield was recorded eventually lower to higher as 12.92, 14.20, 17.36, 22.11 and 22.57kg $ha^{-1}$, respectively with per cent loss in dry latex yield was gradually higher to lower as 58.65, 54.56, 44.45, 29.24 and 27.78 as compared to un-inoculated chemical protected plot, respectively. In terms of seed yield in the year *Rabi* 2016-17 and 2017-18 pointed out that the maximum seed yield found in chemical protected un-inoculated plot was 801.31 kg $ha^{-1}$. Whereas the minimum seed yield 548.42 kg $ha^{-1}$ was found in plot inoculated *Peronospora arborescens* at high inoculum density of $9\times10^5$ spores $ml^{-1}$ with maximum 31.56 per cent loss in seed yield as compared to un-inoculated chemical protected plot. However, the plots inoculated with higher to lower inoculum density levels as $7\times10^5$, $5\times10^5$, $3\times10^5$, $1\times10^5$ and un-inoculated un-protected check the seed yield was recorded eventually lower to higher as 557.87, 559.80, 619.60, 636.77 and 675.15 kg $ha^{-1}$, respectively with per cent loss in seed yield was gradually higher to lower as 30.38, 30.14, 22.68, 20.53

**Table 1: Effect of different inoculum levels of *Peronospora arborescens* (Berkeley) de bary on disease development during *Rabi* 2016-17 and 2017-18**

| Treatments | PDS** | | |
|---|---|---|---|
| | 2016-17 | 2017-18 | Pooled |
| $T_1$–Artificial inoculation of causal organisms @ $1\times10^5$ spores/ml | 31.67 (34.25) | 34.33 (35.87) | 33.00 |
| $T_2$ - Artificial inoculation of causal organisms @ $3\times10^5$ spores/ml | 38.33 (38.25) | 36.67 (37.27) | 37.50 |
| $T_3$ - Artificial inoculation of causal organisms @ $5\times10^5$ spores/ml | 50.00 (45.00) | 50.00 (45.00) | 50.00 |
| $T_4$ - Artificial inoculation of causal organisms @ $7\times10^5$ spores/ml | 58.67 (49.99) | 51.67 (45.96) | 55.17 |
| $T_5$ - Artificial inoculation of causal organisms @ $9\times10^5$ spores/ml | 68.33 (55.75) | 65.67 (54.13) | 67.00 |
| $T_6$–un-inoculated un-protected check | 27.33 (31.52) | 30.00 (33.21) | 28.67 |
| $T_7$ -Chemical protected check – seed treatment (ST) with Metalaxyl @ 8g/kg seed plus three foliar sprays of (Mancozeb 64% + Metalaxyl 8%) 72 WP @ 0.25 % at 30, 45 and 60 DAS | 10.50 (18.91) | 9.17 (17.63) | 9.83 |
| S.E.± | 11.20 | 9.90 | |
| C.D. (P=0.05) | 9.95 | 8.79 | |
| C.D. (P=0.01) | 13.95 | 12.33 | |
| CV(%) | 13.76 | 12.49 | |

*Mean of three replications, **Figures in parentheses are arcsine per cent angular transformed value and 15.74 as compared to un-inoculated chemical protected plot, respectively. The pooled data analysis of the year *Rabi* 2016-17 and 2017-18 pointed out that the maximum husk yield found in chemical protected un-inoculated plot was 889.66 kg ha$^{-1}$. Whereas the minimum husk yield 590.86 kg ha$^{-1}$ was found in plot inoculated *Peronospora arborescens* at high inoculum density of 9×10$^5$ spores ml$^{-1}$with maximum 33.58 per cent loss in husk yield as compared to un-inoculated chemical protected plot. However, the plots inoculated with higher to lower inoculum density levels as 7×10$^5$, 5×10$^5$, 3×10$^5$, 1×10$^5$ and un-inoculated un-protected check the seed yield was recorded eventually lower to higher as 603.78, 637.15, 657.98, 705.82 and 716.43kg ha$^{-1}$, respectively with per cent loss in husk yield was gradually higher to lower as 32.13, 28.38, 26.04, 20.66 and 19.47as compared to un-inoculated chemical protected plot, respectively. In terms of dry latex yield, seed yield and husk yield plots inoculated with lower inoculum density were shown to be considerably superior to plots inoculated with higher concentrations (Table 2).

Our investigation findings are well supported by

**Table 2 : Estimation of losses at different inoculums levels of *Peronospora arborescens* (Berkeley) de bary on opium poppy during *Rabi* 2016-17 and 2017-18**

| Treatments | Dry latex yield* (kg$^{-ha}$) | | | | Seed yield* (kg ha$^{-1}$) | | | | Husk yield* (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016-17 | 2017-18 | Pooled | % Loss in dry latex yield | 2016-17 | 2017-18 | Pooled | % Loss in seed yield | 2016-17 | 2017-18 | Pooled | % Loss in husk yield |
| $T_1$ – Artificial inoculation of causal organisms @ 1×10$^5$ spores/ml | 21.91 | 22.30 | 22.11 | 29.24 | 640.82 | 632.71 | 636.77 | 20.53 | 714.50 | 697.14 | 705.82 | 20.66 |
| $T_2$ - Artificial inoculation of causal organisms @ 3×10$^5$ spores/ml | 17.36 | 17.36 | 17.36 | 44.45 | 621.53 | 617.67 | 619.60 | 22.68 | 656.25 | 659.72 | 657.98 | 26.04 |
| $T_3$ - Artificial inoculation of causal organisms @ 5×10$^5$ spores/ml | 13.73 | 14.66 | 14.20 | 54.56 | 571.76 | 547.84 | 559.80 | 30.14 | 648.53 | 625.77 | 637.15 | 28.38 |
| $T_4$ - Artificial inoculation of causal organisms @ 7×10$^5$ spores/ml | 12.35 | 13.50 | 12.92 | 58.65 | 563.66 | 552.08 | 557.87 | 30.38 | 606.09 | 601.46 | 603.78 | 32.13 |
| $T_5$ - Artificial inoculation of causal organisms @ 9×10$^5$ spores/ml | 6.56 | 7.33 | 6.94 | 77.79 | 560.18 | 536.65 | 548.42 | 31.56 | 598.76 | 582.95 | 590.86 | 33.58 |
| $T_6$ – un-inoculated un-protected check | 23.15 | 21.99 | 22.57 | 27.78 | 682.87 | 667.44 | 675.15 | 15.74 | 730.32 | 702.54 | 716.43 | 19.47 |
| $T_7$ - Chemical protected check – seed treatment (ST) with Metalaxyl @ 8g/kg seed plus three foliar sprays of (Mancozeb 64% + Metalaxyl 8%) 72 WP @ 0.25 % at 30, 45 and 60 DAS | 29.32 | 33.18 | 31.25 | 0.00 | 810.96 | 791.67 | 801.31 | 0.00 | 903.35 | 875.96 | 889.66 | 0.00 |
| S.E.± | 4.99 | 3.92 | | | 66.93 | 92.29 | | | 44.53 | 35.94 | | |
| C.D.(P=0.05) | 4.43 | 3.48 | | | 59.43 | 81.95 | | | 39.54 | 31.92 | | |
| C.D. (P=0.01) | 6.21 | 4.88 | | | 83.35 | 114.93 | | | 55.46 | 44.76 | | |
| CV(%) | 14.05 | 10.54 | | | 5.26 | 7.43 | | | 3.20 | 2.65 | | |

Cheema *et al.,* 1990 who reported that opium poppy downy mildew disease, caused by *Peronospora arborescens*, is widespread in Madhya Pradesh and Rajasthan and has been found to diminish latex and seed yields by upto 25 per cent every year. In surveyed fields in India, secondary infections of opium poppy downy mildew vary from 25 to 75 per cent caused an average drop of 19.20 per cent latex and 12.6 per cent seed yield (Thakore *et al*., 1980). Further work on estimation of yield losses observed that due to secondary infection of disease resulting losses of latex yield between 17 to 22.8 per cent and 12.9 to 14.8 for seed yield (Thakore *et al.,* 1983). Similar findings reported by Sharma (2002), downy mildew infection of the opium poppy caused a 39.9 per cent decrease in opium latex yield and a 45.8 per cent decrease in seed yield. Barnawal *et al.* (2017) demonstrated that downy mildew disease is one of the major limiting factors for successful cultivation of *P. somniferum* in northern India which was similar to our research findings.

## Conclusion:

Chemical protected un-inoculated plot had a minimum per cent disease severity (9.83) with maximum dry latex yield (31.25 kg $ha^{-1}$), seed yield (801.31 kg $ha^{-1}$) and husk yield (889.66 kg $ha^{-1}$). However, plots inoculated with *Peronospora arborescens* at high inoculum density of $9\times10^5$ spores $ml^{-1}$ had considerably higher per cent disease severity (67.00) and minimum dry latex yield (6.94 kg $ha^{-1}$), seed yield (548.42 kg $ha^{-1}$) and husk yield (590.86 kg $ha^{-1}$) with maximum 77.79,31.56 and 33.58 per cent loss as compared to un-inoculated chemical protected plot, respectively.

## Conflict of interest:

The authors declare that they have no conflict of interest.

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