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Research Article

MANAGEMENT OF LINSEED POWDERY MILDEW CAUSED BY *Leveillula taurica* (LEV.) ARN

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Abstract- Linseed (*Linum usitatissimum* L.) is a member of the family Linaceae, an important oilseed crop grown in temperate and tropical zone for its seed as well as fibre, further used in the manufacture of linen. India is an important producer which contributes about 11.2 per cent to world acreage producing about 7 per cent of world production. The oil is rich (> 66 %) in linolenic acid, and is a perfect drying oil. Powdery mildew of linseed caused by *Leveillula taurica* (Lev.) Arn. is one of the economically important diseases that causes loss up to 60 per cent. While management of the disease, two sprays of hexaconazole (1 ml/l) and two sprays of wettable sulphur (4 g/l) at 45 and 60 DAS were found significantly superior (12% and 17.33% respectively). Similarly the plot treated with *P. fluorescens* (5 g/l) on 45 th day followed by hexaconazole on 60 day at 1 ml/l recorded 20 per cent disease severity.

Keywords- Linseed, Powdery Mildew, *Leveillula taurica*, fungicides.

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Introduction

Linseed (*Linum usitatissimum* L.) is a member of the family Linaceae, an important oilseed crop grown in temperate and tropical zone for its seed as well as fiber, further used in the manufacture of linen. The name Linum originated from the Celtic word *lin* which means "thread", and the name *usitatissimum* is from Latin word means "most useful". Linseed occupies a greater importance among oilseeds owing to its various uses and special qualities. It is grown mainly for seed for extracting oil in rainfed conditions. The oil is rich in linolenic acid (> 66%). It is good in taste and contains 36 per cent protein, 85 per cent of which is digestible. It is also used as organic manure. The cake contains about 5 per cent N, 1.4 per cent P_2O_5 and 1.8 per cent K_2O.

Among the various diseases like rust, wilt, seedling blight, pasmo, the powdery mildew of linseed caused by *Leveillula taurica* (Lev.) Arn. is one of the economically important diseases that causes loss up to 60 per cent. The disease usually covers host leaf surface and capsule hence reducing the photosynthetic area and activity. The disease occurs in severe form in *rabi* season which is also the main season for linseed cultivation, particularly when temperature is low (20-25 ^{o}C) and humidity is high (80-90 %).

Use of chemicals to manage the disease is an age-old practice in plant protection in the absence of resistant varieties or where there is break down of resistance in commercial varieties by evolution of virulent strain of a pathogen. Hence, efficacy of fungicide including new generation molecules and bio agents which will help in reducing the loss due to powdery mildew epidemics and thus reduce the environmental hazards and fungicidal resistance. Many systemic and non-systemic fungicides are reported to manage the powdery mildew of linseed. But the information on the efficacy of different fungicides against powdery mildew of linseed is insufficient. There was a need to evaluate fungicides and bioagents against *L. taurica,* as bioagents are found to be environmentally safe and economically viable thus different bioagents are to be evaluated against powdery mildew of linseed.

Material and Methods

A field trial on integrated management of powdery mildew was carried out at MARS, College of Agriculture, Raichur during *rabi* 2014-2015 using a susceptible variety T-397. The experiment was carried out in randomized block design with ten treatments and three replications and in each replication one control plot without fungicidal application was maintained. The chemicals were measured accurately just before spraying and mixed thoroughly with water. Treatments were imposed at 45th and 60th DAS by spraying. Percent Disease Index (PDI) was calculated by using the following formula proposed by Wheeler, [7]. The details of the treatment combinations are furnished here under.

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of all the individual disease ratings}}{\text{Number of plants observed} \times \text{Maximum disease grade}} \times 100$$

Disease scale

Score	Infection	Disease reaction
0	0 %	Immune
1	0-10 %	Resistant
2	10.1-25 %	Moderately resistant
3	25.1-50 %	Moderately susceptible
4	50.1-75 %	Susceptible
5	>75%	Highly susceptible

Experimental details

Treatments	Treatment details
T_1	Two sprays with hexaconazole at 1 ml/l
T_2	Two sprays with wettable sulphur at 4 g/l
T_3	Two sprays with *Pseudomonas flourescens* at 5 g/l
T_4	First spray with *P. fluorescens* at 5 g/l followed by second spray with hexaconazole at 1 ml/l
T_5	First spray with *P. fluorescens* at 5 g/l followed by second spray with wettable sulphur at 4 g/l
T_6	Two sprays with *Bacillus subtilis* at 5 g/l
T_7	First spray with *P. fluorescens* at 5 g/l followed by second spray with *B. subtilis* at 5g/l
T_8	First spray with *B. subtilis* at 5 g/l followed by second spray with wettable sulphur at 4 g/l
T_9	First spray with *B. subtilis* at 5 g/l followed by second spray with hexaconazole at 1 ml/l
T_{10}	Control

Note: In all the treatments first spray was taken at 45 DAS and second spray at 60 DAS.
DAS- Days after sowing

Result and Discussion

The results [Table-1] revealed that, the treatments *viz*., two sprays of hexaconazole (1ml/l) and two sprays of wettable sulphur (4 g/l) at 45th and 60th DAS were on par with each other and found significantly superior (12% and 17.33% respectively) compared to control (89.33%). Similarly, the treatments consisting of two sprays of *P. fluorescens* (5 g/l) and two sprays of *B. subtilis* (5 g/l) at 45th and 60th DAS recorded PDI of between 25.33 and 30.67 per cent respectively. The foliar spray with *P. fluorescens* (5 g/l) on 45th day followed by hexaconazole on 60th day at 1 ml/l recorded PDI of 20.00 per cent and *P. fluorescens* (5 g/l) spray followed by sulphur at 4 g/l has recorded 22.67 PDI on 45th and 60th DAS respectively.

The treatments consisting of one spray with *B. subtilis* (5 g/l) at 45th day followed by hexaconazole (1 ml/l) at 60th day and *B. subtilis* (5 g/l) at 45th day followed by sulphur (4 g/l) at 60th day recorded 24 and 26.66 PDI respectively which were significantly superior over control (89.33%).

Table-1 *Management of linseed powdery mildew using fungicides and bioagents during rabi 2014-15*

Treatment No.	Treatment details	PDI (Percent Disease Index)	Yield (kg/ha)
T_1	Two sprays with hexaconazole at 1 ml/l	12.00	588
T_2	Two sprays with wettable sulphur at 4 g/l	17.33	542
T_3	Two sprays with *P. fluorescens* at 5 g/l	25.33	529
T_4	First spray with *P. fluorescens* at 5 g/l followed by second spray with hexaconazole at 1 ml/l	20.00	477
T_5	First spray with *P. fluorescens* at 5 g/l followed by second spray with wettable sulphur at 4 g/l	22.67	505
T_6	Two sprays with *Bacillus subtilis* at 5 g/l	30.67	483
T_7	First spray with *P. fluorescens* at 5 g/l followed by second spray with *B. subtilis* at 5g/l	28.00	420
T_8	First spray with *B. subtilis* at 5 g/l followed by second spray with wettable sulphur at 4 g/l	26.66	442
T_9	First spray with *B. subtilis* at 5 g/l followed by second spray with hexaconazole at 1 ml/l	24.00	458
T_{10}	Control	89.33	182
S. Em±		01.98	03.76
CD at 5%		06.03	11.60

The yield of linseed was significantly superior in all the treatments compared to untreated control [Fig-1]. Further, the yield differed significantly among the treatments where the control recorded minimum seed yield (182 kg/ha), while the plots which received two sprays of hexaconazole and sulphur recorded highest yields of (588 kg/ha and 542 kg/ha) respectively and were found significantly superior. Further, the treatments with two sprays of *P. flourescens* and *B. subtilis* recorded the seed yield of 529 and 483 kg/ha, respectively.

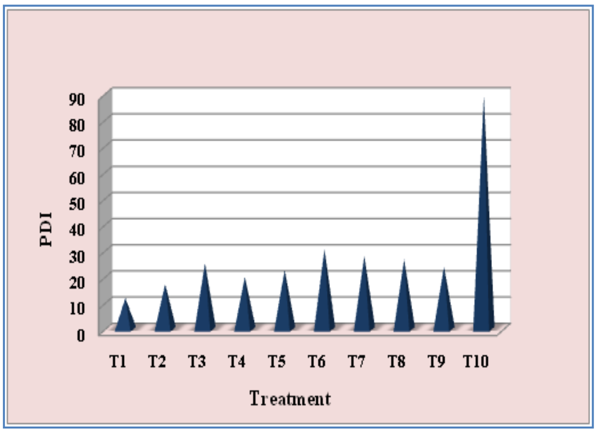

Fig-1 Management of powdery mildew of linseed using fungicides and bioagents

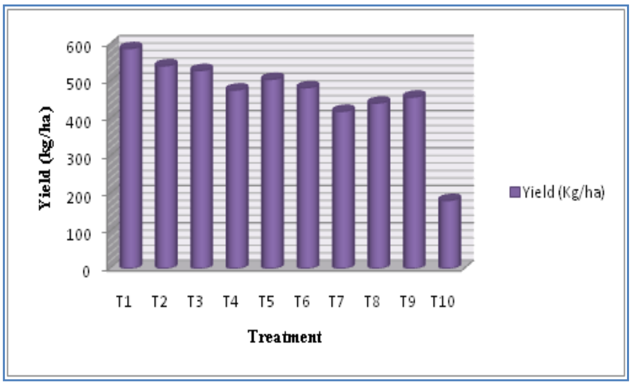

Fig-2 Effect of powdery mildew on linseed yield

From the present findings it is evident that, two applications of hexaconazole 5% EC at 1 ml/l and wettable sulphur 80% WP at 4 g/l at 45 and 60 DAS have reduced the disease severity of linseed powdery mildew (12% and 17.33% respectively), which reflected on yield of linseed as well. Further, spray of hexaconazole at 1 ml/l at 45 DAS followed by *P. fluorescens* at 5g/l at 60 DAS also showed effectiveness in managing the disease to a greater extent (20.00%) when compared to control treatment. This clearly indicated that, spray of *P. fluorescens* in the spray sequence is more useful in reducing the disease and also enhancing yield. The yield differed significantly among the treatments where the control recorded minimum seed yield (182 kg/ha), while the plots which received two sprays of hexaconazole and sulphur recorded highest yields (588 kg/ha and 542 kg/ha, respectively)

The bioagents and chemicals at different concentration against *L. taurica* under *in vivo* conditions showed that bioagent *P. fluorescens* was most effective in inhibiting conidial germination as it produces (2,4- DAPG), the compound responsible for anti-phytopathogenic property followed by *B. subtilis.* However, under chemicals triazole fungicide hexaconazole was found to be best in reducing conidial germination [Fig-2].

Surwase *et al.* [6] evaluated the efficacy of five fungicides in field conditions against the powdery mildew of pea. Among the fungicides, hexaconazole (0.05%) and penconazole (0.05%) were found most effective in controlling the disease with better seed yield. Siddappa bacchihal [5] evaluated bioagents against powdery mildew of okra caused by *E. cichoracearum* and reported that, maximum inhibition of conidial germination was observed in *P. fluorescens* (93.16%) followed by *T. viride* (87.72%) each at 10 per cent concentration. The results were in conformity with the findings of several workers against powdery mildew of different crops *viz*., Dhruj *et al*. [1], Divyajyothi [3], Dinesh [2] and Khunti *et al*. [4].

Conclusion

The concept of organic farming and eco-friendly management encouraged the plant protection specialists to go for the use of bioagents for the management of pest and diseases. Bioagents which were previously known for their antimicrobial nature were evaluated against *L. taurica*. Hence use of specific bioagents and chemicals was done to know their efficacy on powdery mildew of linseed. During the management of the disease, two sprays of hexaconazole (1 ml/l) and two sprays of wettable sulphur (4 g/l) at 45 and 60 DAS were found significantly superior (12% and 17.33% respectively) in managing the disease. Similarly the plot treated with *P. fluorescens* (5 g/l) on 45day followed by hexaconazole on 60 day at 1 ml/l recorded 20 per cent disease severity.

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Abbreviation:

%	:	percentage
^{o}C	:	degree celcius
CD	:	critical difference
DAS	:	days after sowing
et al.,	:	and others
Fig.	:	figure
g	:	gram
hr	:	hour
ha	:	hectare
kg	:	kilograms
l	:	litre
m	:	meter
ml	:	milliliter
PDI	:	per cent disease index
S. Em±	:	standard error of means
Sl	:	serial
t	:	tones
P. fluorescens	:	*Pseudomonas fluorescens*
B. Subtilis	:	*Bacillus subtil*

Authors Contribution: All authors have equally contributed in the research

Conflict of Interest: None declared

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