

Powdery mildew (*Oidium lini*) and PasmO (*Septoria linicola*) combined effect on yield, yield components of linseed (*Linum usitatissimum* L.)**Ermias Teshome**Oromia Agricultural Research Institute, Sinana Agricultural Research Center, P.O.Box-208,
Bale-Robe, Ethiopia**Abstract**

Linseed (Linum usitatissimum L.) has been traditional oil crop of Ethiopia and it is the third most important oilseeds in the higher altitudes. It is the leading oil crop in Bale highlands in terms of its area of production and productivity. Regardless of the potential for linseed production; diseases are the major yield limiting factors in Ethiopia. PasmO (Septoria linicola) and powdery mildew (Oidium lini) are among the most important diseases associated with linseed production. This experiment is intended to develop an option for the management of these major diseases. The experiment was conducted for three years in two locations. An improved linseed variety "Dibene" and a local cultivar were planted in RCB design with three replications. At Sinana On-station, ANOVA has depicted that for pasmo disease there was statistically significant ($P<0.05$) variation among treatments. The highest disease severity of 23.46% and the lowest 12.96% were recorded from local cultivar without fungicide spray and 'Dibene' variety sprayed at seven days interval, respectively. Similarly, statistically justifiable variations ($P<0.05$) were observed for Powdery mildew. The highest and the lowest powdery mildew severities of 46.3% and 22.84 % were recorded from local cultivar without fungicide spray and 'Dibene' variety sprayed at seven days interval, respectively. Similarly, ANOVA have depicted that there are significant difference ($P<0.05$) between treatments for thousand seed weigh (TSW) and grain yields. The highest and lowest TSW of 6.73g and 6.07g were recorded from 'Dibene' variety sprayed at twenty one days local cultivar without fungicide spray, respectively. Whereas, the highest and lowest grain yield of 2859.30kg/ha and 2316.8kg/ha was obtained from 'Dibene' variety sprayed at fourteen days (14) days and local cultivar without fungicide spray. Similarly, the result follows the same trend at welte'i berisa. ANOVA have shown that there application of a fungicide have made a significant difference ($P<0.05$) between treatments for TSW and grain yield. The highest and lowest TSW of 5.87g and 5.27g was recorded from 'Dibene' variety sprayed at twenty one days interval and local cultivar without fungicide spray, respectively. In case of grain yield, the largest and smallest grain yield of 1733.6kg/ha and 1045.6kg/ha were obtained from 'Dibene' variety sprayed at fourteen days days interval and the local cultivar without fungicide spray, respectively. Therefore, One to two times spray of a fungicide Odeon (Chlorothalonil) at a rate of 2.5 kg/ha and at an interval of 14 days is recommended for the management of Powdery mildew and PasmO diseases on linseed.

Key words: Linseed, PasmO, Powdery mildew, Disease severity, percent severity index

Background and Justification

Linseed (*Linum usitatissimum* L.) has been a traditional oil crop of Ethiopia for so long years. It is the leading oil crop in Bale highlands in its area of production and productivity (CSA, 2008/09). Ethiopia is the fifth producer of linseed in the world with a total share of about 5% of the world production. It is usually grown in rotation with wheat; barley and teff. From Ethiopia, Oromia is the first producer of linseed with total share of 75% of domestic production (Wijnands *et al.*, 2009). Regardless of the potential for linseed production in Bale; biotic stresses, particularly diseases are the major yield limiting factors. Among diseases associated with linseed production, Pasmu (*Septoria linicola*) and powdery mildew (*Oidium lini*) are the most important (Michael, 2015). But diseases like, Alternaria, botrytis grey mold and wilt are common diseases across the world where linseed is produced. However, Pasmu and Powdery mildew are the only major and yield constraining diseases in Bale area. Beside the importance these diseases, disease management activities to protect the crop from damage by these diseases is neglected till now. The management activities developed against these diseases is lacking at Bale highlands and management methods are not yet developed. The yield loss assessment studies was also not conducted for major linseed diseases at Bale highlands. Therefore, this work is intended to fill this research gap and will recommend economically and environmentally feasible management option against the targeted diseases for linseed at Bale highlands.

Materials and Methods

The field experiment was conducted in 2013/14, 2014/15 and 2015/16 GC main cropping season of Bale area at Sinana Agricultural Research Center (SARC) on-station field and welte'i berisa farmers' field. The trial was laid out in RCBD with 3 replications. An improved variety 'Dibene', and a local cultivar were used in the study. The disease severity gradient was created by spraying a fungicide Odeon (Chlorothalonil) at a rate of 2.5kg/ha at 7, 14 and 21 days interval and unsprayed plot as a check. The first spray was started immediately after the occurrence the first visible symptom of the diseases. The plot size was 1.2m x 3m with between row, plot and block spacing of 0.2m, 1m and 1.5m, respectively. All other agronomic management practices were under taken as per the recommendation. The diseases development was rated using 1-9 scale (Bernier *et al.*, 1993). The severity rates were converted into percentage disease severity (PDS) for analysis (Wheeler, 1969).

Results and discussion

This trial was initiated in order to investigate the combined effect of Powdery mildew (*Oidium lini*) and PasmO (*Septoria linicola*) on yield, and yield components of linseed. A fungicide Odeon (Chlorothalonil) was sprayed at a rate of 2.5kg/ha and at intervals of every 7 days, 14 days and 21 days to check the development of the diseases at different gradients and unsprayed plot is included as a local check for comparison.

Sinana On-station

Analysis of variance (ANOVA) for PasmO (*Septoria linicola*) disease severity has depicted that there is significant difference ($P<0.05$) among the treatments. The highest PasmO disease severity of 23.46% was recorded from a plot with local cultivar without fungicide spray. While the lowest pasmo diseases severity of 12.96% was recorded from ‘Dibene’ variety sprayed at every 7 (seven) days interval. This finding implies that the disease severity reduction due to fungicide application is 44.76 %. This result agrees with the findings of Islam, 2018; at which they have reported the application of fungicides decreased pasmo disease severity to 15% compared with 59% for the unsprayed control, followed by pyraclostrobin (20%) and fluxapyroxad (39%). Similarly, there was high powdery mildew disease pressure which has resulted in to statistically significant variation ($P<0.05$) between treatments. The highest powdery mildew disease severity of 46.30% was recorded from a plot with local cultivar without fungicide spray. While the lowest powdery mildew diseases severity of 22.84% was recorded from ‘Dibene’ variety sprayed at every 7 days (Table 2). From this result it has observed that the use the fungicide Odeon has reduced the powdery mildew disease severity by 50.66%.

The difference between treatments was not statistically justifiable for yield component parameters such as Number of bolls per plant and Biomass yield. ANOVA for number of tillers and branches per plant have shown that the difference is statistically significant ($P<0.05$). The maximum number of tillers per plant (5.89) and branches per plant (30.89) were recorded from local cultivar sprayed at 7 days and 14 days, respectively. In contrary, the lowest number of tillers per plant (4.00) and branches per plant (22.11) were recorded from local cultivar sprayed at 21 days interval and ‘Dibene’ variety at 14 days interval, respectively. ANOVA for number of seeds per boll has shown statistically significant difference ($P<0.05$) among the treatments. The

maximum number of seed per boll (9.56) was recorded from Local cultivar sprayed at every seven (7) and fourteen (14) days interval. Whereas the lowest number of seeds per boll (7.78) was recorded from local cultivar sprayed at every twenty one (21) days interval. Statistical analysis has shown significant variation ($P < 0.05$) among the treatments for plant height. The highest plant height of 112.67 cm was recorded from “Dibene” variety without fungicide spray. Whereas the lowest plant height of 99.44 cm was recorded from local cultivar sprayed at 21 days interval. This finding can justify that the application of fungicide can decrease the plant height of linseed.

Percent plant stand was one of the parameters influenced by the fungicide application. ANOVA for this parameter has also indicated that there was significant variation among the treatments. The highest stand percentage (88.33%) was recorded from “Dibene” variety sprayed at every seven (7), fourteen (14) and twenty one (21) days interval. And the lowest stand percentage (76.67%) was recorded from local cultivar sprayed at seven (7) and fourteen (14) days interval. From this result, we can understand that the difference in percentage plant stand is due to the genetic performance of “Dibene” variety over local cultivar in this regard. Thousand seed weight (TSW) was also among the parameters influenced by fungicide application. The maximum thousand seed weight of 6.73g was recorded from “Dibene” variety sprayed at every 21 days interval. While, the minimum TSW of 6.07g was recorded from unsprayed local cultivar.

With regard to grain yield, ANOVA showed statistically significant differences ($P < 0.05$) between treatments. The largest grain yield of 2859.30kg/ha was harvested from “Dibene” variety sprayed at every 14 days interval and the lowest grain yield of 2316.8kg/ha was harvested from local cultivar without fungicide spray. Similar results were reported by Islam, 2018; where they have found that the application of fluxapyroxad+pyraclostrobin increased the grain yield to 2562 kg/ha compared with 1874 kg/ha for the unsprayed control. In the current experiment, the application of fungicide has increased the linseed productivity by 19% as compared to the unsprayed check plot. Gohokar *et al.*, 2016, have reported similar result where they have found the highest grain yield ranges of 870 - 1137 kg/ha from fungicides sprayed plots across years and the lowest grain yield ranges of 518 -787 kg/ha from unsprayed control plots.

Table 2: Effect of Powdery mildew (*Oidium lini*) and PasmO (*Septoria linicola*) diseases on yield and yield components of linseed at Sinana On-station

*Parameters											
*Trt.	Pa	PM	Tlr/plnt	Branch/plnt	Boll/plnt	Sd/boll	Plntht	%stnd	BM	1000SW	Yld kg/ha
D0	19.14	31.48	5.56	28.11	86.22	8.11	112.67	81.67	2750.0	6.53	2699.0
D7	12.96	22.84	5.00	23.89	70.44	9.44	108.22	88.33	2783.3	6.53	2802.9
D14	14.82	25.31	4.33	22.11	68.67	9.33	108.33	88.33	2816.7	6.27	2859.3
D21	15.43	27.16	4.33	20.89	73.33	9.11	103.33	88.33	2716.7	6.73	2693.1
L0	23.46	46.30	5.22	30.33	81.78	8.67	102.78	80.00	2583.3	6.07	2316.8
L7	17.28	40.74	5.89	29.11	87.44	9.56	101.11	76.67	2700.0	6.13	2555.8
L14	20.37	36.42	5.00	30.89	97.89	9.56	102.22	76.67	2416.7	6.27	2612.8
L21	21.61	38.27	4.00	27.33	83.89	7.78	99.44	80.00	2700.0	6.13	2498.3
CV (%)	14.74	15.19	14.97	13.55	21.27	9.50	2.52	5.25	13.14	2.03	10.21
LSD_{0.05}	4.63	8.83	1.27	6.23	NS	1.47	4.56	7.50	NS	0.22	464.72

***D0**-’Dibene’ variety with no fungicide, **D7**-’Dibene’ variety sprayed every seven days, **D14**-’Dibene’ variety sprayed every fourteen days, **D21**-’Dibene’ variety sprayed every twenty one days, **L0**-Local cultivar with no fungicide spray, **L7**-Local cultivar sprayed every seven days, **L14**-Local cultivar sprayed every fourteen days, **L21**-Local cultivar sprayed every twenty one days, **Pa**-PasmO Disease severity, **PM**-Powdery mildew disease severity

Welte'i Bersia

Analysis of variance (ANOVA) for Pasmu (*Septoria linicola*) depicted that there was significant difference ($P < 0.05$) between treatments. The highest Pasmu disease severity of 58.03% was recorded from a plot with local cultivar without fungicide spray. While the lowest pasmo disease severity of 23.46% was recorded from 'Dibene' variety sprayed at 7 days interval. Similarly, there was high powdery mildew disease pressure which has resulted in statistically significant variation ($P < 0.05$) among the treatments. The highest powdery mildew disease severity of 64.20% was recorded from a plot with local cultivar without fungicide spray. While the lowest powdery mildew disease severity of 30.86% was recorded from 'Dibene' variety sprayed at 7 days interval (Table 3). This result has indicated that the application of fungicide for the management of linseed diseases have reduced pasmo and powdery mildew diseases severity by 59.57% and 51.93%, respectively. Similarly, different authors have reported that the application of fungicides for the management of linseed diseases is effective where the highest and the lowest disease severities were recorded from unsprayed and sprayed plots, respectively (Anjum *et al.*, 2017). Gohokar *et al.*, 2016, have also reported that the application of fungicide reduced linseed disease severity to 6-16% as compared to the highest disease severity range of 66-70% which was recorded from untreated control plot.

Statistical analysis has shown that there is statistically significantly difference ($P < 0.05$) among the treatments for number of tiller and branches per plant. The highest tillers (4.11) and branches (24.78) per plant were recorded from local cultivar sprayed at 21 days interval. Whereas the lowest tillers (2.11) and branches (10.44) per plant were recorded from 'Dibene' variety sprayed at 14 days interval. Similarly, there was statistically significant variations ($P < 0.05$) between treatments for Number of boll per plant and plant height. The maximum number of boll per plant (35.89) and plant height (98.89 cm) were recorded from local cultivar sprayed at 7 days interval and 'Dibene' variety without fungicide spray, respectively. Whereas the lowest number of boll per plant (18.44) and plant height (71.67 cm) were recorded from local cultivar sprayed at 14 days interval.

ANOVA for seed per boll has shown significantly different ($P < 0.05$) variations between treatments. The maximum number of seeds per boll (9.56) was recorded from Local cultivar

sprayed at 7 days interval. Whereas the lowest number of seeds per boll (7.89) was recorded from local cultivar sprayed at 14 days interval. In case of percentage plant stand and biomass yield similar result was obtained where, ANOVA have shown significant variations ($P < 0.05$) between treatments. The highest percentage of plant stand (90.00%) and biomass yield (2216.7 kg/ha) was recorded from 'Dibene' variety without fungicide spray. The lowest percentage of plant stand (75.00%) was recorded from local cultivar sprayed at 14 and 21 days interval and the lowest biomass yield of 1083.3 kg/ha were recorded from local cultivar sprayed at 14 days interval.

Thousand seed weight (TSW) was also among the parameters influenced by fungicide application. The maximum thousand seed weight of 5.87g was recorded from 'Dibene' variety sprayed at 21 days interval; whereas the lowest thousand seed weight of 5.27g was recorded from local cultivar without fungicide spray. With regard to grain yield, ANOVA has showed statistically significant difference ($P < 0.05$) between treatments. The largest grain yield of 1733.6 kg/ha was obtained from 'Dibene' variety sprayed at 14 days interval and the lowest grain yield of 1045.6 kg/ha was recorded from local cultivar without fungicide spray. Anjum *et al.*, 2017, have reported the same result where they have recorded the highest and the lowest grain yield from fungicides sprayed and unsprayed plots, respectively. Compared to Sinana On-station, the yielding performance of the linseed cultivars at welte'i berisa is very low. This is mainly because of the terminal moisture stresses occurred during the season.

Table 3: Effect of Powdery mildew (*Oidium lini*) and Pasmu (*Septoria linicola*) diseases on yield and yield components of linseed at Welte'i Berisa

*Parameters											
*Trt.	Pa	PM	Tlr/plnt	Branch/plnt	Boll/plnt	Sd/boll	Plntht	%stnd	BM	1000SW	Yld kg/ha
D0	38.27	48.15	3.33	18.56	30.00	8.89	98.89	90.00	2216.7	5.80	1161.3
D7	23.46	30.86	2.56	15.22	32.33	9.00	97.22	86.67	2166.7	5.70	1704.8
D14	30.86	37.04	2.11	10.44	26.89	8.56	87.22	78.33	1983.3	5.80	1733.6
D21	30.86	43.21	2.56	13.00	27.44	9.00	87.22	88.33	2000.0	5.87	1309.0
L0	58.03	64.20	2.44	14.89	30.89	9.44	84.44	86.67	1783.3	5.27	1045.6
L7	45.68	50.62	2.89	18.56	35.89	9.56	91.11	83.33	2100.0	5.30	1646.3
L14	38.27	46.91	2.44	11.22	18.44	7.89	71.67	75.00	1083.3	5.53	1745.2
L21	46.91	56.79	4.11	24.78	33.33	9.11	88.89	75.00	1450.0	5.30	1315.0
CV (%)	18.27	20.38	40.58	31.14	29.76	6.73	11.69	9.92	35.04	3.17	18.21
LSD_{0.05}	12.35	16.66	1.97	8.53	15.14	1.04	17.88	14.24	1120.8	0.31	459.51

***D0**- 'Dibene' variety with no fungicide, **D7**- 'Dibene' variety sprayed every seven days, **D14**- 'Dibene' variety sprayed every fourteen days, **D21**- 'Dibene' variety sprayed every twenty one days, **L0**-Local cultivar with no fungicide spray, **L7**-Local cultivar sprayed every seven days, **L14**-Local cultivar sprayed every fourteen days, **L21**-Local cultivar sprayed every twenty one days, **Pa**-Pasmu Disease severity, **PM**-Powdery mildew disease severity

Conclusion and Recommendation

An application of a fungicide Odeon (Chlorothalonil) has reduced the influence of powdery mildew and pasmo diseases on the yield and yield components of linseed. Therefore, this fungicide can be considered as a crucial production package of linseed for the management of powdery mildew and pasmo diseases. Sprayed plots out yielded the unsprayed plots in general terms. The grain yield from the highest yielding plot exceeds the lowest yielding plot by 542.5 kg/ha at Sinana on-station and 688.0 kg/ha at welte'i berisaa due to the control of pasmo and powdery mildew diseases over unsprayed plots. This dictates that fungicide is one of the most important linseed production packages to be considered. Therefore, a fungicide Odeon (Chlorothalonil) is recommended for both small and large scale linseed producer farmers for the management of Powdery mildew and Pasma of linseed. Based on this study, the development of Powdery mildew and Pasma diseases is well managed by the fungicide on 'Dibene' variety by spraying at every fourteen (14) days. Therefore, One to two times spray of a fungicide Odeon (Chlorothalonil) at a rate of 2.5 kg/ha and at an interval of 14 days is recommended for the management of Powdery mildew and Pasma diseases on linseed.

References

Wheeler, J.B., 1969. An introduction to plant diseases. Wiley, London, P. 347.

Central Statistical Agency, 2008/2009. Agricultural Sample Survey 2008/09 (2001 E.C.) Report on Crop and Livestock Product Utilization (Private Peasant Holdings, Meher Season)," Statistical Bulletin 446, Federal Democratic Republic of Ethiopia.

Wijnands J.H.M., J. Biersteker and E.N. van Loo., 2009. Oilseeds business opportunities in Ethiopia 2009. *Agriculture and Rural Development of Ethiopia*. Pp. 62.

Bernier CC, Hanounik SB, Hussein MM and Mohamed HA. 1993. Field manual of common faba bean diseases in the Nile Valley. International Center for Agricultural Research in the Dry Areas (ICARDA). Information Bulletin No. 3.

Michael Flood, 2015. Control the pasmo in your flax. <https://www.grainews.ca/2015/02/06/control-the-pasmo-in-your-flax/>.

Islam T., 2018. Fungicide Management of PasmO of Flax and Fungicide Sensitivity of *Septoria linicola*. <https://harvest.usask.ca/handle/10388/8357>.

Anjum A., Aswathanarayana D.S. and Ajithkumar K., 2017. Management of Linseed Powdery Mildew Caused by *Leveillula taurica* (Lev.) Arn. *International Journal of Agriculture Sciences*. Vol.9, Issue 32, pp.4479-4481.

Gohokar R.T., Biradar V.K. and Banginwar A.D., 2016. Efficacy of fungicides against linseed powdery mildew. *Int. J. of Life Sciences*. Vol. 6:37-39.