Seed transmission rates of Pea seed-borne mosaic virus among lentil genotypes in Ethiopia

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SUMMARY

Evaluation of Pea seed-borne mosaic virus (PSbMV, genus *Potyvirus*, family *Potyviridae*) seed transmission rate among 62 different lentil genotypes was carried out during 2021-2023 at Amhara Regional Agricultural Research Institute, Bahir Dar, Ethiopia. Seed transmission rates among lentil genotypes ranged from 0.0 to 36.4%. Released lentil varieties (Alemaya and Derso) showed high levels of seed transmission rates (13.5% and 7.1%, respectively). The finding can help lentil breeders to develop PSbMV resistant varieties with low seed transmission rates to combat the disease and expand lentil production in the highlands of Ethiopia.

BACKGROUND

Lentil (*Lens culinaris* Medik.) is an important and widely cultivated crop in the highlands of Ethiopia, and it is considered as one of the main protein sources for a large part of the populations, and lentil straw is a valuable animal feed (Fikiru *et al*., 2007). Lentil productivity in Ethiopia is affected by several biotic factors such as aphids, wilt/root rot and viruses (Tadesse *et al.,* 1999; 2008).

Diseases caused by Pea seed-borne mosaic virus (PSbMV) and Chickpea chlorotic stunt virus (CpCSV) are becoming important and causing a significant yield reduction of legume crops in Ethiopia. For example, field surveys conducted in 2019-2022 showed that PSbMV was the most common virus affecting lentil in Ethiopia (Ademe *et al*., 2023; Kumari *et al.,* 2022). High levels of PSbMV infection reached 100% on different lentil genotypes were observed during 2019/2020 cropping season. PSbMV is one of the most important viruses infecting lentil worldwide and causing yield loss reaching up to 61% (Kumari and Makkouk, 1995). It is transmitted mechanically and by several aphids (e.g. *Acyrthosiphon pisum*, *Aphis fabae*, *A. craccivora*, *Myzus persicae*) in the non-persistent manner (Makkouk *et al.,* 1993). Seed transmission rates of PSbMV in lentil vary widely (0-44%) depending on plant host and virus isolate (Hampton and Muehlbauer, 1977; Kumari and Makkouk, 1995; Makkouk *et al*., 1993).

The aim of this work was to study the variation in seed-transmission rate among lentil genotypes harvested from Chefe Donsa Station in 2019/2020 cropping season with different levels of PSbMV natural infection.

METHODOLOGY

PSbMV infection level in 2019/2020 cropping season

- From each lentil genotype, 10-20 leaf samples were randomly collected from 62 lentil genotypes planted at Chefe Donsa Station, Debre Zeit Agricultural Research Center (DZARC), Ethiopia during 2019/2020 cropping season (Figure 1-A). Collected leaf samples were blotted on Nitrocellulose membranes (Figure 1-A) in Ethiopia and tested by Tissue-blot immunoassay (TBIA) using PSbMV polyclonal antibody (Makkouk *et al.,* 1993; Makkouk and Kumari, 1996) at ICARDA's Virology Laboratory in Lebanon.
- After maturity, seeds were harvested from plants of 62 lentil genotypes (Table 1), and dried seeds were stored to evaluate the rate of PSbMV seed transmission over the next growing season.

Seed transmission study (2022-203)

- Three hundred seeds/genotype of the 62 lentil genotypes (harvested from 2019/2020 season) were planted in pots containing sterilized sand and incubated for 1-2 weeks under greenhouse conditions at Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia (Figure 1-C).
- Two weeks after emergence, seedlings were blotted on nitrocellulose membranes (NCM) and sent them to ICARDA's Virology Laboratory in Lebanon to be tested by TBIA for the presence of PSbMV and determine the seed-transmission rate (Figure 1-D).

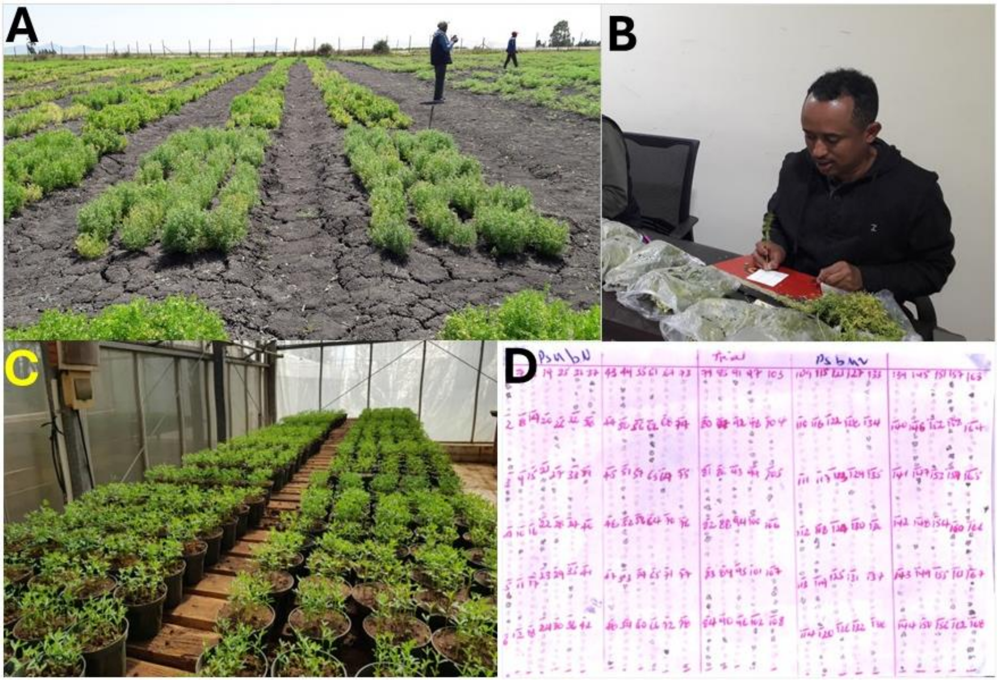

Figure 1. (A) Lentil trial at Chefe Donsa Station of Debre Zeit Agricultural Research Center (DZARC), of different genotypes with different levels of Pea seed-borne mosaic virus (PSbMV) infection during 2019/2020 growing season; **(B)** Blotting lentil samples on Nitrocellulose membranes (NCMs) by Mr Anteneh Ademe (Ethiopian PhD student); **(C)** Seeds of 62 lentil genotypes planted in greenhouse at Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia during 2022-2023 cropping season; **(D)** NCMs tested by TBIA using PSbMV polyclonal antibody at ICARDA's Virology Laboratory, Lebanon.

Table 1. Selected lentil genotypes naturally infected with Pea seed-borne mosaic virus (PSbMV) at Chefe Donsa Station, Ethiopia, during 2019/2020 growing season.

No.	Pedigree	No.	Pedigree	No.	Pedigree
1	ILL7986XILWL074	22	ILL4422	43	ILL10801XILL7950
2	ILL6002XILWL118	23	ILL10731XILL4649	44	ILL10800XILL7201
3	ILL4605XL-4147	24	10848XDPL62	45	ILL7115XILL2585
4	6994XDPL62	25	L-4147XILL4649	46	ILL10800XILL4637
5	88523XILL5714	26	ILL5883XILL8	47	LIRL-22-46-1-1-1-0XAKM302
6	ILL4402XILL7950	27	ILL5883XILL3492	48	**99/209XILWL118**
7	ILL10749XILL7979	28	CIPAL-401	49	**ILL10750XILL1982**
8	DZ-2012-Ln-0054	29	ILL10021	50	ILL1712XILL10072
9	6002XLIRL-21-50-1-1-1	30	ILL8007XILL759	51	F1X2011S-6XF1X2011S-76
10	8406X8006	31	ILL4400	52	ILL8006XSHIRAZ96
11	DZ-2012-Ln-0244	32	ILL8008XL-4147	53	ILL4404XILL7950
12	ILL10732XILL4637	33	ILL4605	54	ILL590
13	FLIP97-34LXFLIP97-33L	34	ILL2245	55	FLIP2011-29L
14	ILL7664-CH/11-2	35	**ILL7664-CH/11-1**	56	ILL2585XILL3796
15	ASHAXILL7979	36	7978XDPL62	**57**	**Derso (FLIP-88-411-02-AK-14)**
16	FLIP2012-246L	37	ILL4605XILL6024	58	FLIP2012-244L
17	99/209XDPL62	38	6994X10141	59	ILL10748XILL4637
18	DZ-2012-Ln-0218	**39**	**Alemaya (FLIP 89-63L)**	60	358X10870
19	ILL10731XILL9889	40	Local	61	ILL10800XILL7979
20	ILL7978XILWL118	41	ILL4605XILL6994	62	**ILL4400X28509**
21	ILL975X28505	42	BARIMASUR-6XLIRL-21-50-1-1-1-0		

RESULTS

Evaluation of seed-transmission rate

- The PSbMV infection rate of the 62 selected lentil genotypes varied between 10-100% under natural infection conditions (Figure 2).
- The level of seed transmission of PSbMV in the 62 lentil genotypes examined during 2022-2023 varied from 0.0 to 36.4% (Figure 2).
- There was a low correlation (R= 0.32) between PSbMV infection levels in the field and seed transmission rates of harvested seeds (Figure 2).
- PSbMV was not detected in the seeds of 18 genotypes out of the 62 lentil genotypes examined, whereas 21 genotypes had seed transmission levels of 0.1-5%, 21 genotypes had 5.1-15%, and only 2 genotypes had >15% (Figure 2).
- The highest rate of seed-transmission of 16.7% and 36.4% were recorded in lentil genotypes ILL-7664-CH/11-1 and ILL4400X28509, respectively.
- The widely grown improved lentil cvs. Alemaya (FLIP 89-63L) and Derso (FLIP-88-411-02-AK-14), and Local variety showed 13.5, 7.1 and 4.4% seed transmission rate, respectively (Figure 2).
- The two lentil genotypes 99/209XILWL118 and ILL10750XILL1982 with 100% PSbMV infection under field conditions did not show seed infection.

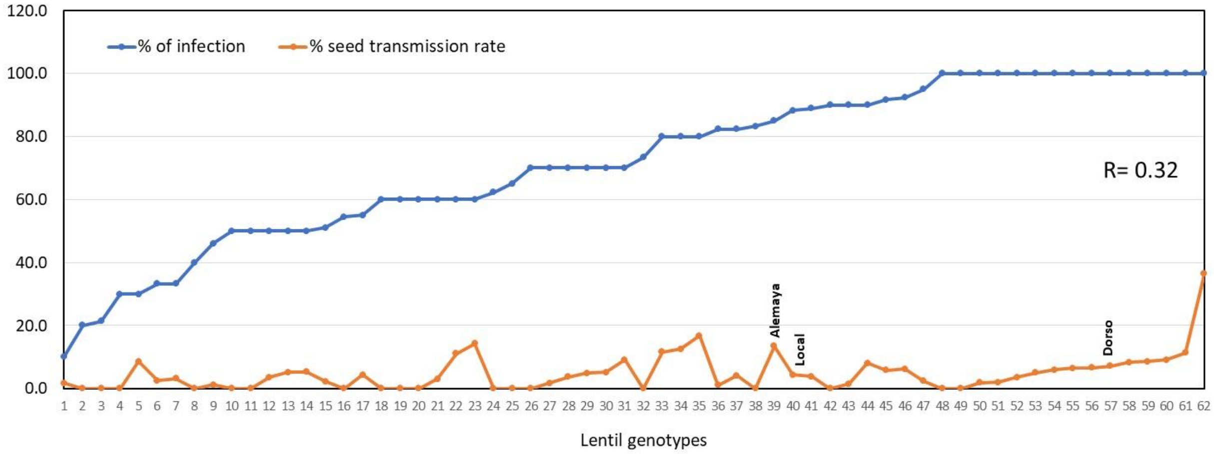

Figure 2. Variability in % of infection under field conditions and % of seed transmission rate among 62 lentil genotypes naturally infected with Pea seed-borne mosaic virus (PSbMV), in Ethiopia. Lentil genotypes 1-62 are listed in Table 1.

CONCLUSIONS

- High incidence of PSbMV in lentil fields in Ethiopia suggests that farmers probably use their own infected seeds for planting.
- The use of virus-free seeds is thus recommended as an effective component of integrated lentil virus disease management.
- The huge difference in seed transmission rate among lentil genotypes opens opportunities to develop virus resistant varieties with low or no seed transmission rate.
- Inheritance of low levels of seed transmission of lentil genotypes needs further studies.
- High virus incidence in the field for genotypes with low or no seed transmission, suggests that transmission by other means (e.g. vectors) prevails in the field which also require management to reduce infection.

The results on PSbMV seed transmission in lentil generated from this study will be published in a referred journal.

REFERENCES

Ademe A., S.G. Kumari, T. Alemu, A. Abraham, Y. Aynewa, A. Moukahel, D. Guadie and S. Ahmed. 2023. Spatial distribution and association of biophysical factors with chickpea chlorotic stunt and pea seed-borne mosaic viruses affecting legume crops in Ethiopia. Journal of Phytopathology, 171(11-12): 731-743. https://doi.org/10.1111/jph.13236 (https://hdl.handle.net/10568/135139)

Fikiru, E., K. Tesfate and E. Bekele. 2007. Genetic diversity and population structure of Ethiopian lentil (*Lens culinaris* Medikus) landraces as revealed by ISSR marker. African Journal of Biotechnology, 6(12): 1460-1468. https://www.researchgate.net/publication/228362227

Hampton R.O. and F.J. Muehlbauer. 1977. Seed transmission of pea seed-borne mosaic virus in lentils. Plant Disease Reporter 61: 235-238.

Kumari, S.G. and K.M. Makkouk. 1995. Variability among twenty lentil genotypes in seed transmission rates and yield loss induced by pea seed-borne mosaic potyvirus infection. Phytopathologia Mediterranea, 34: 129-132. https://www.jstor.org/stable/42685216

Kumari, S.G., A. Moukahel, A. Ademe, Y. Aynewa and S.A. Kemal. 2022. Genetic diversity of two viruses affecting lentil and chickpea crops in the highlands of Ethiopia. International Center for Agricultural Research in the Dry Areas (ICARDA), Beirut, Lebanon. https://hdl.handle.net/10568/127946

Makkouk, K.M. and S.G. Kumari. 1996. Detection of ten viruses by the tissue-blot immunoassay (TBIA). Arab Journal of Plant Protection, 14(1): 3-9. https://asplantprotection.org/wp-content/uploads/2018/07/V14-1_3-9.pdf

Makkouk, K.M., S.G. Kumari and L. Bos. 1993. Pea seed-borne mosaic virus: occurrence in faba bean (*Vicia faba* L.) and lentil (*Lens culinaris* Med.) in West Asia and North Africa, and further information on host range, purification, serology and transmission characteristics. Netherlands Journal of Plant Pathology, 99:115-124. https://doi.org/10.1007/BF01974264; https://hdl.handle.net/20.500.11766/13453

Tadesse N., S. Ahmed, D. Gorfu, T. Beshir, C. Fininsa, A. Abraham, M. Ayalew, A. Tilahun, F. Abebe and K. Meles. 2008. Review of Research on Diseases Food Legumes. In: Tadesse A (ed) Increasing Crop Production through Improved Plant Protection – Volume I. Plant Protection Society of Ethiopia (PPSE), 19-22 December 2006. Addis Ababa, Ethiopia. PPSE and EIAR, Addis Ababa, Ethiopia. 598 pp.

Tadesse, N., K. Ali, D. Gorfu, A. Yusuf, A. Abraham, M. Ayalew, A. Lencho, K.M. Makkouk and S.G. Kumari. 1999. Survey for chickpea and lentil virus diseases in Ethiopia. Phytopathologia Mediterranea, 38: 149-158. https://www.jstor.org/stable/42685994

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