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# New infestation records of two-spotted spider mites on potato tubers under storage conditions and response of genotypes at Kulumsa, Ethiopia

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**ABSTRACT**

The study sought to ascertain spider mite prevalence, infestation, and identification and to assess the response of potato genotypes. In 2022, this pest was only observed on some genotypes in December. In late January, an infestation, incidence, and severity increased from 10 to 13 genotypes on potato tuber stocks stored for irrigation experiments. Those genotypes were planted in irrigated fields, and the sprouted tuber losses ranged from 12.5% to 100% and up to 15.38% in the 2022 and 2023 records, respectively. Following this, spider mites, often known as two-spotted spider mites (TSSM) or *Tetranychus urticae,* were identified. This is the first time a potato sprout infestation has been recorded in Ethiopia. The two-spotted spider mites damaged the tubers quantitatively by sucking the moisture of sprouts up to the 5$^{th}$ grade, with 97 and >75% infestation levels, incidence, and severity, respectively. The pest grows very rapidly and hastens the drying of sprouted tuber leaves. Some genotypes were resistant to TSSM and recovered after the sprouts were infected and dried, which were treated with pesticides in 2023. The typical agricultural insecticides were ineffective in controlling the pest in the first year, and a Profenofos was applied in the second year. Thus, seed tubers are the main production limit unless appropriate research efforts are undertaken and management techniques are created.

**Keywords:** DLS, Potato, *Tetranychus urticae*, TSSM

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## Introduction

Potato (*Solanum tuberosum* L.) is one of the world's most important crops and ranks fourth in terms of production, volume, and area coverage (FAO, 2008; Tkachenko *et al.*, 2021; Amare *et al.*, 2022). In Ethiopia, it leads the list of root and tuber crops (CSA, 2022). With average yields of 16.69 ton ha$^{-1}$, potatoes were grown on about 78,478.72 hectares of land in peasant holdings (CSA, 2022). Most potatoes are produced in Kulumsa areas in the Tiyo district of the Arsi Highlands (FAO, 2008). Farmers grow potatoes in the "Meher" and "Belg" seasons due to the country's increasing demand for the crop and the ensuing drop in the average size of farmland (Birsh *et al.*, 2018; Fekadu and Gizaw, 2020).

Several biotic and abiotic factors limit potato productivity. Unfavorable climatic conditions and the physical and chemical properties of the soil are abiotic factors; biotic factors that reduce crop yields include low-yielding potato varieties, poor-quality potato seed tubers, diseases, and insect pests (Ferdu *et al.*, 2009; Bezabih and Mengistu, 2011; Labarta, 2013). Major insect pests of potatoes include cutworms (*Agrotis* and *Exigua* spp.), green peach aphid (*Myzus persicae*), metallic leaf beetle (*Lagria vilosa*), potato aphid (*Macrosiphum euphorbiae*), potato epilachna (*Epilachna hirta*), potato tuber moth (*Phthorimaea operculella*), red ants (*Dorylus* sp.), and red spider mite (*Tetranychus utricae*) (Bayeh and Tadesse, 1992; Ferdu *et al.*, 2009; Muluken *et al.*, 2016). *P. operculella* received more attention than other insect pests affecting potatoes (Ferdu *et al.*, 2009).

The productivity of potatoes under farmer management is relatively low, ranging from 8 to 15 ton ha$^{-1}$) (ARDO, 2007), compared to that produced under research management (over 20 ton ha$^{-1}$). The low yields of potatoes were linked with the susceptibility of local potato cultivars' to late blight disease in the Arsi highlands (Fekadu and Gizaw, 2020). From previous reports by Gebremedhin *et al.* (2008), the main problems related to very low yields include a lack of improved varieties and poor-quality seed tubers of unknown origin, deprived cultivation practices, storage structures, and seed systems, a high incidence of diseases, and potato tuber moths. Moreover, a lack of advanced storage facilities for seed and ware potatoes and the traditional storage structure used by many farmers are attributed to severe losses of potatoes in storage (Gebremedhin *et al.*, 2008). Nearly 30–50% of the annual potato production is lost after harvest due to poor storage systems at farm and village levels (Buys and Nortje, 1997).The prevalence of the above production constraints contributes to the low productivity of potato cultivation in the Arsi highlands, including Kulumsa, until production technologies, such as improved varieties and production techniques, are introduced through research schemes.

Seed tubers are the central components of potato production, as they represent a higher proportion of total costs and are a major source of disease and pests. The unavailability of good quality and healthy potato seed at the right time and amount is becoming a major problem in potato cultivation. Diffused Light Stores (DLS) allow farmers to store their seed stock instead of purchasing seeds of unknown health from distant suppliers. This is not always the case for many potato growers, and seed shortages force most farmers to buy seeds from other regions. However, the potato tuber moth was a major pest of stored potatoes for many years, causing significant damage to stored tubers. Fekadu and Gizaw, 2020) reported that mealy bugs were serious insect pests under storage conditions, especially in the hottest months of the year on sprouted potato tubers. Similarly, Palaniswami and Pillai (1979) reported new records of mealy bugs as pests on elephant foot yam under storage conditions. A new invasive pest called the red spider mite has emerged as a serious insect pest for potato tubers stored at Kulumsa Agricultural Research Center (KARC). This pest has not been reported as a potential potato pest by KARC or anywhere else in the country as a storage pest, even though it was reported as a field pest of potatoes in 2016 (Muluken *et al.*, 2016). Following this occurrence, KARC agricultural entomologists and potato breeders examined the affected potato tubers and conducted a diagnosis of the pest and its state under DLS and laboratory conditions. The pest had been identified as a two-spotted spider mite *(Tetranychus utricae* Koch, Acari: Tetranychidae*)* after the symptoms and damaged sprouts were recognized with magnifying glasses on the sprouts of potato tubers.

The two-spotted spider mite (TSSM) is a widespread species that can be found on a variety of plants all over the world (Helle and Sabelis, 1985). The pest affects more than 1200 types of host plants, including more than 150 that are commercially important (Zhang, 2003). Under natural conditions, TSSM likes to feed on the underside of the leaves (Reddall *et al.*, 2004). Spider mites eat the contents of plant cells after puncturing the cells with their stylets (Riley, 1989). The subsequent feeding of the pest results in a stippled-bleached appearance of chloroplasts, and later, leaves turn yellow, grey, or bronze (Riley, 1989). A large spider mite population can eliminate plants, resulting in a loss of yield (Stavrinides and Hadjistylli, 2009). There is no information available on the source of the pest under storage circumstances or the total tuber loss following infestation.

The pest was first reported as a potato pest in fields in the Haramaya district of Eastern Ethiopia in 2016 (Muluken *et al.*, 2016). Although the TSSM infestation was severe in the first year, significant damage was caused, and it was not recognized as a potential threat. No attention was paid to the pest, which was considered a minor pest. However, those potato genotypes were brought into the field and could not emerge completely because the sprouts were dried due to the sucking effect of the red spider mite. In 2023, it emerged as a serious pest infesting sprouts of potato tubers in the DLS. The pest occurrence in the DLS has caused great concern among the potato research team. This can also alert researchers to pay due attention, distinguish the pest, and seek apt management alternatives and varietal responses before the pest becomes a potential threat and causes an outbreak in potato production in Southeastern Ethiopia. Monitoring of storage was conducted with the express goal of determining the occurrence, infestation, identification, and response of potato genotypes at Kulumsa, Southeastern Ethiopia, taking into account the economic significance of the pest.

## Materials and Methods

*Description of the study area*

Infestations of mites were recorded at Kulumsa Agricultural Research Center (KARC) in a diffused light store in the Southeastern parts of Ethiopia on spouted potato tubers from December to February and January to May in 2022 and 2023, respectively. The study included all potato experimental materials stored in DLS for the major potato-producing areas of Arsi. KARC is located at 80 00' to 80 02'N latitude and 390 07' to 390 10'E longitude at an elevation of 2210 m.a.s.l. in Tiyo district, the Arsi Administrative Zone of the Oromia Regional State, 167 km southeast of Addis Ababa. In 2022 and 2023, the mean monthly temperature and relative humidity varied from 10.2°C to 24.8°C and 25% to 82%, respectively (Table 1).

Table 1. Mean values of temperature and relative humidity in Kulumsa in 2022 and 2023.

| Parameter | 2022 | 2023 | | | | | |
|---|---|---|---|---|---|---|---|
| | December | January | February | January | February | March | April | May |
| Temperature (°C) | 10.2-22.9 | 10.4-23.2 | 11.0-24.6 | 11.2-24.8 | 11.3-24.7 | 11.0-24.8 | 11.0-24.3 | 12.0-24.7 |
| Relative humidity (%) | 35-76 | 30-82 | 27-67 | 26-70 | 33-79 | 27-68 | 32-63 | 25-62 |

*Source: Kulumsa metrological station data 2022-2023, unpublished*

*Monitoring of diffused light Stores (DLS), specimen collection, and visual identification*

To check on the health of the tubers, the KARC research team monitored the genotypes and varieties of potatoes kept in DLS once a week (Fig. 1). Every genotype was observed every week, and afterward, the monitoring frequency was raised to twice weekly as sprouting had begun. However, at the end of December 2022 and mid-February 2023, an unusual and unanticipated insect was seen on the sprouts of some genotypes during the time in which temperature and relative humidity near the sprouted tubers had increased. However, it was also discovered in storage during the first week of March 2023, when the tubers had sprouted and were ready for planting. With time, the extent of the infestation grew, and the pest quickly expanded by sucking on the sap from sprouts and netting on potato tubers. The insect infested more than 30 genotypes in mid-March 2023, with fewer adult populations on the tubers. Infestation levels rose sharply from the end of March to mid-April.

For the identification of the pest in the laboratory, mite samples were collected from infected tubers within the DLS and placed in white plastic bags. During monitoring, potato tubers were visually inspected in DLS using an aided 10-times magnifying hand lens. Samples of ten randomly selected tubers from each genotype were used for the species identification of the pest. Digital cameras were used to capture images of sprouting potato tubers infested with spider mites. Tubers found in and near infested potato storage columns were also examined for possible mite infestation, and the results were recorded.

*Assessment of Two-Spotted Spider Mites (TSSM)*

The infestations, occurrences, and level of damage caused by two-spotted spider mites in thirteen and thirty-two stored potato genotypes were chosen during the first and second years, respectively. To determine the presence of TSSM on tubers, 10 samples were randomly selected following the "W" pattern from 100 sprouted potato tubers for each potato genotype. The data were collected using a straightforward hand lens and ocular observations. To calculate the number of TSSM per sprouted tuber of potato genotypes, the number of adults per sprout of a tuber was counted. The average TSSM for each sprout collected from a potato was calculated using the formula following the work of Kataria and Kumar (2012) and Gebissa *et al.* (2019).

$$\text{Incidence} = \frac{\text{Number of infested plants}}{\text{Total plant observed}} \text{x } 100$$

The following criteria were used to categorize the levels of mite infestation: According to the research of Steinkraus *et al.* (2003), the severity index was calculated using the following scales: Zero: no spider mites found; light: one to ten spider mites per leaf found on occasional potato tuber sprouts; medium: eleven to fifty spider mites per leaf present on many tubers; leaves mottled yellow or red; and heavy: more than fifty spider mites per potato tuber on most leaves of sprouts; many leaves became reddish brown. The severity index (SI) is the sum of the values of the grade points of infected plants (1 to 5 infestation grades, from I to V, respectively) divided by the total number of infected plants observed. It was graded on a scale of 1 to 5, each denoting zero, 25%, 25–50%, 51–75%, and 75% severity, respectively.

## Results and Discussion

*Visual identification of the pest*

In March 2023, mite sample identification was done. It was recognized at the Kulumsa Protection Laboratory in Asella, Ethiopia. All samples were identified as two-spotted spider mites (*Tetranychus urticae* Koch, Acari: Tetranychidae) (Figures 1 and 2). To the best of our knowledge, this is the first instance of *T. urticae* found in Ethiopian sprouting potatoes under DLS. Individual spider mites are difficult to see with the naked eye due to their small size and cryptic behavior, leaving single individuals and, most of the time, infestations undetected (Tehri and Gulati, 2015). When observed, eggs were white, and adults and nymphs were reddish-orange. Spider mite damage to leaves can be seen with the unaided eye, but a hand lens or stereoscope is typically used to find mites.

The main indicators used to identify TSSM in DLS were morphological characteristics, the sort of damage it caused, and web-developing behaviors on the tubers. According to the author's observations, red spider mites were first discovered on sprouted potatoes at KARC DLS in 2022 and later in 2023. They were then examined in the KARC protection laboratory using a stereo microscope with a resolution power of 100 times the actual size in March 2023. Most morphological methods for identifying herbivorous mites are based on the visual evaluation of morphological traits; currently, this is considered the main method (Razuvaeva *et al*., 2023). The size and shape of the male genitalia are typically used to identify the mite's genus and species (NAPPO, 2014). Their morphological identification is, however, greatly complicated by their microscopic size, slight variations in diagnostic features across species belonging to the same genus, and the laboriousness of preparing the biomaterial for study (Konoplev *et al*., 2017). The study of spider mite population dynamics, prompt control of their numbers in agro- and biocenosis, and the removal of trade barriers based on international plant quarantine are all dependent on the accurate identification of spider mite species (Li *et al*., 2015; Razuvaeva *et al*., 2023). The Tetranychidae family is currently diagnosed using biochemical (protein-based) and molecular (DNA-based) approaches, as well as identification by adult morphological trait techniques (Razuvaeva *et al*., 2023). The principles of the morphological approach for identifying spider mites have made a significant contribution to the management and ongoing scientific study of the pest, in which the concepts derived from earlier research remain applicable (Mitrofanov *et al*., 1987; Mehle and Trdan, 2012; Popov, 2013; Konoplev *et al*., 2017).

Figure 1. Potato tubers infested by the two-spotted spider mites in KARC DLS. (A**)** Tubers covered by spider web-like structures; (B) A swarm of eggs and adults of mites on sprouted potato tubers and dried tips by TSSM infestation.

*The symptoms of the TSSM on the sprouted potato tubers*

The pest's signs and symptoms were noticed on sprouting potato tubers in the KARC DLS. The insect had a white mass of a body that looked like cotton and appeared at various phases of development with different body sizes (Figs. 1A and B). By constructing webs between the sprouting leaves of neighboring tubers, the mites were able to spread to nearby uninfected tubers (Fig. 1A). Both adults and nymphs were reddish-orange when they were examined, with two black spots visible on the adults (Figs. 2B and 2C). Webbing may be a sign that spider mites are present nearby (Fig. 1B and Figs. 2A and C). The two-spotted spider mites are a member of a group of mites that spin webs, and the name "spider" underscores its capacity to create webbing that resembles silk. They were typically hidden beneath the webs, which serve as a vehicle for dispersal, shelter from predators, a suitable microhabitat for the TSSM, protection against abiotic agents, and a means of communication (Le Goff *et al*., 2010; Clotuche *et al*., 2011; Muluken *et al*., 2016; Gebissa *et al*., 2019).

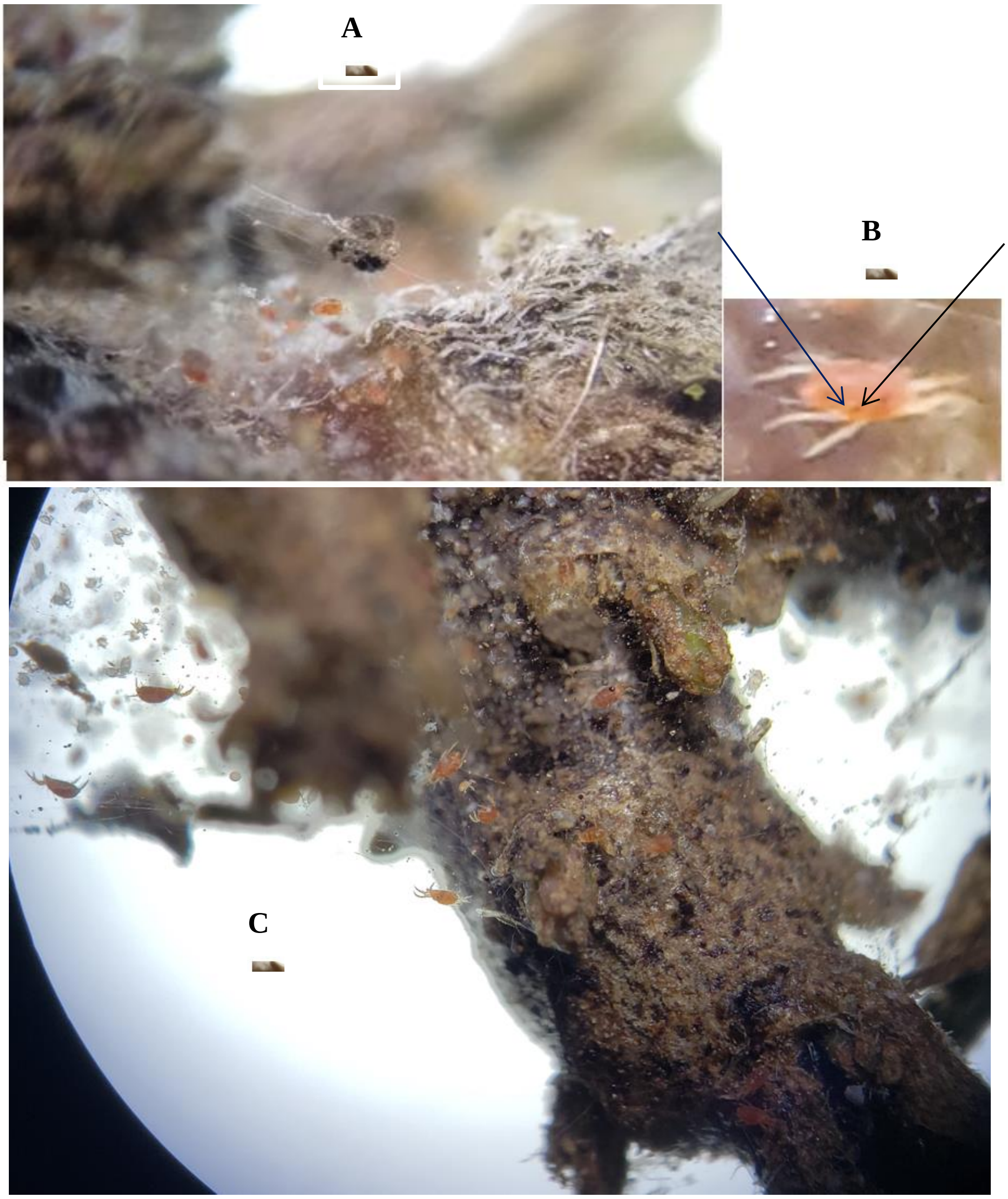


Figure 2. A Red spider mite colony: (A) and (C) enlarged TSSM adults by stereo microscope attached to their web (silk-like structure) (at KARC protection Laboratory); (B) TSSM showing the two black spots.

*Damage due to the red spider mite on potato tubers*

Attacked sprout leaves gradually changed from green to light brown to greyish-white, completely drying them out and ultimately causing the death of the entire plant (Fig. 1B). Even though the damage levels of the pest vary with the population of mites, it dried the entire sprout, including the stem (Fig. 1B). Similarly, the TSSM larval and adult stages prefer to feed on the underside of leaves (Jhonson and Lyon, 1991; Reddall *et al.*, 2004). Following this study, the mites created spider webs all over the apexes of potato plant leaves under significant infestations under field conditions (Muluken *et al.*, 2016; Gebissa *et al.*, 2019). Muluken *et al.* (2016) and Gebissa *et al.* (2019) described similar observations regarding how TSSM damaged potato plants in eastern Ethiopia, from leaf drying to complete plant death. Muluken *et al.* (2016) also outlined how the attacked leaves gradually turned greyish-white or light brown, resulting in the complete drying of potato leaves and ultimately leading to the death of the whole plant. Phytotoxic chemicals can be injected when feeding, which can have various effects on the host plant (Jhonson and Lyon, 1991). Therefore, the ability of the plant to photosynthesize was diminished, which decreased both its production and overall growth (Dara, 2015). Additionally, faecal matter buildups, webbing, and/or defoliation affect the plant's look and marketability (Jhonson and Lyon, 1991).

*Assessment of the Two Spotted Spider Mites (TSSM)*

In 2022 DLS monitoring, the distribution of the mite pest was confined to 10–13 potato genotypes only (Table 2) but expanded to other genotypes in 2023, and the pest heavily infested a number of potato genotypes in different parts (columns) of the DLS (Table 3). The level of infestation increases from light (1–10 mites per sprout) to heavy (>50 spider mites per potato sprout on most tubers) in 2022 and 2023. However, potato tubers observed in other columns were free from a two-spotted spider mite infestation.

Table 2. Infestation, severity, incidence, and loss of tubers of the two-spotted spider mite (*T. urticae*) on potato tubers at Kulumsa, Southeastern Ethiopia, during the 2022 off-season.

| Genotypes | Pedigree | Infestation level (Grade) | Severity (%) | Incidence | Tubers emerged (%) | Tuber loss (%) |
|---|---|---|---|---|---|---|
| G1 | CIP-300065.4 | 3rd | 50 | 56 | 79.17 | 20.83 |
| G2 | CIP-302498.72 | 3rd | 30 | 36 | 47.92 | 52.08 |
| G3 | CIP-302499.30 | 4th | 55 | 86 | 8.33 | 91.67 |
| G4 | CIP-312922.528 | 2nd | 20 | 30 | 43.75 | 56.25 |
| G5 | CIP-312923.637 | 2nd | 15 | 22 | 79.17 | 20.83 |
| G6 | CIP-312923.644 | 2nd | 25 | 28 | 56.25 | 43.75 |
| G7 | CIP-312924.545 | 3rd | 40 | 62 | 45.83 | 54.17 |
| G8 | CIP-312924.618 | 4th | 75 | 100 | 0.00 | 100.00 |
| G9 | CIP-312927.578 | 5th | 85 | 100 | 0.00 | 100.00 |
| G10 | CIP-312928.593 | 3rd | 35 | 50 | 52.08 | 47.92 |
| G11 | CIP-396268.9 | 3rd | 45 | 52 | 87.50 | 12.50 |
| G12 | CIP-396272.12 | 3rd | 48 | 78 | 0.00 | 100.00 |
| Dagim | CIP-396004.337 | 3rd | 50 | 66 | 70.83 | 29.17 |

Similar monitoring of the DLS in April 2023 showed an expansion of the mite pest to other sprouted potato tubers (Table 3). In most of the observed potato genotypes, infestation levels ranged from 1–5th grade of the spider mite on the sprouts (Tables 2 and 3). In some genotypes, whole potato sprout tips and leaves were killed or dried (Fig. 1B). This implies that susceptible and resistant potato genotypes can be used for susceptible check and resistance crop breeding in future crop improvement. The incidence of TSSM on potato tubers was different across the studied genotypes. Incidences of TSSM were highest in G8 (100%) and G9 (100%) in 2022, followed by G3 (86%), G12 (78%), G-9 (72%), and G-6 (69%). G-7 (97%) had the highest incidence level in 2023, followed by G-9 (72%) and G-6 (69%).

The insect damaged the sprouted tubers in 2022, resulting in a loss of tubers of 12.5–100% (Table 2). G8, G9, and G12 were the genotypes that failed to emerge from 16 tubers per net plot, resulting in a 100% loss of sprouted tubers. The tubers from G11 had the highest percentage of germination (87.5%), followed by those from G1 (79.17%) and G5 (79.17%). Tuber losses were 12.5%, 20.8%, and 20.8%, respectively, indicating comparable or greater resistance. This could be inherent like potato genotypes and could be suggested for resistance breeding potatoes for TSSM.

In 2023, the infestation levels varied from 1st grade (no severity) to 5th grade (more than 75% severity) for the sprouted potato genotypes. This could be the inherent nature of the genotypes or the nature of sprouts, with a fewer number of leaves and a higher number of sprouts per individual tuber. The genotypes were planted the following year after being sprayed with the highly lethal herbicide Profit 72 EC, as recommended by Tesfay *et al.* (2018) and Gebissa *et al.* (2019). Compared to the first year's results, the tubers of potato genotypes emerged up to 100%, with a maximum tuber loss of 15.38% for G-2 and G-7 (Table 3). Field and greenhouse-recommended chemical applications can significantly help manage the pest, and the decrease in losses of the tubers was due to timely and repeated chemical treatment. However, some of the treated genotypes displayed burning symptoms on their leaves. This could be due to the dosage (concentration) of the chemical recommended for use under field conditions as well as the lesser resilience of young sprout leaves.

The hot and humid conditions that prevailed in the area from December to February 2022 and January to May 2023 aggravated the damage incurred by the pest (Table 1). Under field conditions, hot and dry conditions influence the density of mites (Chinniah *et al.*, 2007; Rampal *et al.*, 2013; Muluken *et al.*, 2016). Gebissa *et al.* (2019) reported in Eastern Hararghe, Ethiopia, that TSSM severely affected 44.2% and 7.4% of the flowering and seedling stages of potato production, respectively. Similarly, Muluken *et al.* (2016) reported that TSSM severely damaged 80% of potato plant leaves. This might occur because of environmental variables favorable for TSSM growth, reproduction, and development in the warmer seasons of 2022 and 2023, such as temperature and relative humidity.

Table 3. Infestation, severity, incidence, and loss of tubers of the red spider mite (*T. urticae*) on potato tubers at Kulumsa, Southeastern Ethiopia, during the 2023 off-season.

| Genotypes | Pedigree | Infestation Level (Grade) | Severity (%) | Inciden ce (%) | Tubers emerged (%) | Tuber loss (%) |
|---|---|---|---|---|---|---|
| G-1 | CIP 319007.34 | 3rd | 40 | 67 | 92.31 | 7.69 |
| G-2 | CIP 31003.3 | 3rd | 50 | 72 | 84.62 | 15.38 |
| G-3 | CIP 31004.70 | 3rd | 40 | 63 | 92.31 | 7.69 |
| G-4 | CIP 319004.5 | 3rd | 30 | 52 | 100.00 | 0.00 |
| G-5 | CIP 319004.55 | 2nd | 20 | 38 | 100.00 | 0.00 |
| G-6 | CIP 319003.25 | 3rd | 50 | 69 | 100.00 | 0.00 |
| G-7 | CIP 319003.7 | 5th | 90 | 97 | 84.62 | 15.38 |
| G-8 | CIP 319008.10 | 3rd | 30 | 49 | 100.00 | 0.00 |
| G-9 | CIP 31004.4 | 3rd | 50 | 67 | 100.00 | 0.00 |
| G-10 | CIP 319007.28 | 3rd | 30 | 54 | 92.31 | 7.69 |
| G-11 | CIP 319004.40 | 2nd | 10 | 25 | 100.00 | 0.00 |
| G-12 | CIP 319004.32 | 3rd | 30 | 51 | 100.00 | 0.00 |
| G-13 | CIP 319004.35 | 2nd | 20 | 35 | 100.00 | 0.00 |
| G-14 | CIP 319004.20 | 1st | 0 | 1 | 100.00 | 0.00 |
| G-15 | CIP 319004.43 | 1st | 0 | 2 | 100.00 | 0.00 |
| G-16 | CIP 319006.41 | 2nd | 10 | 22 | 100.00 | 0.00 |
| G-17 | CIP 319007.33 | 3rd | 30 | 54 | 92.31 | 7.69 |
| G-18 | CIP 319004.38 | 2nd | 20 | 36 | 100.00 | 0.00 |
| G-19 | CIP 319008.50 | 2nd | 10 | 23 | 92.31 | 7.69 |
| G-20 | CIP 319006.2 | 2nd | 20 | 3 | 100.00 | 0.00 |
| G-21 | CIP 319008.56 | 1st | 0 | 0 | 100.00 | 0.00 |
| G-22 | CIP 319004.22 | 2nd | 10 | 25 | 100.00 | 0.00 |
| G-23 | CIP 319004.61 | 3rd | 40 | 62 | 100.00 | 0.00 |
| G-24 | CIP 319004.12 | 2nd | 10 | 22 | 92.31 | 7.69 |
| G-25 | CIP 319009.25 | 3rd | 30 | 55 | 100.00 | 0.00 |
| G-26 | CIP 319003.30 | 1st | 0 | 0 | 100.00 | 0.00 |
| G-27 | CIP 319003.32 | 3rd | 30 | 55 | 100.00 | 0.00 |
| G-28 | CIP 319008.6 | 2nd | 20 | 37 | 100.00 | 0.00 |
| G-29 | CIP 319004.72 | 3rd | 40 | 66 | 100.00 | 0.00 |
| G-30 | CIP 319001.29 | 2nd | 10 | 26 | 100.00 | 0.00 |
| G-31 | CIP 319004.10 | 2nd | 10 | 24 | 100.00 | 0.00 |
| G-32 | CIP 319008.4 | 1st | 0 | 0 | 100.00 | 0.00 |

***Control measures taken at DLS***

This infestation was accidental and occurred suddenly. The first step was to discuss the best ways to manage the TSSM in the store with an entomologist. Sanitation measures such as hand-peaking and cleaning were taken to control the level of infestation and prevent its spread to more genotypes. At the time of the infestation, no research-recommended pesticides were available for use on sprouted tubers under storage conditions. It could not manage the TSSM in the first year with the conventional insecticides available on the local market. Profit 72 EC (Profenofos) insecticide was sprayed with the perception that spider mites are sap-feeding insects and a field recommendation of the insecticide with a high pest mortality rate (20 ml knapsack spray$^{-1}$) in the second year. However, treatment of the sprouted tubers (chemicals applied) was expected to influence the fresh sprouts of the tubers, as the dosage and concentration were not recommended for potato tubers under storage conditions, and the pests were resistant to the chemical. The key reasons could be the short generation cycle, high fecundity, and haplodiploid sex determination of TSSM, which facilitate the rapid development of pesticide resistance (Van Leeuwen *et al.*, 2010; Grbic *et al.*, 2011).

## Conclusion

Seed tubers are the most important determinant of potato productivity. It can represent a higher proportion of total costs and is a major source of disease and insect pests. Healthy and free seed tubers from insect infestations such as two-spotted spider mites (TSSM) need to be available for farmers' use promptly and at affordable prices. Seeds could be the means of disseminating TSSM to different areas, but infested tubers failed to emerge, with up to 100% tuber loss in some genotypes. Therefore, it is important to ensure the health of the tubers before using them as experimental planting material and supplying them to users. Since the pest is newly reported in the area, visual and molecular species identification should be conducted as part of pest control efforts. Verification of appropriate management options for the TSSM is desirable for use. Generally, creating awareness among different stakeholders about the importance of the insect could decrease the loss of potato seed tubers in other parts of the country.

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