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Ecological Distribution and Infestation Dynamics of Rice Panicle Mite, *Steneotarsonemus spinki* Smiley

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***Abstract*:** Field surveys conducted across major rice-growing villages of the North Coastal districts of Andhra Pradesh between 2017 and 2021 confirmed *Steneotarsonemus spinki* Smiley as the principal factor associated with spikelet sterility and grain discolouration. Mite colonies were predominantly located within the intercellular spaces of the upper leaf sheath and basal midrib regions, producing characteristic necrotic streaks. Infestations began on leaf sheaths during booting and later extended to developing grains. Incidence ranged from 1–15% in most surveyed locations and reached 20–30% in Amadalavalasa. Cultivars such as RNR-15048, BPT-5204 and BPT-3219 recorded higher susceptibility. Mites persisted in stubbles and ratoon rice and survived on associated weeds (*Cyperus rotundus*, *Echinochloa crusgalli, Cynodon dactylon*), confirming their role as off-season hosts. Peak populations occurred during the booting and soft dough stages. The study highlights the increasing economic importance of *S. spinki* in Andhra Pradesh and emphasizes the need for integrated management strategies targeting both the mite and its associated pathogens.

Keywords: *Steneotarsonemus spinki*, Rice, Host range, Distribution

Among non-insect pests of rice, mites are considered significant due to their impact on both field production and storage. In India, as many as 61 species of mites have been reported to be associated with rice cultivation and storage systems (Rao et al., 1999). Of these, the rice panicle mite, *Steneotarsonemus spinki* Smiley (Acarina: Tarsonemidae) is important, as it infests the flag leaf sheath of rice, leading to brown discolouration. Infestation on panicles causes chaffy grains and discoloration of filled or partially filled grains (Srinivasa et al., 2004), while feeding on floral reproductive structures can result in grain sterility (Rao et al., 2000).

Steneotarsonemus spinki has emerged as a major constraint to rice production across Asia and other global rice-growing regions since the 1970s (Tseng 1978). The earliest indirect reference in India dates to Ramaiah (1931), describing a "tiny moving arthropod" infesting rice. The species was formally described by Smiley (1967) from specimens in Louisiana, USA. First documented as a rice pest in China in 1968 (Ou et al., 1977), the mite was detected in India in 1975 (Rao and Das 1977). It has since spread widely, causing severe outbreaks in several countries, including 30–90% yield losses in Cuba (Almaguel et al., 2000). In India, *S. spinki* was reported in 1992 from paddy fields in the south, later becoming a major pest responsible for significant reductions in both the quality and quantity of rice production in Orissa (Rao and Prakash 1992), Gujarat (Rai et al., 1998) and West Bengal (Karmakar 2008; Karmakar and Debnath 2016).

In Andhra Pradesh, widespread spikelet sterility and grain discolouration were observed in 1999 across major rice varieties, including MTU1001 and BPT5204, in the West and East Godavari districts, affecting up to 50% of the fields in certain villages. Subsequent investigations confirmed the involvement of *S. spinki* as the primary causal agent, often in association with fungi and nematodes (Rao et al., 2000). Typical symptoms included black sheath lesions, malformed grains, and mite infestation on seed-raised seedlings, indicating possible seedborne transmission. Over the years, the pest has spread to other parts of Andhra Pradesh, causing grain discolouration and chaffy grains in several widely cultivated rice varieties. In recent years, grain discolouration has become more pronounced in *kharif* (wet season) rice cultivated in the North Coastal districts of Andhra Pradesh, leading to considerable qualitative and quantitative losses. Owing to its frequent association with sheath rot (*Sarocladium oryzae*) and uncertainties surrounding its off-season survival, the present study was undertaken to assess the prevalence and morphological characteristics of *S. spinki* in North Coastal Andhra Pradesh.

MATERIAL AND METHODS

Field surveys were conducted across 24 villages in the districts of Srikakulam, Vizianagaram, and Visakhapatnam during 2017–2021. The specific objectives were (i) to assess the prevalence of *S. spinki* on major rice varieties and (ii) to evaluate the role of ratoon rice and weeds in paddy fields as possible inoculum sources contributing to infestations in subsequent cropping seasons. Rice fields were monitored every two weeks starting from four weeks after planting until harvest covering green ring, early boot, late boot, milk, soft dough and hard-dough stages.

During the surveys, discoloured rice panicles were collected in polythene bags from different rice varieties. To determine possible infestation sources, collected four types of substrates from field sites: (1) rice-associated weeds, (2) soil, (3) rice grains of different ages (pre- and post-harvest), and (4) rice stubbles. Samples were brought to the laboratory, placed on a glass slide and examined under stereo binocular microscope for diagnostic symptoms and mite presence. Morphological identification was carried out using stereo binocular microscopy. Life stages were measured to determine morphometrics. Images of the mycosis were captured using Capture Pro-Camera control software.

RESULTS AND DISCUSSION

Survey on grain discolouration and spikelet sterility: Surveys from October to December (2017–2021) confirmed widespread spikelet sterility and grain discolouration in all 24 surveyed villages (Fig. 1). The most affected rice varieties included MTU1001, RNR 15048, BPT5204, BPT3219, NDLR-7, DRR-DHAN45 (Fig. 2 a-f). The infestation exhibited a patchy distribution pattern across 24 villages and the infestation ranged from 1-15% in most villages, with the highest incidence (20-30%) recorded in Amadalavalasa. Varietal-specific symptoms were also documented: leaf sheath discolouration was observed on Srikurma at Ragolu and MTU1156 at Amadalavalasa. Grain discolouration occurred in MTU1001 (5-10%), Sambhamahsuri (5-10%), and Sonamahsuri (5-10%) at Kusuma Polavalasa (Polaki mandal). In Amadalavalasa (Srikakulam district), discolouration was observed on MTU1239 (5-10%), MTU1156 (5-10%), RNR15048 (20-30%), and NDLR-7 (15-20%). In Anakapalle district, MTU1001, BPT 5204 and RNR 15048 exhibited 20-25% grain discolouration in Chodavaram and Koyyuru mandals during early November, while discolouration of the leaf midrib was observed on RGL 2537 at Anakapalle during November-December. Rao et al. (2000) reported that the cultivars MTU-1001, MTU-2067, MTU-2077, MTU-7029, BPT-5204 and PLA-1100 were most susceptible to rice panicle mite. The variation in incidence among varieties and locations may be attributed to differences in varietal susceptibility, local microclimatic conditions, and cropping intensity. Higher humidity and moderate temperatures prevailing during the *kharif* season likely favoured the population build-up of *S. spinki* which is consistent with previous reports from India and Southeast Asia (Rao et al., 2000).

The panicle mite was observed from the booting to harvest stages, with higher incidences recorded during the *kharif* season compared to the late *kharif* period. The population density peaked at the booting and soft dough grain maturity stages, reaching 78-110 mites per panicle. Thereafter, mite numbers declined progressively from the medium to hard dough stages. Following harvest, *S. spinki* migrated to alternative sources of moisture and sustenance, including rice stubble, ratoon crops, seedlings from fallen grains, and other Poaceae hosts, where it could continue to survive and reproduce. The present findings are consistent with those reported by Begam et al. (2019) who reported that peak incidence of mite occurred at the ripening stage but significantly higher number of mite population and damage symptoms in all plants were observed at the panicle emerging to ripening stage.

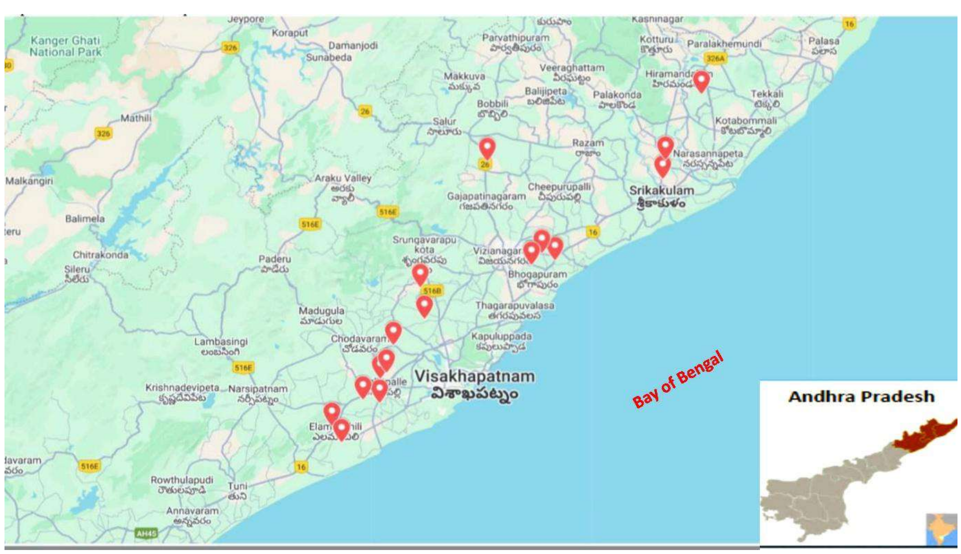

Fig. 1. Map of Coastal Andhra Pradesh showing the mandals of Srikakulam, Vizianagaram and Visakhapatnam districts surveyed

Morphological identification: The panicle rice mite is not visible to the naked eye and requires a minimum 20× hand lens for observation inside the leaf sheath. Stereomicroscopic examination of infested rice samples confirmed *S. spinki* as the causal organism associated with grain discolouration. Mites were observed in colonies within the intercellular spaces of the upper leaf sheath, necrotic lesions, and the basal part of the midrib of the leaf blade, causing necrotic streaks in the interveinal epidermis (Fig. 3). Affected plants exhibited poorly exerted panicles and necrotic leaf sheaths. Mites were primarily located between the stem and leaf sheath, and the affected glumes showed brown to black discolouration of the lemma and palea with shrivelled ovaries.

Fig. 2. Grain discolouration in different varieties (a-e) : (a) Basmati variety; (b) NDLR -7; (c) RNR 15048; (d) DRR Dhan-45; (e) MTU1001; (f) BPT 3219

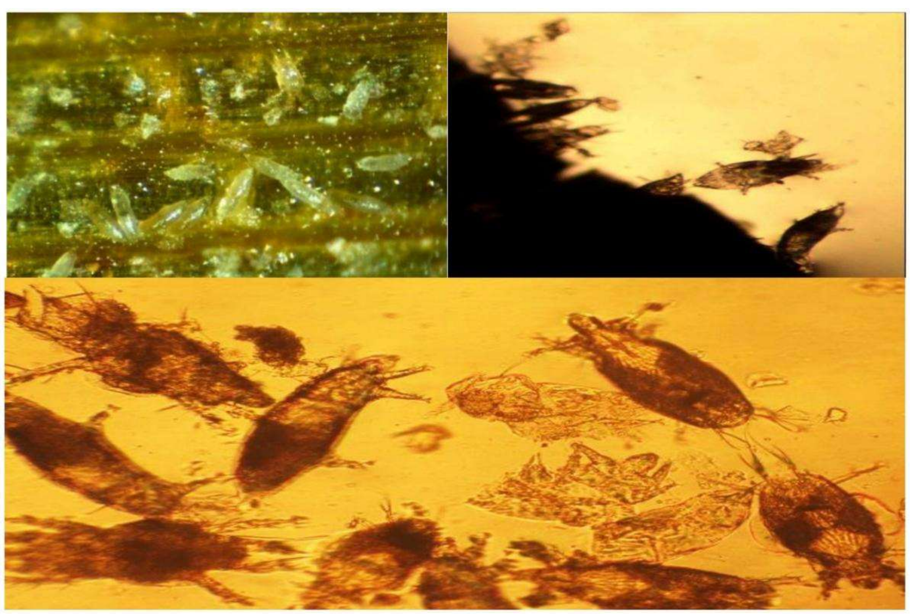

Fig. 3. Colonies of *S. spinki* in the inter cellular space of the leaf sheaths

Life stages of *S. spinki:* These mites are clear to straw-coloured and measure approximately 250 µm in length. Males have elongated rear legs with a pair of prominent spines, which they carry above their bodies. They are highly active and can be seen moving on the leaf surface. Females are ovoid in shape. The larval stages and eggs are about half the size of adults.

Egg: Morphologically, the eggs were cloudy, creamy white to yellowish white, and elongated in shape (Fig. 4a). As embryonic development progressed, the eggs turned more whitish. The eggs measured an average of 0.12 ± 0.006 mm in length and 0.068 ± 0.007 mm in breadth. Eggs laid by adult females were found deposited within the intercellular spaces of rice leaf sheaths, either singly or in small clusters containing 2–5 eggs. These findings are consistent with the observations of Patel and Purohit (2009).

Nymph: Male and female nymphs were distinguished primarily by size (Fig. 4b). Male nymphs were smaller and exhibited a transparent white colouration (Fig. 4d). The average body length and width of male nymphs were 0.148 ± 0.017 mm and 0.069 ± 0.006 mm, respectively, while female nymphs measured 0.174 ± 0.018 mm in length and 0.070 ± 0.006 mm in width. The present findings show slight variation from those reported earlier by Patel and Purohit (2009).

Quiescent stage: The mature larva entered a quiescent stage and feeding of the larva was restricted. Quiescent stage measured 0.213 ± 0.012 mm in length and 0.073 ± 0.014 mm in width.

Adult: Adult males and females were nearly transparent. Males were broader, with characteristic dagger-shaped setae (Fig 4c), whereas females were narrower but slightly longer (Fig. 4d). Morphometric analysis revealed that adult males measured 0.234 ± 0.011 mm in length and 0.106 ± 0.010 mm in width. Adult females measured 0.286 ± 0.016 mm in length and 0.080 ± 0.011 mm in width which are in conformity with Patel and Purohit (2009).

Life cycle: Rice Panicle mite, *S. spinki* has fast and efficient reproduction with females producing 50 to 70 eggs in their lifetimes. Reproduction is arrhenotokous parthenogenetic, whereby virgin female produce male off springs. The sex ratio of female: male *S. spinki* to be 22:1, 32:1 and 8:1at 32^{0}C, 28^{0}C under field condition respectively. Increasing temperature significantly shortened generation time from 11. 3 days at 20^{0}C to 7.8 days at 23.9^{0}C and 4.9 days at 33.9^{0}C and *S. spinki* can produce 48 -55 generations per year under ideal climatic conditions. Thus, a large population of S. spinki can develop very quickly in a rice crop during a single growing season. These findings align with Chaudhari et al. (2019).

Damage symptoms: Microscopic examination of several affected plant samples confirmed *S. spinki* as the predominant causal organism in all cases. Four distinct combinations of visual symptoms were identified on infested

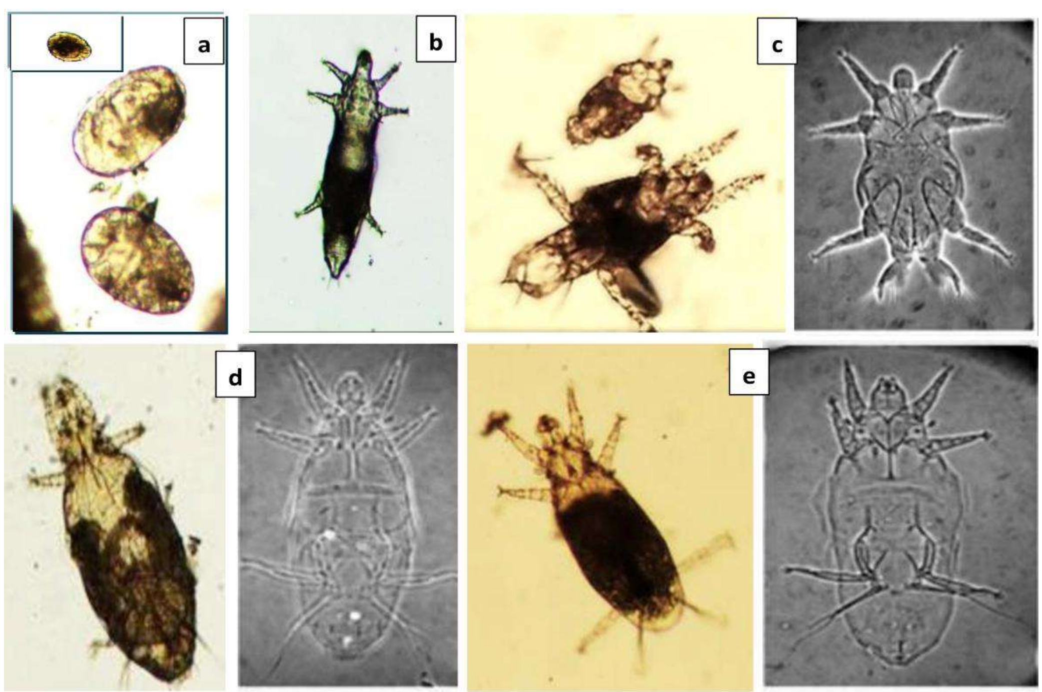

Fig. 4. Life stages of *Steneotarsonemus spinki* (a) Egg (b) Nymph (c) Female adult- Dorsal side & Ventral side (d) Male adult -Dorsal side &Ventral side

plants: (i) mite damage alone; (ii) mite + saprophytic fungus; (iii) mite + saprophytic fungus + sheath rot fungus; and (iv) mite + white-tip nematode (*Aphelenchoides besseyi)* + other saprophytic fungal damage. The present findings corroborate the observations of Rao et al. (1993). Characteristic field symptoms included black lesions on the leaf midrib (Fig. 5a) and leaf sheath (Fig. 5b), discoloured grains (Fig. 5c), partially or completely chaffy grains (Fig. 5d) and other grain deformities (Fig. 5f). These observations are consistent with earlier reports of Karmakar (2008). Distinct mite-associated symptoms were also observed on the leaves of seedlings raised from infested seed material, suggesting the possibility of seed-to-plant transmission of the tarsonemid mite. These observations agree with the findings of Rao et al. (2000). The frequent association of *S. spinki* with fungal pathogen such as *Sarocladium oryzae* observed in the present study suggests a possible synergistic interaction that may exacerbate the severity of grain discolouration and spikelet sterility. Another plausible explanation for this co-occurrence is that feeding damage caused by *S. spinki* predisposes the panicle and sheath tissues to secondary infections, thereby facilitating the entry of pathogens responsible for panicle blight and sheath rot. Further investigations are warranted to elucidate the precise nature of these interactions and to develop integrated management strategies that simultaneously target the mite and its associated pathogens. Rao and Prakash (2003) also found *S. spinki* on plants from which no pathogens were isolated, they concluded that the grain discolouration could be caused by a chemical reaction to toxic saliva of *S. spinki* whereas Chen et al. (1979) found that *S. spinki* carried spores of *Acrocylindrium oryzae* Sawada (*S. oryzae*) on their body and attributed the plant symptoms to a combination of *S. spinki* damage and disease.

The panicle mite causes both direct and indirect damage to rice. Direct injury results from feeding on leaf tissues within the sheath and developing grains during the milk stage, while indirect damage occurs from transmission of fungal and bacterial pathogens. The mite punctures epidermal cells with its stylets, producing brown necrotic lesions on the upper leaf sheath and grain hulls. Feeding weakens tissues and facilitates fungal infection, leading to panicle sterility, grain malformation, and discolouration. Feeding occurs mainly beneath the leaf sheath, where chocolate-brown streaks develop. As new leaves emerge, females migrate to younger sheaths for oviposition, and damage becomes visible only after removing outer sheaths. The mites progress to the innermost sheath and eventually colonize the developing panicle. Infestations during booting to milk stages cause grain sterility, chaffy and deformed grains with a "parrot-beak" shape, and sheath discolouration (Hummel et al., 2009). The mites also carry fungal spores on their body, aiding pathogen spread. These symptoms often resemble sheath rot caused by *Sarocladium oryzae*. Mite populations peaked at the booting stage and declined as the crop matured, consistent with earlier observations (Chandrasena et al., 2018). Infestations were associated with necrotic sheaths, poorly exerted panicles, and discoloured or malformed grains. Similar damage including "unfilled grain syndrome," has been documented in other Asian countries (Srinivasa et al., 2004, Mutthuraju et al., 2014).

Influence of weather parameters : Weather factors such as temperature, relative humidity, rainfall, and sunshine hours play a crucial role in regulating the population dynamics of *S. spinki*. Periods of reduced rainfall and increased sunshine were conducive to the proliferation of *S. spinki*. High temperatures coupled with low rainfall during August–October favoured rapid population buildup. Optimal development occurred at around 28°C and relative humidity above 80%, with maximum growth observed at 90–95%. Rainfall and relative humidity showed a negative correlation with *S. spinki* populations, whereas temperature and sunshine hours exhibited a positive correlation. Continuous rice cultivation and the movement of infested stubbles or contaminated equipment between fields further facilitated the spread and persistence of *S. spinki* populations. Intermittent heavy showers negatively affected mite populations, whereas prolonged dry periods promoted their growth. These observations agree with the findings of Chandrasena et al. (2018).

Sources of infestation: The incidence of *S. spinki* was higher in the *kharif* season than in *rabi*. Ratoon rice plants present during the fallow period (December–June) served as survival habitats, facilitating the persistence of the panicle rice mite between two consecutive kharif seasons. No mites were found in soil samples, but infestations in grains and rice stubbles confirmed these as major inoculum sources (Prabhakara 2002). Three grassy weeds (1) *Cyperus rotundus*, (2) *Cynodon dactylon*, and (3) *Echinochloa crusgalli* were served as alternate hosts, facilitating mite survival and carryover. (Fig. 6 a-c). Khimji (2005) found that *S. spinki* survived on graminaceous weeds such as *Cyperus difformis* and *Cynodon dactylon*, as well as on post-harvest rice residues, acting as a source of infestation for the subsequent *kharif* crop. Srinivasa and Prabhakara (2007) also detected eggs and active stages on *C. dactylon* and *Echinochloa colonum* near rice fields in Karnataka. In Sri Lanka, Chandrasena et al. (2016) identified *Sacciolepis interrupta* as a major alternate host, while *E. crusgalli* and *Leptochloa chinensis* played minor roles. Similarly, Tran et al. (2023) reported *E. crusgalli* and

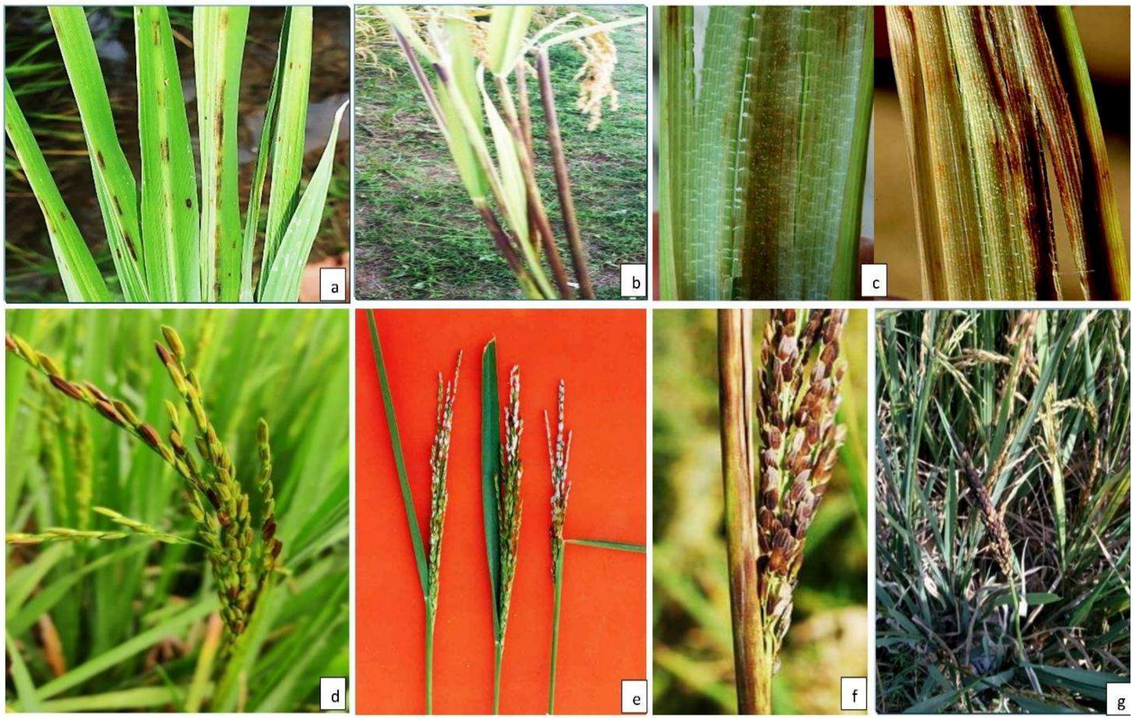

Fig. 5. Damage symptoms of *S. spinki* in rice (a-f): (a) Midrib discolouration; (b) Leaf sheath discolouration (c) Necrotic lesions inside the leaf sheath; (d) Grain discolouration; (e) Chaffy grains; (f) Poor exertion and (f) Malformed panicle

Fig. 6. Alternate hosts of *S. spinki:* Grassy weeds (a) *Cynodon dactylon;* (b) *Cyperus rotundus;* (c) *Echinochloa crusgalli*

Fimbristylis spp. as alternative hosts and important sources of infestation. No tarsonemid mites were detected in soil samples from infested fields, indicating that stubbles serve as the primary site for off-season survival. The rice panicle mite was found on grains of different ages and in stubbles, confirming these as key inoculum sources between cropping seasons. The mite can spread through infested rice seeds since larvae can briefly survive under dry conditions and by passive dispersal via wind or insect vectors such as planthoppers. Even a small number of surviving eggs or immatures can rapidly multiply under favourable conditions due to parthenogenetic reproduction. Thus, both rice grains and stubbles act as important sources of *S. spinki* infestation in successive crops. These findings emphasize the importance of eliminating ratoons and weed hosts during crop-free periods as an effective cultural strategy for managing *S. spinki* under integrated pest management programs in North Coastal Andhra Pradesh and are consistent with the observations of Kayal et al. (2021) and Tran et al. (2023).

Impact on grain quality and yield: In the North Coastal districts of Andhra Pradesh, the highest economic impact of *S. spinki* was recorded in Srikakulam district, where yield losses of 10–20% occurred in medium-duration rice varieties such as MTU 1001, BPT 5204, BPT 3219, and RNR 15048. (Rao et al., 2000) also reported severe grain deterioration characterized by ill-filled, chaffy, and discoloured grains in medium-irrigated rice varieties. Similar results have been documented in India and elsewhere, with *S. spinki* infestations causing yield losses ranging from 5% to 90%. In India, losses have been estimated at 4.9–23.7% (Rao and Prakash 1996) and 10–15% (Rao et al., 2000), while global estimates indicate damage ranging from 5% to 95% across several countries (Navia et al., 2010, Pushpakumari et al., 2010).

CONCLUSIONS

The study confirms that infestation by the panicle mite, *S. spinki* is the primary cause of grain discolouration and chaffy grains in *kharif* rice across the North Coastal districts of Andhra Pradesh. Mite populations peak during the booting stage and persist through ratoons and weeds, leading to significant yield and quality losses. The association of mites with fungal spores suggests a potential role in transmitting secondary pathogens. Therefore, an integrated management strategy is recommended, involving early scouting during the booting stage, removal of ratoon and weed hosts, cultivation of less susceptible varieties, and timely application of acaricides with fungicides to effectively suppress mite populations and reduce grain discolouration and chaffiness.

AUTHOR's CONTRIBUTION

B. Bhavani was responsible for the conceptualization of the study, planning and execution of experiments, supervision of data collection, data analysis, interpretation of results, and preparation of the original manuscript draft. P. Kishore Varma supported the surveys and microscopic examination of affected samples and contributed to data validation. M. Visalakshi assisted in experimentation and data recording, reviewed and edited the manuscript.

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