Agric. Rev., **29** (1) : 31 - 39, 2008

BIO-ECOLOGY AND MANAGEMENT OF RICE MITES - A REVIEW

V. Jhansi Lakshmi, N.V. Krishnaiah, I.C. Pasalu and G. Katti.

Directorate of Rice Research,
Rajendranagar, Hyderabad-500 030. INDIA.

ABSTRACT

Sheath mite, *Steneotarsonemus spinki* and leaf mite, *Oligonychus oryzae* are the two most important mite species damaging rice crop. *S. spinki* remains in the leaf-sheath below epidermis and in association with sheath rot fungus, *Acrocylindrium oryzae*, it causes grain discolouration, ill filled and chaffy grains. Rice is the major host of S. *spinki* and it survives in stubbles and ratoons during off-season. There is facultative parthenogenesis in *S. spinki*. Optimum temperature for its development and multiplication is 25 to 28° C. During a crop season, *S. spinki* becomes very serious from 80 DAT and reaches its peak between 100 to 120 DAT. There are no known sources of high level of host plant resistance to *S. spinki* although some indica types have exhibited lower grain sterility. Predatory mite, *Amblyseius taiwanicus* is the most important natural enemy. Leaf mite, *O. oryzae* damages rice by sucking the sap of mesophyl tissue of leaves. Bright sunny weather followed by slight rainfall is congenial for its multiplication. Profenophos @ 500 g a.i. /ha, spiromesifen @ 72 g a.i. /ha, milbemectin @ 2.5 g a.i. /ha and dicofol @ 500 g a.i. /ha are some acaricides effective against *O. oryzae*.

Rice, the staple food of nearly half of the humanity is mainly grown and consumed in Asian countries such as India, China, Japan, Indonesia, Thailand, Pakistan, Bangladesh, North and South Koreas, Myanmar, Philippines, Sri Lanka etc. India is number one in area with approximately 44.5 million hectares of rice and it ranks second in production with approximately 91 million tones. But India ranks approximately 15th or still lower with regard to per hectare yield or productivity. Traditionally, insect pests, diseases and weeds are the triple evils responsible for low yields of rice in India. Of late, mites are also assuming major pest status.

Among different species of mites associated with rice crop, the sheath mite or panicle mite and the leaf mite are most importan. The sheath mite, *Steneotarsonemus spinki* in association with the sheath rot fungus, *Acrocylindrium oryzae* causes grain discolouration, ill-filled and chaffy grains and often inflicts heavy losses in rice, in almost all Asian countries. Leaf mite, *Oligonychus oryzae,* at times, becomes serious under field conditions particularly during summer months. Some information on these mite pests is available from other Asian countries but the information available from India is searve. Therefore, it is very essential to initiate some research programmes in India on these mites. As a first step, it is very important to review the information available on these mites and their association with sheath-rot fungus. Hence, an attempt was made to collect, arrange and present the information on bio-ecology and management of rice mites including their association with sheath rot fungus in this review.

Sheath mite or panicle mite, *Steneotarsonemus spinki* Smiley

Bio-ecology and damage

Steneotarsonemus spinki Smiley is a small microscopic tarsonemid mite present in colonies, in the intercellular space of the leaf sheaths of rice plants. Occasionally, the mites are also present in basal part of the midrib of leaf blades. These mites remain and multiply there throughout the vegetative phase of plant growth. During the reproductive phase of the crop growth, *S. spinki* migrate to the developing grains in milky stage and cause spikelet sterility and also partially filled and ill filled grains (Sogawa, 1977). Deformed panicles and inflorescences, lesions on the inner surface of leaf sheaths and browning of rice hulls are also caused by this mite (Cho *et al.,* 1999; Ramos and Rodriguez, 2001). Mite population in the leaf sheath and grain has a positive correlation with grain sterility and negative correlation with grain weight confirming that *S. spinki* is responsible for these symptoms (Lo and Ho 1977). Reduction in panicle size, length of panicle neck, panicle weight occurred as a result of damage by *S. spinki* along with sheath rot fungus (Ghosh *et al.* 1997).

S. spinki females are 263.0 mm in length and 92.4 mm in width. The body is pale brown, elongate and broadest in the region of hysterosoma. The legs are robust except for IV legs, which are typical tarsonemid female legs, terminating in a whip-like seta 2 times the length of the leg. *S. spinki* males are smaller in size and measure 196.5 mm in body length and 109.3 mm in width. The anterior ends of apodemes III extend further than apodemes IV. Femur IV has a large inner median lateral flange; and inner anterior and outer median setae are short and equal in length. The tarsal claw is stout and curved ventrally (Cho *et al.,* 1999).

Females of these mites oviposit in the tissues where they feed. The total number of eggs laid by a single female may vary from 59.5 (Lo and Ho, 1979) to 75 (Sogawa, 1977). The oviposition period is 5 days. The eggs hatch in 2-4 days and there is an active larval stage lasting about 1 day and a quiescent stage lasting 2 days. The life cycle is completed in 6 days (Sogawa, 1977). However, the duration of different stages and the total duration of the life cycle is highly temperature dependant. Lo and Ho (1979) observed that egg to adult development lasted for not more than 3 days at 30°C or higher and at least 20 days at 20°C. Chen *et al.* (1979) in Taiwan observed that the mite required 17, 4 and 2.5 days to complete the development from egg to adult at 25, 28 and 30°C respectively. At 25-28°C, adult females and males lived for 15 $\pm$ 1.0 days and 7.6 $\pm$ 0.4 days respectively, while adults of both the sexes lived only 5 days at 30°C. The pre-oviposition period was about 2 – 5 days and the oviposition period varied from 2 days at 30°C and 7 days at 28°C to 13 days at 25°C. Each female lay between 0 and 78 eggs during its life span with an average of 30.8 $\pm$ 3.4 eggs. Thus, temperatures of 28 – 30°C and RH of >80% are most favourable for the development of the mite. Ramos and Rodriguez (1998) observed that the mite needed 7.77 days (with a range of 5.75 to 9.64 days) for development from egg to adult under controlled conditions (24.42°C and 70.47% RH) on rice sheaths (*O. sativa* cv. Perla de Cuba). Xu *et al.* (2001) observed that the mite completed one generation in 13.6 and 8.5 days at 25 and 30°C respectively. A mated female mite could produce 55.5 eggs on an average in the laboratory at 24.5 to 35.4°C. A virgin female adult, in a mite free rice seedling, could develop to an average 79.4 mites at 24.1 to 35.3°C in 17 days.

S. spinki is facultatively parthenogenetic. All of the descendants of virgin females are males. But the mother female can mate with its male off spring and then produce both female and male mites (Xu *et al.* 2001).

The males and females of this mite can be differentiated in the larval stage. Larval males have three pairs of small pseudoanal setae flanking the uropore, while, females have two such setae. The sex-linked difference in larva correlates with a similar difference in the adults. Females retain only one pair of setae, while males retain two pairs, which are modified into accessory copulatory structure. The larvae are physically active and derive energy from the fat reserves for development to adulthood (Lindquist, 1969 and 1986).

Field observations on sheath mite

Most of the mite population is found on lower 2 and 3 leaf sheaths (Ramos and Rodriguez, 2000 and 2001). Sheath mite population is generally higher during wet season compared to dry season (Rao and Prakash, 1992 and 1995). Damage by *S. spinki* is more in short duration varieties compared to medium and long duration ones (Rao and Prakash, 1996). Population size of S. *spinki* increases with rice planting density (Lo and Ho, 1979 and 1980). Mite infestation increased gradually from 80 DAT and reached a peak between 100 to 120 DAT during *kharif* and summer under field conditions in Karnataka, India. However, the mite population was more abundant during summer than *kharif* (Prabhakara, 2002).

Sums of effective temperature (SET) is a useful tool to calculate the number of generations of a pest per year under field conditions. By following this, Almaguel *et al.* (2004) calculated SET as 62.03 $\pm$ 10.03 degrees per day for Cuban conditions. The sheath mite can complete 48 to 55 generations per year under these conditions. It was estimated that the mite can multiply the whole year with a maximum of 6 generations per month in spring and less than 3 in winter.

Pest risk analysis of the possible introduction of a pest in a country is important particularly for the pests where there is scope for their entry. Navia *et al*. (2005) from Brazil studied this phenomenon in relation to rice sheath mite *S. spinki* into South American continent. The potential pathways of entry identified were via rice seeds and via natural means. The climatic conditions existing in Brazil are favorable for the mite and the possibility of its entry are high. Hence, the ecoclimatic index ranged from 25 (low to medium) to 75 (high) in major rice growing regions of Brazil.

Alternate hosts and off-season biology of *Steneotarsonemus spinki*

Adult female mites of *S. spinki* (but not eggs or larvae) are occasionally found in the leaf sheaths of graminaceous weeds in Taiwan (Lo and Ho, 1977, 1979 and 1980). In India, a weed, *Schoenoplectus arficulatus* (Cyperaceae) was observed as an alternate host of panicle mite *S. spinki* (Rao are Prakash 2002).

Usually, a large number of rice sheath mites in different stages are observed infesting rice stubble or ratoon plants in India. Prabhakara (2002) noticed the mites on leaf sheath of stubbles of rice varieties HR 12, IR 36, IR 64, Morro and Mukthi up to 2 months after harvest with conspicuous symptoms of damage. In temperate countries like Taiwan, over-wintering of *S. spinki* occurs in stubble and ratoon rice from harvest (usually during November) until next February (Lo and Ho, 1977, 1979 and 1980). Chen *et al.* (1979) reported that rice is the only food plant of the mite, *S. spinki* and after harvest, mites are found on the leaf sheaths of rice stubble and then on ratoons.

All these observations suggest that there are no serious alternate host plants for rice sheath mite *S. spinki* and its carryover from one season to the next is mainly through stubbles and ratoons both in tropical countries like India and temperate countries like Taiwan.

Association of *Steneotarsonemus spinki* with sheath rot fungus, *Acrocylindrium oryzae* and other pathogens

Usually, the injuries caused by the sheath mites accompany sheath rot disease. But, without wounding, the sheath rot fungus infects the rice plants with difficulty (Chien and Huang, 1979). At heading stage, grain sterility is positively correlated with number of mites/tiller and percentage of mites/panicle; while, length of panicle neck and panicle weight are negatively correlated (Lo and Ho, 1979). Further, the inoculation tests indicated that the chief cause of rice sterility is infection by the sheath mites and that the sheath rot fungus is not a major factor. Many conidia of the fungus are found on the body of the mite. Pure cultures of the fungus could easily be obtained from the bodies, ecdysed exuviae or eggs of the mite. Rice plants inoculated with both the mite and fungus became more heavily infected than those inoculated with either the mite or fungus alone (Chien, 1980). In an attempt to detect the presence of rice sheath rot fungus in diseased leaf sheaths, infected spikelets or grains and infected insect or mite pests by utillising an isolation medium, Hsieh *et al.* (1980) observed that the mite Steneotarsonemus *spinki*, 2 unidentified mites, and rice thrips *Baliothrips biformis* (Bagn) and *Haplothrips aculeatus* (F) collected from brownish lesions on sterile plants were found to carry the fungus. Inoculation of rice plants with *S. spinki* or thrips infected with fungus resulted in diseased plants. *S. spinki* carried the conidia of the fungus all the year round.

The differential inoculation tests also indicated that infestation with the mite caused rice plant sterility and aided the spread of the fungus. But, the fungus merely caused the grains and leaf sheath to turn brown and did not affect plant fertility. When the flag leaf sheath was inoculated with a suspension of Acrocylindrium oryzae 10 days before heading, brown spots developed on the grains but fertility was unaffected (Fang, 1980).

In India, under farmers' conditions, in East and West Godavari districts of A. P., the problem of association of different agents responsible for grain sterility was examined. The affected rice varieties included MTU 1001, MTU 2067, MTU 2077, MTU 7029, BPT 5204 and PLA 1100. Based on the visual symptoms on affected plants, the causal agents were classified as (1) mite alone (2) mite + saprophytic fungus (3) mite + saprophytic fungus + sheath rot fungus (4) mite + white-tip nematode + saprophytic fungus. However, mite was the most dominant organism in all the cases and was identified as *Steneotarsonemus spinki*, while white tip nematode was identified as *Aphelenchoides besseyi*. Visual symptoms such as black lesions in the leaf sheath, discolored grains, complete or partial chaffy grains and various deformities were observed (Rao *et al.*, 2000). Cabrera et.al. (2005) from Cuba also observed that the major fungus associated with S *spinki* was the sheath rot fungus, *Sarocladium oryzae (Acrocylindrium oryzae)* and *S spinki* acted as vector of this fungus.

Host Plant Resistance against *S. spinki*

In general, sterility disease is less severe on indica than japonica rices and the indicas have lower infestations of *S. spinki* (Fang 1980). Indica varieties generally have lighter mite infestations than japonica varieties and harbour less number of eggs and adults inside leaf sheaths (Lee 1980). Among japonicas, Chianung sen No.11, Tainung No.67, Kaohsiung Sheuan No.1 and Taichung sen No. 5 were less susceptible than Kaohsiung sen No. 2, Taichung sen No. 2 and Tainan No. 5 (Lo and Ho 1980).

Among 29 rice varieties observed for their reaction to *S. spinki.* Kaohsiung Selection No. I, Hsinchu 57, Chianung Shen 11, GR-1, Hualien – yu 116, Tainung – yu A6, Taichung – Shen 5, Chianung – Shen yu 19, Nan – Shen – yu 42, and Kaohsiung – Shen – yu 194 were the most resistant varieties and exhibited the lowest percentage sterility (Lee 1980).

In Dominican Republic, among the four rice cultivars viz., ISA-40, Juma-57, Prosedoca-97 and Prosequisa-4 the former two varieties were more susceptible (Ramos *et al., 2001*). Zhang *et al*. (1995) in China studied the occurrence of S. *spinki* and other species *Tarsonemus talpae* in 335 rice varieties and heterozygotic combinations and found that brown sheath index varied among rice varieties from 0 to 73.8 and the differences were highly significant. In India, Rao and Prakash (2006) screened 22 rice varieties under artificial infestation on the potted plants and reported that Ramaboita was the most resistant and Tapaswini was the most susceptible by following the criteria like mite population per tiller at heading stage and mite population per 100 grains at maturation.)

Natural enemies and Biological control of *Steneotarsonemus spinki*

Lo and Ho (1979 and 1980) observed an unidentified protozoan to parasitize all the instars of S. *spinki*, and the highest parasitism occurred in October. Wei and Chow (1980) also reported that *S. spinki* collected from rice fields in Taiwan were infected with unidentified internal parasite. Lo *et al.* (1979) reported that a predatory mite, *Amblyseius taiwanicus* Ehara was an important natural enemy of panicle mite, *Steneotarsonemus spinki* Smiley. The total female development period of the predator was 14.0, 7.18, 4.24 and 4.04 days, the average number of eggs laid were 21.3, 25.5, 31.0 and 12.0; adult female life span was 30.3, 27.7, 14.0 and 12.6 days. The female: male sex ratio of the F1 generation was 6:1, 7.2:1, 6.5:1 and 5:1 and the mortality of the immature stages was 16, 12.4, 8.7 and 30% respectively. Oviposition by the predator females occurred only after insemination and repeated insemination was required for continued oviposition. They attempted to mass rear the mycophagous mite *Tarsonemus* sp. on the fungus *Magnoporthe salvinii* (*Helmenthosporium sigmoideum*) (grown on potato dextrose agar medium) as a substitute prey for the phytoseiid mite. At constant temperatures of 20, 25, 30 and 35° C, the total female development period of *Tarsonemus* sp. was 6.83, 5.46, 3.63 and 3.66 days respectively.

Leaf dip residue method was used on mass reared examples of the predator to determine the toxicity of commonly used pesticides. LC50s showed that monocrotophos, carbofuran, vamidothion, methomyl and isoprocarb were highly toxic to the predator. Hokbal (a mixture of 3- (1, 1-dimethylethyl) phenyl methyl carbamate and 2- (1-methylpropyl) phenyl methyl carbamate) was relatively harmless. Lo and Ho (1980) reported that predatory mites were present all the year round to prey on S. *spinki* and other tarsonemids. They stated that nearly all the pesticides recommended against *S. spinki* were highly toxic to natural enemies and ineffective against *S. spinki* and opined this might be responsible for the build up of populations of the pest. Ramos and Rodriguez (1998) reported the occurrence of predatory phytoseiid mites associated with *S. spinki* from Cuba.

Management of *Steneotarsonemus spinki* with chemicals

Parathion and dicofol were highly effective against *S. spinki* and reduced the mite numbers by 97 – 99.9 % and resulted in only 7.3 to 7.7 % sterility of rice (Lo *et al.*1981). The other compounds such as azomite, diazinon and isoprocarb (MIPC) were less effective, reducing the mite numbers by 45 – 82.9 % and causing 13.5 – 39.8 % sterility of rice. Untreated control showed 34-fold increase in mite numbers and resulted in a grain sterility of 72.0%. Dicofol was recommended for the control of *S. spinki* because of high mammalian toxicity of parathion. Fang (1980) observed that parathion controlled the tarsonemid mite *Steneotarsonemus spinki* and there were no symptoms of sterility disease. The treatment increased plant fertility and reduced the development of brownish leaf sheaths and discoloured grain.

Jiang *et al* (1994) in China obtained effective control of the mite by using chlorfensulphide with etrofolan (isoprocarb); DDVP (dichlorvos) with thiophanate. Brown leaf sheath index was reduced from 52.44 to 25.11 and rice grain production increased by 24 to 27% due to application of those combination treatments. Several fungicides including carbendazim, TCMTB (Busan) and benomyl (Benlate) formulations were effective against the fungus, *Sarocladium oryzae* (Chien and Huang 1979).

In India, dimethoate (0.04%) application once during active tillering stage was found effective in reducing mite population and grain deterioration while a recommended acaricide dicofol exhibited poor control (Ghosh *et al.* 1998).

Evaluation of acaricides /insecticides against panicle mite *Steneotarsonemus spinki* has been initiated under All-India coordinated entomology program in 2002. During kharif 2002& 2003 and rabi 2003, Profenophos (Carina 50 EC); ethion (Fosmite 50 EC; Mit 505 EC) each at 500 g a.i./ha, propargite (Simba 57 EC, Omite 57 EC) at 570 g a.i./ha; bifenthrin (Talstar 10 EC) at 60 g a.i./ha, fenpropathrin (Meothrin 30 EC @ 150 g a.i./ha), a fermentation product milbemectin (Milbeknock 1% @ 2.5 g a.i./ha) and a new molecule spiromesifen (at 72 g a.i./ha) belonging to keto enol group were evaluated and compared with standard acaricide dicofol (Kelthane 18.5 EC @ 500 g a.i./ha) and untreated control. The results at multi-locations revealed that none of the acaricides was effective against panicle mite (DRR 2003 and 2004). However, Bhanu *et. al.* (2006) from Maruteru, A.P. reported that dicofol @ 500 g a.i. /ha, ethion @ 500g a.i. /ha, spiromesifen @ 72 g a.i. /ha and profenophos @ 500 g a.i. /ha were relatively better against sheath mite. Rao and Prakash (2006) from Cuttack also reported that profenophos was effective against sheath mite.

Prabhakara (2002) found that a treatment schedule inclusive of application of dicofol (0.05%) between 75 and 90 days after planting significantly reduced the extent of mite infestation as well as mite population (on leaf blade and panicle) for 15 – 20 days and the proportion of ill filled or chaffy grains was also significantly low. No definite relationship between the application of fungicides, hexaconazole and carbendazim, as two-five applications at 40, 50, 70, 80 and 100 days after planting and the percentage of hills infested by mites as well as the abundance of mites (on leaf blade, leaf sheath, and panicle) was evident. How ever, the proportion of chaffy or filled grains showing discolouration of glumes was relatively low in plots treated with fungicides compared to untreated plots revealing that discolouration of glumes is the result of fungal infection.

Other species of tarsonemid mites observed from Rice

Tseng and Lo (1980) described 13 species of tarsonemid mites collected from rice leaf sheaths in Taiwan. Six new species described include *Steneotarsonemus chiaoi* sp.n., *Cheylotarsonemus minutus* gen. et. sp. n; *Neosteneotarsonemus mirabilis* gen. et. sp.n. *Steneotarsonemus madecassus* Gutierrez. Synonym of *S. spinki, Tarsonemus smithi* Ewing, *Steneotarsonemus furcatus; others* are *T. floricolus* C & F, *S. furcatus* Deheon, *Polyphagotarsonemus latus* (Banks).

Paddy spider mite or leaf mite *Oligonychus oryzae* Hirst

This mite damaged rice in nymphal and adult stages by sucking the sap of leaves and inflicting damage on mesophyll cells of the interveinal tissues. This resulted in characteristic whitish patches on leaves, which later turned to ash colour and dried from tip down-ward (Nagarajan, 1957; Mishra and Israel, 1968[a]). Rai *et al.* (1977) also found this mite infestation on the under surface of the rice leaves causing similar damage. Later, several workers observed the damage by leaf mite in different regions of India like Kerala (Vivekanandan *et al.*, 1978; Karuppuchamy, 1987), Tamil Nadu (Velusamy *et al.*, 1987) and Orissa (Prakash *et al.*, 1984).

Misra & Israel (1968[a]) reported that bright sunny weather followed by light rain during September – October was congenial for the multiplication of this mite. Misra and Israel (1968[a]) also reared successfully and studied the biology of this mite. Mating of adults was observed immediately after emergence; preoviposition period was for 1 to 3 days, while, oviposition period was for 6-12 days. The fertilized female laid 8-21 eggs while unfertilized females laid eggs, which developed into males confirming the presence of parthenogenesis in this mite. Larval period lasted for 2 to 3 days followed by quiescent stage; protonymphal period of 1.5 to 2 day followed by second quiescent stage, while deutonymphal period lasted for 2 to 3 days followed by another quiescent stage (Misra and Israel, 1968[a]; Rao and Kulshreshtha, 1985). Male to female ratio was 1:2.7; Males lived for 5-6 days while female lifespan was 1-3 days.

Preliminary evaluation of acaricides/ insecticides against leaf mite revealed that sulphur was effective against adults (Nagarajan, 1957), while parathion 0.04% and fenitrothion 0.05% were effective against nymphs (Anonymous, 1962). Gupta *et al.* (1972) reported Galecron 0.025% and tetradelfon 0.025% as effective ovicides. Rai *et al.* (1977) observed that the insecticides phosphamidon 0.05% and dimethoate 0.03% as effective against this mite. Chakravorthy *et al.* (1982) suggested spraying with monocrotophos 0.025% while several workers recommended dicofol (0.018%) spray against this leaf mite (Sridharan *et al.,* 1997; Patil *et al.*, 1999).

Of late, Roshan Singh *et al.* (2001) reported the damage of this mite in Jammu and Kashmir; Singh (2001) claimed the first report of this mite from Faizabad in U.P.

In a greenhouse study at DRR, seven test acaricides viz., profenophos (Carina 50 EC), ethion (Fosmite 50 EC), propargite (Omite 57 EC), propargite (Simba 57 EC), spiromesifen (Oberon 240 SC), fenpropathrin (Meothrin 30 EC), milbemectin (Milbeknock 1%) and check acaricide dicofol (Kelthane 18.5 EC) were evaluated at recommended concentrations and one tenth of recommended concentration along with water spray against leaf mite *Oligonychus oryzae*. All the acaricides exhibited moderate to good degree of efficacy against leaf mite at recommended concentration (DRR Annual Report 2003–04).

Evaluation of acaricides/insecticides in All-India Coordinated Rice Entomological trials all over the country confirmed that profenophos @ 500 g a.i. / ha, spiromesifen @ 72 g a.i./ ha, and milbemectin @ 2.5g a.i./ ha were effective against leaf mite *Oligonychus oryzae* and were at par with the check acaricide dicofol @ 500 g a.i./ ha. (DRR 2003-07). Bhanu *et a*l. (2006) observed that profenophos @ 500 g a.i. / ha and dicofol @ 500 g a.i. /ha were the best treatments against leaf mite under field conditions at Maruteru, A.P.

CONCLUSIONS

1. Among the mite pests that infest rice crop sheath mite *Steneotarsonemus spinkii* and leaf mite *Oligonychus oryzae* are the most important. *S. spinkii* in association with sheath rot fungus *Acrocylindrium oryzae* causes grain discolouration, ill-filled and chaffy grains.

2. Some information is available on bioecology of sheath mite, from Asian countries like China, Taiwan, Japan, and Korea etc. The information available from India is very limited. Hence, there is need to generate more information on bioecology of sheath mite and its association with sheath rot fungus in different agro-ecological zones of India.

3. The information on alternate hosts of S. *spinkii* from other countries revealed that rice is the major host. In view of its seriousness in Northern areas of India, there is need to have detailed studies on alternate host plants and off-season biology of sheath mite in Indo-Gangetic belt where rice-wheat rotation is predominantly followed.

4. The studies so far conducted on the efficacy of acaricides against *S. spinkii* and *O. oryzae* showed that these are very hardy pests to control with chemicals. Hence, there is need to have research at global level to develop chemicals which are effective against rice mites in general and sheath mite in particular.

REFERENCES

Anonymous, (1981). *New Records, Quarterly Newsletter FAO*, Plant Protection Committee for South East Asia and Pacific Region, **24**: 4-11.

Almaguel, L. *et al*. (2004). *Fitosanidad*, **8**: 37-40.

Bhanu, K.V. *et al*. (2006). *Indian J. Pl. Prot.*, **34**:132-133.
Cabrera, R.I. *et al*. (2005). *Folia Entomol. Mexicana.*, **44**:115-121.
Chakravorthy, G. *et al*. (1982). *Rice Res. News L.*, **7**:14.
Chen, C.N. *et al*. (1979). *Recent Adv. Acar.*, Volume I, 111-117.
Chen, C.N. *et al*. (1980). *Pl. Prot. Bull., Taiwan*, **22**: 63-82.
Chien, C.C. (1980). *Pl. Prot. Bull., Taiwan*, **22:** 31-39.
Chien, C.C. and Huang, C.H. (1979). *J. Agric. Res. China*, **28**: 7-16.
Cho, M.R. *et al*. (1999). *Korean J. Appl. Entomol.*, **38**:157-164.
Chow, Y. S. *et al*. (1980). *Pl. Prot. Bull., Taiwan*, **22**:17-21.
DRR (Directorate of Rice Research) *Annual Report*, 2003-2004.
DRR 2003-2007. *Progress Report*, 2002-2006, Vol.2. Entomology and Pathology, Directorate of Rice Research, Hyderabad.
Fang H.C. (1980). *Pl. Prot. Bull., Taiwan,* **22:** 83-89.
Gonzalez, M. and Cardens, R.M. (2003). *Cultivos Tropicales*, **24**: 41-44.
Ghosh, S.K. *et al*. (1998). *Environ. Ecol.*, **16**: 913-915.
Ghosh, S.K. *et al*. (1997). *Entomon*, **22**:105-110.
Gupta, S. K. *et al*. (1972). *J. Res. Punjab Agric. Univ*. **9**: 614-615.
Hsieh, S.P.Y. *et al*. (1980). *Pl. Prot. Bull., Taiwan*, **22**: 41-46.
Jiang, P. Z. *et al*. (1994). *Guangdong Agric. Sci*., No. **5**, 37-40.
Karuppuchamy, P. *et al*. (1987). *IRRN.,* **12**: 20.
Kim, D. S. *et al*. (2001). *Korean J. Crop Sci*., **46**: 180-183.
Lee, S. C. (1980). *Pl. Prot. Bull., Taiwan*, **22**: 91-100.
Lindquist, E.E. (1969). *Memoirs Entomol. Soc*. Canada, **60**: 111.
Lindquist, E.E. (1986). *Exper. App. Acar.*, **2**:323-328.
Lo, K.C. and Ho, C. C. (1977). *National Sci. Council Monthly*, **5**: 274-284.
Lo, K. C. and Ho, C.C. (1979). *J. Agric. Res., China*, **28**: 181-192.
Lo, K. C and Ho, C. C. (1979[b]). *J. Agric. Res., China*, **28**: 193-197.
Lo, K. C. and Ho, C. C. (1980). *Pl. Prot. Bull., Taiwan*, **22**:1-9.
Lo, K.C. et al. (1979). *J. Agric. Res., China*, **28**: 251-259.
Lo, K.C. et al. (1981). *J. Agric. Res., China*, **30**: 303-307.
Misra, B.C. and Israel, P. (1968). *Oryza*, **5:** 84-85.
Nagarajan, K.R. (1957). *Madras Agric. J*., **44**: 480.
Navia, D. *et al*. (2005). *Plant Protection and Plant Health in Europe-Introduction and Spread of Invasive Species*, held at Humbold University, Berlin, Germany. 9-11 June 2005, 267-268.
Patil, V. L. *et al*. (1999). *Pestology*, **23**: 127-136.
Prabhakara, H. (2002). M.Sc. (Ag) Thesis. Univ. Agric. Sci. Bangalore, 137 p.
Prakash, A. *et al*. (1984). Farmer and Parliament, **9–10**, 30-31.
Rai, P. S. *et al*. (1977). *Acar. News L.*, **4**:3.
Ramos, M. B. *et al*. (2001). *Revista de Proteccion Vegetal*, **16**: 6-9.
Ramos, M. and Rodriguez, H. (1998). *Revista de Proteccion Vegetal*, **13**: 25-28.
Ramos, M. and Rodriguez, H. (2000). *Revista de Proteccion Vegetal*, **15**: 130-131.
Ramos, M. and Rodriguez, H. (2001). *Manejo Integrado de Plagas*, No.61, 48-52.
Ramos, M. *et al*. (2001). *Revista de Proteccion Vegetal*, **16**: 6-9.
Rao, J. and Prakash, A. (2002). *J. Appl. Zool. Res*., **13**: 174-175.
Rao, J. and Prakash, A. (2006). *Entomon*, **31**: 69-72.
Rao, Y. S. and Kulshreshtha, J. P. (1985). In: *Rice Research in India.* Indian Council of Agricultural Research, New Delhi, Pub. Pp. 726.
Rao, Y. S. and Das, P. K. (1977). *IRRN.*, **2**: 8.
Rao, J. and Prakash, A. (1992). *J. Appl. Zool. Res*., **3**: 103.
Rao, J. and Prakash, A. (1995). *J. Appl. Zool. Res*., **6:** 68.
Rao, J. and Prakash, A. (1996). *J. Appl. Zool. Res*., **7**: 103.
Rao, P.R.M. *et al*. (2000). *IRRN*., **25**: 40.
Roshan Singh *et al*. (2000). *Insect Environ*., **5**:183.
Singh, R. A. (2001). *J. Appl. Zool. Res*. **12**:59.
Sogawa, K. (1977). *IRRN*., **2**: 17.

Sridharan, S. *et al*. (1997). *Pestology,* **21**: 40-44.
Tseng, Y. H. and Lo, P.K.C. (1980). *Pl. Prot. Bull., Taiwan*, **22**:113-140.
Veluswamy, R. *et al*. (1987). *IRRN*., **7**: 11.
Vivekanandan, P. *et al*. (1978). *IRRN*., **3**: 10-11.
Wei, L.Y., and Chow, Y.S. (1980). *Pl. Prot. Bull., Taiwan,* **22**: 11-15.
Xu, G. L. *et al*. (2001). *Systematic App. Acar*., **6**: 45-49.
Zhang, W. X. *et al*. (1995). *Guangdong Agric. Sci.,* **6**, 38-39.