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Management of coconut eriophyid mite (*Aceria guerreronis* Keifer) with INM and azadirachtin under field condition in Karnataka

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Abstract
Presently, a large number of chemical pesticides are being tested against the coconut eriophyid mite *Aceria guerreronis* Keifer (Acari: Eriophyidae). Most of these chemicals are not eco-friendly, there is a chance of development of resistance and many are having a residual effect. Hence, there is an urgent need to search for safer and eco-friendly chemicals to control the mite. Considering the extensive damage caused by a mite, attempt was made to evaluate efficacy of an INM (Integrated Nutrient Management) practice along with root feeding of azadirachtin for the management of eriophyid mite. A field experiment was conducted at Horticulture Research and Extension Centre, All India Co-ordinated Research Project on Palms, Arsikere, Hassan district, and Karnataka state during 2014-16. The experiment was laid out in randomized block design with three treatments. The pre-treatment observations on mite damage were recorded before imposing the treatments. Post treatment observations were recorded at four month's interval. Simultaneous observations were also made in the control plot. Two years pooled data (2014-15 and 2015-16) revealed that INM with root feeding of azadirachtin (50000 ppm or (5%) -7.5 ml + 7.5 ml water) thrice in a year during April, September and February was effective in reducing the mite population in coconut. After 12 months of imposing the treatments, the per cent nut damage gradually reduced to 55.62 to 62.47 per cent in the treatment plot as against 91.65 per cent in control. Similarly the 'INM with root feeding treatment' imposed gardens exhibited the least Mite Grade Index (1.47) and were followed by INM without root feeding gardens with a MGI of 2.26 and were significantly superior over the control plot (MGI = 3.88). This experiment clearly indicated that Azadirachtin has unique features and can act as an efficient miticide and is safe to natural enemies and other organisms.

Keywords: *Aceria guerreronis*, INM, azadirachtin, coconut and Karnataka

Introduction
The coconut palm, *Cocos nucifera* L., is an important plantation crop grown in India, also called 'Kalpavriksha' as it provides a variety of useful products like food, fuel, fibre and timber. Coconut is grown in more than 93 countries on a total area of 12.5 million ha producing 5562 million nuts annually. India, Indonesia, the philippines and Sri Lanka are the four major producers contributing about 78 per cent of the total world's production [29]. The coconut palm is infested by a large number of insects and mites during different stages of its growth and development, [24] had listed as many as 830 insects and mites on coconut palm. Among different pests infesting the crop, eriophyid mite, *A. guerreronis* is a serious pest in many coconut growing areas in India. This mite species was first described in 1965 from a specimen of Guerrero State, Mexico [24]. The rapid outbreak of this pest in coconut plantations endangered the copra industry in India, reducing coconut yields and economic profits. This has drawn the attention of farming communities and researchers. The first report on the occurrence of this exotic mite in India was made by [53] at Amballur panchayat in Ernakulam district of Kerala during 1998, followed by parts of Tamil Nadu and Karnataka [61]. The host range of *A. guerreronis* was also recorded from palmyrah palm (*Borassus flabellifer*) in India [48].
Coconut eriophyid mite is a tiny creamy-white, vermiform organism measuring 200-250 microns in length and 20-30 µm in width [61]. The body is elongated, cylindrical, finely ringed and bears two pairs of legs at the anterior end. Mites attain sexual maturity within a week time and start laying eggs. An adult mite lays about 100-150 eggs. The eggs hatch into protonymphs which develop in to deutronymphs and finally to adults.

The full life - cycle is completed in 7-10 days [15, 16, 30]. Although the pest persists in the gardens throughout the year, the infestation becomes more severe in relatively dry climates or during the dry periods of wetter climates [62]. Colonization of nuts by coconut mites takes place shortly after fertilization [31]. The mite colonizes on the basal portion of the nuts below the perianth. They feed on the meristematic tissues beneath the perianth of young nuts. The damage becomes evident as brown deep scars on the nut surface with cracks, accompanied by gummy ooze, when the nut grows. Coconut mite populations peak on 3 to 6-month old nuts, after which, the numbers decline sharply so that nuts over nine months old have relatively low populations. Severe damage can lead to premature nut drop or extreme reduction in the size of nuts. Such nuts are difficult to dehusk [27, 37] due to nut malformation and it reduces copra yield [11, 31, 47, 49]. Heavy damage, result in the loss of quality and quantity to coconut [26, 39, 48]. In the recent past, the pest has spread rapidly to all coconut growing states of India [14, 34, 59]. In Karnataka, though the initial pest damage ranged from 18-42 per cent, later during a severe infestation, symptoms were seen on more than 50 per cent of the surface area of infested nuts [27]. Similar studies were undertaken in Tamil Nadu during 2000, which revealed an average loss of copra yield to the tune of 27.5% [48] and later 50-70%. Surveys carried out in Alappuzha district In Kerala, during 2000 has shown a significant reduction in crop yield indicating an average loss of 30.94% in terms of copra and 41.74% in terms of husk production [33].

Soil test based balanced nutrition play a key role in improving the palm health status thereby imparting tolerance to the mite attack. The nutrient management package consists of the balanced application of NPK fertilizers at recommended doses in two splits (NPK @500g, 300g, 1200g/palm/year), recycling of organic biomass in coconut ecosystem using *in situ* vermi- composting or growing of green manure crops like cow pea or sun hemp at a seed rate of 100g/palm and its incorporation in coconut basin and conservation of soil moisture by appropriate mulching methods. Well maintained trees, with appropriate fertilizer application, were found to suffer less from mite attack. Inter-cropping of sun hemp with coconut reduced the mite incidence upto 13.6 per cent and reduced the damage grade. The least damage of 29% was seen in palms treated with neem cake 2 kg + bone meal 0.5 kg + mill ash 4 kg (per palm/ year) [35]. Low incidence of coconut eriophyid mite was observed in coconut gardens with intercrops *viz*., flowering plants, banana etc than the garden raised as monocrop in Andhra Pradesh. Well maintained coconut plantations with proper irrigation and nutritional care exhibited a marked reduction in mite incidence when compared to neglected plantations [46].

The current burgeoning scientific interest in biopesticides in general, and in botanical pesticides in particular, has slow action, brief persistence, relatively high cost for large-scale production and legislative limitations are the main reasons for the limited expansion of biopesticide's use in agriculture [2, 19, 60]. The 1960s Western discovery of the insecticidal activity of the limonoid triterpene azadirachtin, extracted from the seeds of the Indian neem tree (*Azadirachta indica* A. Juss (Meliaceae)), is one of the likely catalysts of the latest growth in interest and spurt in academic research on botanical insecticides, as well as the subsequent commercialization of plant essential oils as insecticides [19, 51]. It is also interesting that azadirachtin remains the most successful botanical pesticide in agricultural use worldwide [10, 19, 32].

Number of control measures mostly involving aerial application and root feeding with chemical pesticides are banned due to hazardous residue noticed. There is a practical difficulty in insecticidal spray to reach the height of coconut trees. Since it is difficult to spray the chemicals in taller coconut palms, root feeding is considered to be a better alternative [3, 47]. The information on performance of root feeding, effect of neem products and application methods are very scanty. Presently, the effect of several chemicals have been tested against the mite. But these chemicals are not eco-friendly and have residual effect. There may be chance of development of resistance by the mites against chemicals. The information on the ecofriendly management of coconut mite involving nutrient management and agronomic practices is very much lacking. Hence, there is a need to search for the compounds to control the mite which are eco-friendly. Considering the importance of coconut as a plantation crop in this country and the potential of this mite pest to cause extensive damage, attempt was made to evaluate the efficacy of an INM and azadirachtin for the management of eriophyid mite. The present study was carried out with ecofriendly approaches to manage coconut mite.

Methodology

A field experiment was conducted at Horticulture Research and Extension Centre, Arsikere, Hassan district, Karnataka state to know the effect of INM (Integrated Nutrient Management) along with root feeding of azadirachtin for the management of coconut eriophyid mite during the year 2014-15 and 2015-16. The palms in the garden were in the age group of 25 years with 15 to 20 meter height. The experiment was laid out in randomized block design with three treatments. Fifty palms in each treatment were selected; a totally one hundred and fifty palms were selected for the experiment. The pre-treatment observations were recorded before imposing the treatments, tagged the first pollinated bunch as the number 1 bunch. That bunch was scored for mite infestation index at the 12th month maturity stage. Counted and recorded the total number of nuts and mite infested nuts (shown external symptom), bunch wise from the 1st tagged bunch onwards till the last matured. For counting mites from infested nuts, single nut has been selected from 4th bunch as sample nut for assessment of mite population, approximately middle of nut bunch was selected from spathe. The selected nut was removed from the bunch. The perianth of the nut was removed properly without disturbing the surface of the nut below the perianth. Then patch of surface from perianth circumference was removed with help of sharp knife. This cut patch was taken on the stage of the binocular microscope to observe the presence of mite or to in known space of 4 mm2. Score the last bunch nut wise for mite severity symptom in a 0 – 4 score.

A score of 0-4 scale was developed for recording the extent of mite damage on coconuts. Nuts without mite infestation (healthy-score 0), nuts with less than 25% surface damage (low infestation-score 1), 25-50% nut surface damage (medium infestation-score 2) and 51-75% nut surface damage (high- score -3) and more than 75% surface damage, malformed and puny nuts (severe-score 4). The damage of the nut surface was assessed based on the gradings of zero to 4 as described by [20].

Table 1: Recorded mite grade index (MGI) of harvested nuts as per the scale

Percent damage on nut surface	Scale	Grade index	Intensity
Nuts with no mite damage	0	0	Nil
< 25%	1	0.1 – 1.0	Mild
25 – 50%	2	1.1 – 2.0	Moderate
50 – 75%	3	2.1 – 3.0	High
> 75%	4	3.1 – 4.0	Severe

Post treatment observations were recorded at four month's interval. Simultaneous observations were also made in the control plot. Data on per cent nut damage was recorded before to the treatment and at four months interval. The following INM package has been taken up along with root feeding for the 2nd treatment:

1. Adopted of phytosanitary measures in coconut gardens
2. Root feeding of azadirachtin 5% (50000 ppm) (7.5 ml + 7.5 ml of water) was given to coconut palms about three times a year during May, October and March.
3. Recycled the biomass generated within the coconut system by vermi-compost method and by using Lignin degrading fungus.
4. Raised the cowpea as green manure crops in the coconut basins
5. Applied the recommended dosage of fertilizers in two split doses as per the package of practices (Urea-1.3 kg; Super phosphate - 2.0 kg; potash - 3.5 kg; neem cake-5.0 kg; Farm Yard Manure - 50 kg/ palm/year).
6. Recommended level of irrigation was provided during summer months
7. Soil moisture conservation was adopted by the following methods:
   a) Burial of coconut husk in the basin
   b) Mulching the basins (2 m radius) with coconut leaves
   c) Mulching with coir pith (2 m radius)

Method of root feeding

The predetermined quantity of 7.5 ml azadirachtin 5% was mixed in the known quantity of ml of water and applied by root feeding. The live roots were searched by digging the pit near coconut trunk 2 -3 feet apart. A freshly developed brick red coloured feeding root of pencil thickness was selected [12]. The precaution was taken to avoid injury or any sort of damage to selected root. Such root was given slant cut with the help of sharp knife. The cut was given in one stroke so that it should not blurt. The azadirachtin 5% mixed in water were taken in polythene bag of 15×10cm size. Then the cut section of the root was dipped in the solution. The root was placed in such a way to have access to total quantity of solution was absorbed. Then the bag was tied to the root with help of cotton thread. It was observed for 24 hrs for complete absorption of solution by the root. After 24 hrs if the solution was not absorbed by the root then the root was replaced by another root and the process was repeated till the solution was successfully taken by the root. The application of azadirachtin 5% through root feeding was done three times in year (Table 3) [5, 25, 38].

Observations recorded

1. Population from 6 mite colonies from one sample nut of 3rd and 4th bunch (3 from nut surface and 3 from inner perianth lobes) in an area of 4 mm x 4mm was counted under microscope and expressed as average mite/mm2.
2. Incidence: percent of nuts showing eriophyid mite damage on 50 palms was recorded (Nuts with damage symptoms per palm/Total nuts observed X 100).
3. Grade index of harvested nuts as per the scale

Results and Discussion

In the year 2014-15 the per cent nut damage was assessed in the experimental plots prior to the experiments and later at four months interval. The per cent nut damage ranged between 86.11 and 87.84% before treatment imposition. Upon imposing the treatments, the per cent nut damage gradually reduced and by the fourth month, the per cent nut damage recorded was in the range of 71.19 to 78.84 per cent in the treatments (T1and T2) as against 89.12 per cent in control. By eighth month, the IPM and INM treatments with and without root feeding were effective in reducing mite infestation with 63.41 and 71.22% nut damage as against 91.18% nut damage in control plot. Similarly after 12 months of imposing the treatments, the per cent nut damage gradually reduced to 57.15 to 66.64 per cent in the treatments (T1 and T2) as against 92.33 per cent in control. (Table 2)

Table 2: Percent nut damage due to eriophyid mite infestation in experimental plots at Arsikere, Hassan district (2014-2015)

Treatment	Damaged nuts (%)			
	Pre treatment (May-2014)	After 4 months (Sept.-2014)	After 8 months (Jan.-2014)	After 12 months (May-2015)
T1 (INM without root feeding)	86.11 (68.12)	78.84 (62.61)	71.22 (57.56)	66.64 (54.72)
T2 (INM With root feeding)	87.84 (69.59)	71.19 (57.54)	63.41 (52.78)	57.15 (49.11)
T3 (Control)	87.03 (68.89)	89.12 (70.74)	91.18 (72.72)	92.33 (72.93)
Significance	NS	Sig	Sig	Sig
SE m+	0.30	1.22	0.91	1.64
CD (*p*=0.05)	0.91	3.67	2.75	4.89

Values followed by a common letter are not significantly different by LSD (*P*=0.05). Figures in parenthesis are arcsine transformed values.

A similar trend was also noticed in the Mean Grade Index due to eriophyid mite infestation. After twelve months of imposing treatments, the IPM+INM (with root feeding) treatment imposed gardens exhibited the least MGI (1.65) and was on par with IPM+INM (without root feeding) gardens with an MGI of 2.28 and were significantly superior to the control plot (MGI = 3.84) (Table 3)

Table 3: Mean damage grade index of eriophyid mite in experimental plots at Arsikere, Hassan district (2014-2015)

Treatment	Mean grade index			
	Pre treatment (May-2014)	After 4 months (Sept.-2014)	After 8 months (Jan.-2014)	After 12 months (May-2015)
T1 (INM without root feeding)	3.81 (1.95)	3.05 (1.75)	2.74 (1.66)	2.28 (1.51)
T2 (INM With root feeding)	3.65 (1.91)	2.91 (1.71)	2.44 (1.56)	1.65 (1.28)
T3 (Control)	3.72 (1.93)	3.81 (1.95)	3.88 (1.97)	3.84 (1.96)
Significance	NS	Sig	Sig	Sig
SE m+	NS	0.02	0.047	0.16
CD (*p*=0.05)	NS	0.06	0.14	0.48

Figures in parenthesis are square root transformed values. Values followed by a common letter are not significantly different by LSD (*P*=0.05).

In the year 2015-16 similar type of experiment was carried out at HRES Arsikere, the per cent nut damage ranged between 78.61 and 79.88% before treatment imposition. Upon imposing the treatments, the per cent nut damage gradually reduced and by the fourth month, the per cent nut damage recorded was in the range of 66.37 to 73.55 per cent in the treatments (T1 & T2) as against 84.26 per cent in control. By the eighth month, the IPM and INM treatments with and without root feeding were effective in reducing mite infestation with 59.41 and 67.14% nut damage as against 87.84% nut damage in the control plot. Similarly after 12 months of imposing the treatments, the per cent nut damage gradually reduced to 52.16 to 61.85 per cent in the treatments (T1 and T2) as against 90.45 per cent in control. (Table 4)

Table 4: Percent nut damage due to eriophyid mite infestation in experimental plots at Arsikere, Hassan district (2015-2016)

Treatment	Damaged nuts (%)			
	Pre treatment (May-2015)	After 4 months (Sept.-2015)	After 8 months (Jan.-2015)	After 12 months (May-2016)
T1 (INM without root feeding)	79.88 (63.34)	73.55 (59.04)	67.14 (55.02)	61.85 (51.85)
T2 (INM With root feeding)	78.61 (62.45)	66.37 (54.55)	59.41 (50.42)	52.16 (46.23)
T3 (Control)	79.24 (62.89)	84.26 (66.62)	87.84 (69.59)	90.45 (71.99)
Significance	NS	Sig	Sig	Sig
SE m+	0.28	3.40	4.81	8.19
CD (*p*=0.05)	0.70	8.52	12.10	20.50

Figures in parenthesis are square root transformed values. Values followed by a common letter are not significantly different by LSD (*P*=0.05).

A similar trend was also observed in the Mean Grade Index due to eriophyid mite infestation. After twelve months of imposing treatments, the IPM+INM (with root feeding) treatment imposed gardens exhibited the least MGI (1.46) and was on par with IPM+INM (without root feeding) gardens with an MGI of 2.12 and were significantly superior to the control plot (MGI = 3.88) (Table 5)

Table 5: Mean damage grade index of eriophyid mite in experimental plots at Arsikere, Hassan district (2015-2016)

Treatment	Mean grade index			
	Pre treatment (May-2015)	After 4 months (Sept.-2015)	After 8 months (Jan.-2015)	After 12 months (May-2016)
T1 (INM without root feeding)	3.94 (1.98)	3.34 (1.83)	3.08 (1.75)	2.12 (1.46)
T2 (INM With root feeding)	3.71 (1.93)	3.05 (1.75)	2.42 (1.56)	1.46 (1.21)
T3 (Control)	3.63 (1.91)	3.78 (1.94)	3.84 (1.96)	3.88 (1.97)
Significance	NS	Sig	Sig	Sig
SE m+	0.03	0.02	0.06	0.15
CD (*p*=0.05)	0.08	0.07	0.17	0.13

Figures in parenthesis are square root transformed values. Values followed by a common letter are not significantly different by LSD (*P*=0.05).

The pooled data results on per cent nut damage ranged between 81.42 and 82.25% before treatment imposition. Upon imposing the treatments, the per cent nut damage gradually reduced and by the fourth month, the per cent nut damage recorded was in the range of 66.54 to 77.22 per cent in the treatments (T1& T2) as against 85.63 per cent in control. Bythe eighth month, the IPM and INM treatments with and without root feeding were effective in reducing mite infestation with 62.84 and 68.18% nut damage as against 88.57% nut damage in the control plot. Similarly after 12 months of imposing the treatments, the per cent nut damage gradually reduced to 55.62 to 62.47 per cent in the treatments (T1 and T2) as against 91.65 per cent in control. (Table 6)

Table 6: Percent nut damage due to eriophyid mite infestation in experimental plots at Arsikere, Hassan district (Pooled data of 2014-15 and 2015-16)

Treatment	Damaged nuts (%)			
	Pre treatment (May)	After 4 months (September)	After 8 months (January)	After 12 months (May)
T1 (INM without root feeding)	81.58 (64.58)	77.22 (61.49)	68.18 (55.66)	62.47 (52.22)
T2 (INM With root feeding)	82.25 (65.08)	66.54 (54.66)	62.84 (52.44)	55.62 (48.23)
T3 (Control)	81.42 (64.47)	85.63 (67.72)	88.57 (70.24)	91.65 (73.20)
Significance	NS	Sig.	Sig.	Sig.
SE m+	NS	1.45	0.73	1.16
CD (*p*=0.05)	NS	4.36	2.17	3.54

Figures in parenthesis are square root transformed values. Values followed by a common letter are not significantly different by LSD (*P*=0.05).

A similar trend was also observed in the Mean Grade Index due to eriophyid mite infestation. After twelve months of imposing treatments, the IPM+INM (with root feeding) treatment imposed gardens exhibited the least MGI (1.47) and were followed by IPM+INM (without root feeding) gardens with a MGI of 2.26 and were significantly superior to the control plot (MGI = 3.88) (Table 7)

Table 7: Mean damage grade index of eriophyid mite in experimental plots at Arsikere, Hassan district (Pooled data of 2014-15 and 2015-16)

Treatment	Mean grade index			
	Pre treatment (May)	After 4 months (September)	After 8 months (January)	After 12 months (May)
T1 (INM without root feeding)	3.75 (1.94)	3.35 (1.83)	2.81 (1.68)	2.26 (1.50)
T2 (INM With root feeding)	3.58 (1.89)	2.78 (1.67)	2.14 (1.46)	1.47 (1.21)
T3 (Control)	3.68 (1.92)	3.51 (1.87)	3.76 (1.94)	3.88 (1.97)
Significance	NS	Sig.	Sig.	Sig.
SE m+	NS	0.04	0.07	0.09
CD (*p*=0.05)	NS	0.12	0.18	0.27

Figures in parenthesis are square root transformed values. Values followed by a common letter are not significantly different by LSD (*P*=0.05).

The past experiences of unexpected resistance towards new chemicals, their adverse effect on the environment, a shorter period of efficacy and high investment involved in the development of new pesticides, suggest the need for development of alternative control strategies that are sustainable, ecofriendly and economical. Plant nutrients exert pronounced effect on resistance to pest through the host plant [52]. The present findings are in confirmatory with the [21] who suggested regarding nutritional management as follows, balanced application of NPK fertilizers in two splits (Urea 1.3 kg, Super phosphate 2 kg, Muriate of potash 3.5 kg, Farm Yard Manure @ 50 kg and neem cake @ 5 kg per palm per year), Insitu growing of green manure crop sunnhemp in the garden and its incorporation in coconut basin. Judicious irrigation and mulching with coconut leaves and husk in the basin. Soil application of micronutrients: Borax (Sodium tetra borate) 400-600 g/palm/year; Gypsum 1 kg/palm/year, Magnesium sulphate 500g /palm/year helpful in reducing infestation of this mite. Among the micronutrients boron is quite essential for higher plants. It activates certain dehydrogenase enzymes, facilitates sugar translocation and synthesis of nucleic acid and plant hormones which are essential for cell division and development of meristematic tissues, flowering and fruit/seed set, translocation of sugar [58]. Boron deficiency causes cracking of nuts [58]. Cracking is associated with mite feeding on coconut meristem. Boron deficiency produces more quinones, which lead to cell damage, cessation of growth and browning of tissue [21]. Boron nutrition to the palm in the form of borax (Sodium tetra borate) makes the palm oppose the mite attack since boron is an essential micronutrient required to strengthen the cells of the growing plant tissues. Borax has applied to soil at the rate of 400-600 g/palm. It is dissolved in water and applied as a drench around the palms. Following the boron nutrition the palms produce more phenols at the mite feeding zones. Thus the infested nuts resist the mite infestation which results in significantly low levels of damage to the tender nuts. Application of more quantity of organic manure also results in significantly less harm due to the mite since organic manure makes boron freely available to the palms. Gypsum contains Calcium and Sulphur. Calcium ions are used in the synthesis of new cell walls and are also used in the mitotic spindle during cell division [17].

Sulphur possesses acaricidal property, which probably helped in reducing the mite population, whereas magnesium has a specific role in the synthesis of DNA and RNA.

Neem cake contains 2 per cent of terpenoids mainly azadirachtin which is responsible for the anti-feedant, anti-ovipositional, growth disruption, fecundity and fitness reducing properties on insects. Pest suppressing activity of neem cake was attributed during decomposition [1] apart from the stimulatory effect on root growth which helped profuse growth of roots and absorbed nutrients easily. A high dose of potash (muriate of potash 4 kg/palm) coupled with the normal dose of borax (200 g/palm) also lowers the mite attack. Any mechanical injury to the peduncle of the flower bunches causes the nuts to become less suitable for the mites to infest subsequently.

The present findings are in confirmatory with [13, 41, 42, 44, 61], who opined that neem pesticides found effective in controlling mite population. botanicals such as neem oil have been preferred, through less effective, due to their eco-friendliness. Proper management of the palms helps to contain the pest and reduce economic loss [36, 50] also reported effectiveness of botanical against eriophyid mite. The use of botanical insecticides either solely or in combination in integrated pest management systems is increasingly becoming important. Neem bio-pesticides are best suited for use in organic food production in industrialized countries but can play a much greater role in developing countries as a new

class of eco-friendly products for controlling mite pests. Conventional insecticides have inherent toxicities that cause danger to the health of the applicators, consumers and the environment. In the case of systematic pesticides various chances of presence of considerable residue levels in kernel and water. Negative effects on human health led to a reappearance in interest in botanical insecticides because of their minimal costs and fewer ecological side effects. However, in the current state botanical insecticides plays only a minor role in IPM and crop protection. Moreover, some of these botanical extracts could find a place in IPM strategies. With increasing concern over coconut mite management researchers should look after the multi- location field trials for conforming efficacy of neem bio-pesticides on mites and investigation on the resistance development among mite population [5].

The present findings corroborates with [5]. who reported that continuous supply of major and micronutrients to coconut palm throughout the year will impart resistance and produce healthy nuts. The importance of potassium in pest management has been well documented in many crops [28, 40] stated that potassium is a highly essential element which impart resistance to coconut palms from insect and non-insect pests. Among the micronutrients 'Boron' is quite essential for higher plants [18]. Superiority of the neem products compared to other botanicals might be due to its azadiractin content, which exhibited high ovicidal, antifeedant and insecticidal property resulting in suppressing of mite population. NSKE @ 5 per cent was found effective in managing mite [8]. Root feeding with Neemazal 10ml/palm was significantly superior treatment and recorded (24.75%), reduction of mites [8]. These reports support the present findings of better nutrient management followed by adoption of eco-friendly methods to manage coconut mite.

Superiority of the neem product compared to other botanicals is due to its azadirachitin content, which exhibited high ovicidal, antifeedent and toxic properties resulted in suppression of mite population. The present findings are in agreement with [57] observed effective reduction of mite population with an application of NSKE (10%) [47] agreed that TNAU neem oil 60 EC three percent gave 55.14 percent mite mortality. The present findings are in agreement with [55] who reported that NSKE 4 percent was effective up to 21 days by recording a 75.45 percent reduction of mite population. Azadirachtin arguably stands out as the most widely used botanical pesticide since the onset of synthetic pesticides for pest control, which is well established in organic agriculture, public health, home and garden, and selected agricultural settings [32]. This biopesticide has unique features and can act as an arthropod anti-feedant, growth regulator and sterilant, while its safety to vertebrates is broadly recognized [10, 19].

The treatment which comprises spraying and root feeding of Neemazal 5% found most effective followed by treatment (Neemazal 1% (Spray) + Neemazal 5% (root feeding), Neemazal 5% (Spray) and Neemazal 1% (Spray) + Neemazal 1% (Root feeding) in management of eriophyid mite which causes significant percent reduction in egg count over untreated plants [57] reported that NSKE (10%), azadirachtin (0.009%) and neem oil (6%) were significantly effective in reducing mite population and nut damage [41] indicated that among the different botanicals NSKE 5 per cent was found effective in reducing mite and egg population. The neem oil was proven to be effective treatment by recording significantly lowest mite population [3, 9, 37].

In South India, State Agricultural Universities, ICAR Institutions and private institutions have recommended an integrated and holistic approach for managing the mite population based on the findings of individual tactics tested against the pest. Removal of dried spathes, inflorescence parts, and fallen nuts etc. and burying in the soil or by burning minimizes the pest inoculum. Crown cleaning is to be taken up periodically. The movement of mite infested nuts from place to place is to be restricted to minimize the spread of mite. IPM package was demonstrated in farmer's fields at Krishnapuram village, Kerala covering 25 ha area of coconut gardens in 208 farmer holdings. Here the integrated nutrient management technology was implemented along with the use of azadirachtin and the mite incidence could be brought down to 15.3% from 68% in period of three years [45]. In the present study also INM+azadirachtin was found to be the eco-friendly and sustainable method of mite management.

Conclusion

The two years data (2014-15 and 2015-16) revealed that INM with root feeding of azadirachtin (50000 ppm or (5%) -7.5 ml + 7.5 ml water) thrice in a year was effective in reducing the mite population in coconut at Arsikere centre, Karnataka. This treatment can be recommended against coconut eriophyid mite as it is an efficient, eco-friendly, cost effective and sustainable method of mite management.

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