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Screening of coconut varieties against invasive Bondar's nesting whitefly (BNW), *Paraleyrodes bondari* Peracchi on coconut and management using biopesticides

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Abstract
Coconut breeding for biotic and abiotic stress is vital and screening of coconut varieties against whitefly complex is important to know the tolerance levels which could be helpful in breeding programs for developing resistant varieties against whitefly complex. The present study was conducted at HRS, Ambajipeta on ten different cultivars of coconut. The mean population count of different stages of BNW was 22.51 webs, 9.30 nymphs, 6.88 pupa and 18.05 adults, minimum pest population was observed in Kera Bastar variety. In Gautami ganga, among the various biopesticides tested against nymphs, pupa and adults of BNW *Isaria fumosoroseas* NBAIR pfu-5 @ 5 ml/L was found to be effective in reducing the nymphal population by 44.11%, pupal population by 42.42% and adult population by 54.75% followed by Azadirachtin.

Keywords: Evaluation, coconut, Bondars nesting whitefly

Introduction
Coconut (*Cocos nucifera* L.), a member of the family *Palmae* (Arecaceae), is widely recognized as a "Kalpavriksha" or the divine tree, owing to its versatile uses in nutrition, medicine, cosmetics, and industry. Every part of the coconut palm is utilized in daily life, especially in regions where it is cultivated extensively. Key by-products such as tender coconut water, copra, oil, and coir pith contribute significantly to both rural livelihoods and the agro-economy.

India stands as the third-largest coconut producer in the world, with an annual output of over 21 billion nuts from 2.16 million hectares, averaging 21,274 nuts per hectare (APCC, 2024) [3]. The cultivation is largely concentrated in the southern states, with Andhra Pradesh alone accounting for 1,07,370 hectares and a productivity of 10,894 nuts per hectare (CDB, 2024).

In the context of increasing global trade, the unintentional introduction of invasive pests has emerged as a major concern for coconut farming. One such pest is the rugose spiralling whitefly (*Aleurodicus rugioperculatus* Martin), first reported in Tamil Nadu and Andhra Pradesh (Sundararaj & Selvaraj, 2016; Chalapathirao *et al.*, 2018) [15, 7]. Since then, it has spread rapidly, causing significant yield and quality losses and other whitefly species like *Paraleyrodes* have also been reported in coconut plantations in Kerala and Karnataka (Josephrajkumar *et al.*, 2019; Vidya *et al.*, 2019) [12, 18].

Given the increasing incidence and threat of whitefly infestations, there is an urgent need to develop coconut varieties that can tolerate or resist such pests. Screening of existing varieties for resistance plays a crucial role in guiding breeding programs aimed at developing whitefly-tolerant cultivars to ensure sustainable coconut production in the future.

Materials and Methods
List of coconut cultivars included to study varietal preference by whitefly complex

1. Gauthami Ganga: (A selection from Ganga Bondam GBGD) (Dwarf variety)
2. Vasista Ganga: (Ganga Bondam GBGD X Philippines Ordinary Tall PHOT) (Hybrid)

1. Abhaya Ganga: (Ganga Bondam GBGD X Laccadive Ordinary Tall LCOT) (Hybrid)
2. Vynateya Ganga: (Philippines Ordinary Tall PHOT X Ganga Bondam GBGD) (Hybrid)
3. Pillalakodi Green: (IC:610306) (Tall variety)
4. Pillalakodi Brown: (IC: 610307) (Tall variety)
5. Jonnalarasi Brown: (IC: 610309) (Tall variety)
6. East Coast Tall: (Tall variety)
7. Philippines Ordinary Tall: (Tall variety)
8. Kera Bastar: (Tall variety)

Methods of observation

BNW population assessment

Three palms per cultivar were selected randomly and population assessment (nymphs, pupae and adults) was made from four randomly selected pest infested leaflets per leaf from four leaves of each palm (including top, middle and lower whorl) representing four directions (16 leaftets per palm) and expressed as mean of leaflet/leaf/palm.

List of various bio-pesticides tested against Bondars nesting whitefly.

	Treatments	Concentration	Dosage
T_1	*Isaria fumosorosea*	1 X 10^8 cfu	5 ml/L
T_2	Azadiractin	10000 ppm	1 ml/L
T_3	*Cladosporium perangustum* (Dr. YSRHU strain 1)	1 X 10^8 cfu	5 ml/L
T_4	*Fusarium equiseti* (Dr. YSRHU strain 2)	1 X 10^8 cfu	5 ml/L
T_5	*Lecanicillium lecanii*	1 X 10^8 cfu	5 ml/L
T_6	*Beauveria bassiana*	1 X 10^8 cfu	5 ml/L
T_7	*Metarhizium anisopliae*	1 X 10^8 cfu	5 ml/L
T_8	Jet water spray	-	-
T_9	Control (no spraying)	-	-

Spray fluid

The required quantity of spray solution was prepared at the time of application. Jet water spray was applied and high jet sprayer (Honda four stroke petrol) was used for spraying.

Spray schedule and Interval period followed for recording observations

The sprayings were scheduled at 15 days interval. After the pre-treatment count, the data on whitefly was recorded at seven days interval.

Method of recording observations

Three palms per cultivar were selected randomly and population assessment (nymphs, pupae and adults) was made from four randomly selected pest infested leaflets per leaf from four leaves of each palm (including top, middle and lower whorl) representing four directions (16 leaftets per palm) and expressed as mean of leaflet/leaf/palm. The data pertaining to nymphs, pupae was recorded using under Nikon SMZ18 stereomicroscope and adults on visual basis. The pest population reduction is obtained by using following formula

$$\text{Pest population reduction\%} = \frac{\text{Pretreatment count-treatment count}}{\text{Treatment count}} \text{X } 100$$

Results

Pest Population on different coconut cultivars

Webs of BNW

As per the data presented in the Table 1 variety Gauthami Ganga recorded maximum number of webs of BNW *i.e.*, 22.51webs/leaflet, followed by hybrids (16.42-19.37 webs/leaflet), local tall varieties Pillalakodi Green, Pillalakodi Brown, Jonnalarasi Brown with web population per leaflet of 15.50, 12.60, 7.80 respectively followed by other talls Phillippines Ordinary Tall, East Coast Tall and Kera Bastar with webs/leaflet of 5.12, 4.77, 3.74 respectively.

Nymphs, Pupae and adults of whitefly complex

The nymphal, pupal and adult population of BNW was recorded highest in dwarf Gauthami Ganga followed by hybrids, local talls and Kera Bastar being less preferred. The various life stages observed are presented here under (figure1).

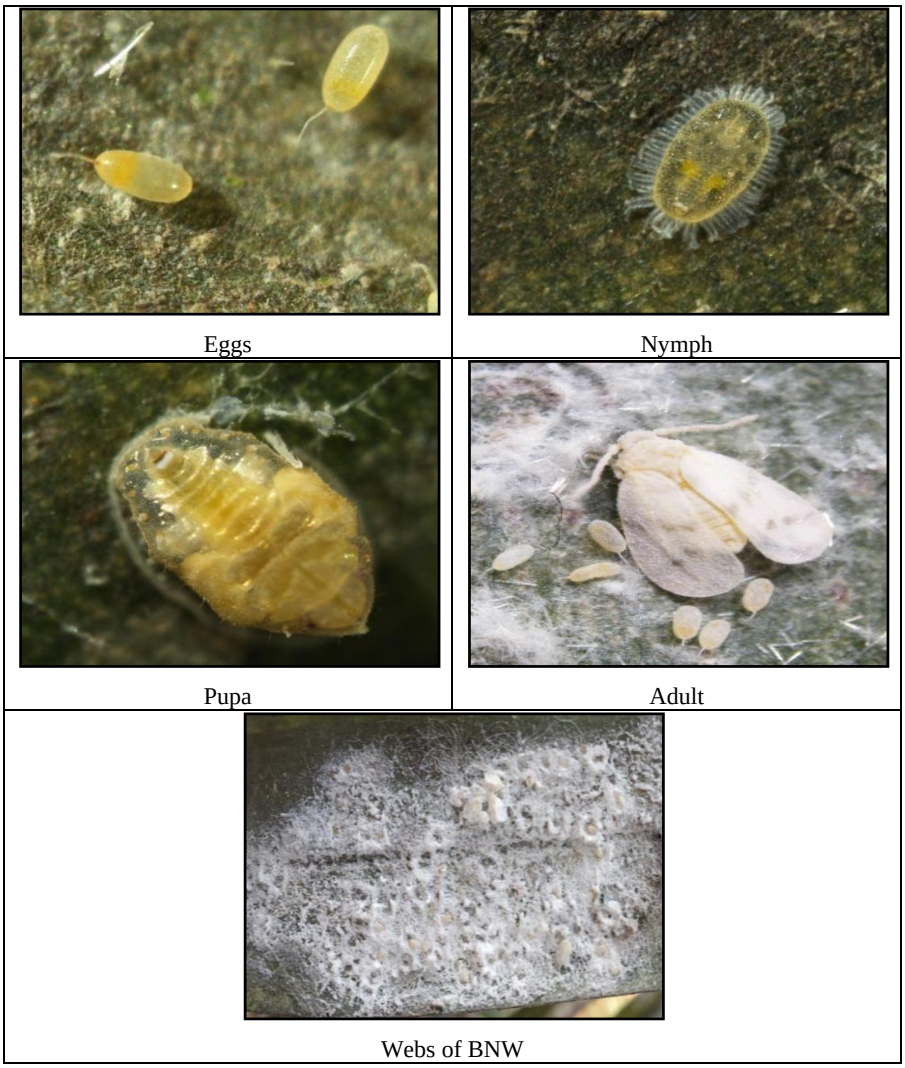
Gauthami Ganga is with highest nymphs, pupa and adult population of 9.30 nymphs/leaflet, 6.88 pupae/leaflet and 18.05 adults/leaflet, respectively of BNW. Lowest nymph, pupa and adult population/leaflet was recorded in tall variety Kera Bastar with 2.19, 1.66, 2.04 nymphs, pupa and adults/leaflet, respectively.

Gautami ganga (dwarf) was found be infested with more pest population when compared to other varieties. Previous studies have shown that dwarf coconut cultivars are more preferred by RSW than tall varieties (Sundaraj and Selvaraj, 2017; Chandrika *et al.*, 2017) [17, 9]. Higher incidence of RSW has been reported on dwarf and hybrid cultivars such as Chowghat Orange Dwarf, Malayan Orange Dwarf, and Gauthami Ganga (Selvaraj *et al.*, 2016) [15]. Similar trends were observed in Gujarat and Chhattisgarh, where severe infestation occurred on dwarf and hybrid.

Table 1: Mean population of Webs, Nymphs, Pupa and Adults of BNW on various coconut cultivars.

Cultivar	BNW (*P. bondari*)/leaf let			
	Webs*	Nymphs*	Pupa*	Adult*
Gauthami Ganga	22.51±4.31	9.30±1.91	6.88±1.59	18.05±3.71
Vasista Ganga	19.37±3.98	8.60±1.77	5.61±1.30	16.61±3.42
Abhaya Ganga	16.85±3.47	7.45±1.53	4.72±1.09	15.34±3.15
Vynateya Ganga	16.42±3.38	6.36±1.30	3.87±0.89	14.50±2.98
Pillalakodi Green	15.50±3.19	5.94±1.22	3.74±0.86	11.53±2.37
Pillalakodi Brown	12.60±2.59	6.03±1.24	3.76±0.87	8.71±1.79
Jonnalarasi Brown	7.80±1.60	5.13±1.05	3.36±0.77	5.71±1.17
East Coast Tall	4.77±0.98	3.65±0.75	2.56±0.59	3.19±0.65
Philippines Ordinary Tall	5.12±1.05	4.78±0.98	2.97±0.68	3.83±0.78
Kera Bastar	3.74±0.76	2.19±0.45	1.66±0.38	2.04±0.42

*Mean of 3 replicates; Values in the table are represented as mean ± standard error for population count.



Life stages of Bondars nesting whitefly, *Paralerodes bondari*

Table 2: Evaluation of different biopesticides against BNW nymphs.

Treatment	PTC	7 DAS	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS	Reduction % Over PTC
T_1	15.26 (4.01)	13.63 (3.80)	12.66 (3.67)	11.29 (3.48)	10.43 (3.36)	9.24 (3.18)	8.53 (3.07)	44.11
T_2	12.12 (3.60)	10.89 (3.42)	10.14 (3.32)	9.04 (3.15)	8.41 (3.05)	7.46 (2.89)	6.94 (2.80)	42.72
T_3	15.11 (3.99)	13.68 (3.81)	12.72 (3.68)	11.48 (3.51)	10.65 (3.39)	9.51 (3.22)	8.79 (3.11)	41.80
T_4	14.39 (3.90)	13.01 (3.72)	12.07 (3.59)	10.85 (3.42)	10.04 (3.30)	8.92 (3.13)	8.24 (3.02)	42.70
T_5	13.16 (3.74)	11.96 (3.58)	11.21 (3.47)	10.10 (3.31)	9.45 (3.21)	8.50 (3.06)	7.91 (2.97)	39.87
T_6	15.23 (4.00)	13.98 (3.85)	13.28 (3.75)	12.11 (3.60)	11.47 (3.51)	10.41 (3.36)	9.83 (3.27)	35.47
T_7	12.67 (3.67)	11.74 (3.58)	11.26 (3.48)	10.36 (3.35)	9.89 (3.28)	9.07 (3.15)	8.63 (3.08)	31.85
T_8	12.19 (3.61)	12.01 (4.00)	11.82 (3.56)	11.64 (3.53)	11.49 (3.51)	11.36 (3.49)	11.17 (3.47)	8.344
T_9	13.01 (3.72)	15.20 (4.00)	18.79 (4.42)	21.48 (4.71)	25.46 (5.11)	27.12 (5.27)	31.45 (5.66)	-
SE (m)±	-	0.01	0.02	0.03	0.05	0.06	0.07	-
C.D at 5%	NS	0.04	0.08	0.11	0.15	0.18	0.22	-

Table 3: Evaluation of different biopesticides against BNW pupae.

Treatment	PTC	7 DAS	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS	Reduction% Over PTC
T_1	8.93 (3.13)	8.06 (2.99)	7.51 (2.90)	6.69 (2.76)	6.23 (2.67)	5.53 (2.54)	5.14 (2.46)	42.42
T_2	10.12 (3.31)	9.20 (3.17)	8.53 (3.07)	7.67 (2.93)	7.10 (2.83)	6.31 (2.69)	5.83 (2.60)	42.38
T_3	8.33 (3.03)	7.65 (2.92)	7.17 (2.84)	6.46 (2.71)	6.04 (2.64)	5.44 (2.52)	5.06 (2.45)	39.21
T_4	11.27 (3.48)	10.31 (3.34)	9.58 (3.23)	8.65 (3.09)	8.02 (2.98)	7.16 (2.84)	6.62 (2.74)	41.23
T_5	9.21 (3.17)	8.52 (3.06)	8.07 (2.99)	7.35 (2.87)	6.93 (2.80)	6.29 (2.68)	5.92 (2.61)	35.73
T_6	10.26 (3.33)	9.53 (3.22)	9.04 (3.15)	8.32 (3.03)	7.86 (2.96)	7.20 (2.85)	6.86 (2.79)	33.12
T_7	9.11 (3.16)	8.54 (3.07)	8.17 (3.01)	7.61 (2.92)	7.26 (2.86)	6.74 (2.76)	6.41 (2.70)	29.68
T_8	8.26 (3.02)	8.15 (3.01)	8.02 (2.99)	7.90 (2.96)	7.80 (2.95)	7.71 (2.93)	7.59 (2.91)	8.15
T_9	8.12 (3.00)	10.78 (3.41)	13.74 (3.81)	16.87 (4.20)	18.19 (4.35)	22.74 (4.84)	28.71 (5.41)	-
SE (m)±	-	0.01	0.02	0.03	0.04	0.06	0.08	-
C.D at 5%	NS	0.04	0.07	0.11	0.13	0.18	0.24	-

Table 4. Evaluation of different biopesticides against BNW adults.

Treatment	PTC	7 DAS	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS	Reduction% Over PTC
T_1	20.23 (4.58)	17.52 (4.27)	15.63 (4.05)	13.43 (3.77)	11.99 (3.58)	10.28 (3.34)	9.16 (3.17)	54.72
T_2	21.26 (4.69)	18.64 (4.40)	16.65 (4.17)	14.48 (3.91)	13.05 (3.72)	11.26 (3.48)	10.06 (3.30)	52.66
T_3	21.13 (4.67)	18.65 (4.40)	16.80 (4.19)	14.88 (3.96)	13.64 (3.80)	12.05 (3.59)	10.83 (3.42)	48.75
T_4	18.32 (4.37)	16.08 (4.11)	14.46 (3.91)	12.60 (3.66)	11.45 (3.51)	9.97 (3.29)	8.93 (3.13)	51.24
T_5	19.23 (4.47)	17.11 (4.23)	15.54 (4.04)	13.75 (3.82)	12.66 (3.67)	11.18 (3.47)	10.10 (3.31)	47.47
T_6	19.69 (4.52)	17.68 (4.29)	16.26 (4.13)	14.49 (3.91)	13.49 (3.78)	12.02 (3.59)	11.01 (3.44)	44.08
T_7	21.01 (4.66)	19.05 (4.45)	17.68 (4.29)	15.86 (4.08)	14.92 (3.96)	13.35 (3.76)	12.36 (3.63)	41.15
T_8	17.37 (4.26)	17.19 (4.24)	17.03 (4.22)	16.85 (4.20)	16.68 (4.18)	16.49 (4.15)	16.30 (4.13)	6.17
T_9	18.24 (4.36)	21.22 (4.68)	24.79 (5.04)	26.23 (5.18)	29.83 (5.52)	32.14 (5.72)	34.37 (5.91)	-
SE (m)±	-	0.01	0.02	0.03	0.05	0.06	0.07	-
C.D at 5%	NS	0.04	0.08	0.11	0.15	0.19	0.22	-

*values in the table are mean/leaflet; DAS: Days after spraying, PTC: Pre treatment data, Figures in the parenthesis are √x + 0.5 transformed values.

BNW nymphs

I. fumosorosea NBAIR pfu-5 @ 5 ml/L was found to be effective in reducing the nymphal population of BNW with 44.11% reduction after 42 DAS followed by Azadirachtin 10,000 ppm @ 1 ml/L with reduction of 42.72%. Among the other entomopathogenic fungi, evaluated *F. equiseti* and *C. perangustum* were found to be promising with reduction 42.70% and 41.80% after 42 DAS. However, control (untreated) recorded highest population of nymphs of 31.45/leaflet after 28 days (Table 2)

BNW pupae

The overall results revealed that there was existence of significant difference among different treatments against BNW pupae. Least number of pupae were recorded in treatment *I. fumosorosea* NBAIR pfu-5 @ 5 ml/L with 42.42% reduction after spraying and proved to be superior compared to that of other treatments followed by Azadirachtin 10,000 ppm @ 1 ml/L showing 42.38% reduction. The control (untreated) was recorded with highest population of 28.71 after 42 days per leaflet (Table 3)

BNW adults

The overall results indicated that, significant difference was observed among different treatments against adults of BNW.*I. fumosorosea* (T_1) NBAIR pfu-5 @ 5 ml/L recorded lowest number of adults after 42 DAS with 54.72% reduction and found to be promising followed by Azadirachtin 10,000 ppm @ 1 ml/L (T_2) with reduction of 52.66%. Among the treated biopesticides *M. anisopliae* has least effect on adult population with 41.15% reduction after 42 days. The control (untreated) recorded with highest population of 34.37 per leaflet after 42 days (Table 4).

The present study revealed that foliar application of entomopathogenic fungi (EPF) significantly reduced the population of whitefly. EPF infect insect hosts through enzymatic degradation of the cuticle by producing proteases, chitinases, and lipases, facilitating conidial attachment and penetration. Among the tested treatments, *Isaria fumosorosea* was the most effective in suppressing whitefly populations compared to *Beauveria bassiana*, *Metarhizium anisopliae*, *Cladosporium perangustum*, *Fusarium equiseti*, and *Lecanicillium lecanii*. Its superior efficacy may be attributed to the production of cuticle-degrading enzymes that disrupt host physiological regulation (Ali *et al.*, 2010) [2]. These findings corroborate earlier reports demonstrating significant reduction of RSW nymphal stages by *I. fumosorosea* NBAIR pfu-5 under field conditions (Boopathi *et al.*, 2013, 2015; Chalapathirao *et al.*, 2020; Selvaraj *et al.*, 2020) [5, 6, 8, 14].

Azadirachtin 10,000 ppm was the next most effective treatment, effectively suppressing all developmental stages of BNW by acting as a growth regulator, antifeedant, and repellent through inhibition of moulting hormone synthesis (Copping and Duke, 2007) [10]. These results are in agreement with earlier studies reporting reduced adult intensity of RSW following azadirachtin application (Chandrika *et al.*, 2017; Alagar *et al.*, 2021) [9, 1]. *Cladosporium perangustum* showed moderate efficacy against nymphs and adults, whereas *Metarhizium anisopliae* was less effective, possibly due to reduced conidial density and poor field persistence, as also reported by Boopathi *et al.* (2013, 2015) [5, 6].

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