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Field Efficacy of Andrographolide Based Formulations Against Cowpea Aphids, *Aphis craccivora* Koch (Homoptera: Aphididae), and their Safety to Predator, *Coccinella transversalis* Fab. (Coleoptera: Coccinellidae) in Cowpea

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Abstract

A field experiment was carried out to evaluate the efficacy of developed formulations of andrographolide (Formulation A and Formulation B) against cowpea aphids, *Aphis craccivora* and predatory coccinellids, *Coccinella transversalis* on cowpea during 2022- 2023 at the College of Agriculture, Vellayani. All concentrations (3, 5 and 7%) of both formulations A and B demonstrated minimal aphid populations, comparable to the chemical checks (thiamethoxam 25 WG and chlorantraniliprole 18.5% SC). Following the second spray, thiamethoxam 25 WG (90.44%) and chlorantraniliprole 18.5% SC (87.73%) exhibited the highest efficacy, followed by 7% concentration of both formulations A (86.97%) and B (85.87%). Additionally, both formulations A and B were found to be safer for predatory coccinellids, *C. transversalis*, compared to chemical checks, demonstrating their potential as environmentally friendly alternatives in pest management.

Key words: Cowpea, *Andrographis paniculata,* Andrographolide, Neem oil, Pungam oil, Triton X-100, Thiamethoxam, Chlorantraniliprole

Cowpea (*Vigna unguiculata*) is an important legume crop, well known for its adaptability to diverse agro-climatic conditions and high protein content [1]. However, its productivity is consistently challenged by a large number of insect pests including aphids (*Aphis craccivora* Koch), spotted pod borer (*Maruca vitrata* Fabricius), mealy bug (*Ferrisia virgata* Cockerell), pod bug (*Riptortus pedestris* Fabricius), thrips (*Ayyaria chaetophora* Karny), spotted red mite (*Tetranychus truncatus* Ehara), pod borer (*Lampides boeticus* Linnaeus), tobacco caterpillar (*Spodoptera litura* Fabricius), and American serpentine leaf miner (*Liriomyza trifolii* Burgess). Among these, *A. craccivora* Koch stands out as a, prevalent and destructive pest across various regions of India, causing yield losses of 20 to 40 per cent [2]. Cowpea (*Vigna unguiculata*) is indeed a crucial legume crop known for its adaptability to diverse agro-climatic conditions and high protein content. However, its productivity faces significant challenges due to various insect pests, among which *Aphis craccivora* Koch, commonly known as the cowpea aphid, is particularly notable for its prevalence and destructive impact in many regions of India. The cowpea aphid infestation can cause substantial yield losses, ranging from 20 to 40 percent. This pest poses a significant threat to cowpea cultivation and requires effective management strategies to mitigate its impact [3-4].

To address the challenges posed by *Aphis craccivora* and other insect pests in cowpea cultivation, integrated pest management (IPM) practices are commonly employed. These practices involve a combination of cultural, biological, and chemical control measures tailored to specific pest pressures and environmental conditions. Cultural practices such as crop rotation, intercropping, and maintaining proper plant density can help reduce pest populations by disrupting their reproductive cycles and reducing host plant availability. Biological control methods, including the introduction of natural enemies such as parasitoids, predators, and pathogens, play a crucial role in suppressing aphid populations [5-6]. Additionally, the use of resistant or tolerant cowpea varieties can offer effective protection against aphid infestations. Breeding programs aimed at developing cowpea cultivars with resistance or tolerance to *Aphis craccivora* can contribute significantly to sustainable pest management efforts [7].

Chemical control measures, such as the judicious application of insecticides, should be integrated into pest management programs as a last resort and used selectively to minimize negative impacts on beneficial organisms and the environment. Furthermore, continuous monitoring of pest populations, timely action thresholds, and regular scouting of fields are essential components of effective pest management in cowpea cultivation. By implementing comprehensive IPM strategies, farmers can mitigate the damaging effects of *Aphis craccivora* and other insect pests, thereby enhancing cowpea productivity and ensuring food security [8-9].

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Conventional control measures predominantly rely on synthetic insecticides. However, the environmental and health impacts of synthetic insecticides have prompted a search for sustainable alternatives. This has led to the exploration of botanical pesticides derived from plant-based sources like *Andrographis paniculata* (Burn. F.), commonly known as the 'King of Bitter'. Recent studies have highlighted the insecticidal potential of *Andrographis paniculata*, attributed to its active constituent, andrographolide, a labdane diterpenoid [10]. In light of these, the present study aims to assess the field efficacy of andrographolide based formulations against cowpea aphids, offering insights into potential of botanical pesticides as eco-friendly alternatives for pest management. The shift towards sustainable pest management strategies has prompted research into botanical pesticides as alternatives to synthetic insecticides. Andrographis paniculata, commonly known as the 'King of Bitter', has garnered attention due to its insecticidal properties, primarily attributed to its active constituent, andrographolide, a labdane diterpenoid [11-12].

Recent studies have highlighted the insecticidal potential of andrographolide derived from *A. paniculata* against various insect pests, including cowpea aphids (*Aphis craccivora* Koch) [13-14]. This natural compound offers promise as an eco-friendly alternative for pest management in agricultural settings. The present study aims to assess the field efficacy of formulations containing andrographolide against cowpea aphids [15-16]. By evaluating the performance of these botanical pesticides under real-world conditions, the study seeks to provide valuable insights into their potential as sustainable pest management tools for cowpea cultivation [17]. Field trials will be conducted to evaluate the effectiveness of andrographolide-based formulations in controlling cowpea aphid populations and reducing crop damage [18]. Parameters such as aphid population dynamics, crop yield, and plant health will be monitored and compared with conventional insecticide treatments to assess the relative efficacy of botanical pesticides [19-20].

The study will explore the broader ecological and socio-economic implications of adopting botanical pesticides in cowpea production. Considerations such as environmental impact, human health risks, cost-effectiveness, and farmer acceptance will be addressed to provide a comprehensive evaluation of the feasibility and practicality of integrating botanical pesticides into pest management strategies. Overall, the findings of this study are expected to contribute valuable information to the ongoing efforts to develop sustainable and environmentally friendly solutions for pest control in agriculture. By harnessing the insecticidal potential of plant-based compounds like andrographolide, researchers aim to promote a more holistic and ecologically sound approach to pest management while ensuring food security and environmental sustainability.

MATERIALS AND METHODS

The field experiment was conducted at the college of Agriculture, Vellayani during 2022-2023. It was laid in randomized block design with 9 treatments including untreated control and replicated thrice. Plot sizes of 2 × 3 m^2 were prepared with 16 plants per plot at a spacing of 30 × 45cm. Cowpea variety Vellayani Jyothika was raised and trailed, and each plot was separated by a gap of 0.50 m to reduce the drift of sprays. Treatments including 3,5 and 7% of botanical formulations A and B, chemical checks, Thiamethoxam 25% WG and Chlorantraniliprole 18.5% SC and untreated control were tested, whereas Formulation A represents, Andrographolide solution (70%) + Neem oil (20%) + Triton × 100 (10%) and Formulation B represents, Andrographolide solution (70%) + Pungam oil (20%) + Triton × 100 (10%). A total of two applications were given during the crop growth period. The pest incidence was recorded one day before spraying as pre-treatment count and on one, three, five, seven and fourteen days after spraying as post-treatment count. The *A. craccivora* population were counted on 10 tagged plants of each plot, the number of aphids from each plant was assessed from 30cm of the terminal twig with the unopened and two opened leaves, and the mean number was recorded [21]. The percentage reduction over control expressed as % field efficacy was calculated using Henderson and Tilton's formula [22] as given below. The statistical analysis of variance (ANOVA) using GRAPES software and the treatment differences were compared [23].

$$\text{Per cent field efficacy} = 1 - \left(\frac{Ta}{Tb} \text{ X } \frac{Cb}{Ca}\right) \text{ X } 100$$

Where;
Ta = population in the treated plot after spray
Tb = population in the treated plot before spray
Ca = population in the control plot after spray and
Cb = population in the control plot before spray

RESULTS AND DISCUSSION

The data on the efficacy of treatments after first spray on the aphid population is detailed in (Table 1). Notably, complete population suppression was observed in 7% concentration of formulation B by 5 days after spraying (DAS), comparable to thiamethoxam 25% WG and chlorantraniliprole 18.5% SC and this trend persisted up to 7 DAS. The mean population of aphids at 7% concentration of formulation B and A recorded the lowest aphid counts (2.25 and 2.58 aphids/plant), comparable to chemical checks, followed by 5% formulations of B and A (3.09 and 3.85 aphids/plant, respectively). Similarly, following the second spray of treatments, the mean population of aphids at thiamethoxam 25% WG recorded the lowest population (1.84 aphids/plant), followed by chlorantraniliprole 18.5% SC and 7% concentration of formulation B (2.73 and 3.25 aphids/plant, respectively) (Table 2). The overall per cent reduction in aphid population was recorded maximum in thiamethoxam (90.44%), followed by chlorantraniliprole 18.5% SC (87.73%) and 7% concentration of formulations A and B (86.97 and 85.37%) (Fig 1). These findings highlight the potential of formulations A and B as effective biopesticides for controlling cowpea aphids.

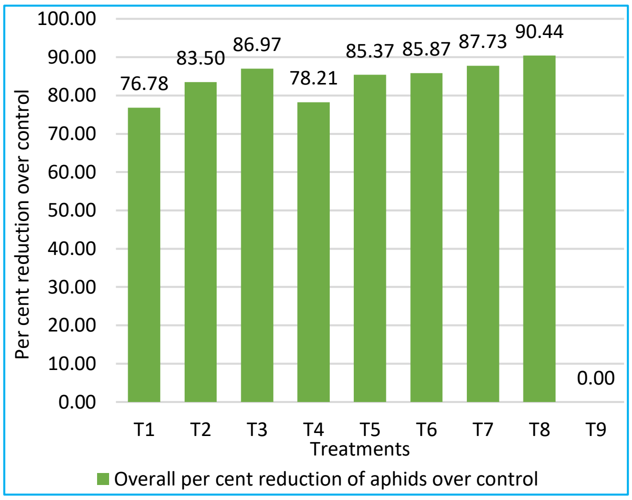

Fig 1 Overall per cent reduction of aphids population over control

Table 1 Effect of formulations A and B on the population of *Aphis craccivora* at different intervals after first spray

Treatments	Precount	*Mean population of *A. craccivora* /plant					
		1DAS	3DAS	5DAS	7DAS	14DAS	Overall mean
3% of formulation A	8.50 (2.90)	6.00 (2.54)^{d}	3.44 (1.98)^{b}	2.70 (1.79)^{c}	2.67 (1.77)^{c}	17.59 (4.25)^{d}	6.49 (2.47)^{c}
5% of formulation A	8.41 (2.89)	2.11 (1.60)^{c}	1.00 (1.17)^{a}	0.70 (1.07)^{ab}	0.70 (1.07)^{ab}	14.76 (3.91)^{c}	3.85 (1.79)^{abc}
7% of formulation A	8.66 (2.94)	1.17 (1.29)^{bc}	0.33 (0.88)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	10.38 (3.30)^{a}	2.58 (1.50)^{ab}
3% of formulation B	8.52 (2.92)	4.77 (2.28)^{d}	2.92 (1.80)^{b}	1.43 (1.37)^{b}	1.33 (1.37)^{b}	17.56 (4.25)^{d}	5.62 (2.24)^{bc}
5% of formulation B	9.18 (3.03)	1.67 (1.47)^{bc}	0.33 (0.88)^{a}	0.33 (0.88)^{a}	0.33 (1.05)^{a}	12.45 (3.59)^{b}	3.09 (1.60)^{ab}
7% of formulation B	8.19 (2.86)	0.33 (0.88)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	9.89 (3.22)^{a}	2.25 (1.37)^{a}
Chlorantraniliprole 18.5% SC	9.06 (2.89)	0.83 (1.12)^{ab}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	9.90 (3.23)^{a}	2.41 (1.45)^{ab}
Thiamethoxam 25% WG 50	7.77 (2.78)	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	9.66 (3.19)^{a}	2.00 (1.24)^{a}
Control	8.03 (2.83)	11.48 (3.46)^{e}	25.96 (5.87)^{c}	60.62 (7.82)^{d}	65.59 (8.11)^{d}	88.77 (9.45)^{e}	53.20 (7.09)^{d}
SE (m)	0.25	0.14	0.18	0.12	0.15	0.08	0.27
CD (0.05)	NS	0.40	0.54	0.37	0.44	0.23	0.79

*Mean of three replications,
DAS – Days after spraying,
Figures in parentheses are values after square root transformation

Table 2 Effect of formulations A and B on the population of *Aphis craccivora* at different intervals after second spray

Treatments	Precount	*Mean population of *Aphis craccivora* /plant					
		1DAS	3DAS	5DAS	7DAS	14DAS	Overall mean
3% of formulation A	35.21 (5.97^{b}	21.14 (4.65)^{e}	13.93 (3.80)^{e}	8.15 (2.92)^{d}	7.67 (2.83)^{d}	22.37 (4.78)^{b}	14.65 (3.81)^{d}
5% of formulation A	16.55 (4.10)^{a}	6.56 (2.65)^{c}	3.70 (2.04)^{d}	2.50 (1.70)^{c}	2.33 (1.66)^{c}	10.62 (3.33)^{a}	5.14 (2.29)^{c}
7% of formulation A	14.49 (3.74)^{a}	5.10 (2.31)^{bc}	1.85 (1.44)^{bcd}	0.93 (1.15)^{ab}	0.67 (1.05)^{abc}	10.07 (3.25)^{a}	3.72 (1.89)^{bc}
3% of formulation B	30.67 (5.58)^{b}	15.74 (4.03)^{d}	9.92 (3.22)^{e}	7.41 (2.79)^{d}	7.27 (2.77)^{d}	21.08 (4.64)^{b}	12.28 (3.50)^{d}
5% of formulation B	16.16 (4.00)^{a}	6.37 (2.59)^{c}	3.30 (1.91)^{cd}	2.00 (1.56)^{bc}	1.60 (1.36)^{bc}	10.00 (3.24)^{a}	4.65 (2.17)^{bc}
7% of formulation B	11.31 (3.40)^{a}	4.07 (2.13)^{bc}	1.33 (1.29)^{abc}	0.73 (1.08)^{ab}	0.33 (0.88)^{ab}	9.79 (3.21)^{a}	3.25 (1.74)^{abc}
Chlorantraniliprole 18.5% SC 30 ml ha^{-1}	11.19 (3.42)^{a}	2.50 (1.72)^{ab}	1.33 (1.10)^{ab}	0.33 (0.88)^{a}	0.33 (0.88)^{ab}	9.17 (3.11)^{a}	2.73 (1.60)^{ab}
Thiamethoxam 25% WG 50 g a.i ha^{-1}	10.12 (3.26)^{a}	1.00 (1.17)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	8.19 (2.94)^{a}	1.84 (1.26)^{a}
Control	97.32 (9.87)^{c}	93.78 (9.70)^{f}	93.33 (9.68)^{f}	120.00 (10.97)^{e}	131.33 (11.47)^{e}	141.33 (11.86)^{c}	115.96 (10.75)^{e}
SE (m)	0.37	0.21	0.22	0.18	0.21	0.27	0.20
CD (0.05)	0.10	0.62	0.65	0.53	0.64	0.80	0.57

*Mean of three replications,
DAS – Days after spraying,
Figures in parentheses are values after square root transformation

The mean population of coccinellids following the first and second spray is summarized in (Table 3). The highest coccinellid population was observed in the untreated control (1.63 and 2.85 coccinellids/plant, respectively), followed by various concentrations of formulations A and B. Formulations A and B at various concentrations recorded significantly higher populations of natural enemies compared to the thiamethoxam 25% WG and chlorantraniliprole 18.5% SC. After the first spray, 3, 5 and 7% concentrations of formulations A and B were statistically comparable to each other, while after the second spray, the 3% formulations of both A (1.99 coccinellids / plant) and B (2.09 coccinellids / plant) were statistically on par. Conversely, the lowest population of coccinellids was observed in the chemical checks, with thiamethoxam 25% WG (0.05 and 0.05 coccinellids / plant) and chlorantraniliprole 18.5% SC (0.27 and 0.29 coccinellids / plant) exhibiting significantly lower counts. Overall, these results suggest that andrographolide-based formulations offer a safer alternative to chemical insecticides in terms of their impact on predatory coccinellids.

Table 3 Effect of formulations A and B on the population of *Coccinella transversalis* at different intervals after the first and second spray

Treatments	**Coccinella transversalis* / plant at different intervals after first spray						** Coccinella transversalis* / plant at different intervals after second spray					
	1 DAS	3 DAS	5 DAS	7 DAS	14 DAS	Mean	1 DAS	3 DAS	5 DAS	7 DAS	14 DAS	Mean
3% of formulation A	0.47 (0.98)^{b}	0.53 (1.02)^{b}	0.70 (1.09)^{b}	1.00 (1.22)^{b}	2.00 (1.58)^{bc}	0.94 (1.18)^{b}	1.83 (1.53)^{b}	1.80 (1.52)^{b}	1.90 (1.55)^{b}	1.97 (1.57)^{bc}	2.43 (1.71)^{b}	1.99 (1.58)^{b}
5% of formulation A	0.40 (0.95)^{b}	0.47 (0.98)^{b}	0.60 (1.05)^{b}	0.90 (1.18)^{b}	1.70 (1.48)^{d}	0.81 (1.13)^{b}	1.43 (1.39)^{c}	1.40 (1.38)^{cd}	1.47 (1.40)^{c}	1.87 (1.54)^{c}	2.00 (1.58)^{c}	1.63 (1.46)^{c}
7% of formulation A	0.37 (0.93)^{b}	0.43 (0.97)^{b}	0.60 (1.05)^{b}	0.87 (1.17)^{b}	1.60 (1.45)^{d}	0.77 (1.11)^{b}	1.43 (1.39)^{c}	1.37 (1.37)^{d}	1.43 (1.39)^{c}	1.80 (1.53)^{c}	1.97 (1.57)^{c}	1.60 (1.45)^{c}
3% of formulation B	0.47 (0.98)^{b}	0.50 (1.00)^{b}	0.73 (1.11)^{b}	1.03 (1.24)^{b}	2.10 (1.61)^{ab}	0.97 (1.19)^{b}	1.90 (1.55)^{b}	1.90 (1.55)^{b}	2.00 (1.58)^{b}	2.10 (1.61)^{b}	2.53 (1.74)^{b}	2.09 (1.61)^{b}
5% of formulation B	0.47 (0.98)^{b}	0.50 (1.00)^{b}	0.67 (1.08)^{b}	0.90 (1.18)^{b}	1.77 (1.50)^{cd}	0.86 (1.15)^{b}	1.50 (1.41)^{c}	1.47 (1.40)^{c}	1.53 (1.43)^{c}	1.97 (1.57)^{bc}	2.07 (1.60)^{c}	1.71 (1.48)^{c}
7% of formulation B	0.43 (0.97)^{b}	0.47 (0.98)^{b}	0.63 (1.06)^{b}	0.90 (1.18)^{b}	1.73 (1.49)^{d}	0.83 (1.14)^{b}	1.47 (1.40)^{c}	1.43 (1.39)^{cd}	1.53 (1.43)^{c}	1.87 (1.54)^{c}	2.03 (1.59)^{c}	1.67 (1.47)^{c}
Chlorantraniliprole 18.5% SC	0.10 (0.77)^{c}	0.10 (0.77)^{c}	0.00 (0.71)^{c}	0.13 (0.80)^{c}	1.00 (1.22)^{e}	0.27 (0.86)^{c}	0.30 (0.89)^{d}	0.00 (0.71)^{e}	0.03 (0.73)^{d}	0.10 (0.77)^{d}	1.00 (1.22)^{d}	0.29 (0.87)^{d}
Thiamethoxam 25% WG	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.03 (0.73)^{c}	0.23 (0.85)^{f}	0.05 (0.74)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.07 (0.75)^{d}	0.20 (0.83)^{e}	0.05 (0.74)^{e}
Control	0.90 (1.18)^{a}	1.27 (1.33)^{a}	1,60 (1.45)^{a}	2.00 (1.58)^{a}	2.37 (1.69)^{a}	1.63 (1.45)^{a}	2.43 (1.71)^{a}	2.53 (1.74)^{a}	2.80 (1.82)^{a}	3.17 (1.91)^{a}	3.30 (1.95)^{a}	2.85 (1.83)^{a}
SE (m)	0.02	0.02	0.02	0.02	0.03	0.04	0.02	0.01	0.01	0.02	0.02	0.03
CD (0.05)	0.07	0.07	0.07	0.06	0.10	0.09	0.04	0.03	0.04	0.06	0.07	0.08

*Mean of three replications,

DAS – Days after spraying,

Figures in parentheses are values after square root transformation

Literature on formulations utilizing *A. paniculata* against insect pests supports the present study findings. Bhavyasree [24] demonstrated that a 5% concentration formulation containing *A. paniculata* extract, pongamia oil, and Triton X-100 (7:2:1) effectively controlled sucking pests of chilli, performing on par with synthetic insecticides, thiamethoxam 25% WG and spiromesifen 22.9% SC and also revealed the safety of formulations for natural enemies including coccinellid beetles and spiders. Similarly, Raveendran [25] found that neem-based oil formulation of *A. paniculata* at 6% concentration effectively controlled the sucking pests of cowpea, comparable to chemical check, thiamethoxam 25% WG, while also demonstrating safety to natural enemies. Moreover, previous studies on neem-based formulations highlight the efficacy of botanical extracts in controlling aphid populations. Chandrasekharan and Balasubramanian [26] reported significant control over *A. craccivora* with TNAU neem oil, resulting in a substantial reduction in their population. Additionally, Egho [27] highlighted the aphidicidal activity of neem seed kernel extract (NSKE) and neem oil, resulting in a 92% mortality of *A. craccivora* due to both contact toxicity and antifeedant effects. Similar studies by Sreerag and Jayprakash [28] demonstrated the effectiveness of neem oil-based formulations against cowpea aphids and papaya mealybugs. Similarly, research findings by Sujay *et al.* [29] support this notion, indicating that pesticides of biological origin might be relatively less harmful to natural enemies than conventional chemical pesticides. These findings align with the efficacy and safety observed in the current study, indicating the potential of andrographolide-based formulations as alternatives to synthetic insecticides for aphid management in cowpea. Formulations containing Andrographis paniculata extracts, particularly formulation B at 7% concentration, have significant potential for controlling aphid populations in cowpea while maintaining the populations of beneficial predators like coccinellids [30]. These formulations offer promising alternatives to conventional synthetic insecticides, aligning with the broader trend toward more sustainable pest management practices.

CONCLUSION

The study highlights the field efficacy of andrographolide-based formulations in controlling cowpea aphids while maintaining populations of predatory coccinellids, suggesting their potential as eco-friendly alternatives to synthetic insecticides. These findings highlight the importance of botanicals in integrated pest management for sustainable agriculture.

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