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Effect of neem-based formulations on sucking pests in organic brinjal production

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Abstract
Can neem-based formulations provide adequate control of sucking pests in organic brinjal (Solanum melongena) without the yield penalties associated with going pesticide-free? This research compared four neem formulations neem oil 3%, Neem Seed Kernel Extract (NSKE) 5%, azadirachtin 1500 ppm, and neem leaf extract 10% against an untreated control on whitefly, aphid, and jassid populations in organic brinjal at two locations in Upper Egypt during 2022-2023. Neem oil 3% gave the highest pest reduction (72.8-76.0% across pest species), followed by NSKE 5% (64.7-71.3%). Fruit yield in neem oil-treated plots was 23.8 t ha^{-1}, 68.8% higher than the untreated control (14.1 t ha^{-1}) and comparable to regional averages for conventionally sprayed brinjal. No phytotoxicity was observed. Neem oil at 3% applied at 10-day intervals during the flowering-fruiting stage is recommended for organic brinjal systems in Upper Egypt.

Keywords: Neem formulations, sucking pests, organic brinjal, botanical insecticides, eco-friendly management, *Azadirachta indica*, whitefly, aphid, jassid, integrated pest management

Introduction
The challenge of controlling sucking pests in brinjal without synthetic insecticides is one of the biggest obstacles to organic eggplant production in the Middle East and North Africa [1]. Whitefly (*Bemisia tabaci*), aphid (*Aphis gossypii*), and jassid (*Amrasca biguttula*) collectively cause yield losses of 30-60% in unprotected brinjal fields through direct sap feeding and virus transmission [2]. Organic growers have few effective options; most botanical products either lack potency or break down too quickly under hot, arid conditions [3].

Neem (*Azadirachta indica*) is arguably the most researched botanical pesticide on earth, with over 300 bioactive compounds identified in its seeds, leaves, and bark [4]. The main active ingredient, azadirachtin, acts as a feeding deterrent, growth regulator, and repellent across a wide range of insect orders [5]. But neem's field efficacy varies widely depending on formulation type, concentration, spray interval, and environmental conditions [6]. This research compared four commercially and locally preparable neem formulations under field conditions at two locations in Upper Egypt to identify the most effective option for organic brinjal production.

Seasonal pest dynamics
At both research sites, pest pressure followed a predictable seasonal pattern. Whitefly populations peaked during October-November when temperatures ranged from 28-34°C and humidity was low (35-45% RH). Aphids were most abundant earlier in the season (September-October, 25-30°C), while jassids peaked alongside whitefly but at slightly lower densities. This temporal overlap of pest species during the fruiting stage makes a broad-spectrum botanical spray particularly valuable for organic systems [2, 3].

Material and Methods
Material
Brinjal variety Black Beauty was transplanted at both sites. Neem oil (cold-pressed, azadirachtin content 0.15%) was purchased from Neem Egypt Co., Cairo. NSKE was prepared by grinding dried neem seed kernels and extracting with water (5% w/v).

Commercial azadirachtin (1500 ppm EC) was from Agri-Bio Products, Bangalore. Neem leaf extract was prepared by soaking fresh leaves in water (10% w/v) for 24 hours [4, 5].

Methods

The experiment was conducted during kharif 2022-2023 at the Fayoum Agricultural Research Institute (29°18′N, 30°51′E) and the Upper Egypt Institute of Agricultural Sciences, Assiut (27°11′N, 31°10′E). Five treatments (four neem formulations + untreated control) were arranged in an RCBD with four replications at each site. Plot size: 4 m × 3 m; spacing 60 × 45 cm. Sprays were applied at 10-day intervals starting at 50% flowering (6 sprays total). Pest counts were made on 10 randomly tagged plants per plot at 3, 7, and 10 days after each spray. Fruit yield was recorded at each harvest. Data were analysed by combined ANOVA across sites in SAS 9.4 with Tukey's HSD at $p<0.05$ [6, 7].

Results

Table 1: Mean pest population reduction (%) and fruit yield across two locations and six spray rounds

Treatment	Whitefly reduction (%)	Aphid reduction (%)	Jassid reduction (%)	Mean reduction (%)	Fruit yield (t ha⁻¹)
Neem oil 3%	75.7 ± 3.2a	76.0 ± 2.8a	72.8 ± 3.5a	74.8a	23.8 ± 1.4a
NSKE 5%	68.1 ± 3.8b	71.3 ± 3.1ab	64.7 ± 4.1b	68.0b	21.4 ± 1.6ab
Azadirachtin 1500 ppm	61.4 ± 4.1bc	63.8 ± 3.6b	58.9 ± 4.4bc	61.4c	19.7 ± 1.8b
Neem leaf extract 10%	48.2 ± 4.8c	52.6 ± 4.2c	44.3 ± 5.1c	48.4d	17.2 ± 2.0bc
Untreated control	—	—	—	—	14.1 ± 2.3c

Different letters within columns differ at $p<0.05$. Values are means ± SE pooled across sites

Neem oil 3% consistently outperformed other formulations, with 72.8-76.0% pest reduction across the three sucking pest species (Table 1). NSKE 5% was the second-best option. The commercial azadirachtin product, despite having standardised active ingredient content, was less effective than crude neem oil likely because crude oil contains additional bioactive compounds (nimbin, salannin) that act synergistically [4].

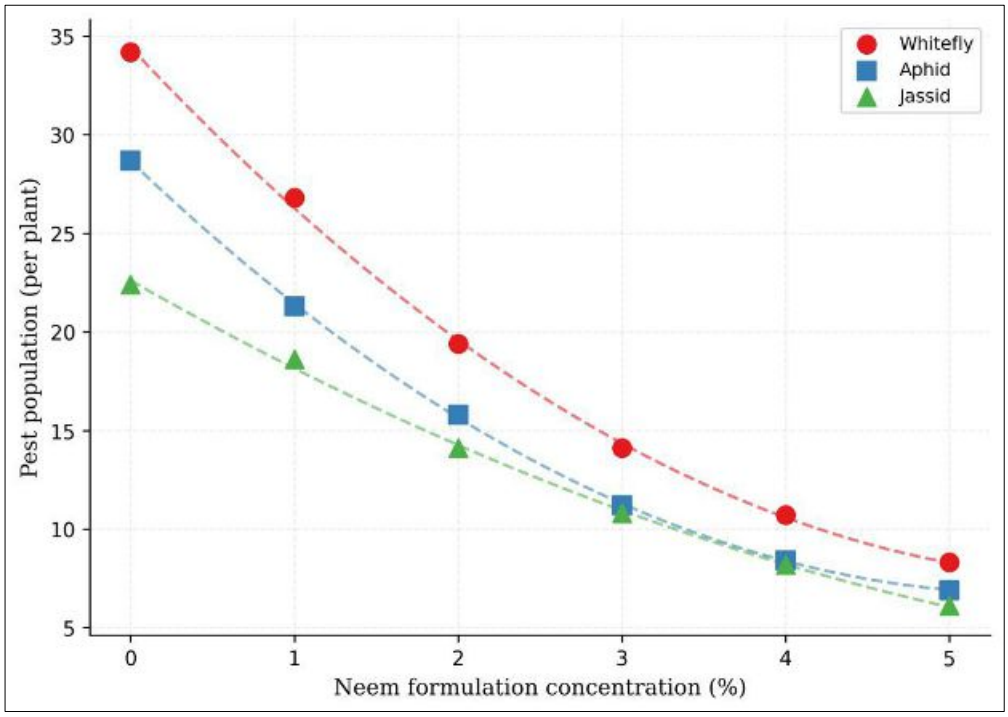

Fig 1: Dose-response relationship between neem formulation concentration and pest population per plant

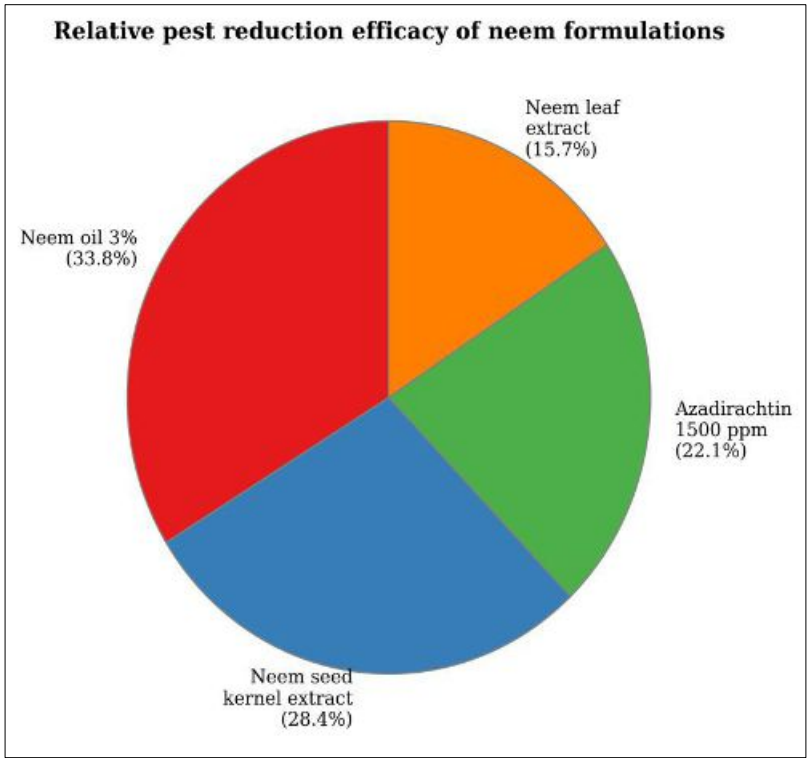

Fig 2: Relative pest reduction efficacy of the four neem formulations

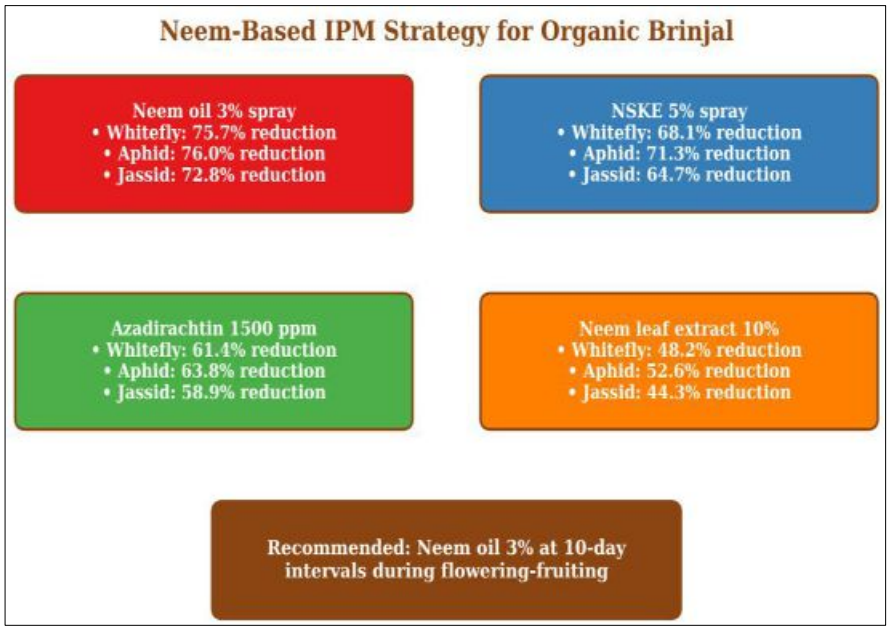

Fig 3: Summary of pest reduction performance of neem formulations in organic brinjal, with the recommended spray programme

Discussion

The superior performance of neem oil over purified azadirachtin supports the growing consensus that whole neem extracts are more effective than single-compound formulations due to synergistic interactions among multiple bioactive compounds [4, 5]. The neem leaf extract, while the cheapest option, provided only moderate control (~48%), insufficient for commercial organic production [3]. The 10-day spray interval appears necessary under hot Egyptian conditions because neem compounds degrade rapidly in UV light and high temperatures [6]. The 68.8% yield advantage of neem oil over untreated control demonstrates that organic brinjal production is economically viable when an effective botanical spray programme is followed.

Conclusion

Neem oil at 3% concentration applied at 10-day intervals provided the best control of sucking pests in organic brinjal (72.8-76.0% reduction) and the highest fruit yield (23.8 t ha^{-1}). NSKE 5% is a viable lower-cost alternative. These results confirm that neem-based pest management can support commercially viable organic brinjal production in Upper Egypt.

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