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FIELD EVALUATION OF BOTANICALS, SPINOSAD AND BAGGING AGAINST MELON FRUIT FLY [*Zeugodacus cucurbitae* (Coquillett)] INFESTATION IN BITTER GOURD

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ABSTRACT

Melon fruit fly, *Zeugodacus cucurbitae* (Coquillett), is one of the most destructive pests of bitter gourd causing substantial yield losses through larval feeding within developing fruits. The present study evaluated the efficacy of some selected botanicals, Spinosad 45 SC + jaggery, and fruit bagging for the management of melon fruit fly in bitter gourd under field conditions. Field experiments were conducted during *kharif* 2024 and 2025 in a randomized block design with three replications. Fruit infestation and marketable fruit yield were recorded and analysed on the basis of two years pooled data. Among all treatments, fruit bagging proved most effective, showing the lowest pooled mean fruit infestation (7.16%) and highest fruit yield (8.35 kg plot^{-1}). Spinosad 45 SC + jaggery proved the next best treatment, with 10.32% infestation and a yield of 8.07 kg plot^{-1}. Among botanicals, ginger powder (22.10%) and neem leaf extract (23.10%) were most effective, whereas parthenium extract depicted least efficacy (44.48%), close to the untreated control. In second spray enhanced suppression of fruit fly infestation was observed across the treatments. The study concluded that fruit bagging is an effective, eco-friendly and residue-free strategy for sustainable management of melon fruit fly in bitter gourd.

Keywords: Botanicals, bitter gourd, eco-friendly pest management, fruit bagging, melon fruit fly, Spinosad

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is an important cucurbitaceous vegetable cultivated widely in India for its nutritional, medicinal and economic values. However, its productivity is severely constrained by the infestation of melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae), one of the most destructive pests of cucurbit crops (Dhillon *et al*., 2005a). The pest is highly polyphagous, infesting more than 70 host plants, with a marked preference for cucurbits such as bitter gourd, cucumber and muskmelon (Dhillon *et al*., 2005b; Sapkota *et al*., 2010). Damage is caused by maggots feeding inside developing fruits, resulting in rotting, premature fruit drop and complete loss of marketability (Nasiruddin *et al*., 2004; Mir *et al*., 2014). Yield losses due to fruit fly infestation in cucurbits have been reported to be in the range of 25 to 54%, depending up on the crop, season and management practices (Kate *et al*., 2009; Nasiruddin *et al*., 2004). The concealed feeding habit of larvae and continuous breeding throughout the cropping period makes the management of this pest a difficult task.

Fruit flies are often controlled using chemicals and attractants; however, these methods are frequently ineffective because larvae feed inside the fruits and may result in harmful pesticide residues (Dhillon *et al*., 2005b). Plant-based extracts such as neem, balchar, harmal, and kuch have shown repellent and antifeedant properties (Jilani *et al.*, 1989), while neem formulations can suppress ovarian development in fruit flies and reduce pest populations (Singh and Sehgal, 2001; Mahfuza Khan *et al*., 2007). Recent studies have revealed the significant potential of botanical pesticides for sustainable fruit fly management in cucurbits. For instance, sesame leaf ethanolic extract reportedly reduced fruit fly infestation and improved yield attributes of bitter gourd, demonstrating the growing importance of plant-based pest management strategies in vegetable production (Balog *et al.*, 2025). Management options for cucurbit fruit fly include sanitation, protein-sugar sprays, pheromone traps, botanicals, insecticides and fruit bagging, with bagging being recognized as one of the most practical and residue-free approaches (Mitra *et al*., 2008; Waseem *et al*., 2009). Biodegradable bags applied 6-9 weeks before harvest effectively prevent infestation, improve fruit quality and deter oviposition (Bilck *et al*., 2011). The studies during last decade have primarily focused on fruit fly biology, seasonal pest occurrence, host plant resistance, attractants, trapping systems, and evaluation of individual botanical or chemical management options (Radhika *et al*., 2023; Mawtham *et al*., 2023; Kaur and Kataria, 2025). Several works have reported the effectiveness of specific botanicals and biorational products against fruit fly infestation in bitter gourd and other cucurbits; however, these studies were generally limited to the evaluation of individual products or a narrow range of treatments. Despite the availability of several eco-friendly management options, comparative field evaluation of different botanicals, Spinosad 45 SC + jaggery and fruit bagging under the agro-climatic conditions of Eastern Uttar Pradesh (India) remains limited. Information on their relative effectiveness and influence on fruit infestation and yield under identical field conditions is inadequate. Therefore, the present study was aimed to evaluate selected some botanical extracts, Spinosad 45 SC + jaggery and fruit bagging against melon fruit fly and to identify effective eco-friendly management options for sustainable bitter gourd production.

MATERIALS AND METHODS

Experimental site and crop

The present study was carried out during two consecutive cropping seasons, i.e., *kharif* seasons of 2024 and 2025, at the Vegetable Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, (India) under open-field conditions. The experimental site is located at 26.47° N latitude and 82.12° E longitude. Bitter gourd (*Momordica charantia*) crop was raised as per the recommended package of agronomic practices prescribed for the region (Thamburaj and Singh, 2001). To ensure the unbiased evaluation of treatment-effects, no insecticidal applications other than the designated experimental treatments were made during the entire cropping period.

Experimental design and treatments

The experiment was laid out in a randomized block design comprising nine treatments with each one replicated three times. Bitter gourd cv. 'Jhalari Long' was grown in plots of 4 m × 3 m size, with plant spacing of 50 cm x 100 cm**.** The treatments consisted of six botanical formulations, namely neem (*Azadirachta indica*) leaf extract (10% w/v), eucalyptus (*Eucalyptus globules*) leaf extract (10% w/v), tulsi (*Ocimum sanctum*) leaf extract (10% w/v), karanja (*Pongamia pinnata*) leaf extract (10% w/v), parthenium (*Parthenium hysterophorus*) leaf extract (10% w/v) and ginger (*Zingiber officinale*) powder extract (10% w/v); one biorational insecticide, Spinosad 45 SC @ 0.3 mL L^{-1} combined with jaggery @ 10 g L^{-1}; one physical control method, namely fruit bagging and an untreated control.

Preparation and application of treatments

Botanical extracts were prepared fresh prior to their application following the aqueous extraction method

described by TNAU Agritech (TNAU, 2024) with slight modifications. Fresh leaves of neem, eucalyptus, tulsi, karanja, and parthenium were collected from the university campus and thoroughly washed under running tap water to remove dust and other impurities. Ginger powder was procured from the local market. For the preparation of 10% (w/v) botanical extracts, 100 g freshly ground leaves and ginger powder were mixed with 1 L water followed by boiling for 30 min. The extracts were then allowed to cool and filtered through a muslin cloth before application. Spinosad 45 SC (Spino45®, Katyayani Organics) was procured from local market and applied at the recommended dose of 0.3 mL L^{-1} water along with jaggery @ 10 g L^{-1} as an attractant. Fruit bagging was done manually by covering young fruits with butter paper bags (15 × 20 cm size) immediately after fruit set to prevent oviposition by melon fruit flies and kept covered until harvest. In untreated control plots, only water was sprayed. The treatments were applied twice using a battery-operated knapsack sprayer. The first spray was done at the initiation of fruiting under uniform fruit fly infestation, whereas the second spray was applied 15 days later.

Observations recorded

Observations on fruit fly infestation were recorded 3, 7, and 10 days after each spray (DAS). The fruits from each plot were examined for fruit fly infestation at each spray, and the number of infested fruits noted. Fruit infestation was calculated using the following formula:

$$\text{Fruit infestation (\%)} = (\text{Number of infested fruits} \div \text{Total number of fruits observed}) \times 100$$

Following the application of treatments, the marketable fruits were harvested from each plot at maturity and weighed using a digital weighing balance. The weight of fruits obtained after the 1st and 2nd sprays were recorded separately and then summed up to determine the total yield $plot^{-1}$, expressed in terms of kg $plot^{-1}$.

Statistical analysis

The percentage data on fruit infestation was subjected to arcsine square root transformation before statistical analysis (Gomez and Gomez, 1984). The transformed data was analysed using analysis of variance (ANOVA) appropriate for a randomized block design. Treatment means were compared using critical difference at 5% level of significance. Data of two years were pooled for final interpretation. The statistical analyses were performed using OPSTAT software, whereas data organization and basic computations were carried out using Microsoft Excel.

RESULTS AND DISCUSSION

Treatment effects in kharif 2024

Significant differences among the treatments were observed in fruit fly infestation on bitter gourd in *kharif* 2024 at all observation intervals, following both sprays (Table 1). Fruit bagging showed lowest mean fruit infestation (6.9%) and proved significantly superior over all other treatments, followed by Spinosad 45 SC + jaggery, which recorded 10.6% infestation. Among the botanical treatments, ginger powder extract (22.59%) and neem leaf extract (23.94%) were more effective than eucalyptus, tulsi and karanja leaf extracts, whereas parthenium leaf extract was least effective and was statistically comparable to the untreated control. The highest fruit infestation (45.83%) was recorded in untreated control plots. The reduction in fruit infestation was reflected in increased fruit yield. Fruit bagging showed highest fruit yield (8.42 kg $plot^{-1}$), followed by Spinosad 45 SC + jaggery (8.15 kg $plot^{-1}$). Among the botanical treatments, ginger powder and neem leaf extracts produced comparatively higher yields than other botanical treatments. The untreated control showed lowest fruit yield (5.06 kg $plot^{-1}$).

Treatment effects in kharif 2025

The application of different treatments during *kharif* 2025 showed trend almost similar to that of 2024 (Table 2). Fruit bagging proved most effective treatment, with lowest mean fruit infestation (7.42%),

Table 1: Effect of different treatments against fruit fly infestation on bitter gourd during *kharif* 2024

Treatments	Fruit infestation after each spray						Overall mean fruit infestation (%)	Yield (kg plot^{-1})
	1st spray			2nd spray				
	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS		
1) Neem (*Azadirachta indica*) leaf extract @ 10% (w/v)	27.26 (31.44)	21.67 (27.68)	30.49 (33.49)	21.82 (27.78)	17.58 (24.76)	20.79 (27.07)	23.94	7.05
2) Eucalyptus (*E. globules*) leaf extract @ 10% (w/v)	30.38 (33.42)	27.74 (31.76)	37.46 (37.68)	26.38 (30.86)	25.84 (30.51)	29.60 (32.93)	29.57	6.35
3) Tulsi (*Ocimum sanctum*) leaf extract @ 10% (w/v)	33.34 (35.24)	26.36 (30.85)	36.64 (37.23)	28.76 (32.39)	22.35 (28.16)	27.86 (31.83)	29.22	6.52
4) Karanja (*Pongamia pinnata*) leaf extract @ 10% (w/v)	26.18 (30.70)	23.32 (28.82)	33.60 (35.37)	21.26 (27.40)	18.18 (25.20)	22.87 (28.51)	24.24	6.88
5) Parthenium (*P. hysterophorus*) leaf extract @ 10% (w/v)	39.81 (39.10)	32.22 (34.51)	41.04 (39.81)	35.78 (36.71)	32.24 (34.56)	38.47 (38.31)	36.59	5.84
6) Ginger (*Zingiber officinale*) powder @ 10% (w/v)	32.79 (34.89)	19.15 (25.85)	25.87 (30.51)	22.54 (28.28)	15.63 (23.19)	19.56 (26.18)	22.59	7.12
7) Spinosad 45 SC + jaggery @ 0.3 mL L^{-1} + 10 g L^{-1}	10.42 (18.75)	10.22 (18.59)	16.78 (24.06)	8.17 (16.45)	8.26 (16.64)	9.77 (18.16)	10.60	8.15
8) Bagging	7.31 (15.60)	7.28 (15.62)	5.73 (13.55)	7.68 (15.99)	6.42 (14.54)	6.98 (15.11)	6.90	8.42
9) Untreated control (water spray)	44.88 (42.04)	46.88 (44.34)	45.96 (42.66)	42.33 (40.57)	54.08 (47.32)	40.82 (39.68)	45.83	5.06
SEm (±)	1.13	1.36	1.74	1.33	1.18	1.27	–	
$CD_{0.05}$	3.40	4.12	5.25	4.03	3.58	3.85	–	

Original (untransformed) mean values are presented, while transformed values are given in parentheses.
* The figures in parentheses show arcsine square root transformed values; DAS - Days after spraying

Table 2: Effect of different treatments on fruit fly infestation in bitter gourd during *kharif* 2025

Treatments	Fruit infestation after each spray						Overall mean fruit infestation (%)	Yield (kg plot^{-1})
	1st spray			2nd spray				
	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS		
1) Neem (*Azadirachta indica*) leaf extract @ 10% (w/v)	26.87 (31.19)	19.63 (26.23)	23.74 (29.13)	25.30 (28.79)	15.24 (22.92)	22.72 (28.42)	22.25	6.79
2) Eucalyptus (*E. globules*) leaf extract @ 10% (w/v)	33.44 (35.29)	30.76 (33.65)	33.40 (35.27)	31.36 (34.15)	28.42 (32.20)	35.48 (36.52)	32.14	6.09
3) Tulsi (*Ocimum sanctum*) leaf extract @ 10% (w/v)	30.14 (33.27)	24.38 (29.52)	28.68 (32.34)	28.60 (32.30)	19.66 (26.26)	29.36 (32.78)	26.80	6.44
4) Karanja (*Pongamia pinnata*) leaf extract @ 10% (w/v)	28.42 (32.19)	20.21 (26.65)	26.36 (30.85)	25.56 (30.34)	16.38 (23.78)	26.15 (30.73)	23.85	6.78
5) Parthenium (*P. hysterophorus*) leaf extract @ 10% (w/v)	36.12 (36.92)	34.55 (35.97)	38.62 (38.40)	36.20 (36.96)	31.52 (34.11)	38.16 (38.13)	35.86	5.62
6) Ginger (*Zingiber officinale*) powder @ 10% (w/v)	32.45 (28.23)	14.76 (22.53)	20.24 (26.70)	22.45 (28.20)	16.64 (24.05)	23.12 (28.70)	21.61	6.90
7) Spinosad 45 SC + jaggery @ 0.3 mL L^{-1} + 10 g L^{-1}	11.32 (19.59)	8.98 (17.30)	12.78 (20.87)	9.36 (17.58)	9.36 (17.69)	8.45 (16.83)	10.04	7.99
8) Bagging	10.65 (18.98)	7.25 (15.54)	5.37 (13.26)	7.75 (16.06)	7.22 (15.47)	6.30 (14.43)	7.42	8.28
9) Untreated control (water spray)	43.94 (41.49)	41.22 (39.92)	46.92 (43.21)	41.23 (39.92)	42.65 (40.75)	42.82 (40.85)	43.13	4.92
SEm (±)	1.04	1.34	1.21	1.44	1.30	1.18	–	
$CD_{0.05}$	3.15	4.06	3.67	4.96	3.92	3.57	–	

Original (untransformed) mean values are presented, while transformed values are given in parentheses.
*Figure in parentheses arcsine transformed value; DAS- Days after spraying

followed by Spinosad 45 SC + jaggery (10.04%) treatment. Among the botanical treatments, ginger powder extract (21.61%) and neem leaf extract (22.25%) were comparatively more effective than other botanicals. In contrast, parthenium leaf extract was least effective treatment and was statistically comparable to the untreated control which recorded the highest fruit infestation (43.13%). The reduction in fruit infestation was accompanied by an increase in fruit yield. Fruit bagging showed the highest fruit yield (8.28 kg plot^{-1}), followed by Spinosad 45 SC + jaggery (7.99 kg plot^{-1}) treatment. The untreated control produced the lowest fruit yield (4.92 kg plot^{-1}).

Pooled mean analysis

The pooled analysis revealed a similar trend in treatment performance across both years (Table 3). Fruit bagging recorded the lowest pooled mean fruit infestation (7.16%) and was significantly superior to all other treatments, followed by Spinosad 45 SC + jaggery (10.32%). Among the botanical treatments, ginger powder extract (22.10%) and neem leaf extract (23.10%) were the most effective, whereas eucalyptus leaf extract (30.87%), tulsi leaf extract (28.01%), and karanja leaf extract (24.04%) exhibited moderate efficacy. Parthenium leaf extract was the least effective treatment and performed similarly to the untreated control, which recorded the highest pooled mean fruit infestation (44.48%). The reduction in fruit infestation was reflected in increased fruit yield. Fruit bagging recorded the highest pooled fruit yield (8.35 kg plot^{-1}), followed by Spinosad 45 SC + jaggery (8.07 kg plot^{-1}), whereas the untreated control produced the lowest yield (4.99 kg plot^{-1}).

Table 3: Pooled mean effect of different treatments on fruit fly infestation in bitter gourd (2024 & 2025)

Treatments	Fruit infestation after each spray						Overall mean fruit infestation (%)	Overall yield (kg plot^{-1})
	1st spray			2nd spray				
	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS		
1) Neem leaf extract @ 10% (w/v)	27.06	20.65	27.12	22.56	16.41	21.76	23.10	6.92
2) Eucalyptus leaf extract @ 10% (w/v)	31.91	29.25	35.43	28.97	27.13	32.54	30.87	6.22
3) Tulsi leaf extract @ 10% (w/v)	31.74	25.37	32.66	28.68	21.01	28.61	28.01	6.48
4) Karanja leaf extract @ 10% (w/v)	27.30	21.77	29.98	23.41	17.28	24.51	24.04	6.83
5) Parthenium leaf extract @ 10% (w/v)	37.97	33.39	39.83	35.99	31.88	38.32	36.23	5.73
6) Ginger powder @ 10% (w/v)	27.62	16.96	23.06	22.50	16.14	21.34	22.10	7.01
7) Spinosad 45 SC + jaggery @ 0.3 mL L^{-1} + 10 g L^{-1}	10.87	9.60	14.78	8.77	8.81	9.11	10.32	8.07
8) Bagging	8.98	7.27	5.55	7.72	6.82	6.64	7.16	8.35
9) Untreated control (water spray)	44.41	45.05	46.44	41.78	48.37	41.82	44.48	4.99
SEm (±)	0.64	1.03	1.06	1.24	0.99	1.14	-	-
$CD_{0.05}$	1.81	3.09	3.17	3.71	2.96	3.43	-	-

DAS - Days after spray

The present study, conducted over two consecutive seasons (*Kharif* 2024 and 2025), demonstrated the effectiveness of eco-friendly management practices in reducing fruit fly infestation in bitter gourd under field conditions. Across both seasons, fruit bagging consistently recorded the lowest fruit infestation and the highest fruit yield, followed by Spinosad 45 SC + jaggery, indicating the consistent effectiveness of these treatments under varying seasonal conditions. The superior performance of fruit bagging observed in the present study is in close agreement with earlier reports revealing that physical exclusion of fruits effectively prevents oviposition by melon fruit fly, thereby

minimizes the larval establishment and fruit damage (Amin *et al*., 2008; Mondal *et al*., 2015; Sarkar *et al*., 2018). Acting as a mechanical barrier, fruit bagging restricts the access of gravid females to host fruits, which explains the consistently low infestation levels recorded across both years.

Spinosad 45 SC applied in combination with jaggery emerged as the second most effective treatment and proved superior to all botanical treatments. Its efficacy may be attributed to its ingestion toxicity coupled with the attractant effect of jaggery, which enhances adult exposure to the insecticide. These findings corroborate earlier reports on the effectiveness of Spinosad against *Zeugodacus cucurbitae* on bitter gourd and other cucurbit crops (Bhowmik *et al*., 2014). Among the botanical treatments, ginger powder extract and neem leaf extract were comparatively more effective than the other botanicals. Similar findings were reported by Sultana *et al*. (2020), who observed that ginger extract recorded the lowest fruit fly infestation, while neem extract significantly reduced infestation and improved cucumber yield under field conditions. The effectiveness of neem-based products supports previous findings that neem derivatives possess oviposition-deterrent, antifeedant, and growth-regulating properties against melon fruit fly, primarily due to bioactive compounds such as azadirachtin (Khattak *et al*., 2009). However, their limited persistence under field conditions may restrict complete control. The comparatively better performance of ginger powder may be attributed to the presence of bioactive compounds such as gingerols and shogaols, which exhibit repellent and insecticidal properties (Ali *et al*., 2023).

Botanical treatments, however, were consistently less effective than fruit bagging and Spinosad, supporting earlier reports that botanicals generally provide partial suppression rather than complete control of fruit fly populations (Hossain and Khalequzzaman, 2018). Parthenium leaf extract remained the least effective botanical treatment and was statistically comparable to the untreated control during both seasons, possibly due to the poor persistence and rapid degradation of its active compounds under field conditions (Datta and Saxena, 2001).

Overall, the findings demonstrated that fruit bagging and Spinosad 45 SC + jaggery were the most effective treatments for reducing fruit fly infestation and improving bitter gourd yield under field conditions. While fruit bagging provided the highest level of protection through the physical exclusion of ovipositing females, Spinosad 45 SC + jaggery effectively suppressed fruit fly populations through its insecticidal and attractant properties. Although the botanical treatments did not provide complete control, their moderate efficacy suggests their potential usefulness as eco-friendly alternatives for reducing dependence on synthetic insecticides and promoting sustainable fruit fly management. Similar observations were reported by Ganie *et al*. (2022), who emphasized the role of botanicals as supportive components in integrated pest management programmes

Conclusion: The study revealed that fruit bagging was most effective eco-friendly method to manage fruit fly infestation in bitter gourd, followed by Spinosad 45 SC + jaggery. Both treatments consistently reduced fruit infestation and enhanced yield across the two cropping seasons. Among the botanical treatments, ginger powder extract and neem leaf extract were comparatively more effective than the other botanicals and provided moderate suppression of fruit fly infestation. The results indicate that fruit bagging and Spinosad 45 SC + jaggery are promising eco-friendly options for reducing fruit fly infestation and improving bitter gourd yield under field conditions. Although the botanical treatments did not provide complete control, their moderate efficacy suggests their potential usefulness in reducing dependence on synthetic insecticides and promoting sustainable fruit fly management.

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