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Evaluation of different botanicals against flower buds damage by Chilli gall midge (*Asphondylia capsici*)

Kiran Ghatage, MH Tatagar, Nagesh, Gurav SG and Dileepkumar A Masuthi

Abstract
The gall midge mainly infests the flower buds and fruits that lead to the deformation of flower buds and fruits resulting in severe flower bud drop, decreasing in fruit size, seed number and finally reduction in yield. Therefore, it is an essential to develop pest management strategies by incorporating various IPM components such as use of organic amendments and botanicals. Among the various botanical management practices against chilli gall midge, in case of flower bud damage T_{11} (T_1+spray with profenofos 50 EC @ 2 ml/l) registered its superiority over rest of treatments. The next best treatment is T_8 (T_1+spray with NSKE 5% @ 100 g/l) and T_5 (T_1+spray with ginger 10% @ 100 g/l). However, T_3 (T_1+spray with parthenium 10% @ 100 g/l) shows less effectiveness and significantly superior over untreated control. The highest benefit cost ratio recorded in T_8 (T_1+Spray with NSKE 5% @ 50 g/l) with B:C ratio of 2.83 followed by T_{11} (T_1+Spray with profenofos 50 EC @ 2 ml/l), T_6 (T_1+Spray with Tulsi leaf extract @ 10%), T_3 (T_1+Spray with parthenium leaf extract @ 10%), T_2 (T_1+Spray with Pongamia oil @ 2%), T_1 (Application of Neem cake at 2.5 q/acre), T_4 (T_1+Spray with Garlic extract @ 10%), T_5 (T_1+Spray with Ginger extract @ 10%), T_9 (T_1+Spray with Lemon grass oil @ 10%), T_7 (T_1+Spray with Neem oil @ 3%), T_{10} (T_1+Spray with Citronella oil @ 10%) with benefit cost ratio of 2.69, 2.66, 2.55, 2.54, 2.53, 2.21, 2.10, 1.91, 1.89 and 1.84 respectively.

Keywords: Management, gall, neem oil, citronella oil, botanicals

Introduction
Chilli (*Capsicum annum*) is a most diverse vegetable species and is considered to be high value crop. Which belongs to genus Capsicum, family Solanaceae with chromosome number 2n=24.

India is one of the major chilli producing country in the world which shares 25-26% of dry chilli production and occupies an area of 8.31 lakh with production of 18.72 lakh mt and productivity is 2.25 mt per ha in India.

The major chilli growing states includes Andra Pradesh (49%), Maharashtra (26%), Karnataka (15%), West Bengal (12%) and Tamil Nadu (3%) consisting nearly 75% of total area and production and Andhra Pradesh is the major growing state where area under chilli is 2.06 lakh ha with the production of 8.83 lakh ha under Byadagi variety and other chilli cultivars producing 1.03 lakh MT (Anon, 2017).

Byadagi chilli is one of the most important cultivated farmers variety which is mainly grown in different parts of Karnataka *viz.*, Haveri, Dharwad, Gadag.. The name Byadagi comes after a town of Byadagi District. The business of Byadagi chilli has 2nd largest turnover among all chilli variety of India.

Chilli blossom midge *(A capsici)* is a serious pest on chilli crop in Maharashtra, Madhya Pradesh, Karnataka, Tamil Nadu and Andhra Pradesh. The extent of loss ranges from 16.3 to 64 per cent (Basavaraj *et al*., 2011) [4].

The gall midge mainly infests the flower buds and fruits that leads to the deformation of flower buds and fruits resulting in severe flower bud drop, decreasing in fruit size, seed number and finally reduction in yield.

Therefore, it is an essential to develop pest management strategies by incorporating various IPM components such as use of organic amendments and botanicals. Keeping these points in view, detail investigations were undertaken.

Materials and Method
The experiment was laid out in a randomized block design with three replications and twelve

treatments (Table-1) at HRES, Devihosur during *Kharif* season 2018. The seedlings were raised in nursery bed. Same was used for transplanting during 8 July 2018 with the spacing of 60 x 60 cm with the plot size of 17.28 m^2. In each plot ten plants were selected randomly and tagged and observations were recorded on one day before spray and 3, 5, 7 and 11 days after imposition of treatments and all these spray were given at 15 day interval.

Total number of flower buds and total number of deformed flower buds per plant were recorded, and the total dry chilli yield/plot was recorded. However, before flowering need based spray of profenofos 50EC @ 2 ml/l and imidacloprid 17.8SL @ 0.25 ml/l was taken to manage thrips, mites and cut worm. The percentage of galled flower bud was computed by following formulas.

$$\text{Per cent damage} = \frac{\text{No of deformed flower buds per plant}}{\text{Total no flower buds per plant}} \text{ X } 100$$

The mean (%) over control and% increase in yield over control were calculated by using following formula.

$$\text{Reduction over UTC (\%)} = \frac{\text{Control} - \text{Treatment}}{\text{Control}} \text{ X } 100$$

$$\text{Increase in yield (\%)} = \frac{\text{Treatment} - \text{Control}}{\text{Treatment}} \text{ X } 100$$

Results and Discussion

Management of chilli gall midge through botanicals

The experiment was conducted at Horticulture Research and Extension Station (HRES), Haveri (Devihosur), Karnataka during *kharif* 2018-19. Byadagi dabbi 35 days old seedlings were transplanted to main field on 8th July 2018 and 3 sprays were taken at 15 days intervals against gall midge and result are elaborated as follows.

Efficacy of botanical treatments against chilli gall midge for flower bud damage during first spray

The observation recorded a day before spray and 3, 5, 7 and 11 days after first spray presented in Table 4 revealed that, before taking up first spray, there was no significant difference among treatments in incidence of gall midge on flower bud of chilli and mean per cent of flower bud damage ranged from 22.98 to 35.39 (Table 2)

Efficacy of botanical treatments against chilli gall midge for flower bud damage during first spray at 3 DAS

The observation recorded and data presented in Table-4 revealed that, 3 day after spray, among various botanical treatments, T_8 (T_1+Spray with NSKE 50g/l) recorded lowest (23.33%) flower bud damage which was on par with T_{11} (T_1+Spray with profenophos 50EC @ 2 ml/l) (23.78%), T_5 (T_1+Spray with ginger extract 10% @ 100 g/l) (24.20%), T_4 (T_1+Spray with garlic extract 10% @ 100 g/l) (24.85%), T_2 (T_1+Spray with pongamia oil 2% @ 20 ml/l) (27.09%), T_1 (Application of neem cake @ 2.5 q/ha) (29.02%) and T_9 (T_1+Spray with lemon grass oil 10% @ 100 ml/l) (30.05%) and found significantly superior to other treatments *viz*., T_6 (T_1+Spray with tulsi leaf extract 10% @ 100 g/l) (31.51%), T_{10} (T_1+Spray with citronella oil 10% @ 100 ml/l) (31.86%), T_3 (T_1+Spray with neem oil 3% @ 30 ml/l) (33.00%) and T_{12} (control) (36.63%) (Table 2).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during first spray at 5 DAS

The observation recorded and data presented in Table-4 revealed that, 5 day after spray, among various botanical treatments, incidence of gall midge was found significantly lowest in T_{11} (25.02%) which was on par with T_8 (26.79%), T_5 (26.97%), T_4 (27.36%), T_9 (29.91%), T_6 (30.04%), T_2 (30.39%), T_{10} (30.34%), T_1 (31.97%) and found significantly superior to T_7 (33.43%), T_{12} (38.03%) and T_3 (39.52%) (Table 2).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during first spray at 7 DAS

The observation recorded and data presented in Table-4 revealed that, 7 day after spray, among various botanical treatments, T_{11} (26.28%) showed lowest bud damage which was on par with T_8 (27.74%), T_2 (28.43%), T_4 (29.25%), T_1 (29.53%), T_5 (29.63%), T_{10} (31.11%) and T_9 (31.51%) and found significantly superior to T_7 (35.69%), T_3 (36.33%), T_6 (36.45%) and T_{12} (42.10%) (Table 2).

Efficacy of various botanicals against chilli gall midge for flower bud damage during first spray at 11 DAS

The observation recorded and data presented in Table-4 revealed that, 11 day after spray, among various botanical treatments, incidence of gall midge was found significantly lowest in T_{11} recorded the least per cent flower bud damage (27.61%) which was on par with T_5 (29.66%), T_8 (30.57%), T_4 (30.63%), T_{10} (31.01%), T_2 (31.32%), T_9 (31.25%), T_1 (32.90%), T_6 (33.92%), T_7 (34.74%), T_3 (35.33%) and found significantly superior to untreated control T_{12} (45.67%) (Table 2).

Mean efficacy of botanical treatments during first spray against gall midge for flower bud damage indicated that T_{11} (25.67%) recorded least flower bud damage with highest per cent reduction (36.78%) in flower bud damage over untreated control. The next best treatment is T_8 (27.11%) which was statistically on par with T_5 (27.62%), T_4 (28.02%), T_2 (29.31%), T_1 (30.86%), T_9 (30.68%), T_{10} (31.08%), T_6 (32.98%) and found significantly superior over T_7 (34.27%), T_3 (36.05%) and T_{12} (40.61%) and found inferior to T_{11} (25.67%) and significantly superior to untreated control T_{12} (40.61%) and lowest per cent reduction of flower bud damage over untreated control recorded in T_3 (11.22%) (Table 2).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during second spray

The spray was imposed at 15 days after first spray and before taking up second spray, there was no significant difference among treatments in incidence of gall midge on flower bud of chilli and mean per cent of flower bud damage ranged from 32.81 to 45.58 per cent (Table 3).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during second spray at 3 DAS

In subsequent observation during 3 day after second spray same trend was noticed as that of previous spray. The per cent occurrence of flower bud damage was found lowest in T_{11} (23.33%) which was statistically superior to all other treatments and the next best treatment is T_8 (30.67%) which was on par with T_{10} (33.33%), T_4 (34.54%), T_5 (35.02%), T_6

(35.34%), T_1 (36.30%), T_7 (37.68%), T_2 (37.95%), T_3 (38.96%) and T_{12} (47.54%) (Table 3).

Efficacy of botanicals against chilli gall midge for flower bud damage during second spray at 5 DAS

At 5 DAS, the incidence of flower damage was found significantly lowest in T_5 (33.29%) which was on par with T_4 (34.29%), T_7 (35.16%), T_8 (35.54%), T_9 (35.76%), T_6 (36.25%), T_1 (36.96%), T_{11} (37.02%) and found significantly superior to T_2 (42.25%), T_{10} (43.37%), T_3 (44.29%) and T_{12} (49.02%) (Table 3).

Efficacy of botanicals against chilli gall midge for flower bud damage during second spray at 7 DAS

At 7 DAS, significant difference was noticed among the various treatments and T_5 recorded least per cent of flower bud damage (32.38%) which was statistically on par with T_4 (32.93%), T_7 (32.86%), T_9 (36.36%), T_8 (34.05%), T_{11} (34.09%), T_1 (35.31%) and T_6 (36.09%) and found significantly superior to T_2 (40.42%), T_3 (44.69%) and T_{12} (50.98%) (Table 3).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during second spray at 11 DAS

The observation recorded and data presented in table 5 revealed that, 11 day after spray, among various botanical treatments,T_{11} recorded least per cent of flower bud damage (31.54%) which was statistically on par with T_8 (32.27%), T_4 (32.90%), T_5 (33.60%), T_7 (32.63%), T_1 (35.46%) and T_9 (37.02%) and found significantly superior to T_{10} (40.90%), T_2 (40.60%), T_3 (46.31%) and T_{12} (50.83%) (Table 3).

Mean efficacy of botanical treatments during second spray against gall midge for flower bud damage indicated that T_{11} (31.50%) recorded least flower bud damage with highest per cent reduction (36.47%) in flower bud damage over untreated control. The next best treatment is T_8 (T_1+spray with NSKE 5% @ 50 g/l) (33.13%) which was statistically on par with T_4 (33.66%), T_5 (33.57%), T_7 (34.58%), T_1 (36.01%), T_6 (36.85%), T_9 (36.82%) and found significantly superior over T_{10} (39.08%), T_2 (39.42%), T_3 (41.28%) and T_{12} (44.76%) and found inferior to T_{11} (31.50%). Treatment T_{12} recorded highest per cent flower bud damage (49.59%) and Treatment T_3 recorded lowest per cent reduction in flower bud damage (12.15%) (Table 3).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during third spray

The spray was imposed at 15 day after second spray and before taking up second spray, there was no significant difference among treatments in incidence gall midge on flower bud of chilli and mean per cent of flower bud damage ranged from 18.07 to 25.57 per cent (Table 4).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during third spray at 3 DAS

In subsequent observation during 3 day of third spray same trend was noticed as that of previous spray. The per cent occurrence of flower bud damage was found lowest in T_{11} (10.67%) which was on par with T_5 (15.15%) and T_8 (15.63%) and found significantly superior to T_4 (17.79%), T_7 (18.87%), T_9 (19.13%), T_2 (20.53%), T_{10} (20.78%), T_6 (21.08%), T_1 (21.98%), T_{12} (22.90%) and T_3 (26.70%) (Table 4).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during third spray at 5 DAS

The observation recorded and data presented in Table-6 revealed that, 5 day after spray, among various botanical treatments,T_{11} recorded least per cent of flower bud damage (13.73%) which was on par with T_8 (16.26%), T_4 (18.25%), T_9 (18.48%) and T_7 (18.73%), and found significantly superior to T_5 (19.70%), T_6 (20.66%), T_2 (20.84%), T_{10} (22.64%) T_3 (22.98%), T_1 (25.18%) and T_{12} (26.33%) (Table 4).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during third spray at 7 DAS

The observation recorded and data presented in Table-6 revealed that, 7 day after spray, among various botanical treatments,T_{11} recorded least per cent of flower bud damage (13.50%) which was statistically on par with T_8 (17.43%), T_5 (17.83%), T_7 (18.48%), T_9 (19.15%) and T_4 (19.26%) and found significantly superior to T_6 (20.14%), T_2 (22.36%), T_{10} (22.62%), T_1 (23.08%), T_3 (23.37%) and T_{12} (24.89%) (Table 4).

Efficacy of botanical treatments against chilli gall midge for flower bud damage during third spray at 11 DAS

The observation recorded and data presented in Table-6 revealed that, 11 day after spray, among various botanical treatments,T_{11} recorded least per cent of flower bud damage (13.50%) which was statistically superior to all other treatments and significantly differ with T_8 (18.64%), T_5 (19.43%), T_7 (19.83%), T_9 (19.86%), T_4 (20.17%), T_6 (21.38%), T_{10} (23.48%), T_2 (23.60%), T_3 (25.43%), T_1 (25.45%) and T_{12} (27.00%) (Table 4).

Mean efficacy of botanical treatments during third spray against gall midge for flower bud damage indicated that T_{11} (12.85%) recorded least flower bud damage with highest per cent reduction (49.17%) in flower bud damage over untreated control. The next best treatment is T_8 (T_1+Spray with NSKE 5% @ 50 g/l) (32.80%) which was statistically on par with T_5 (18.03%), T_4 (18.91%), T_7 (18.98%), T_9 (19.15%), T_6 (20.81%), T_2 (21.83%), T_{10} (22.38%), T_1 (23.92%), T_3 (24.62%) and T_{12} (25.28%) and found inferior to T_{11} (12.85%). Highest per cent flower bud damage recorded in untreated control (25.28%) and low per cent reduction in flower bud damage over untreated control recorded in T_3 (2.61%) (Table 4).

Efficacy of different botanical treatments against chilli gall midge for flower bud damage during 2018-19

The observation recorded and data presented in Table-10 revealed, among various botanical treatments, after three sprays it was found that T_{11} (T_1+Spray with profenofos 50EC @ 2 ml/l) recorded lowest (12.85%) flower bud damage and these findings are due to it exhibits ovicide cum adulticide, fast knock down action with long residual activity and less waiting period between last spray and harvest. Hence the incidence of gall midge on flower bud less in chilli. The present results are in agreement with Archana (2011) [3] reported that the effectiveness of profenofos 50EC on gall midge and recorded 8.59 per cent of gall midge damage. The next best treatment is T_8 (T_1+ Spray with NSKE 5% @ 50 g/l) (16.99%) in controlling the flower bud damage and these findings are due it act as antifeedant, growth regulatant, repellent and direct effect on mortality factor against gall midge. The present results are in agreement with Omara *et al*

(1996) [17] recorded the effectiveness of ANSKP @ 4% reduced the number of *Liriomyza congest* by 79.48% and *Aphis craccivora* by 52.39% in 1993-1994 respectively. Krishnakumar *et al* 2010 [10], reported that management of gall midge, *Asphondylia capsici* on chilli and brinjal with application of neem cake followed by spray with NSKE 4% as most effective treatment. Chandrashekaran *et al* (1998) reported that, achook 1.5 per cent recorded 72.9 per cent reduction of thrips population followed by neem oil 5 per cent (60.1%). Veena *et al.* (2018) [21] reported that crop planting with Neem cake (250 kg/ha) and vermicompost (1t/ha) were effective in suppression of gall midge infesting chilli crop, as comparable to recommended insecticides. Pongamia cake (250kg/ha) was next in the order of effectiveness. Shivaramu (1999) [18] reported effectiveness of neem oil @ 5 ml/l, NSKE 5% and achook @ 5 ml/l recorded 12.99, 9.77, and 96 per cent of fruit damage. Singh *et al* (1999) [19] observed the effectiveness of garlic, neem, and tagak-tagak (*Rhinocanthus nusuta*) on chilli against aphids, neem extract @ 5000 ppm recorded low aphid population as compared with unsprayed control, malathion. Which was significantly differ with T_5 (18.03%), T_4 (18.91%), T_7 (18.98%), T_9 (19.15%), T_6 (20.81%), T_2 (21.83%), T_{10} (22.38%), T_1 (23.92%) and T_{12} (38.49%) flower bud damage. The present results are in agreement with Vijayalakshmi *et al* (1996) [20] indicated that application of garlic extract in combination with cow urine, chilli, neem, ginger with soap solution was effective against *S.litura* and *H.armigera* up to 13 days of spray. Fathima *et al* (2015) reported that application of red chilli and garlic extract reduced the mite population and also helps to increase the yield. Whereas effectiveness of T_7 (T_1+spray with neem oil 3% @ 30ml/l) is in conformity with reports of Ahmed *et al* (2001) [1] reported that the application of neem oil at 5ml/l that helps to reduced chilli mite populations to 34.28 per cent over control. Kumar *et al* (2017) [11] reported that treatment with application of NSKE, neem oil and garlic sap extract 53.03, 55.64 and 50.03 per cent reduction in thrips population respectively. Whereas, effectiveness of T_2 (T_1+Spray with pongamia oil 2% @ 20 ml/l) is in conformity with the reports of Meena and Tayde (2017) [15] reported use of imidacloprid, neem oil, pongamia oil, NSKE and garlic sap extract registered 67.58, 53.03, 55.4, and 50.03 per cent and reduction in thrips population. Whereas T_1 (application of neem cake 2.5 q/ha) is in conformity with results of Chandramani (2010) [6], reported application of FYM + neem cake in splits significantly reduced the incidence of gall former (66.81%). Treatment, T_3 (24.62%) showed least effective in controlling the flower bud damage but found superior to the untreated control (30.12%) and this is close agreement with Mallapur and Lingappa (2005) [13] observed that the application of parthenium extract, cowurine and nimbecidine were moderate efficacy against the pest of chilli. The per cent reduction in gall midge over untreated control recorded highest in T_{11} (66.61%) and T_8 (55.85%). Lowest per cent reduction recorded in T_3 (36.03%) over untreated control. Remaining treatment *viz.*, T_5 (53.15%), T_4 (50.87%), T_7 (50.68%), T_9 (50.28%), T_6 (45.93%), T_2 (43.28%), T_{10} (41.85%) and T_1 (37.85%) indicated moderate per cent reduction in gall midge over untreated control (Table-8 and Fig-1).

Fruit yield (q/ha)

Based on the observations recorded on dry chilli yield and presented in Table-11, it was found that, significant difference was recorded and it ranged from 4.29 q/ha to 7.44 q/ha. Among various treatments, T_8 (T_1+ Spray with NSK 5% @ 50 g/l) recorded maximum yield in (7.44 q/ha) and these results are in conformity with Gasukar (2011) reported NCE (5%) or NO (1%) recorded highest chilli yield. Ogan and Ogbodo (2012) reported that application of NSKE could help in management of African rice gall midge and also increase yield without the disruption of agro-ecosystem, followed T_7 (T_1+ Spray with Neem oil 3% @ 30 ml/l) (7.38 q/ha) which is followed by T_{11} (7.19 q/ha), T_2 (7.14 q/ha), T_4 (7.04 q/ha), T_9 (6.90 q/ha), T_{10} (6.76 q/ha), T_6 (6.75q/ha), T_5 (6.74 q/ha), T_1 (6.59 q/ha), T_3 (6.48 q/ha) and it was lowest in untreated control T_{12} (4.29 q/ha) (Table 9 and Fig 3). Similarly, treatment T_8 (T_1+Spray with NSKE 5% @ 50 g/l) recorded significantly highest per cent increase in yield over untreated control 42.33 per cent which was followed by treatments T_7 (41.86%), T_{11} (40.33%), T_2 (39.91%), T_4 (39.06%), T_9 (37.82%), T_{10} (36.53%), T_6 (36.44%), T_5 (36.35%), T_1 (34.90%) and T_3 (33.79%) yield increase over control (Table 9).

Economics of various botanical treatments for the management of chilli gall midge during 2018-19

The observation recorded and data presented in Table-12 revealed that, among various botanical treatments, highest net return recorded in treatment T_8 (T_1+ Spray with NSK 5% @ 50g/l) (Rs. 72298/h) in comparison to all other treatments *viz.*, T_{11} (T_1+Spray with Profenofos 50 EC @ 2 ml/l) (Rs. 67850/h), T_2 (T_1+Spray with Pongamia oil @ 2%) (Rs. 65160/h), T_6 (T_1+Spray with Tulsi leaf extract @ 10%) (Rs. 63400/h), T_1 (Application of Neem cake at 2.5 q/acre) (Rs. 59787/h), T_3 (T_1+Spray with Parthenium leaf extract @ 10%) (Rs. 59200/h), T_4 (T_1+Spray with Garlic extract @ 10%) (Rs. 57934/h), T_5 (T_1+Spray with Ginger extract @ 10%) (Rs. 54736/h), T_7 (T_1+ Spray with Neem oil @ 3%) (Rs. 52296/h), T_9 (T_1+ Spray with Lemon grass oil @ 10%) (Rs. 49455/h), T_{10} (T_1+ Spray with Citronella oil @ 10%) (Rs. 46458/h) and untreated control (Rs. 29350/h).

The highest benefit cost ratio recorded in T_8 (T_1+Spray with NSKE 5% @ 50 g/l) with B:C ratio of 2.83 followed by T_{11} (T_1+Spray with profenofos 50 EC @ 2 ml/l), T_6 (T_1+Spray with Tulsi leaf extract @ 10%), T_3 (T_1+Spray with parthenium leaf extract @ 10%), T_2 (T_1+Spray with Pongamia oil @ 2%), T_1 (Application of Neem cake at 2.5 q/acre), T_4 (T_1+Spray with Garlic extract @ 10%), T_5 (T_1+Spray with Ginger extract @ 10%), T_9 (T_1+Spray with Lemon grass oil @ 10%), T_7 (T_1+Spray with Neem oil @ 3%), T_{10} (T_1+Spray with Citronella oil @ 10%) with benefit cost ratio of 2.69, 2.66, 2.55, 2.54, 2.53, 2.21, 2.10, 1.91, 1.89 and 1.84 respectively (Table 10).

Table 1: Treatment details

Sl. No	Treatments
T_1	Application of Neem cake at 2.5 q/ha
T_2	T_1+ Spray with Pongamia oil @ 2%
T_3	T_1+ Spray with Parthenium leaf extract @ 10%
T_4	T_1+ Spray with Garlic extract @ 10%
T_5	T_1+Spray with Ginger extract @ 10%
T_6	T_1+ Spray with Tulsi leaf extract @ 10%
T_7	T_1+ Spray with Neem oil @ 3%
T_8	T_1+ Spray with NSKE @ 5%
T_9	T_1+ Spray with Lemon grass oil @ 10%
T_{10}	T_1+ Spray with Citronella oil @ 10%
T_{11}	T_1+ Spray with Profenofos 50 EC @ 2 ml/l
T_{12}	Control

Table 2: Efficacy of different treatments against chilli gall midge for flower bud damage after first spray during *Kharif* 2018-19

Treatment No.	Treatment details	Dosage	1 DBS	Flower bud damage (%)					
				3 DAS	5 DAS	7 DAS	11 DAS	Mean	Reduction in gall midge over UTC (%)
T_1	Application of Neem cake	2.5 q/ha	29.02 (32.36)	29.02 (32.36)^{abcde}	31.97 (34.04)^{abcd}	29.53 (32.68)^{bcd}	32.90 (34.72)^{b}	30.86 (33.46)^{bcd}	24.00
T_2	T_1+ Spray with Pongamia oil @ 2%	2.5 q/ha+ 20 ml/l	28.75 (32.06)	27.09 (31.22)^{bcde}	30.39 (33.22)^{bcd}	28.43 (31.97)^{bcd}	31.32 (33.86)^{b}	29.31 (32.58)^{bcd}	27.82
T_3	T_1+ Spray with Parthenium leaf extract @ 10%	2.5 q/ha+100 g/l	32.07 (32.06)	33.00 (35.04)^{ab}	39.52 (38.94)^{a}	36.33 (37.06)^{ab}	35.33 (36.47)^{b}	36.05 (36.89)^{ab}	11.22
T_4	T_1+ Spray with Garlic extract @ 10%	2.5 q/ha+100 g/l	22.98 (29.00)	24.85 (29.88)^{cde}	27.36 (31.41)^{cd}	29.25 (32.68)^{bcd}	30.63 (33.51)^{b}	28.02 (31.90)^{cd}	31.00
T_5	T_1+Spray with Ginger extract @ 10%	2.5 q/ha+100 g/l	24.78 (29.79)	24.20 (29.42)^{de}	26.97 (31.19)^{cd}	29.63 (32.84)^{bcd}	29.66 (32.89)^{b}	27.62 (31.61)^{cd}	31.98
T_6	T_1+ Spray with Tulsi leaf extract @ 10%	2.5 q/ha+100 g/l	31.65 (34.14)	31.51 (34.06)^{abcd}	30.04 (33.16)^{bcd}	36.45 (37.00)^{abc}	33.92 (35.60)^{b}	32.98 (35.01)^{abc}	18.78
T_7	T_1+ Spray with Neem oil @ 3%	2.5 q/ha+30 ml/l	33.24 (35.18)	33.24 (35.18)^{ab}	33.43 (35.29)^{abc}	35.69 (36.65)^{abc}	34.74 (36.10)^{b}	34.27 (35.82)^{abc}	15.61
T_8	T_1+ Spray with NSKE @ 5%	2.5 q/ha+50 g/l	23.33 (28.85)	23.33 (28.85)^{e}	26.79 (31.1)^{cd}	27.74 (31.62)^{cd}	30.57 (33.48)^{b}	27.11 (31.29)^{cd}	33.24
T_9	T_1+ Spray with Lemon grass oil @ 10%	2.5 q/ha+100 ml/l	30.05 (33.19)	30.05 (33.19)^{abcde}	29.91 (33.1)^{bcd}	31.51 (34.13)^{bcd}	31.25 (33.96)^{b}	30.68 (33.60)^{bcd}	24.45
T_{10}	T_1+ Spray with Citronella oil @ 10%	2.5 q/ha+100 ml/l	35.39 (36.47)	31.86 (34.27)^{abc}	30.34 (33.31)^{bcd}	31.11 (33.77)^{bcd}	31.01 (33.72)^{b}	31.08 (33.77)^{bcd}	23.46
T_{11}	T_1+Spray with Profenofos 50 EC @ 2ml/l	2.5 q/ha+2 ml/l	23.78 (29.03)	23.78 (29.03)^{e}	25.02 (29.81)^{d}	26.28 (30.65)^{d}	27.61 (31.49)^{b}	25.67 (30.26)^{d}	36.78
T_{12}	Control	–	30.12 (33.19)	36.63 (37.19)^{a}	38.03 (38.02)^{ab}	42.10 (40.43)^{a}	45.67 (42.50)^{a}	40.61 (39.55)^{a}	–
S.Em±			-	1.65	1.79	1.83	1.80	1.59	
CD at 5%			NS	4.84	5.25	5.38	5.29	4.69	
CV (%)			11.27	8.80	9.24	9.28	8.96	8.19	

* Figures in the parentheses are arc sin transformed values
* Figures with same alphabetical superscript are statistically non-significant

Table 3: Efficacy of different treatments against chilli gall midge for flower bud damage after second spray during *Kharif* 2018-19

Treatment No.	Treatments details	Dosage	1 DBS	Flower bud damage (%)					
				3 DAS	5 DAS	7 DAS	11 DAS	Mean	Reduction in gall midge over UTC (%)
T_1	Application of Neem cake	2.5 q/ha	36.43 (37.09)	36.30 (37.01)^{b}	36.96 (37.40)^{cd}	35.31 (36.43)^{cde}	35.46 (36.49)^{cd}	36.01 (36.83)^{cd}	27.38
T_2	T_1+ Spray with Pongamia oil @ 2%	2.5 q/ha+ 20 ml/l	41.77 (40.25)	37.95 (37.99)^{b}	42.45 (40.64)^{bc}	40.42 (39.46)^{bcd}	40.60 (39.56)^{b}	40.35 (39.42)^{bc}	18.63
T_3	T_1+ Spray with Parthenium leaf extract @ 10%	2.5 q/ha+100 g/l	45.58 (42.45)	38.96 (38.58)^{ab}	44.29 (41.69)^{ab}	44.69 (41.93)^{ab}	46.31 (39.56)^{a}	43.56 (41.28)^{ab}	12.15
T_4	T_1+ Spray with Garlic extract @ 10%	2.5 q/ha+100 g/l	32.81 (34.73)	34.54 (35.75)^{b}	34.29 (35.64)^{d}	32.93 (34.85)^{e}	32.90 (34.86)^{cd}	33.66 (35.28)^{d}	32.12
T_5	T_1+ Spray with Ginger extract @ 10%	2.5 q/ha+100 g/l	35.02 (36.19)	35.02 (36.19)^{b}	33.29 (35.16)^{d}	32.38 (34.61)^{e}	33.60 (35.28)^{cd}	33.57 (35.31)^{d}	32.30
T_6	T_1+ Spray with Tulsi leaf extract @ 10%	2.5 q/ha+100 g/l	35.62 (36.62)	35.34 (36.45)^{b}	36.25 (36.99)^{cd}	36.09 (36.91)^{cde}	36.36 (37.05)^{bcd}	36.01 (36.85)^{cd}	27.39
T_7	T_1+ Spray with Neem oil @ 3%	2.5 q/ha+30 ml/l	36.57 (37.09)	37.68 (37.80)^{b}	35.16 (36.29)^{d}	32.86 (34.91)^{e}	32.63 (34.74)^{cd}	34.58 (35.94)^{cd}	30.26
T_8	T_1+ Spray with NSKE @ 5%	2.5 q/ha+50 g/l	37.67 (37.85)	30.67 (33.61)^{bc}	35.54 (36.57)^{d}	34.05 (35.65)^{de}	32.27 (34.58)^{cd}	33.13 (35.11)^{d}	33.19
T_9	T_1+ Spray with Lemon grass oil @ 10%	2.5 q/ha+100 ml/l	37.80 (37.91)	38.13 (38.11)^{ab}	35.76 (36.70)^{d}	36.36 (34.91)^{cde}	37.02 (37.47)^{bc}	36.82 (37.34)^{cd}	25.76
T_{10}	T_1+ Spray with Citronella oil @ 10%	2.5 q/ha+100 ml/l	43.42 (41.20)	33.33 (35.26)^{b}	43.37 (41.16)^{ab}	41.51 (40.08)^{bc}	40.90 (39.72)^{b}	39.78 (39.08)^{bc}	19.78
T_{11}	T_1+Spray with Profenofos 50 EC @ 2 ml/l	2.5 q/ha+2 ml/l	40.39 (39.37)	23.33 (28.87)^{c}	37.02 (37.40)^{cd}	34.09 (35.66)^{de}	31.54 (34.09)^{d}	31.50 (34.08)^{d}	36.47
T_{12}	Control	–	42.47 (40.65)	47.54 (43.57)^{a}	49.02 (44.43)^{a}	50.98 (45.56)^{a}	50.83 (45.48)^{a}	49.59 (44.76)^{a}	–
S.Em±			_	1.87	1.27	1.44	1.04	1.21	
CD at 5%			NS	5.49	3.72	4.25	3.06	3.57	
CV (%)			7.12	8.86	5.73	6.64	4.80	5.61	

* Figures in the parentheses are arc sin transformed values
* Figures with same alphabetical superscript are statistically non-significant

Table 4: Efficacy of different treatments against chilli gall midge for flower bud damage after third spray during *Kharif* 2018-19

Treatment No.	Treatments details	Dosage	1 DBS	Flower bud damage (%)					
				3 DAS	5 DAS	7 DAS	11 DAS	Mean	Reduction in gall midge over UTC (%)
T_1	Application of Neem cake	2.5 q/ha	25.57 (30.36)	21.98 (27.88)^{ab}	25.18 (30.11)^{ab}	23.08 (28.69)^{ab}	25.45 (30.29)^{ab}	23.92 (29.29)^{ab}	5.37
T_2	T_1+ Spray with Pongamia oil @ 2%	2.5 q/ha+ 20 ml/l	22.01 (27.97)	20.53 (26.91)^{ab}	20.84 (27.14)^{abcd}	22.36 (28.21)^{ab}	23.60 (29.00)^{abc}	21.83 (27.85)^{abc}	13.64
T_3	T_1+ Spray with Parthenium leaf extract @ 10%	2.5 q/ha+100 g/l	21.69 (27.75)	26.70 (31.03)^{a}	22.98 (28.63)^{abc}	23.37 (28.83)^{ab}	25.43 (30.27)^{ab}	24.62 (29.72)^{ab}	2.61
T_4	T_1+ Spray with Garlic extract @ 10%	2.5 q/ha+100 g/l	19.20 (25.95)	17.79 (25.03)^{b}	18.25 (25.20)^{cde}	19.26 (26.00)^{abc}	20.17 (26.65)^{bc}	18.91 (25.75)^{bc}	25.19
T_5	T_1+ Spray with Ginger extract @ 10%	2.5 q/ha+100 g/l	19.23 (25.79)	15.15 (22.88)^{bc}	19.70 (26.16)^{bcd}	17.83 (24.90)^{bc}	19.43 (26.05)^{bc}	18.03 (25.03)^{c}	28.69
T_6	T_1+ Spray with Tulsi leaf extract @ 10%	2.5 q/ha+100 g/l	19.70 (26.19)	21.08 (27.25)^{ab}	20.66 (26.96)^{abcd}	20.14 (26.61)^{ab}	21.38 (27.48)^{abc}	20.81 (27.08)^{abc}	17.67
T_7	T_1+ Spray with Neem oil @ 3%	2.5 q/ha+30 ml/l	18.78 (25.66)	18.87 (25.73)^{ab}	18.73 (25.64)^{cde}	18.48 (25.45)^{abc}	19.83 (26.43)^{bc}	18.98 (25.82)^{bc}	24.94
T_8	T_1+ Spray with NSKE @ 5%	2.5 q/ha+50 g/l	18.09 (24.93)	15.63 (22.93)^{bc}	16.26 (23.65)^{de}	17.43 (24.53)^{bc}	18.64 (25.43)^{cd}	16.99 (24.21)^{cd}	32.80
T_9	T_1+ Spray with Lemon grass oil @ 10%	2.5 q/ha+100 ml/l	18.07 (25.15)	19.13 (25.93)^{ab}	18.48 (25.45)^{cde}	19.15 (25.95)^{abc}	19.86 (26.47)^{bc}	19.15 (25.95)^{bc}	24.23
T_{10}	T_1+ Spray with Citronella oil @ 10%	2.5 q/ha+100 ml/l	22.95 (28.50)	20.78 (26.92)^{ab}	22.64 (28.30)^{abc}	22.62 (28.27)^{ab}	23.48 (28.90)^{abc}	22.38 (28.12)^{abc}	11.48
T_{11}	T_1+Spray with Profenofos 50 EC @ 2 ml/l	2.5 q/ha+2 ml/l	19.23 (25.87)	10.67 (19.05)^{c}	13.73 (21.74)^{e}	13.50 (21.55)^{c}	13.50 (21.52)^{d}	12.85 (21.01)^{d}	49.17
T_{12}	Control	–	20.07 (26.40)	22.90 (28.43)^{ab}	26.33 (30.84)^{a}	24.89 (29.80)^{a}	27 (31.25)^{a}	25.28 (30.12)^{a}	–
S.Em±			_	1.96	1.45	1.51	1.51	1.35	
CD at 5%			NS	5.79	4.27	4.46	4.45	3.91	
CV (%)			12.54	13.20	9.47	9.91	9.56	8.82	

Table 5: Efficacy of different treatments against chilli gall midge for flower bud damage and dry chilli fruit yield during 2018-19

Treatment		Dosage	I spray		II spray		III spray		Average		Dry fruit yield (q/ha)	Increase in yield over UTC (%)
No.	Details		Gall midge damage	Reduction in gall midge over UTC (%)	Gall midge damage	Reduction in gall midge over UTC (%)	Gall midge damage	Reduction in gall midge over UTC (%)	Gall midge damage	Reduction in gall midge over UTC (%)		
T_1	Application of Neem cake	2.5q/ha	30.86 (33.46)^{bcd}	24.00	36.01 (36.83)^{cd}	27.38	23.92 (29.29)^{ab}	5.37	23.92 (29.29)^{ab}	37.85	6.59^{de}	34.90
T_2	T_1+Spray with Pongamia oil @ 2%	2.5 q/ha+ 20 ml/l	29.31 (32.58)^{bcd}	27.82	40.35 (39.42)^{bc}	18.63	21.83 (27.85)^{abc}	13.64	21.83 (27.85)^{abc}	43.28	7.14^{ab}	39.91
T_3	T_1+ Spray with Parthenium leaf extract @ 10%	2.5 q/ha+ 100 g/l	36.05 (36.89)^{ab}	11.22	43.56 (41.28)^{ab}	12.15	24.59 (29.72)^{ab}	2.71	24.62 (29.72)^{ab}	36.03	6.48^{e}	33.79
T_4	T_1+ Spray with Garlic extract @ 10%	2.5 q/ha+ 100 g/l	28.02 (31.90)^{cd}	31.00	33.66 (35.28)^{d}	32.12	18.98 (25.82)^{bc}	24.94	18.91 (25.75)^{bc}	50.87	7.04^{bc}	39.06
T_5	T_1+Spray with Ginger extra @ 10%	2.5 q/ha+ 100 g/l	27.62 (31.61)^{cd}	31.98	33.57 (35.31)^{d}	32.30	20.81 (27.08)^{abc}	17.67	18.03 (25.03)^{c}	53.15	6.74^{cde}	36.35
T_6	T_1+ Spray with Tulsi leaf extract @ 10%	2.5 q/ha+ 100 g/l	32.98 (35.01)^{abc}	18.78	36.01 (36.85)^{cd}	27.39	18.03 (25.03)^{c}	28.69	20.81 (27.08)^{abc}	45.93	6.75^{cde}	36.44
T_7	T_1+ Spray with Neem oil @ 3%	2.5 q/ha+ 30 ml/l	34.27 (35.82)^{abc}	15.61	34.58 (35.94)^{cd}	30.26	18.91 (25.75)^{bc}	25.19	18.98 (25.82)^{bc}	50.68	7.38^{a}	41.86
T_8	T_1+ Spray with NSKE @ 5%	2.5 q/ha+ 50 g/l	27.11 (31.29)^{cd}	33.24	33.13 (35.11)^{d}	33.19	16.99 (24.21)^{cd}	32.80	16.99 (24.21)^{cd}	55.85	7.44^{a}	42.33
T_9	T_1+ Spray with Lemon grass oil @ 10%	2.5 q/ha+ 100 ml/l	30.68 (33.60)^{bcd}	24.45	36.82 (37.34)^{cd}	25.76	19.15 (25.95)^{bc}	24.23	19.15 (25.95)^{bc}	50.28	6.90^{bcd}	37.82
T_{10}	T_1+ Spray with Citronella oil @ 10%	2.5 q/ha+ 100 ml/l	31.08 (33.77)^{bcd}	23.46	39.78 (39.08)^{bc}	19.78	22.38 (28.12)^{abc}	11.48	22.38 (28.12)^{abc}	41.85	6.76^{cde}	36.53
T_{11}	T_1+Spray with Profenofos 50 EC @ 2 ml/l	2.5 q/ha+2 ml/l	25.67 (30.26)^{d}	36.78	31.50 (34.08)^{d}	36.47	12.85 (21.01)^{d}	49.17	12.85 (21.01)^{d}	66.61	7.19^{ab}	40.33
T_{12}	Control	–	40.61 (39.55)^{a}	–	49.59 (44.76)^{a}	–	25.28 (30.12)^{a}	–	38.49 (30.12)^{a}	–	4.29^{f}	–
S.Em±			1.59		1.59		1.21		0.96		1.35	
CD at 5%			4.69		4.69		3.57		2.83		3.91	
CV (%)			8.19		8.19		5.61		5.08		8.82	

* Figures in the parentheses are arc sin transformed values
* Figures with same alphabetical superscript are statistically non-significant

Table 6: Economics of various treatments for the management of chilli gall midge during *Kharif* 2018-1

Treatment details	Dosage	Dry fruit yield (q/ha)	Cost of plant protection (Rs/ha)	Total cost of plant production (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C Ratio
Application of Neem cake	2.5 q/ha	6.59	4063	39063	98850	59787	2.53
T_1+ Spray with Pongamia oil @ 2%	2.5 q/ha+ 20 ml/l	7.14	6595	41595	107100	65505	2.57
T_1+ Spray with Parthenium leaf extract @ 10%	2.5 q/ha+100 g/l	6.48	3000	38000	97200	59200	2.55
T_1+ Spray with Garlic extract @ 10%	2.5 q/ha+100 g/l	7.04	12666	47666	105600	57934	2.21
T_1+ Spray with Ginger extract @ 10%	2.5 q/ha+100 g/l	6.74	11364	46364	101100	54736	2.10
T_1+ Spray with Tulsi leaf extract @ 10%	2.5 q/ha+100 g/l	6.76	3000	38000	101400	63400	2.66
T_1+ Spray with Neem oil @ 3%	2.5 q/ha+30 ml/l	7.38	23400	58404	110700	52296	1.89
T_1+ Spray with NSKE @ 5%	2.5 q/ha+50 g/l	7.44	4302	39302	111600	72298	2.83
T_1+ Spray with Lemon grass oil @ 10%	2.5 q/ha+100 ml/l	6.90	19045	54045	103500	49455	1.91
T_1+ Spray with Citronella oil @ 10%	2.5 q/ha+100 ml/l	6.76	30942	54942	101400	46458	1.84
T_1+Spray with Profenofos 50 EC @ 2 ml/l	2.5 q/ha+2 ml/l	7.19	5000	40000	107850	67850	2.69
Control	_	4.29	0.00	35000	64350	29350	1.83

Market price: Rs.15000/q, B: C ratio = Gross returns/Total cost of production
Gross return = Yield × Market price, Net returns = Gross returns – Total cost of production

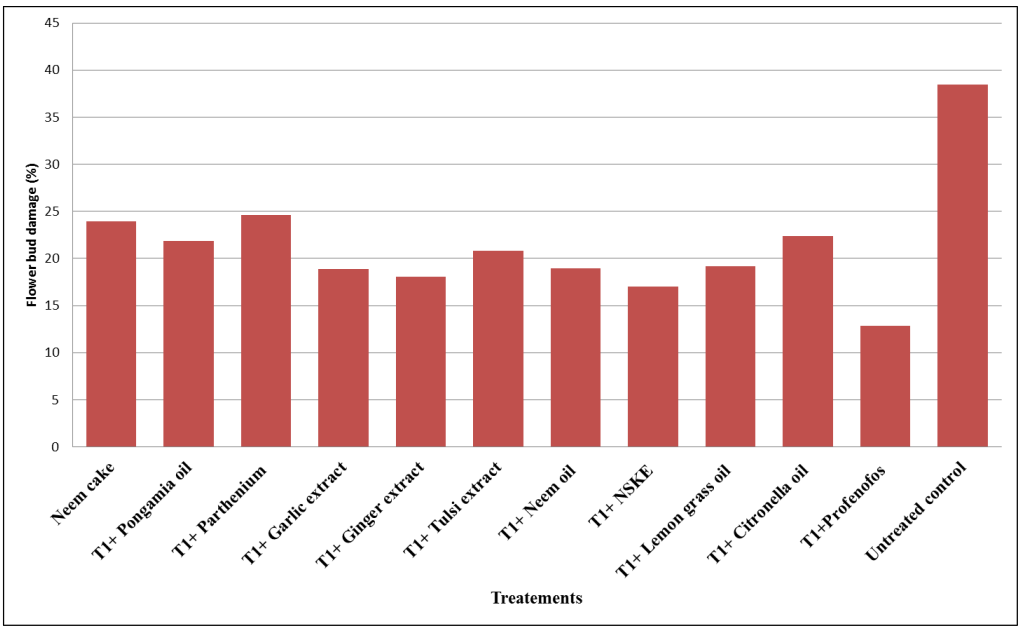

Fig 1: Effect of botanical spray on chilli for flower bud damage during *Kharif* 2018-19

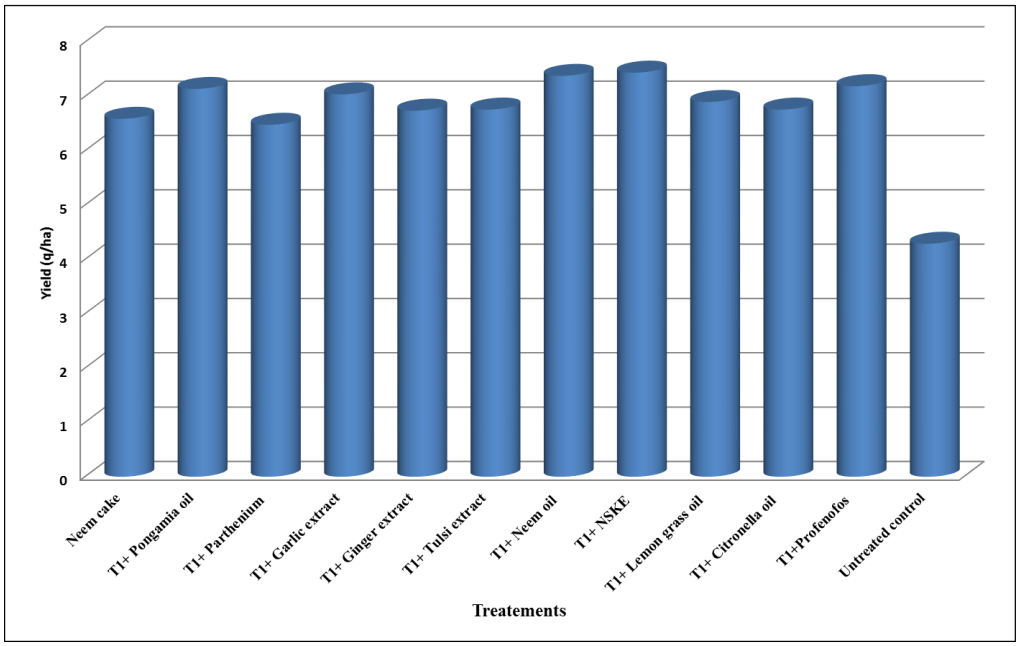

Fig 2: Effect of botanical spray on dry chilli fruit yield during *Kharif* 2018-19

Conclusion

Among the various management practices evaluated against chilli gall midge, in case of flower bud damage treatment, T_{11} (T_1+Spray with profenofos 50EC @ 2 ml/l) registered its superiority over rest of treatment and the next best treatment is T_8 (T_1+Spray with NSKE 5% @ 50 g/l), T_5 (T_1+Spray with ginger extract 10% @ 100 g/l) and T_4 (T_1+Spray with garlic extract 10% @ 100 g/l) by recording for flower bud damage.

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