

INFLUENCE OF WEATHER FACTORS ON POPULATION DYNAMICS OF GERBERA THRIPS (*SCIRTOTHRIPS DORSALIS* HOOD) AND ITS MANAGEMENT IN POT-PLANTED GERBERA

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ABSTRACT

Thrips (*Scirtothrips dorsalis* Hood) is a major sucking pest of gerbera (*Gerbera jamesonii*), yet information on its seasonal abundance, cultivar preference and management on this crop is scarce. Three experiments were conducted at the Hi-tech Horticulture Unit, Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar), during Rabi 2023–24. On pot-planted gerbera cv. Atlanta, thrips were present from the first standard meteorological week (SMW) of January to the last week of March, rising from 3.20 plant⁻¹ (SMW 1) to a maximum of 26.07 plant⁻¹ (SMW 10) before declining to 9.93 plant⁻¹ (SMW 13). Weekly counts were negatively correlated with evening relative humidity ($r = -0.718$, $P < 0.01$) and positively, but only marginally significantly, with maximum temperature ($r = 0.547$, $P = 0.053$). Among ten cultivars screened in a polyhouse, mean thrips counts ranged from 12.63 (Soulmate) to 18.19 plant⁻¹ (Brilliance); Soulmate, Stanza and Balance fell in the highly resistant group and Goliath, Atlanta and Brilliance in the highly susceptible group. In a field trial on cv. Goliath, two sprays of six insecticides reduced thrips by 21.3–74.2% over control; spinosad 45 SC (162 ml ha⁻¹) was the most effective (74.2% and 47.6% after the first and second spray), followed by flonicamid 50 WG (65.6% and 44.3%), while dimethoate 30 EC was the least effective. Spinosad also gave the highest additional yield (15,392 cut stems ha⁻¹ over control) and incremental benefit–cost ratio (7.38:1), followed by flonicamid (6.89:1). Regular monitoring, less-susceptible cultivars and alternation of spinosad and flonicamid at threshold are suggested for thrips management in gerbera.

KEYWORDS: Gerbera, thrips, *Scirtothrips dorsalis*, population dynamics, weather factors, varietal screening, spinosad, flonicamid

INTRODUCTION

Gerbera (*Gerbera jamesonii*), also known as Transvaal, African or Barberton daisy, belongs to the family Asteraceae, which also includes sunflower, daisy and aster. The genus comprises about 30 species distributed over Africa, Madagascar, tropical Asia and South America, and the crop is grown mainly in South Africa and Eastern countries. Gerbera has a long, leafless flower stalk bearing a daisy-like head and is among the top commercial cut flowers of the world; its popularity rests on the attractive shape and wide colour range of the flowers (Nair *et al.*, 2003) and their long vase life (Kumar *et al.*, 2010). It is grown under a wide range of climatic conditions across the world.

Several insect pests attack gerbera from establishment to flowering, including the aphid *Macrosiphoniella sanborni* (Gillette), the tobacco caterpillar *Spodoptera litura* (Fabricius), the two-spotted spider mite *Tetranychus urticae* Koch, the whitefly *Trialeurodes vaporariorum* (Westwood) and the thrips *S. dorsalis*. Thrips cause direct damage by sucking sap and scraping the leaf surface, which leads to stunted, curled and distorted foliage, desiccation of the apical portion and blemished petals, and thrips as a group can also vector tospoviruses (Reitz *et al.*, 2020). Published work on thrips in gerbera is limited; Reddy and Aswath (2008) screened exotic gerbera accessions against *Thrips palmi* and whitefly, and Gawade (2003) evaluated insecticides against the pest complex of polyhouse gerbera. Most information on *S. dorsalis* comes from chilli, cotton and rose, where seasonal incidence has been linked to temperature, humidity and rainfall.

Weather strongly influences the biology and life cycle of thrips and therefore the timing and intensity of outbreaks, so knowledge of population build-up in relation to weather helps in timing preventive measures. Host-plant resistance offers a low-cost, compatible component of management, and newer insecticides with distinct modes of action can complement it once populations approach the economic threshold. The present investigation was therefore undertaken (i) to study the population dynamics of thrips on gerbera in relation to abiotic factors, (ii) to evaluate the response of ten gerbera cultivars to thrips under polyhouse conditions, and (iii) to determine the efficacy and economics of six insecticides against thrips on gerbera.

MATERIALS AND METHODS

All experiments were conducted at the Hi-tech Horticulture Unit of Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Samastipur, Bihar, during the *Rabi* season of 2023-24. Pusa lies in north Bihar, in the subtropical humid zone, on the southern bank of the Burhi Gandak river, at 25.98° N, 85.64° E and 55 m above mean sea level. Annual rainfall is about 1021 mm and the soil is sandy loam. Recommended agronomic practices (weeding, fertilization and irrigation) were followed in all experiments, except that no insecticide was applied in experiments 1 and 2.

Population dynamics of thrips and weather factors

Gerbera cv. Atlanta was transplanted into pots on 28 December 2023. Thrips (nymphs and adults) were counted weekly from the first SMW of January 2024 (5 January) until harvest in the last week of March (SMW 13). Five pots were selected at random and tagged in each replication, and thrips were counted with a hand lens on five leaves per plant in the early morning (before 08:00 h), when the insects are least active; counts were averaged to obtain the mean number of thrips per plant. Weekly weather data (maximum and minimum temperature, morning and evening relative humidity and total rainfall) were obtained from the observatory of the Department of Agricultural Meteorology, RPCAU, Pusa. Pearson correlation coefficients (*r*) between weekly mean thrips per plant and each weather variable were computed (*n* = 13 weeks; 11 d.f.; critical *r* = 0.553 at *P* = 0.05 and 0.684 at *P* = 0.01), and simple linear regressions of thrips count on each weather variable were fitted.

Varietal response

Ten gerbera cultivars (Goliath, Atlanta, Stanza, Intense, Balance, Capella, Shimmer, Fiagro, Soulmate and Brilliance) were screened under polyhouse conditions in a completely randomized design (CRD) with three replications. Seedlings were transplanted on 8 January 2024 in plots of 2.0 × 1.5 m at a spacing of 30 × 30 cm. Brilliance was included as the susceptible check. No insecticide was applied. Five plants were selected at random in each plot and thrips were counted on five leaves per plant at weekly intervals from the first appearance of the pest (SMW 3) to crop maturity (SMW 15). Counts were transformed to $\sqrt{(x + 0.5)}$ before analysis of variance (Steel and Torrie, 1980) using OPSTAT, and treatment means were compared using the critical difference (CD) at *P* = 0.05. Cultivars were grouped using the mean thrips count over all observations (*x_i*) in relation to the grand mean of all cultivars ($\bar{x}$) and the standard deviation (SD), following the modified scale of Patel *et al.* (2002): highly resistant (HR), $x_i < \bar{x} - SD$; resistant (R), $\bar{x} - SD \leq x_i < \bar{x}$; susceptible (S), $\bar{x} \leq x_i < \bar{x} + SD$; and highly susceptible (HS), $\bar{x} + SD \leq x_i < \bar{x} + 2SD$.

Efficacy and economics of insecticides

The trial was laid out in a CRD with seven treatments (six insecticides and an untreated control) and three replications, using gerbera cv. Goliath (transplanted on 20 December 2023) in plots of 2.0 × 1.5 m at 30 × 30 cm spacing. The insecticides, their doses and chemical groups are given in Table 1. Two sprays were applied in the evening with a battery-operated knapsack sprayer at a spray volume of 500 L ha⁻¹: the first on 5 March 2024, when thrips reached the economic threshold level (15–20 thrips plant⁻¹), and the second on 20 March 2024, 15 days later. The sprayer and nozzle were washed with clean water after each treatment to avoid contamination.

Table 1. Details of insecticidal treatments evaluated against *S. dorsalis* on gerbera cv. Goliath

Code	Insecticide (formulation)	Dose (g or ml formulation ha ⁻¹)	Chemical group	IRAC MoA group
T1	Spinosad 45 SC	162 ml	Spinosyn	5
T2	Flonicamid 50 WG	150 g	Pyridinecarboxamide	29
T3	Thiamethoxam 25 WG	100 g	Neonicotinoid	4A
T4	Acetamiprid 20 SP	50 g	Neonicotinoid	4A
T5	Dimethoate 30 EC	200 ml	Organophosphate	1B
T6	Clothianidin 50 WDG	40 g	Neonicotinoid	4A
T7	Untreated control (water spray)	—	—	—

IRAC = Insecticide Resistance Action Committee; MoA = mode of action.

Thrips were counted on five leaves of each of five tagged plants per plot one day before spraying (1 DBS) and 1, 3, 7 and 14 days after spraying (DAS). Per cent reduction in thrips population over control was calculated with the Henderson and Tilton (1955) formula, which corrects for differences in pre-treatment counts: reduction (%) = $[1 - (T_a \times C_b)/(T_b \times C_a)] \times 100$, where *T_b* and *T_a* are the counts in a treated plot before and after spraying and *C_b* and *C_a* are the corresponding counts in the control. Data were transformed to $\sqrt{(x + 0.5)}$ and analysed as for the varietal trial. Cut stems were harvested from each plot and converted to a per-hectare basis; additional yield over control was valued at Rs 3 per cut stem. Cost of treatment comprised the cost of insecticide and labour (Rs 800 per spray per person per hectare for two sprays), and the incremental benefit–cost ratio (ICBR) was calculated as the value of additional yield divided by the cost of treatment.

RESULTS AND DISCUSSION

Seasonal abundance of thrips on gerbera

Thrips were first recorded in the first SMW of January (3.20 plant⁻¹) and remained on the crop until harvest in SMW 13 (Table 2, Fig. 1). The population increased steadily to a first peak of 17.87 plant⁻¹ in SMW 6 (9 February), declined slightly to 16.20 plant⁻¹ in SMW 7, and then rose again to the seasonal maximum of 26.07 plant⁻¹ in SMW 10 (9 March), with a similarly high count of 25.27 plant⁻¹ in SMW 9. Thereafter the population fell to 20.87, 18.00 and 9.93 plant⁻¹ in SMW 11, 12 and 13, respectively. The slight dip in SMW 7 followed the highest weekly rainfall of the season (13.11 mm in SMW 6), which may have dislodged part of the population. The peak weeks (SMW 9–10) were characterized by a maximum temperature of 26.0–26.6 °C, a minimum of 12.1–12.6 °C, evening relative humidity of 47.9–52.4% and little or no rainfall (5.76 and 0.00 mm), whereas the decline in SMW 11–13 coincided with maximum temperatures of about 28–32 °C and minimum temperatures that rose from 13.8 to 19.9 °C.

Similar seasonal patterns have been described for *S. dorsalis* on other crops. Lingeri *et al.* (1998) recorded the pest throughout the cropping period of chilli, with the highest populations in December–January, and Panickar and Patel (2001) observed activity on chilli from early September to mid-January. Duraimurugan and Jagdish (2004) found thrips throughout the flowering period of rose, with severe infestation from February to May, a decline with the onset of rains and a resurgence in November. The February–March peak recorded here on gerbera is in line with these reports of build-up in the dry, warming part of the year.

Table 2. Weekly population of thrips (*S. dorsalis*) on pot-planted gerbera cv. Atlanta and prevailing weather, Rabi 2023–24

SMW	Date	Thrips plant ⁻¹	Max. temp. (°C)	Min. temp. (°C)	RH morning (%)	RH evening (%)	Rainfall (mm)
1	5/01/2024	3.20	19.51	10.23	97.43	71.43	6.20
2	12/01/2024	6.86	18.82	9.57	98.71	66.29	7.81
3	19/01/2024	8.53	15.13	9.33	96.71	85.71	4.26
4	26/01/2024	12.33	15.30	7.47	97.43	77.14	5.53
5	2/02/2024	15.06	22.59	8.24	96.86	55.57	7.16
6	9/02/2024	17.87	22.12	9.70	95.86	57.86	13.11
7	16/02/2024	16.20	24.74	11.70	98.43	62.14	7.89
8	23/02/2024	18.00	26.16	12.69	92.00	51.86	6.97
9	2/03/2024	25.27	26.00	12.64	94.71	52.43	5.76
10	9/03/2024	26.07	26.64	12.09	90.43	47.86	0.00
11	15/03/2024	20.87	30.97	13.81	89.86	42.43	0.00
12	22/03/2024	18.00	28.39	16.37	92.14	60.29	6.11
13	29/03/2024	9.93	31.64	19.90	87.14	55.14	0.00

SMW = standard meteorological week; RH = relative humidity. Rainfall is the weekly total; other weather values are weekly means.

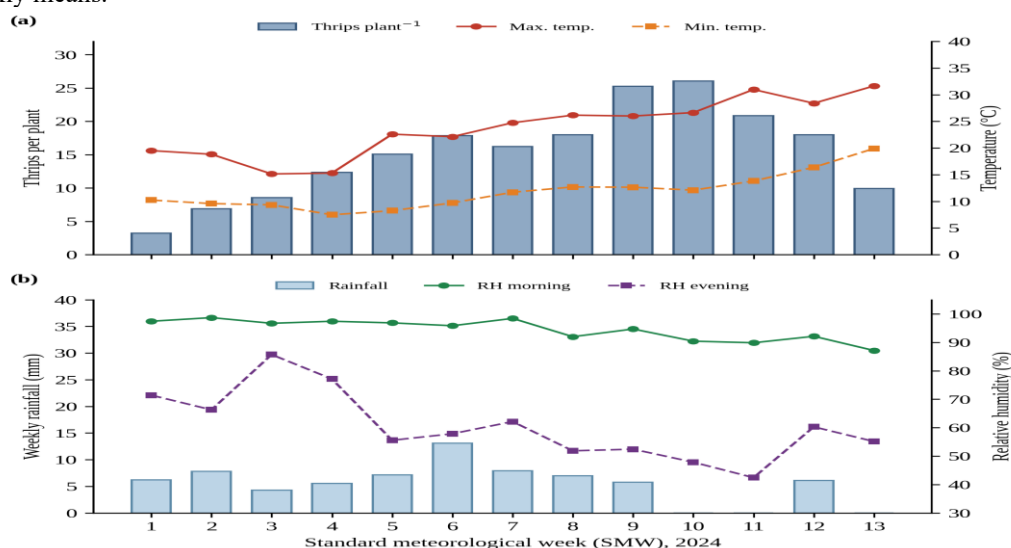


Fig. 1. Weekly thrips population on gerbera in relation to (a) maximum and minimum temperature and (b) rainfall and morning and evening relative humidity, Rabi 2023–24.

The relationships between thrips abundance and weather are given in Table 3 and Fig. 2. Evening relative humidity showed a significant negative correlation with thrips population ($r = -0.718$, $P < 0.01$) and explained 51.6% of the variation in weekly counts; each one-unit fall in evening humidity was associated with about 0.41 more thrips per plant. Maximum temperature was positively correlated with thrips population, but the relationship was only marginally significant ($r = 0.547$, $P = 0.053$; $R^2 = 0.300$). Minimum temperature ($r = 0.200$), morning relative humidity ($r = -0.420$) and rainfall ($r = -0.164$) were not significantly correlated with thrips counts. The weather variables were themselves strongly intercorrelated over the season (for example maximum temperature with evening relative humidity, $r = -0.858$, and with minimum temperature, $r = 0.845$), so their individual effects cannot be fully separated in a single-season data set of 13 weeks.

Table 3. Correlation and simple linear regression of weekly thrips population on weather factors (n = 13)

Weather factor (X)	r	P	Regression equation (Y = thrips plant ⁻¹)	R ²
Maximum temperature (°C)	0.547	0.053	$Y = -1.35 + 0.700X$	0.300
Minimum temperature (°C)	0.200	0.513	$Y = 10.50 + 0.401X$	0.040
Relative humidity, morning (%)	-0.420	0.153	$Y = 88.55 - 0.776X$	0.176
Relative humidity, evening (%)	-0.718**	0.006	$Y = 39.99 - 0.409X$	0.516
Rainfall (mm)	-0.164	0.593	$Y = 16.89 - 0.302X$	0.027

** Significant at $P = 0.01$ (critical $r = 0.684$ for 11 d.f.; $r = 0.553$ at $P = 0.05$).

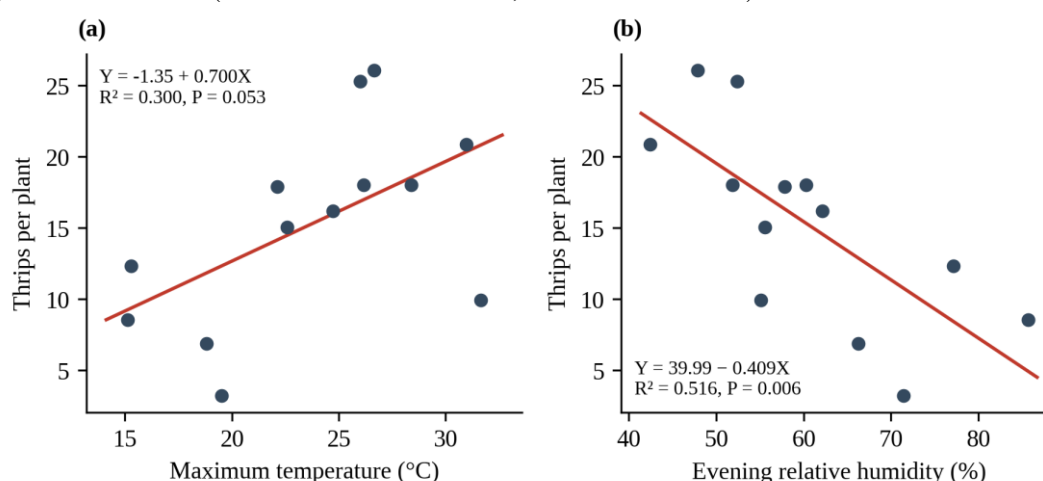


Fig. 2. Linear regression of weekly thrips population on (a) maximum temperature and (b) evening relative humidity.

The negative association with humidity agrees with several earlier studies on *S. dorsalis*: Bagle (1993) and Kumar *et al.* (2006) reported negative relationships of thrips with relative humidity, as did Meena *et al.* (2013) on chilli, Bhede *et al.* (2008) with evening humidity and rainfall, Panickar and Patel (2001) with average relative humidity, and De Assis *et al.* (2023) with rainfall and humidity for thrips on cut chrysanthemum. The positive tendency with maximum temperature is consistent with the findings of Bagle (1993), Varadharajan and Veeravel (1995), Duraimurugan and Jagdish (2004) and Asma and Hanumantharaya (2015). However, Varadharajan and Veeravel (1995) also noted the lowest populations at about 35 °C, and the fall in gerbera thrips in the last three weeks of this study, when temperatures were rising, is compatible with an upper thermal limit to build-up. Our result for minimum temperature differs from that of Bagle (1993), who recorded a negative correlation, while Kumar *et al.* (1994) on mango and Shukla (2006) on chilli found no or weak relationships with weather, indicating that the influence of individual weather factors varies with crop, location and season. The weather data used here were recorded at the university observatory, and the thrips counts come from a single season, so the regressions should be taken as indicative and tested over more seasons and under the microclimate of protected cultivation.

Response of gerbera cultivars to thrips

Thrips infested all ten cultivars from the first observation, and counts differed significantly among cultivars in every one of the 13 weekly observations (Table 4). Brilliance, the susceptible check, carried the highest population in 12 of the 13 weeks (13.33–31.70 plant⁻¹ during SMW 3–9), the exception being SMW 10, when Atlanta recorded the highest count. Soulmate recorded the lowest count in 10 of 13 weeks (for example 9.73 plant⁻¹ in SMW 3 and 18.17 in SMW 8), with Stanza (SMW 5 and 14) and Balance (SMW 7) the lowest in the remaining weeks. Soulmate, Balance and Stanza were generally at par with each other, and Goliath and Atlanta at par with Brilliance, in most weeks. All cultivars followed a common temporal pattern: counts rose to a peak in SMW 7 (22.24–31.70 plant⁻¹), fell sharply in SMW 10 (4.40–6.62 plant⁻¹), recovered to a second peak in SMW 12 (17.97–

24.50 plant⁻¹) and declined to 3.77–6.03 plant⁻¹ in SMW 15 (Fig. 3), so that the relative ranking of cultivars was largely stable across the crop stages.

Table 4. Thrips population (plant⁻¹) on ten gerbera cultivars at weekly intervals (standard meteorological weeks 3–15), polyhouse, *Rabi* 2023–24

Cultivar	3	4	5	6	7	8	9	10	11	12	13	14	15	Mean
Goliath	12.77 ^{ab}	16.83 ^{ab}	20.13 ^{bc}	25.81 ^b	28.00 ^{ab}	24.83 ^{ab}	15.90 ^a	6.47 ^{ab}	17.30 ^{ab}	23.46 ^{ab}	12.38 ^{bc}	7.07 ^a	5.60 ^{ab}	16.66
Atlanta	12.87 ^{ab}	17.13 ^{ab}	21.20 ^{ab}	26.60 ^{ab}	28.27 ^{ab}	24.30 ^{bc}	15.00 ^{ab}	6.62 ^a	17.23 ^{ab}	23.62 ^{ab}	14.27 ^{ab}	6.83 ^a	5.77 ^{ab}	16.90
Stanza	10.23 ^{cd}	12.97 ^{cde}	15.20 ^f	22.10 ^c	23.17 ^{cd}	19.87 ^{de}	11.87 ^c	4.97 ^{de}	13.07 ^c	18.62 ^{cd}	10.66 ^{cde}	4.28 ^d	3.97 ^c	13.15
Intense	10.70 ^{cd}	13.10 ^{cde}	17.50 ^{de}	23.47 ^{bc}	25.50 ^{bcd}	21.60 ^d	12.20 ^c	5.83 ^{bc}	14.30 ^c	20.47 ^{cd}	11.70 ^{cde}	6.40 ^{abc}	4.57 ^{bc}	14.41
Balance	10.13 ^{cd}	12.43 ^{de}	16.77 ^{def}	22.03 ^c	22.24 ^d	19.62 ^{de}	11.47 ^c	4.80 ^{de}	14.03 ^c	18.43 ^{cd}	10.27 ^{de}	5.10 ^{cd}	4.27 ^c	13.20
Capella	11.53 ^{bc}	14.80 ^{bc}	18.77 ^{bcd}	23.60 ^{bc}	25.20 ^{bcd}	21.67 ^d	12.80 ^{bc}	5.97 ^{abc}	14.23 ^c	20.50 ^{cd}	11.62 ^{cde}	5.90 ^{abc}	4.87 ^{abc}	14.73
Shimmer	10.60 ^{cd}	13.50 ^{cd}	18.23 ^{cd}	24.43 ^{bc}	26.83 ^{bc}	21.40 ^d	12.33 ^c	5.90 ^{abc}	14.20 ^c	20.10 ^{cd}	11.80 ^{cd}	6.57 ^{ab}	4.62 ^{bc}	14.65
Diagro	10.80 ^{cd}	13.90 ^{cd}	17.20 ^{def}	24.97 ^{bc}	27.00 ^{bc}	22.00 ^{cd}	12.83 ^{bc}	5.47 ^{cd}	14.62 ^{bc}	20.93 ^{bc}	11.27 ^{cde}	6.17 ^{abc}	4.80 ^{abc}	14.77
Soulmate	9.73 ^d	11.17 ^e	15.43 ^{ef}	21.70 ^c	22.75 ^d	18.17 ^e	10.90 ^c	4.40 ^e	13.03 ^c	17.97 ^d	10.00 ^e	5.17 ^{bcd}	3.77 ^c	12.63
Brilliance*	13.33 ^a	17.47 ^a	23.47 ^a	30.10 ^a	31.70 ^a	27.13 ^a	16.70 ^a	6.40 ^{ab}	17.60 ^a	24.50 ^a	14.83 ^a	7.20 ^a	6.03 ^a	18.19
CD (P = 0.05)	0.25	0.29	0.27	0.36	0.40	0.27	0.32	0.15	0.36	0.31	0.26	0.28	0.28	–
SE(m) ±	0.08	0.10	0.09	0.12	0.13	0.09	0.11	0.05	0.12	0.10	0.09	0.09	0.09	–
CV (%)	4.37	4.51	3.76	4.25	4.61	3.36	5.17	3.68	5.45	4.04	4.45	6.56	6.73	–

* Susceptible check. Column headings are SMW. Within a column, means followed by the same letter do not differ significantly at P = 0.05 (CD); letters were assigned from the CD of the $\sqrt{(x + 0.5)}$ -transformed data, which is also the scale of the CD, SE(m) and CV given. Mean = mean of the 13 weekly observations.

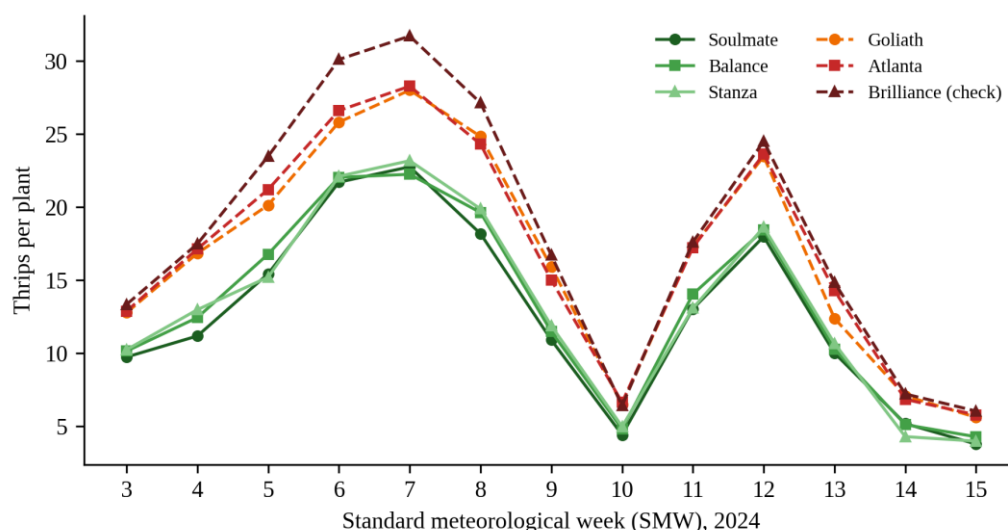


Fig. 3. Weekly thrips population on the three least and three most infested cultivars (SMW 3–15).

Based on the mean thrips count over all observations (Table 5, Fig. 4), the grand mean of the ten cultivars was 14.93 plant⁻¹ with an SD of 1.71, giving class limits of 13.22 ($\bar{x} - \text{SD}$), 16.64 ($\bar{x} + \text{SD}$) and 18.35 ($\bar{x} + 2\text{SD}$). Soulmate (12.63), Stanza (13.15) and Balance (13.20) fell below 13.22 and were classified as highly resistant, that is, the least infested group. Intense (14.41), Shimmer (14.66), Capella (14.73) and Fiagro (14.77) lay between 13.22 and the grand mean and were classified as resistant. No cultivar fell in the susceptible class (14.93–16.64). Goliath (16.66), Atlanta (16.90) and the susceptible check Brilliance (18.19) exceeded 16.64 and were classified as highly susceptible; Goliath exceeded the limit only marginally.

Table 5. Categorization of gerbera cultivars for susceptibility to *S. dorsalis* ($\bar{x} = 14.93$, SD = 1.71)

Category	Scale (thrips plant ⁻¹)	Cultivars (mean thrips plant ⁻¹)
Highly resistant (HR)	$x_i < 13.22$	Soulmate (12.63), Stanza (13.15), Balance (13.20)
Resistant (R)	$13.22 \leq x_i < 14.93$	Intense (14.41), Shimmer (14.66), Capella (14.73), Fiagro (14.77)
Susceptible (S)	$14.93 \leq x_i < 16.64$	None
Highly susceptible (HS)	$16.64 \leq x_i < 18.35$	Goliath (16.66), Atlanta (16.90), Brilliance (18.19)

The scale is relative to the cultivars tested; all cultivars were infested.

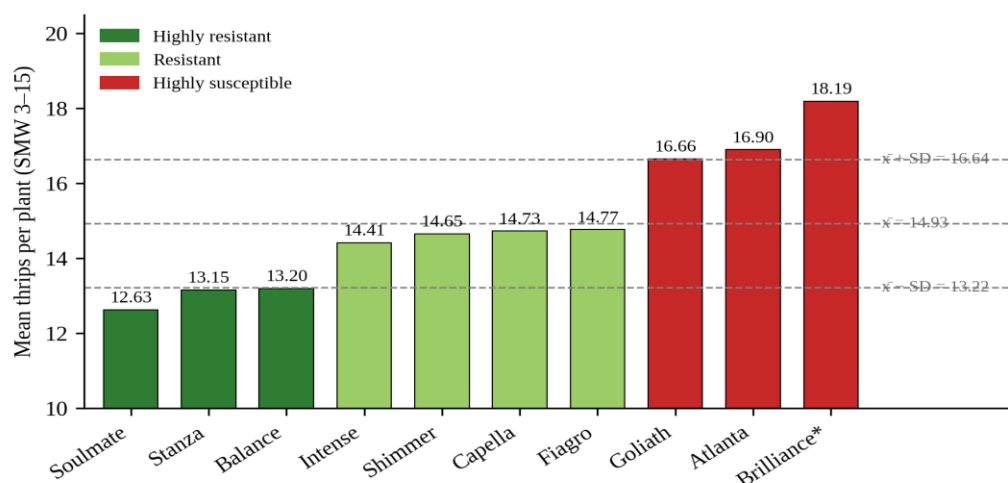


Fig. 4. Mean thrips population on ten gerbera cultivars (SMW 3–15) and their classification. Dashed lines show $\bar{x} - \text{SD}$, $\bar{x}$ and $\bar{x} + \text{SD}$. *Susceptible check.

We could not find earlier reports on the response of these gerbera cultivars to *S. dorsalis*. Reddy and Aswath (2008) likewise found marked differences among exotic gerbera accessions in infestation by *T. palmi* and whitefly, with some accessions resistant and others highly susceptible, and reported that flower form and colour influenced

damage. Differences in thrips preference among varieties have also been documented in rose (Gahukar, 2003; Jhansi Rani and Sridhar, 2003), chrysanthemum (Rahardjo *et al.*, 2021), onion (Shaikh *et al.*, 2014; Raut *et al.*, 2020) and garlic (Hossain *et al.*, 2014). The traits underlying the differences among the present cultivars (for example flower colour and form, leaf pubescence or biochemical composition) were not studied and merit investigation. Two cautions apply. First, the classification is relative to the set of cultivars tested, and even the least infested cultivar carried a mean of 12.6 thrips plant⁻¹, so none of them is immune. Second, the weekly pattern in the polyhouse (a pronounced dip at SMW 10) differs from that on the pot-planted crop (maximum at SMW 10), so inferences from the two experiments should not be combined. Cultivars Soulmate, Stanza and Balance appear to be the better options for reducing thrips pressure, while Atlanta, used in the population study, and Goliath, used in the insecticide trial, are both highly susceptible and therefore represent high-pressure conditions.

Efficacy of insecticides against thrips

First spray. Pre-treatment thrips counts (15.25–19.47 plant⁻¹) did not differ significantly among plots (Table 6). All insecticides significantly reduced the thrips population relative to the control at every interval (Fig. 5a). One day after spraying, all insecticides except dimethoate (13.84 plant⁻¹) were at par, with counts of 8.26 (spinosad) to 10.44 plant⁻¹ (flonicamid). Three days after spraying, spinosad had the lowest count (3.47), which was at par with acetamiprid (5.07) and flonicamid (5.28). At 7 DAS flonicamid recorded the lowest count (6.16), at par with spinosad (8.14) and significantly lower than the other insecticides, whereas at 14 DAS spinosad again recorded the lowest count (11.01), significantly lower than the others except dimethoate (13.03). Acetamiprid gave a rapid knock-down (5.07 plant⁻¹ at 3 DAS) but the poorest persistence, with 12.16 and 16.03 plant⁻¹ at 7 and 14 DAS, the latter being the highest of all treated plots. Over the four post-treatment intervals, the mean count was lowest in spinosad (7.72) and flonicamid (9.23), which were at par, followed by clothianidin (10.03), acetamiprid (10.41) and thiamethoxam (10.65), which were at par with one another, and dimethoate (12.44), against 27.60 in the control. The corresponding reductions over control were 74.15% (spinosad), 65.57% (flonicamid), 59.59% (clothianidin), 59.00% (acetamiprid), 57.76% (thiamethoxam) and 46.01% (dimethoate).

Table 6. Efficacy of insecticides against *S. dorsalis* on gerbera (thrips plant⁻¹) after the first spray (5 March 2024)

Treatment	Dose (ha ⁻¹)	1 DBS	1 DAS	3 DAS	7 DAS	14 DAS	Mean (1–14 DAS)	Reduction over control (%)
Spinosad 45 SC	162 ml	19.47	8.26 ^c	3.47 ^e	8.14 ^{cd}	11.01 ^c	7.72 ^d	74.15
Flonicamid 50 WG	150 g	17.47	10.44 ^c	5.28 ^{de}	6.16 ^d	15.05 ^b	9.23 ^{cd}	65.57
Thiamethoxam 25 WG	100 g	16.46	10.35 ^c	8.10 ^c	10.14 ^{bc}	14.03 ^b	10.65 ^{bc}	57.76
Acetamiprid 20 SP	50 g	16.33	8.40 ^c	5.07 ^{de}	12.16 ^b	16.03 ^b	10.41 ^{bc}	59.00
Dimethoate 30 EC	200 ml	15.25	13.84 ^b	11.50 ^b	11.40 ^b	13.03 ^{bc}	12.44 ^b	46.01
Clothianidin 50 WDG	40 g	16.07	9.22 ^c	6.28 ^{cd}	9.56 ^{bc}	15.06 ^b	10.03 ^{bc}	59.59
Untreated control	–	18.04	23.81 ^a	27.24 ^a	28.20 ^a	31.17 ^a	27.60 ^a	–

DBS = day before spraying; DAS = days after spraying. Within a column, means followed by the same letter do not differ significantly at $P = 0.05$ (CD on $\sqrt{(x + 0.5)}$ -transformed data: 1 DAS 0.35, 3 DAS 0.43, 7 DAS 0.42, 14 DAS 0.39, mean 0.35); pre-treatment counts did not differ significantly. Reduction over control was calculated by the Henderson and Tilton (1955) formula and is the mean of the four post-treatment intervals. Dose is formulation (g or ml) ha⁻¹.

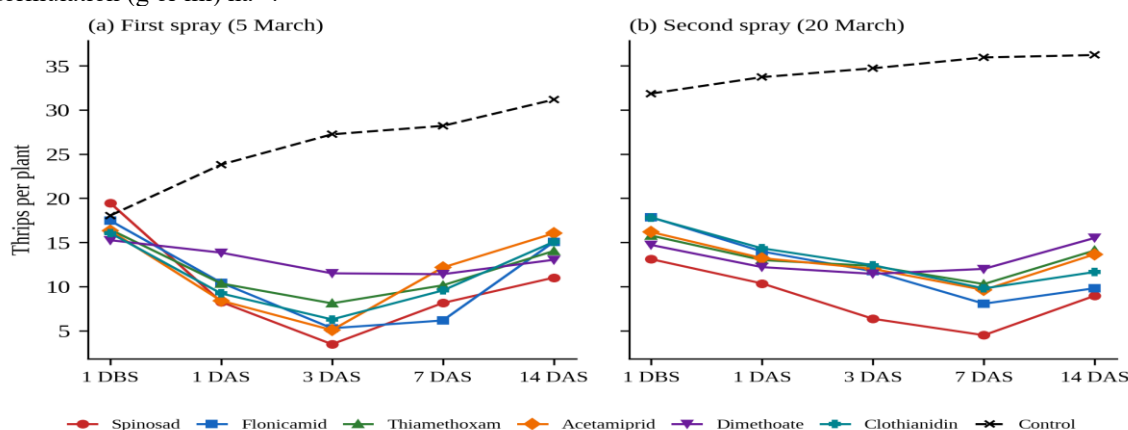


Fig. 5. Thrips population on gerbera before and after (a) the first and (b) the second spray of insecticides. DBS = day before spraying; DAS = days after spraying.

Second spray. Pre-treatment counts differed significantly among plots before the second spray (Table 7), being lowest in the spinosad plots (13.10) and highest in the flonicamid (17.84) and clothianidin (17.82) plots; the

Henderson and Tilton correction accounts for this. Spinosad again gave the lowest thrips count at all four intervals (10.35, 6.35, 4.49 and 8.96 plant⁻¹ at 1, 3, 7 and 14 DAS) and was significantly better than all other insecticides at 3 and 7 DAS, followed by flonicamid at 7 DAS (8.06) and 14 DAS (9.81). Dimethoate was the weakest treatment at 7 and 14 DAS (12.00 and 15.51 plant⁻¹). Mean counts were 7.53 (spinosad), 10.89 (flonicamid), 12.05 (clothianidin), 12.12 (acetamiprid), 12.42 (thiamethoxam) and 12.79 (dimethoate), against 35.15 in the control, and the corresponding reductions over control were 47.58, 44.32, 38.46, 31.91, 28.50 and 21.31%. The order of efficacy was therefore the same after both sprays (Table 8, Fig. 6): spinosad > flonicamid > clothianidin > acetamiprid > thiamethoxam > dimethoate, although the differences among clothianidin, acetamiprid and thiamethoxam were not significant. Reductions after the second spray were lower for every insecticide than after the first, while the control population continued to rise (27.60 to 35.15 plant⁻¹). The reason was not examined; immigration from neighbouring plots in small unbordered plots and the higher pest pressure at the second spray may have contributed.

Table 7. Efficacy of insecticides against *S. dorsalis* on gerbera (thrips plant⁻¹) after the second spray (20 March 2024)

Treatment	Dose (ha ⁻¹)	1 DBS	1 DAS	3 DAS	7 DAS	14 DAS	Mean (1–14 DAS)	Reduction over control (%)
Spinosad 45 SC	162 ml	13.10 ^d	10.35 ^c	6.35 ^c	4.49 ^d	8.96 ^c	7.53 ^d	47.58
Flonicamid 50 WG	150 g	17.84 ^b	13.97 ^b	11.73 ^b	8.06 ^c	9.81 ^{de}	10.89 ^c	44.32
Thiamethoxam 25 WG	100 g	15.77 ^{bcd}	13.00 ^b	12.33 ^b	10.28 ^{bc}	14.09 ^{bc}	12.42 ^{bc}	28.50
Acetamiprid 20 SP	50 g	16.17 ^{bc}	13.22 ^b	12.00 ^b	9.61 ^{bc}	13.66 ^{bc}	12.12 ^{bc}	31.91
Dimethoate 30 EC	200 ml	14.71 ^{cd}	12.20 ^{bc}	11.44 ^b	12.00 ^b	15.51 ^b	12.79 ^b	21.31
Clothianidin 50 WDG	40 g	17.82 ^b	14.33 ^b	12.42 ^b	9.79 ^{bc}	11.65 ^{cd}	12.05 ^{bc}	38.46
Untreated control	–	31.86 ^a	33.72 ^a	34.72 ^a	35.95 ^a	36.22 ^a	35.15 ^a	–

Letters as in Table 6; CD (P = 0.05) on $\sqrt{(x + 0.5)}$ -transformed data: 1 DBS 0.36, 1 DAS 0.32, 3 DAS 0.43, 7 DAS 0.38, 14 DAS 0.32, mean 0.26.

Table 8. Combined efficacy of two successive sprays of insecticides against *S. dorsalis* on gerbera

Treatment	Thrips plant ⁻¹ , first spray	Thrips plant ⁻¹ , second spray	Mean thrips plant ⁻¹	Reduction, first spray (%)	Reduction, second spray (%)	Mean reduction (%)
Spinosad 45 SC	7.72	7.53	7.63	74.15	47.58	60.87
Flonicamid 50 WG	9.23	10.89	10.06	65.57	44.32	54.94
Thiamethoxam 25 WG	10.65	12.42	11.54	57.76	28.50	43.13
Acetamiprid 20 SP	10.41	12.12	11.27	59.00	31.91	45.45
Dimethoate 30 EC	12.44	12.79	12.61	46.01	21.31	33.66
Clothianidin 50 WDG	10.03	12.05	11.04	59.59	38.46	49.03
Untreated control	27.60	35.15	31.38	–	–	–

Values are means of the four post-treatment observations after each spray; combined values are arithmetic means of the two sprays.

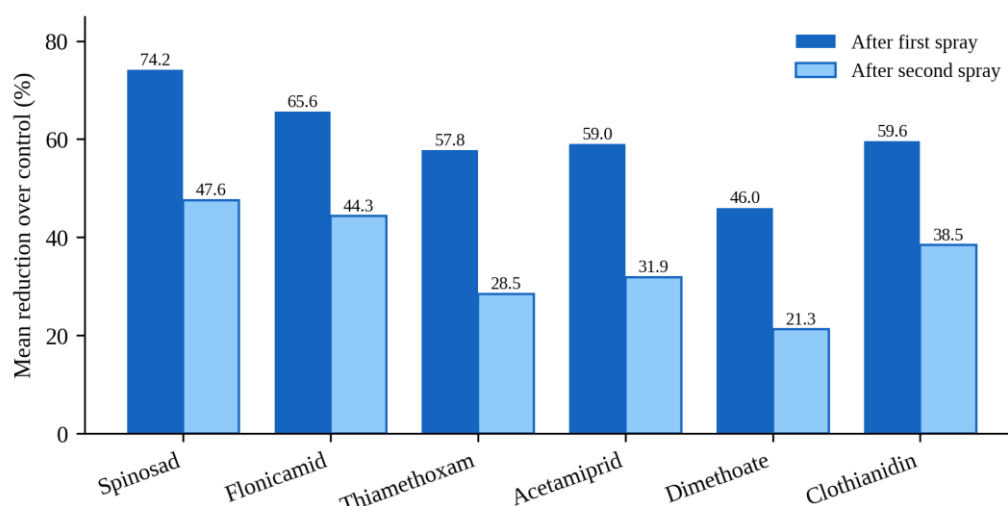


Fig. 6. Mean reduction in thrips population over control after the first and second spray (Henderson and Tilton, 1955).

The superiority of spinosad agrees with reports on other crops: Jadhao *et al.* (2019) on pomegranate thrips, Vanisree *et al.* (2013) and Shinde *et al.* (2018) on chilli thrips, Kansagara *et al.* (2018) on green gram and Manideep *et al.* (2023) on thrips in chrysanthemum all found spinosad among the most effective treatments. By contrast, Mandal and Mondal (2022) found broflanilide the most effective against chilli thrips, with spinosad not significantly different from several other newer insecticides, and Gawade (2003) reported imidacloprid and acetamiprid as effective against pests of polyhouse gerbera; neither broflanilide nor imidacloprid was included here. The faster onset of the neonicotinoid acetamiprid and the slower but more sustained activity of flonicamid and spinosad seen in our data may be useful in timing sprays. The poor performance of dimethoate, an organophosphate, contrasts with the high efficacy reported against mango thrips by Khuhro *et al.* (1987); this may reflect differences in crop, species and local exposure history, but this was not tested.

Economics of insecticidal treatments

Marketable yield was highest in the spinosad plots (610,452 cut stems ha^{-1}), followed by flonicamid (606,076), clothianidin (600,056), acetamiprid (598,000), thiamethoxam (597,075) and dimethoate (596,450), against 595,060 in the untreated control (Table 9). Additional yield over control ranged from 1,390 to 15,392 stems ha^{-1} (0.23–2.59%), worth Rs 4,170–46,176 ha^{-1} . Although the relative yield gain was small, the value of the additional stems exceeded the cost of all treatments. The ICBR was highest for spinosad (7.38:1) and flonicamid (6.89:1), followed by clothianidin (5.38:1), acetamiprid (4.73:1), thiamethoxam (3.41:1) and dimethoate (1.29:1). The net gain over the cost of treatment was Rs 39,923 ha^{-1} for spinosad and Rs 28,253 ha^{-1} for flonicamid, but only Rs 936 ha^{-1} for dimethoate. Spinosad, despite having the highest treatment cost (Rs 6,252.80 ha^{-1}), was therefore the most profitable choice, in agreement with Vanisree *et al.* (2013), who found spinosad the most economical option for chilli. Yield values are treatment means extrapolated from small plots to a hectare basis and should be confirmed in larger plots.

Table 9. Economics of insecticides applied against thrips on gerbera (two sprays), Rabi 2023–24

Treatment	Marketable yield (cut stems ha^{-1})	Additional yield over control (stems ha^{-1})	Increase over control (%)	Value of additional yield (Rs ha^{-1})	Cost of treatment (Rs ha^{-1})	Net gain (Rs ha^{-1})	ICBR
Spinosad 45 SC	610,452	15,392	2.59	46,176	6,252.80	39,923	7.38:1
Flonicamid 50 WG	606,076	11,016	1.85	33,048	4,795.00	28,253	6.89:1
Thiamethoxam 25 WG	597,075	2,015	0.34	6,045	1,775.20	4,270	3.41:1
Acetamiprid 20 SP	598,000	2,940	0.49	8,820	1,863.60	6,956	4.73:1
Dimethoate 30 EC	596,450	1,390	0.23	4,170	3,234.16	936	1.29:1
Clothianidin 50 WDG	600,056	4,996	0.84	14,988	2,784.00	12,204	5.38:1
Untreated control	595,060	–	–	–	–	–	–

Price of cut stem = Rs 3; labour = Rs 800 per spray per person per hectare. Cost of treatment includes insecticide and labour for two sprays. Net gain = value of additional yield – cost of treatment; ICBR = value of additional yield $\div$ cost of treatment.

CONCLUSION

Thrips occurred on gerbera throughout the January–March crop period at Pusa, peaking at 26.07 plant⁻¹ in the second week of March, and the population was significantly and negatively associated with evening relative humidity, with a marginally significant positive association with maximum temperature. Cultivars Soulmate, Stanza and Balance carried the lowest thrips populations and Goliath, Atlanta and Brilliance the highest, so choice of cultivar can reduce, though not remove, thrips pressure. Among the insecticides, spinosad 45 SC (162 ml ha⁻¹) was the most effective and most economical, followed by flonicamid 50 WG (150 g ha⁻¹); dimethoate 30 EC was the least effective and least remunerative. Because spinosad and flonicamid belong to different IRAC mode-of-action groups, they can be alternated when thrips reach the economic threshold, in line with label recommendations. These results are from a single season and should be validated over further seasons and in commercial polyhouses.

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