



RESEARCH ARTICLE

Effect of biodynamics on arthropod populations in green gram (*Vigna radiata* (L.) R.Wilczek)

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Received: 24 November 2025; Accepted: 16 March 2026; Available online: Version 1.0: 31 May 2026

Cite this article: Shradha P, Soumitra BD, Jyoti K, Shraddha T, Nirmal P. Effect of biodynamics on arthropod populations in green gram (*Vigna radiata* (L.) R.Wilczek). Plant Science Today. 2026; 13(sp2): 1-15. <https://doi.org/10.14719/pst.12913>

Abstract

During the kharif season, green gram is a crucial pulse crop. However, arthropod pests, especially jassids and whiteflies, which also serve as yellow mosaic virus vectors, severely limit its yield. Biodynamic formulations and other sustainable pest management strategies are becoming increasingly popular since they are safe for beneficial insects and environment. A field study was carried out on management of arthropods on green gram with biodynamics at Jabalpur, Madhya Pradesh, during the 2022–23 kharif season. Nine treatments, including an untreated control and three replications, were included in the randomised block design experiment. Two concentrations of biodynamic formulations, including Brahmastra, Agniastra, Neemastra and Dasparni Ark, were used. Crop yield, economics, safety to natural enemies, yellow mosaic virus incidence and pest populations all were observed. The result revealed that the most successful treatment was Brahmastra at 45 mL/L, which significantly reduced the infection of yellow mosaic virus as well as the populations of whiteflies and jassids. Brahmastra at 30 mL/L, Agniastra at 45 mL/L, Agniastra at 30 mL/L, Neemastra at 45 mL/L and Neemastra at 30 mL/L followed this treatment, which also produced the best seed production and economic benefits. In comparison, Dasparni Ark at 30 mL/L treatments were less successful. Additionally, it was discovered that all biodynamic treatments were safe for natural enemies. The study showed that biodynamic formulations, especially Brahmastra at 45 mL/L, provide a cost-effective, environmentally safe and efficient way to control whitefly and jassids in green gram. Adoption of these formulations can promote integrated pest control techniques and sustainable crop production, particularly for farmers looking for affordable and environmentally suitable substitutes.

Keywords: green gram; organic farming; whitefly; yellow mosaic virus

Introduction

Mung bean, (*Vigna radiata* (L.) R. Wilczek) (Family: Leguminosae, Subfamily: Papilionaceae) is third important pulse crop of India grown in nearly 16 % of the country's total pulse cultivation area (1). India is the world largest mung bean producer covering 65 % of world's acreage and 54 % global production (2, 3). In India it is grown in about 4.5 million hectares with total production of 2.5 million tonnes with a productivity of 584 kg/ha (1). In Madhya Pradesh, the total area under mung bean cultivation is 4.18 lakh hectares with the production of 3.46 lakh tonnes and productivity of 828 kg/ha (4). In Jabalpur, mung bean is cultivated over an area of 428 ha with the production of 241 metric tonnes and the productivity is 563 kg/ha (1). Green gram can be grown all year round due to its short growing season and suitability for crop rotation and intercropping. Historically, pulses have played a significant role in the Indian cuisine (5). It is regarded as the best option for balanced meals since it is a highly nutritious pulse crop with 24 % protein, 59.9 % carbohydrates and 40–70 ppm iron (6, 7). In addition to seeds, Asian cuisine also greatly enjoys its sprouts, which are rich in vitamin C and folate (8). It also provides adequate amounts of vitamin B. Different parts of the nation consume them in different ways (5). Bugs are

the key pests that are known to cause a yield reduction of approximately 54.9 % in green gram (9–11).

The green gram is infested by various insects which are categorised as pod borers such as spotted pod borer (*Maruca vitrata*), gram caterpillar (*Helicoverpa armigera*), foliage feeders like tobacco caterpillar (*Spodoptera litura*), bihar hairy caterpillar (*Spilarctia obliqua*) and sucking pests such as jassids (*Empoasca* sp.), whiteflies (*Bemisia tabaci*), green leaf hopper (*Nephotettix* sp.), aphid (*Aphis craccivora*) and other like grey weevil (*Myloccerus* sp.), blister beetle (*Mylabris pustulata*), epilachna beetle (*Epilachna* sp.) thrips (*Caliothrips* sp. and *Megalurothrips distalis* Karny) (12). For the natural regulation of these insects in green gram crop some natural enemies also recorded which includes spider (Fig. 1), lady bird beetle (Fig. 2 and 3), dragonfly, damselfly, rove beetle and black garden ant (13). Whitefly (*B. tabaci*) (Fig. 4), jassids (*E. kerr*) (Fig. 5) and thrips (*Caliothrips indicus*) are the major sucking pest complex in green gram during summer (14). Infestation by these pests results in leaf blistering and cupping (15). *Bemisia tabaci* is undoubtedly the most challenging polyphagous pest with more than 900 host plant species belonging to more than 89 families (16, 17). Whitefly adults and nymphs directly feed on the cell sap (18). In addition to reducing photosynthetic activity, yellowing of the leaves manifests as



Fig. 1. Lynx spider (*Oxyopes birmanicus*).



Fig. 2. Transverse ladybird beetle (*Coccinella transversalis*).



Fig. 3. Zigzag ladybird beetle (*Cheilomenes sexmaculata*).



Fig. 4. White fly (*Bemisia tabaci*).



Fig. 5. Jassid (*Empoasca kerri*).

undefined blotches along the veins. In addition, leaves that are severely attacked dry out too quickly, wrinkle and wither. Reduced yields are the result of affected plants producing fewer flowers and pods that shrivel and produce smaller grains (19). Sowing timing has a significant impact on pest appearance, population fluctuations, infestation rate and crop output (20). Without considering the best times to sow, most farmers typically plant mung bean just after harvesting the rabi crops (21).

Among the sucking pests, whitefly act as vector of mungbean yellow mosaic virus (MYMV) (22) which was first reported from mungbean field in India by Nariani in 1960 (23). Viral aggregates show up in the host cell nuclei around two days prior to the onset of symptoms after entering the host's phloem cells via the whitefly proboscis (24). The obvious signs start off as sporadic yellow spots on the young leaves, which eventually develop into a yellow mosaic pattern and lead to the leaves total yellowing, drying and withering (Fig. 6). The infected mungbean plants pods shrink in size and the leaves turn yellow, which reduces photosynthetic efficiency and eventually results in a significant yield penalty (19).



Fig. 6. Yellow mosaic virus infection.

Numerous variables are endangering the effectiveness and sustained use of agrochemical pesticides, despite their long history of effective control. These include the emergence of pesticide resistance and the use-cancellation or deregistration of some pesticides because of environmental and health risks. The environmentally friendly substitute is the requirement for better pest management techniques, which is one way to produce agricultural products of higher quality (25). Insecticides not only kill the intended creatures but also affect non-target organisms like humans, fish, birds and natural adversaries of insect pests, as well as contaminating the soil and water (26). In India, organic farming based on natural products and indigenous approaches has been practiced for many years and is now forming an important component of modern farming practices. Therefore, there is a need to use bio-pesticides which are effective, biodegradable and do not leave any harmful effect on environment. To minimise ill effects of synthetic insecticides, it is now high time to use bio-pesticides. Four new bio-pesticides viz., Brahmastra, Agniashtra, Neemastra and Dasparni Ark extract from Neem, *Ipomoea*, *Calotropis*, *Annona squamosa* L., Garlic, Chilli, Tobacco, etc. with cow urine and cow dung have been evaluated.

Materials and Methods

The field experiment was carried out at the Integrated Farming System Unit of Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalyaya, Jabalpur (Madhya Pradesh). The experiment was conducted during kharif season from August to October 2022. Mung bean variety Shikha was sown on the plot size 11 × 6 m² with 30 cm row to row and 10 cm plant to plant distance. All the agronomical procedure were fulfilled.

Pre-treatment observations of major green gram insect pests were recorded 24 hr before spray and post-treatment observations was recorded 3, 7 and 10 days after each spray. Observations of arthropods was recorded from 10 randomly

selected plants from each plot. Jassids population was recorded on two leaves, uppers, middle and lower per plant. The population of whitefly was counted using a caging method based on the number of adults per plant. Ladybird beetle and spider population were recorded on the basic of adult per plant. Yellow mosaic virus infection (%) was calculated by using below formula and infection was recorded by tagging each infected plant in the plot.

$$\text{Yellow mosaic virus infection (\%)} = \frac{\text{Yellow mosaic virus infected plants in a plot}}{\text{Total number of plants in a plot}} \times 100$$

The 30 mL/L and 45 mL/L doses chosen for this analysis are within the concentration range (30–50 mL/L) that previously assessed (27). To improve the dose response relationship and choose an economically viable and physiologically efficient concentration under field conditions, 45 mL/L was selected as an intermediate dose between 40 mL/L and 50 mL/L evaluated previously, even though 30 mL/L represents a validated lower effective concentration.

Spray schedule

The treatment detail presented in Table 1

1st spray: 21 days after germination

2nd spray: 15 days after 1st spray

3rd spray: 15 days after 2nd spray

Preparation of biodynamics

Brahmastra

Inputs needed: Cow urine (20 L), paste of neem, karanj, custard apple, mango leaves (2 kg each) and water (100 L).

Preparation: Mixed cow urine (20 L), paste of neem (2 kg), karanj (2 kg), custard apple (2 kg), mango leaves (2 kg) in 100 L of water in a container and stirring it in clockwise direction with the help of wooden stick and boiled it for half an hour, after this allowed to cool for 48 hr. After cooling filtered the solution with muslin cloth and stored in plastic drum under shade condition and then use the solution for spray. Take 15 L solution, dilute it in 500 L water and use it for 1 ha area. Water quantity can be varied according to crop. It can be store for 6 to 12 months.

Agniashtra

Inputs needed: Cow urine (20 L), paste of neem leaves (2 kg), tobacco powder and paste of green chilli (500 g each), paste of garlic (250 g), turmeric powder (200 g) and water (200 L).

Preparation: Mixed cow urine (20 L), paste of neem leaves (2 kg), tobacco powder (500 g) and paste of chilli (500 g), paste of garlic (250 g), turmeric powder (200 g) and water (200 L) in a container and allowed for boiling for half an hour, then it kept for cooling up to 48 hr and then filtered with muslin cloth and stored in plastic

Table 1. Details of treatments

Treatments	Treatments name	Dose (mL/L)
T ₁	Agniashtra	45
T ₂	Agniashtra	30
T ₃	Brahmastra	30
T ₄	Brahmastra	45
T ₅	Dasparni Ark	30
T ₆	Dasparni Ark	45
T ₇	Neemastra	30
T ₈	Neemastra	45
T ₉	Untreated control	-

drum. Stirring of mixture twice in a day at morning and evening. Dilute 15 L of solution in 500 L water to 1 ha area. It can be stored for 3 months.

Neemastra

Inputs needed: Cow urine (10 L), cow dung (2 kg), paste of neem leaves (10 kg) and 200 L water.

Preparation: Added cow urine (10 L), cow dung (2 kg) and paste of neem leaves (10 kg) in 200 L water in a container and stirred well in clockwise direction than it covered with muslin cloth. After that the solution was kept in shade for 48 hr and stirred every morning and evening in clockwise direction. After 48 hr the prepared solution was filtered with muslin cloth and kept in a plastic drum. Mix 15 L of the solution with 500 L of water and use as a spray for one ha of land. Quantity of water depends on crop. It can be stored for 6 months.

Dasparni Ark

Inputs needed: Cow urine 20 L, cow dung 2 kg, 200 L of water, leaves of neem, karanj, castor, beal, tulsi, mango, calotropis, hibiscus, guava, marigold 2 kg of each, tobacco powder and green chili paste (1 kg each), ginger paste (200 g) and garlic paste (500 g).

Preparation: Cow urine 20 L and cow dung 2 kg was taken in a plastic drum having 200 L of water and mixed well. Leaves of neem, karanj, castor, beal, tulsi, mango, calotropis, hibiscus, guava and marigold (2 kg of each) was added after that tobacco leaves (1 kg), ginger paste (200 g), chili paste (1 kg) and garlic paste (500 g) was added in the mixture and kept overnight. Stirred well with the help of wooden stick in clockwise direction, covered with muslin cloth and after that mixture was kept for 48 days under shade condition for fermentation and stirred twice morning and evening every day. At last mixture was filtered after 48 days with the muslin cloth. Add 15 L of solution to 500 L of water and spray it over 1 ha area. The amount of water depending on the crop.

Statistical analysis

All the research data was transformed using the relevant transformation technique (i.e. square root transformation for whitefly, jassids, spider and ladybird beetle and arcsine transformation for yellow mosaic virus) and then statistically analysed using the proper analysis of variance technique (28).

Analysis of randomized block design

The results obtained from the randomized block design (RBD) experiment are presented in Table 2.

$$\text{Correction factor (CF)} = \frac{\text{Grand total (GT)}}{RT}$$

$$\text{TSS} = [(y_{11})^2 + \dots + (y_{93})^2] - \text{CF}$$

$$\text{SST} = \frac{(t_1)^2 + \dots + (t_9)^2}{R} - \text{CF}$$

$$\text{SSR} = \frac{(r_1)^2 + (r_2)^2 + (r_3)^2}{T}$$

$$\text{SSE} = \text{TSS} - \text{SST} - \text{SSR}$$

Where,

TSS = Total sum of square

SST = Treatment sum of square

SSR = Replication sum of square

SSE = Error sum of square

Skeleton of analysis of variance

The statistical framework used for the randomised block design (RBD) is presented as the skeleton of analysis in Table 3

Where,

R = Number of replications

T = Number of treatments

Table 2. Layout for analysis of randomised block design (RBD)

Treatments	R ₁	R ₂	R ₃	Total
T ₁	y ₁₁	y ₁₂	y ₁₃	t ₁
T ₂	y ₂₁	y ₂₂	y ₂₃	t ₂
T ₃	y ₃₁	y ₃₂	y ₃₃	t ₃
T ₄	y ₄₁	y ₄₂	y ₄₃	t ₄
T ₅	y ₅₁	y ₅₂	y ₅₃	t ₅
T ₆	y ₆₁	y ₆₂	y ₆₃	t ₆
T ₇	y ₇₁	y ₇₂	y ₇₃	t ₇
T ₈	y ₈₁	y ₈₂	y ₈₃	t ₈
T ₉	y ₉₁	y ₉₂	y ₉₃	t ₉
Total	r ₁	r ₂	r ₃	GT

Table 3. Skeleton of analysis of variance (ANOVA)

Source of Variance	d.f.	S.S.	M.S.S.	F-calculated	F-tabulated
Replication	(r-1)	SSR	$VR = \frac{SSR}{r-1}$	VR/VE	-
Treatments	(t-1)	SST	$VT = \frac{SST}{t-1}$	VT/VE	F at 5% (t-1), (r-1) (t-1)
Error	(r-1) (t-1)	SSE	$VE = \frac{SSE}{(r-1)(t-1)}$	-	-
Total	(rt-1)	-	-	-	-

VR = Replication mean sum of square

VT = Treatment mean sum of square

VE = Error mean sum of square

The significance among different treatment means was estimated by critical difference (CD) at a 5 % level of significance for association among the treatments, for which the marginal means of each treatment was considered.

The following formula was used for various estimations.

Standard error of mean ($SEm \pm$) = $\sqrt{[(E.ms)/R]}$

Critical difference (C.D.) = $SEm \pm x\sqrt{2} \times t_{0.05}$

Where,

EMS = Error mean sum of square

$t_{0.05}$ = 't' value at 5 % level at error degree of freedom.

$SEm \pm$ = Standard error of any treatment mean

CD = Critical Difference

Assessment of benefit cost ratio

Incremental cost benefit ratio (ICBR) was also worked out to compare the economics of different treatments as given formula:

Where,

Adjusted net return = Net return from individual treated plot (₹/ha)
– Cost of pest management (₹/ha)

Cost of pest management (₹/ha) = Cost of treatments + Labour charges per hectare

Results

Efficacy of biodynamics against whitefly incidence

Effect after first and second spray

The population of whitefly in all the treatments was significantly lower than control as shown in Table 4. The lowest population of whitefly was recorded with Brahmastra at 45 mL/L which was significantly superior to all other treatments except Brahmastra at 30 mL/L. Brahmastra is more effective than Agniastra, Neemastra and Daspami Ark due to its chemical profile (more insecticidal/antifeedant compounds and microbial compounds produced after fermentation), superior persistence and systemic action in the field and desirable composition used in trials that produce stronger mortality or repellence against sucking pests. Followed by Agniastra at 45 mL/L however it was at par with Agniastra at 30 mL/L and Neemastra at 45 mL/L. Neemastra at 30 mL/L and Daspami Ark at 45 mL/L were the next effective treatments and they were comparable to one another. The highest whitefly population was observed in Daspami Ark at 30 mL/L because Daspami Ark, an aqueous distillate or ferment of many leaves, typically contains less of the hydrophobic/stable insecticidal compounds (such as azadirachtin and some terpenoids) that neem-based or combined fermented preparations provide, but more polar phytochemicals (phenols, saponins, proteins). Its residual action and broad-spectrum lethality are diminished by this shift in phytochemical spectrum.

Effect after third spray

The lowest population of whitefly which was recorded with the application of Brahmastra at 45 mL/L and is represented in Table 5. It was then followed by Brahmastra at 30 mL/L and Agniastra at

45 mL/L which were at par and significantly superior to Neemastra at 45 mL/L, Neemastra at 30 mL/L, Daspami Ark at 45 mL/L, Daspami Ark at 30 mL/L and control plot.

Overall mean of three sprays

The lowest mean population of whitefly by incorporating Brahmastra at 45 mL/L was significantly superior to all other treatments (Fig. 7; Table 5). Followed by Brahmastra at 30 mL/L which was significantly better than all other treatments except Agniastra at 45 mL/L. The next effective treatment was T_2 which was found to be significantly better than T_7 , T_6 and T_5 except T_8 . The highest population was recorded in control which was again significantly inferior to all other treatments.

Efficacy of biodynamics against jassids incidence

Effect after first spray

The population of jassids in all the treatments was significantly lower than control as the data showed in the Table 6. The lowest population of jassids was recorded with Brahmastra at 45 mL/L which was significantly superior to all other treatments except Brahmastra at 30 mL/L. Followed by Agniastra at 45 mL/L however it was at par with Agniastra a 30 mL/L. The next best treatments were Neemastra at 45 mL/L, Neemastra at 30 mL/L, Daspami Ark at 45 mL/L which were similar to each other and Daspami Ark at 30 mL/L had the highest population of jassids which were significantly inferior to all the treatments.

Effect after second spray

The values in the Table 6 depicted that the population of jassids in all the treatments was significantly lower than control. The lowest population of jassids was recorded with Brahmastra at 45 mL/L which was significantly superior to all other treatments except Brahmastra at 30 mL/L. Followed by Agniastra at 45 mL/L and which was comparable to Agniastra at 30 mL/L and Neemastra @ 45 mL/L. The highest jassids population was observed in Daspami Ark at 30 mL/L which was significantly inferior to all other treatments except Daspami Ark at 45 mL/L and Neemastra at 30 mL/L.

Effect after third spray

The population of jassids in all the treatments was significantly lower than control as represented in Table 7. The lowest population of jassids was recorded with Brahmastra at 45 mL/L which was significantly better than other treatments. The next effective treatments were Brahmastra at 30 mL/L, Agniastra at 45 mL/L and Agniastra at 30 mL/L which were found at par with each other and significantly superior to Neemastra at 45 mL/L, Neemastra at 30 mL/L, Daspami Ark at 45 mL/L and Daspami Ark at 30 mL/L.

Overall mean of three sprays

The population of jassids in all the treatments was significantly inferior to that of the control, it is represented in Fig. 8 and Table 7. The lowest population of jassids was recorded with Brahmastra at 45 mL/L which was significantly superior to all other treatments except Brahmastra at 30 mL/L. Followed by Agniastra at 45 mL/L which was significantly better than all other treatments except T_2 . Next effective treatment was T_8 which was significantly better than T_5 except T_7 and T_6 .

Efficacy of biodynamics against yellow mosaic virus

No infected plants were observed before third spray of treatments.

Table 4. Bio-efficacy of bio-dynamics against whitefly infestation in green gram

Treatment code	Treatment	Dose (mL/L)	Mean population of white fly/plant										Reduction (%)		
			Pre treatment			After first spray			Reduction (%)						
			3 DAS	7 DAS	10 DAS	Mean	Mean	Pre treatment	3 DAS	7 DAS	10 DAS	Mean			
T ₁	Agniastra	45	5.61 (2.37)	4.57 (2.14) ^e	4.44 (2.11) ^f	4.52 (2.13) ^{de}	4.55 (2.13) ^{ef}	4.52 (2.13) ^{de}	29.42 (32.77) ^c	5.46 (2.34)	4.49 (2.12) ^{ef}	4.39 (2.10) ^f	4.56 (2.14) ^{ef}	4.48 (2.12) ^{de}	35.25 (36.40) ^c
T ₂	Agniastra	30	6.15 (2.48)	4.71 (2.17) ^d	4.52 (2.13) ^{ef}	4.62 (2.15) ^{cd}	4.63 (2.15) ^e	4.62 (2.15) ^{cd}	27.85 (31.75) ^d	5.89 (2.43)	4.58 (2.14) ^e	4.48 (2.12) ^{ef}	4.66 (2.16) ^{def}	4.57 (2.14) ^d	33.88 (35.57) ^d
T ₃	Brahmastra	30	5.90 (2.43)	4.39 (2.09) ^f	4.27 (2.07) ^g	4.38 (2.09) ^{ef}	4.47 (2.11) ^g	4.38 (2.09) ^{ef}	31.69 (34.21) ^b	5.75 (2.40)	4.41 (2.10) ^{fg}	4.26 (2.06) ^g	4.48 (2.12) ^g	4.38 (2.09) ^{ef}	36.61 (37.21) ^b
T ₄	Brahmastra	45	6.20 (2.49)	4.29 (L) (2.07) ^f	4.12 (L) (2.03) ^h	4.25 (L) (2.06) ^f	4.35 (L) (2.09) ^g	4.25 (L) (2.06) ^f	33.61 (H) (35.38) ^a	5.69 (2.39)	4.33 (L) (2.08) ^g	4.19 (L) (2.05) ^g	4.32 (L) (2.08) ^g	4.28 (L) (2.07) ^f	38.11 (H) (38.10) ^a
T ₅	Daspami Ark	30	6.06 (2.46)	5.07 (2.25) ^b	5.03 (2.24) ^b	5.07 (2.25) ^b	5.12 (2.26) ^b	5.07 (2.25) ^b	20.52 (L) (26.77) ^g	6.02 (2.45)	5.18 (2.28) ^b	5.02 (2.24) ^b	5.17 (2.27) ^b	5.12 (2.26) ^b	25.90 (L) (30.54) ^g
T ₆	Daspami Ark	45	6.10 (2.47)	5.00 (2.24) ^b	4.90 (2.21) ^c	4.97 (2.23) ^b	5.01 (2.24) ^b	4.97 (2.23) ^b	22.40 (28.12) ^f	6.04 (2.46)	4.94 (2.22) ^c	4.82 (2.20) ^c	4.92 (2.22) ^c	4.90 (2.21) ^c	29.21 (32.68) ^f
T ₇	Neemastra	30	6.03 (2.45)	4.84 (2.20) ^c	4.74 (2.18) ^d	4.82 (2.20) ^{bc}	4.89 (2.21) ^c	4.82 (2.20) ^{bc}	24.70 (29.71) ^e	5.81 (2.41)	4.81 (2.19) ^{cd}	4.70 (2.17) ^{cd}	4.86 (2.20) ^{cd}	4.79 (2.19) ^c	30.75 (33.65) ^e
T ₈	Neemastra	45	6.24 (H) (2.50)	4.72 (2.17) ^d	4.60 (2.14) ^e	4.69 (2.17) ^{cd}	4.76 (2.18) ^d	4.69 (2.17) ^{cd}	26.78 (31.08) ^d	6.08 (2.47)	4.76 (2.18) ^d	4.64 (2.15) ^{de}	4.81 (2.19) ^{cde}	4.74 (2.18) ^c	31.50 (34.11) ^e
T ₉	Control	-	5.50 (2.35)	5.98 (H) (2.45) ^a	6.43 (H) (2.54) ^a	6.43 (H) (2.53) ^a	6.87 (H) (2.62) ^a	6.43 (H) (2.53) ^a	-	5.89 (3.43)	6.63 (H) (2.57) ^a	7.01 (H) (2.65) ^a	7.13 (H) (2.67) ^a	6.92 (H) (2.63) ^a	-
	SEm±		0.06	0.007	0.007	0.02	0.007	0.02	0.32	0.04	0.01	0.01	0.02	0.01	0.18
	CD at 5%		NS	0.02	0.02	0.05	0.02	0.05	0.97	NS	0.03	0.03	0.05	0.03	0.55

NS = Non-significant; H= Highest; L= Lowest, as per DMRT test – means followed by different letters are significantly different () Figures in the parentheses are square root transformed value and arcsine transformed values

Table 5. Bio-efficacy of bio-dynamics against whitefly infestation in green gram

Treatment code	Treatment	Dose (mL/L)	Mean population of white fly/plant												
			Pre treatment			After third spray			Reduction (%) Pre treatment			After overall spray			Reduction (%)
			3 DAS	7 DAS	10 DAS	Mean	3 DAS	7 DAS	10 DAS	Mean	3 DAS	7 DAS	10 DAS	Mean	
T ₁	Agniastra	45	5.55 (2.35)	3.69 (1.92) ^{de}	3.39 (1.84) ^{cd}	3.55 (1.88) ^{de}	48.13 (43.91) ^c	5.54 (2.35)	4.25 (2.06) ^{fg}	4.14 (2.03) ^{ef}	4.17 (2.04) ^f	4.18 (2.05) ^g	37.79 (37.90) ^c		
T ₂	Agniastra	30	5.92 (2.43)	3.80 (1.95) ^{cde}	3.57 (1.89) ^{bcd}	3.69 (1.92) ^d	46.16 (42.78) ^d	5.99 (2.45)	4.36 (2.09) ^{ef}	4.23 (2.06) ^e	4.29 (2.07) ^{ef}	4.29 (2.07) ^{ef}	36.16 (36.93) ^d		
T ₃	Brahmastra	30	5.67 (2.38)	3.54 (1.88) ^{ef}	3.35 (1.83) ^d	3.45 (1.86) ^e	49.71 (44.82) ^b	5.77 (2.40)	4.11 (2.03) ^g	3.99 (2.00) ^f	4.10 (2.03) ^f	4.07 (2.02) ^g	39.52 (38.92) ^b		
T ₄	Brahmastra	45	5.58 (2.36)	3.15 (L) (1.77) ^f	3.03 (L) (1.74) ^f	2.79 (L) (1.67) ^e	2.99 (L) (1.73) ^f	56.35 (H) (48.64) ^a	5.82 (2.41)	3.92 (L) (1.98) ^h	3.78 (L) (1.94) ^g	3.82 (L) (1.95) ^g	3.84 (L) (1.96) ^h	42.89 (H) (40.89) ^a	
T ₅	Dasparni Ark	30	6.04 (2.46)	4.42 (2.10) ^b	4.24 (2.06) ^b	4.10 (2.02) ^b	4.25 (2.06) ^b	37.94 (L) (37.98) ^h	6.04 (2.46)	4.91 (2.22) ^b	4.76 (2.18) ^b	4.80 (2.19) ^b	4.82 (2.20) ^b	28.31 (L) (32.08) ^h	
T ₆	Dasparni Ark	45	6.10 (2.47)	4.26 (2.06) ^{bc}	4.15 (2.03) ^{bc}	4.02 (2.00) ^b	4.14 (2.03) ^{bc}	39.55 (38.93) ^g	6.08 (2.47)	4.74 (2.18) ^{bc}	4.62 (2.15) ^{bc}	4.65 (2.16) ^{bc}	4.67 (2.16) ^{bc}	30.58 (33.53) ^g	
T ₇	Neemastra	30	5.88 (2.43)	4.17 (2.04) ^{bcd}	4.05 (2.01) ^{bc}	3.89 (1.97) ^{bc}	4.03 (2.01) ^{bc}	41.13 (39.86) ^f	5.91 (2.43)	4.61 (2.15) ^{cd}	4.50 (2.12) ^{cd}	4.54 (2.13) ^{cd}	4.55 (2.13) ^{cd}	32.37 (34.64) ^f	
T ₈	Neemastra	45	6.16 (2.48)	4.03 (2.01) ^{bcd}	4.00 (2.00) ^{bcd}	3.81 (1.95) ^{bcd}	3.95 (1.98) ^c	42.44 (40.63) ^e	6.16 (2.48)	4.50 (2.12) ^{de}	4.41 (2.10) ^d	4.46 (2.11) ^{de}	4.46 (2.11) ^{de}	33.73 (35.43) ^e	
T ₉	Control	-	6.57 (2.56)	6.55 (H) (2.56) ^a	6.98 (H) (2.64) ^a	7.07 (H) (2.66) ^a	6.87 (H) (2.62) ^a	-	6.09 (2.47)	6.39 (H) (2.53) ^a	6.81 (H) (2.61) ^a	7.02 (H) (2.65) ^a	6.74 (H) (2.60) ^a	-	
	SEm±		0.04	0.04	0.04	0.04	0.02	0.19	0.04	0.01	0.01	0.01	0.01	0.19	
	CD at 5%		NS	0.11	0.12	0.11	0.05	0.57	NS	0.04	0.03	0.04	0.04	0.57	

Table 6. Bio-efficacy of bio-dynamics against jassids infestation in green gram

Treatment code	Treatment	Dose (mL/L)	Mean population of jassids/plant									
			Pre treatment		After first spray		After second spray		Reduction (%)		Reduction (%)	
			3 DAS	7 DAS	10 DAS	Mean	3 DAS	7 DAS	10 DAS	Mean	3 DAS	Mean
T ₁	Agniastra	45	5.76 (2.40)	4.67 (2.16) ^{ef}	4.57 (2.11) ^{de}	4.56 (2.13) ^{ef}	5.67 (2.38)	4.42 (2.10) ^d	4.67 (2.16) ^d	4.60 (2.14) ^{de}	23.53 (28.90) ^c	30.36 (33.38) ^c
T ₂	Agniastra	30	5.71 (2.39)	4.78 (2.19) ^{de}	4.56 (2.13) ^{de}	4.68 (2.16) ^{de}	5.61 (2.37)	4.64 (2.15) ^{cd}	4.78 (2.19) ^{cd}	4.75 (2.18) ^{cd}	21.47 (27.47) ^d	28.16 (31.99) ^d
T ₃	Brahmastra	30	5.39 (2.32)	4.58 (2.14) ^{fg}	4.32 (2.08) ^{ef}	4.45 (2.11) ^{fg}	5.31 (2.30)	4.14 (2.03) ^e	4.36 (2.09) ^e	4.39 (2.09) ^{ef}	25.24 (30.05) ^b	33.54 (35.30) ^b
T ₄	Brahmastra	45	5.48 (2.34)	4.42 (2.10) ^g	4.13 (2.03) ^f	4.28 (2.07) ^g	5.42 (2.33)	3.98 (1.99) ^e	4.18 (2.04) ^e	4.23 (2.06) ^f	28.12 (31.94) ^a	35.84 (36.69) ^a
T ₅	Daspami Ark	30	5.72 (2.39)	5.13 (2.27) ^b	5.00 (2.24) ^b	5.11 (2.26) ^b	5.55 (2.35)	5.04 (2.25) ^b	5.16 (2.27) ^b	5.14 (2.27) ^g	14.31 (22.03) ^h	22.14 (27.97) ^g
T ₆	Daspami Ark	45	5.45 (2.33)	5.05 (2.25) ^{bc}	4.85 (2.20) ^{bc}	4.98 (2.23) ^{bc}	5.36 (2.31)	4.89 (2.21) ^{bc}	5.02 (2.24) ^{bc}	5.01 (2.24) ^{bc}	16.41 (23.71) ^g	24.16 (29.35) ^f
T ₇	Neemastra	30	5.81 (2.41)	4.96 (2.23) ^{bcd}	4.78 (2.19) ^{bc}	4.90 (2.21) ^c	5.70 (2.39)	4.84 (2.20) ^{bc}	4.93 (2.22) ^{bc}	4.93 (2.22) ^{bc}	17.83 (24.82) ^f	25.36 (30.17) ^{ef}
T ₈	Neemastra	45	5.56 (2.36)	4.88 (2.21) ^{cd}	4.66 (2.16) ^{cd}	4.80 (2.19) ^{cd}	5.40 (2.32)	4.74 (2.18) ^c	4.86 (2.20) ^{bc}	4.84 (2.20) ^{cd}	19.41 (25.99) ^e	26.66 (31.02) ^{de}
T ₉	Control	-	5.55 (2.35)	5.65 (2.38) ^a	6.10 (2.47) ^a	5.97 (2.44) ^a	5.60 (2.36)	6.68 (2.58) ^a	6.88 (2.62) ^a	6.62 (2.57) ^a	-	-
	SEm±		0.04	0.02	0.02	0.02	0.04	0.02	0.02	0.02	0.13	0.37
	CD at 5%		NS	0.05	0.05	0.03	NS	0.06	0.06	0.06	0.39	1.13

Table 7. Bio-efficacy of bio-dynamics against jassids infestation in green gram

Treatment code	Treatment	Dose (mL/L)	Mean population of jassids/plant									
			Pre treatment		After third spray		After overall spray		Reduction (%)		Reduction (%)	
			3 DAS	7 DAS	10 DAS	Mean	3 DAS	7 DAS	10 DAS	Mean	3 DAS	Mean
T ₁	Agniastra	45	5.79 (2.41)	4.26 (2.06) ^{bc}	4.11 (2.03) ^{cd}	4.13 (2.03) ^{ef}	5.74 (2.40)	4.32 (2.08) ^{ef}	4.42 (2.10) ^f	4.43 (2.10) ^{ef}	37.22 (37.56) ^c	30.60 (33.53) ^c
T ₂	Agniastra	30	5.74 (2.40)	4.38 (2.09) ^{bc}	4.21 (2.05) ^{bcd}	4.23 (2.06) ^{def}	5.69 (2.38)	4.47 (2.11) ^{de}	4.53 (2.13) ^e	4.55 (2.13) ^{de}	35.67 (36.64) ^d	28.67 (32.31) ^d
T ₃	Brahmastra	30	5.45 (2.33)	4.20 (2.05) ^{bc}	4.01 (2.00) ^{de}	4.04 (2.01) ^f	5.38 (2.32)	4.16 (2.04) ^f	4.25 (2.06) ^g	4.29 (2.07) ^g	38.52 (38.33) ^b	32.68 (34.80) ^b
T ₄	Brahmastra	45	5.54 (2.35)	3.98 (1.99) ^c	3.71 (1.93) ^e	3.76 (1.94) ^g	5.48 (2.34)	3.94 (1.98) ^g	4.01 (2.00) ^h	4.09 (2.02) ^g	42.89 (40.88) ^a	35.87 (36.73) ^a
T ₅	Daspami Ark	30	5.65 (2.38)	4.72 (2.17) ^b	4.54 (2.13) ^b	4.57 (2.14) ^b	5.64 (2.37)	4.86 (2.20) ^b	4.93 (2.22) ^b	4.94 (2.22) ^b	30.56 (33.50) ^h	22.61 (28.30) ^h
T ₆	Daspami Ark	45	5.40 (2.32)	4.60 (2.14) ^b	4.48 (2.12) ^b	4.48 (2.12) ^{bc}	5.40 (2.32)	4.74 (2.18) ^{bc}	4.81 (2.19) ^c	4.82 (2.20) ^{bc}	31.87 (34.33) ^g	24.41 (29.53) ^g
T ₇	Neemastra	30	5.71 (2.39)	4.55 (2.13) ^b	4.40 (2.10) ^{bc}	4.41 (2.10) ^{bcd}	5.74 (2.39)	4.67 (2.16) ^{bc}	4.73 (2.17) ^{cd}	4.75 (2.18) ^{bcd}	32.92 (34.97) ^f	25.63 (30.35) ^f
T ₈	Neemastra	45	5.44 (2.33)	4.48 (2.12) ^b	4.32 (2.08) ^{bcd}	4.35 (2.08) ^{cde}	5.47 (2.34)	4.58 (2.14) ^{cd}	4.65 (2.16) ^d	4.66 (2.16) ^{cd}	33.94 (35.59) ^e	26.92 (31.19) ^e
T ₉	Control	-	6.43 (2.53)	6.34 (2.52) ^a	6.62 (2.57) ^a	6.59 (2.57) ^a	5.86 (2.42)	6.47 (2.54) ^a	6.62 (2.57) ^a	6.39 (2.53) ^a	-	-
	SEm±		0.05	0.04	0.03	0.02	0.04	0.02	0.02	0.02	0.13	0.15
	CD at 5%		NS	0.11	0.08	0.11	NS	0.05	0.03	0.05	0.38	0.44

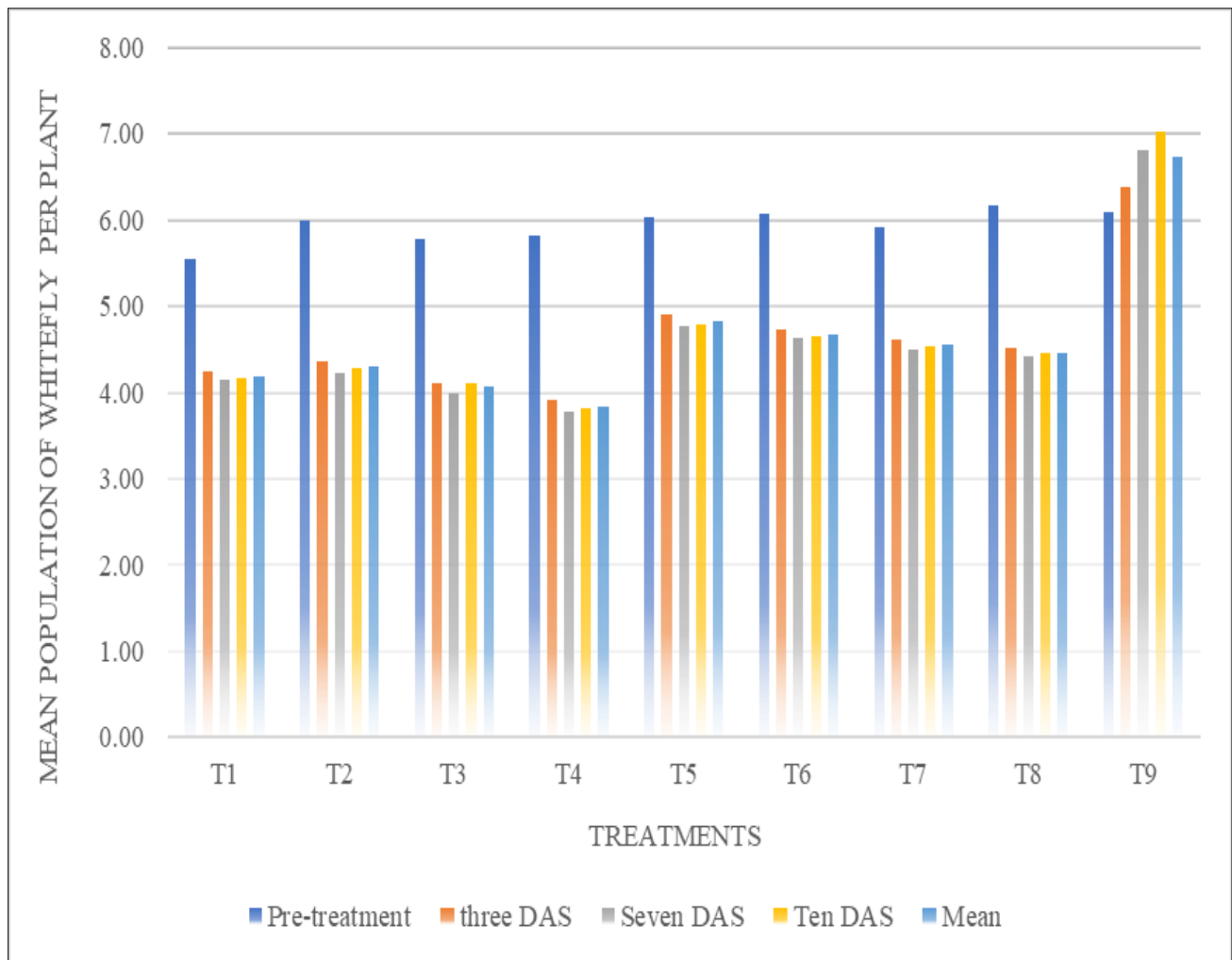


Fig. 7. Overall mean population of whitefly per plant after three sprays.

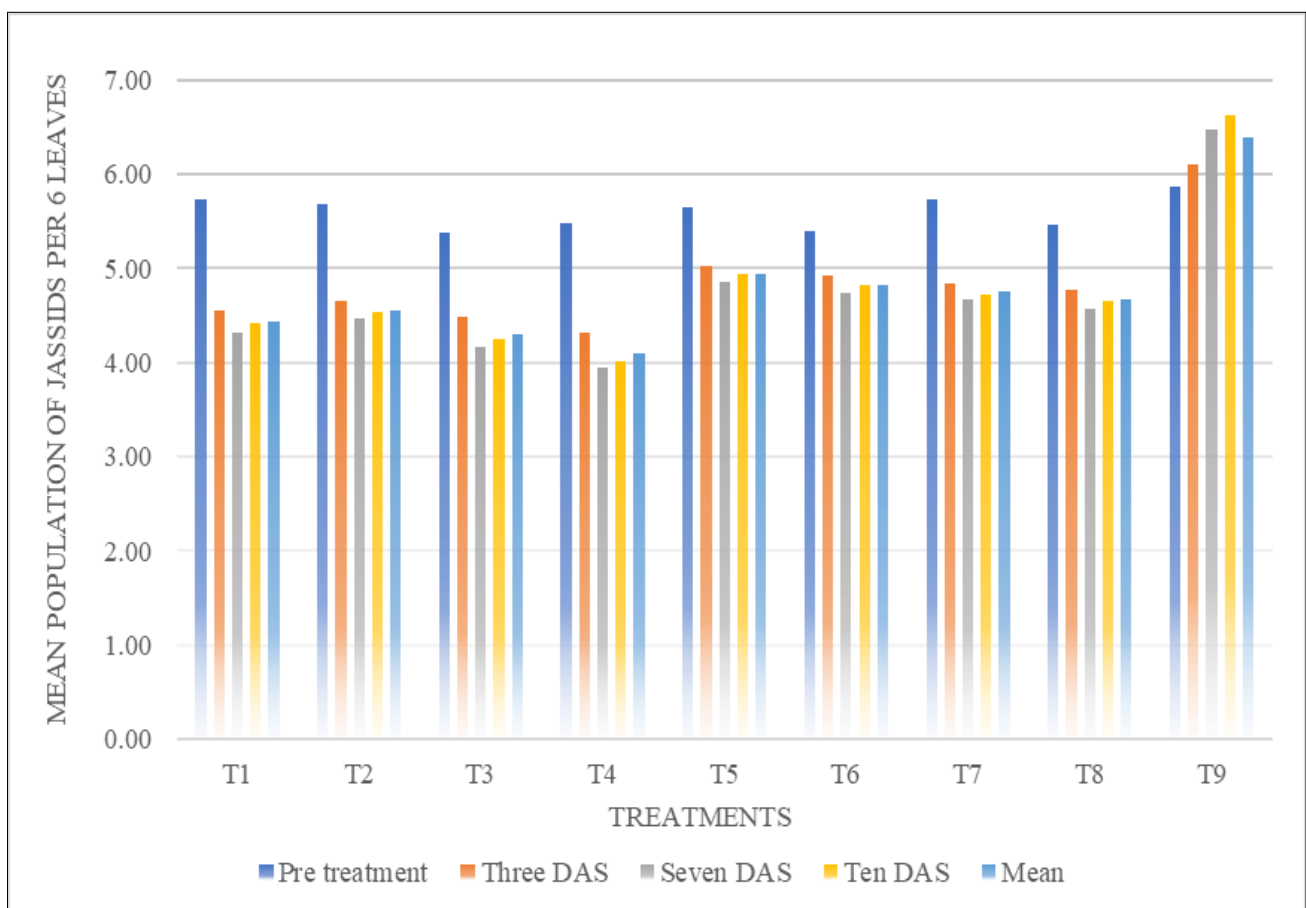


Fig. 8. Overall mean population of jassids per 6 leaves after three sprays.

After third spray

The infection of yellow mosaic virus (Fig. 9; Table 8) in all the treatments was significantly lower than control. The lowest infection of yellow mosaic virus was recorded with Brahmastra at 45 mL/L which was significantly better than all other treatments except Brahmastra at 30 mL/L. Followed by Agniastra at 45 mL/L, Agniastra at 30 mL/L and Neemastra at 45 mL/L which were at par and significantly superior to Neemastra at 30 mL/L, Dasparni Ark at 45 mL/L and Dasparni Ark at 30 mL/L.

Efficacy of biodynamics against ladybird beetle

Mean of three sprays schedule, the mean population of ladybird beetles varied from 0.66 to 0.83 adult per plant and the differences among treatments were found to be non-significant (Fig. 10; Table 9).

Efficacy of biodynamics against spider

Data of the Fig. 11 and Table 9 represented the mean of three sprays schedule; the mean population of spider varied from 0.87 to 0.98 adult per plant and the differences among treatments were found to be non-significant.

Economics of treatments

Impact of biodynamics on yield of kharif green gram

Data presented in Table 10 showed that among the different treatments, maximum yield of green gram during 2022–23 was recorded in Brahmastra at 45 mL/L which was superior to all other treatments. Brahmastra at 30 mL/L was the next effective treatment followed by Agniastra at 45 mL/L which were at par with each other. The next effective treatments were Agniastra at 30 mL/L, Neemastra at 45 mL/L and Neemastra at 30 mL/L which were non-significant with each other. Followed by Dasparni Ark at 45 mL/L and Dasparni Ark at 30 mL/L which were at par with each other.

Cost benefit ratio

Among the treatments, highest cost benefit ratio was registered in Brahmastra at 45 mL/L followed by Brahmastra at 30 mL/L, Agniastra at 45 mL/L, Agniastra at 30 mL/L, Neemastra at 45 mL/L, Neemastra at 30 mL/L, Dasparni Ark at 45 mL/L and Dasparni Ark at 30 mL/L respectively (Table 10).

Discussion

Efficacy of biodynamics against whitefly incidence

The number of whiteflies in each treatment was much lower than the control. The application of Brahmastra at 45 mL/L produced the lowest mean population of whiteflies, which was significantly better than all other treatments, whereas Dasparni Ark at 30 mL/L produced the highest population, which was significantly worse than all other treatments.

The finding was in full conformity with the findings which reported that Brahmastra at 20 % was found highly effective in suppressing the sucking pests viz, whitefly followed by Agniastra and Neemastra at 20 % [Because of various modes of action (repellence + antifeedant), Brahmastra is more efficient than Agniastra and Neemastra in reducing pest longevity] (25). Present finding also supported by the another finding which revealed that Brahmastra 5 % was the best for the control of whitefly followed by Agniastra 3 % (29).

Efficacy of biodynamics against jassids incidence

The jassids population was significantly lower than the control in every treatment. The highest population of jassids was found in Dasparni Ark at 30 mL/L, while the lowest population was found in Brahmastra at 45 mL/L, which was noticeably better than all other treatments except Brahmastra at 30 mL/L.

The findings revealed that the application of Brahmastra at 20 % was found highly effective in suppressing the sucking pests viz, leafhopper followed by Agniastra and Neemastra at 20 % which was similar to present finding (25). It was also compatible with another finding which showed that the leaf hopper population is minimum in the plot treated by Brahmastra followed by Neemastra at 20 % and Agniastra at 20 % (30).

Efficacy of biodynamics against yellow mosaic virus

Yellow mosaic virus infection was significantly lower in all treatments than in the control. Brahmastra at 45 mL/L had the lowest yellow mosaic virus infection, which was significantly better than all other treatments except Brahmastra at 30 mL/L. Dasparni Ark at 30 mL/L had the greatest infection.

Efficacy of biodynamics against ladybird beetle and spider

Spider populations ranged from 0.87 to 0.98 adults per plant, while ladybird beetle populations ranged from 0.66 to 0.83 adults per plant. The population of natural enemies evaluated the treatments were safe and the differences between them were found to be non-significant.

The finding was somewhat compatible with another finding reported that the Brahmastra, Agniastra and Neemastra (20 % each) had no adverse effects on the natural enemies (25).

Economics of treatments

Impact of biodynamics on yield of kharif green gram

Maximum yield of green gram during 2022–23 was recorded in Brahmastra at 45 mL/L which was superior to all other treatments.

Present finding was supported by the result which revealed that the highest seed yield was recorded in plots treated with Brahmastra at 20 % followed by Agniastra at 20 % and Neemastra at 20 % (25). This finding contradicts the results of another one, which reported the highest seed yield in plot treated by Neemastra 10 % followed by Dasparni Ark 10 %, Agniastra 3 % and Brahmastra 5 % because they used the different concentration of biodynamics the higher concentration is more effective than the lower and the parameter is also different, they used it for yield and seed quality purpose (31).

Cost benefit ratio

Highest incremental cost benefit ratio (ICBR) was registered in Brahmastra at 45 mL/L.

The present finding was in accordance with the report that had highest ICBR found in Brahmastra followed by Agniastra and Neemastra (32). Again, similar finding suggested that the highest cost benefit ration found in Brahmastra 5 % followed by Agniastra 5 % and Neemastra 5 % (33).

Table 8. Bio-efficacy of bio-dynamics against yellow mosaic virus infection in green gram

Treatment code	Treatment	Dose (mL/L)	Infection of yellow mosaic virus (%)					
			Pre treatment	3 DAS	7 DAS	10 DAS	Mean	Reduction %
T ₁	Agniastra	45	0.91 (5.44)	1.27 (6.45) ^{de}	1.75 (7.51) ^{cd}	2.02 (8.12) ^d	1.68 (7.36) ^{de}	77.54 (61.88) ^b
T ₂	Agniastra	30	1.14 (6.11)	1.82 (7.74) ^{cd}	1.99 (8.10) ^{bc}	2.27 (8.65) ^{cd}	2.02 (8.16) ^{cd}	73.09 (58.81) ^{bc}
T ₃	Brahmastra	30	0.79 (5.08)	0.91 (5.46) ^{ef}	1.04 (L) (5.84) ^e	1.28 (6.48) ^e	1.08 (5.93) ^{ef}	85.74 (67.87) ^a
T ₄	Brahmastra	45	0.56 (4.26)	0.57 (L) (4.17) ^f	1.37 (6.72) ^{de}	0.81 (L) (5.14) ^f	0.92 (L) (5.34) ^f	86.98 (H) (69.48) ^a
T ₅	Daspami Ark	30	1.35 (6.54)	3.29 (10.33) ^b	2.47 (9.02) ^b	3.25 (10.35) ^b	3.00 (9.90) ^b	60.80 (L) (51.22) ^d
T ₆	Daspami Ark	45	1.25 (6.31)	3.10 (10.10) ^b	2.61 (9.28) ^b	2.80 (9.63) ^{bc}	2.84 (9.67) ^{bc}	62.39 (52.20) ^d
T ₇	Neemastra	30	1.25 (6.09)	2.75 (9.50) ^{bc}	2.60 (9.25) ^b	2.54 (9.16) ^c	2.63 (9.30) ^{bc}	64.89 (53.72) ^d
T ₈	Neemastra	45	1.48 (6.97)	2.19 (8.46) ^{bc}	2.47 (9.03) ^b	2.42 (8.93) ^{cd}	2.36 (8.81) ^{bcd}	68.32 (55.84) ^{cd}
T ₉	Control	-	1.23 (6.27)	8.29 (H) (16.72) ^a	5.94 (H) (14.10) ^a	8.94 (H) (17.37) ^a	7.72 (H) (16.06) ^a	-
	SEm±		0.77	0.60	0.40	0.31	0.49	1.39
	CD at 5%		NS	1.81	1.20	0.94	1.48	4.23

(*)* Figures in the parentheses are arcsine transformed values

Table 9. Bio-efficacy of bio-dynamics against ladybird beetles and spider in green gram

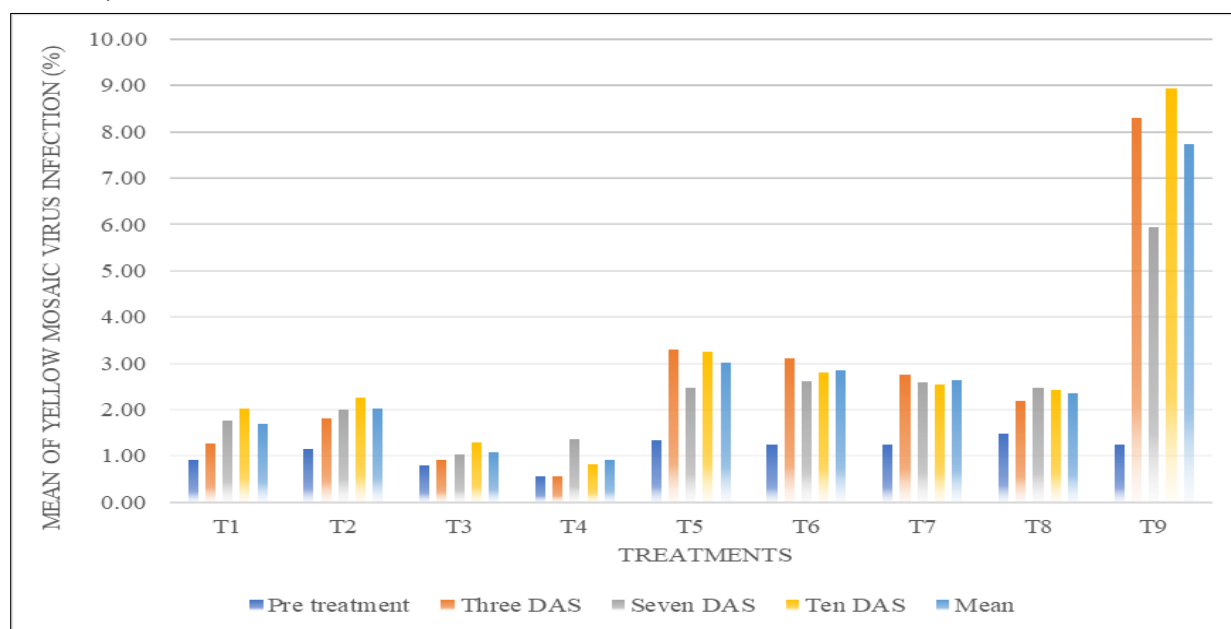
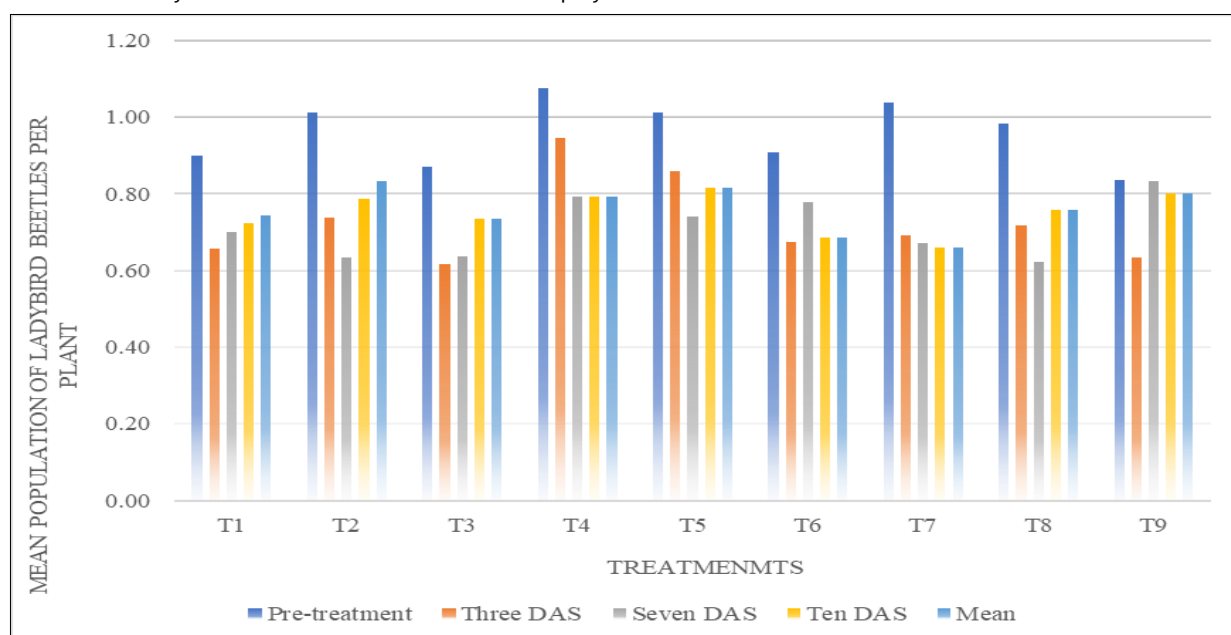
Treatment code	Treatment	Dose (mL/L)	Mean population of ladybird beetles/plant										Mean population of spider/plant			
			Pre treatment					After all three sprays					After all three sprays			
			3 DAS	7 DAS	10 DAS	Mean	Pre treatment	3 DAS	7 DAS	10 DAS	Mean	Pre treatment	3 DAS	7 DAS	10 DAS	Mean
T ₁	Agniastra	45	0.90 (0.95)	0.66 (0.81)	0.70 (0.84)	0.74 (0.84)	0.99 (0.99)	0.75 (0.87)	0.89 (0.94)	0.99 (1.00)	0.88 (0.93)	0.99 (1.00)	0.99 (1.00)	0.89 (0.94)	0.99 (1.00)	0.88 (0.93)
T ₂	Agniastra	30	1.01 (1.01)	0.74 (0.86)	0.63 (0.79)	0.83 (0.85)	1.04 (1.02)	0.98 (0.99)	1.01 (1.01)	0.90 (0.95)	0.96 (0.98)	1.04 (1.02)	0.98 (0.99)	1.01 (1.01)	0.90 (0.95)	0.96 (0.98)
T ₃	Brahmastra	30	0.87 (0.93)	0.62 (0.78)	0.64 (0.80)	0.73 (0.81)	1.01 (1.01)	0.90 (0.95)	0.89 (0.94)	0.83 (0.91)	0.90 (0.95)	1.01 (1.01)	0.90 (0.95)	0.89 (0.94)	0.83 (0.91)	0.90 (0.95)
T ₄	Brahmastra	45	1.07 (1.04)	0.95 (0.97)	0.79 (0.89)	0.79 (0.92)	1.12 (1.06)	0.97 (0.98)	0.98 (0.99)	0.92 (0.95)	0.98 (0.99)	1.12 (1.06)	0.97 (0.98)	0.98 (0.99)	0.92 (0.95)	0.98 (0.99)
T ₅	Daspami Ark	30	1.01 (1.00)	0.86 (0.93)	0.74 (0.85)	0.82 (0.89)	1.11 (1.05)	0.88 (0.94)	0.90 (0.95)	0.87 (0.93)	0.89 (0.94)	1.11 (1.05)	0.88 (0.94)	0.90 (0.95)	0.87 (0.93)	0.89 (0.94)
T ₆	Daspami Ark	45	0.91 (0.95)	0.67 (0.82)	0.78 (0.88)	0.68 (0.84)	1.01 (1.01)	0.86 (0.93)	0.92 (0.96)	1.01 (1.00)	0.95 (0.98)	1.01 (1.01)	0.86 (0.93)	0.92 (0.96)	1.01 (1.00)	0.95 (0.98)
T ₇	Neemastra	30	1.04 (1.02)	0.69 (0.83)	0.67 (0.82)	0.66 (0.82)	1.00 (1.00)	0.87 (0.93)	0.81 (0.90)	0.91 (0.96)	0.87 (0.93)	1.00 (1.00)	0.87 (0.93)	0.81 (0.90)	0.91 (0.96)	0.87 (0.93)
T ₈	Neemastra	45	0.98 (0.99)	0.72 (0.85)	0.62 (0.79)	0.76 (0.83)	0.96 (0.98)	0.99 (0.99)	0.93 (0.96)	0.88 (0.93)	0.93 (0.96)	0.96 (0.98)	0.99 (0.99)	0.93 (0.96)	0.88 (0.93)	0.93 (0.96)
T ₉	Control	-	0.84 (0.91)	0.63 (0.79)	0.83 (0.90)	0.80 (0.87)	0.95 (0.97)	0.96 (0.98)	0.91 (0.95)	0.93 (0.96)	0.93 (0.97)	0.95 (0.97)	0.96 (0.98)	0.91 (0.95)	0.93 (0.96)	0.93 (0.97)
	SEm±		0.03	0.05	0.04	0.03	0.034	0.035	0.038	0.041	0.012	0.034	0.035	0.038	0.041	0.012
	CD at 5%		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

() Figures in the parentheses are square root transformed values

Table 10. Bio-efficacy of bio-dynamics on yield (kg/ha) of green gram 2022-23

Treatment	Grain yield (kg/ha)	Yield increase over control (%)	Increased in yield over control (kg/ha)	Cost of increased yield over control (Rs/ha)	Cost of treatment (Rs/ha)	Net return (Rs/ha)	ICBR
Agniastra at 45mL/L	(898.35) ^{bc}	50.06 (45.02) ^{ab}	451.21	34991.34	3900	31091.34	1:7.97
Agniastra at 30mL/L	(804.22) ^{cd}	44.44 (41.75) ^{bc}	357.08	27691.55	3900	23791.55	1:6.10
Brahmastra at 30 mL/L	(926.32) ^b	51.79 (46.02) ^{ab}	479.18	37160.15	3600	33560.15	1:9.32
Brahmastra at 45 mL/L	(1082.67) ^a (H)	58.70 (50.03) ^a (L)	635.53	49285.61	3600	45685.61	1:12.69
Dasparni Ark at 30 mL/L	(583.43) ^e	23.40 (28.28) ^e (H)	136.29	10569.29	4200	6369.29	1:1.52
Dasparni Ark at 45 mL/L	(656.98) ^e	31.17 (33.24) ^{de}	209.84	16273.35	4200	12073.35	1:2.87
Neemastra at 30 mL/L	(692.67) ^{de}	34.37 (35.49) ^{cd}	245.53	19040.59	3600	15440.59	1:4.29
Neemastra at 45 mL/L	(773.33) ^d	42.00 (40.32) ^{bc}	326.19	25295.78	3600	21695.78	1:6.03
Control	(447.14) ^f (L)	-	-	-	-	-	-
SEm±	36.58	2.09	-	-	-	-	-
CD (5%)	109.67	6.35	-	-	-	-	-

(i) Figures in the parentheses are arcsine transformed values.

**Fig. 9.** Overall mean of yellow mosaic virus infection after third spray.**Fig. 10.** Overall mean population of ladybird beetles adult per plant after all three sprays.

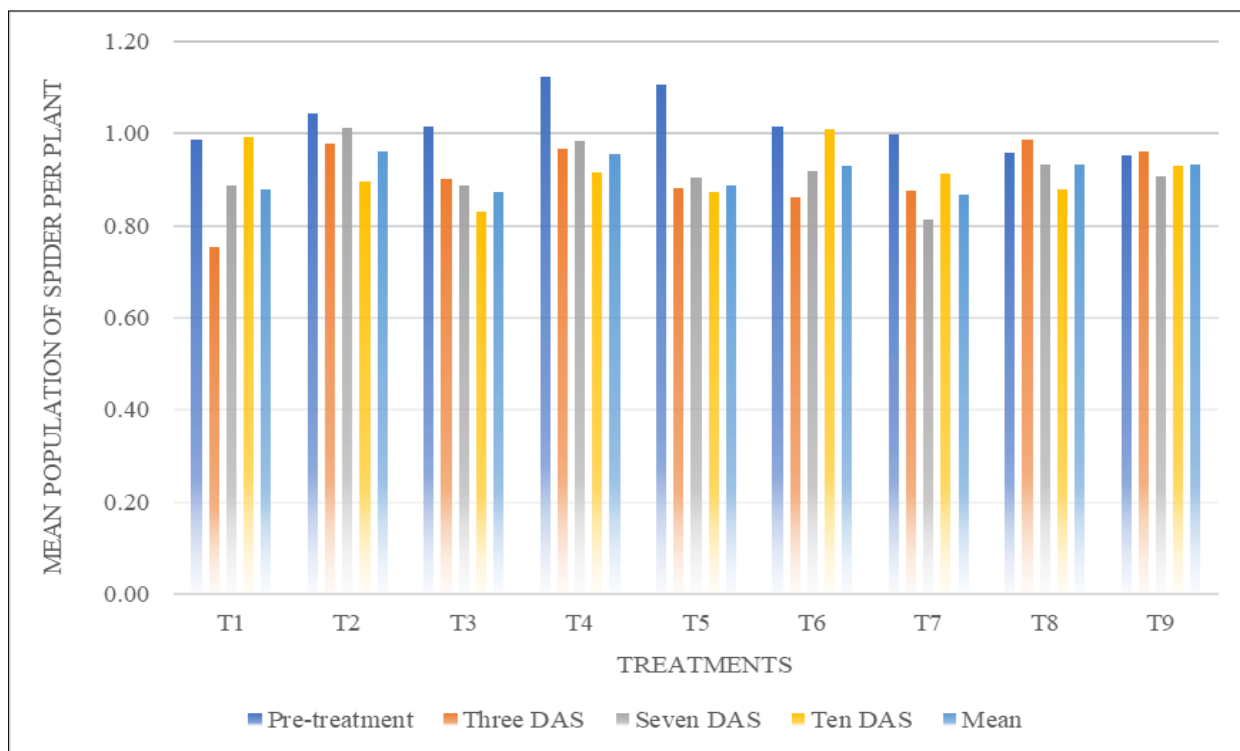


Fig. 11. Overall mean population of spider adult per plant after all three sprays.

Conclusion

Bio-efficacy of 8 biodynamics was evaluated against population of whitefly, jassids, ladybird beetle, spider and yellow mosaic virus infection. Brahmastra at 45 mL/L was found to be the most effective among all the biodynamics against the insects. Followed by Brahmastra at 30 mL/L while Daspami at 30 mL/L was least effective and they were safe for natural enemies. Compared to Daspami Ark, whose distillate/aqueous character can be more volatile and short-lived on foliage, Brahmastra treatments frequently exhibit long-lasting inhibition of sucking pests (measured across repeated sprays). Because of this, Brahmastra had more cumulative control over repeated spray schedules. Cost benefit ratio was highest in Brahmastra 45 mL/L followed by Brahmastra 30 mL/L while Daspami Ark 30 mL/L had lowest cost benefit ratio. This biodynamics had cheap production costs and could be used by farmers to reduce the negative impacts of synthetic pesticides. These biodynamics work well against chewing and sucking pests as well as it improves soil health and crop quality. Despite these advantages, the study acknowledges several drawbacks, such as variations in preparation techniques, required more time to suppress the insect population. To validate and support the wider application of result, more multilocation and long-term experiments are needed.

Authors' contributions

SP carried out the research, collect the data and drafted the manuscript. SBD participated in the design of the study and performed the statistical analysis. SP participated in drafted the manuscript. JK, ST and NP conceived of the study and participated in its design and coordination. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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