

Management of mango stem borer, *Batocera rufomaculata* De Geer by using 'Arka Borer Control'- A multi-location study

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Abstract

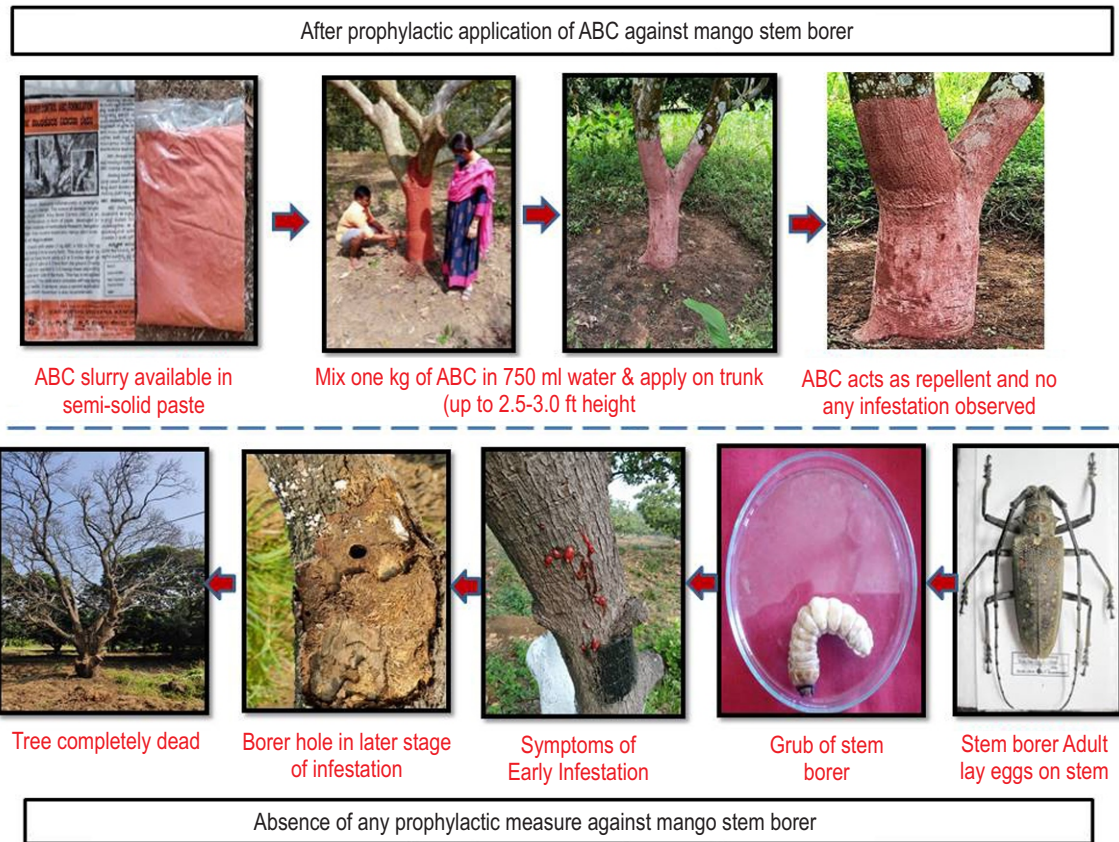
Aim: The mango stem borer, *Batocera rufomaculata* De Geer has been observed to cause an alarming in old and young orchards. ICAR-IIHR, Bengaluru has developed a formulation called "Arka Borer Control" (ABC) for effective management of stem borers. The present study aimed to test the efficacy of ABC product against *B. rufomaculata*.

Methodology: The ABC formulation (T₁) was tested among 17 centers across the country through All India Coordinated Research Project on Fruits (AICRP-F) with other three treatments viz., pasting trunk with Bordeaux paste (BP) @ 10% + chlorpyrifos 20 % EC @ 10 ml l⁻¹ of BP (T₂), recommended/existing practice of the region (T₃) and untreated control (T₄) in RBD design with five replications during 2021 and 2022. Persistency of ABC product applied was also noted as supplementary observation.

Results: The application of ABC minimized the stem borer infestation (79.75 % reduction over control) with lower number of live borer hole (76.00 % reduction over control) at Gangian, Lembuchera, Ludhiana, Medziphema, Rahuri, Rewa, Sabour, Sangareddy and Udaipur centres. The product also persisted for a longer period of time.



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Interpretation: In the present era of organic farming, ABC can be applied as a prophylactic measures on mango tree trunk up to height of 2.5 to 3.0 ft from ground level before the onset of rain for management of stem borer.

Key words: Arka Borer Control, Bordeaux paste, Live borer hole, Mango stem borer

Introduction

Longicorn beetles belonging to the genus *Batocera* are considered as a menace in India (Veeresh, 1989). During the last decade, the mango stem borer, *B. rufomaculata* has been observed to cause an alarming situation in old and young orchards, posing a significant threat to mango cultivation in India (Kannan and Rao, 2006). The extent of damage varies between 5 to 25 per cent, with an additional observation upto 40 per cent damage occurring in high-density planting areas. The recorded species in India encompass *Batocera rufomaculata* De Geer, *B. rubus* (Linnaeus), *B. roylie* (Hope), *B. numitor* (Newmen) and *B. titana* Thompson, and among them *B. rufomaculata* is considered as the most destructive and commonly encountered borer (Gundappa et al., 2021). Major hosts of horticultural importance are mango (*Mangifera indica* L.), jackfruit (*Artocarpus heterophyllus* Lam.), *Ficus* spp., papaya (*Carica papaya* L.), guava (*Psidium guajava* L.) and pomegranate (*Punica granatum* L.) (Singh et al., 2001). In India it has been recorded from

Andaman and Nikobar, Arunachal Pradesh, Assam, Bihar, Jammu and Kashmir, Karnataka, Kerala, Manipur, Madhya Pradesh, Maharashtra, Mizoram, Meghalaya, Nagaland, Punjab, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, Chattisgarh and West Bengal (Mitra, 2016). Upadhyaya et al. (2013) reported mango stem borer as a major pest of mango in the Eastern tharai region of Nepal. Vasanthi and Raviprasad (2015) reported that *B. rufomaculata* infest cashew (*Anacardium occidentale* L.) as a secondary borer.

Borer infestation often goes unnoticed until trees show external symptoms of damage. This results in sequence of symptoms like girdling, die back, structural weakness, decline and eventual death of trees (Shivananda et al., 2012). The grub has a prolonged growth period ranging from 6-8 months (Venkata et al., 2018; Reddy et al., 2016). After pupation inside the trunk, the adults emerge and fly out by making characteristic exit holes. Flight period of adult beetles occurs any time between June and August (Palaniswamy et al., 1979). The most preferred varieties

of mangoes are Alphonso and langra, Jehangir being the most susceptible variety (experiencing 25 to 50 per cent damage), while Himayuddin and Banganapalli are among the least susceptible varieties (Palaniswamy *et al.*, 1979; Reddy *et al.*, 2015; Potter and Potter, 2008). It has been found that organic mango is highly susceptible to borer because of non-usage of insecticides. Failure to address stem borer infestation can promptly result in death of the entire productive plant, leading to significant economic losses (Gundappa *et al.*, 2015; Mir and Chisti, 2012). Recently, there has been a rise in the stem borer infestation in the major mango-producing regions throughout India. During severe infestations, locating and mechanical removal or destruction of all grubs is an exceptionally challenging task. So, adaption of reliable preventive measures is one of the best options to get rid of this hidden enemy.

ICAR-IIHR has developed a formulation called "Arka Borer Control" (ABC), which is more effective than earlier developed "Sealer cum Healer" (SCH) for the effective management of stem borers. This innovated formulation consists of several inert materials to serve as a carrier and herbal oils to be effective for one season without adding any insecticide. The swabbed formulation work both as a repellent as well as a curative treatment to neutralize the eggs, early and mature grub instars residing in the stem. It has shown significant control by avoiding infestation up to 8 weeks in laboratory trial and 4 months in the field conditions. It is suitable for both low and heavy rainfall areas and can be applied as an effective prophylactic measure. According to Mouly (2018), grub inactivation and damage control can be achieved through SCH application. The organic SCH has been effective in arresting the borer infestation under field conditions for more than six months. In view of the above, and considering the economic importance of stem borer in the present era of organic farming, the efficacy of Arka Borer Control (ABC) product was tested against mango stem borer across the India.

Materials and Methods

Study area: The experiment was executed at 17 different centers of All India Co-ordinated Research Project (AICRP) on Fruits across the country (Anantharajupet, Gangian, Imphal, Lembucherra, Ludhiana, Medziphema, Mohanpur, Neri, Pantnagar, Paria, Periyakulam, Rahuri, Rewa, Sabour, Sangareddy, Udaipur and Vengurle) to test the efficacy of ABC against mango stem borer during 2021 and 2022.

Experimental layout: The experiment was laid out in a Randomized Block Design (RBD) with four treatments viz., Arka Borer Control (T_1), pasting trunk with Bordeaux paste (BP) @ 10% + chlorpyrifos 20 % EC @ 10 ml lit⁻¹ of BP (T_2), Standard check (T_3 -recommended/existing practice of the region) and untreated trees serving as control (T_4). Five replications were used with three plants per replication. The information on Geo Co-ordinates of each location, varieties used, spacing and details of T_3 a recommended/existing practice of the region at different centers are given in Table 1.

Methodology for ABC application: The ABC product was mixed with 750 ml of water to bring a slurry solution. The slurry was swabbed on the tree trunk using a 2 or 3-inch brush approximately 2 to 3 feet height from the ground. The prepared slurry was applied on 5 mango trees that varied depending upon the age and girth of the trunk.

Data recording: Observations in terms of number of trees infested before and 3 and 6 months after the application of each treatment were recorded. Based on this, the percent stem borer infestation was worked out. The per cent efficacy of ABC product over control was also recorded as per the formula given by Abbott (1925).

The number of live borer holes per stem before application, and 3 and 6 months after the application of each treatment were also noted. Leakage of sticky fluid sap from various spots on tree trunk initially and actual frass secretion site from loose bark on the trunk followed by presence of frass below the active/live borer hole on the ground along the periphery of trunk indicated the borer infestation. If the frass, white colour indicated the damage was fresh and the grub was alive and the damage was done on the day of observation. The presence of stem borer, marked by holes and black spots was often noticed with oozing of gum. These visible symptoms were considered in advanced stages (3 and 6 months after treatment) for counting the number of live borer holes/stem. Persistency of ABC product applied was also noted as supplementary observation, which was marked as persisted (if the product remained intact with dark red brown colour), moderately persisted (if the product was partially fed with dark red brown to red brown colour), partially persisted (if the product was moderately fed with red brown to pale brown colour) and non-persisted (if the product was completely absent or washed up).

Statistical analyses: The recorded data was statistical analyzed after suitable transformation, and the significant differences in mean per cent infestation of stem borer and number of live borer holes per stem as influenced by various treatments were separated using Duncan's Multiple Range Test ($P=0.05$).

Results and Discussion

A two-year study (2021–2022) was conducted across the diverse agro-climatic zones in India evaluating the efficacy of four treatments for managing mango stem borer: T_1 (Arka Borer Control), T_2 (Pasting trunk with Bordeaux paste (BP) @ 10% + chlorpyrifos 20 % EC@ 10 ml l⁻¹ of BP), T_3 (Standard Check/recommended/existing practice of the region), and T_4 (Untreated Control). The efficacy treatments was assessed by measuring the reduction in the number of live borer holes per stem per tree and percentage infestation (Tables 2-9) during both years. The data obtained during the study period 2021 (Tables 2, 4, 6, 8) and 2022 (Tables 3, 5, 7, 9) revealed that the pre-treatment counts (PTC) of live borer holes per stem/tree were statistically non-significant across all the centers. Similarly, the percentage infestation at PTC showed variability, ranging 0.08 to 68.0 per cent in 2021 and 0.08 to 51.67 per cent in 2022 across the centers.

Table 1: Details of variety used with spacing and Treatment-3 applied at different centers

Centers	Geo co-ordinates	Variety tested	Spacing (m)	Treatment-T ₃ (A recommended/existing practice of the region)
Anantharajupet	13°59'34.127"N 79°19'50.66"E	Khadar	7.5 x 7.5	Swabbing with Copper Oxychloride 50 % WP @ 10 g + Monocrotophos 36% SL @ 5 ml lit ⁻¹ of water on tree trunk (2 to 3 feet height from the ground)
Gangian	31°47'28.399"N 75°41'9.776"E	Dasheri	9 x 9	Removing/killing the grubs using iron hook followed by plugging the hole with cotton dipped in kerosene @ 10 ml per hole ⁻¹
Imphal	24°45'50.321"N 94°03'12.506"E	Totapuri	6 x 6	Spray with Emamectin benzoate 5 % SG @ 5g lit ⁻¹ of water on tree trunk up to a height of 3 to 4 feet from the ground
Lembucherra	23°54'15.372"N 91°19'22.760"E	Amrapali	6 x 6	Plugging the bore hole with cotton dipped in kerosene @ 10 ml/hole and then sealing it with mud
Ludhiana	30°53'49.711"N 75°48'26.013"E	Dasheri	9 x 9	Removing/killing the grubs using iron hook followed by plugging the hole with cotton dipped in kerosene @ 10 ml per hole
Medzhiphema	25°45'5.292"N 93°51'23.148"E	Amrapali	5 x 5	Pouring kerosene @ 10 ml hole ⁻¹ and closing hole with mud paste
Mohanpur	22°56'13.2"N 88°30'24.119"E	Himsagar	10 x 10	Spray with Chlorpyrifos 20 % EC @ 5ml lit ⁻¹ of water on tree trunk up to a height of 3 to 4 feet from the ground
Neri	31°41'47.479"N 76°28'5.131"E	Dasheri	10 x 10	Spray with Methyl Parathion 50 % EC @ 0.2% on tree trunk up to a height of 3 to 4 feet from the ground
Pantnagar	29°01'42.337"N 79°24'56.163"E	Dasheri	8 x 8	Paste of Chlorpyrifos @ 1ml + Neem oil @ 10 ml + Copper Oxychloride @ 4 g lit ⁻¹ of water
Paria	20°26'58.427"N 72°57'5.723"E	Alphonso	10 x 10	Spraying of Imidacloprid 17.8% SL @ 1 ml lit ⁻¹ water (five sprays at fortnightly interval on trunk)
Periakulam	10°07'39.168"N 77°35'31.424"E	Imampasand	10 x 10	Hooking out of grub from the bore hole followed by the application of Monocrotophos 36% SL 10 to 20 ml/hole
Rahuri	19°21'5.846"N 74°38'55.428"E	Kesar	10 x 10	Spray on bark with Chlorpyrifos 20% EC @ 2ml + Neem oil @ 10 ml + Copper Oxychloride @ 4 g lit ⁻¹ of water
Rewa	24°30'59.803"N 81°17'26.321"E	Langra	10 x 10	Swabbing of Chlorpyrifos 20% EC @ 10ml lit ⁻¹
Sabour	25°14'8.902"N 87°02'25.101"E	Langra	10 x 10	Cleaning the bore hole followed by plugging with cotton dipped in kerosene @ 10 ml per hole and then sealing it with mud.
Sangareddy	17°37'16.878"N 78°04'40.159"E	Banganapalli	10x 10	Removing the grubs using iron hook and plastering the hole with dung
Udaipur	23°30'10.825"N 74°22'34.168"E	Dasheri	10 x 10	Spray with Imidacloprid 17.8 % SL @ 1 ml 3 lit ⁻¹ on tree trunk up to a height of about 2 to 3 feet from the ground
Vengurle	15°51'23.929"N 73°39'27.442"E	Alphonso	10 x 10	Swabbing of Chlorpyrifos 20 % EC @ 5ml lit ⁻¹ at 3 months interval

The evaluation of stem borer infestation at Southern Zone centers—Anantharajupet (Andhra Pradesh), Sangareddy (Telangana), and Periyakulam (Tamil Nadu)—during 2021 (Table 2) and 2022 (Table 3) revealed significant variation in treatment efficacy across locations. At Anantharajupet in 2021, T₁ treatment, involving the application of ABC, effectively maintained a steady infestation level of 13.38 per cent, while reducing borer holes from 1.20 (pre-treatment count, PTC) to 0.60 at 6 months after application. Conversely, the control treatment (T₄) exhibited an increase in infestation, with live borer holes rising from 2.40 (PTC) to 4.00 per stem/tree 6 months post application. Similarly, at Sangareddy, T₁ treatment consistently outperformed other treatments, reducing live borer holes from 3.80 (PTC) to 2.08 per stem/tree 6 months post application and lowering infestation levels from 28.20 (PTC) to 19.04 per cent (6 months post application). In contrast, T₃ treatment recorded a higher infestation rate of 61.08 per cent, while the control treatment (T₄) showed a significant

increase of 76.16 per cent infestation during the same period. At Periyakulam, T₃ treatment demonstrated exceptional efficacy, reducing borer holes from 5.41 (PTC) to 2.54 (6 months post application) and decreasing infestation levels to 0.80 per cent. T₁ treatments and T₂ also showed notable reduction, lowering infestation levels to 3.43 and 3.09 live borer holes/tree (6 months post application), respectively (Table 2). In 2022, a similar trend was observed, with significant reduction in the stem borer infestation across all the centers. T₁ treatment maintained its efficacy at Anantharajupet (13.38 per cent) and Sangareddy (17.4 per cent), while T₃ treatment demonstrated superior performance at Periyakulam, reducing infestation to 0.57 per cent (Table 3). These findings highlight the effectiveness of specific treatments, particularly T₁ and T₃ treatments, in managing stem borer infestations across varied agro-climatic conditions in the Southern Zone. The results also emphasize the importance of site-specific pest management strategies for sustainable orchard health.

Table 2: Effect of ABC product against stem borer infestation at different centres of South Zone in 2021

Treatments	*Mean number of live borer holes/stem																								
	Anantharajupet				Sangareddy				Periyakulam				Anantharajupet				Sangareddy				Periyakulam				
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	
T ₁	1.20 ^a (1.16)	0.80 (1.04)	0.60 (0.99)	3.80 (2.07)	1.62 (1.44)	2.08 (1.58)	5.99 (2.55)	4.16 (2.16) ^c	3.43 (1.98) ^c	13.38 ^a (15.08)	13.38 (15.08)	13.38 (15.08)	28.20 (31.89)	9.52 (17.94) ^a	19.04 (25.84) ^a	3.56 (10.88) ^c	2.76 (9.57) ^c	2.25 (8.63) ^c							
T ₂	1.00 (1.03)	1.20 (1.08)	1.20 (1.08)	4.00 (2.09)	2.09 (1.60)	2.52 (1.72)	6.22 (2.59)	3.38 (1.97) ^b	3.09 (1.89) ^b	6.73 (8.35)	6.73 (8.35)	6.73 (8.35)	35.20 (36.37)	33.32 (35.23) ^b	52.32 (46.34) ^b	3.05 (10.05) ^b	2.44 (8.98) ^b	1.55 (7.15) ^b							
T ₃	0.80 (0.99)	1.20 (1.08)	1.60 (1.15)	3.60 (2.02)	2.40 (1.70)	2.64 (1.75)	5.41 (2.43)	3.20 (1.92) ^a	2.54 (1.74) ^a	6.73 (8.35)	6.73 (8.35)	6.73 (8.35)	39.60 (38.99)	37.40 (37.67) ^{ab}	61.08 (51.72) ^b	2.68 (9.41) ^a	2.09 (8.31) ^a	0.80 (5.14) ^a							
T ₄	2.40 (1.44)	3.60 (1.66)	4.00 (1.72)	3.40 (1.96)	1.94 (1.52)	2.84 (1.81)	5.00 (2.34)	5.39 (2.43) ^d	5.84 (2.52) ^d	13.38 (15.08)	20.03 (21.81)	20.03 (21.81)	30.20 (33.22)	47.62 (43.61) ^c	76.16 (60.97) ^c	4.12 (11.70) ^d	4.74 (12.57) ^d	6.66 (14.96) ^d							
S.E.m±	0.32	0.44	0.43	0.12	0.12	0.14	0.01	0.01	0.01	6.59	7.14	8.79	1.73	1.45	2.83	0.03	0.03	0.03							
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	0.02	0.02	NS	NS	NS	NS	4.46	8.74	0.10	0.10	0.10							

Table 3: Effect of ABC product against stem borer infestation at different centres of South Zone in 2022

Treatments	*Mean number of live borer holes/stem																								
	Anantharajupet				Sangareddy				Periyakulam				Anantharajupet				Sangareddy				Periyakulam				
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	
T ₁	0.47 [#] (0.94)	0.27 (0.86)	0.13 (0.79)	0.80 (1.09)	1.20 (1.22) ^a	3.60 (2.01)	5.41 (2.43)	3.84 (2.08) ^c	3.10 (1.90) ^c	13.38 ^a (15.08)	13.38 (15.08)	13.38 (15.08)	30.80 (33.65)	7.60 (15.90) ^a	17.40 (24.64) ^a	4.25 (11.90)	3.58 (10.90) ^b	2.15 (8.43) ^c							
T ₂	0.40 (0.88)	0.40 (0.88)	0.87 (1.07)	1.80 (1.50)	2.20 (1.63) ^a	3.80 (2.05)	5.61 (2.47)	3.12 (1.90) ^b	2.24 (1.66) ^b	6.73 (8.35)	6.73 (8.35)	6.73 (8.35)	32.60 (34.74)	23.20 (28.75) ^b	35.40 (36.44) ^b	3.87 (11.34)	3.16 (10.23) ^b	1.29 (6.51) ^b							
T ₃	0.73 (1.03)	0.87 (1.08)	1.20 (1.23)	2.40 (1.70)	2.80 (1.81) ^b	3.60 (2.02)	5.04 (2.35)	2.85 (1.83) ^a	1.88 (1.54) ^a	13.38 (15.08)	13.38 (15.08)	13.38 (15.08)	30.60 (33.56)	27.80 (31.79) ^b	44.00 (41.55) ^b	4.00 (11.54)	2.20 (8.50) ^a	0.57 (4.33) ^a							
T ₄	1.07 (1.19)	1.33 (1.25)	1.67 (1.35)	2.40 (1.70)	3.40 (1.96) ^b	3.20 (1.89)	4.89 (2.32)	5.28 (2.40) ^d	6.00 (2.55) ^d	20.03 (21.81)	26.70 (25.70)	26.70 (25.70)	34.20 (35.61)	37.40 (37.67) ^c	55.60 (48.28) ^c	4.15 (11.72)	5.87 (14.00) ^c	6.48 (14.74) ^b							
S.E.m±	0.20	0.23	0.24	0.15	0.14	0.15	0.01	0.01	0.01	8.79	9.65	10.98	1.82	1.11	1.78	0.22	0.31	0.05							
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	0.03	0.02	NS	NS	NS	NS	3.43	5.48	NS	NS	0.14							

T₁-Arka Borer Control; T₂-Pasting trunk with Bordeaux paste (BP) @ 10% + chlorpyrifos 20 % EC @ 10 ml lit⁻¹ of BP; T₃-Standard check (recommended/existing practice of the region), T₄-Untreated control; PTC - Pre-treatment count, MAP-Months after application; *Mean of three replication; Figures in parenthesis are ^asquare root transformed values, ^b arcsine transformed values and those outside are original values; Means followed by same superscripted letter(s) do not differ significantly (P < 0.05) by DMRT.

Table 4: Effect of ABC product against stem borer infestation at different centres of North Zone in 2021

Treatments	*Mean number of live borer holes/stem																			
	Gangian				Ludhiana				Neri											
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA								
T ₁	4.70 ^a (2.28)	1.10 (1.27) ^a	0.60 (0.99)	4.90 (2.32)	1.30 (1.34) ^a	1.00 (1.22) ^a	6.00 (2.52) ^a	7.00 (2.73) ^a	10.00 (3.24) ^a	6.00 (2.55) ^a	3.60 (2.02) ^b	1.20 ^a (6.29) ^a	0.08 (1.62) ^a	0.90 (5.33) ^a	39.95 (38.95) ^a	46.62 (43.02) ^b	30.00 (33.20) ^a	12.40 (20.61) ^c	10.14 (18.56) ^c	
T ₂	3.80 (2.07)	2.10 (1.61) ^b	1.20 (1.08)	4.70 (2.28)	1.60 (1.45) ^b	1.80 (1.52) ^b	4.00 (2.09) ^a	7.20 (2.74) ^a	7.80 (2.88) ^a	4.30 (2.18) ^b	2.76 (1.80) ^b	1.80 (7.71) ^b	1.50 (3.99) ^b	0.50 (3.97) ^b	1.00 (5.73) ^{ab}	26.64 (30.70) ^{ab}	47.95 (43.82) ^b	15.70 (23.33) ^b	8.50 (16.94) ^a	5.90 (14.04) ^a
T ₃	6.80 (2.70)	2.30 (1.67) ^c	1.60 (1.15)	5.80 (2.51)	2.50 (1.73) ^c	2.90 (1.84) ^c	3.00 (1.85) ^c	3.00 (1.85) ^c	9.00 (3.07) ^b	5.60 (2.47) ^b	4.24 (2.17) ^b	2.30 (8.71) ^b	1.40 (6.80) ^b	1.10 (6.02) ^b	1.30 (6.54) ^b	19.98 (26.23) ^b	19.90 (26.17) ^b	18.00 (25.09) ^b	10.40 (18.80) ^b	8.30 (16.73) ^b
T ₄	5.60 (2.47)	9.70 (3.19) ^d	4.00 (1.72)	4.90 (2.32)	8.70 (3.03) ^d	9.20 (3.11) ^d	5.00 (2.34) ^d	9.00 (3.06) ^d	11.80 (3.51) ^d	11.40 (3.45) ^d	11.70 (3.49) ^d	3.10 (10.13) ^d	9.70 (17.15) ^d	7.80 (16.22) ^d	8.10 (16.54) ^d	33.29 (35.16) ^d	59.94 (50.98) ^d	22.50 (28.31) ^d	41.10 (39.87) ^d	70.60 (57.17) ^d
S.E.m±	0.00	0.00	0.43	0.00	0.01	0.01	0.13	0.16	0.04	0.04	0.03	0.15	0.12	0.31	2.58	3.62	0.42	0.22	0.30	
CD (p=0.05)	NS	0.02	NS	NS	0.03	0.04	0.41	0.50	0.11	0.14	0.10	0.46	0.57	0.60	7.94	11.17	1.30	0.67	0.93	

Table 5: Effect of ABC product against stem borer infestation at different centres of North Zone in 2022

Treatments	*Mean number of live borer holes/stem																			
	Gangian				Ludhiana				Neri											
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA								
T ₁	4.90 ^a (2.32)	2.01 (1.53) ^a	1.25 (1.32) ^a	5.10 (2.37)	1.50 (1.41) ^a	1.20 (1.30) ^a	6.00 (2.52)	8.00 (2.91) ^a	13.00 (3.67)	8.00 (2.92) ^a	5.60 (2.47) ^a	1.30 ^a (6.55) ^a	0.08 (3.95) ^a	0.50 (4.79) ^a	39.96 (38.96) ^a	47.94 (44.55) ^a	32.12 (34.52) ^a	14.74 (22.57) ^b	13.73 (21.74) ^b	
T ₂	4.20 (2.17)	2.66 (1.77) ^b	1.72 (1.48) ^b	4.50 (2.23)	1.70 (1.48) ^b	1.90 (1.55) ^b	8.00 (2.91)	7.00 (2.73) ^a	12.00 (3.53)	6.00 (2.55) ^b	3.80 (2.07) ^b	2.10 (8.34) ^b	1.70 (7.49) ^b	0.40 (3.62) ^b	0.90 (5.45) ^b	53.26 (46.88) ^b	46.61 (43.02) ^b	17.57 (24.78) ^b	10.56 (18.96) ^b	8.65 (17.10) ^b
T ₃	7.10 (2.76)	3.35 (1.92) ^b	2.52 (1.74) ^b	5.60 (2.47)	2.30 (1.67) ^b	2.70 (1.79) ^b	6.00 (2.50)	6.00 (2.50) ^a	11.00 (3.39)	6.60 (2.66) ^b	6.60 (2.66) ^b	2.30 (8.72) ^b	1.90 (7.93) ^b	1.20 (6.28) ^b	1.50 (7.03) ^b	39.96 (38.72) ^b	39.96 (38.72) ^b	19.22 (26.00) ^b	12.64 (20.82) ^b	13.45 (21.51) ^b
T ₄	4.90 (2.32)	7.47 (2.81) ^b	10.33 (3.28) ^b	4.50 (2.24)	7.60 (2.85) ^b	10.20 (3.27) ^b	9.00 (3.08)	10.00 (3.22) ^b	14.00 (3.81)	12.45 (3.60) ^b	12.30 (3.58) ^b	2.90 (9.81) ^b	7.60 (17.15) ^b	6.90 (15.23) ^b	8.50 (16.95) ^b	59.92 (50.77) ^b	66.62 (54.87) ^b	22.50 (28.32) ^b	45.58 (42.46) ^b	70.14 (57.15) ^b
S.E.m±	0.01	0.15	0.10	0.02	0.03	0.02	0.13	0.15	0.02	0.03	0.04	0.04	0.23	0.10	2.67	3.69	0.01	0.29	1.86	
CD (p=0.05)	NS	0.47	0.29	NS	0.10	0.05	NS	0.48	0.49	NS	0.05	0.14	0.22	0.10	8.24	11.37	NS	0.89	2.73	

T₁ - Arka Borer Control; T₂ - Pasting trunk with Bordeaux paste (BP) @ 10% + chlorpyrifos 20% EC @ 10 ml lit⁻¹ of BP; T₃ - Standard check (recommended/existing practice of the region); T₄ - Untreated control; PTC - Pre-treatment count, MAP - Months after application; *Mean of three replication; Figures in parenthesis are square root transformed values; ^asquare root transformed values; ^barcsine transformed values; Means followed by same superscripted letter(s) do not differ significantly (P < 0.05) by DMRT.

Table 6: Effect of ABC product against stem borer infestation at Eastern Zone centres in 2021

Treatments	*Mean number of live borer holes/stem														
	Medziphema			Imphal			Lembuchera			Mohanpur			Sabour		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	3.50 (1.98) [#]	1.00 (1.22) ^b	0.74 (1.10) ^a	5.45 (2.31)	4.49 (2.14)	3.12 (1.82)	4.20 (2.17)	1.00 (1.22) ^a	0.20 (0.81) ^a	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.80 (1.31)
T ₂	4.66 (2.25)	2.66 (1.77) ^c	2.01 (1.56) ^a	7.07 (2.66)	4.02 (2.05)	3.12 (1.82)	2.40 (1.70)	2.20 (1.64) ^b	0.60 (1.02) ^{ab}	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.60 (1.27)
T ₃	3.33 (1.95)	0.00 (0.71) ^a	4.89 (2.31) ^b	6.71 (2.60)	4.49 (2.14)	4.02 (2.05)	1.60 (1.45)	2.60 (1.76) ^c	1.60 (1.39) ^b	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.80 (1.52)
T ₄	6.33 (2.60)	5.66 (2.47) ^d	8.66 (3.00) ^c	6.71 (2.60)	6.29 (2.60)	4.92 (2.28)	3.60 (2.02)	5.80 (2.51) ^d	5.20 (2.38) ^c	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.20 (1.08)	4.80 (2.03)
S.Em±	0.13	0.09	0.16	0.30	0.30	0.25	0.02	0.02	0.15	-	-	-	0.00	0.18	0.48
CD (p=0.05)	NS	0.28	0.48	NS	NS	NS	NS	0.06	0.46	-	-	-	NS	NS	NS

Treatments	*Mean per cent stem borer infestation														
	Medziphema			Imphal			Lembuchera			Mohanpur			Sabour		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	36.00 (36.76) ^{a@}	32.00 (34.30) ^a	30.05 (33.09) ^a	4.97 (12.09)	3.60 (10.08)	3.12 (9.55)	20.13 (26.63) ^b	8.80 (17.25) ^a	2.36 (8.83) ^a	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	8.05 (11.60)
T ₂	57.00 (49.09) ^b	43.00 (40.93) ^{ab}	42.30 (40.55) ^b	31.90 (32.67)	4.49 (11.55)	4.02 (11.02)	28.57 (32.29) ^c	23.12 (28.73) ^b	8.57 (16.97) ^b	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	8.05 (11.60)
T ₃	61.00 (51.45) ^b	52.00 (46.16) ^b	69.00 (56.21) ^c	42.02 (38.83)	4.02 (11.02)	3.12 (9.55)	38.00 (38.05) ^d	27.72 (31.77) ^c	18.85 (25.71) ^c	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	8.05 (11.60)
T ₄	68.00 (55.94) ^b	77.00 (61.59) ^c	77.66 (62.20) ^d	33.26 (34.19)	3.96 (10.44)	4.49 (11.55)	17.14 (24.45) ^a	33.76 (35.52) ^d	30.91 (33.77) ^d	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	4.06 (6.61)	12.03 (16.59)
S.Em±	2.75	2.37	2.25	6.26	2.09	1.69	0.65	0.34	0.50	-	-	-	0.00	2.49	6.52
CD (p=0.05)	8.48	7.32	6.95	19.30	NS	NS	2.01	1.06	1.55	-	-	-	NS	NS	NS

T₁-Arka Borer Control; T₂- Pasting trunk with *Bordeaux* paste (BP) @ 10% + chlorpyriphos 20 % EC @ 10 ml lit⁻¹ of BP; T₃- Standard check (recommended/existing practice of the region), T₄- Untreated control; PTC - Pre-treatment count, MAP-Months after application; *Mean of three replication; Figures in parenthesis are [#]square root transformed values; [@]arcsine transformed values and those outside are original values; Means followed by same superscripted letter(s) do not differ significantly (P < 0.05) by DMRT.

The data obtained from the Northern Zone of India including four centers—Gangian and Ludhiana (Punjab), Pantnagar (Uttarakhand) and Neri (Himachal Pradesh), revealed significant differences in the stem borer infestation across treatments during the year 2021 (Table 4). In Gangian, T₁ treatment effectively reduced the number of borer holes from 4.70 to 0.60 per tree and infestation levels from 1.20 (PTC) to 0.40 per cent (6 months post treatment). This performance surpassed that of T₂ (1.50 per cent) and T₃ treatment (1.80 per cent) whereas T₄ treatment elevated infestation level of 9.70 per cent (Table 4). Similarly, in Ludhiana, the T₁ treatment reduced borer holes from 4.90 (PTC) to 1.00 holes per tree (6 months post application) and infestation levels from 1.40 to 0.90 per cent, while T₄ treatment increased in infestation from 3.30 to 8.10 per cent. In contrast, the Tarai region of Pantnagar exhibited comparatively higher stem borer infestation. Among the treatments, T₃ treatment consistently demonstrated superior effectiveness, maintaining a lower

infestation level of 19.90 per cent 6 months post treatment. This overall higher infestation in the region could be attributed to heavy rainfall in the Uttarakhand region, which creates favourable conditions for stem borer incidence. In the orchards of Neri, Himachal Pradesh, the T₂ treatment achieved a substantial reduction in live borer holes from 7.80 (PTC) to 2.76 holes per tree (6 MAA) and infestation levels from 15.70 (PTC) to 5.90 per cent (6 months post treatment) (Table 4). Treatments T₁ and T₃ also maintained a low level of infestation, demonstrating their effectiveness in mitigating stem borer damage. Similar results were also observed in 2022 across all the respective centers, reaffirming the treatments' efficacy (Table 5). The consistency of these results during 2021 and 2022 reaffirms the efficacy of these treatments in mitigating stem borer damage. The findings emphasize the importance of location-specific strategies, taking into account the regional climatic factors and pest pressure. Among the treatments, T₁ and T₃ treatments demonstrated broad

Table 7: Effect of ABCproduct against stem borer infestation at Eastern Zone centres in 2022

Treatments	*Mean number of live borer holes/stem														
	Medziphema			Imphal			Lembuchera			Mohanpur			Sabour		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	4.67 (2.26) [®]	1.67 (1.45)	0.33 (0.90) ^a	0.47 (0.94)	0.86 (1.17)	0.79 (1.13)	0.60 (0.99)	0.40 (0.91) ^a	0.20 (0.81) ^a	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71) ^a	1.20 (1.08) ^a
T ₂	6.67 (2.66)	4.67 (2.27)	2.33 (1.67) ^b	0.40 (0.88)	0.83 (1.15)	0.79 (1.13)	7.00 (2.74)	2.60 (1.75) ^b	2.80 (1.81) ^b	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71) ^a	1.40 (1.11) ^a
T ₃	3.00 (1.84)	2.12 (3.15)	1.67 (1.47) ^b	0.73 (1.03)	0.86 (1.17)	0.83 (1.15)	8.80 (3.05)	4.40 (2.21) ^c	3.60 (2.02) ^c	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.60 (0.94) ^b	2.90 (1.75) ^a
T ₄	4.67 (2.25)	6.33 (2.61)	7.00 (2.73) ^c	1.07 (1.19)	0.95 (1.20)	0.87 (1.17)	3.00 (3.86)	7.60 (2.84) ^d	6.60 (2.66) ^d	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	4.40 (2.19) ^c	6.42 (2.61) ^b
S.Em±	0.16	0.90	0.07	0.20	0.03	0.02	0.09	0.10	0.06	-	-	-	-	0.13	0.32
CD (p=0.05)	NS	NS	0.20	NS	NS	NS	NS	0.32	0.19	-	-	-	-	0.39	0.98

Treatments	*Mean per cent stem borer infestation														
	Medziphema			Imphal			Lembuchera			Mohanpur			Sabour		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	38.67 (38.35) [®]	31.33 (33.72) ^a	14.67 (22.47) ^a	5.45 (12.62)	4.49 (11.55)	3.12 (9.55)	13.10 (21.22) ^a	12.22 (20.46) ^a	11.30 (19.64) ^a	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62) ^a	6.73 (8.35) ^a
T ₂	46.67 (43.13)	40.33 (39.40) [®]	28.67 (32.36) ^b	7.07 (14.82)	4.02 (11.02)	3.12 (9.55)	18.22 (25.26) ^c	16.08 (23.64) ^b	15.26 (22.99) ^b	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62) ^a	13.40 (12.24) ^a
T ₃	51.67 (45.99)	48.67 (44.23) [®]	33.33 (35.23) ^c	6.71 (14.46)	4.49 (11.55)	4.02 (11.02)	17.50 (24.73) ^b	21.20 (27.40) ^c	20.08 (26.62) ^c	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	6.73 (8.35) ^a	33.35 (32.43) [®]
T ₄	44.00 (41.52)	49.67 (44.81) ^c	64.67 (53.55) ^d	6.71 (14.46)	6.29 (14.49)	4.92 (12.49)	25.28 (30.18) ^d	24.38 (29.59) ^d	23.84 (29.23) ^d	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	40.00 (39.16) ^b	66.65 (57.57) ^b
S.Em±	3.15	2.26	0.92	1.88	1.89	1.56	0.23	0.33	0.11	0.00	0.00	0.00	0.00	3.28	8.20
CD (p=0.05)	NS	6.95	2.83	NS	NS	NS	0.72	1.01	0.34	NS	NS	NS	NS	10.10	25.26

T₁-Arka Borer Control; T₂- Pasting trunk with *Bordeaux* paste (BP) @ 10% + chlorpyriphos 20 % EC @ 10 ml lit⁻¹ of BP; T₃- Standard check (recommended/existing practice of the region), T₄- Untreated control; PTC - Pre-treatment count, MAP-Months after application; *Mean of three replication; Figures in parenthesis are [®]square root transformed values; [®]arcsine transformed values and those outside are original values; Means followed by same superscripted letter(s) do not differ significantly (P<0.05) by DMRT.

applicability across multiple centers, while T₂ treatment showed specific efficacy under certain conditions, highlighting its potential for targeted use. These results provide valuable insights for developing sustainable and effective pest management practices in the Northern Zone.

The evaluation of mango stem borer infestation conducted across the Eastern Zone centers-Medziphema (Nagaland), Imphal (Manipur), Lembucherra (Tripura), Mohanpur (West Bengal) and Sabour (Bihar)—revealed notable variations in infestation levels during the years 2021 (Table 6) and 2022 (Table 7). In 2021, a negligible infestation was recorded in the orchards at Mohanpur and Sabour during the trial period (Table 6). This low infestation could be attributed to factors such as the younger age of trees, well-managed orchard practices, or unfavourable climatic conditions for the pest incidence. In Imphal, no significant differences in the stem borer infestation were

observed across treatments. However, at Lembucherra, T₁ treatment demonstrated substantial efficacy in reducing the stem borer infestation, with a decrease from 20.13 (PTC) to 2.36 per cent 6, months post application (Table 6). Medziphema recorded a high stem borer infestation ranging from 36.0 to 68.0 per cent before application. Among the treatments, T₁ demonstrated consistent control, reducing the infestation from 36.00 per cent (PTC) to 30.05 per cent 6 months post application. A similar trend was observed in 2022 for the centers at Mohanpur (negligible stem borer infestation), Imphal (no significance in treatments) and in Lembucherra and Medziphema, T₁ treatment consistently demonstrated the maximum efficacy in managing the stem borer infestation (Table 7). However, at Sabour, an increase in the infestation was recorded across all treatments. Among these, T₁ treatment exhibited the lowest infestation (6.73 per cent), 6 months post application, while T₄ treatment (untreated) recorded the highest infestation (66.65 per cent).

Table 8: Effect of ABC product against stem borer infestation at Western Zone centres in 2021

Treatments	*Mean number of live borer holes/stem														
	Rahuri			Vengurle			Rewa			Paria			Udaipur		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	0.00 (0.71) [#]	0.00 (0.71)	0.13 (0.78) ^a	0.00 (0.71)	0.13 (0.78)	0.13 (0.78)	0.00 (0.71)	0.07 (0.75) ^a	0.07 (0.75) ^a	0.00 (0.71)	0.00 (0.71)	0.07 (0.75)	0.00 (0.71)	0.40 (0.88) ^a	0.60 (0.99) ^a
T ₂	0.00 (0.71)	0.20 (0.81)	0.73 (1.09) ^b	0.00 (0.71)	0.13 (0.78)	0.13 (0.78)	0.00 (0.71)	0.07 (0.75) ^a	0.08 (0.76) ^a	0.00 (0.71)	0.13 (0.78)	0.13 (0.78)	0.00 (0.71)	1.80 (1.46) ^b	2.00 (1.57) ^b
T ₃	0.00 (0.71)	0.00 (0.71)	0.20 (0.82) ^a	0.00 (0.71)	0.13 (0.78)	0.13 (0.78)	0.00 (0.71)	0.08 (0.76) ^a	0.08 (0.76) ^a	0.00 (0.71)	0.07 (0.75)	0.13 (0.78)	0.00 (0.71)	1.80 (1.50) ^b	2.40 (1.70) ^b
T ₄	0.00 (0.71)	0.47 (0.96)	1.67 (1.46) ^c	0.00 (0.71)	0.20 (0.81)	0.33 (0.86)	0.00 (0.71)	0.15 (0.81) ^b	0.23 (0.85) ^b	0.00 (0.71)	0.00 (0.71)	0.20 (0.82)	0.00 (0.71)	2.20 (1.63) ^b	3.00 (1.86) ^b
S.Em±	-	0.08	0.09	-	0.07	0.09	0.00	0.01	0.02	0.00	0.04	0.07	-	0.17	0.13
CD (p=0.05)	-	NS	0.29	-	NS	NS	-	0.03	0.05	-	NS	NS	-	0.53	0.39

Treatments	*Mean per cent stem borer infestation														
	Rahuri			Vengurle			Rewa			Paria			Udaipur		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	0.08 (1.62) [@]	0.08 (1.62) ^a	6.73 (8.35)	0.08 (1.62)	6.73 (8.35)	6.73 (8.35)	0.08 (1.62)	1.70 (7.49) ^a	1.70 (7.49) ^a	0.08 (1.62)	0.08 (1.62)	6.73 (8.35)	0.08 (1.62)	6.73 (8.35) ^a	13.38 (15.08) ^a
T ₂	0.08 (1.62)	6.73 (8.35) ^b	26.67 (28.21)	0.08 (1.62)	6.73 (8.35)	6.73 (8.35)	0.08 (1.62)	2.25 (8.62) ^b	2.25 (8.62) ^b	0.08 (1.62)	6.73 (8.35)	6.73 (8.35)	0.08 (1.62)	33.35 (32.43) ^b	46.67 (43.05) ^b
T ₃	0.08 (1.62)	0.08 (1.62) ^a	13.38 (15.08)	0.08 (1.62)	6.73 (8.35)	6.73 (8.35)	0.08 (1.62)	2.50 (9.10) ^b	2.50 (9.10) ^b	0.08 (1.62)	6.73 (8.35)	6.73 (8.35)	0.08 (1.62)	46.67 (43.05) ^b	66.66 (57.73) ^b
T ₄	0.08 (1.62)	20.03 (21.81) ^c	33.33 (35.26)	0.08 (1.62)	6.73 (8.35)	13.37 (15.07)	0.08 (1.62)	4.70 (12.52) ^c	7.80 (16.22) ^c	0.08 (1.62)	0.08 (1.62)	13.38 (15.08)	0.08 (1.62)	53.33 (46.95) ^b	79.99 (68.52) ^b
S.Em±	0.00	4.95	6.99	0.00	5.32	6.29	0.00	0.17	0.15	0.00	4.95	7.65	0.00	7.10	8.64
CD (p=0.05)	NS	15.26	NS	NS	NS	NS	NS	0.51	0.48	NS	NS	NS	NS	21.86	26.63

T₁-Arka Borer Control; T₂- Pasting trunk with *Bordeaux* paste (BP) @ 10% + chlorpyrifos 20 % EC @ 10 ml lit⁻¹ of BP; T₃- Standard check (recommended/existing practice of the region), T₄- Untreated control; PTC - Pre-treatment count, MAP-Months after application; *Mean of three replication; Figures in parenthesis are [#]square root transformed values; [@]arcsine transformed values and those outside are original values; Means followed by same superscripted letter(s) do not differ significantly (P<0.05) by DMRT.

The results underscore the effectiveness of T₁ treatment in managing the stem borer infestation, particularly in Lembucherra, and highlights the influence of orchard conditions and tree age on infestation levels. However, the increase in infestation at Sabour warrants further investigation into factors such as local climatic conditions, orchard practices, or pest dynamics to refine the management strategies. The evaluation of mango stem borer infestation across the Western Zone centers—Rahuri and Vengurla (Maharashtra), Rewa (Madhya Pradesh), Paria (Gujrat) and Udaipur (Rajasthan)—revealed varied levels of infestation during the study period (Table 8,9).

In 2021, Paria, Rahuri and Vengurla recorded non-significant differences in stem borer infestation across all treatments (Table 8). This could be attributed to factors such as orchard management practices, environmental conditions, or

other unidentified variables. At Rewa, a negligible incidence of stem borer infestation was observed. In contrast, Udaipur recorded a notable variation among the treatments, with T₁ treatment demonstrating the lowest infestation (13.38 per cent) compared to T₄ treatment, which had the highest infestation (79.99 per cent) 6 months post application (Table 8). A similar trend was observed in 2022, with Paria, Rahuri, Vengurla and Rewa maintaining a low or non-significant differences in the infestation levels, while Udaipur again highlighted the superior efficacy of T₁ treatment in reducing the infestation levels compared to other treatments (Table 9).

These findings highlight the varying impact of geographic and climatic conditions on the effectiveness of treatments against stem borer infestation. The consistent performance of T₁ treatment with ABC in Udaipur suggests its potential as an

Table 9: Effect of ABC product against stem borer infestation at Western Zone centres in 2022

Treatments	*Mean number of live borer holes/stem														
	Rahuri			Vengurle			Rewa			Paria			Udaipur		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	0.00 (0.71) [#]	0.00 (0.71)	0.20 (0.83) ^a	0.00 (0.71)	0.00 (0.71)	0.13 (0.78)	0.00 (0.71)	0.05 (0.74) ^a	0.05 (0.74) ^a	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.40 (0.91) ^a	0.80 (1.09) ^a
T ₂	0.00 (0.71)	0.13 (0.78)	0.27 (0.87) ^a	0.00 (0.71)	0.13 (0.78)	0.13 (0.78)	0.00 (0.71)	0.06 (0.75) ^a	0.06 (0.75) ^a	0.00 (0.71)	0.00 (0.71)	0.13 (0.78)	0.00 (0.71)	1.40 (1.37) ^b	1.80 (1.51) ^b
T ₃	0.00 (0.71)	0.00 (0.71)	1.00 (1.21) ^b	0.00 (0.71)	0.13 (0.78)	0.13 (0.78)	0.00 (0.71)	0.09 (0.77) ^a	0.09 (0.77) ^b	0.00 (0.71)	0.00 (0.71)	0.07 (0.75)	0.00 (0.71)	2.00 (1.55) ^b	2.20 (1.63) ^b
T ₄	0.00 (0.71)	0.27 (0.86)	1.93 (1.55) ^c	0.00 (0.71)	0.13 (0.78)	0.13 (0.78)	0.00 (0.71)	0.13 (0.79) ^b	0.21 (0.84) ^c	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	2.40 (1.70) ^b	3.20 (1.92) ^c
S.Em±	-	0.06	0.08	-	0.07	0.08	-	0.01	0.02	-	0.00	0.04	-	0.12	0.12
CD (p=0.05)	-	NS	0.25	-	NS	NS	-	0.03	0.05	-	NS	NS	-	0.37	0.38

Treatments	*Mean per cent stem borer infestation														
	Rahuri			Vengurle			Rewa			Paria			Udaipur		
	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA	PTC	3MAA	6MAA
T ₁	0.08 (1.62) [@]	0.08 (1.62) ^a	13.40 (12.24)	0.08 (1.62)	0.08 (1.62)	6.72 (8.35)	0.08 (1.62)	1.50 (7.03) ^a	1.50 (7.03) ^a	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	13.38 (15.08) ^a	13.38 (15.08) ^a
T ₂	0.08 (1.62)	13.38 (15.08) ^a	33.35 (32.43)	0.08 (1.62)	6.72 (8.35)	6.72 (8.35)	0.08 (1.62)	2.10 (8.32) ^b	2.10 (8.32) ^b	0.08 (1.62)	0.08 (1.62)	6.73 (8.35)	0.08 (1.62)	40.00 (39.16) ^{ab}	40.00 (39.16) ^b
T ₃	0.08 (1.62)	0.08 (1.62) ^a	20.05 (18.97)	0.08 (1.62)	6.72 (8.35)	6.72 (8.35)	0.08 (1.62)	2.35 (8.82) ^c	2.35 (8.82) ^c	0.08 (1.62)	0.08 (1.62)	6.73 (8.35)	0.08 (1.62)	53.33 (46.95) ^b	53.33 (46.95) ^{bc}
T ₄	0.08 (1.62)	26.68 (28.54) ^b	46.67 (43.05)	0.08 (1.62)	6.72 (8.35)	13.37 (15.07)	0.08 (1.62)	4.40 (12.10) ^d	7.30 (15.67) ^d	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	0.08 (1.62)	66.65 (57.57) ^b	79.97 (68.19) ^c
S.Em±	0.00	5.83	9.60	0.00	6.29	7.64	0.00	0.17	0.16	0.00	0.00	4.95	0.00	9.58	7.07
CD (p=0.05)	NS	17.96	NS	NS	NS	NS	NS	0.49	0.47	NS	NS	NS	NS	29.53	21.79

T₁-Arka Borer Control; T₂- Pasting trunk with *Bordeaux* paste (BP) @ 10% + chlorpyrifos 20 % EC @ 10 ml lit⁻¹ of BP; T₃- Standard check (recommended/existing practice of the region), T₄- Untreated control; PTC - Pre-treatment count, MAP-Months after application; *Mean of three replication; Figures in parenthesis are [#]square root transformed values; [@]arcsine transformed values and those outside are original values; Means followed by same superscripted letter(s) do not differ significantly (P<0.05) by DMRT.

effective management strategy in regions with similar pest pressure. Further investigations are required to understand the reasons behind the non-significant differences observed in Rahuri and Vengurla regions and to optimize the management practices for these locations. The pooled results from 2021 and 2022, 6 months post application of different treatments (Fig. 1,3), indicated that T₁ treatment was most effective in controlling mango stem borer infestation across several centers, with lowest infestation levels at Gangain (0.93 live borer hole /stem and 0.45 per cent infestation), Lumbuchera (0.20 hole /stem and 6.83 per cent), Ludhiana (1.10 hole /stem and 0.80 per cent), Medziphema (1.21 hole /stem and 22.36 per cent), Rahuri (0.17 hole /stem and 10.06 per cent), Rewa (0.06 hole /stem and 01.60 per cent), Sangareddy (2.84 hole /stem and 18.22 per cent), and Udaipur ((0.70 hole /stem and 13.38 per cent). However, at Sabour (Fig. 4), the lowest infestation was observed with T₁

treatment (7.39 per cent), although this was statistically similar to T₂ (10.72 per cent) and T₃ (20.70 per cent). At Neri, T₂ treatment proved to be the most effective, with an infestation level of 7.28 per cent (3.28 holes/stem), followed by T₃ treatments with 10.88 per cent and T₁ at 11.93 per cent (Fig. 1, 3).

Conversely, at Pantnagar and Periyakulam, T₃ treatment proved to be the most effective treatment against stem borer infestation, with infestation levels of 29.93 and 0.69 per cent, followed by T₂ (47.28 and 1.42 per cent, respectively) and T₁ treatments (47.94 and 2.20 per cent), respectively (Fig. 3). The per cent reduction in number of live borer holes per stem over control in T₁ treatment was observed to the tune of 56 to 97 per cent with an average of 76.00 per cent at those centers where T₁ was found superior treatment (Fig.2). The maximum per cent

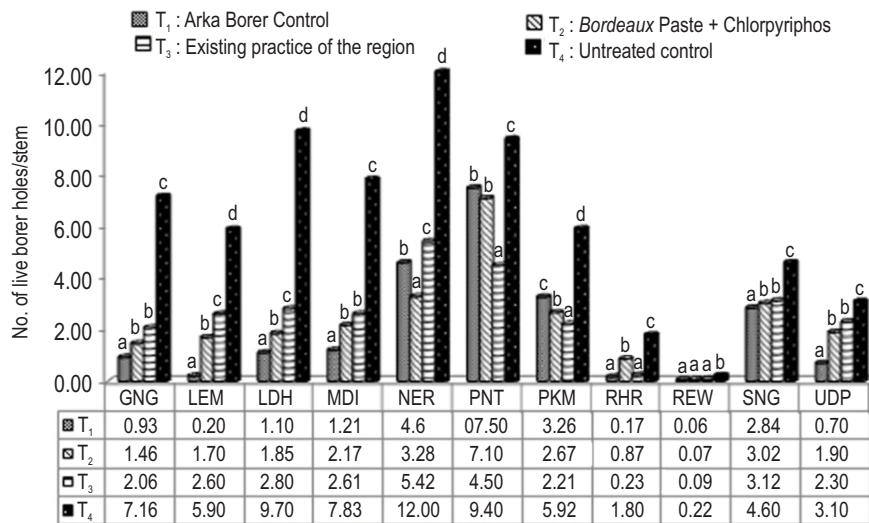


Fig. 1: Pooled effects of different treatments on number of live borer holes/stem 6 months after application (Centers with significant results obtained during 2021 & 2022 are given) Bars with same letters are not differ statistically ($P < 0.05$) by DMRT; GNG: Gangian, LEM: Lembucherra, LDN: Ludhiana, MDI: Medziphema, NER: Neri, PNT: Pantnagar, PKM: Periyakulam, RHR: Rahuri, REW: Rewa, UDP: Udaipur.

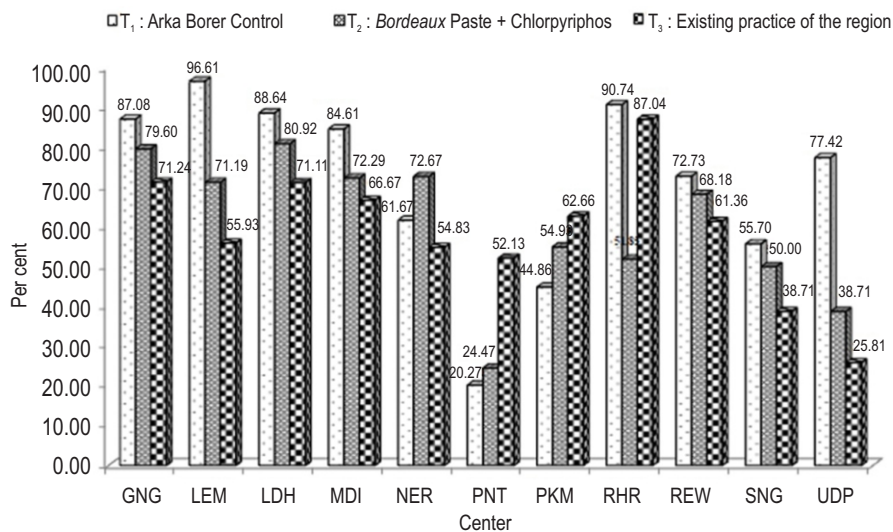


Fig. 2: Pooled effects of different treatments (6 months after application) on per cent reduction of number of live borer hole/ stem over control (Centers with significant results obtained during 2021 & 2022 are given) GNG: Gangian, LEM: Lembucherra, LDN: Ludhiana, MDI: Medziphema, NER: Neri, PNT: Pantnagar, PKM: Periyakulam, RHR: Rahuri, REW: Rewa, UDP: Udaipur.

reduction over control was observed in T₂ treatment at Neri (72.67). Inversely, at Pantnagar and Periyakulam, 52.13 and 62.66 per cent reduction over control was observed in T₃ treatment (Fig. 3). Similarly, the maximum per cent reduction of stem borer infestation over control was observed in T₂ treatment at Neri (89.66) (Fig.4). The per cent reduction of stem borer infestation over control in T₃ treatment was 52.20% and 89.54 % at Pantnagar and Periyakulam, respectively (Fig. 4). These results underscore the varying efficacy of treatments across

different regions, with T₁ treatment generally proving the most effective in many centers, while T₂ and T₃ treatments showed superior performance at specific locations. This highlights the importance of region-specific pest management strategies for effective control of mango stem borer infestation.

The efficacy of ABC product remained intact upto 3 months after application at Anantharajupet, Gangian, Ludhiana, Medziphema, Mohanpur, Pantnagar, Periyakulam, Rewa,

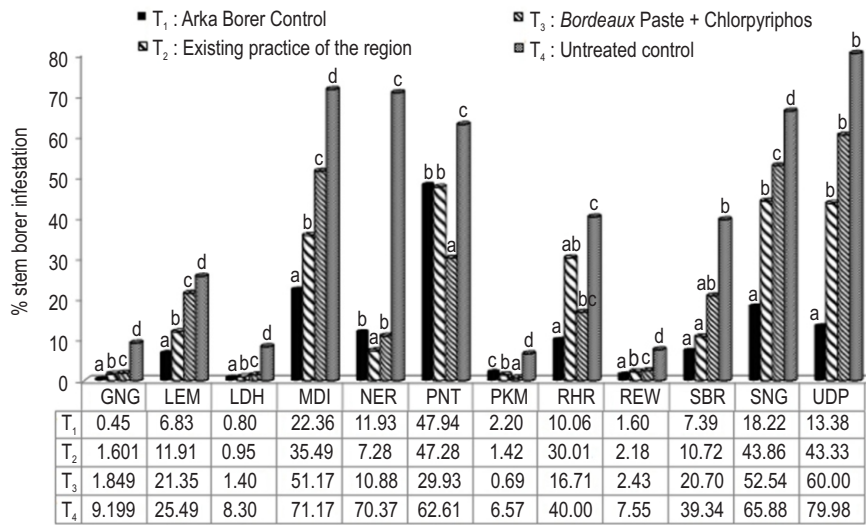


Fig. 3: Pooled effects of different treatments on stem borer infestation (%) 6 months after application (Centers with significant results obtained during 2021 & 2022 are given). Bars with same letters are not differ statistically ($P < 0.05$) by DMRT, GNG: Gangian, LEM: Lembucherra, LDN: Ludhiana, MDI: Medziphema, NER: Neri, PNT: Pantnagar, PKM: Periyakulam, RHR: Rahuri, REW: Rewa, SBR: Sabour, SNG: Sangareddy, UDP: Udaipur.

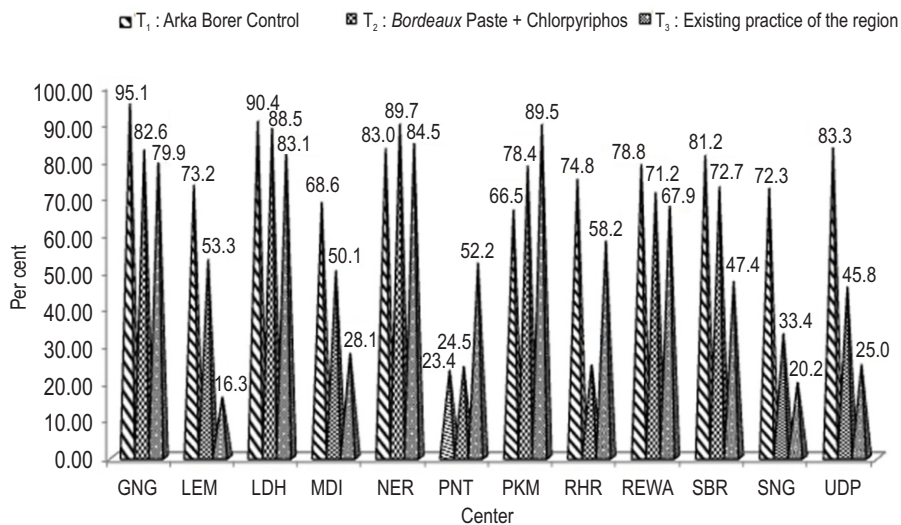


Fig. 4: Pooled effects of different treatments (6 months after application) on per cent reduction of borer infestation over control (Centers with significant results obtained during 2021 & 2022 are given); GNG: Gangian, LEM: Lembucherra, LDN: Ludhiana, MDI: Medziphema, NER: Neri, PNT: Pantnagar, PKM: Periyakulam, RHR: Rahuri, REW: Rewa, UDP: Udaipur.

Sangareddy and Udaipur, with moderate efficacy observed at 6 months. In contrast, at Lembuchera, Neri, Rahuri and Sabour, the product showed moderate efficacy for 3 months and partial efficacy after 6 months. At Imphal, Paria and Vengurla, ABC demonstrated partial efficacy after 3 months, but its efficacy was no longer significant after 6 months (Table 10). The combined analysis of live borer holes and per cent infestation over two years highlighted the superior efficacy of T₁ treatment in managing

mango stem borer. T₁ treatment consistently reduced the infestation levels and minimized borer hole formation across diverse agro-climatic zones. Its ability to provide effective control up to 6 months post-application underscores its potential as a sustainable pest management solution.

T₂ treatment (*Bordeaux* paste + chlorpyrifos) offered intermediate control with some site-specific effectiveness.

Table 10: Persistency of ABC product applied at different centers

Centers	3 MAA	6 MAA	Center	3 MAA	6 MAA
ANP	Persisted	Moderately Persisted	PRI	Partially persisted	Non-persisted
GNG	Persisted	Moderately Persisted	PKM	Persisted	Moderately Persisted
IMP	Partially persisted	Non-persisted	RHR	Moderately persisted	Partially persisted
LEM	Moderately persisted	Partially persisted	REW	Persisted	Moderately Persisted
LDN	Persisted	Moderately Persisted	SBR	Moderately persisted	Partially persisted
MDI	Persisted	Moderately persisted	SNG	Persisted	Moderately Persisted
MHR	Persisted	Moderately Persisted	UDP	Persisted	Moderately Persisted
NER	Moderately persisted	Partially persisted	VNG	Partially persisted	Non-persisted
PNT	Persisted	Moderately Persisted			

ANP: Anantharajupet, GNG: Gangian, IMP: Imphal, LEM: Lembucherra, LDN Ludhiana, MDI: Medzhiphema, MHR: Mohanpur, NER: Neri, PNT: Pantnagar, PRI: Paria, PKM: Periyakulam, RHR: Rahuri, REW: Rewa, SBR: Sabour, SNG: Sangareddy, UDP: Udaipur, VNG: Vengurle; MAA- Months After Application

However, its performance was inconsistent, and environmental concerns related to chemical pesticide usage necessitate cautious application. In comparison, T_3 treatment (Standard Check) demonstrated moderate efficacy but was less reliable than T_1 treatment, particularly in regions with high infestation pressure. This variability suggests the need for refinement or integration with supplementary control measures. The untreated control (T_4) consistently recorded the highest infestation levels, reaffirming the significant damage caused by mango stem borer in the absence of effective interventions. The progression of infestation in T_4 emphasizes the importance of proactive and sustainable management strategies. The key advantage of ABC formulation is its non-invasive application, which avoids plant scarring or physical damage, distinguishing it from conventional chemical treatments like T_2 . This feature aligns with sustainable agricultural practices, ensuring long-term plant health while minimizing environmental impact. The current study aligns with established practices for managing mango stem borer infestations, which predominantly involve identifying affected trees and physically or mechanically removing beetles. Techniques such as using flexible wires to extract grubs, pruning heavily damaged stems, and applying kerosene or petrol to kill larvae are widely practiced (Crocker *et al.*, 2014; Gundappa *et al.*, 2021; Bajracharya, 2012). However, these methods, while effective to some extent, are labor-intensive and may not provide sustainable long-term solutions.

Physical methods like light traps have been explored as an alternative for attracting and capturing adult beetles, though their lack of species specificity limits their utility (Reddy *et al.*, 2016). In cases where physical methods fail, chemical treatments such as spraying chlorpyrifos, imidacloprid, or thiamethoxam have demonstrated efficacy in controlling stem borer infestation (Venkata *et al.*, 2018). Additionally, plugging holes with cotton soaked in dichlorvos or petrol has shown success in killing active larvae (Bajracharya, 2012). Prophylactic application of insecticides, including monocrotophos, phosalone, imidacloprid and thiamethoxam have also been found effective (Tom and Samson, 2013; Upadhyay *et al.*, 2013). Furthermore, aluminum phosphide combined with *Bordeaux* paste has emerged as one of the most effective treatments, achieving an 83.33 per cent

reduction in infestation and a significant yield increase (Singh, 1993; Ahmed *et al.*, 2013; Gundappa *et al.*, 2021).

Despite these strategies, their efficacy often depends on precise knowledge of grub location within the plant, which is challenging given that many Cerambycid beetles spend prolonged periods inside stems or trunks (Higashiyama *et al.*, 1984; Keena, 2017). Severe infestations make locating and removing all grubs or heavily damaged branches even more difficult. Furthermore, chemical treatments become ineffective if the pest burrows deep into the trunk, as reported by Gundappa *et al.* (2021). In this context, Arka Borer Control represents an innovative approach. Thin coating of ABC prevents egg-laying by adult beetles, blocks grub tunnels, and effectively kills the larvae inside. Moreover, the medicinal herb extracts promote tissue regeneration, healing the damage caused by stem borers (Shivananda *et al.*, 2012).

Prophylactic application of ABC has been shown to protect healthy trees from egg-laying and subsequent damage, making it a sustainable and non-invasive solution. This aligns with the earlier findings on Sealer Cum Healer (SCH), an earlier version of ABC, which effectively arrested borer infestation for over six months under field conditions (Mouly, 2018). The results of the present study further substantiate the efficacy of ABC as a preventive and curative solution, offering a significant advantage in the current era of organic farming (Bimal *et al.*, 2022). Integrating preventive and curative methods, based on the known behavior and biology of mango stem borer, can provide a holistic approach to pest management (Veeresh, 1989). By adopting prophylactic measures using ABC, this research bridges the gap between scientific advancements and practical applications, empowering farmers to combat this hidden enemy effectively.

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