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Field efficacy of treatment combinations against termites in chickpea and their economics in hot arid climates

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ABSTRACT

A study carried out two consecutive *Rabi* seasons at Agronomy Farm, College of Agriculture, Swami Keshwanad Rajasthan Agricultural University, Bikaner,aimed to evaluate the field efficacy of treatment combinations against termites and assess the economies aspects of various treatments. The experiment was laid out in simple randomized block design with nine treatments replicated thrice. The treatments comprised seed treatments and soil applications of differentinsecticides, including Imidacloprid 600 FS, Clothianidin 50 WDG, Fipronil 5 SC, *Beauveria bassiana* 1.15 WP, and *Metarhizium anisopliae* 1.15 WP, as well as their combinations. The results showed that using Imidacloprid 600 FS at 5 ml/kg seeds and *Beauveria bassiana* 1.15 WP on the soil at a rate of 2 kg/ha consistently led to the lowest total and percentage avoidable losses, as well as the highest increase and percentage yield compared to the untreated control.Economic analysis revealed varying levels of net returns and benefit-cost ratios across treatments.Plots treated with Fipronil 5 SC at 5 ml/kg had the best benefit-cost ratio,followed by plots treated with Fipronil 5 SC plus *Metarhizium anisopliae* 1.15 WP at 2 kg/ha. These findings provide valuable insights into the management of termite-induced losses in chickpea cultivation,as well as feasible treatment strategies for farmers to improve crop yield and profitability.

Keywords: Avoidable losses, Benefit-cost ratio, Chickpea, Economics, Insecticides and biopesticides, Termite.

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INTRODUCTION

hickpea, *Cicer arietinum* (L.), is a vital pulse crop cultivated predominantly during *Rabi* season, covering approximately 14.8 million hectares globally. India contributes significantly to this cultivation, accounting for about 74% of the total area (MOAF&W, GoI2021). In India alone, chickpea occupies 10.95 million hectares, boasting an annual production of approximately 11.81 million tonnes and a productivity rate of 1012 kg/ha. In the state of Rajasthan, chickpea covers an area of 2.11 million hectares, yielding an annual production of 2.26 million tonnes and a productivity of 1072 kg/ha (MOAF&W, GoI 2021). Chickpea is renowned for its nutritional composition, serving as a rich source of protein (18-22%), carbohydrates (52-70%), fats (4-10%), minerals (calcium, phosphorus, iron), and vitamins B6 and C. Chickpea cultivation faces a myriad of challenges, with over 60 species of insect pests posing threats, among which termites stand out as particularly significant (Parsai, 2005). Termitesare prevalent in tropical and subtropical regions of India, and the situation is particularly severe in Rajasthan, where they inflict heavy damage on crops grown in sandy loam soils. The most important species attacking crops were*Microtermesobesi*and *Odontotermesobesus* (Rajagopal, 2002).They attack the crop throughout thegrowth stages, causing substantial yield loss, up to 90% during the flowering and podformation stages (Patil *et al.*,2017).The termites tunnel into chickpea roots and stems, feeding earthen galleries (Gaur *et al.*,2010). Additionally, the use of un-decomposed farmyard manure under unirrigated conditions can exacerbate termite attacks.To formulate effective management strategies against termites in chickpea crops, it is crucial to assess avoidable losses and yield increases compared to untreated controls across various pest management treatments.Hence, this study aimed to effectively managetermite in chickpea using different treatments, including insecticides and biopesticides applied as seed treatments, soil applications, or in combination, to reduce yield lossesand improve ceonomic viability through the assessment of the benefit-cost ratio in chickpea.

MATERIALS AND METHODS

The study was conducted at the Agronomy Farm, College of Agriculture, Swami Keshwanad Rajasthan Agricultural University in Bikaner over two consecutive *Rabi* seasons (2021-22 and 2022-23) to effectively managetermites in chickpeas. Various treatments, including insecticides and biopesticides applied as seed treatments, soil applications, or

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in combination, were evaluated to reduce yield losses and improve economic viability through the assessment of the benefit-cost ratio in chickpeasinhot arid climates. The experiment was laid out in a simple randomized block design with nine treatments, including an untreated control, each replicated thrice. The chickpea variety GNG-1958 was sown on the 30th October during *Rabi*, 2021–22 and 4th November during *Rabi* 2022- 23, in a plot size of 4x 2.4 m^2, keeping row to row and plant to plant spacing of 30 and 10 cm, respectively.

The treatments were includes seed treatment withimidacloprid 600 FS @ 5 ml/ kg seed, clothianidin 50 WDG @ 2 gm/ kg seed and fipronil 5 SC @ 5 ml/ kg seed, andsoil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha and *Metarhizium anisopliae* 1.15 WP @ 2 kg/ha and combination of both *i.e.*, seed treatment of imidacloprid 600 FS @ 5 ml/kg + soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha, seed treatment of clothianidin 50 WDG @ 2 gm/ kg + soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha and seed treatment of fipronil 5 SC @ 5 ml/ kg + soil application of*Metarhizium anisopliae* 1.15 WP @ 2 kg/ha.The seed treatments were done at the time of seed sowing and soil application treatments in field were applied mixed in soil before seed sowing. Observations on the yield of each replicated plot treatment-wise were recorded at the time of harvesting and converted into per hectare basis. Net profit and benefit-cost ratio were calculated by considering the expenditure on individual treatments and the corresponding yield. Avoidable loss and increase in seed yield over untreated control were calculated for each treatment using the formula given by Pradhan (1969).

$$\text{Avoidable loss (\%)} = \frac{\text{Highest yield in treated plot} - \text{Yield in the treatment}}{\text{Highest yield in treated plot}} \times 100$$

$$\text{Increase in yield (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

As some damage still happens even with the finest treatment, these methods were unable to calculate accurate losses or yield increases. Still, this is the most useful method for estimating the percentage of loss brought on by insect pests in any treatment, according to Pradhan (1964).

RESULTS AND DISCUSSION

In the 2021-22 season, treatment combinations such as fipronil 5 SC at 5 ml/kg with soilapplication of *Metarhiziumanisopliae* 1.15 WP at 2 kg/ha (0.45 q/ha and 2.27%) and clothianidin 50 WDG at 2 g/kg with soil application of*Beauveriabassiana* 1.15 WP at 2 kg/ha (0.75 q/ha and 3.78%) exhibited the lowest total and percentage avoidable losses over the untreated

Table 1: Assessment of losses caused by termites on chickpea during Rabi, 2021-23

Treatments	Yield (q/ ha)	Total avoidable losses (q/ ha)	Per cent avoidable losses	Total increase in yield over control (q/ ha)	Per cent increase in yield over control	Yield (q/ ha)	Total avoidable losses (q/ ha)	Per cent avoidable losses	Total increase in yield over control (q/ ha)	Per cent increase in yield over control
	2021-22					**2022-23**				
Seed treatment of Imidacloprid 600 FS @ 5 ml/ kg seed	18.40	1.40	7.07	3.10	20.26	16.05	1.55	8.80	2.90	22.05
Seed treatment of Clothianidin 50 WDG @ 2 gm/ kg seed	17.75	2.05	10.35	2.45	16.01	15.20	2.40	13.63	2.05	15.58
Seed treatment of Fipronil 5 SC @ 5 ml/ kg seed	18.05	1.75	8.83	2.75	17.97	15.80	1.80	10.22	2.65	20.15
Soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha	16.02	3.78	19.09	0.72	4.70	14.10	3.50	14.20	0.95	7.22
Soil application of *Metarhizium anisopliae* 1.15 WP @ 2 kg/ha	16.05	3.75	18.83	0.75	4.90	13.92	3.68	20.90	0.77	5.85
T-1+ soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha	19.80*	0.00	0.00	4.50	29.41	17.60*	0.00	0.00	4.45	33.84
T-2+ soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha	19.05	0.75	3.78	3.75	24.50	16.95	0.65	3.69	3.80	28.29
T-3+soil application of *Metarhizium anisopliae* 1.15 WP @ 2 kg/ha	19.35	0.45	2.27	4.05	26.47	17.05	0.55	3.12	3.90	29.65
Untreated control	15.30	4.50	22.72	0.00	0.00	13.15	4.45	25.56	0.00	0.00
S.Em±	0.65					0.39				
C.D. at 5%	1.67					1.13				
C.V	9.25					7.35				

* Highest yield in the treated plots

control (4.50 q/ha and 22.72%).Notably, plots that were treated with imidacloprid 600 FS at 5 ml/kg in combination with *Beauveria bassiana* 1.15 WP at 2 kg/ha had maximum increase in yield (4.50 q/ha) and percentage increase in yield (29.41%).Similar trends were observed in the subsequent year (Table 1).

Consistent patterns emerged across both study years regarding total and percentage avoidable losses, as well as increases in yield compared the untreated control. Treatment combinations such as fipronil 5 SC at 5 ml/kg with soil application of *Metarhizium anisopliae* 1.15 WP at 2 kg/ha and clothianidin 50 WDG at 2 gm/kg with *Beauveria bassiana* 1.15 WP at 2 kg/ha consistently demonstrated the lowest total avoidable losses. Conversely, plots treated with imidacloprid 600 FS at 5 ml/kg seed in combination with *Beauveria bassiana* 1.15 WP at 2 kg/ha showed the highest total and percentage increase in yield over the control (4.47 q/ha and 31.41%). Conversely, plots treated solely with soil application of *Metarhizium anisopliae* 1.15 WP at 2 kg/ha and soil application of *Beauveria bassiana* 1.15 WP at 2 kg/ha exhibited the lowest total increase in yield over control (Table 2).The effectiveness of the treatments in this study is consistent with previous research findings.Panigrahi (2010) showed that *O. obesus*did a lot less damage to chickpea plants, and the highest grain yield (1254 kg/ha) was achieved with a seed treatment of imidacloprid at a rate of 10 ml/kg seed. Bali *et al*., (2010) observed the lowest mean percentage of damage to wheat tillers with fipronil and imidacloprid 200 SL. Sundriya and Acharya (2012) identified imidacloprid 70 WS at 10 g/kg seeds as highly effective against *O. obesus* in wheat when applied as a seed treatment. These results are supported by Kumar (2013) concluded that wheat seed treated with imidacloprid 600 FS at 3 ml/kg seed and clothianidin 50 WDG at 2 g/kg was highly effective against *O. obesus*.

The analysis of economies associated with different treatments revealed varying levels of net returns and benefit-cost ratios. The plots that were treated with imidacloprid 600 FS with *Beauveria bassiana* 1.15 WP had the highest net return of Rs. 21,143. It was closely followed by plots that were treated with fipronil 5 SC with *Metarhizium anisopliae* 1.15 WP, which earned Rs. 19,595, and plots that were treated with clothianidin 50 WDG with *Beauveria bassiana* 1.15 WP, which earned Rs. 16,830. Conversely, the plots treated solely with *Metarhizium anisopliae* 1.15 WP (Rs. 3,341) and *Beauveria bassiana* 1.15 WP (Rs. 4,208) yielded the lowest net returns.In terms of benefit-cost ratio, plots treated with fipronil 5 SC

Table 2: Assessment of losses caused by termites on chickpea and economics of the treatments during Rabi, 2021-23

Treatments	Yield (q/ ha)	Total avoidable losses (q/ ha)	Per cent avoidable losses	Total increase in yield over control (q/ ha)	Per cent increase in yield over control	Return of increased yield (Rs)	Total cost of expenditure (Rs)	Net profit (Rs/ ha)	B:C ratio
Seed treatment of Imidacloprid 600 FS @ 5 ml/ kg seed	17.23	1.48	7.89	3.00	21.05	15745	1850	13895	7.51
Seed treatment of Clothianidin 50 WDG @ 2 gm/ kg seed	16.48	2.23	11.90	2.25	15.78	11813	2490	9323	3.74
Seed treatment of Fipronil 5 SC @ 5 ml/ kg seed	16.93	1.78	9.49	2.70	18.94	14173	770	13403	17.41
Soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha	15.06	3.64	19.47	0.83	5.83	4858	650	4208	6.47
Soil application of *Metarhizium anisopliae* 1.15 WP @ 2 kg/ha	14.99	3.72	19.87	0.75	5.31	3991	650	3341	5.14
T-1+ soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha	18.70*	0.00	0.00	4.47	31.41	23493	2350	21143	9.00
T-2+ soil application of *Beauveria bassiana*1.15 WP @ 2 kg /ha	18.00	0.70	3.74	3.77	26.49	19820	2990	16830	5.63
T-3+soil application of *Metarhizium anisopliae* 1.15 WP @ 2 kg/ha	18.20	0.50	2.67	3.97	27.90	20865	1270	19595	15.43
Untreated control	14.23	4.48	23.93	0.00	0.00	0	0	0	0
S.Em±	0.52								
C.D. at 5%	1.50								
C.V	8.30								

* Highest yield in the treated plots

exhibited the highest ratio at 1:17.41, followed by fipronil 5 SC combined with *Metarhizium anisopliae* 1.15 WP at 1:15.43, imidacloprid 600 FS combined with *Beauveria bassiana* 1.15 WP at 1:9.0, and imidacloprid 600 FS alone at 1:7.51. However, the benefit-cost ratios for clothianidin 50 WDG with *Beauveria bassiana* 1.15 WP (5.63) and clothianidin 50 WDG alone (3.74) were lower because they were more expensive,even though they worked better(Table 2). Gadhiya and Borad (2013) observed that the seed treatments of fipronil 5 SC at 5 ml/kg and imidacloprid 600 FS at 3 ml/kg were highly effective in suppressing the termite population in wheat, with net incremental cost-benefit ratios of 55.47 and 36.11, respectively, without detrimental effects on seed germination and tiller numbers. Gohil, 2013 found that imidacloprid 600 FS at 3 ml/kg seed and fipronil 5 SC at 5 ml/kg seed were both effective at controlling termites and increasing crop yield. However, fipronil 5 SC had the highest incremental cost-benefit ratio (ICBR) of 58.71.Amar Chand (2017) identified imidacloprid 600 FS at 5 ml/kg seed as most effective against termites in chickpea, yielding higher (1346 kg/ha) with a maximum net profit of 17362 ha^{-1}, with a maximum ICBR of35.19 in fipronil 5 SC at 4 ml/kg seed. Additionally, Rana andKachhawa (2014), found promising results in suppressing the termite population when applied at $5x10^{13}$ spores/ha, supporting the effectiveness of biopesticides such as *Metarhizium anisopliae* 1.15 WP and *Beauveria bassiana* 1.15 WP.

CONCLUSIONS

The study revealed that applying fipronil 5 SC at 5 ml/kg seed in combination with *Metarhizium anisopliae* 1.15 WP at 2 kg/ha on the soil resulted in the lowest total and percentage of avoidable losses, while also yielding the highest benefit-cost ratio. These findings suggest that this combination is effective in minimizing termite incidence in chickpea fields while ensuring economic viability.

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CONFLICT OF INTEREST

All the author both individually and collectively, affirms that they do not possess any conflicts of interest either directly or indirectly related to the research being reported in the publication.

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