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Research Article

Evaluation of variable doses of tachnid fly, *Sturmiopsis inferens* for the management of *Sesamia inferens* under field conditions in rice and wheat

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ABSTRACT: Evaluation of variable doses of tachnid fly, *Sturmiopsis inferens* for the management of pink stem borer, *Sesamia inferens* under field conditions in *basmati* rice (var. Pusa *Basmati* 1121) and wheat (var. HD 2967) was carried out at a farmer's field in Ludhiana. Two intervals, i.e. one at 10 days and the other at 15 days were followed for releasing different doses (75, 100, 125 and 150 gravid females/ha) of *S. inferens* during August-October in rice and November-December in wheat. In case of *Basmati* rice, the minimum incidence of *Sesamia inferens* was recorded in treatment where a higher dose of 150 gravid females per ha was released (1.05 % DH at 75 DAT, 1.09 % WE), which was significantly at par with the dose of 125 gravid females per ha. The untreated control plot observed the highest incidence of *Sesamia inferens* (1.81% DH, 2.11% WE). The observations on grain yield revealed that higher doses of 125 and 150 per ha were significantly superior (37.90-38.41 q/ha) while doses of 100 and 75 per ha were at par with each other (36.35 and 36.91 q/ha, respectively) and minimum grain yield was recorded in untreated plots (34.73 q/ha). In the case of wheat, the minimum incidence was recorded in a treatment where a higher dose of 150 gravid females per ha was released (1.49% DH at 45 DAS, 1.28% WE), which was significantly at par with the dose of 125 gravid females per ha (1.66 % DH at 45 DAS, 1.50% WE). The untreated control plot observed the highest incidence (2.48 % DH at 45 DAS, 2.65% WE). The higher doses of 125 and 150 per ha were significantly superior in terms of grain yield (46.68-47.17 q/ha), while doses of 100 and 75 per ha gave a yield of 45.41 and 44.13 q/ha, respectively.

KEYWORDS: *Basmati* rice, biocontrol, Pink Stem Borer (PSB), *Sesamia inferens, Sturmiopsis inferens,* wheat

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INTRODUCTION

Rice and wheat are major cereal crops grown in India. Rice is grown in the *Kharif* season, while wheat is in the *Rabi* season. Rice requires a hot and humid climate whereas wheat requires warmth and moisture during the early stages, however, in the later stages, it needs a sunny and dry climate (Anonymous, 2021a and b). This cropping system is the major cropping system on which the food security of the country depends (Prasad and Nagarajan, 2004). The primary reason for the wide adaptation of this cropping system is varied agro-climatic conditions present in the country, Minimum Support Price (MSP) and the availability of better marketing systems. The share of Punjab in the central pool was 25.5 and 37.8 per cent for rice and wheat, respectively in the year 2018-19 (Anonymous, 2021c). The production of these crops is affected by several biotic and abiotic factors. Among biotic factors, diseases, insects and weeds cause huge losses. Furthermore, several insect pests cause qualitative and quantitative losses in these crops.

Sesamia inferens (PSB) Walker (Lepidoptera: Noctuidae), is the new emerging pest of this cropping system due to mild winters and a reduction in the time gap between the harvesting of rice and sowing of the wheat crop (Singh and Kular, 2015) and promotion of zero tillage. PSB is known by different names viz. Graminaceous stem borer, pink borer, pink rice stem borer, purple borer, purple stem borer and purplish stem borer in different parts of the country (Baladhiya *et al.,*2018). It is also referred to as "Goolabitannachhedak" in North Indian states, "khod kid" in Maharashtra and "Gulabigaabhmaranieyal" in Gujarat. Among different species of stem borers, the PSB has assumed the status of major pest in cereals recently. In addition to its pestiferous nature in rice, its economic damage has been recorded in wheat and maize too (Ram *et al.,* 2011; Singh and Kular, 2011; Singh *et al.,* 2014). The signs and symptoms of the damage caused by the larvae of the PSB in wheat and rice include dead hearts (bores into the stem and kills central shoot) in early stages and white ears in later stages. Although chemical control is the primary method of its management, its deleterious effects like development of resistance, resurgence and secondary pest outbreaks making it less suitable in the longer run.

Sturmiopsis inferens Townsend is a fly belonging to the order Diptera, and family Tachinidae. It is a key larval endoparasitoid of various moth species whose larvae feed inside the stems, i.e. borers viz. Gurdaspur borer (*Bissetia steniellus* /*Acigona steniellus*), gold-fringed rice stem borer (*Chilo auricilius*) in Haryana (Singh and Yadav, 1979; Chaudhary *et al.,* 1986), ragi stem borer (*S. inferens*) in Karnataka (Krishnamurthi and Usman, 1952), sugarcane shoot borer (*Chilo infuscatellus*) in Odisha (Kalra and Dutta, 1971). Tachinid parasitoids are more promising than hymenopterous parasitoids because these parasitoids have a tough time depositing eggs on the host's body in a thick-stemmed tunnel, whereas flies place maggots in borer tunnels and these maggots then by crawling, reach up to the host and parasitize it.

Keeping in view the importance of these ecologically safe and efficient method of pest control, the present studies were planned to ascertain the efficacy of *S. inferens* for the management of PSB under field conditions of Punjab in rice and wheat.

MATERIALS AND METHODS

Raising of host plant

Seeds of Maize hybrid PMH 11 were sown at weekly intervals in earthen pots (8×4×6 inches) having a mixture of soil and well-rotten farm yard manure, in cages and under field conditions for growing *S. inferens* larvae in the laboratory. Plants were watered and observed daily. To provide enough food for the insect culture, successive maize plant raisings were carried out at weekly intervals. The crop was raised as per the practices recommended by Punjab Agricultural University, Ludhiana except for plant protection measures (Anonymous, 2021a).

Rearing of the host, *S. inferens*

Laboratory culture of *S. inferens* was maintained on the maize stems and artificial diet in a room with controlled temperature (25±2°C) and relative humidity (70±5 %) conditions. The larvae were kept separately in plastic vials. The emerging adult pairs (male and female) were released in an oviposition cage for egg-laying. The adults were provided honey solution in cotton swabs as food. The PSB thus multiplied was used for further rearing of the larval parasitoid, *S. inferens.*

Production of the gravid female of *S. inferens*

The laboratory culture of the larval parasitoid, *S. inferens* was maintained on the 5th instar larvae of *S. inferens* under controlled laboratory conditions (temperature 25±2°C and relative humidity 70±5 %). The honey streak was provided in the glass jar food for the parasitoid adults. One gravid female parasitoid was released in each glass jar for 24 hours to allow parasitization. Subsequently, the host larvae were reared on the artificial diet till pupa formation or the emergence of parasitoid pupae. Newly emerged females of *S. inferens* were mated with 2–3-day-old males in 15×2.5 cm glass specimen tubes. Females were kept in glass jars after mating to complete their gestation period.

Augmentation of the gravid female of *S. inferens* in *Basmati* rice and wheat

Basmati rice (var. Pusa *Basmati* 1121) was transplanted during the second week of July and wheat (var. HD 2967) was sown during the last week of October, according to PAU recommendations (Anonymous, 2021a and b) at farmer fields in Ludhiana. The experiment was conducted in a randomized block design with four replications and a plot size of 250 m^2. In all, there were five treatments comprising the release of gravid females of *S. inferens* @ 75, 100, 125, 150, and one untreated control treatment. Two intervals, i.e. one at 10 days and the other at 15 days were followed for releasing different doses of *S. inferens* during August-October in rice and November-December in wheat. The initial release of both time intervals was started on the same day and subsequent releases were made as per the time interval. In total, there were seven releases at 10-day intervals, five releases were made when parasitoids were released at 15-day intervals in rice (Table 1) and six releases at 10-day intervals and four releases were made when parasitoids were released at 15-day intervals in wheat (Table 2). An isolation distance of 10 m was maintained between the treatments to avoid the undue effect of one treatment on the other.

Observations

Observations were recorded from randomly selected 10 plants per treatment per replication at 45 days after sowing in case of wheat and 75 days after transplanting in case of *basmati* rice for *dead hearts* (DH). The data on *White Earheads* (WE) were recorded once, about a week before harvest. The per cent stem borer incidence was calculated.

$$\text{Stem borer incidence}\left(\%\right)=\frac{\text{Number of DH or WE}}{\text{Total number of tiller / panicles / Ear}}\times 100$$

The grain yield for all the treatments was recorded at the time of harvest on a whole plot basis.

Statistical analysis

The data were subjected to statistical analysis in Factorial Randomized Block design as per Gomez and Gomez (1984). The per cent values were subjected to square root transformation for *dead hearts* and *white earheads* before analysis.

Table 1. Release of *S. inferens* in *Basmati* rice during 2021

Releases (7)	Date (At 10-day interval)	Releases (5)	Date (At 15-day interval)
1st release	10 Aug.	1st release	10 Aug.
2nd release	20 Aug.	2nd release	25 Aug.
3rd release	30 Aug.	3rd release	10 Sept.
4th release	10 Sept.	4th release	25 Sept.
5th release	20 Sept.	5th release	10 Oct.
6th release	30 Sept.		
7th release	10 Oct.		

Table 2. Release of *S. inferens* in wheat during 2021-22

Releases (6)	Date (At 10-day interval)	Releases (4)	Date (At 15-day interval)
1st release	7 Nov.	1st release	7 Nov.
2nd release	17 Nov.	2nd release	22 Nov.
3rd release	27 Nov.	3rd release	7 Dec.
4th release	7 Dec.	4th release	22 Dec.
5th release	17 Dec.		
6th release	27 Dec.		

RESULTS AND DISCUSSION

In rice

Stem borer incidence

Dead hearts

The results of the experiments conducted in 2021 on *basmati* rice (var. Pusa *Basmati* 1121) showed that the incidence of *S. inferens* varied significantly at different doses of *S. inferens* applied at two intervals. The minimum incidence was recorded in treatment where 150 gravid females per ha were released (1.05% DH at 75 DAT) which is significantly at par with the dose of 125 gravid females per ha; while lower doses of 100 and 75 gravid females per ha reduced incidence and these are at par with each other (Table 3). The untreated control plot observed the highest incidence (1.81% DH) (Figure 1). The incidence was significantly lower at a release interval of 10 days in comparison to 15 days. The interaction was non-significant between different doses and release intervals.

White earheads

The minimum incidence was recorded in treatment where 150 gravid females per ha were released (1.09% WE) which is significantly at par with the dose of 125 gravid females per ha (1.26% WE) (Table 3); while lower doses of 100 and 75 gravid females per ha reduced incidence. The untreated control plot observed the highest incidence (2.11% WE) (Figure 1). The incidence was significantly lower at a release interval of 10 days in comparison to 15 days. The interaction was non-significant between different doses and release intervals.

Crop yield

The observations on grain yield revealed that higher doses of 125 and 150 gravid females per ha were significantly superior (37.90-38.41 q/ha) while doses of 100 and 75 gravid females per ha were at par with each other (36.35 and 36.91 q/ha). However; minimum grain yield was recorded in untreated plots (34.73 q/ha) (Figure 2). The mean yield in two release intervals showed that a higher yield (37.33 q/ha) was recorded in the interval of 10 days than that of 15 days (36.39 q/ha) (Table 3). The interaction was non-significant between different doses and release intervals.

In wheat

Stem borer incidence

Dead hearts

The results of the experiments conducted on wheat (var. HD 2967) showed that the incidence of *S. inferens* varied significantly at different doses of *S. inferens* applied incidence was observed in the untreated control plot (2.48% DH). The incidence was significantly lower at a release interval of 10 days (1.87 %) in comparison to 15 days (2.11%).

White earheads

The minimum incidence was recorded in treatment where 150 gravid females per ha were released (1.28% WE)

Table 3. Impact of different *S. inferens* doses at different release intervals on the incidence of *dead heart*, *white earheads* and grain yield in *Basmati* during 2021

Dose (Gravid female/ha)	Dead Hearts (%) (at 75 DAT)			White earheads (%) (one week before harvest)			Yield (q/ha)		
	Release interval (Days)		Mean	Release interval (Days)		Mean	Release interval (Days)		Mean
	10	15		10	15		10	15	
75	1.51 (1.58)	1.70 (1.64)	1.61 (1.61)	1.65 (1.63)	2.07 (1.75)	1.86 (1.69)	36.60	36.10	36.35
100	1.35 (1.53)	1.53 (1.59)	1.44 (1.56)	1.45 (1.56)	1.84 (1.68)	1.64 (1.62)	37.40	36.43	36.91
125	1.08 (1.44)	1.25 (1.50)	1.17 (1.47)	1.17 (1.47)	1.35 (1.53)	1.26 (1.50)	38.60	37.20	37.90
150	0.99 (1.41)	1.12 (1.45)	1.05 (1.43)	0.99 (1.41)	1.19 (1.48)	1.09 (1.44)	39.10	37.73	38.41
(Untreated Control)	1.70 (1.64)	1.91 (1.71)	1.81 (1.67)	1.91 (1.71)	2.30 (1.82)	2.11 (1.76)	34.98	34.48	34.73
Mean	1.33 (1.52)	1.50 (1.58)		1.44 (1.56)	1.75 (1.65)		37.33	36.39	
LSD (p=0.05)	RI= (0.03) D= (0.05) I*D= (NS)			RI= (0.04) D= (0.06) I*D= (NS)			RI= 0.36 D=0.56 I*D=NS		

RI = Release Interval, D = Dose factor, I*D = Interaction
Data in parentheses are square root transformed values; DAT: Days after transplanting
#Seven releases were made in 10-day release intervals and Five releases were made in 15-day release intervals

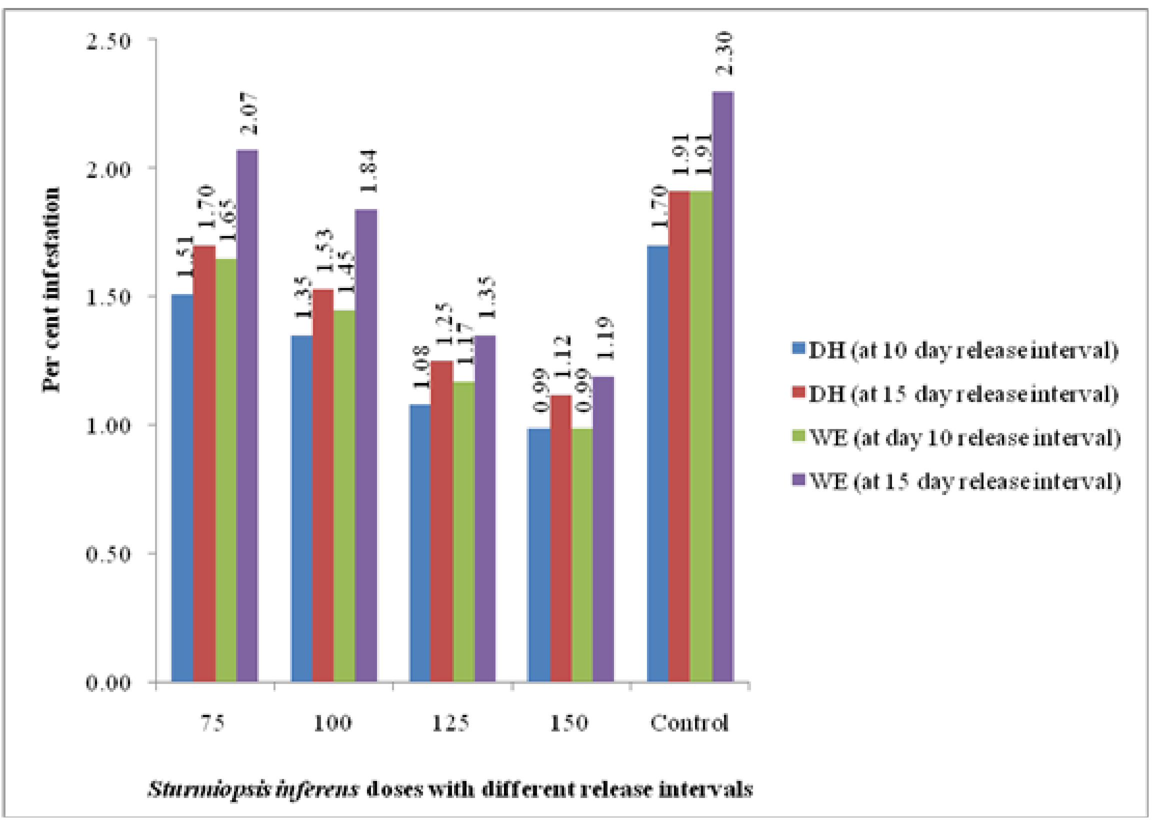

Figure 1. Effect of *S. inferens* doses with different release intervals on the incidence of *Dead Hearts* (DH) and *White Earheads* (WE) in *basmati* rice during 2021.

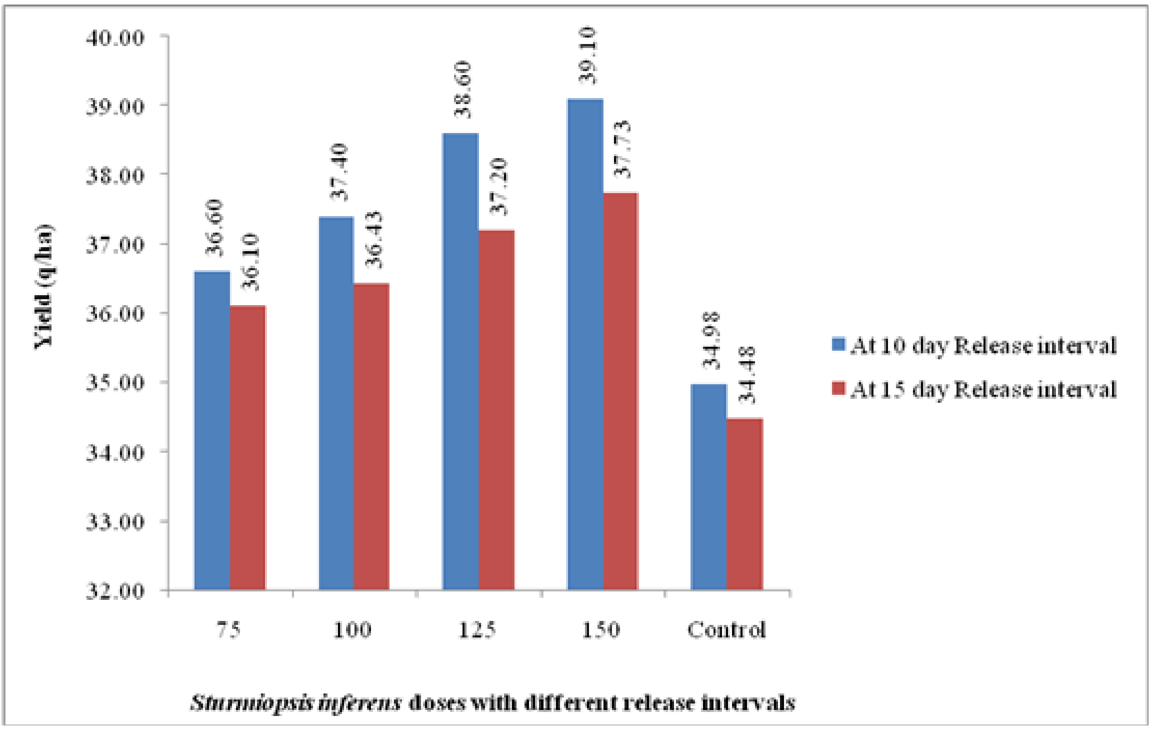

Figure 2. Effect of *S. inferens* doses with different release intervals on the grain yield in *basmati* rice during 2021.

which is significantly at par with the dose of 125 gravid females per ha (1.50% WE) (Figure 3); while lower doses of 100 and 75 gravid females per ha reduced incidence up to 1.85 and 2.14 per cent, respectively (Table 4). The untreated control plot observed the highest incidence (2.65% WE). The incidence was significantly lower at a release interval of 10 days in comparison to 15 days. The interaction was non-significant between different doses and release intervals.

Crop yield

The observations on grain yield (Table 4) revealed that higher doses of 125 and 150 gravid females per ha were significantly superior (46.68-47.17 q/ha) while doses of 100 and 75 per ha give a yield of 45.41 and 44.13 q/ha. However, minimum grain yield was recorded in untreated plots (42.69 q/ha) (Figure 4). The mean yield in two release intervals showed that a higher yield (45.98 q/ha) was recorded in the interval of 10 days than that of 15 days (44.45 q/ha).

The findings of the current investigation are in line with previous studies where augmentative releases of *S. inferens* gravid females at dosages of 25-95 females/ha enhanced parasitism rates and reduced sugarcane shoot borer, *Chilo infuscatellus* incidence in some trials but produced variable effects in some other trials at Coimbatore, India (Srikanth *et al.,* 2009). Overall higher post-release parasitism rate in release plots (0.0-13.2%) than in control plots (0.0-6.2%) of the 22 trials indicated post-release enhancement of parasitoid activity. Parasitism rates increased from 0 per cent to 43.5 per cent when 15 gravid females of the parasitoid were released against *Chilo infuscatellus* at fortnightly intervals (Rai *et al.*, 1999). Given the overlapping generations of the borer, this study demonstrated that the parasitoid could be effective at low dosages if administered sequentially over a 2–3-week period in small numbers. According to David and Sithanantham (1986), the parasitoid has been recommended at a theoretical dosage of 125 females/ha, apparently based on the borer's economic threshold level, the parasitoid's fecundity and potential to deposit maggots close to the borehole, as well as its preference for older larvae.

The findings of the current investigation show that the incidence of PSB changed in response to various doses and release intervals of larval parasitoids. However, compared to release intervals, this reaction was more pronounced in dosages. All the doses were better than the untreated control. In comparison to other gravid female doses, 125 gravid females per ha had the greatest impact on a decrease in *dead hearts* and *white earheads* and an increase in the yield of *basmati* rice and wheat. It was statistically equivalent to the higher dose of 150 gravid females per ha. The present study may serve as a key for better utilization of parasitoids in the eco-friendly management of PSB.

Table 4. Impact of different *S. inferens* doses at different release intervals on the incidence of *dead heart*, *white earheads* and grain yield in wheat during 2021-22

Dose (Gravid female/ha)	Dead Hearts (%) (at 45 DAS)			White earheads (%) (one week before harvest)			Yield (q/ha)		
	Release interval (Days)		Mean	Release interval (Days)		Mean	Release interval (Days)		Mean
	10	15		10	15		10	15	
75	2.24 (1.80)	2.36 (1.83)	2.30 (1.82)	2.02 (1.74)	2.26 (1.81)	2.14 (1.77)	45.10	43.15	44.13
100	2.00 (1.73)	2.09 (1.76)	2.04 (1.74)	1.75 (1.66)	1.95 (1.72)	1.85 (1.69)	46.35	44.48	45.41
125	1.45 (1.56)	1.87 (1.70)	1.66 (1.63)	1.35 (1.53)	1.65 (1.63)	1.50 (1.58)	47.38	45.98	46.68
150	1.29 (1.51)	1.69 (1.64)	1.49 (1.57)	1.13 (1.46)	1.44 (1.56)	1.28 (1.51)	47.98	46.36	47.17
(Untreated Control)	2.40 (1.84)	2.56 (1.89)	2.48 (1.87)	2.48 (1.86)	2.82 (1.96)	2.65 (1.91)	43.10	42.28	42.69
Mean	1.87 (1.69)	2.11 (1.76)		1.75 (1.65)	2.03 (1.73)		45.98	44.45	
LSD (p=0.05)	RI= (0.04) D= (0.06) RI*D= (NS)			RI= (0.04) D= (0.07) RI*D= (NS)			RI= 0.44 D= 0.70 RI*D= NS		

RI= Release Interval, D=Dose factor, RI*D= Interaction
Data in parentheses are square root transformed values, DAS: Days after sowing
[#]Six releases were made in 10-day release intervals and four releases were made in 15-day release interval

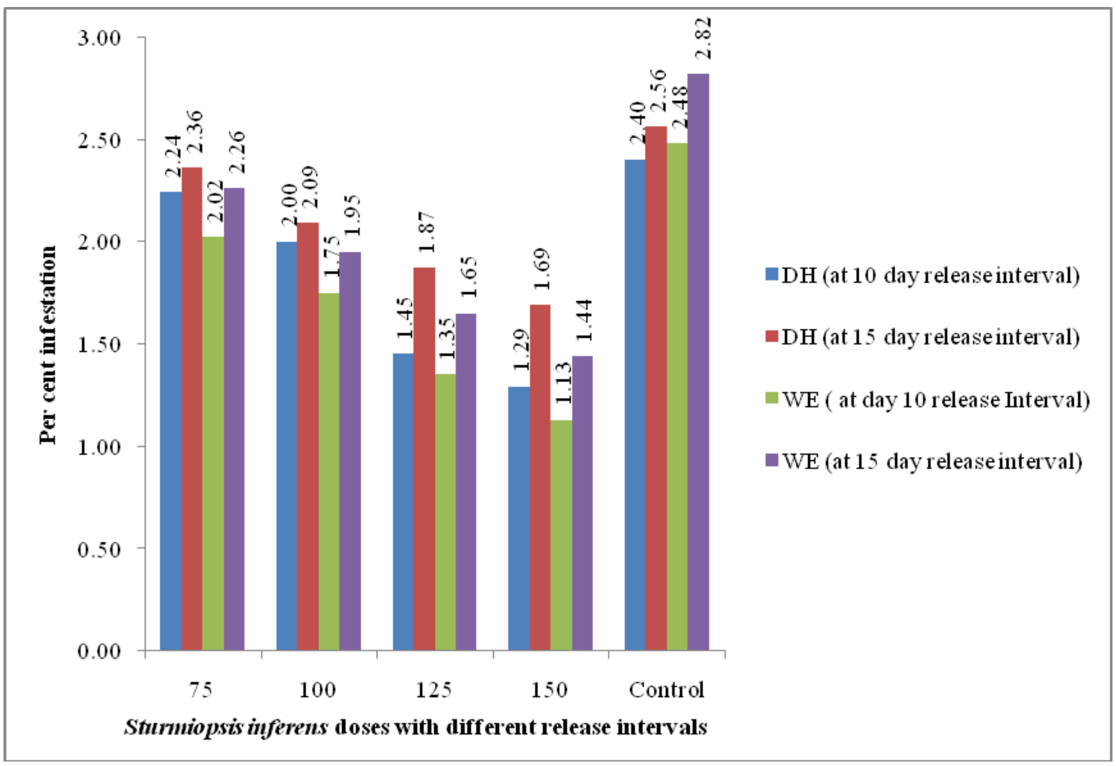

Figure 3. Effect of *S. inferens* doses with different release intervals on the incidence of *Dead Hearts* (DH) and *White Earheads* (WE) in wheat during 2021-22.

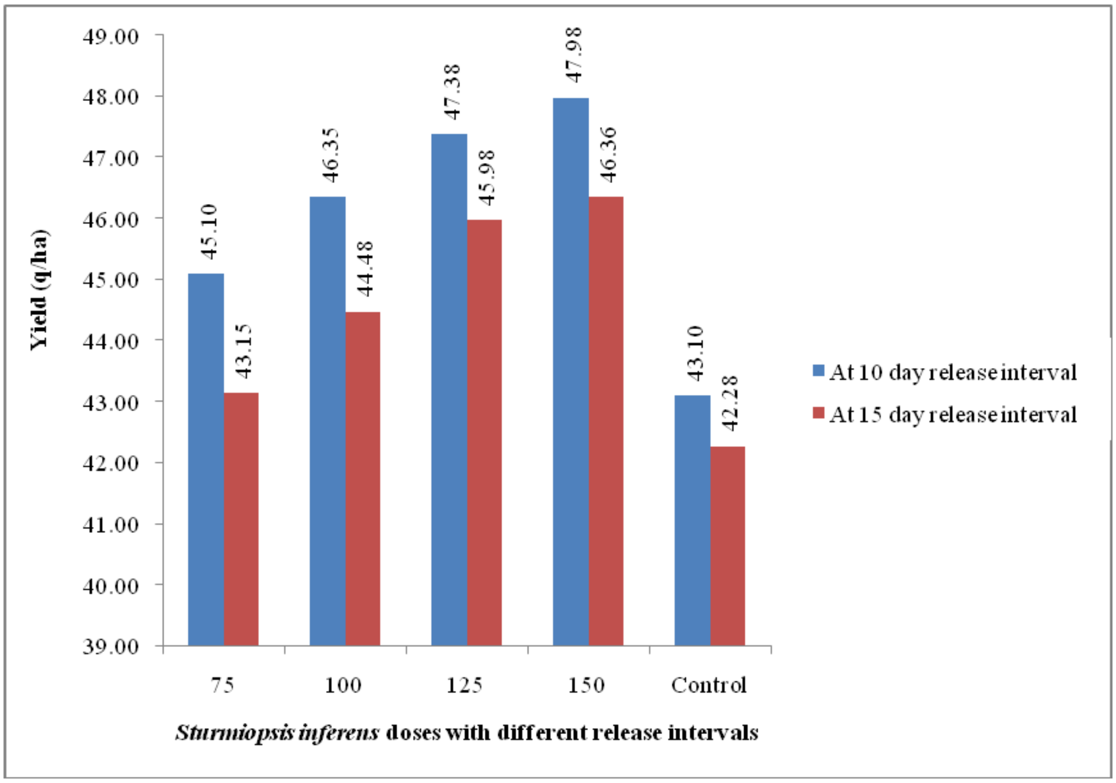

Figure 4. Effect of *S. inferens* doses with different release intervals on the grain yield in wheat during 2021-22.

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