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All author's name and affiliations are given below, after references

Corresponding Author:
KU Ranher
M.Sc. Scholar, Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India

Impact of diverse nutrient integration on insect pests of rice

KU Ranher, SS Chavan, MS Karmarkar, VA Rajemahadik, VN Jalgaonkar, VS Desai, MK Bhoyar, SP Patankar, RS Pawar and Karthikeyan M

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Abstract

The present field investigation entitled "Impact of Diverse Nutrient Integration on Insect Pests of Rice" was conducted during the *Kharif* season of 2024 at the Instructional Farm, College of Agriculture, Dapoli. The study aimed to evaluate the influence of various nutrient management practices on the incidence of key insect pests in rice. The experiment was laid out with 15 nutrient management treatments, including combinations of recommended dose of fertilizers (RDF), organic manures, biofertilizers, and silica and observations were recorded on major pests such as blue beetle (*Leptispa pygmaea*), rice skipper (*Parnara mathias*), leaf folder (*Cnaphalocrocis medinalis*), rice horn caterpillar (*Melanitis leda ismene*), and yellow stem borer (*Scirpophaga incertulas*).

The effect of nutrient management on pest incidence was noteworthy and statistically significant. Among the treatments, the lowest pest infestations were consistently observed in T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica @ 15 kg/ha), followed by T_{11} (RDF 75% + biofertilizers). These treatments significantly reduced leaf damage caused by all targeted pests throughout the crop growth stages. The suppression of pest population was attributed to enhanced plant vigor, increased nutrient uptake efficiency, induced systemic resistance from biofertilizers, and physical defense offered by silica. In contrast, treatments with high nitrogen levels, especially T_2 (150% nitrogen), and the untreated control (T_{15}) recorded the highest infestation levels, reinforce the understanding that excessive nitrogen can lead to increased pest susceptibility by making foliage more tender and nutrient-rich for pest feeding.

Furthermore, organic nutrient sources (T_9 and T_{10}, involving FYM and Gliricidia) and biofertilizer-alone treatments (T_{13} and T_{14}) exhibited moderate efficacy in pest suppression. In most cases addition of silica provided additional level of protection, enhancing the effectiveness of these treatments. Silica played a crucial role in reducing pest damage by strengthening plant tissues and possibly interfering with insect feeding behavior and oviposition. NPK treatments with silica (T_6, T_8) also showed reduced pest levels compared to their non-silica counterparts, emphasizing the beneficial role of silica across different nutrient regimes.

Keywords: Integrated nutrient management, rice pests, biofertilizers, silica, pest dynamics, sustainable agriculture

Introduction

Rice (*Oryza sativa* L.) is a vital food crop cultivated across diverse agro-ecological regions, but its productivity is often limited by insect pest infestations. Among the many factors influencing pest outbreaks in rice, nutrient management plays a significant role. The way fertilizers are applied-whether organic, inorganic, or a combination-can influence the crop's susceptibility or resistance to various insect pests. Excessive nitrogen application, a common practice among rice farmers aiming for high yields, has been found to promote lush vegetative growth with soft plant tissues that are highly attractive to pests such as the brown planthopper (*Nilaparvata lugens*), rice leaf folder (*Cnaphalocrocis medinalis*), and green leafhopper (*Nephotettix* spp.). These pests feed on nitrogen-rich plants more aggressively, leading to severe damage and yield losses. Moreover, high nitrogen levels can suppress the plant's natural defense mechanisms and reduce the population of beneficial insects, further aggravating pest problems.

However, nitrogen is not the only nutrient that influences pest dynamics. Phosphorus (P) and potassium (K), both essential macronutrients, also play key roles in strengthening plant health and resistance. Potassium, in particular, helps in reinforcing plant tissues, improving water use efficiency, and increasing resilience against pests. The inclusion of micronutrients like silicon (Si), can further enhance the plant's defensive capabilities. Silicon, for example, is known to strengthen cell walls and make them less palatable to chewing insects such as the yellow stem borer (*Scirpophaga incertulas*) and blue beetle (*Leptispa pygmaea*). Zinc and iron contribute to vital physiological functions such as enzyme activation and chlorophyll formation, indirectly supporting plant vigor and resistance to biotic stress.

To reduce the negative effects of excessive chemical inputs and enhance the sustainability of rice farming, integrated nutrient management (INM) is being promoted. INM involves the combined use of organic manures, chemical fertilizers, and biofertilizers to optimize nutrient availability while maintaining soil health. The application of farmyard manure, compost, green manure, and microbial inoculants not only improves soil fertility but also encourages the growth of beneficial microorganisms that enhance plant growth and suppress pests.

The relevance of nutrient integration in pest management is particularly high in the Konkan region of Maharashtra, which is characterized by high rainfall, lateritic soils, and rainfed rice cultivation. These soils are often deficient in nitrogen, phosphorus, and micronutrients, prompting farmers to rely heavily on nitrogenous fertilizers to maintain productivity. However, this practice unintentionally fosters pest outbreaks, especially under the region's humid climatic conditions that are already favourable for pest development. In such a context, studying the impact of diverse nutrient integration on insect pests of rice is essential. By analysing how different nutrient combinations affect pest population.

Ultimately, effective nutrient management not only contributes to plant nutrition but also plays a key role in pest control. The overuse of nitrogen without balancing it with other essential nutrients often leads to higher pest incidence and environmental degradation. Conversely, adopting a diverse and balanced nutrient management approach, such as INM, offers a pathway toward sustainable rice farming. It promotes soil health, reduces reliance on chemical pesticides, supports beneficial organisms, and enhances plant resistance to pest attacks. Understanding the intricate relationship between nutrient inputs and insect pest dynamics is therefore critical for designing integrated crop and pest management strategies. Especially in vulnerable regions like the Konkan, integrating scientific knowledge with local practices can lead to more resilient and productive farming systems, ensuring food security and environmental sustainability for the future.

Material and Methods

To study the impact of diverse nutrient integration on insect pests of rice

For studying the impact of diverse nutrients integration, the experimental plot will be prepared in Randomized Block Design (RBD). The design consists of 2 replications and 15 treatments. The seedlings of ratnagiri-1 variety of rice will be prepared on raised nursery beds and transplanted on experimental plot. All the treatments will be randomly allotted in each replication. All the necessary cultural practices and fertilizer requirements will be fulfilled as per requirement.

Details of the experiment and treatments are as follows

Details of the field experiment for the impact of diverse nutrient integration on insect pests of rice

Period of study	**:**	***Kharif* -2024**
Variety	:	Ratnagiri-1
Spacing	:	20 cm x 15 cm
Size of treatment plot	:	5.4 m x 4 m
Total plot size	:	1056 sq. m.
Design	:	Randomized Block Design (RBD)
Number of replications	:	2
Number of treatments	:	15

Details of the treatment

Tr.no	Treatments
T_1	Nitrogen (100 kg/ha) 100%
T_2	Nitrogen (200 kg/ha) 150%
T_3	Nitrogen (100 kg/ha)100% + Silica @ 15 kg/ ha
T_4	Nitrogen (200 kg/ha)150% + Silica @ 15 kg/ ha
T_5	Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) standard check
T_6	Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) + Silica @ 15 kg ha
T_7	Nitrogen + Phosphorous + Potassium (200:100:100 kg/ ha)
T_8	Nitrogen + Phosphorous + Potassium (200:100:100 kg/ ha) + Silica @ 15 kg/ ha
T_9	RDF 100 %+ FYM 10ton/ha + Gliricidia leaves 10 ton per ha
T_{10}	RDF 100%+ FYM 10ton/ha + Gliricidia leaves 10 ton per ha + Silica @ 15 kg /ha
T_{11}	RDF (75%) + Azotobacter + Azospirillum + PSB @ (2 kg/ha)
T_{12}	RDF (75%) + Azotobacter + Azospirillum + PSB @ (2 kg/ha) + Silica @ 15 kg /ha
T_{13}	Only biofertilizers Azotobacter + Azospirillum+ PSB @ (2 kg/ha)
T_{14}	Only biofertilizers Azotobacter + Azospirillum + PSB @ (2 kg/ha) + Silica @ 15 kg/ ha
T_{15}	Untreated check (control)

Application of treatment

The entire quantity of FYM, Gliricidia leaves, *Azotobacter, Azospirillum*, PSB and pure form of silica will be applied as a basal dose in the plot before the transplanting the seedlings. The treatments involving of inorganic fertilizers will be applied at varying doses. Nitrogen will be applied in the form of urea, while phosphorus and potassium will be applied in the form of single super phosphate and muriate of potash respectively. Forty per cent of the nitrogen, along with recommended dose of phosphorus and potassium, will be applied as basal dose before transplanting. The remaining nitrogen will be applied in two split doses, 40% at the 30

DAT stage and 20% at 60 DAT. A thin film of water will be maintained during fertilizer application to enhance nutrient availability and uptake efficiency.

Observations to be recorded

Observations on insect pest incidence will be recorded on ten randomly selected hills from each treatment. Observations will be taken at 7-day intervals starting from day after transplanting (DAT), following standard procedures.

Rice Blue Beetle, Rice Skipper and Leaf Folder:

The numbers of total as well as damaged leaves will be counted in 10 selected and marked hills and percent damage will be calculated as given below:

$$\text{The \% leaf infestation} = \frac{\text{Total number of infested leaves per hill}}{\text{Total number of leaves per hill}} \times 100$$

Rice yellow stem borer

Total number of tillers and dead hearts as well as white ears will be counted at both vegetative and reproductive phases respectively from10 randomly selected and marked hills in each plot starting from the pest incidence till the harvest of the crop.

$$\text{Percent dead hearts} = \frac{\text{Number of dead hearts per hills}}{\text{Total number of tillers per hills}} \times 100$$

$$\text{Per cent white ears} = \frac{\text{Number of white ear per hills}}{\text{Total number of tillers per hills}} \times 100$$

Result

Impact of diverse nutrient integration on insect pests of rice

Incidence of blue beetle in rice under different nutrient management practices (*Kharif*-2024)

The incidence of the blue beetle (*Leptispa pygmaea*) in rice was significantly influenced by various nutrient management treatments applied during the *Kharif* season 2024. The infestation, expressed as mean percentage of leaf damage, was monitored from 35 to 84 days after transplanting (DAT).

Among all treatments, the lowest leaf infestation was recorded in T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica @ 15 kg/ha), which recorded 0.00% infestation at 35 DAT and a maximum of only 14.48% at 84 DAT. This was closely followed by T_{11} (RDF 75% + biofertilizers only), which recorded a gradual increase from 0.63% at 35 DAT to 17.87% at 84 DAT. These two treatments demonstrated superior performance in reducing pest incidence, clearly indicating the beneficial role of integrated nutrient management with biofertilizers and silica. The improved plant health and enhanced resistance to pest attack under these treatments are likely contributing factors to the reduce pest attack.

In contrast, the highest infestation was noted in T_2 (150% Nitrogen), followed by T_{15} (untreated control). T_2 recorded 1.77% leaf infestation at 35 DAT and showed a steep rise up to 37.66% by 84 DAT. Similarly, the control plot (T_{15}) exhibited 1.55% initial infestation, culminating in the highest peak of 37.80% at 84 DAT. This trend indicates that excess nitrogen application without balanced nutrient support can predispose rice plants to higher susceptibility to blue beetle attack, possibly by making the foliage more succulent and attractive to the pest.

Treatments combining NPK with silica, such as T_6 (NPK + Silica @ 15 kg/ha) and T_8 (NPK 200:100:100 kg/ha + Silica), also recorded moderate reductions in infestation compared to their respective treatments without silica. For example, T_6 showed infestation from 1.02% at 35 DAT to 27.02% at 84 DAT, which was lower than T_5 (standard NPK) that recorded 30.95% at 84 DAT. Similarly, T8 showed a lower final infestation of 34.19%, compared to 34.44% in T_7 (NPK 200:100:100 without silica). This underscores the ameliorative effect of silica, which possibly acts by improving structural toughness of leaf tissues and enhancing natural defences.

Among organic nutrient management strategies, T_9 (RDF 100% + FYM 10 t/ha + Gliricidia leaves 10 t/ha) also showed lower pest incidence, with infestation increasing from 1.47% at 35 DAT to 23.81% at 84 DAT, which was significantly lower than most inorganic treatments. When silica was added (T_{10}), infestation was further reduced to 20.74%, highlighting a synergistic effect between organic manures and silica application. These treatments likely improve soil health and induce systemic resistance in the crop.

Treatments involving only biofertilizers (T_{13} and T_{14}) also exhibited beneficial effects, especially when silica was supplemented. T_{13} (biofertilizers only) showed infestation ranging from 1.56% to 33.87%, while T_{14} (biofertilizers + silica) recorded a slightly lower final infestation of 32.28%. Though not as effective as integrated treatments like T_{12} and T_{11}, these still offered notable reductions compared to conventional N or NPK treatments.

The overall trend across DAT stages indicated a progressive build-up of pest population, typically peaking between 70 and 84 DAT, which corresponds to the tillering to panicle initiation stage of rice, a physiologically tender and pest-favourable growth phase. This reinforces the importance of effective nutrient management in mitigating pest pressure during vulnerable crop stages.

The integration of balanced fertilization (RDF), organic amendments (FYM, Gliricidia), biofertilizers, and silica (especially in T_{12} and T_{11}) was most effective in minimizing blue beetle incidence. In contrast, treatments with excess nitrogen or unbalanced nutrients favoured higher pest infestation. These findings underscore the potential of eco-friendly, integrated nutrient management strategies in sustainable rice pest management, reducing reliance on chemical pesticides while enhancing crop resilience.

Incidence of rice skipper in rice under different nutrient management practices (*Kharif*-2024)

The incidence of rice skipper (*Parnara mathias*) in rice was significantly influenced by different nutrient management treatments during Kharif 2024. Observations were recorded at 35, 42, 49, 56, 63, 70, 77, and 84 days after transplanting (DAT) on the rice variety 'Ratnagiri -1'.

Among all treatments, the lowest leaf infestation was consistently recorded in T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica), with values ranging from 0.00% at 35 DAT to 10.42% at 84 DAT, indicating the highest level of rice skipper suppression. This treatment remained significantly superior throughout the crop growth period, suggesting the potential synergistic effect of biofertilizers and silica in suppressing pest infestation. The next best effective treatment was T_{11} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB), which also showed consistently low infestation (0.46%–12.86%), proving the beneficial impact of biofertilizers in reducing pest pressure even without silica.

In contrast, the untreated control (T_{15}) exhibited the highest leaf infestation, starting from 1.12% at 35 DAT and reaching 27.22% at 84 DAT, closely followed by T_2 (Nitrogen 200 kg/ha), which recorded 27.11% at 84 DAT. This clearly indicates that higher nitrogen levels favoured increased rice skipper infestation, likely due to enhanced vegetative growth that promotes a favourable microclimate for pest multiplication.

Treatments involving integrated nutrient management such as T_9 (RDF + FYM + Gliricidia) and T_{10} (RDF + FYM + Gliricidia + Silica) also showed comparatively lower infestation than high nitrogen-only treatments. Particularly, T_{10} maintained moderate pest levels (0.80% to 14.94%), indicating that addition of silica to organic-based treatments enhanced pest suppression.

Among NPK-based treatments, the combination of recommended dose with silica, as seen in T6 (NPK + Silica), was notably effective, reducing infestation to 19.46% at 84 DAT compared to 22.29% in the standard NPK check (T_5). This further emphasized silica's role as a physical and biochemical barrier against pest feeding. Similarly, T_8 (NPK 200:100:100 + Silica) resulted in slightly lower infestation (24.62%) than its non-silica counterpart T_7 (24.79%).

Biofertilizer-alone treatments (T_{13} and T_{14}) also demonstrated moderate efficacy. While T_{13} (only biofertilizers) showed infestation as high as 24.38%, adding silica (T_{14}) lowered it to 23.24%, highlighting silica's additive protective effect even in less nutrient-rich systems.

Overall, the data clearly reveal that nutrient management significantly influences rice skipper infestation. Treatments integrating biofertilizers with silica (especially T_{12}) were most effective, followed by reduced fertilizer combinations and organic manures. In contrast, high nitrogen doses, particularly without balancing nutrients or silica, aggravated pest infestation.

Incidence of rice leaf folder under different nutrient management practices (*Kharif*- 2024)

The incidence of rice leaf folder (*Cnaphalocrocis medinalis*) was significantly influenced by different nutrient management practices across various crop growth stages. Observations recorded at 35, 42, 49, 56, 63, 70, 77, and 84 days after transplanting (DAT).

At the early growth stage (35 DAT), all treatments exhibited very low infestation levels. The untreated check (T_{15}) recorded 0.35% infestation, while the minimum infestation (0.00%) was observed in T_{12}, which received RDF (75%) along with biofertilizers and silica. Treatments involving integrated nutrient management with biofertilizers and silica (T_{12}, T_{11}, and T_{10}) consistently showed lower infestation levels across all time intervals compared to the sole application of chemical fertilizers.

As the crop matured, the infestation gradually increased. By 49 DAT, the infestation levels ranged from 0.28% (T_{12}) to 3.30% (T_1). The highest infestation was observed in T_1 (100% Nitrogen only), indicating that sole application of nitrogen without other amendments may promote higher susceptibility to leaf folder infestation. Similarly, T_2 (150% Nitrogen) showed increased incidence (2.78%) by 49 DAT, supporting the hypothesis that excessive nitrogen application may predispose the crop to higher pest incidence. Treatments incorporating silica (T_3, T_4, T_6, T_8, T_{10}, T_{12}, T_{14}) generally recorded lower infestation percentages compared to their non-silica counterparts, suggesting a suppressive role of silica in reducing pest damage.

By 70 DAT, infestation had increased across all treatments, peaking in T_2 (7.12%), T1 (7.00%), and T_{15} (7.24%). Conversely, the lowest infestation during this stage was recorded in T_{12} (2.17%), followed by T_{11} (2.91%) and T_{10} (3.44%). These treatments involved the combined use of RDF at 75% with biofertilizers and/or silica, highlighting the effectiveness of integrated nutrient management in reducing pest infestation. The trend continued until 84 DAT, where T_1, T_2, and T_{15} maintained the highest infestation levels (8.27%, 8.47%, and 8.51%, respectively), while the lowest values were recorded in T_{12} (3.26%) and T_{11} (4.02%).

The application of balanced NPK (T_5 and T_7) reduced infestation compared to nitrogen-only treatments but remained higher than integrated treatments with organic inputs. For instance, T_5 (NPK standard) and T_7 (double NPK) recorded final infestations of 6.97% and 7.75%, respectively. Incorporation of silica in these regimes (T_6 and T_8) reduced the damage further, with T_6 and T_8 showing 6.08% and 7.69% infestation by 84 DAT.

The treatment involving only biofertilizers (T_{13}) resulted in moderate infestation level (7.62% at 84 DAT), which was still lower than chemical treatments without silica, yet higher than the infestation observed in integrated biofertilizer-silica treatments. The inclusion of silica in the biofertilizer-only treatment (T_{14}) slightly improved resistance, reducing final infestation to 7.26%. Among the organically enriched treatments, T_9 (RDF 100% + FYM + Gliricidia) and T_{10} (same treatment with silica) performed better than chemical-only treatments, with final infestations of 5.36% and 4.68%, respectively.

Overall, the study revealed that the integrated application of RDF (75%) along with biofertilizers and silica (T_{12}) was most effective in minimizing rice leaf folder *(Cnaphalocrocis medinalis)* infestation throughout the crop growth period. This was followed by T_{11} and T_{10}. In contrast, the highest pest incidence was consistently associated with treatments involving high nitrogen doses (T_1 and T_2) and the untreated control (T_{15}). These findings emphasize the importance of balanced nutrient management and the role of silica and biofertilizers in enhancing pest resistance in rice. Integrated approaches not only reduced infestation but also potentially contributed to improved soil health and sustainability in rice production.

Incidence of rice horn caterpillar under different nutrient management practices during *Kharif*- 2024

The incidence of the rice horn caterpillar (*Melanitis leda ismene*) on rice under various nutrient management regimes revealed significant variation in infestation levels over crop growth stages. Leaf infestation was recorded at eight distinct intervals (35, 42, 49, 56, 63, 70, 77, and 84 days after transplanting DAT).

Among all treatments, the highest infestation throughout the observation period was recorded in the untreated control (T_{15}), reaching a maximum of 4.25% (11.84 transformed value) at 84 DAT, indicating a steadily rising trend from 0.18% at 35 DAT. Treatments receiving only nitrogen (T_1, T_2) or high doses of NPK without any amendments (T_7) also showed relatively higher infestation level, highlighting the pest-promoting effect of imbalanced or excessive nitrogen application. For instance, T_2 (Nitrogen 200 kg/ha) showed 4.24% infestation at 84 DAT, slightly less than control but substantially higher than integrated treatments.

Contrastingly, integrated nutrient management strategies significantly suppressed rice horn caterpillar incidence. The lowest infestation was observed in T_{12}, which combined RDF (75%) with biofertilizers (*Azotobacter*, *Azospirillum*, PSB) and silica at 15 kg/ha, with an infestation level of only 1.63% (7.30) at 84 DAT and complete absence of infestation at 35 DAT (0.00%). These finding suggests that reduced use of synthetic fertilizer usage when coupled with microbial inoculants and silica not only improves soil health but also creates less favourable conditions for pest development. Another biofertilizer-based treatment, T_{11} (RDF 75% + biofertilizers), also performed well with infestation peaking only at 2.01% (8.11), further supporting the pest-suppressive potential of microbial inputs.

Treatments incorporating silica amendments consistently outperformed their non-silica counterparts across all nutrient regimes. For instance, T_6 (NPK standard dose + silica) had a lower infestation (3.04%) at 84 DAT compared to T_5 (NPK alone) with 3.48%, demonstrating silica's positive influence on plant defence mechanism against chewing pests. Similar trends were observed in T_4 vs. T_2 and T_8 vs. T_7 comparisons, reinforcing the synergistic role of silica. This protective effect is attributable to the mechanical barrier formed by silica in leaf tissues, reducing larval feeding efficiency and leaf palatability.

Organic-based treatments such as T_9 (RDF 100% + FYM + Gliricidia) and T_{10} (same + silica), showed moderate pest suppression of rice horn caterpillar, with infestation level ranging between 2.34%–2.68% at 84 DAT. These results highlight the beneficial role of organic matter and green manuring in managing pest dynamics, likely through enhanced plant vigour and induced systemic resistance.

In general, pest infestation progressively increased from 35 to 84 DAT across all treatments, aligning with crop phenology and canopy development. However, the rate of increase was notably slower in treatments combining organic amendment, microbial inoculant, and silica-based inputs, highlighting the long-term benefits of integrated nutrient management over conventional high-input fertilization strategies.

The study clearly demonstrates that the rice horn caterpillar infestation can be effectively mitigated through integrated nutrient management, particularly with the use of biofertilizers and silica amendment. Such strategies not only reduce dependency on synthetic fertilizers but also promote sustainable pest suppression. Treatments such as T_{12} and T_{11}, which involved reduction in use of synthetic fertilizer application alongside enhanced biological activity and improved plant structural defence, represent promising tools in ecological rice pest management. Their adoption could lead to lower pest incidence, a reduced environmental footprint, and greater crop resilience under field conditions in the Konkan region.

Incidence of rice yellow stem borer under different nutrient management practices in *Kharif*- 2024

The influence of various nutrient management practices on the incidence of stem borer (*Scirpophaga incertulas*) was evaluated by recording the mean percentage of leaf infestation at weekly intervals from 35 to 84 days after transplanting (DAT).

The untreated control (T_{15}) consistently recorded higher leaf infestation, starting from 0.23% at 35 DAT and steadily rising to 5.31% at 84 DAT. This indicates that the absence of nutrient inputs results in a vulnerable crop stand, providing a favourable environment for pest buildup. Similarly, the treatment receiving a high dose of nitrogen alone (T_2 Nitrogen @ 200 kg/ha) also recorded high infestation, reaching 5.16% at 84 DAT. A similar trend was noted in T_7 (NPK @ 200:100:100 kg/ha), where the infestation increased progressively to 5.30%. These results suggest that excessive nitrogen application, particularly in the absence of balancing nutrients or organic amendments, exacerbates the susceptibility of rice plants to stem borer attack. Nitrogen-rich plants are known to be more succulent and attractive to insect pests, leading to increased infestation.

On the other hand, integrated nutrient management (INM) practices combining organic manures, biofertilizers, and silica supplementation significantly reduced stem borer incidence. Among all treatments, T_{12} (RDF @ 75% + *Azotobacter* + *Azospirillum* + PSB + Silica @ 15 kg/ha) recorded the lowest infestation across all stages, starting from 0.00% at 35 DAT and rising only to 2.04% at 84 DAT. This was closely followed by T10 (RDF + FYM @ 10 t/ha + Gliricidia @ 10 t/ha + Silica), which also maintained low infestation levels (2.51% at 84 DAT). The reduction in pest incidence under these treatments may be attributed to the combined effect of improved plant vigour due to balanced nutrition, enhancement of plant defensive mechanisms by silica, and increased activity of beneficial soil microbes provided through biofertilizers and organic amendments.

Treatments that included silica in combination with inorganic fertilizers also showed comparatively lower stem borer infestation level than their counterparts without silica. For instance, T_4 (Nitrogen @ 200 kg/ha + Silica) and T_8 (NPK @ 200:100:100 + Silica) recorded maximum infestations of 4.35% and 3.35% respectively, which were lower than T_2 and T_7. Silica is known to fortify plant cell walls and act as a physical barrier against pest penetration, reducing feeding damage by borers.

Biofertilizer-only treatments, such as T_{13} (*Azotobacter* + *Azospirillum* + PSB) and T_{14} (Biofertilizers + Silica), exhibited moderate level of infestation, with T_{13} peaking at 4.99% and T_{14} at 4.54% infestation by 84 days after treatment (DAT). Although these values were lower than those recorded in untreated control and high nitrogen treatments, they remain higher than infestation level observed under integrated management systems.

Standard NPK fertilization (T_5) also resulted moderate levels of infestation, reaching 4.84% at 84 days after treatment (DAT). However, the addition of silica to this combination (T_6) significantly reduced infestation level to 2.93%. This finding highlights the importance of silica in pest suppression when applied in combination with standard nutrient doses.

The results clearly demonstrate that integrated nutrient management (INM) strategies, particularly those combining reduced rate of chemical fertilizer with biofertilizers, FYM, green manures, and silica, provide effective protection against stem borer infestation in rice. These approaches not only promote plant health but also create an unfavourable environment for pest proliferation, thereby supporting sustainable pest management in rice ecosystems.

Table 1: Incidence of bule beetle in rice during *Kharif* – 2024

Tr. No.	Treatments	Mean of Leaf infestation (%) * by blue beetle at							
		35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	70 DAT	77 DAT	84 DAT
T_1	Nitrogen (100 kg/ha) 100%	1.41 (6.80)	6.26 (14.45)	14.68 (22.47)	18.43 (25.36)	21.29 (27.42)	31.12 (33.85)	34.89 (36.15)	36.74 (37.26)
T_2	Nitrogen (200 kg/ha) 150%	1.77 (7.61)	5.14 (13.04)	12.36 (20.49)	17.6 (24.71)	22.55 (28.24)	31.63 (34.12)	35.29 (36.35)	37.66 (37.77)
T_3	Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha	1.51 (7.02)	6.11 (14.24)	11.23 (19.49)	16.97 (24.22)	21.34 (27.40)	30.12 (33.18)	32.95 (34.93)	33.22 (35.09)
T_4	Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha	1.37 (6.69)	4.88 (12.70)	10.48 (18.80)	15.67 (23.22)	20.11 (26.53)	30.29 (33.28)	33.36 (35.18)	35.49 (36.47)
T_5	N + P + K (100:50:50 kg/ha) standard check	1.35 (6.64)	5.17 (13.08)	10.83 (19.12)	14.28 (22.10)	17.44 (24.58)	23.53 (28.91)	27.66 (31.62)	30.95 (33.69)
T_6	N + P + K (100:50:50 kg/ha) + Silica @ 15 kg/ha	1.02 (5.77)	5.61 (13.63)	9.25 (17.62)	13.48 (21.44)	16.78 (24.08)	20.10 (26.53)	23.57 (28.93)	27.02 (31.21)
T_7	N + P + K (200:100:100 kg/ha)	1.22 (6.31)	4.45 (12.12)	10.52 (18.84)	15.59 (23.15)	18.46 (25.34)	29.60 (32.85)	32.35 (34.56)	34.44 (35.83)
T_8	N + P + K (200:100:100 kg/ha) + Silica @15 kg/ha	1.43 (6.83)	3.54 (10.79)	10.82 (19.12)	14.40 (22.20)	17.26 (24.44)	27.59 (31.57)	32.61 (34.72)	34.19 (35.68)
T_9	RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha	1.47 (6.93)	4.93 (12.77)	9.60 (17.96)	13.52 (21.48)	16.29 (23.70)	17.42 (24.56)	20.45 (26.78)	23.81 (29.09)
T_{10}	RDF 100% + FYM 10 ton/ha + Gliricidia + Silica	1.11 (6.02)	4.75 (12.53)	9.25 (17.62)	13.16 (21.17)	15.10 (22.77)	15.29 (22.92)	18.18 (25.56)	20.74 (26.98)
T_{11}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB (2 kg/ha)	0.63 (4.53)	2.49 (9.03)	6.85 (15.10)	9.41 (17.78)	12.29 (20.43)	12.93 (20.98)	15.76 (23.29)	17.87 (24.90)
T_{12}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB + Silica	0.00 (0.00)	0.45 (3.83)	1.22 (6.31)	4.39 (12.04)	8.12 (16.48)	9.64 (18.00)	12.42 (20.54)	14.48 (22.27)
T_{13}	Only biofertilizers Azotobacter + Azospirillum + PSB	1.56 (7.14)	6.84 (15.09)	10.37 (18.70)	15.20 (22.85)	18.31 (25.23)	25.25 (30.05)	31.71 (34.17)	33.87 (35.49)
T_{14}	Only biofertilizers + Silica @ 15 kg/ha	1.08 (5.94)	4.63 (12.36)	10.24 (18.58)	14.49 (22.28)	17.80 (24.85)	24.10 (29.29)	30.95 (33.69)	32.28 (34.52)
T_{15}	Untreated check (control)	1.55 (7.12)	4.96 (12.81)	10.78 (19.08)	20.34 (26.70)	23.91 (29.16)	32.17 (34.45)	35.41 (36.42)	37.80 (37.85)
	S. Em (±)	0.19	0.28	0.36	0.39	0.39	0.65	0.69	0.67
	CD @0.05	0.57	0.84	1.09	1.17	1.17	1.98	2.09	2.02

Figures in the parentheses are Arc sin transformed values, * Mean of two replications, DAT – Days after transplanting

Table 2: Incidence of rice skipper in rice during *Kharif* – 2024

Tr. No.	Treatments	Mean of Leaf infestation (%)* by Rice skipper at							
		35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	70 DAT	77 DAT	84 DAT
T_1	Nitrogen (100 kg/ha) 100%	1.02 (5.77)	4.50 (12.22)	10.57 (18.92)	13.27 (21.31)	15.33 (22.99)	22.41 (28.19)	25.12 (30.02)	26.46 (30.89)
T_2	Nitrogen (200 kg/ha) 150%	1.27 (6.44)	3.70 (11.04)	8.90 (17.27)	12.68 (20.77)	16.24 (23.66)	22.78 (28.39)	25.41 (30.16)	27.11 (31.27)
T_3	Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha	1.09 (5.96)	4.40 (12.05)	8.09 (16.44)	12.22 (20.36)	15.37 (22.98)	21.69 (27.65)	23.73 (29.04)	23.92 (29.17)
T_4	Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha	0.98 (5.66)	3.51 (10.75)	7.54 (15.87)	11.28 (19.53)	14.48 (22.27)	21.81 (27.73)	24.02 (29.23)	25.55 (30.25)
T_5	N + P + K (100:50:50 kg/ha) standard check	0.98 (5.64)	3.72 (11.07)	7.80 (16.14)	10.28 (18.61)	12.56 (20.66)	16.94 (24.20)	19.91 (26.39)	22.29 (28.06)
T_6	N + P + K (100:50:50 kg/ha) + Silica @15 kg/ha	0.74 (4.90)	4.04 (11.54)	6.66 (14.89)	9.70 (18.07)	12.08 (20.25)	14.47 (22.26)	16.97 (24.22)	19.46 (26.07)
T_7	N + P + K (200:100:100 kg/ha)	0.88 (5.36)	3.21 (10.27)	7.58 (15.90)	11.22 (19.48)	13.29 (21.28)	21.31 (27.38)	23.29 (28.74)	24.79 (29.75)
T_8	N + P + K (200:100:100 kg/ha) + Silica @ 15 kg/ha	1.03 (5.80)	2.55 (9.15)	7.79 (16.13)	10.37 (18.70)	12.42 (20.55)	19.86 (26.36)	23.48 (28.87)	24.62 (29.63)
T_9	RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha	1.06 (5.87)	3.55 (10.81)	6.91 (15.17)	9.74 (18.10)	11.73 (19.94)	12.54 (20.65)	14.73 (22.47)	17.14 (24.35)
T_{10}	RDF 100% + FYM 10 ton/ha + Gliricidia + Silica	0.80 (5.11)	3.42 (10.61)	6.66 (14.89)	9.47 (17.84)	10.87 (19.16)	11.01 (19.29)	12.37 (20.50)	14.94 (22.63)
T_{11}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB (2 kg/ha)	0.46 (3.85)	1.79 (7.65)	4.94 (12.77)	6.78 (15.02)	8.85 (17.22)	9.31 (17.68)	11.34 (19.59)	12.86 (20.92)
T_{12}	RDF (75%) + Azotobacter + *Azospirillum* + PSB + Silica	0.00 (0.00)	0.33 (3.27)	0.88 (5.36)	3.16 (10.19)	5.85 (13.93)	6.94 (15.21)	8.94 (17.32)	10.42 (18.75)
T_{13}	Only biofertilizers *Azotobacter* + *Azospirillum* + PSB	1.12 (6.04)	4.93 (12.76)	7.46 (15.78)	10.94 (19.23)	13.18 (21.19)	18.18 (25.13)	22.83 (28.43)	24.38 (29.48)
T_{14}	Only biofertilizers + Silica @ 15 kg/ha	0.78 (5.03)	3.34 (10.47)	7.38 (15.68)	10.43 (18.76)	12.82 (20.88)	17.35 (24.51)	22.29 (28.06)	23.24 (28.71)
T_{15}	Untreated check (control)	1.12 (6.04)	3.57 (10.83)	7.76 (16.10)	14.65 (22.40)	17.22 (24.41)	23.16 (28.66)	25.50 (30.22)	27.22 (31.33)
	S. Em (±)	0.16	0.23	0.30	0.31	0.30	0.50	0.52	0.49
	CD @0.05	0.48	0.71	0.90	0.94	0.92	1.51	1.56	1.49

Figures in the parentheses are Arc sin transformed values, * Mean of two replications, DAT – Days after transplanting

Table 3: Incidence of rice leaf folder in rice during *Kharif* –2024

Tr. No.	Treatments	Mean of leaf infestation (%)* by leaf folder at							
		35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	70 DAT	77 DAT	84 DAT
T_{1}	Nitrogen (100 kg/ha) 100%	0.32 (3.22)	1.41 (6.79)	3.30 (10.44)	4.15 (11.72)	4.79 (12.61)	7.00 (15.30)	7.85 (16.23)	8.27 (16.67)
T_{2}	Nitrogen (200 kg/ha) 150%	0.40 (3.60)	1.16 (6.15)	2.78 (9.55)	3.96 (11.43)	5.08 (12.96)	7.12 (15.40)	7.94 (16.29)	8.47 (16.84)
T_{3}	Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha	0.34 (3.33)	1.38 (6.70)	2.53 (9.10)	3.82 (11.21)	4.80 (12.60)	6.78 (15.02)	7.42 (15.73)	7.48 (15.79)
T_{4}	Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha	0.31 (3.16)	1.10 (5.98)	2.36 (8.79)	3.53 (10.77)	4.53 (12.22)	6.82 (15.06)	7.51 (15.82)	7.99 (16.34)
T_{5}	N + P + K (100:50:50 kg/ha) standard check	0.31 (3.15)	1.16 (6.16)	2.44 (8.94)	3.21 (10.27)	3.93 (11.37)	5.30 (13.24)	6.22 (14.38)	6.97 (15.23)
T_{6}	N + P + K (100:50:50 kg/ha) + Silica @ 15 kg/ha	0.23 (2.73)	1.26 (6.42)	2.08 (8.26)	3.03 (9.98)	3.78 (11.15)	4.52 (12.22)	5.30 (13.25)	6.08 (14.21)
T_{7}	N + P + K (200:100:100 kg/ha)	0.28 (2.99)	1.00 (5.72)	2.37 (8.81)	3.51 (10.74)	4.15 (11.70)	6.66 (14.88)	7.28 (15.58)	7.75 (16.08)
T_{8}	N + P + K (200:100:100 kg/ha) + Silica @ 15 kg/ha	0.32 (3.24)	0.80 (5.10)	2.44 (8.93)	3.24 (10.32)	3.88 (11.31)	6.21 (14.36)	7.34 (15.64)	7.69 (16.03)
T_{9}	RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha	0.33 (3.28)	1.11 (6.02)	2.16 (8.41)	3.04 (10.00)	3.67 (10.98)	3.92 (11.36)	4.60 (12.33)	5.36 (13.32)
T_{10}	RDF 100% + FYM 10 ton/ha + Gliricidia + Silica	0.25 (2.85)	1.07 (5.91)	2.08 (8.26)	2.96 (9.86)	3.40 (10.57)	3.44 (10.64)	3.87 (11.28)	4.68 (12.43)
T_{11}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB (2 kg/ha)	0.14 (2.15)	0.56 (4.27)	1.54 (7.10)	2.12 (8.33)	2.77 (9.52)	2.91 (9.77)	3.55 (10.80)	4.02 (11.51)
T_{12}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB + Silica	0.00 (0.00)	0.10 (1.83)	0.28 (2.99)	0.99 (5.67)	1.83 (7.73)	2.17 (8.43)	2.80 (9.58)	3.26 (10.35)
T_{13}	Only biofertilizers *Azotobacter* + *Azospirillum* + PSB	0.35 (3.37)	1.54 (7.09)	2.33 (8.74)	3.42 (10.60)	4.12 (11.65)	5.68 (13.72)	7.14 (15.42)	7.62 (15.95)
T_{14}	Only biofertilizers + Silica @ 15 kg/ha	0.24 (2.81)	1.04 (5.83)	2.31 (8.69)	3.26 (10.35)	4.01 (11.49)	5.42 (13.40)	6.97 (15.23)	7.26 (15.56)
T_{15}	Untreated check (control)	0.35 (3.37)	1.12 (6.03)	2.43 (8.91)	4.58 (12.29)	5.38 (13.35)	7.24 (15.53)	7.97 (16.32)	8.51 (16.88)
	S. Em (±)	0.09	0.13	0.16	0.16	0.15	0.23	0.24	0.22
	CD @0.05	0.27	0.39	0.48	0.49	0.46	0.71	0.72	0.67

Figures in the parentheses are Arc sin transformed values, * Mean of two replications, DAT – Days after transplanting

Table 4: Incidence of rice horn caterpillar in rice during *Kharif* – 2024

Tr. No.	Treatments	Mean of Leaf infestation (%)* by Rice horn caterpillar at							
		35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	70 DAT	77 DAT	84 DAT
T_{1}	Nitrogen (100 kg/ha) 100%	0.16 (2.28)	0.70 (4.80)	1.65 (7.36)	2.07 (8.26)	2.40 (8.88)	3.50 (10.75)	3.93 (11.40)	4.13 (11.70)
T_{2}	Nitrogen (200 kg/ha) 150%	0.20 (2.54)	0.58 (4.34)	1.39 (6.74)	1.98 (8.05)	2.54 (9.12)	3.56 (10.82)	3.97 (11.44)	4.24 (11.82)
T_{3}	Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha	0.17 (2.35)	0.69 (4.73)	1.26 (6.42)	1.91 (7.90)	2.40 (8.87)	3.39 (10.56)	3.71 (11.05)	3.74 (11.09)
T_{4}	Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha	0.15 (2.24)	0.55 (4.23)	1.18 (6.20)	1.76 (7.59)	2.26 (8.61)	3.41 (10.58)	3.75 (11.11)	3.99 (11.47)
T_{5}	N + P + K (100:50:50 kg/ha) standard check	0.15 (2.23)	0.58 (4.35)	1.22 (6.31)	1.61 (7.24)	1.96 (8.01)	2.65 (9.32)	3.11 (10.11)	3.48 (10.70)
T_{6}	N + P + K (100:50:50 kg/ha) + Silica @ 15 kg/ha	0.12 (1.93)	0.63 (4.53)	1.04 (5.83)	1.52 (7.04)	1.89 (7.86)	2.26 (8.61)	2.65 (9.32)	3.04 (9.99)
T_{7}	N + P + K (200:100:100 kg/ha)	0.14 (2.11)	0.50 (4.04)	1.18 (6.21)	1.75 (7.57)	2.08 (8.24)	3.33 (10.46)	3.64 (10.94)	3.87 (11.30)
T_{8}	N + P + K (200:100:100 kg/ha) + Silica @ 15 kg/ha	0.16 (2.29)	0.40 (3.60)	1.22 (6.30)	1.62 (7.28)	1.94 (7.97)	3.10 (10.10)	3.67 (10.99)	3.85 (11.25)
T_{9}	RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha	0.17 (2.32)	0.56 (4.25)	1.08 (5.94)	1.52 (7.05)	1.83 (7.74)	1.96 (8.01)	2.30 (8.68)	2.68 (9.37)
T_{10}	RDF 100% + FYM 10 ton/ha + Gliricidia + Silica	0.13 (2.02)	0.54 (4.17)	1.04 (5.83)	1.48 (6.95)	1.70 (7.45)	1.72 (7.50)	1.98 (8.05)	2.34 (8.75)
T_{11}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB (2 kg/ha)	0.07 (1.52)	0.28 (3.02)	0.77 (5.01)	1.06 (5.88)	1.38 (6.72)	1.46 (6.89)	1.77 (7.61)	2.01 (8.11)
T_{12}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB + Silica	0.00 (0.00)	0.05 (1.29)	0.14 (2.11)	0.49 (4.01)	0.91 (5.46)	1.09 (5.95)	1.40 (6.76)	1.63 (7.30)
T_{13}	Only biofertilizers *Azotobacter* + *Azospirillum* + PSB	0.18 (2.39)	0.77 (5.01)	1.17 (6.17)	1.71 (7.48)	2.06 (8.21)	2.84 (9.66)	3.57 (10.83)	3.81 (11.20)
T_{14}	Only biofertilizers + Silica @ 15 kg/ha	0.12 (1.99)	0.52 (4.12)	1.15 (6.13)	1.63 (7.30)	2.00 (8.09)	2.71 (9.43)	3.48 (10.70)	3.63 (10.93)
T_{15}	Untreated check (control)	0.18 (2.39)	0.56 (4.26)	1.21 (6.29)	2.29 (8.66)	2.69 (9.39)	3.62 (10.91)	3.98 (11.46)	4.25 (11.84)
	S. Em (±)	0.06	0.09	0.11	0.11	0.10	0.16	0.16	0.15
	CD @0.05	0.19	0.27	0.34	0.34	0.32	0.49	0.49	0.46

Figures in the parentheses are Arc sin transformed values, * Mean of two replications, DAT – Days after transplanting

Table 5: Incidence of yellow stem borer in rice during *Kharif* – 2024

Tr. No.	Treatments	Mean of Leaf infestation (%)* by Stem borer at							
		Dead heart					White ear		
		35 DAT	42 DAT	49 DAT	56 DAT	63 DAT	70 DAT	77 DAT	84 DAT
T_1	Nitrogen (100 kg/ha) 100%	0.21 (2.62)	0.86 (5.31)	1.58 (7.20)	2.39 (8.87)	3.00 (9.95)	4.24 (11.85)	4.64 (12.41)	4.68 (12.46)
T_2	Nitrogen (200 kg/ha) 150%	0.20 (2.55)	0.88 (5.36)	2.06 (8.21)	2.59 (9.22)	3.00 (9.92)	4.38 (12.02)	4.91 (12.74)	5.16 (13.07)
T_3	Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha	0.15 (2.21)	0.79 (5.07)	1.30 (6.51)	1.90 (7.88)	2.36 (8.79)	2.83 (9.64)	3.31 (10.43)	3.80 (11.19)
T_4	Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha	0.19 (2.49)	0.72 (4.84)	1.53 (7.07)	2.01 (8.11)	2.45 (8.96)	3.31 (10.43)	3.89 (11.32)	4.35 (11.98)
T_5	N + P + K (100:50:50 kg/ha) standard check	0.18 (2.42)	0.63 (4.53)	1.48 (6.95)	2.19 (8.47)	2.60 (9.23)	4.16 (11.71)	4.55 (12.26)	4.84 (12.65)
T_6	N + P + K (100:50:50 kg/ha) + Silica @ 15 kg/ha	0.16 (2.28)	0.68 (4.71)	1.30 (6.51)	1.85 (7.78)	2.13 (8.35)	2.15 (8.39)	2.56 (9.46)	2.93 (9.81)
T_7	N + P + K (200:100:100 kg/ha)	0.25 (2.85)	0.73 (4.88)	1.74 (7.54)	2.48 (9.02)	3.18 (10.22)	4.45 (12.12)	4.96 (12.81)	5.30 (13.25)
T_8	N + P + K (200:100:100 kg/ha) + Silica @ 15 kg/ha	0.21 (2.61)	0.70 (4.78)	1.35 (6.64)	1.90 (7.88)	2.29 (8.66)	2.45 (8.96)	2.88 (9.72)	3.35 (10.49)
T_9	RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha	0.20 (2.55)	0.50 (4.03)	1.53 (7.07)	2.03 (8.15)	2.43 (8.92)	3.88 (11.30)	4.59 (12.31)	4.81 (12.61)
T_{10}	RDF 100% + FYM 10 ton/ha + Gliricidia + Silica	0.09 (1.71)	0.35 (3.37)	0.96 (5.59)	1.32 (6.56)	1.73 (7.52)	1.83 (7.74)	2.21 (8.51)	2.51 (9.07)
T_{11}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB (2 kg/ha)	0.23 (2.73)	0.96 (5.59)	1.46 (6.91)	2.14 (8.37)	2.57 (9.18)	3.55 (10.81)	4.46 (12.13)	4.76 (12.54)
T_{12}	RDF (75%) + *Azotobacter* + *Azospirillum* + PSB + Silica	0.00 (0.00)	0.06 (1.40)	0.18 (2.42)	0.61 (4.46)	1.14 (6.10)	1.36 (6.66)	1.75 (7.56)	2.04 (8.17)
T_{13}	Only biofertilizers *Azotobacter* + *Azospirillum* + PSB	0.19 (2.49)	0.69 (4.74)	1.48 (6.95)	2.20 (8.49)	2.83 (9.64)	4.26 (11.85)	4.69 (12.45)	4.99 (12.84)
T_{14}	Only biofertilizers + Silica @ 15 kg/ha	0.15 (2.21)	0.65 (4.60)	1.44 (6.86)	2.04 (8.17)	2.50 (9.05)	3.39 (10.56)	4.35 (11.98)	4.54 (12.24)
T_{15}	Untreated check (control)	0.23 (2.73)	0.70 (4.78)	1.51 (7.02)	2.86 (9.69)	3.36 (10.51)	4.52 (12.21)	4.98 (12.83)	5.31 (13.26)
	S. Em (±)	0.07	0.10	0.13	0.13	0.12	0.18	0.19	0.18
	CD @0.05	0.21	0.31	0.41	0.39	0.36	0.55	0.57	0.54

Figures in the parentheses are Arc sin transformed values, * Mean of two replications, DAT – Days after transplanting

Incidence of blue beetle in rice under different nutrient management practices (*Kharif*- 2024)

The incidence of rice blue beetle (*Leptispa pygmaea*) was significantly influenced by the type of nutrient management applied. The lowest infestation was consistently observed in T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica), with only 14.48% infestation recorded at 84 DAT, indicating the strong suppressive effect of combined application biofertilizers and silica. This aligns with findings of Chandramani *et al*. (2010) [10] and Chau and Heong (2005) [4], who reported that integrated nutrient strategies, especially those involving organics and silica, enhance plant tolerance and reduce pest incidence. In contrast, the highest infestation was observed in the untreated control (T_{15}) and in nitrogen-dominant treatments such as T_2 (150% N) and T_1 (100% N), which recorded 37.80%, 37.66%, and 36.74% infestation, respectively, at 84 DAT. These results are consistent with the findings of Ramzan *et al*. (2007b) [10] and Lu *et al*. (2007) [7], who reported increased pest susceptibility under excessive nitrogen application due to enhanced foliage growth and increase plant succulence.

The inclusion of silica significantly reduced blue beetle incidence across treatments. For instance, T_{10} (RDF + FYM + Gliricidia + Silica) and T_6 (NPK + Silica) recorded only 26.98% and 31.21% infestation, respectively, compared to their non-silica counterparts. Silica likely acts by strengthening the epidermal cell wall and reducing palatability, as supported by Dash *et al*. (2008) [5] and Sarwar (2011) [12]. Furthermore, T_9 (RDF + FYM + Gliricidia) and T_{11} (RDF 75% + biofertilizers) showed moderate infestation (29.09% and 24.90%, respectively), reflecting the positive role of organics and microbial inoculants in suppressing blue beetle populations. These results are further supported by Masal *et al.* (2015) [8], who observed that blue beetle infestation peaked during panicle initiation stages is positively correlated with vegetative growth conditions promoted by high nitrogen availability and elevated humidity.

Overall, treatments combining reduced chemical fertilizers with organic manures, biofertilizers, and silica (particularly T12 and T10) proved highly effective in managing blue beetle incidence, underscoring the importance of integrated nutrient management for sustainable pest suppression in rice cultivation under Konkan condition.

Incidence of rice skipper under different nutrient management practices during *Kharif*- 2024

The findings of the present study revealed that nutrient management practices had a significant influence on the leaf infestation caused by rice skipper (*Pelopidas mathias*). Among all the treatments, T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica) recorded the lowest infestation consistently throughout the crop growth stages, with a maximum of only 10.42% at 84 DAT. This result aligns with Chakraborty (2011a) [1] and Chau and Heong (2005) [4], who reported that incorporation of organic sources and biofertilizers effectively reduced pest incidence.

In contrast, the highest infestation was observed in the untreated control (T_{15}) and high nitrogen intensive treatments such as T_2 (150% N), which reached up to 27.22% and 27.11% infestation, respectively, at 84 DAT. These observations consistent with the report of Ramzan *et al*. (2007) [10] and Lu *et al*. (2007) [7], who noted that excessive nitrogen application promote vegetative growth and plant succulence, thereby increasing vulnerability to herbivorous pest like the skipper. The inclusion of silica (T_4, T_6, T_8, T_{10}, T_{12}, and T_{14}) generally resulted in a reduced infestation, likely due to the enhanced mechanical strength and induced resistance in plant tissues, as also reported by Sarwar (2011) [12] and Dash *et al*. (2008) [5]. For example, T10 (RDF + FYM + Gliricidia + Silica) limited the infestation to 14.94% at 84 DAT, a significant reduction compared to the control. The standard NPK treatment (T_5) and its higher dose counterpart (T_7) recorded moderate infestations (22.29% and 24.79%, respectively), confirming the adverse impact of unbalanced fertilization in pest incidence.

Similarly, organic-based treatments like T_9 (RDF + FYM + Gliricidia) and T_{11} (RDF 75% + biofertilizers) also resulted in lower infestation, demonstrating the effectiveness of integrated nutrient management in reducing rice skipper pressure. These finding further supported by Hendawy *et al*. (2022) [6] and H. N. Patel *et al*. (2011) [9], who reported that the infestation of rice skipper can be managed effectively through crop nutrition strategies that enhance crop resilience and reduce pest attraction. Overall, the integration of reduced chemical inputs with biofertilizers and silica proved most beneficial in suppressing rice skipper infestation, offering a sustainable pest management option in rice agroecosystems

Incidence of rice leaf folder under different nutrient management practices (*Kharif*- 2024)

The results of the present investigation clearly demonstrated that diverse nutrient management practices significantly influenced the incidence of rice leaf folder (*Cnaphalocrocis medinalis*). Among the treatments, the lowest leaf infestation was recorded in T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica), with only 3.26% infestation at 84 DAT, followed closely by T_{11} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB) at 4.02%. These findings highlight the suppressive effect of biofertilizers and silica on leaf folder population, likely due to induced plant resistance and reduced nitrogen-induced succulence, as also reported by Chau and Heong (2005) [4] and Chakraborty (2011b) [2]. In contrast, the highest infestation was noted in T_{15} (untreated control) and T_2 (150% N), recording 8.51% and 8.47% at 84 DAT, respectively, supporting earlier reports by Ramzan *et al*. (2007b) [10] and Lu *et al*. (2007) [7] that excessive nitrogen application promotes pest incidence by enhancing luxuriant growth and soft foliage, favorable for larval feeding and oviposition.

Silica-amended treatments such as T_6, T_8, and T_{10} consistently recorded lower infestation (6.08–7.69%) compared to their non-silica counterparts, further substantiating the role of silica in strengthening plant tissue and enhancing structural defense against leaf folder damage, as described by Dash *et al*. (2008) [5] and Sarwar (2011) [12].

Interestingly, T_9 (RDF + FYM + Gliricidia) also exhibited reduced infestation (5.36%) compared to conventional NPK treatments, corroborating the observations by Rani *et al*. (2006) [11] regarding the role of organic amendments in pest suppression. Thus, these results affirm that integrated nutrient management involving balanced fertilization with biofertilizers, organics, and silica not only supports plant health but also minimizes pest incidence, making it a sustainable approach for leaf folder management in rice ecosystems.

Incidence of rice horn caterpillar under different nutrient management practices (*kharif*- 2024)

The data on rice horn caterpillar (*Melanitis leda ismene*) infestation revealed that nutrient management had a significant impact on pest incidence across crop growth stages. Among the treatments, the lowest infestation was consistently recorded in T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica), with only 1.63% infestation at 84 DAT. This was followed closely by T_{11} (RDF 75% + biofertilizers) which recorded 2.01%, indicating the effectiveness of biofertilizer-based integrated nutrient management in suppressing horn caterpillar infestation. These findings align with Chandramani *et al*. (2010) [10] and Chau and Heong (2005) [4], who reported that plots amended with organic inputs and biofertilizers showed reduced pest infestation due to improved plant health and induced systemic resistance.

The addition of silica further enhanced pest suppression, as seen in treatments like T_{10} (RDF + FYM + Gliricidia + Silica) and T_6 (NPK + Silica), which maintained relatively low infestation levels (2.34% and 3.04% respectively at 84 DAT). The role of silica in improving plant structural integrity and functioning as a mechanical barrier to insect feeding is well documented by Sarwar (2011) [12] and Dash *et al*. (2008) [5].

Conversely, the highest infestation levels were recorded in T_{15} (untreated control), T_2 (150% nitrogen), and T_1 (100% nitrogen), which exhibited 4.25%, 4.24%, and 4.13% infestation respectively at 84 DAT. These results corroborate the earlier findings of Ramzan *et al*. (2007) [10] and Lu *et al*. (2007) [7], who reported that excessive nitrogen application leads to luxuriant vegetative growth, creating favourable environment for herbivorous insects like horn caterpillars. The increased infestation in nitrogen-dominated treatments highlights the potential risk of over-fertilization in pest-prone environments. In contrast, integrated nutrient management strategies involving RDF, biofertilizers, and silica consistently resulted in significantly lower pest pressure, as demonstrated by performance of T_{12} and T_{11}.

Overall, the study confirms that integrated nutrient management, particularly incorporation of biofertilizer and silica, offer a sustainable strategy for mitigating rice horn caterpillar infestation, enhancing crop resilience, and minimizing reliance on chemical control measures.

Incidence of rice yellow stem borer under Different Nutrient Management Practices (*Kharif*- 2024)

The present investigation revealed significant differences in stem borer (*Scirpophaga incertulas*) infestation among various nutrient management treatments. The treatment T_{12} (RDF 75% + *Azotobacter* + *Azospirillum* + PSB + Silica) recorded the lowest stem borer infestation throughout the crop period, with a maximum of only 2.04% at 84 DAT, indicating the effectiveness of integrated application of biofertilizers and silica in suppressing pest incidence. Similarly, T_{10} (RDF 100% + FYM 10 ton/ha + Gliricidia + Silica) was also highly effective, with stem borer incidence remaining consistently low (2.51% at 84 DAT), suggesting a synergistic effect of organic inputs and silica in building plant resistance.

In contrast, the highest incidence of stem borer was observed in T_{15} (untreated control) and T7 (NPK at 200:100:100 kg/ha), which recorded maximum leaf infestation of 5.31% and 5.30%, respectively, at 84 DAT.

This aligns with findings by Ramzan *et al.* (2007) [10] and Chakraborty (2011b) [2], who reported that higher doses of nitrogen alone increased stem borer damage due to enhanced plant succulence, making them more attractive to pests.
The treatments supplemented with silica (e.g., T_3, T_4, T_6, T_8, T_{10}, T_{12}, and T_{14}) generally showed reduced infestation, supporting results by Dash *et al.* (2008) [12] and Sarwar (2011), who noted that silicon reduces stem borer incidence by enhancing plant structural resistance. Furthermore, T_9 (RDF + FYM + Gliricidia) also reduced pest infestation (4.81% at 84 DAT), confirming the role of organic matter in pest suppression as reported by Rani *et al.* (2006) [11] and Chau and Heong (2005) [4].
These results strongly suggest that integrated nutrient management, especially the use of organic amendments, biofertilizers, and silicon, is more effective in reducing stem borer incidence compared to the use of inorganic fertilizers alone.

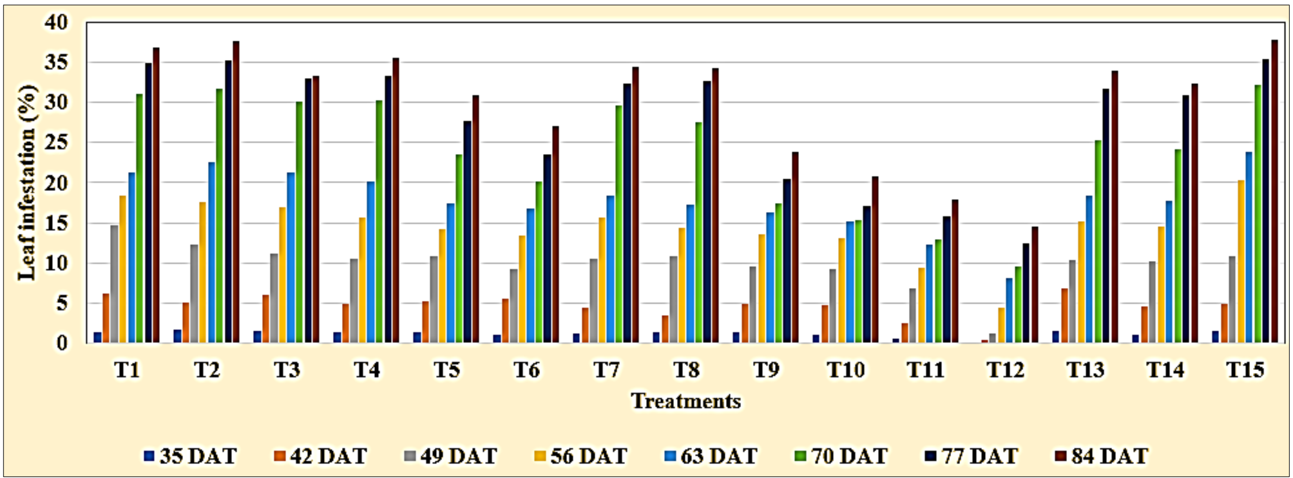

Fig 1: Incidence of Bule beetle in rice during *Kharif* – 2024

T_1: Nitrogen (100 kg/ha) 100%, T_2: Nitrogen (200 kg/ha) 150%, T_3: Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha, T_4: Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha, T_5: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) standard check, T_6: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) + Silica @ 15 kg/ha, T_7: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha), T_8: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha) + Silica @ 15 kg/ha, T_9: RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha, T_{10}: RDF 100% + FYM 10ton/ha+ Gliricidia leaves10 ton/ha+ Silica@15kg/ha, T_{11}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha, T_{12}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha + Silica @ 15 kg/ha, T_{13}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha),T_{14}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha) + Silica @ 15 kg/ha, T_{15}: Untreated check (control).

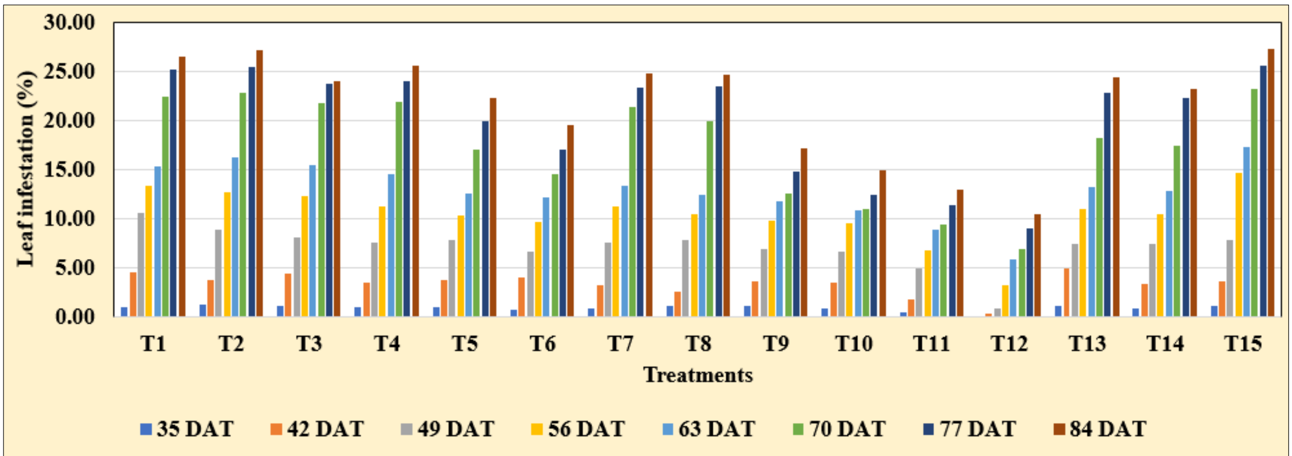

Fig 2: Incidence of Rice skipper in rice during *Kharif* – 2024

T_1: Nitrogen (100 kg/ha) 100%, T_2: Nitrogen (200 kg/ha) 150%, T_3: Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha, T_4: Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha, T_5: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) standard check, T_6: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) + Silica @ 15 kg/ha, T_7: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha), T_8: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha) + Silica @ 15 kg/ha, T_9: RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha, T_{10}: RDF 100% + FYM 10ton/ha+ Gliricidia leaves10 ton/ha+ Silica@15kg/ha, T_{11}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha, T_{12}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha + Silica @ 15 kg/ha, T_{13}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha),T_{14}**:** Only biofertilizers

(*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha) + Silica @ 15 kg/ha, T_{15}: Untreated check (control).

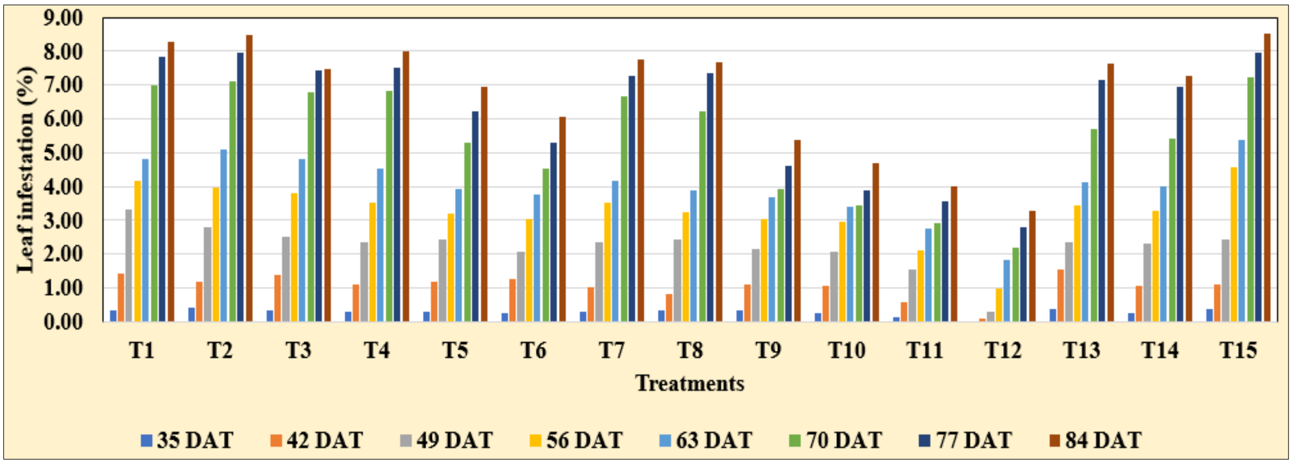

Fig 3: Incidence of Rice Leaf folder in rice during *Kharif* – 2024

T_1: Nitrogen (100 kg/ha) 100%, T_2: Nitrogen (200 kg/ha) 150%, T_3: Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha, T_4: Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha, T_5: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) standard check, T_6: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) + Silica @ 15 kg/ha, T_7: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha), T_8: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha) + Silica @ 15 kg/ha, T_9: RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha, T_{10}: RDF 100% + FYM 10ton/ha+ Gliricidia leaves10 ton/ha+ Silica@15kg/ha, T_{11}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha, T_{12}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha + Silica @ 15 kg/ha, T_{13}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha),T_{14}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha) + Silica @ 15 kg/ha, T_{15}: Untreated check (control).

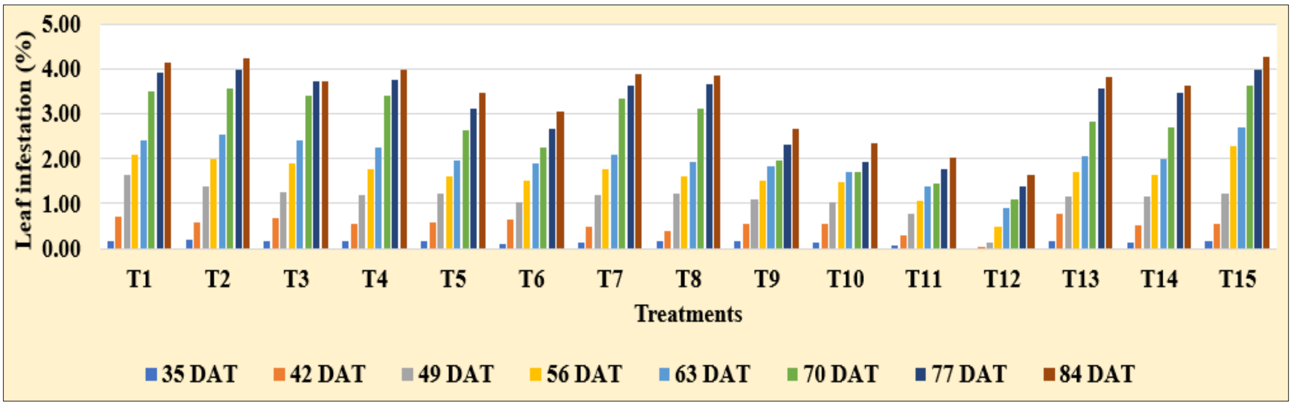

Fig 4: Incidence of Rice horn caterpillar in rice during *Kharif* – 2024

T_1: Nitrogen (100 kg/ha) 100%, T_2: Nitrogen (200 kg/ha) 150%, T_3: Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha, T_4: Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha, T_5: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) standard check, T_6: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) + Silica @ 15 kg/ha, T_7: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha), T_8: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha) + Silica @ 15 kg/ha, T_9: RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha, T_{10}: RDF 100% + FYM 10ton/ha+ Gliricidia leaves10 ton/ha+ Silica@15kg/ha, T_{11}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha, T_{12}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha + Silica @ 15 kg/ha, T_{13}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha),T_{14}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha) + Silica @ 15 kg/ha, T_{15}: Untreated check (control).

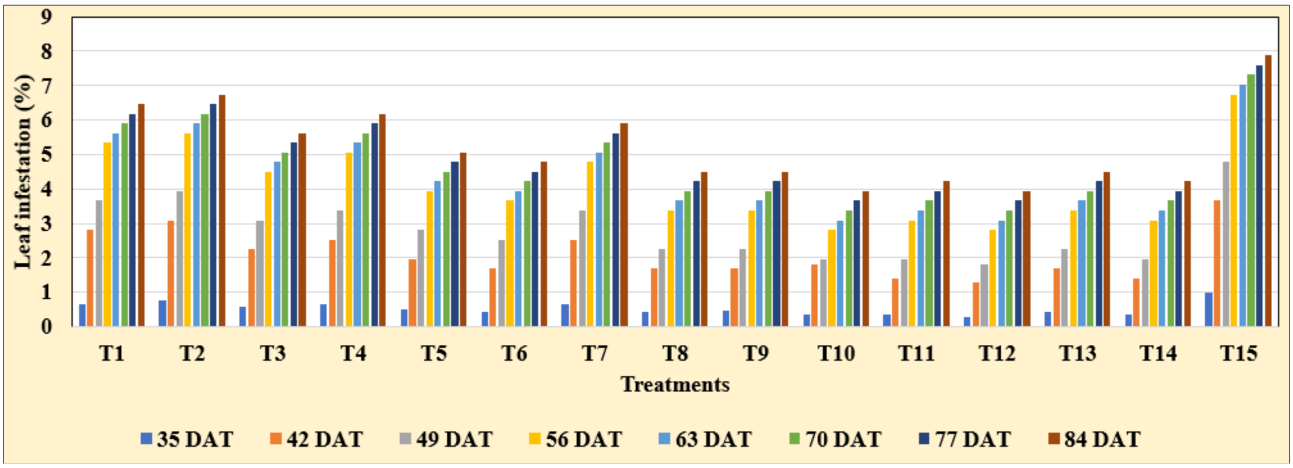

Fig 5: Incidence of yellow stem borer in rice during *Kharif* – 2024

T_1: Nitrogen (100 kg/ha) 100%, T_2: Nitrogen (200 kg/ha) 150%, T_3: Nitrogen (100 kg/ha) 100% + Silica @ 15 kg/ha, T_4: Nitrogen (200 kg/ha) 150% + Silica @ 15 kg/ha, T_5: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) standard check, T_6: Nitrogen + Phosphorous + Potassium (100:50:50 kg/ha) + Silica @ 15 kg/ha, T_7: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha), T_8: Nitrogen + Phosphorous + Potassium (200:100:100 kg/ha) + Silica @ 15 kg/ha, T_9: RDF 100% + FYM 10 ton/ha + Gliricidia leaves 10 ton/ha, T_{10}: RDF 100% + FYM 10ton/ha+ Gliricidia leaves10 ton/ha+ Silica@15kg/ha, T_{11}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha, T_{12}: RDF (75%) + *Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha + Silica @ 15 kg/ha, T_{13}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha),T_{14}: Only biofertilizers (*Azotobacter* + *Azospirillum* + PSB @ 2 kg/ha) + Silica @ 15 kg/ha, T_{15}: Untreated check (control).

Conclusion

The present investigation clearly demonstrated that nutrient management practices exert a profound influence on the incidence of major insect pests of rice. Treatments integrating a reduced dose of chemical fertilizers with biofertilizers and silica, particularly T12 (RDF 75% + Azotobacter + Azospirillum + PSB + Silica @ 15 kg/ha), consistently recorded the lowest infestations of blue beetle, rice skipper, leaf folder, rice horn caterpillar, and yellow stem borer across all crop growth stages. This superior performance was followed by T11 (RDF 75% + biofertilizers) and T10 (RDF + FYM + Gliricidia + silica), which also maintained lower pest levels compared to chemical-only regimes. The beneficial effects can be attributed to improved plant vigor, better nutrient uptake, induced systemic resistance from biofertilizers, and the mechanical strengthening of plant tissues by silica that hampers pest feeding and oviposition. In contrast, high nitrogen treatments (T1 and T2) and the untreated control (T15) consistently favored higher pest incidence, reaffirming the adverse impact of excessive nitrogen on pest dynamics. Overall, the results highlight that integrated nutrient management involving biofertilizers and silica not only suppresses pest infestations effectively but also promotes sustainable rice cultivation by reducing reliance on chemical fertilizers and enhancing ecological resilience.

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Author name and Affiliation
KU Ranher
M.Sc. Scholar, Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India

SS Chavan
Subject Matter Specialist, KVK, Lanja, District Ratnagiri, Maharashtra, India

MS Karmarkar
Professor (CAS) Department of Agricultural Entomology, College of Agriculture, Dapoli, District Ratnagiri Maharashtra, India District Ratnagiri, Maharashtra, India

VA Rajemahadik
Associate Professor (CAS) Department of Agronomy, College of Agriculture, Dapoli, District Ratnagiri Maharashtra, India

VN Jalgaonkar
Deputy Director of Research (Agri.), Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India

V S Desai
Head, Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India

MK Bhoyar
M.Sc. Scholar, Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India

SP Patankar
M.Sc. Scholar, Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India

RS Pawar
M.Sc. Scholar, Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India

Karthikeyan M
M.Sc. Scholar, Department of Agricultural Entomology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri, Maharashtra, India