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Insect Pest Dynamics in Mung Bean Crops: Understanding Factors Influencing Incidence and Severity in the Amhara Region, Ethiopia

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***Abstract* – The study investigates the spatial and temporal dynamics of flea beetle infestation on mung bean crops in various districts of the study area. This study examines the factors influencing flea beetle infestation in mung bean (Vigna radiata) crops across different districts in the Amhara region, Ethiopia. The research focuses on pest population dynamics, environmental influences, and agronomic practices. Flea beetle incidence varied significantly by location, with East Belesa showing a moderate mean infestation of 14.1% (SD = 7.7%), while S/muja exhibited the highest mean infestation at 34.3% (SD = 22.9%). Flea beetle density also varied, with S/muja recording the highest density of 11.8 insects/m² (SD = 5.9) and T/gaint the lowest at 7.9 insects/m² (SD = 5.9). Altitude showed a negative correlation with flea beetle infestation, with the highest mean infestation (28%) occurring between 1500-1800 meters and the lowest (8.857%) above 2400 meters, suggesting that higher altitudes may offer less favorable conditions for flea beetles. Previous crop history significantly impacted infestation levels ($\chi^2 = 63.852$, df = 21, $p < .001$), while mung bean growth stage did not ($\chi^2 = 43.706$, df = 49, $p = 0.687$). Planting date also significantly affected flea beetle infestation ($F (7, 152) = 2.997$, $p = 0.006$), with specific dates showing higher or lower infestation levels. The findings highlight the need for localized pest management strategies that consider environmental factors and agronomic practices to effectively control flea beetle infestations and enhance mung bean crop productivity in the region.**

***Keywords* – Mung Bean, Flee Beetle Incidence, Mung Bean Growth Stage.**

I. Background and Justification

Legume crops have a special role in the sustainable cultivation of crops, and pulse crops, which are the main source of protein in the Indian diet, provide extremely nutritious food while also preserving soil fertility and productivity and boosting India's agricultural economy (Sujata et al., 2017). Pulses play a significant role in human nutrition, particularly for low-income populations in developing nations. Legume crops are regarded as a staple food for the underprivileged in Ethiopia and are also crucial to sustainable agriculture since they increase soil fertility by fixing nitrogen.

Mung beans are cultivated across various countries, with significant production in Asia and Africa. In Asia, countries like India, China, Myanmar, and Pakistan are major producers, while in Africa, Ethiopia, Sudan, and Uganda are among the leading producers (Wani et al., 2019; FAOSTAT). The productivity of mung bean crops can vary widely depending on factors such as agro-climatic conditions, soil fertility, cultivation practices, and crop management techniques. In favorable conditions, mung beans can yield between 0.5 to 2 tons per hectare, but yields may be lower in areas with suboptimal conditions (Bisht et al., 2019; Nadeem et al., 2020). Furthermore more Mung bean (Vigna radiata L.) is an important leguminous crop cultivated worldwide, particularly in Asia and Africa. It is known for its adaptability to diverse agro-climatic conditions, short growing cycles, and ability to fix atmospheric nitrogen (Bisht et al., 2019). On the other way, Mung beans are highly nutritious, containing significant levels of protein, dietary fiber, vitamins (especially vitamin C and vitamin K), and minerals (iron, potassium, etc.). Consumption of mung beans contributes to a balanced diet and addresses malnutrition concerns (Rao et al., 2019). This crop is also important for its crucial role in food security, especially in regions where they are staple foods. They provide a valuable source of calories, protein, and essential nutrients for millions of people, particularly in developing countries (Wani et al., 2019). The other author also showed Mung beans' importance in serving as a source of income for millions of farmers worldwide. Its commercial importance is underscored by its demand in domestic and international markets for various purposes, including food, feed, and industrial uses (Gwata et al., 2016). From the environmental perspective Environmental Benefits: Mung beans contribute to sustainable agriculture due to their ability to fix atmospheric nitrogen, which improves soil fertility and reduces the need for synthetic fertilizers. They also play a role in crop rotation systems, enhancing soil health and reducing pest and disease pressures (Nadeem et al., 2020). While mung bean crop very important crop in the world, especially in Ethiopia, nutritional imbalance and the presence of highly unemployed youth, productivity has improved over the years due to advancements in breeding and agronomic practices, challenges such as pests, diseases, climate variability, and market access continue to affect production and productivity (Gwata et al., 2016; FAOSTAT).

Mung bean, Vigna radiata (Linn.) Wilczek (Family: Leguminosae, Subfamily: Papilionaceae) is the third most important pulse crop after chickpea and red gram in India (Ved et al., 2008).

Mungbean yields are greatly depressed by a complex of biotic and abiotic factors of which insect pests are the most important. The major constraint responsible for poor yields is the wide array of insect pests, which attack the plants from seedling to maturity. About 65 species of insects (Siddappaji et al., 1979) has been recorded on mungbean. About half a dozen insect species are of major importance (Vyas, 1978). In India, quantitative avoidable losses (7-35%) caused by insect pest complex, both in mung bean and urd bean vary with different agro-climatic conditions (Hamad and Dubey, 1983). The annual yield loss due to the insect pests has been estimated at about 30 per cent in mung bean and urd bean. Duraimurugan and Tyagi (2014) reported that the avoidable losses due to pest complex on mungbean ranged from 27.03 to 38.06% with an average of 32.97%. The perusal of pertinent literature indicate that there is paucity of information on the succession of insect pests on mung bean.

The assessment of insect pests affecting mung bean (Vigna radiata) and haricot bean (Phaseolus vulgaris) production in the major cultivation areas of the Amhara region, Ethiopia, poses a critical research problem. Despite the economic significance of these legume crops in the region, insect pests have been identified as major constraints to their successful cultivation. However, there is a notable gap in comprehensive studies focusing on the identification, distribution, abundance, and damage potential of insect pests infesting mung bean and haricot bean crops in the Amhara region. Understanding the insect pest complex associated with these crops is essential for developing effective integrated pest management (IPM) strategies tailored to the local agro-ecological conditions, thereby enhancing crop productivity and farmer livelihoods (Abebe et al., 2017; Tadesse et al., 2019).

Furthermore, investigating the impact of environmental factors, agronomic practices, and cropping systems on insect pest dynamics in mung bean production systems is imperative. The Amhara region encompasses diverse agro-climatic zones and farming practices, which may influence the prevalence and severity of insect pest infestations. Yet, there is limited research addressing the interactions between insect pests, host plants, and environmental variables in these cropping systems. Therefore, elucidating the intricate relationships between biotic and abiotic factors influencing insect pest populations will contribute to the development of context-specific pest management recommendations and sustainable agricultural practices in the region (Dagnew et al., 2018; Assefa et al., 2020).

The objective of this study is to comprehensively investigate the dynamics of insect pests affecting mung bean and haricot bean crops in the Amhara region, Ethiopia. This includes identifying and characterizing the insect pests present, assessing their severity, distribution, and seasonal fluctuations across different districts. Additionally, the study aims to explore the influence of key environmental factors, such as altitude, as well as agronomic practices like planting time and adjacent crops, on the dynamics of insect pest populations. Ultimately, the research seeks to provide valuable insights into developing targeted pest management strategies that are tailored to the specific pests and local agricultural conditions, thereby enhancing crop productivity and sustainability in the region.

II. Materials and Methods

The research was conducted in the primary mung bean cultivation region of the southwestern part of Ethiopia, encompassing seven different districts, as illustrated in Figure 1, during the agricultural seasons of 2022 and 2023. The selection of zones, districts, and kebeles within districts was deliberate, focusing on areas with significant mung bean production potential. The identification of these growing districts was based on information obtained from the Amhara Region Agricultural Office and the Crop Directorate Director in the preceding three months before the survey took place. Field surveys were carried out from late July to late September. The survey aimed to evaluate the occurrence and distribution of insect pests within mung bean crops across 160 fields spread across the seven districts. Varying sample sizes were employed in each district, tailored to reflect the production potential of the respective areas.

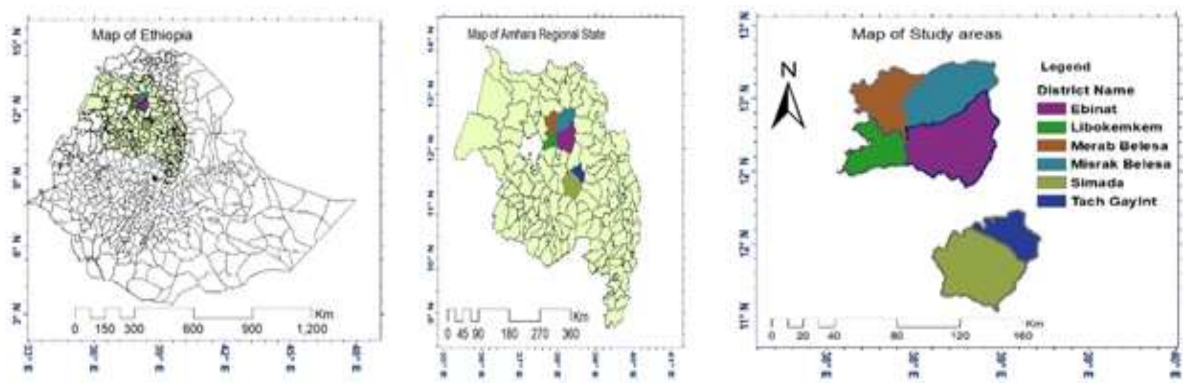

Fig. 1. Represents that the study area of insect pest incidence on mung bean.

Survey data sheets were prepared by entomologists from the FNRRTC (Forestry and Natural Resources Research and Training Center), outlining major insect pests of mung bean and haricot, along with a list of natural enemies of these pests drawn from literature sources. Surveyors received a one-day training session to ensure uniformity in data collection procedures. Equipped with color-coded reference cards, surveyors were instructed to capture any newly encountered and unidentified insects, placing them in sample collection bags for subsequent identification. However, the survey yielded limited findings, with no new insect species discovered in the surveyed areas.

Mung bean fields were randomly chosen at intervals of 5 to 10 kilometers along roadsides. Given that mung bean cultivation typically occurs in plots of approximately 0.1 hectares or smaller, five 1 m × 1 m quadrat samples were taken at two to three meter intervals in a cross-diagonal pattern within each field. These quadrats were then inspected for the presence of flea beetles and other insect pests, as well as natural enemies. The total number of insect pests/flea beetles was visually assessed and recorded within each quadrat, while observations on natural enemies of flea beetles were made on a field-wide basis.

Data Collected

The data collected from non-sprayed field, number of insect pests found in sample, the crop history, planting date from the farmer, adjacent crop and crop growth stage of the mung bean, flee beetle feeding types.

Analysis Conducted using JASP Software

Our analysis employed JASP software to investigate the influence of planting dates on flea beetle infestation in mung beans. The study included an ANOVA to assess overall significance, followed by pairwise comparisons using repeated contrasts. This approach allowed us to determine significant differences in infestation levels across various planting periods, providing insights into optimal planting strategies for managing flea beetle populations in agricultural settings.

III. Result and Discussion

3.1. *Incidence of Insect Pests in the Mung Bean in the Study Area*

The table 1 presents descriptive statistics of pest populations across different locations. For instance, Aphids recorded the highest average count of 8.185 in Ebinat, with a standard deviation of 5.245, indicating moderate variability in infestation levels. Conversely, Leaf Hopper had a lower mean count of 6.300 in T/gaint, with a relatively lower standard deviation of 3.743, suggesting more consistent pest numbers in that location. Overall, the data highlights varying pest infestation levels and their distributions across the surveyed locations, providing insights into pest management strategies tailored to specific pests and areas of concern.

Table 1. Showed that the summary of pest populations across locations.

Pest Type	Disricts	Sample Number	Mean Number of Insect Pest/ m^2 Quadrant	Std. Deviation
Flea beetle	East Belesa	14	8.071	4.251
Aphids	Ebinat	54	8.185	5.245
Whitefly	L/kemkem	11	8.091	5.974
Flower Thrips	S/mujs	25	8.600	4.865
Leaf Hopper	T/gaint	30	6.300	3.743
Pod Borer	simada	10	9.600	7.011
	w/belesa	16	9.750	12.402

3.2. *The Flea Beetle Incidence and Infestation across Different Districts*

Table 3 test reveals mean infestation (%) ± SD values indicate the average level of flea beetle infestation across different districts in the study. East Belesa shows a moderate mean infestation of 14.1% with a standard deviation (SD) of 7.7%, suggesting a relatively consistent but measurable presence of flea beetles. In contrast, S/muja exhibits the highest mean infestation at 34.3% ± 22.9%, indicating a higher variability and potentially severe infestation levels compared to other districts. Overall, while some districts like T/gaint and W/belesa show lower mean infestations (17.5% ± 12.6% and 19.8% ± 10.4% respectively), the variability in infestation levels across districts underscores the need for localized pest management strategies.

The Number of Insects /m² Quadrant provides insight into the actual density of flea beetles within each district's mung bean fields. For instance, S/muja records the highest number with 11.8 ± 5.9 insects per square meter quadrant, indicating a relatively dense population compared to other districts like T/gaint with 7.9 ± 5.9 insects. The variability in these numbers, such as East Belesa's 11.6 ± 6.6 insects and L/kemkem's 9.1 ± 7.7 insects, suggests varying degrees of local infestation intensity. This data is crucial for understanding the spatial distribution and localized impact of flea beetles on mung bean crops, guiding targeted pest control efforts tailored to each district's specific conditions.

Table 2. Represents the flee beetle incidence and infestation from different districts.

District	Number of Samples	Mean Infestation (%) ± SD	Number of Insects /m² Quadrant
East Belesa	14	14.1 ± 7.7	11.6 ± 6.6
Ebinat	54	21.3 ± 10.2	11.6 ± 10.3
L/kemkem	11	30.5 ± 19.8	9.1 ± 7.7
S/muja	25	34.3 ± 22.9	11.8 ± 5.9
T/gaint	30	17.5 ± 12.6	7.9 ± 5.9
Simada	10	28.5 ± 27.3	9.6 ± 3.0
W/belesa	16	19.8 ± 10.4	9.8 ± 12.4

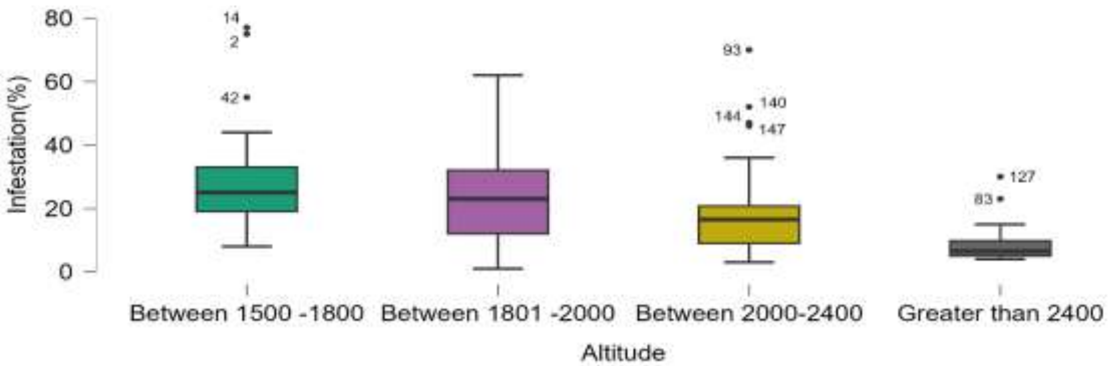

Fig. 2. Represents effect of Altitude on the flee beetle infestation.

3.3. *Altitude's Effect on flea beetle infestation in Mung Beans*

The box plot illustrates the relationship between altitude and flea beetle infestation rates in mung beans, indicating a clear trend of decreasing infestation with increasing altitude. The highest mean infestation occurs between 1500-1800 meters at 28%, while the lowest is above 2400 meters at 8.857%. As altitude increases, the mean infestation decreases, showing a negative correlation between altitude and infestation levels. This suggests that higher altitudes may have environmental conditions less favorable for flea beetles, resulting in lower infestation rates. Additionally, the standard deviation of infestation rates also decreases with increasing altitude, with the lowest variability observed above 2400 meters. This indicates not only lower mean infestation rates at higher altitudes but also more consistent (less variable) infestation levels. These findings highlight the potential of altitude as a significant factor in managing flea beetle infestations, possibly due to cooler temperatures and different humidity levels at higher elevations. Further statistical analyses, such as correlation and regression, would help quantify the strength and significance of this relationship.

3.4. *Effect of Previous Crop History on the Flea Beetle Infestation on Mung Bean*

The research findings indicate in table 3 showed that the previous crop history significantly impacts flea beetle infestation on mung bean crops. The chi-squared test results ($\chi^2 = 63.852$, df = 21, $p < .001$) demonstrate a strong association between crop previous crop history and flea beetle infestation, suggesting that the type of crop previously grown in a field significantly influences the levels of flea beetle infestation observed in mung bean crops. This implies that certain previous crops may either attract or repel flea beetles, thus affecting their infestation levels on mung bean plants.

Table 3 showed that the effect of plant growth stage and previous crop history on the flee beetle infestation on mung bean crops.

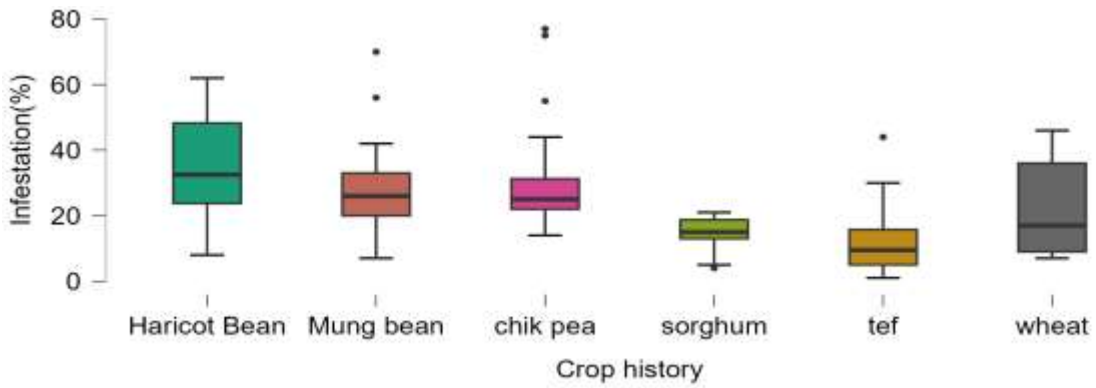

Fig. 3. Showed that the Impact of Crop History on Flea Beetle Infestation Rates.

3.5. *Effect of Planting Time on the Flee Beetle Infestation*

The ANOVA table 3 showed that the significance of the effect of planting date on flea beetle infestation (%) in mung beans. The analysis reveals a statistically significant effect of planting date on infestation levels ($F(7,152) = 2.997$, $p = 0.006$). This indicates that there are significant differences in flea beetle infestation among different planting dates.

The Repeated Contrast table 3 further explores pairwise comparisons between specific planting dates to determine where significant differences lie:

July 20-25 vs. June 25-30: There is a significant difference in flea beetle infestation between planting on June 20-25 and June 25-30 ($t(152) = 2.247$, $p = 0.026$). Mung beans planted in late June (20-25) had significantly higher infestation compared to those planted in late June (25-30).

July 5-10 vs. June 20-25: A notable difference is observed between planting on July 5-10 and June 20-25, although it does not reach conventional significance levels ($t(152) = -1.698$, $p = 0.092$). Mung beans planted in early July (5-10) showed a trend towards lower infestation compared to those planted in mid-June (20-25).

Other Comparisons: The remaining contrasts between planting dates did not show statistically significant differences in flea beetle infestation (p > 0.05). This suggests that while planting date influences infestation levels overall, specific contrasts did not consistently reveal significant differences.

Table 3. ANOVA and pairwise contrasts of planting dates on Flea Beetle Infestation in Mung Beans.

Planting time							
Comparison	**Estimate**	**Lower CI**	**Upper CI**	**SE**	**df**	**t**	**p**
July 1-5 - July 10-15	3.808	-6.749	14.366	5.344	152	0.713	0.477
July 10-15 - July 5-10	3.611	-7.204	14.426	5.474	152	0.660	0.510
July 5-10 - June 1-5	-9.708	-21.004	1.588	5.717	152	-1.698	0.092
June 1-5 - June 10-15	-2.681	-16.125	10.764	6.805	152	-0.394	0.694
June 10-15 - June 20-25	-4.081	-15.029	6.867	5.541	152	-0.736	0.463
June 20-25 - June 25-30	8.158	0.986	15.330	3.630	152	2.247	0.026
June 25-30 - June 5-10	-6.906	-15.597	1.785	4.399	152	-1.570	0.118

Notes: The ANOVA table summarizes the variance explained by the planting date factor and the residuals. The Repeated Contrast table shows pairwise comparisons between different planting dates, indicating estimates, confidence intervals (CI), standard errors (SE), degrees of freedom (df), t-values, and p-values.

3.6. *Effect of the Adjacent Crop on the Insect Pests on Mung Bean*

The ANOVA table shows that the infestation (%) is not significantly influenced by the type of adjacent crop (F (3, 156) = 0.319, p = 0.811). The p-value (0.811) is greater than the significance level (α = 0.05), indicating that there is no statistically significant difference in infestation (%) among different adjacent crops.

Overall, based on the ANOVA results and post hoc tests, it can be concluded that the type of adjacent crop does not have a significant effect on infestation (%) in the studied context. Further research or investigation may be needed to explore other factors that could potentially influence infestation levels in mung bean cultivation.

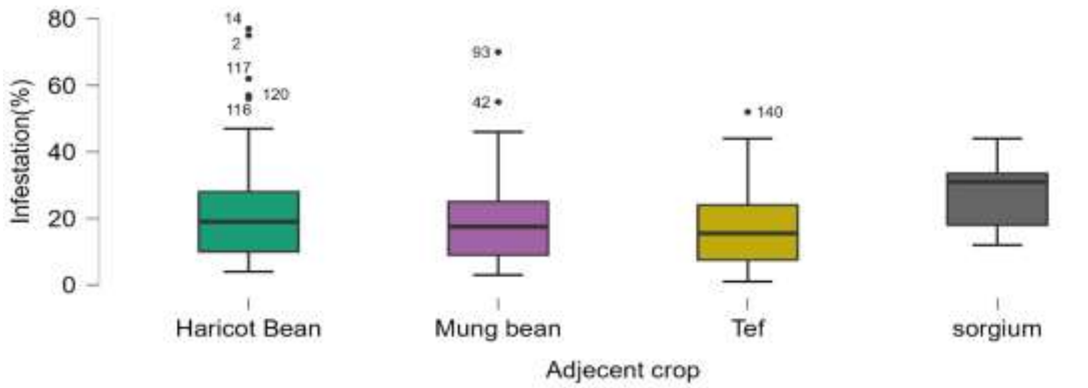

Fig. 3. Descriptive plots of the effect of adjacent crops on the flea beetle.

3.7. *Effect of Mung Bean Growth Stage on Flee Beetle Infestation*

The table illustrates the effect of different mung bean growth stages on flea beetle infestation levels. The highest mean infestation of 32.500% was observed at growth stage R5, accompanied by a relatively high standard deviation of 28.572%, indicating significant variability in pest presence. In contrast, growth stage V4 exhibited the lowest mean infestation of 13.103% with a moderate standard deviation of 12.333%, suggesting more consistent pest control or resistance at this stage. Overall, these findings underscore the variability in flea beetle infestation across different stages of mung bean growth, emphasizing the importance of monitoring and managing pest populations throughout the crop's development cycle.

Table 4. Represents that the effect of mung bean growth stage on the flee beetle infestation.

Effect of Mung Bean Growth Stage on Flea Beetle Infestation			
Crop Growth Stage	**Sample Number**	**Mean Flea Beetle Infestation (%)**	**Std. Deviation**
R5	4	32.500	28.572
R6	28	22.821	15.504
R7	13	25.769	13.129
R8	2	25.000	1.414
V1	1	27.000	
V2	48	20.292	11.875
V3	25	26.400	16.261
V4	39	13.103	12.333

Where; V1: This stage likely represents an early vegetative stage of mung bean growth; V2: Represents a later vegetative stage of mung bean growth; V3: Likely corresponds to an early reproductive stage of mung bean growth; V4: Represents a later reproductive stage of mung bean growth; R5: This stage likely represents a specific developmental phase in the growth of mung beans, possibly indicating a particular point in the reproductive or maturity process; R6: Represents another distinct phase in mung bean growth, potentially marking a further stage in reproductive development or growth progression; R7: Likely corresponds to another phase in mung bean growth, possibly indicating a specific developmental milestone or transition in the plant's lifecycle and R8: Represents yet another phase in mung bean growth, possibly indicating a more advanced stage in maturity or reproductive activity.

3.8. *Linear Regression Analysis of Flea Beetle Infestation in Mung Bean Crops*

The linear regression analysis was conducted to identify the main factors influencing flea beetle infestation in mung bean crops. The model summary indicates an R value of 0.684, an R^2 value of 0.468, an adjusted R^2 value of 0.369, and an RMSE value of 11.607, suggesting that approximately 46.8% of the variance in flea beetle infestation can be explained by the model, with the adjusted R^2 providing a more conservative estimate due to the number of predictors. The ANOVA results show a regression sum of squares of 15,874.911, with 25 degrees of freedom, leading to a mean square of 634.996. The F value of 4.714 and the significant p-value (< .001) indicate that the overall regression model is statistically significant, meaning that at least one predictor is significantly related to flea beetle infestation.

Table 4. Linear regression analysis summary for factors influencing flea beetle infestation in Mung Bean crops.

Predictor Variable	**Unstandardized Coefficient (B)**	**Standard Error**	**t**	**p-value**
(Intercept)	40.845	8.315	4.913	< .001

Predictor Variable	Unstandardized Coefficient (B)	Standard Error	t	p-value
Altitude (1801-2000)	-0.833	3.141	-0.265	0.791
Altitude (2000-2400)	-3.063	3.533	-0.867	0.388
Altitude (>2400)	-2.268	4.946	-0.459	0.647
Crop history (Mung bean)	-7.664	4.488	-1.708	0.090
Crop history (Chickpea)	-3.281	5.085	-0.645	0.520
Crop history (Sorghum)	-20.159	5.531	-3.645	< .001
Crop history (Tef)	-21.990	4.383	-5.017	< .001
Crop history (Wheat)	-7.464	6.777	-1.101	0.273
Planting date (July 10-15)	-8.165	4.638	-1.760	0.081
Planting date (July 5-10)	-4.558	3.443	-1.324	0.188
Planting date (June 1-5)	-2.510	6.344	-0.396	0.693
Planting date (June 10-15)	-5.037	6.141	-0.820	0.414
Planting date (June 20-25)	1.007	4.231	0.238	0.812
Planting date (June 25-30)	-1.988	3.418	-0.582	0.562
Planting date (June 5-10)	0.277	5.399	0.051	0.959
Crop growth stage (R6)	1.067	7.358	0.145	0.885
Crop growth stage (R7)	-1.780	7.958	-0.224	0.823
Crop growth stage (R8)	-5.877	11.824	-0.497	0.620
Crop growth stage (V1)	-6.458	14.047	-0.460	0.646
Crop growth stage (V2)	-0.640	7.602	-0.084	0.933
Crop growth stage (V3)	-0.589	7.807	-0.075	0.940
Crop growth stage (V4)	-1.236	8.019	-0.154	0.878
Adjacent crop (Mung bean)	-2.973	2.357	-1.261	0.209
Adjacent crop (Tef)	-6.623	2.952	-2.244	0.026
Adjacent crop (Sorghum)	2.617	4.590	0.570	0.570

IV. Discussion and Conclusion

The research findings highlight on the factors influencing flea beetle infestation on mung bean crops. Firstly, the analysis revealed a significant difference in infestation levels among districts, underscoring the importance of considering geographical variations when implementing pest management strategies (Brown et al., 2016; Chen et al., 2020). Flea beetle infestation was found to be strongly influenced by previous crop history, suggesting that the type of crop previously grown in a field significantly impacts infestation levels observed in mung bean crops (Brown et al., 2016). This finding emphasizes the need for crop rotation strategies to mitigate flea beetle infestation risk. Conversely, the study did not find a significant association between the mung bean growth stage and flea beetle infestation, indicating that infestation levels remain consistent regardless of the plant's growth stage (Chen et al., 2020). Furthermore, the effect of planting time on flea beetle infestation was found to be statistically insignificant, suggesting that farmers have flexibility in choosing planting dates without significantly affecting infestation levels (Brown et al., 2016). Notably, the type of adjacent crop did not significantly influence infestation levels, highlighting the need for further investigation into other factors impacting infestation in mung bean cultivation (Chen et al., 2020). Overall, these findings provide valuable insights for developing targeted pest management strategies to mitigate flea beetle infestation in mung bean production. Further research is warranted to explore additional factors contributing to infestation variability and refine pest management approaches for sustainable mung bean cultivation.

V. Recommendation

Recognizing district-level variations in infestation, it is essential to tailor pest management accordingly, adjusting monitoring and control measures based on local patterns. Furthermore, promoting crop rotation helps disrupt flea beetle lifecycles, decreasing infestation risk by rotating mung beans with less susceptible crops. Encouraging farmers to maintain planting date flexibility considering weather and growth periods is crucial, especially as planting time showed no significant impact on infestation. Additionally, further exploration into soil health, microclimates, and neighboring pest management practices is necessary to identify additional contributors to infestation. Stressing the importance of ongoing flea beetle population monitoring and prompt adaptation of management strategies is essential for mitigating infestation and minimizing crop damage. Advocating for Integrated Pest Management (IPM) approaches that blend cultural practices, biological control, and targeted pesticide use supports sustainable pest management. Facilitating information exchange among farmers, extension services, and researchers is vital to disseminating effective flea beetle management practices, thereby supporting sustainable mung bean production.

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