



# First Report of *Nezara viridula* (Hemiptera: Pentatomidae) as an Emerging Insect Pest of Maize in India

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

The green stink bug *Nezara viridula* (Linnaeus) (Hemiptera: Pentatomidae) is an economic insect pest of many cultivated plants around the world. Recently, high population of green stink bug were observed in maize crop during March–May 2020 in Bihar, a leading state of maize production in India. The population changes, damage symptoms, morpho-variants of *N. viridula* on maize were

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studied during 2020 and 2021 and presented in this report. For this study, 1 m<sup>2</sup> area were randomly selected at three places in the maize field grown at Dumraon, Bihar to record the population of *N. viridula* at weekly during crop period in the year 2020 and 2021. Also number of maximum adults per plants and per cobs were recorded. The adults of *N. viridula* were first recorded in maize field during third week of March 2020 and in the same period of year 2021. The mean maximum adults' population of *N. viridula* was 43 adults/ m<sup>2</sup> and 34.33 adults/ m<sup>2</sup> observed during April 2020 and 2021, respectively on maize crop. The high population densities of the pest may be due to the migration of bugs from other field crops and native vegetation to the cultivated maize crop. During the course of the investigation, maximum 18 adult bugs per plant and 13 adult bugs per corn were recorded during fourth week of April 2020, whereas, maximum 12 adults per plant and 8 adults per cob were recorded during April 2021. The bugs were damage standing maize plants and corn by sucking saps and hindering the growth of plants, cobs as well as the developing kernels. Considering the high population densities, regular appearance of the pest and damage caused to maize crop in the state created an alarming situation for the pest management researchers of the country to develop suitable integrated pest management strategies for the management of *N. viridula* on maize in the near future.

**Keywords:** Green vegetable bug; corn; *Zea mays*; stink bug.

## 1. INTRODUCTION

Green stink bug, *Nezara viridula* is a polyphagous and widely distributed insect pest of agriculture throughout the world [1,2]. More than 150 host plant species have been reported for *N. viridula* from different part of the world [3]. It attacks mainly fruit trees and vegetables, but also reported from field crops and some ornamental plants and weeds [1,4]. In India, *N. viridula* is an endemic insect pest on many crops, but neither reported on maize for its economic damage nor listed as insect pest of maize at national level or regional level by National Centre for Integrated Pest Management, New Delhi, India [5].

Stink bugs damage maize crops at various stages [6]. At early stages, severe infestations and feeding by *N. viridula* may deform the maize cob and stops cob development. High infestation at maturity of crops, especially near the tip of the cob showed shrunken and missing kernels [7]. The shrivelled kernels are more susceptible to fungal diseases [4]. The damage level due to infestation of stink bug varies from 3% to 100% depending on crop varieties and type of maize [7,8]. The economic threshold level of *N. viridula* on maize has not been found in literature; whereas Cissel et al. [9] suggested one brown marmorated stink bug (*Halyomorpha halys* Stål) per cob is enough to cause significant quality reductions in maize. Nevertheless, one stink bug per two plants has been recommended by Koch et al. [10] as economic threshold level for stink bugs (Pentatomidae) on maize regardless of the species.

Bihar is an agrarian state located in the eastern region of India between *latitude* 24°20'10" N to 27°31'15" N and *longitude* 83°19'50" E to 88°17'40" E. Bihar is one of the leading producers of maize in the country with production of 2.42 million tonnes of maize grain with area of 0.67 million ha during 2018-19 [11]. Previously, the stink bug, *N. viridula* is occasionally seen on maize field. In the present study, during the March, 2020, exceptionally large numbers of adults with few nymphs were observed on maize causing severe damage to the maize plants especially cobs. This region is strategically important with respect to maize production in the country due to high productivity and good quality of maize grain. Keeping in mind, the emerging potentiality of the region on maize production and the threat of the stink bug, we describe the population changes, damage symptoms, morpho-variants and impact of infestation of *N. viridula* on post harvest storage of maize in Bihar, an eastern state of India.

## 2. MATERIALS AND METHODS

The weekly population of *N. viridula* was recorded by direct counting from first week of March 2020 and 2021 to till harvest of maize crop (Variety: Sabour Sankar Makka-1) during May 2020 and 2021 in the experimental farm of Veer Kunwar Singh College of Agriculture, Dumraon, Buxar, Bihar (*latitude* 25.55° N, *longitude* 84.15° E and elevation 61m above mean sea level). The 1 m<sup>2</sup> area (12 plants) at three different spots of maize field was selected randomly every week and counted the stink bug population. Level of plant and cob infestations by

*N. viridula* were also recorded and presented in percent infestation {% infestation= (number of plants or cobs infested/ total number of plant or cobs under observation) X 100} at weekly interval. The colour variations in the stink bug adults were recorded visually. During observations, highest number of stink bug on one plant as well as one cob was recorded. Damage symptoms on green cobs as well as on dried mature cobs were also recorded. The mature dried cobs were kept under observations at room temperature ( $25\pm 2^{\circ}\text{C}$ ) for six months to record development of any fungal infection as well as any other stored grain insect pests by observing the stored cobs on monthly interval visually.

### 3. RESULTS

#### 3.1 Damage Symptoms

Direct damage of *N. viridula* was observed with feeding of adults at different immature part of the maize plants (Fig. 1). Whereas, the symptoms of damage were seen with the spot of honey dew excretion during feeding by *N. viridula* at different parts of maize plants (Fig. 2). Post feeding damage lesions were also observed on maize cob and kernels (Fig. 3). Results of the study revealed that the mature cobs infested with *N. viridula* were susceptible to stored grain insect pest because infestation of stored grain insect pest was started in the kernel previously damaged by *N. viridula* (Fig. 3e).

#### 3.2 Level of Infestation

The highest maize plant infestations of 83.33 per cent and 88.89 per cent by *N. viridula* were recorded during third week of April 2020 and 2021 (Table 1). During this period, maximum no. of 18 adults and 12 adults of *N. viridula* on single plant was recorded during 2020 and 2021, respectively. Maximum 91.48 percent and 77.78 per cent infestation of cobs by *N. viridula* was recorded during year 2020 and 2021, respectively. Maximum numbers of adults i.e. 13 adults and 8 adults of *N. viridula* were recorded on single cob during observations in both the years.

#### 3.3 Morpho- variants of *N. viridula*

Morphological variations were also recorded in the adult stages of *N. viridula*. Six morpho-variants were recorded. Among six morpho-variants, three were from basic morpho-variants

i.e. entirely green, green with anterior margin of the pronotum and head yellow and entirely yellow (Fig. 4). Others were derived from these three basic types. Mating between different morpho-variants were recorded and found that they were compatible to mate between different morpho-variants (Fig. 5).

#### 3.4 Population Changes of *N. viridula*

During first week of March 2020 and 2021, *N. viridula* population in the maize field was very low. Whereas, increase in populations were recorded during last week of March 2020 and 2021 with 1.33 bugs/  $\text{m}^2$  and 1.67 bugs/  $\text{m}^2$ . Population of *N. viridula* attained peak during the last week of April 2020 and third week of April 2021 with 43 bugs/  $\text{m}^2$  and 34.33 bugs/  $\text{m}^2$ , respectively. Thereafter, decrease in population was recorded and disappear during May 2020 and 2021 with harvest of maize crops (Fig. 6).

### 4. DISCUSSION

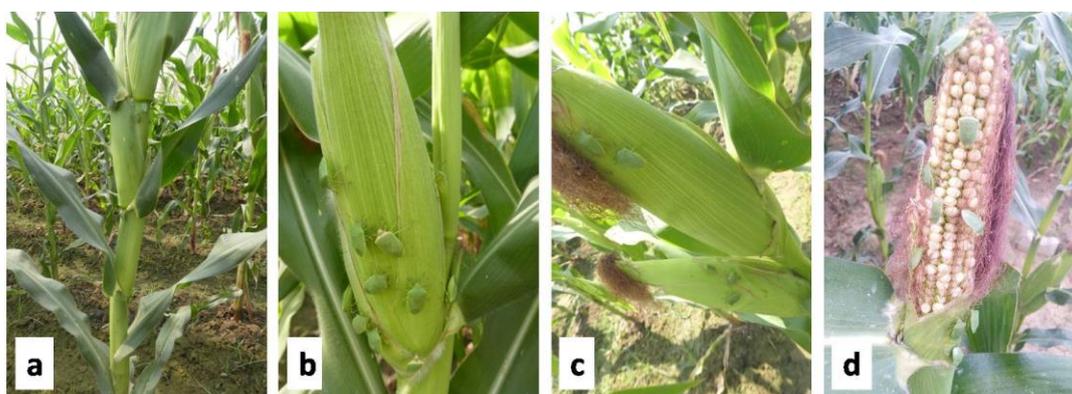
Adults of stink bugs entered into the maize field to begin feeding on plant and sooner or later started feeding on maize cobs. This feeding habit of stink bugs on maize can result in economic damage [12,13]. In the present study, adults of *N. viridula* appear in the maize field during third week of March 2020 and 2021, when maize plants in the area entered into the reproductive phase. Weekly observations revealed the sudden increase in the population of *N. viridula* in maize field during April 2020 and 2021 and recorded maximum of 18 adult bugs and 13 adult bugs on single maize plant and 13 adult bugs and 8 adult bugs on single maize cob along with maximum 43 bugs population / $\text{m}^2$  and 34.33 bugs/  $\text{m}^2$  respectively in two years. Ciceoi et al. [4] reported a maximum of seven stink bugs adults/cob and 16 adults/plant (12 *H. halys* and 4 *N. viridula*) during cob formation and grain filling phases until the wax maturity in the maize field of Bucharest, Romania. The high population density of *N. viridula* may cause the significant yield loss as Cissel et al. [9] suggested that one stink bug per plant is enough to cause maize damages, while Koch et al. [10] suggested 1 stink bug/2 plants as economic threshold. The population of stink bugs recorded were very high in the present study for yield loss in maize as per observations of Koch et al. [10] and Cissel et al. [9] as we did not quantify the yield loss in the present study. No eggs and nymphs of *N. viridula* were recorded from the maize field under observations. Whereas, mating between pairs of

adults were recorded in the field including between different morphological variants. Six morpho-variants of *N. viridula* were recorded in the present study. Polymorphism with colour variations is very common in *N. viridula*. Earlier 10 different colour morphs which are derived from four basic types are reported by different researchers from various region of the world [14-17]. The timing of infestations during mid to late March in maize, suggests that the majority of *N. viridula* adults were offspring of the generation earlier in the season which developed on other unknown host plants in the area. The sudden increase of the population of *N. viridula* on maize may be due to unavailability of suitable host plant

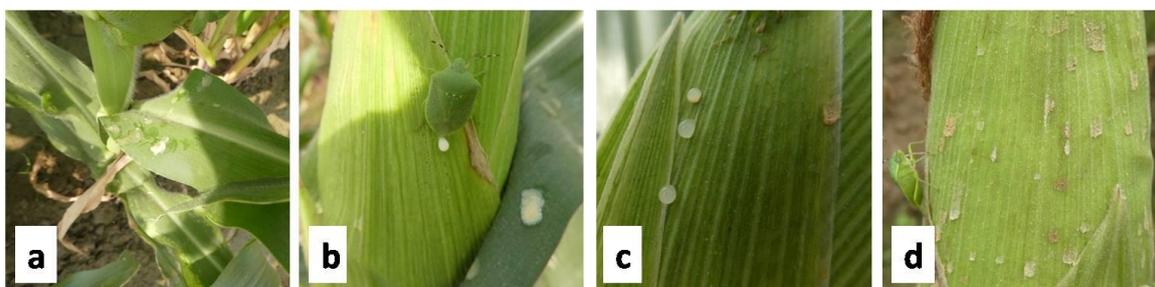
in the area due to start of harsh summer season leads the migration of *N. viridula*. Shifting of stink bug populations to a suitable host due to unavailability of native vegetation is also reported earlier by Venugopal et al. [18]. Shifting of stink bugs result from their movement in an area in response to deteriorating suitability of host crops or native vegetation to the target crop plants [1]. In Bihar state, wheat and maize along with seasonal vegetables like tomato, potato and brinjal is the major crops in *Kharij*(winter season) season in the area. Most of the winter crops have beenharvestedin the area from the field during end of March leads the shifting of stink bug adults to maize filed. Adults of *N. viridula* were

**Table 1. Level of infestation of *N. viridula* on maize plants and cobs during Year 2020 and 2021 at Dumraon, Bihar**

Date of Observation	Number of plant observed	No of plant infested	Percent plant infestation	No of cob observed	Number of cob infested	Percent cob infestation
<b>Year 2020</b>						
21-03-2020	36	1	2.78	25	0	0
28-03-2020	36	4	11.11	35	1	2.86
04-04-2020	36	8	22.22	45	6	13.33
11-04-2020	36	15	41.67	52	20	38.46
18-04-2020	36	25	69.44	47	43	91.49
25-04-2020	36	30	83.33	55	48	87.27
02-05-2020	36	23	63.89	51	39	76.47
09-05-2020	36	2	5.56	53	2	3.77
<b>Year 2021</b>						
25-03-2021	36	3	8.33	20	3	15
01-04-2021	36	10	27.78	29	8	27.59
08-04-2021	36	25	69.44	47	30	63.83
15-04-2021	36	30	83.33	45	35	77.78
22-04-2021	36	32	88.89	49	33	67.35
29-04-2021	36	29	80.56	50	35	70
06-05-2021	36	17	47.22	48	20	41.67
13-05-2021	36	5	13.89	45	5	11.11



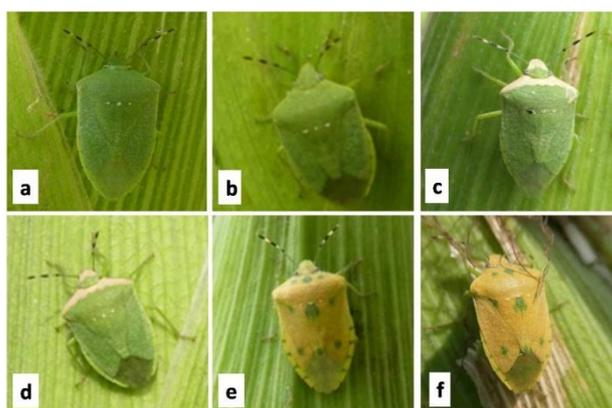
**Fig. 1. Infestation of *N. viridula* on maize plant. a) adult bugs feeding at plant nodal area, b) adult bugs feeding on basal part of the developing cob, c) adult bugs feeding on apical part of the developing cobs, and d) adult bugs feeding on an open developing cob**



**Fig. 2. Excretion of honeydew by *N. viridula* on maize plant. a) Sign of honeydew excretion by bugs on leaf, b) adult bug excreting honeydew during feeding, c) excreted honeydew droplet on cob, and d) dried honeydew on cob**



**Fig. 3. Damage symptoms of *N. viridula* on maize cob. a) brown spot on maize cob at the site of bug feeding b) bug feeding causes white/ cloudy spot on maize kernel, c) abortion, whitening, distortion of maize kernels due to excessive bug feeding, d) feeding damage sign on mature maize cob and e) infestation of stored grain insect pest on *N. viridula* infested mature cob**



**Fig. 4. Morphotypes of *N. viridula* on maize plant. a) entirely green, b) entirely green with dark wing membrane, c) green with anterior margin of the pronotum and head yellow d) green with anterior margin of the pronotum and head yellow with dark wing membrane, e) entirely yellow, and f) entirely yellow with dark wing membrane**

observed aggressively feeding on the maize plant and cobs causing brown spots on the site of feeding on the green maize cobs. Infestation of stink bugs at the time of grain filling causes cloudy or white spot on the grain which continued till the harvest of mature cobs. We also observed

that the early infestation of *N. viridula* on maize ear causes ovule abortion resulted in undeveloped maize grain. Earlier similar damage on maize by *N. viridula* was recorded by different researchers. During the early stages, before the grain fill, severe infestations and



Fig. 5. Mating between different morphotypes of *N. viridula*. a) mating between entirely green, b) mating between entirely green and green with anterior margin of the pronotum and head yellow and c) mating between entirely green and entirely yellow

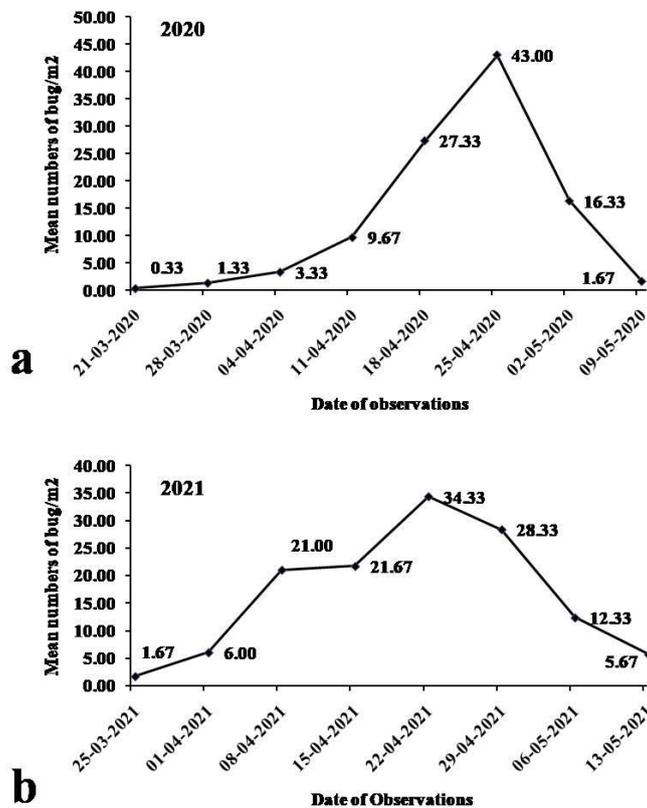


Fig. 6. Population changes of *N. viridula* on maize. a) in the year 2020 and b) in the year 2021

feeding may deform the maize cob, making it look like a cow horn or boomerang, and expose the kernels to bird and insect damages because the cob shuck also stops developing [4]. At later stages, feeding is associated with a

'mottled' appearance, due to kernels scarring or bruising, especially near the tip of the ear, and shrunken and missing kernels [7]. High population of *N. viridula* during reproductive phase in maize field resulted in 83.33 per cent and 88.89 per

cent infested plants and 91.48 per cent and 77.78 per cent infested cobs in two years cause significant damage to the maize crops. Earlier, Leskey et al. [7] mentioned that sweet maize is a highly preferred host of stink bugs, with reported losses of 100%. Infestation of *N. viridula* on maize grain not only affects the quality of grain but also makes harvested cobs susceptible for stored grain insect pest. We observed the infestation of stored grain insect pest begins with the site of infestation mark on kernel by *N. viridula*. Although information on impact of *N. viridula* infestation on storage is not available in literature. Whereas, similar observation was also recorded by Ciceoi et al. [4] that the stink bug damaged kernels are more susceptible to fungal diseases.

## 5. CONCLUSION

The high population of green stink bug, *N. viridula* in the maize field of Bihar suggests alarming situation for maize cultivation in the state as well as in the country as this insect not only causes quantitative losses but also qualitatively to maize grain, makes maize grain unsuitable for long term storage. The alarming situations of infestation in maize by green stink bug in Bihar, ecological study with respect to host plants of *N. viridula* as well as timing of maize planting which leads to the timely harvest of the crops in the end of March before shifting of *N. viridula* on maize.

Considering the recent high population and regular appearance of *N. viridula* from last two years along with significant damage to the maize crop in this region, there is a need for urgent investigations of the eco-biology, behaviour, spatial and temporal distribution, and response to management practices of this species, so that effective management strategies can be designed in the near future. Failing this, the maize cultivation in Bihar as well as in different state of India may suffer seriously from this bug.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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