Rapid assessment of *boro* paddy infestation by brown planthopper in Morigaon district, Assam, India using unmanned aerial vehicle

In April 2016, farmers from Morigaon and Nagaon districts of Assam, India encountered severe pest infestation in their *boro* paddy (summer paddy) areas, which was unusual. Morigaon district with an area of 1550 sq. km having a population of about 9.6 lakhs (as of 2011), was the worst affected with four out of the five revenue circles, viz. Mayong, Bhuragaon, Laharighat, Morigaon and Mikirbheta being affected. Investigations by the District Agricultural Department and Regional Agricultural Research Station, Nagaon confirmed it to be infestation by brown planthopper (BPH), *Nilaparvata lugens* (Stal). Planthoppers are a problem in rainfed and irrigated wetland environments. They occur in areas with continuous submerged conditions in the field, high shade and humidity. Closed canopy of rice plants, densely seeded crops, excessive use of urea as nitrogenous fertilizer and early season insecticide spraying favour insect development[1,2]. Climate change in terms of increasing temperature and CO_2 has varying impact on population build-up of BPH[3].

Boro paddy has the highest productivity among the three types of rice grown in three different seasons, viz. sali (winter rice), ahu (autumn rice) and *boro* (summer rice) in the state of Assam. As *boro* paddy is grown mostly under irrigated conditions unlike sali and ahu investments made by the farmers are more and majority of the farmers are cultivating the crop on a cooperative basis or under self-help groups. Considering the severity of pest infestation and its spread, it was planned to conduct a rapid assessment of the extent of crop damage through a survey with an unmanned aerial vehicle (UAV) in the state. Till the introduction of UAVs for selected thematic surveys in India, satellite-based surveys were mostly employed for damage assessment, and pest and disease forecasts at plot level[4–6]. The fundamental advantage of UAVs is that they are not burdened with the physiological limitations and economic expenses of human pilots[7]. UAVs are cheaper, smaller and lighter than manned aerial vehicles. UAV operations are far less expensive than any manned aircraft and far more environment-friendly (generate less CO_2 and noise). A typical UAV consists of an unmanned aircraft (UA), a control system (CS), usually a ground control system (GCS) and a communications data link between the UA and the CS[8].

In the present study we have used an Inspire 1 UAV (DJI, Shenzhen, China; Figure 1). The aircraft (model T600) had a total weight of 2935 g. An X3 camera was also used (model name FC 350). Table 1 lists the salient technical specifications in terms of aircraft and camera systems of the UAV.

The survey was conducted in four locations reporting severe infestation by BPM in Morigan district, viz. Naramari, Mikirbheta, Bhurbandha and Jaluguti. Necessary permissions were obtained from the local administration for UAV survey. Table 2 provides details of the survey location and observations made.

The first UAV flight was conducted in Naramari village under Mayong development block reporting severe BPH infestation. A total area of 54.94 ha was covered with flying time of 15 min. The height of the UAV was maintained at 240 m. At this height ground resolution obtained was about 50 cm and the infested areas could clearly be identified. Multiple images were obtained at the speed of one image per 5 sec (Figure 2 *a*). The second flight was undertaken in Mikirbheta village under Mikirbheta block covering an area of 24 ha. The UAV flight height was maintained 210 m. As the infestations were more sporadic and smaller in size, the lower flying height could give better discrimination of infested fields (Figure 2 *b*).

Figure 2. Infested fields in (***a***) Naramari and (***b***) Mikirbheta.

Figure 3. Inclined view during video recording in Bhurbhandha.

Figure 1. Inspire 1 unmanned aerial vehicle.

Table 1. Technical specifications of aircraft and camera of the unmanned aerial vehicle

Aircraft		Camera	
Model	DJI Inspire 1 (T600)	Name	X3
Weight (battery included)	2935 g	Model	FC350
Dimensions	438 × 451 × 301 mm	Effective pixels	12.4 M
Hovering accuracy (GPS mode)	Vertical: 0.5 m Horizontal: 2.5 m	FOV (field of view)	94°
Maximum speed	22 m/s (ATTI mode, no wind)	Photo/video format	JPEG, DNG/MP4 MOV
Maximum range	2000 m radius (with line of sight)	Lens	20 mm anti-distortion
Maximum height	2500 m	Still photography modes	Single shoot Burst shooting: 3/5/7 frames Time-lapse
Maximum wind speed resistance	10 m/s	Video recording modes	UHD (4K), FHD, HD
Maximum flight time	Approximately 18 min (per battery)	Supported SD	Micro SD
		Card types	Maximum capacity: 64 GB. Class 10 or UHS-1 rating required

Table 2. Details of survey locations and observations made

Locations	Latitude/ longitude	Height of UAV (m)	Survey mode (image/video)	Total area covered (Ha)	Completely affected (Ha)	Partially affected area (Ha)	Observations
Naramari	26°12′42″N 92°21′51″E	240	Image	54.94	1.24	1.96	Infested paddy fields are relatively of larger size, clearly visible at higher UAV flight.
Mikirbheta	26°20′19″N 92°29'58"E	210	Image	24.00	2.64	3.02	Sporadic infested paddy fields, surveyed at lower UAV flights.
Bhurbandha	26°20′19″N 92°29′58″E	225	Image and video (30°)	32.56	3.11	4.67	Large area visualization due to angular view of the camera.
Jaluguti	26°16′ 41.17″N 92°25'24″E	225	Image	18.60	1.10	2.55	Initial period of pest infestation, smaller patches.

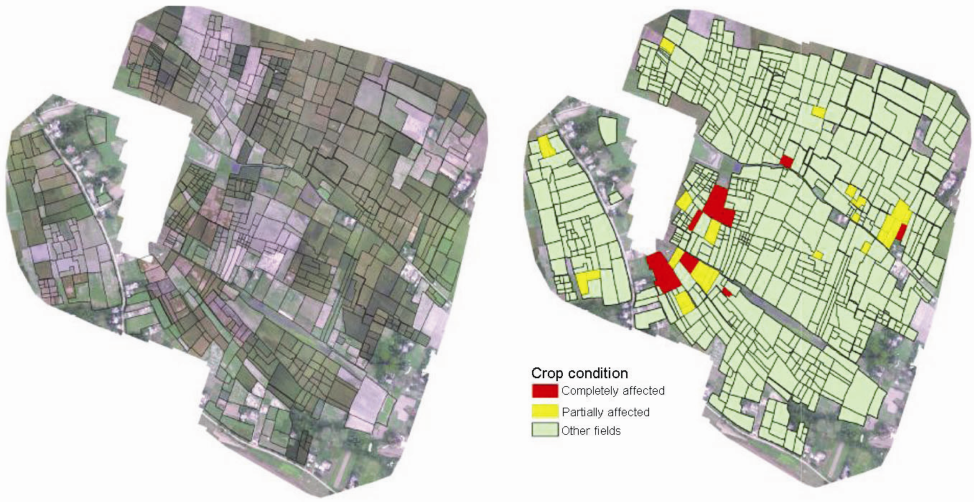

Figure 4. Categorization of brown planthopper infested rice fields (Naramari village).

The survey in the third location in Bhurbandha under Morigaon block was conducted for both image and video recording. The UAV height was maintained at 225 m and 30° inclination was maintained for video recording. Large area visualization was possible due to angular view of the camera (Figure 3). In the fourth site in Jaluguti, an area of 32 ha was covered and images were taken from a height of 225 m. Varying size of infested areas was observed in this site.

The images and videos were transferred to the computer and processed using Pix4D software. Mosaicing of the images was done for seamless boundaries of the scenes. Digitization of the rice fields was done along the field boundaries. Based on the severity of infestation, fields were categorized as completely affected, partially affected and other fields (Figure 4). The infestation occurs as a result of feeding by both nymphs and adults of the insect at the base of the tillers; the plants turn yellow and dry up rapidly. It was observed that at early infestation, round and yellow patches appear, which eventually turn brownish due to the drying up of the plants. The infested fields could be clearly identified in the images based on the tonal variations with the healthy rice fields (marked with yellow boundaries in Figures 2 and 3). Rice plots having more than 50% infestation were categorized as completely affected, and less than 50% as partially affected. It has been observed that there will be hardly any yield from the plots categorized as completely affected, whereas with immediate intervention measures, part of the crop areas could be saved.

Plots in which there were only patches of damage were recovered with immediate control measures such as application of insecticides, under technical guidance by the Agriculture Department field functionaries.

The assessment report was provided to the concerned department to take immediate intervention measures. The survey also helped the District Agriculture Department to visualize and assess the extent of damage to provide compensation for the affected farmers. It has been realized that the information will provide valuable inputs to ‘Pradhanmantri Fasal Bima Yojana’ and KISAN (Crop Insurance using Space Technology and Geoinformatics) programme which have emphasized use of mobile and satellite technology, including UAVs to facilitate accurate assessment and quick settlement of claims for insured crops.

1. Preap, V., Zalucki, M. P. and Jahn, G. C., *Cambodian J. Agric*., 2006, **7**(1), 17–25.
2. Holt, J., Chancellor, T. C. B., Reynolds, D. R. and Tiongco, E., *Crop Prot.*, 1996, **14**(4), 359–368.
3. Prasannakumar, N. R., Chander, S. and Pal, M., *Curr. Sci.*, 2012, **103**(10), 1201–1205.
4. Dubey, R. C., Maske, S. J. and Ronghe, J. A., *Mausam*, 1985, **36**(4), 509–512.
5. Nageswara Rao, P. P. and Rao, V. R., Proceedings of the third Asian Conference of Remote Sensing, Dhaka, Bangladesh, 4–7 December 1982, pp. 1–12.
6. Ranganath, B. K., Pradeep, N., Manjula V. B., Gowda, B., Ranjana, M. D., Shettgar, D. and Nageswara Rao, P. P., *J. Indian Soc. Remote Sensing*, 2004, **32**(10), 49–58.
7. Everaerts, J., *The Int. Arch. Photogramm., Remote Sensing Spatial Inf. Sci.*, 2008, **XXXVII**(part B1), 1187–1191.
8. Colomina, I. and Molina, P., *ISPRS J. Photogramm. Remote Sensing*, 2014, **92**, 79–97.

ACKNOWLEDGEMENTS. We thank the Directorate of Agriculture, Government of Assam and District Agricultural Officer of Morigaon district, Assam for providing the necessary permissions and field support.

Received 25 August 2016; revised accepted 7 September 2016

B. K. HANDIQUE*
JONALI GOSWAMI
ABDUL QADIR
CHIRAG GUPTA
P. L. N. RAJU

North Eastern Space Applications Centre, Department of Space, Government of India, Umiam 793 103, India
**For correspondence.*
e-mail: bkhandique@gmail.com