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Research Article

Evaluation of probable hot spots of mealybug concentration in cotton growing areas of Sirsa district using satellite data

S.K. Singh*, Sujay Dutta and Nishith Dharaiya***

*Hemchandracharya North Gujarat University, Patan, Gujarat,Dept. of Life Science,
**Space Application Centre (ISRO), Ahmedabad, Gujarat

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Abstract

Analysis of pest impact assessment using remote sensing is based on that pest infestation change the photosynthesis and physical structure in plants, which in term alter the absorption and reflectance property of plant in electromagnetic spectrum. Productivity of cotton crop grown in India is at risk due to the incidence of new emerging pests, especially after introduction of BT cotton varieties. Crop losses due to new pests like mealybug can be substantial and may be prevented, or reduced, by crop protection measures. An attempt has been made on identification of probable hot spots of mealybug concentration zones in cotton crop. A methodology is developed for estimation of pest affected areas using two years Indian Remote Sensing and MODIS satellite data and ground measured severity index of the pest concentration. The pest severity index seems to have high correlation with the satellite derived index which can be used to locate the severely affected zones in the district so that correction measures can be taken up in a more concentrated effort and for effective pest management of the crop.

Key words: MPDI, mealybug, Severity Index and Remote sensing

Introduction

Mealybug (*Phenacoccus solenopsis*) is one of the pests seem to be predominant during the post monsoon season after the first picking. Mealybug's occurrence is sporadic in nature and is reported that its outbreak occurs after first picking due to its contagious nature dispersed through clothes of the farmers or carried by the weeds bordering along the farm lands. This pest was the major pest during the kharif season 2010 in cotton growing region in northern India. In addition the plants become covered in a dense mat of sooty moulds that grow on the large amount of exuded honeydew. In severe infestation cases, the plants exhibit stunted bushy leaves that dry completely causing significant reduction in yield. Remote sensing data obtained from Indian Remote Sensing (IRS) satellite using Advanced Wide Field Sensor (AWiFS) having 56 m spatial resolution has been regularly used for crop discrimination/identification (Dadhwal *et al*., 2002). Earlier remote sensing data have been used for detection of pest affected areas in mustard crop using satellite based meteorological data and crop indices (Dutta *et al*., 2008). Absorption of incident light changes in the visible range and NIR range when plant gets affected by pest or disease (Carter and Knapp, 2001). If this methodology is developed further, it can become a handy tool for cotton managers to initiate action for its better management practices and improve yield. Here in this study, multi-date AWiFS data have been used at first to map the area and extent of cotton growing fields in Sirsa district in 2010. Within the crop growing areas the location of pest infested areas were marked using information from field visits with GPS location and its severity index is also derived by field visits. The growth of

*Corresponding Author : S.K. Singh, Email : itsmerathore@gmail.com

pest severity was indicated to be correlated to drier fields of cotton. Although the crop is grown in irrigated condition, the location of comparatively drier areas showed more concentration of severely infested crop. Using multi-date data, an index called Modified Perpendicular Drought Index (MPDI) was derived to know the overall drier fields of cotton. Mealybug is seen to be associated in severity index in these areas. This can be a supplementary tool along with weather data for forewarning the outbreak of this pest in cotton.

Materials and methods

Study area and data used

The pest infested crop locations (Fig. 1) were collected during ground survey for cotton growing areas in Sirsa district in 2009 and 2010. The positions of the pest affected fields were recorded using GPS from August to October. Cloud free AWiFS and MODIS data were collected for year 2010 and 2009 respectively.

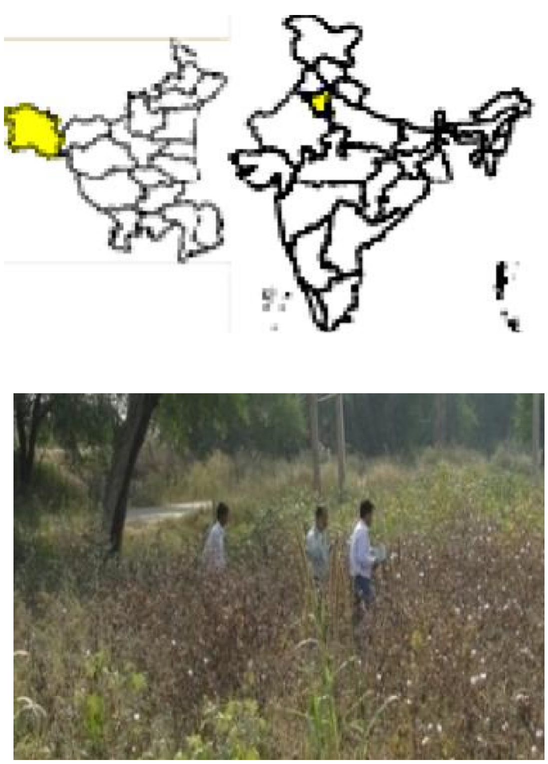

Fig.1: study area map and field location of infestation

Different grading of pest severity was used such as 0-no mealybug, 1 - about 1-10 mealybug scattered over the plant,2-One branch infested heavily with the mealybug,3- two or three branches infested heavily with the mealybug upto 50% plant affected and 4-complete plant affected.

Using IRS satellite borne multi-date AWiFS data, Normalized Difference Vegetation Index (NDVI) profiles of cotton crop are obtained based on GPS locations of ground truth information. A stack of registered NDVI images of the selected dates are created. An ISODATA clustering technique was applied over the stacked multi-date NDVI images to classify the major cotton growing areas in the Sirsa district. Within this cotton growing areas, a Modified Perpendicular Drought Index (MPDI) developed by Ghulam *et al.* (2007) was derived for the acquired dates in 2009 and 2010. Ghulam *et al*. (2007) suggested a new and robust method to derive drought index which takes into account both vegetation status and soil moisture condition and based on NIR-Red spectral reflectance. The advantage of this index is that it can be derived with AWiFS data at 56 m resolution compared to other soil moisture index like TVDI which requires land surface temperature which is generally available at 1 km resolution. Since the pest infested areas are found in small patches, higher resolution data may be useful in capturing the changes in the index values. MPDI is found to have negative relationship with soil moisture. MPDI is calculated as

$$MPDI = \frac{R_{Red} + R_{NIR} - f_v (R_{v,Red} + MR_{v,NIR})}{(1 - f_v)\sqrt{M^2 + 1}}$$

Where,

$R_{V, Red}$ = vegetation reflectance in the red, taken as 0.05

$R_{V,NIR}$ = vegetation reflectance in near infrared bands taken as 0.5

R_{Red} = Reflectance in Red band

R_{NIR} = Reflectance in near infrared band

M = Soil line slope

f_v = Fraction of vegetation cover

Fractional Vegetation cover (f_v) proposed by Baret *et al*. (1995) is given as

$$f_v = 1 - \left(\frac{NDVI_{max} - NDVI}{NDVI_{max} - NDVI_{min}} \right)^{0.6175}$$

Where,

$NDVI_{max}$= maximum NDVI of the vegetation

$NDVI_{min}$= NDVI of Bare soils

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}}$$

Where,

ρ_{NIR} = reflectance in near infrared band

ρ_{RED} = reflectance in red band

Results and Discussion

Analysis of seasonal variation of crop growth and land cover pattern

The multi date AWiFS data was used to classify the cotton growing areas in Sirsa district. Fig. 2 shows the cropping pattern in the district with major areas are cotton growing region shown in yellow colour in the classified map except the river belt of Ghaggar which is rice dominant region and few locations in the northern part shown in green colour. The cotton crop is generally sown in June- July almost at equal time throughout the district. We have analysed temporal cloud free MODIS reflectance data of the study area and derived NDVI profiles of sample cotton pixels taken throughout length and breadth of the district shown in Fig. 3.

It revealed that the crop matured to peak stage around September 22, 2010. Although the peak intensity varied according to the crop health prevailing there, which varied from 0.7-0.8, the timing of peak coincided in all places. This showed that the crop stages did not vary within the district. Since all places had similar crop stages therefore, crop stage was found not to be a factor for this pest incidence.

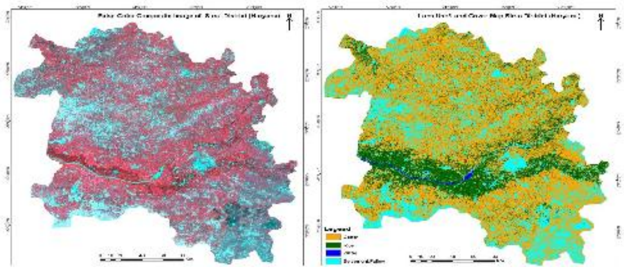

Fig. 2. False Color Composite (Left) and classified Map (right)

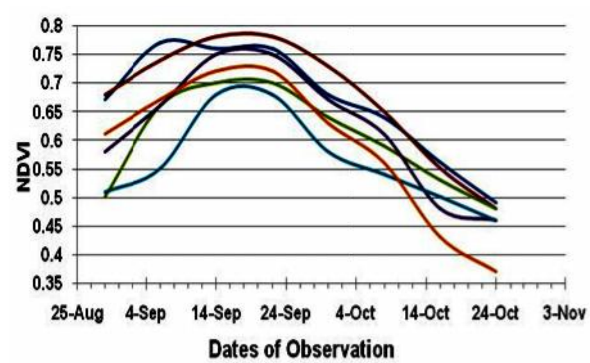

Fig. 3. NDVI profiles of sample cotton growing areas throughout Sirsa district in Kharif 2010

Within the cotton growing areas, Modified Perpendicular Drought Index (MPDI) was found to be correlated with the dryness factor which was associated with mealybug concentration. MPDI was found to have positive correlation with the severity index of mealybug concentration. As MPDI have negative correlation with soil moisture, so higher the MPDI, higher is the dryness condition of the cotton field. A regression analysis was carried out to find relationship between mealybug and MPDI and the degree of relationship was good and has been used to identify the spatial distribution of pest damage area.

SI = 4.9114 x MPDI + 0.6642

R^2=0.76, n = 16 ------------------------ (1)

Where, S.I = Severity Index of pest population count.

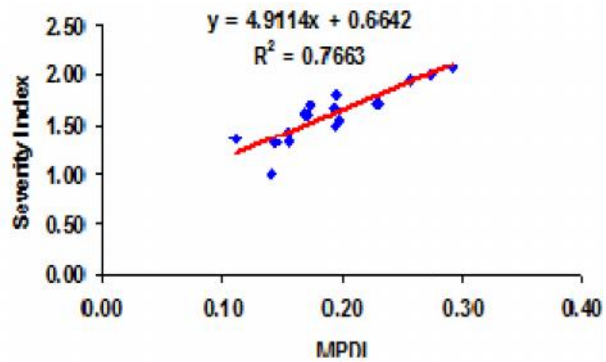

Fig. 4. Relationship between MPDI and S.I of pest population count

Final regression model was applied on NDVI and LSWI image of 12 October 2012 to get spatial distribution of pest zone. Final output is shown in Fig.5.

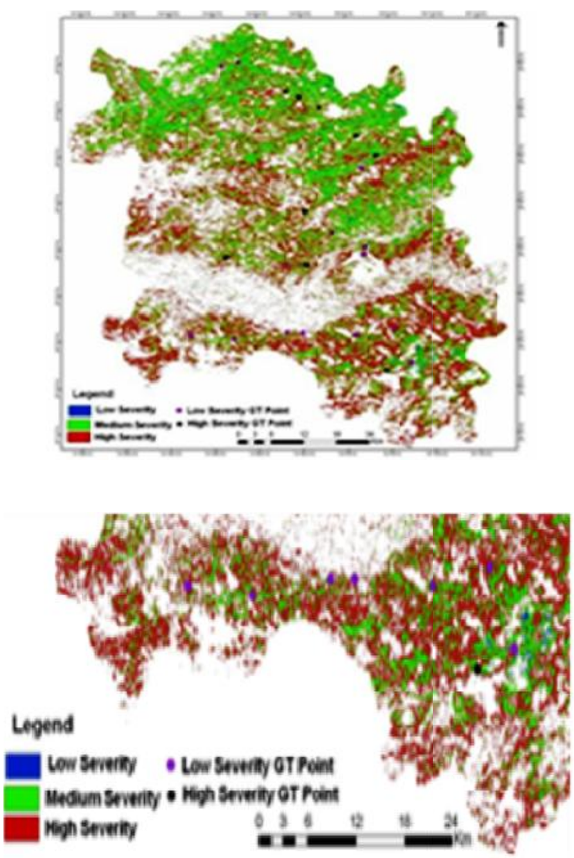

Fig. 5. Spatial variability of pest damage area and zoom view

Red color patches in Fig. 5 show high intensity of pest severity while green color shows medium severity. South part has high severity show low moisture area.

Validation of the model

Validation using blind sites (excluding data points taken for model development) is shown in Fig.6

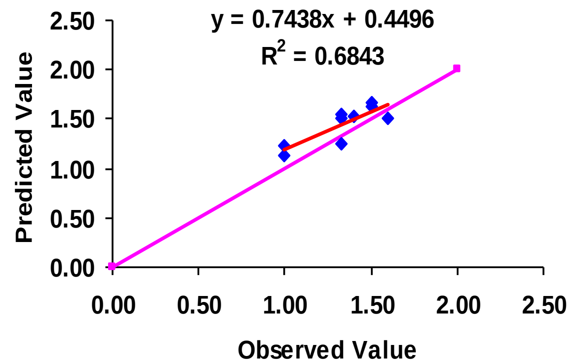

Fig.6. Validation of blind sites for pest incidence level

The model seemed to overestimate from the observed values as it showed a positive bias over 1:1 line shown in Fig. 6. The sources of error were due to association of alternate hosts and other factor etc. From the study it found that incidence of pest increases as the soil moisture decrease, it means chances of pest incidence is maximum at low soil moisture area. Low moisture mean temperature is high and high temperature favor the survival of mealybug .our finding is similar to (Prasad *et al.*, 2012) who also point out that increase in temperature favor the growth of mealybug. With the help of high spatial resolution data, it is possible to assess the soil moisture at regional scale. Eq. (1) is based on remote sensing index MPDI, soil moisture index explain only spatial variation of soil moisture which are very important to understand the behavior of the pest. MPDI is a function of soil moisture, higher soil moisture value correspondence lower value of MPDI. MPDI reflect the soil moisture status and vegetation capacity.

Conclusion

This model developed showed a little positive bias over the observed field data of different concentration zones. Still this captured the location of the pest infested areas. This model would be further improved if spatial level meteorological parameters as well as large scale soil moisture data in future will be included in future study.

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References

Baret, F., Clevers, J.G.P.W. and Stevens, M.D. 1995. The robustness of canopy gap fraction estimation from red and near infra-red reflectance : a comparison of apporache. Remote sensing of Environment., 54 (3) : 141 – 151.

Carter, G.A. and Knapp, A.K., 2001. Leaf optical properties in higher plants: linking spectral characteristics to stress and chlorophyll concentration. *Am. J. Bot.*, 88 (4): 677–684.

Dadhwal, V.K., Singh, R.P. Dutta, S. and Parihar, J.S. 2002. Remote sensing based crop discrimination and area estimation: a review of Indian experience. *Tropical ecology*., 43(1): 107 - 122.

Dutta., Sujay., Bhattacharya, B.K., Rajak, D.R., Chattopadhyay, C. Dadhwal, V. K. , Patel, N. K.. Parihar, J.S. and Verma, R.S. 2008. Modelling Regional Level Spatial Distribution of Aphid (*Lipaphis erysimi*) Growth in Indian Mustard Using Satellite Based Remote Sensing Data. *Int. J. of Pest Management.,* 54 (1): 51 - 62.

Ghulam Abduwasit, Qin Qiming, Teyip Tashpolat and Zhao-Liang Li 2007. Modified perpendicular drought index (MPDI): a real-time drought monitoring method. *ISPRS Journal of Photogrammetry & Remote Sensing*., 62 : 150 – 164.

Prasad, Y.G., Prabhakar, M., Sreedevi, G., Ramachandra Rao, G. and Venkateshwarlu, B. 2012. Effect of temperature on development, survival and reproduction of the mealybug, Phenacoccus solenopsis Tinsley (*Hemiptera: Pseudococcidae*) on cotton*. J. Crop protection.,* 39 : 81 - 88.

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