Genetically modified Cotton species detection by LISS-III satellite data

Saumitra Mukherjee[1], Satyanarayan Shashtri[1], Chander Kumar Singh[1], Bindu Kumari[1], Reena Kumari[1], Ram Avatar[1] Anita Mukherjee[2] and Bhoop Singh[3].

[1]Remote sensing applications laboratory, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi-110067, India
[2]Biochemistry Department, Institute of Public Health and Hygiene, Mahipalpur, New Delhi-110037, India
[3]Natural Resources Database Management, Department of Science and Technology, Technology Bhawan, Government of India, New Delhi-110016, India

Corresponding author: Saumitra Mukherjee
Email: dr.saumitramukherjee@usa.net

It is possible to infer the genetically modified species by using remotely sensed data. Using ERDAS software the algorithm of BT (***Bacillus thuringiensis)*** Cotton in Punjab, India was developed successfully. GPS enabled space technology has the potential to identify the exact location of Bt Cotton by generating Normalized Difference Vegetation Index (NDVI) for the calculation of total area covered by this species. It was possible to develop a correlation in between genetically modified Cotton crop and NDVI value. In parts of Bhatinda district of Punjab the yield of Bt Cotton and NDVI showing R^2 value of more than 4.5 in regression analysis. A correlation matrix was also generated which shows that NDVI values of BT cotton has reasonably acceptable correlation with Total Dissolved Solids (TDS) of soil and water also.

Through remote sensing it is possible to quantify on a global scale the total acreage dedicated to these and other crops at any time. Of greater importance is accurately (best case 90%) estimating the expected yields of each crop locally, regionally or globally. It can be done by first computing the areas dedicated to each crop and then incorporating reliable yield assessment per unit area, which can be measured at representative ground truth sites. Usually, the yield estimates obtained from satellite data are more comprehensive and earlier (often by weeks) than determined conventionally as harvesting approaches[1]. Use of Satellite data for genetically modified crop needs to generate location specific spectral anomalies[2,3]. Use of multispectral satellite data helps to generate NDVI (Normalized Difference Vegetation Index), which can be correlated with the landuse, landcover, soil moisture, soil quality and groundwater quality to estimate the deterministic yield of BT cotton crops[4, 5, 6].

The study area is Bathinda District (Figure 1) situated in the Southern part of Punjab State in the heart of Malwa region, India. It forms part of newly created division Faridkot Revenue Commissioners Division and is situated between 29°33 & 30°36 North latitude and 74°38 and 75°46 East longitudes. The district is surrounded with Sirsa and Fatehabad of Haryana State in the south, Sangrur and Mansa district in the East, Moga in the Northeast and Faridkot & Muktsar in the Northwest.

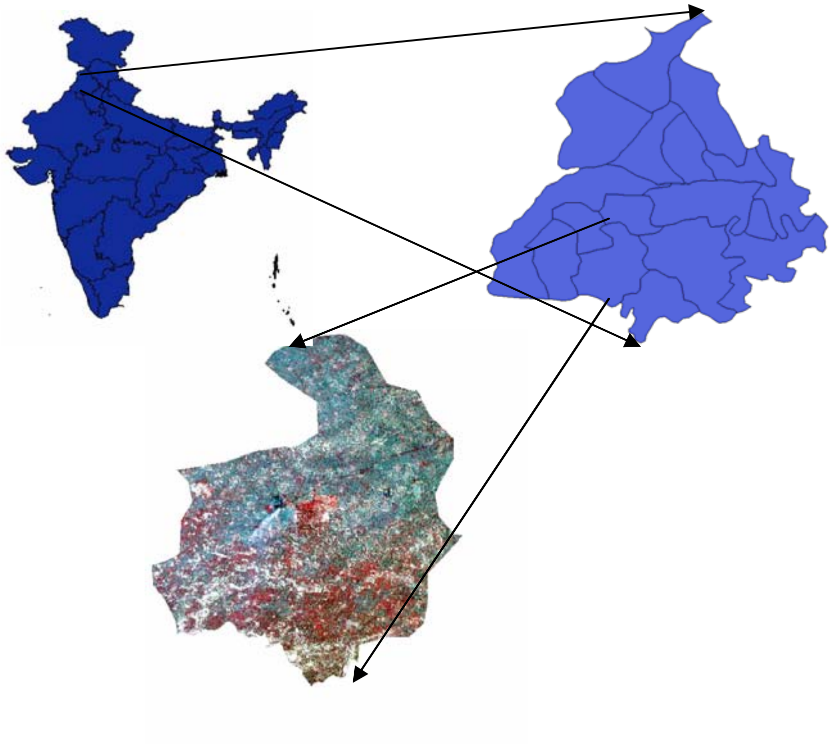

Figure.1. Study area showing genetically modified BT-Cotton area in satellite image as red patches.

Remote sensing has proven to be a powerful tool for assessing the identity, characteristics, and growth potential of most kinds of vegetative matter at several levels (from biomes to individual plants). Vegetation behavior depends on the nature of the vegetation itself, its interaction with solar radiation and other climate factors, and the availability of chemical nutrients and water between the host medium (usually soil or water in the marine environments). Because many remote sensing devices operate in the green, red and near infrared regions of the electromagnetic spectrum, they can discriminate radiation absorption and reflectance of vegetation.

The brightness or reflectance of vegetation varies across the electromagnetic spectrum Actively growing plants show a strong contrast between strong absorption in the red and high reflectance in the near-infrared regions of the spectrum. The amount of absorption in the red and reflectance in the near-infrared varies with both the type of vegetation and the vigor of the plants. When we look in the near-infrared region using color-infrared photography, which is just beyond what we can see with our eyes, actively growing plants are highly reflective because of the multiple scattering that takes place between the spongy-mesophyll cells of the plant.

Studies dealing with the regional level potential production are limited mainly because of the non-availability of the relevant data at appropriate scales and the analytical procedures to integrate the data. Satellite-based remote sensing data can provide the in-season spatial information on the extent and distribution of the crops. The information of the spatial distribution of crops as retrieved from satellite data is highly compatible for analysis in GIS environment, which can be incorporated into the crop models. The GIS facilitates the computation of regional level products by integrating the relevant factors in a spatial domain as well as temporal domain. Hence, it is envisaged in this study to integrate RS and GIS and crop models in a synergy to derive information on the potential production of cotton crop, which is useful in yield and yield gap analysis. Spectral reflectance data obtained from remote sensing is manifestation of integrated effect of weather, soil, cultural practices and crop characteristics can be used for identifying, monitoring and assessment. In India series of controlled ground experiments were conducted in different agro-climatic region and to understand the spectral behavior of variety of crops[7]. Identification of crop type using RS data requires understanding of the spectral behavior of crop in different level and influence spectral response. Such understanding of spectral response helps in interpretation of data collected by various sensors. Therefore, the cropping pattern to be studied, field size, and crop distribution determine the choice regarding the spatial resolution and time of acquisition of digital RS data. Coarser resolution data such as IRS-I D LISS III data with 23.5 m spatial resolutions is useful to identify vegetation. This can also be used in multi-cropped regions characterized by a small field size and scattered crop distribution. Satellite data should be acquired by large heterogeneity. The optimum acquisition period can be based on crop calendars of the area and information collected during pre-field surveys. Amongst above-mentioned parameters, field size is one of the most important influencing variables. Size of the field in relation to pixel size determines whether individual field can be resolved or not. Therefore pixels belonging to large proportion of fields are mixed pixels and reflectance of these depends upon the crop/ land cover proportion constituting a pixel[8].

Hybrid classification of image was performed using ERDAS (image processing software). The image was classified into several classes and the spectral signature not belonging to vegetation, crop or plantation was classed as zero. Thus we had only the classes from which we had to pick out the cotton cropped areas. When the image of November, 2006 was classified we got 18.44% of the total area as cotton based on the spectral reflectance of pixels (Figure.2) which accounted for about 5638.45 hectares . Since this is the time of cotton harvesting so in most of the area the crops were harvested. The areas which had sown the crop a little late were only seen with cotton crops. Some of the spectral signatures were mixed up with wheat or potato crops which were at seedling stage at the time of sampling. In September 2007 total cotton area calculated was 13704.74 ha comprising 44.82% of the study area (Figure. 3).

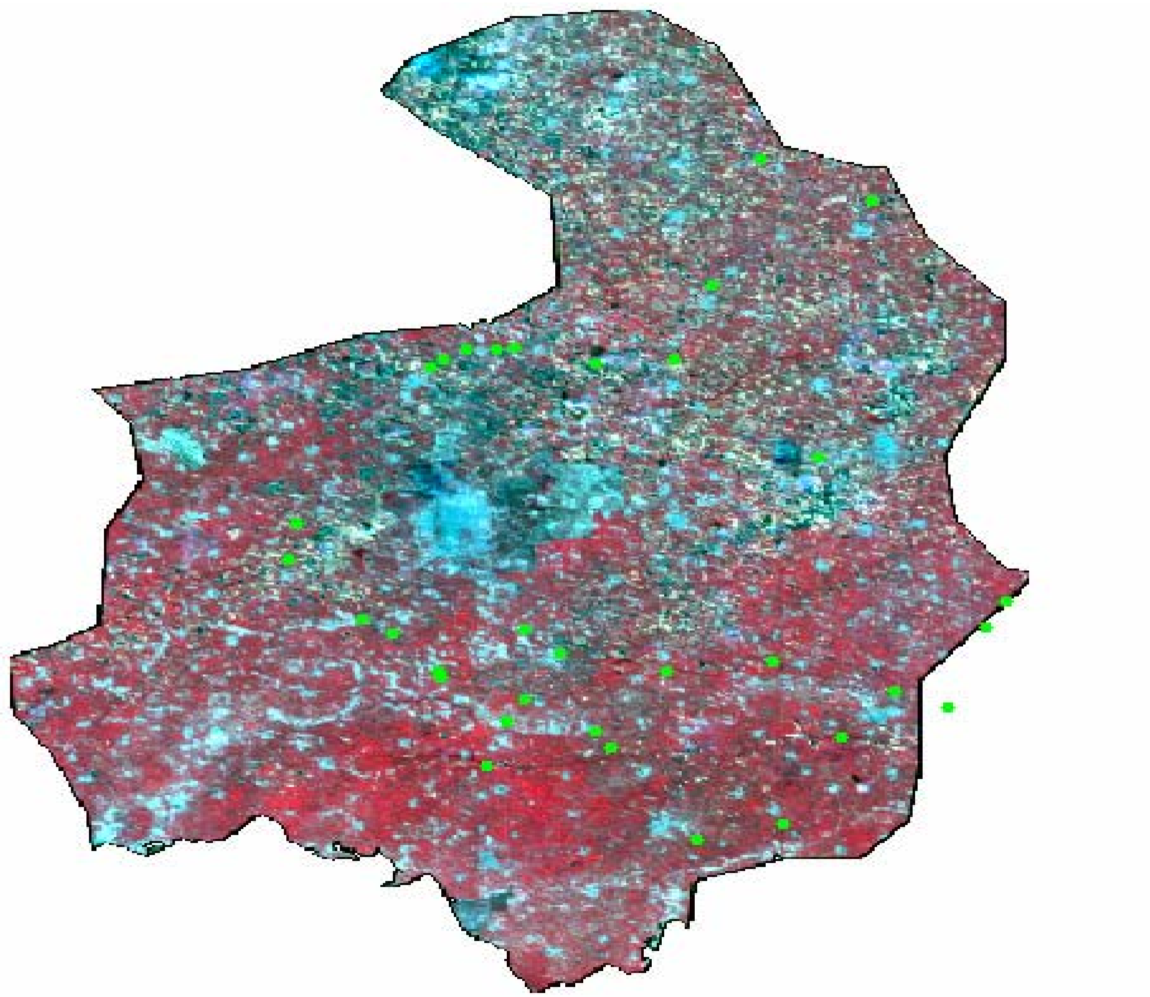

Figure.2. IRS-1D, LISS III satellite Image showing sampling points done in November 2006 (harvesting time of cotton) of Bhatinda, Punjab with GPS points.

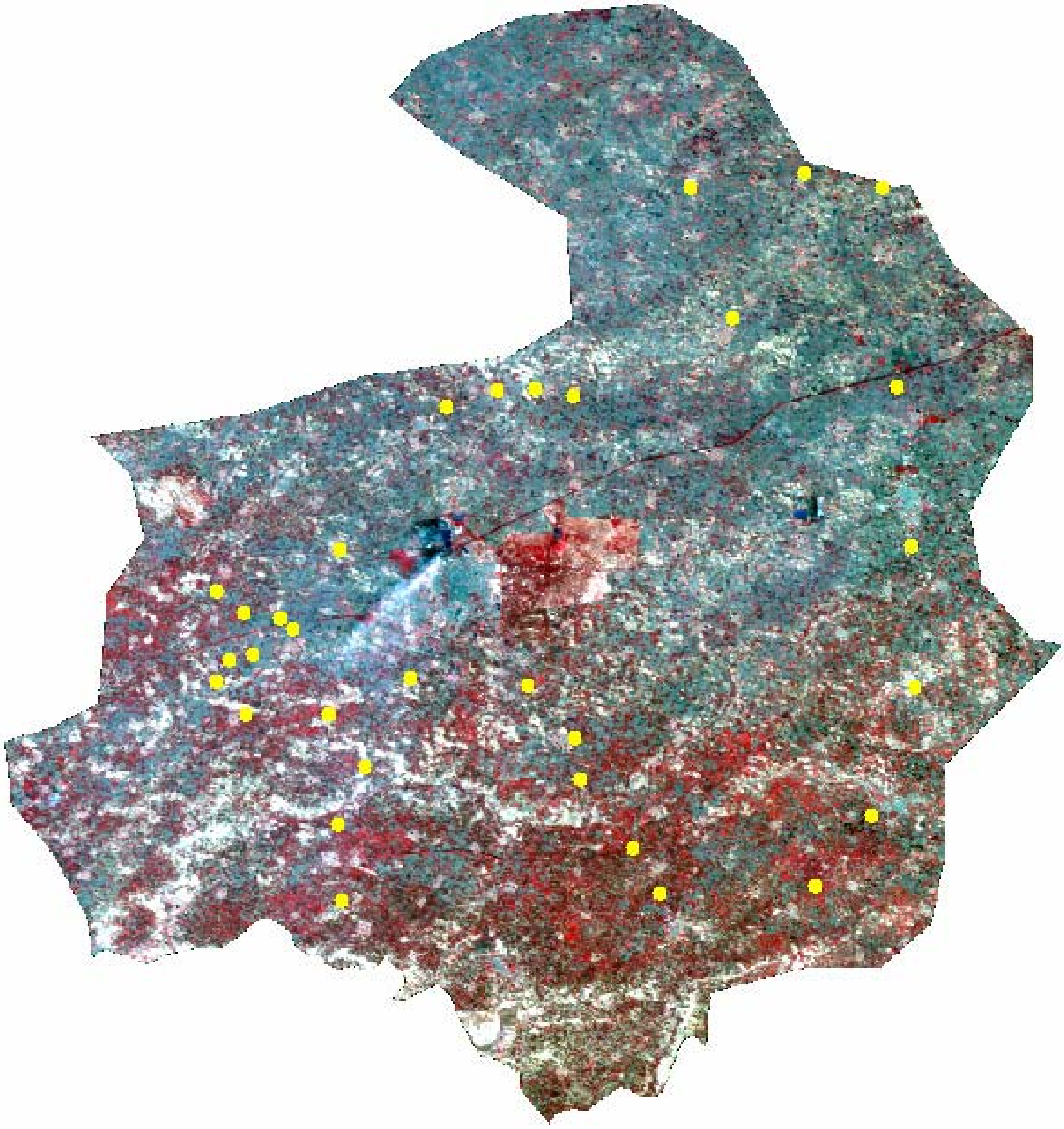

Figure 3. IRS-1D, LISS III satellite Image showing sampling points done in March 2007 (before sowing of cotton) of Bhatinda, Punjab with GPS points.

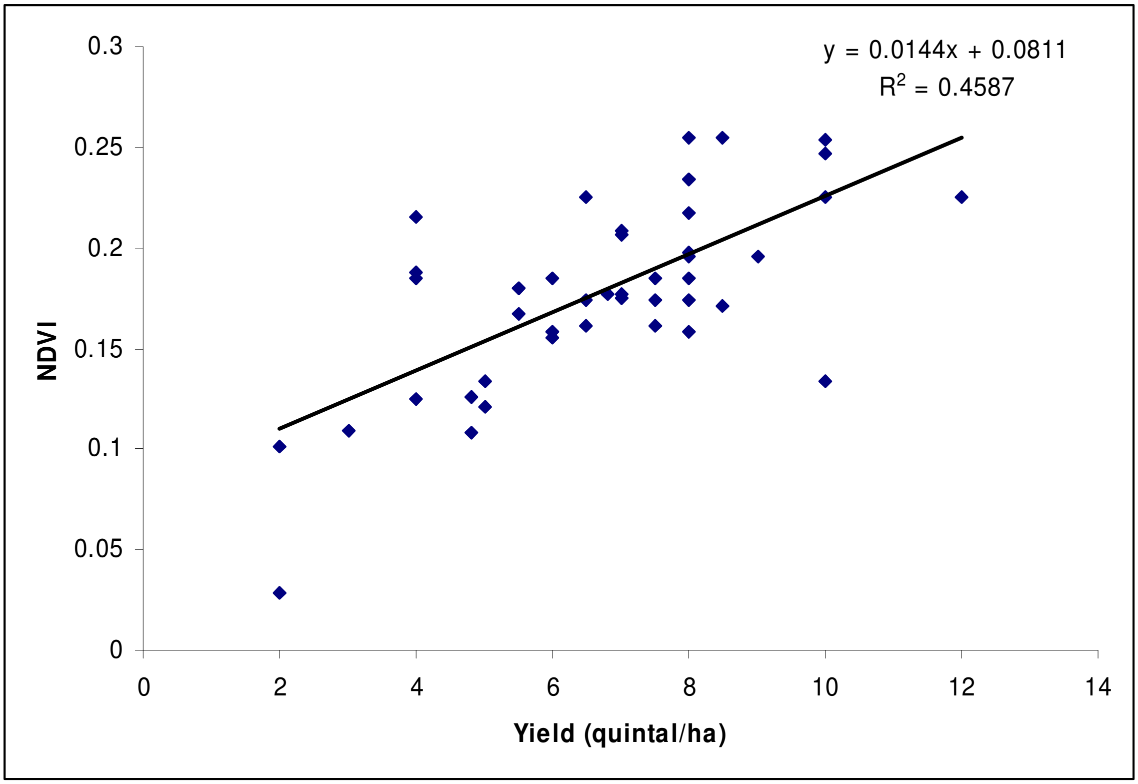

Figure.4.A regression analysis was performed to verify that how NDVI was able to predict the yield and it was found that a good correlation (0.697) existed between the NDVI yield and the R^2 value was also found to be very significant (0.4587).

Forecasting of anything refers to foresee the future scenario on the basis of present or past situations. Yield estimation of BT cotton deals with perception of the future activity of biotic agents which adversely affect crop production. The physical and genetic condition has tremendous influence on the yield and survival of BT cotton in Bhatinda, Punjab. Estimation of cotton has been done so far with weather and pest parameters. In Punjab the yield of cotton database shows that there were two peaks of month every year. The main peak was during March- April in which mix varieties of crop were there and the second peak was during October in which cotton was only the main crop.

Multispectral and multi-date satellite data were interpreted to develop a component for identification of location specific yield of BT cotton.

Normalized difference vegetation index (NDVI) for BT cotton was generated by using LISS-III sensor with spatial resolution of 23.5 meters. Ground-truthing was done on the specific anomalous location of NDVI data to correlate with soil texture, soil moisture and other pedological data including pH, TDS, EC, % TOC, Phosphorus and groundwater quality data.

NDVI values September, 2007 were attempted to correlate with other collateral data in GIS environment. A correlation matrix was also generated which shows that NDVI values of Bt cotton has reasonably acceptable correlation with TDS of soil and water. In geo-specific location of study area it was found out that if NDVI values of Bt cotton increases the TDS of soil as well as of water also increases.

References:

1. Mukherjee, S. (2004). Text Book of Environmental remote Sensing. Published by *Macmillan India Limited* New Delhi

2. Tucker, C. J., Townsend R. G., and Goff T. E. (1985). African landcover classification using satellite data. *Science,* **227**, 369–375.

3. Sys, E. Ir., Ranst E. van, and Debaveyl J. (1991). Land evaluation Part –I Principles in Land Evaluation and Crop Production Calculations. *Unpublished Report* 1-274 pp.

4. Arshad M. A., Martin S., "Identifying critical limits for soil quality indicators in agro-ecosystems." Agriculture, *Ecosystems and Environment*, **88**,153–160, 2002.

5.Burgheimera J., Wilskeb B., Maseykb K., Karnielia A., Zaayad E., Yakirb D., Kesselmeierc J.(2006). Relationships between Normalized Difference Vegetation Index (NDVI) and carbon fluxes of biologic soil crusts assessed by ground Measurements *Journal of Arid Environments* **64**, 651–669.

6. Srivastava, S. K., Jayaraman V., Nageswara P. P., Manikiam B., and Chandrasekhar M. G.(1997). Interlinkages of NOAA/AVHRR derived integrated NDVI to seasonal precipitation and transpiration in dry land Tropics. *Int. J. Remote Sens*., **18**, 2931–2952.

7. Vinnikov, K. Y., A. Robock, S. Velayutham, M., Mandal, D. K., Mandal, C. and Sehgal, J. (1999). Agroecological sub regions of India for Development and Planning, *NBSS Publ*. **35**, p. 452