Original Research Article

Spatial variability of Bt cotton on-farm situation (A Survey)

Abstract: There is lot of variation in the seed cotton yields among *Bt* cotton farmers across Upper Krishna project and Tunga Bhadra Project irrigation commands of the state. Soils cultivated and cultivars used though often remain same the difference in yield could be due to nutritional management, occurrence of leaf reddening or due to other factors or combination of many of these attributing characters.Since leaf health is the indicative of plant health and yield in turn, and leaf health could be assessed through leaf spectral reflectance viz, NDVI, SPAD, and LRI. Based on this a survey was undertaken during November 2015 at Raichur (in three taluks) and Yadgir (in four taluks) districts falling under TBP and UKP irrigation commands, respectively, taking in all 90 farmer. The spectral observations were made on standing field crop besides leaf samples were collected to estimate leaf anthocyanin in the laboratory and GIS mapping was done using ESRI made ArcGIS version 10.4 from Sujala-III, Remote Sensing and GIS laboratory, College of Agriculture, Raichur, was used to import GPS data and field data attachment for spatial analysis of leaf reddening incidence in cotton. The results on Spectral observations on NDVI, SPAD, leaf reddening index, reddening percentage in addition to leaf anthocyanin content varied due to locations, irrigation or otherwise, foliar spray, fertilization level, date of sowing and cultivars. Leaf chlorophyll content is an important biometric character, the content quality and duration (stability) indicates general crop health and ultimately yield directly if not influenced by rate and efficiency of translocation to sink (*kapas* yield in case of cotton), therefore, it is often used to monitor real time N fertilization (LCC, SPAD, Green Seeker) as well as to forecast crop condition and yield. Periodic spectral observations on SPAD and NDVI are the useful indicators of crop health and performance in commercial crop like cotton which could be extrapolated to filed scale for crop management and production forecast.

Key words: Bt cotton, SSNM and RDF

Introduction: Cotton (Gossypium spp.), 'the king of fibers' also popularly known as 'the white gold' enjoys a pre-eminent position amongst cash crops in the world and in India as well. In India, the crop is cultivated in 10.50 m ha with a production of 35.10 million bales of seed cotton

Comment [NMS@AR1]: 1.Incomplete abstract. 2.In the abstract must include the research problem, research objectives, case study, respondents & methodology of research.

Comment [NMS@AR2]: 1. To short. Not appropriate to explain about the introduction for this research.

2.What is the objective of this research?

(2016-2017), and the country is very close in production to China ranking first in the world. Average productivity of cotton in India, however, is low (568 kg lint ha-1) when compared to the world average (725 kg lint ha^{-1}) (CAB, 2016) or the leading producers namely, Australia (1781 kg ha^{-1}), China (1719 kg ha^{-1}), Brazil (1522 kg ha^{-1}), the USA (974 kg ha^{-1}) and Pakistan (699 kg ha^{-1}).

Material and Methods: Since leaf health is the indicative of plant health and yield in turn, and leaf health could be assessed through leaf spectral reflectance viz, NDVI, SPAD, and LRI. Based on this a survey was undertaken during November 2015 at Raichur (in three taluks) and Yadgir (in four taluks) districts falling under TBP and UKP irrigation commands, respectively, taking in all 90 farmer. The spectral observations were made on standing field crop besides leaf samples were collected to estimate leaf anthocyanin in the laboratory. A questionnaire was prepared for collecting details of farmers and their production practices of surveyed farmers are presented. The means values are presented along with correlations between spectral observation and yield.Geographical Information System (GIS):ESRI made ArcGIS version 10.4 from Sujala-III, Remote Sensing and GIS laboratory, College of Agriculture, Raichur, was used to import GPS data and field data attachment for spatial analysis of leaf reddening incidence in cotton. Global Positioning System (GPS)**:** Trimble made Juno SB handheld GPS was used to collect latitude and longitude of the sampling point. The Juno SB GPS is capable of receiving GNSS (Global Navigation Satellite System) signals. The care was taken to record latitude and longitude when the PDOP (Positional Dilution of Precision) value was less than 3 to achieve better accuracy.

Results and Discussion:

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The survey was carried out during November 2015 in selected cotton fields of seven villages *viz.*,Kalmala, Jagir Venkatapur and Ijapur of Raichur district and Gogi, Ulalkal, Hothpet and Maddarki villages of Yadgir districts covering part of TBP and UKP irrigation commands, respectively. The villages were selected based on the predominance of cotton area. Farmers plots were visited and location were recorded using GPS and observations were made on management practices, leaf reddening incidence and per cent leaf reddening, NDVI values, chlorophyll content, anthocyanin content and seed cotton yield. The spatial variability maps were generated using “krigging”, and interpolation method under GIS environment using observations on spatial spectral variability in NDVI, SPAD (chlorophyll content), anthocyanin content, leaf reddening index, reddening percentage and seed cotton as influenced by irrigation ecosystem, soil type and

foliar spray of 19:19:19, date of sowing and cultivars. The data was further subjected for correlation studies. The results are presented here.

The survey data on spectral observations (NDVI, SPAD, LRI and reddening percentage) and leaf anthocyanin revealed variability between the irrigation commands across villages, among villages in the individual commands, between irrigated and rainfed culture and soil types (black soil and red soil), foliar spray (19:19:19), cultivars used (17 cultivars), rate of fertilizer nutrient (N, P and K) application and dates of planting (Table 1 and 2). Between the irrigation commands, NDVI, SPAD and LRI values were relatively higher in UKP irrigation command (0.64, 36.7 and 2.12, respectively) compared to TBP irrigation command (0.61, 34.5 and 2.07, respectively). Leaf anthocyanin was also lower (0.14 mg g^{-1} fresh weight) in UKP command compared to TBP irrigation command. This was also reflected in leaf reddening index. Consequent upon which, average seed cotton yield was higher in UKP command compared to TBP (2980 kg ha^{-1} and 2683 kg ha^{-1}, respectively).

Among the villages, Kalmala fared better in TBP irrigation command and Hothpet fared better in UKP command. Further, across the irrigation commands, irrigated culture fared better with higher NDVI and SPAD values, and lower anthocyanin content, LRI and reddening percentage and consequently higher yield (0.66, 37.7, 0.13 mg g^{-1} fresh weight, 2.00, 21.79 and 3056 kg ha^{-1}, respectively). Yield also revealed wide range in irrigated culture. Between the soils, black soils fared better with higher spectral indices, and lower leaf anthocyanin contents and lower leaf reddening index and reddening percentage which resulted in higher seed cotton yield in black soil (0.63, 35.8, 0.15 mg g^{-1} fresh weight, 2.04, 22.39 and 2804 kg ha^{-1},respectively) compared to red soil (0.55, 33.01, 0.14 mg g^{-1} fresh weight, 2.49, 25.65 and 2348 kg ha^{-1},respectively). Foliar spray had a appreciable influence wherein spray of 19:19:19 soluble fertilizer at 1% resulted in higher NDVI and SPAD values, and lower leaf anthocyanin, leaf reddening index and reddening percentage (0.66, 37.3, 0.14 mg g^{-1} fresh weight, 1.99 and 21.47,respectively) which resulted in higher kapas yield (3068 kg ha^{-1}) over no spray; control.

Leaf chlorophyll content is an important biometric character, the content quality and duration (stability) indicates general crop health and ultimately yield directly if not influenced by rate and efficiency of translocation to sink (*kapas* yield in case of cotton), therefore, it is often used to monitor real time N fertilization (LCC, SPAD, Green Seeker) as well as to forecast crop condition and yield.Being constituent of chlorophyll N content can be directly related to

chlorophyll content of the leaf, so also balance among P, K, Mg, and Zn etc. in the leaf. In the study, spatial spectral observation *viz.*, SPAD readings and NDVI were considered for the purpose. SPAD Chlorophyll is a simpler and non destructive tool for relative contents of chlorophyll that is directly proportional to leaf nitrogen (Markwell, 1995). Similarly NDVI is the measure of light reflectance in the visible reason spectrum (400-700 mm) depending primarily on chlorophyll concentration and hence it is also used as on non destructive indicator of plant health and productivity (Rou *et al*., 2005). Therefore, NDVI and SPAD were recorded. Correlation studies indicated positive and significant relation between them, and both with yield.

From above the results, study reveals usefulness of spectral vegetation indices at critical stages (flowering to boll development) for crop health and yield assessment in cotton. Similarly, earlier Chandrashekar *et al*. (2016), Potdar (2016) and Chetan and Potdar (2016) revealed possibility of use of spectral indices for crop health assessment and yield forecast in sugar cane, pigeon pea and maize, respectively. Chetan and Potdar (2016) also indicated that spectral indices namely SPAD at 55 DAS and NDVI at 60 DAS are the best indices for crop health and yield predication. Further, these indices being non-distractive could also be obtained from satellite imagery and on ground truthing would facilitate precision agriculture on large scale, and quality decisions by policy makers could be accomplished effectively as well.

References:

Chandrashekara, C. P., Potdar, M. P. and Chittapur, B. M., 2016, Remote sensing and GIS application for crop condition assessment and yield forecasting. In: Chittapur, B. M., Halepyati, A. S., Umesh, M. R. and Desai, B. K. (Eds.) *Climate Smart Agriculture: Status and Strategies*, University of Agricultural Sciences, Raichur, Karnataka, pp. 218-231.

Chetan, H. T. and Potdar, M. P., 2016, Yield prediction models in maize using SPAD and NDVI. *Res,Enviro. Life Sci.*, 9(8): 1002-1004 (http://rels.comxa.com).

Markwell, J., Oaterman, J. C. and Mitchell, J. L., 1995, Calibration of the Minolta SPAD-502 leaf chlorophyll meter. *Photosynthesis Research*, 46: 467-472.

Raun, W.R., Solie, J.B., Stone, K.K. and Johnson,V., 2005, optical sensor based algorithm for crop nitrogen fertilization. communications in soil science and plant analysis., 36:2759-271.

Comment [NMS@AR4]: 1.Make sure the listed references are also mention in the text and the references in the text are also listed at the list of references.

2.Only 4 references is not enough and the references is not the latest references.

3.Refer to the 5 years latest references.

Table 1. Spatial variation of spectral reflectance, leaf reddening, chlorophyll content, NDVI values, Anthocyanin content and cotton yield (kg ha^{-1})

Comment [NMS@AR5]: All tables & figures placed in the text after you mention about it.

Name of village		LRI	SPAD chlorophyll	NDVI	Anthocyanin Content	Cotton yield
		TBP irrigation command				
Kalmala	TBP commands	1.35	41.9	0.79	0.13	3916
Jagir Venkatapur		2.21	30.3	0.54	0.16	2041
Ijapur		2.66	31.3	0.5	0.17	2093
AVERAGE		**2.07**	**34.51**	**0.61**	**0.15**	**2683**
		UKP irrigation command				
Gogi	UKP command	1.94	36.8	0.66	0.15	2780
Hothpet		2.04	37.4	0.68	0.13	3414
Ulkal		2.05	37.2	0.64	0.15	2866
Maddarki		2.43	35.2	0.57	0.13	2858
AVERAGE		**2.12**	**36.7**	**0.64**	**0.14**	**2980**

Table 2. Data on farmers field about average chlorophyll content, NDVI values, anthocyanin content, leaf reddening index, reddening percentage and seed cotton yield of cotton influenced by irrigation ecosystem, soil type and foliar spray of 19:19:19 during flowering to boll bursting stage

	Chlorophyll content	NDVI	Anthocyanin content	Leaf reddening index	Reddening percentage (Visual)	Yield (kg/ha)
Irrigated	37.7 (21.2-49.7)*	0.66 (0.24-0.94)*	0.13 (0.19-0.08)*	2.00 (0.7-3.6)*	21.79 (10-35)*	3056 (1200-4800)*
Rainfed	30.8 (24.3-40.8)*	0.52 (0.41-0.71)*	0.16 (0.12-0.19)*	2.41 (1.6-3.0)*	25.59 (20-30)*	2081 1200-3400*
Black	35.8 (21.2-49.7)*	0.63 (0.24-0.94)*	0.14 (0.08-0.19)*	2.04 (0.7-3.6)*	22.39 (10-35)*	2804 (1200-4800)*
Red	33.01 (28.2-48.3)*	0.55 (0.34-0.93)*	0.15 (0.08-0.19)*	2.49 (0.8-3.1)*	25.65 (10-30)*	2348 (1200-4700)*
19:19:19	37.23 26.45-49.7*	0.66 0.42-0.93*	0.14 0.08-0.19*	1.99 0.7-3.1*	21.47 10-30*	3068 1200-4800*
Without spray	31.2 21.2-47.0*	0.52 0.24-0.84*	0.15 0.11-0.18*	2.42 0.9-3.6*	26.13 10-35*	2170 1200-4200*

***range**

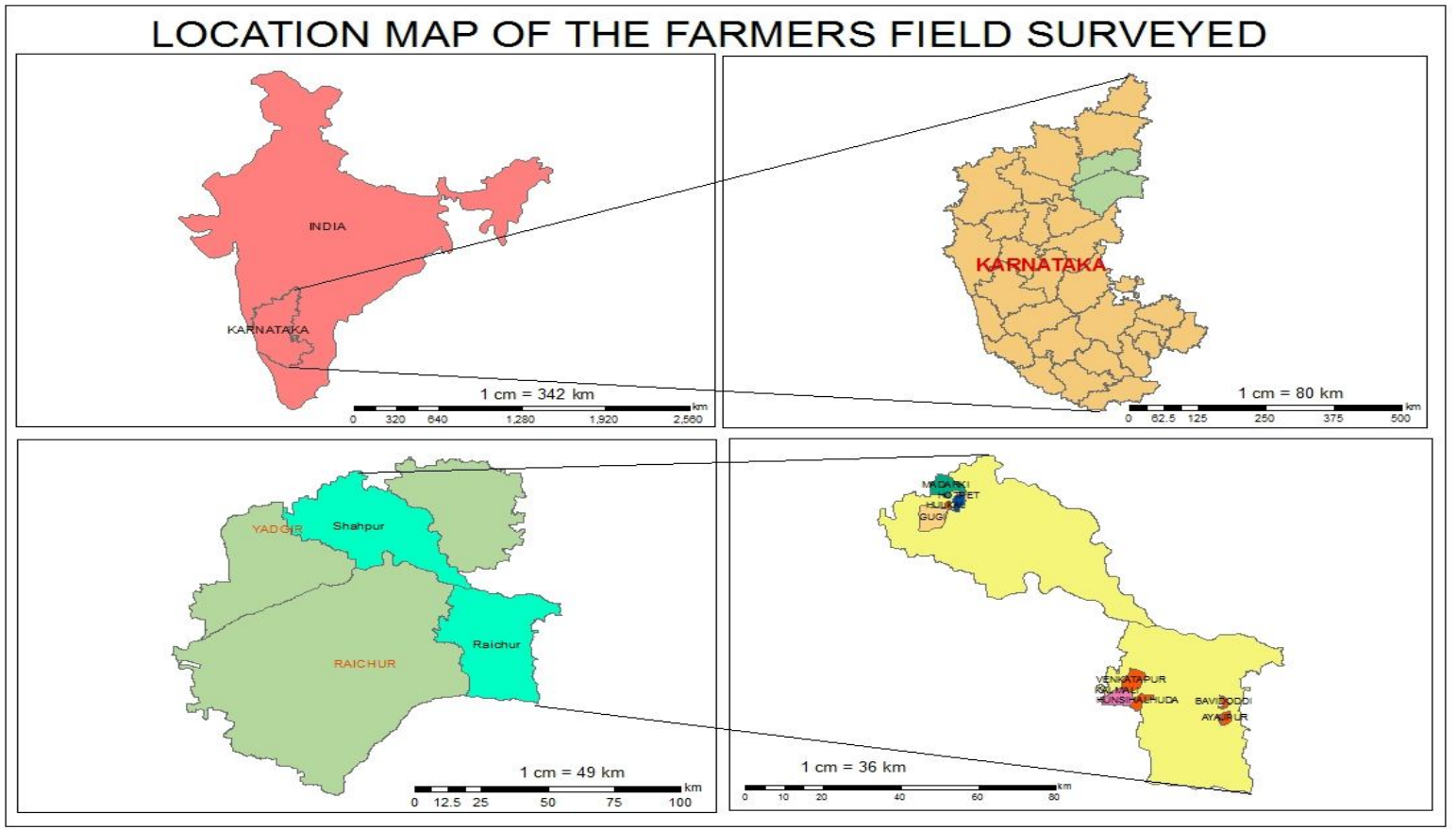

Fig. 1: Location map of the survey area

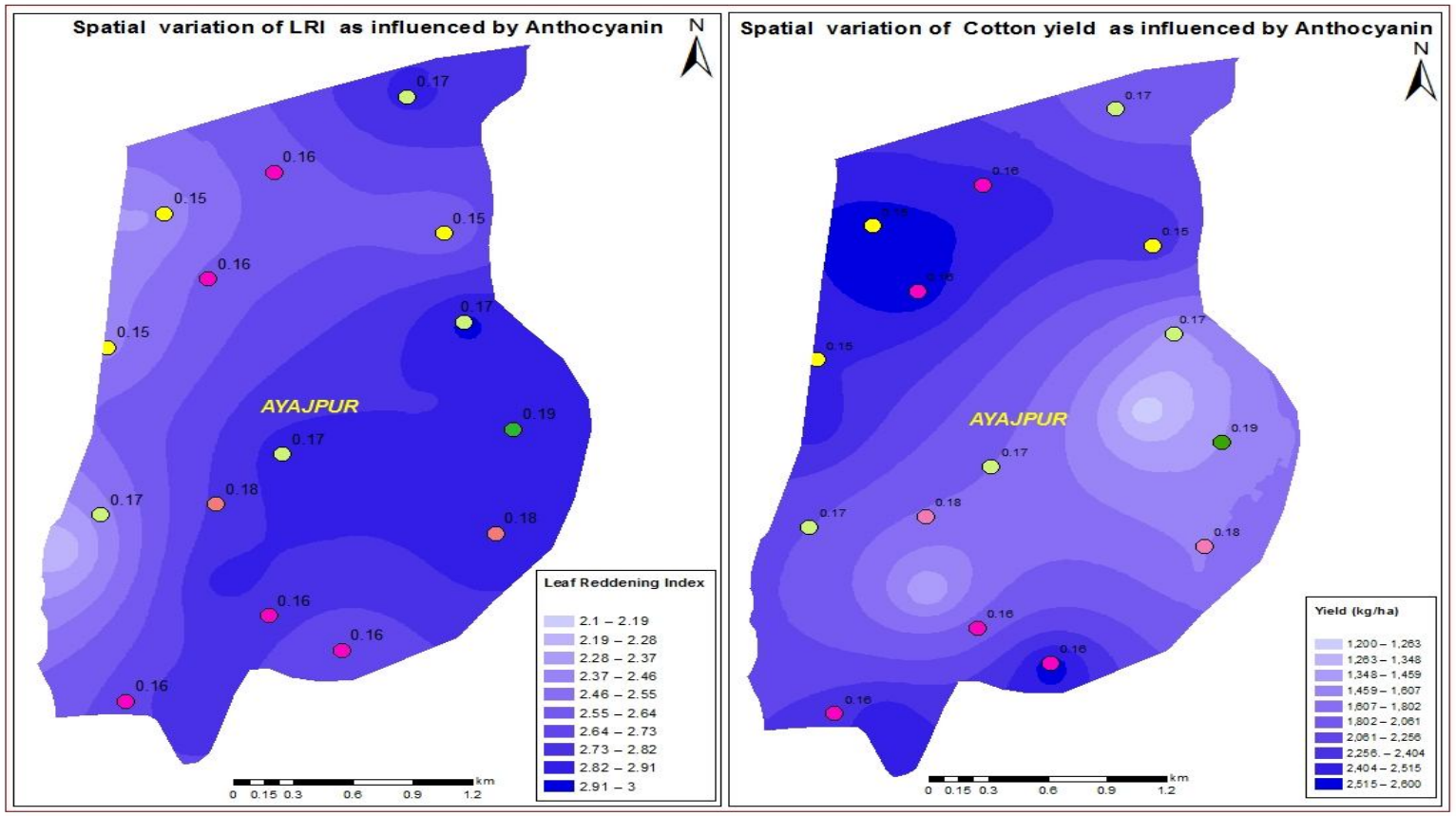

Fig. 2: Spatial variation of leaf reddening index and cotton yield with respect to anthocyanin content at Ayajpur village

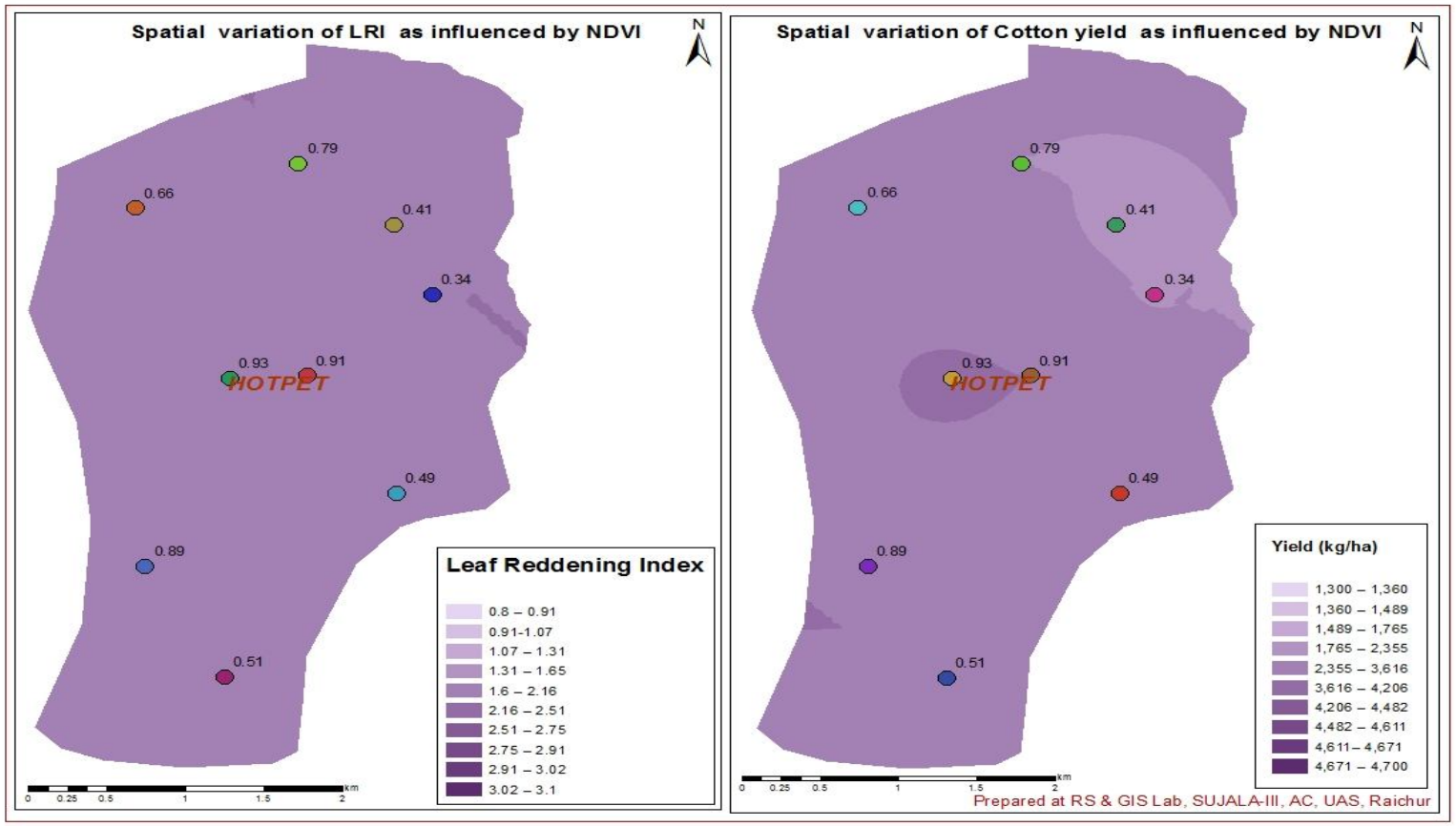

Fig. 3: Spatial variation of leaf reddening index and cotton yield with respect to NDVI values at Hothpet village

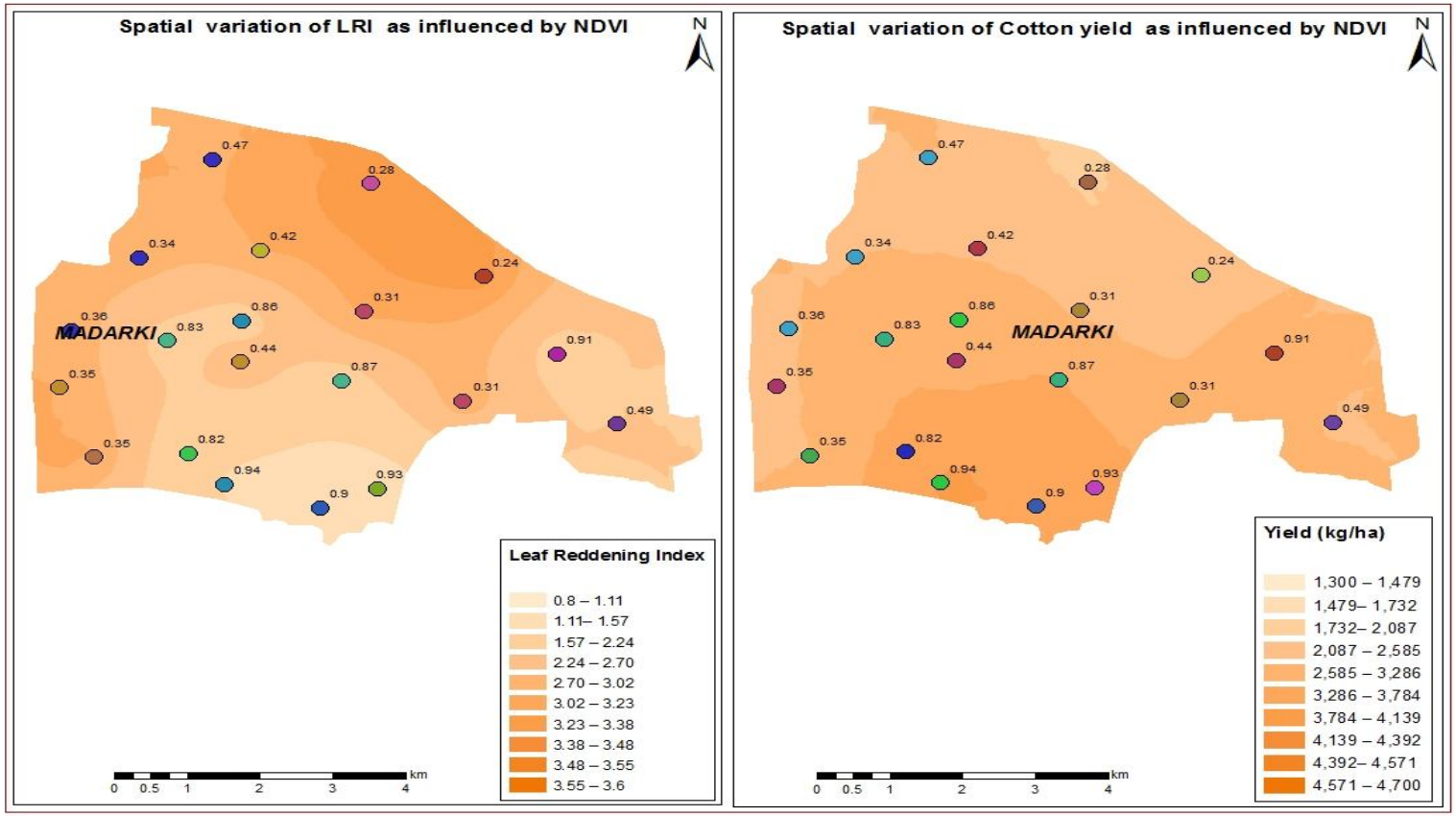

Fig. 4: Spatial variation of leaf reddening index and cotton yield with respect to NDVI values at Maddarki village

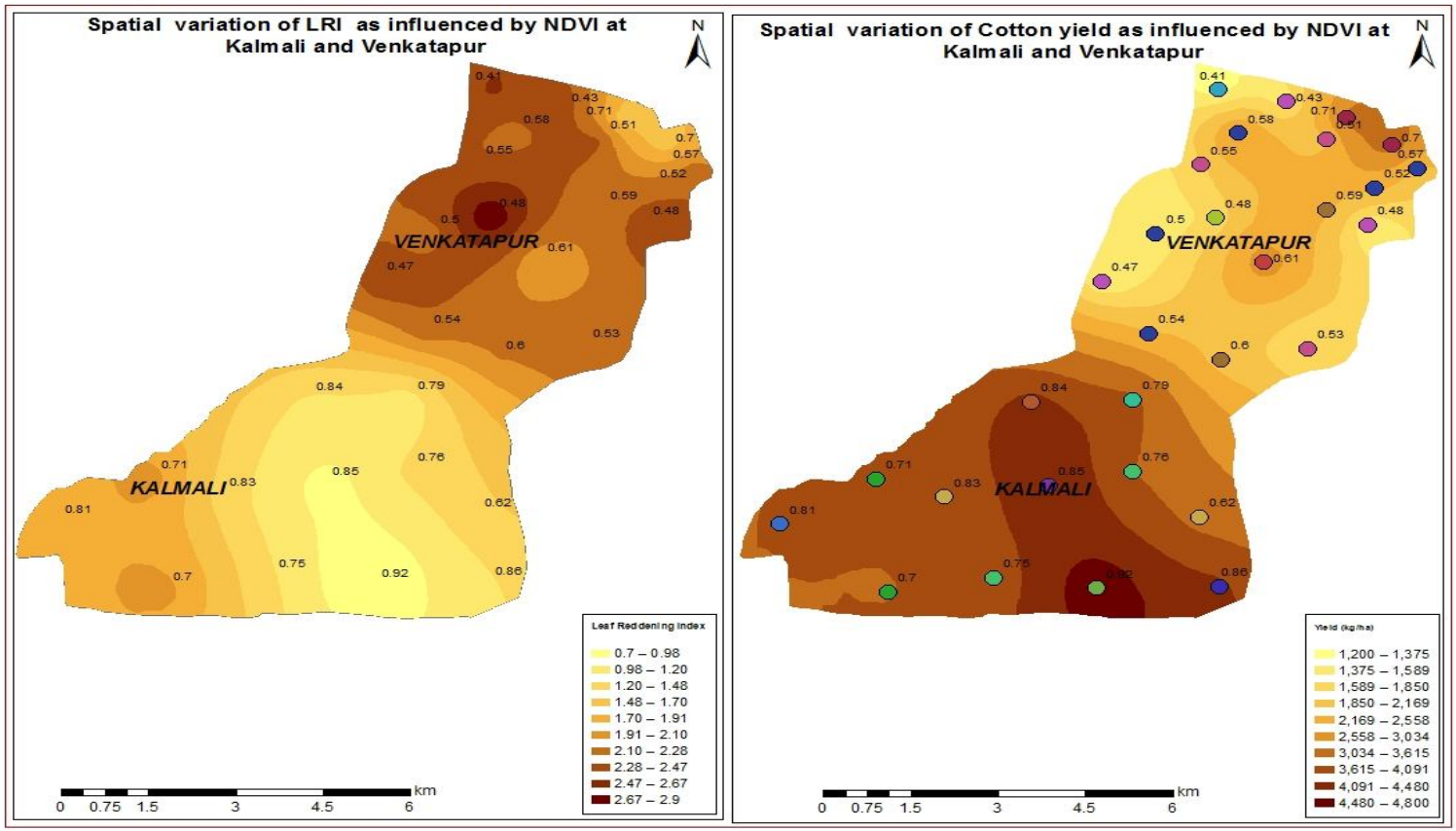

Fig. 5: Spatial variation of leaf reddening index and cotton yield with respect to NDVI values at Kalmala and Venkatapur village

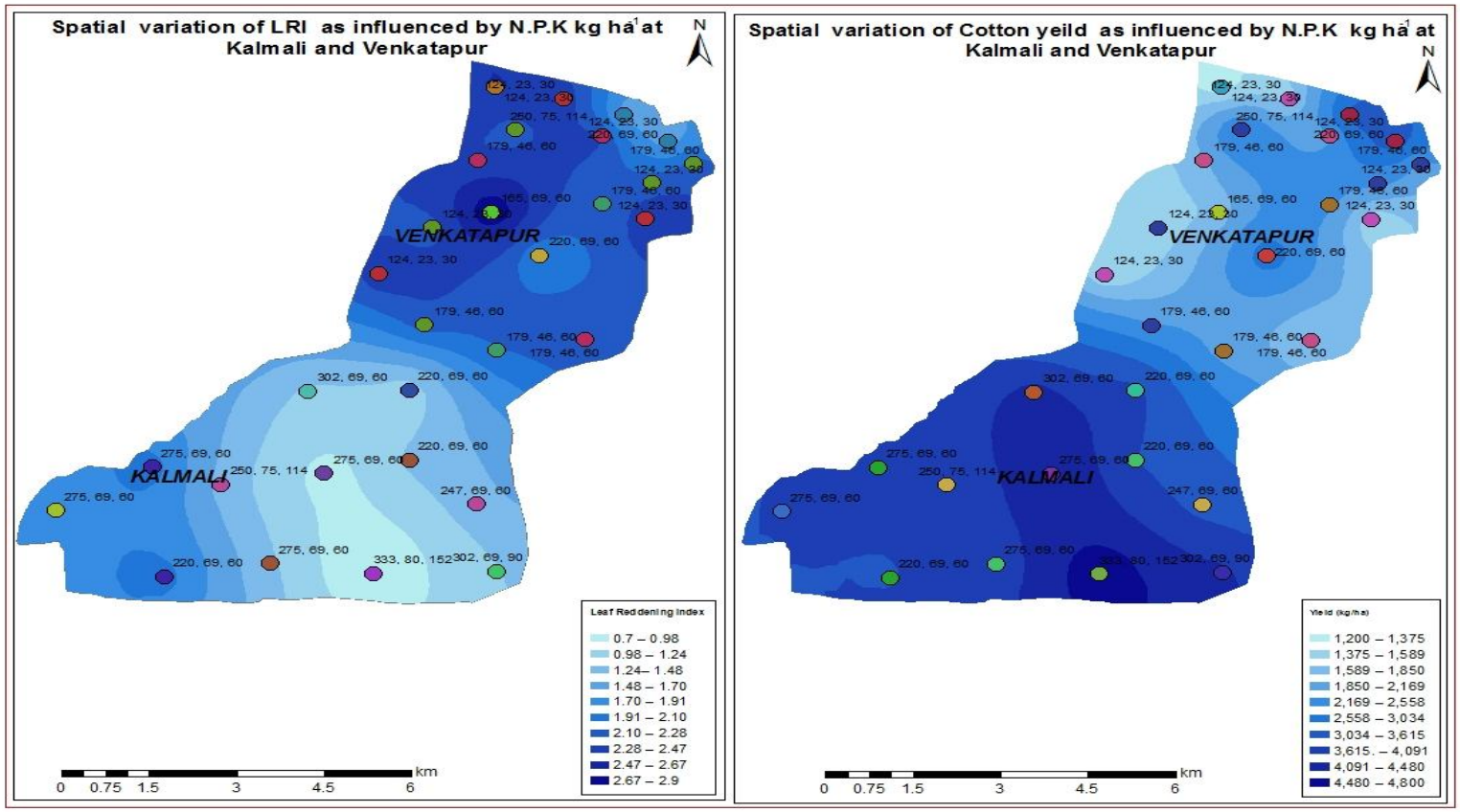

Fig. 6: Spatial variation of leaf reddening index and cotton yield with respect to fertilizer levels at Kalmala and Venkatapur village