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Visual Discrimination of Surface features of Salt affected soils Using Satellite Images in Arid region of Rajasthan (India)

D C JOSHI*, TIBOR TÓTH** AND DIANA SÁRI***
*Central Arid Zone Research Institute, Jodhpur-342003, India
**Research Institute for Soil Science and Agricultural Chemistry (RISSAC), Budapest, Hungary
***Szent István University, Budapest, Hungary

ABSTRACT

The study has been carried for visual discrimination of natural salt affected soils on FCC images of IRS 1 B in Pali district of Rajasthan. The salt affected soils show wide variations in salinity ($EC_{2.5}$ 3.7 to 28 dSm^{-1}), alkalinity (pH 8.5-9.8), cover of *P. juliflora* (10-90%), salt tolerant grasses (10-55%) and gravelly surface (20-35%). Though *P. juliflora* and grasses were present at most of the observation points their cover decreased with soil $EC_{2.5}$ values more than 10 and 13 dSm^{-1}, respectively. Five darkness categories derived as the result of visual interpretation of FCCs; and ground and laboratory studies revealed that the darkness category 1 represented fewer plant community with high salinity (EC 28.7 dSm^{-1}) and gravelly surface, categories 2 and 3 were characterised by grass cover and moderate salt affected soils (EC 3-10 dSm^{-1}) whereas category 4 was dominated by thicket of *P. juliflora*. The derived numerical darkness categories of the FCC images were slightly low for February images. The darkness values of observation pixel on February images correlated positively with *P. juliflora* cover and negatively with grass cover and soil pH indicating that surface features on FCC were related with the immediate observation pixels.

Introduction

Natural salt affected soils widely occur in the arid and semi arid regions of India and a close soil-vegetation relationship, particularly with respect to salt affected soils have been reported (Sankar and Kumar, 1988, Singh *et al.*, 2000). Classification and accurate delineation of the salt affected soils on satellite imageries is often difficult because these salt affected soils are generally associated with gravelly surface, thickets of *Prosopis juliflora* and salt tolerant grasses. In the great Hungarian plain relationship between vegetation cover and the sodium concentration in the solonetz grassland has been observed (Várallyay, 1989; Toth and Rajkai,

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1994) and this relationship has been utilised to create a sampling design by using satellite image (Tóth and Kertész, 1996). In Indian arid zone, Kalra and Joshi (1994, 1996) have reported moderate white and white tone with occasional reddish mottles on the FCC imageries of salt affected soils. Spectral characteristics of multi-date and multi-season images have been used (Dwivedi *et al.*, 1987; Joshi *et al.*, 2000) for mapping natural salt affected soils. But contribution of features associated with salt affected soils has not been investigated. Therefore, study has been taken to assess the contribution of soil salinity and associated surface features on characteristics on satellite images in arid region of Rajasthan.

Study Area

The study area is located in Pali district of Rajasthan near villages Bhambolai and Bhalelao between 25°50' to 25°55' N and 73°20' to 73°25' E. The salt affected area occurs in micro-depression, intercepted by ephemeral streams and gravelly surface surrounded by stony/ gravelly upland. The soils are light grayish brown, sandy loam, 30-50 cm deep underlain by lime concretionary horizon. The surface is covered with the thicket of *P. juliflora.* This bush is associated with few grass species, such as *Aeluropus lagopoides*, *Sporobolus marginatus.* The climate is arid with 400-450 mm mean annual rainfall.

Methodology

The natural salt affected land covering several square km was located on the FCC images of Indian Remote Sensing Satellite (IRS 1-B), Path-032 and Row-50, geocoded, 1:50,000 scale, October 27, 1992 and February 14, 1993, and used for field traverses during November, 1999 in conjunction with Survey of India topographic maps of the same scale. The satellite imagery was visually interpreted and classified in five darkness categories. Along two transacts (Fig. 1) sampling point were taken at 65 m interval, and observations recorded for percent cover of *P. juliflora*, grasses, bare ground and gravelly surface. Transact points were classified to fall into one of the above five categories. These observations were estimated for 100 m x 100 m neighbourhood of the sampling. At each point electrical conductivity (ECa) was measured by using a four-electrode probe (Rhoades, 1991). From the same spot, soil samples (0-10 cm depth) were collected. The pH and electrical conductivity of the soil samples were measured in 1: 2.5 soil water suspension ($EC_{2.5}$) in the laboratory (Richards, 1954).

During transacts proper only three categories namely 2-yellow, 3-pale pink, 4-pinkish orange were encountered. This categorisation was made for immediate vicinity of the soil sampling point (One pixel) and also for 100 m x100 m neighbourhood of the point (Nine pixels) for October and February images and these were designated respectively, as OCTone and OCTnine and FEBone and FEBnine.

Results and Discussion

The surface cover and the salinity alkalinity parameters were recorded for thirty-six transacts point. The gravelly area was encountered at five points covering 20 to 35 % area at each point. High salinity was encountered at eight points with the $EC_{2.5}$ ranging from 3.74 to 28.4 dSm^{-1}. Soil pH was highly alkaline (8.5-9.9) at 26 points out of total 37 points. *Prosopis Juliflora* cover occupied 15 to 45 % area at each of the 34 points out of 37 points. The grass cover occupied 10 to 60 % area at 32 points. On highly saline and bare crusted sites the grass cover was negligible. The relationship of vegetation cover with salinity (Fig. 2) revealed that the cover of grass and *P. juliflora* started declining with increase in salinity. The grass cover (40-50%) between EC 3.7-13 dSm^{-1} decreased to <10 % at EC 28.7 dSm^{-1}. The cover of *P. juliflora* (30-80%) at EC 3.7 to 10 dSm^{-1} decreased to 15 % at EC 28.7 dSm^{-1}. The cover of *P. juliflora* and grass was higher (20-60 %) between pH 8.2 to 9 which is found to decrease (10-20%) with soils having pH between 9 and 10 (Fig. 3). The cover of

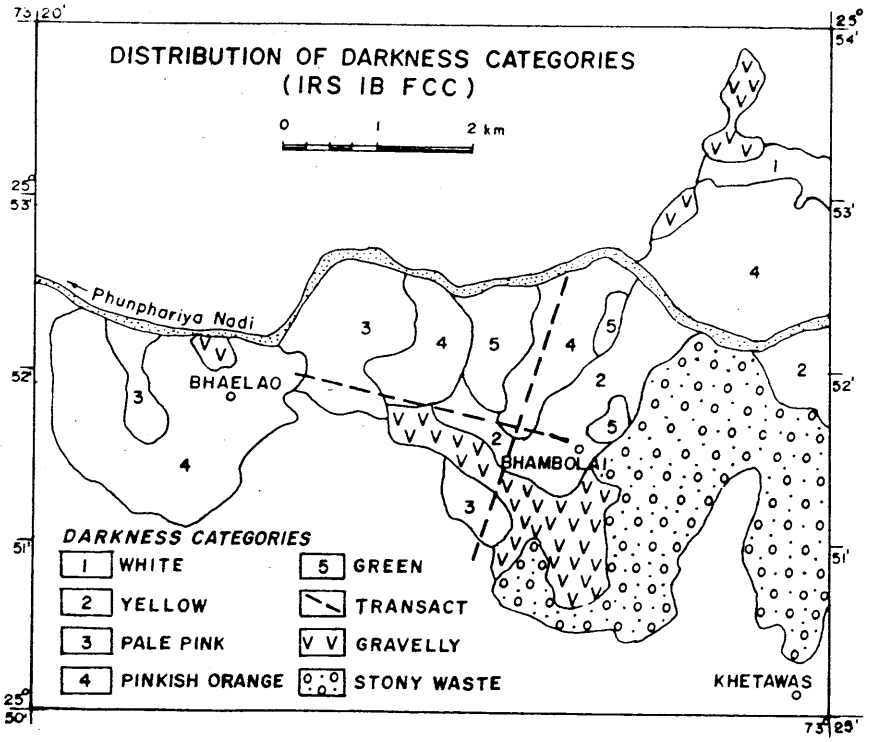

Fig. 1. Location of study site indicating traveses and darkness categories.

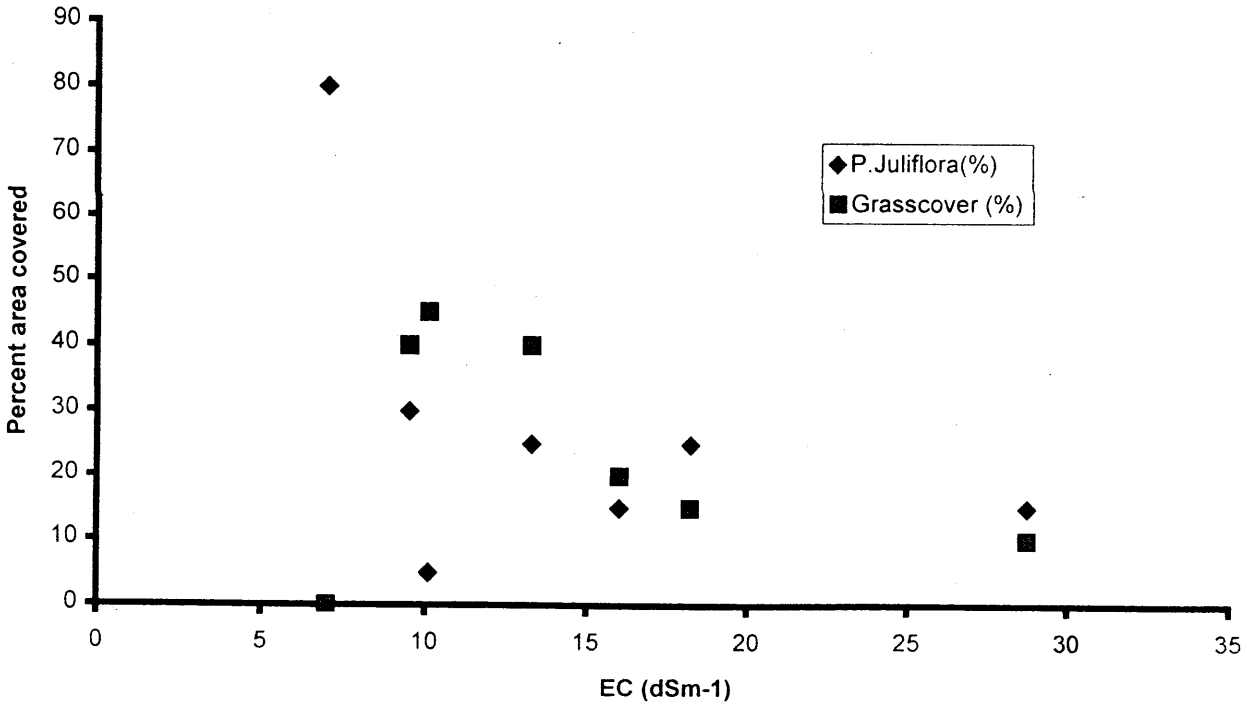

Fig. 2. Relationship of vegetation cover with soil salinity.

P.juliflora was positively significantly related (P=0.05) with grass cover (r=0.461) and bare crusted area (r=0.511). The grass cover was negatively related (P=0.01) with soil ECa (r = -0.570) and the gravelly area with $EC_{2.5}$ (r= -0.856) indicating that on highly salt affected and gravelly area the grass cover is low.

Studies with FCCs

Based on ground observation and laboratory analysis interpretation key was developed (Table 1).

Table 1: Interpretation key for darkness categories and the surface features

Darkness category	*Image characteristics*	*Ground features*
1	White (least dark)	Highly saline ($EC_{2.5}$ >10 dSm^{-1})/ gravelly surface
2	Yellow	Moderately saline ($EC_{2.5}$ 3-10 dSm^{-1})/ high alkalinity (pH >8.5)/ grass cover
3	pale pink	Moderately saline ($EC_{2.5}$ 3-10 dSm^{-1})/ high alkalinity (pH >8.5)/ occasional *P. juliflora*
4	pinkish orange	Thicket of *P. juliflora*/ high salinity/ alkalinity
5	green (darkest)	Dried water bodies

For each sampling point the darkness category as per the key was inferred for October and February images. The mean values of numerical darkness categories and the statistics of observations on immediate vicinity of the sampling point (one pixel) and for 100 m x 100 m neighbourhood point (nine pixels) for the months of February (2.97 and 2.92) and October (3.17 and 2.75) indicate that the darkness values were slightly low for February images. This finding supported the use of the same numerical darkness categories for the two images. However, in both the cases, the coefficients of variation (20.7 to 26) were quite small. The value of numerical darkness category of the pixels at observation point on the February FCCs were significantly correlated (P=0.01) to value of numerical darkness category on the neighbourhood pixels of February (r=0.545) and October (r=0.414). On October FCC the numerical darkness values of observation pixel was significantly related with the darkness values of neighbourhood pixel (r=0.666). However the value of numerical darkness category of observation pixel on October imageries had weak correlation with the numerical darkness values of the observation pixel and neighbourhood pixels on the February FCC.

Darkness categories vs. surface features

Values of numerical darkness categories of observation pixels on February image were significantly correlated positively with cover of *P. juliflora* (r=0.469, P=0.05) and negatively with soil pH (r= -0.478, P=0.05) and grass cover (r= -0.405, P=0.1). But such correlation was not observed for the neighbourhood pixels. Similarly the value of numerical darkness categories of the observation pixels on October FCC were related negatively with pH (r= -0.70, P=0.01) and bare surface (r= -0.403, P=0.1) and positively with gravelly surface (r=0.521, P=0.01). The value of numerical darkness categories of neighbourhood pixels on October FCC images were positively related to gravelly surface. Thus it could be inferred that the surface properties affecting reflectance were more closely related to the

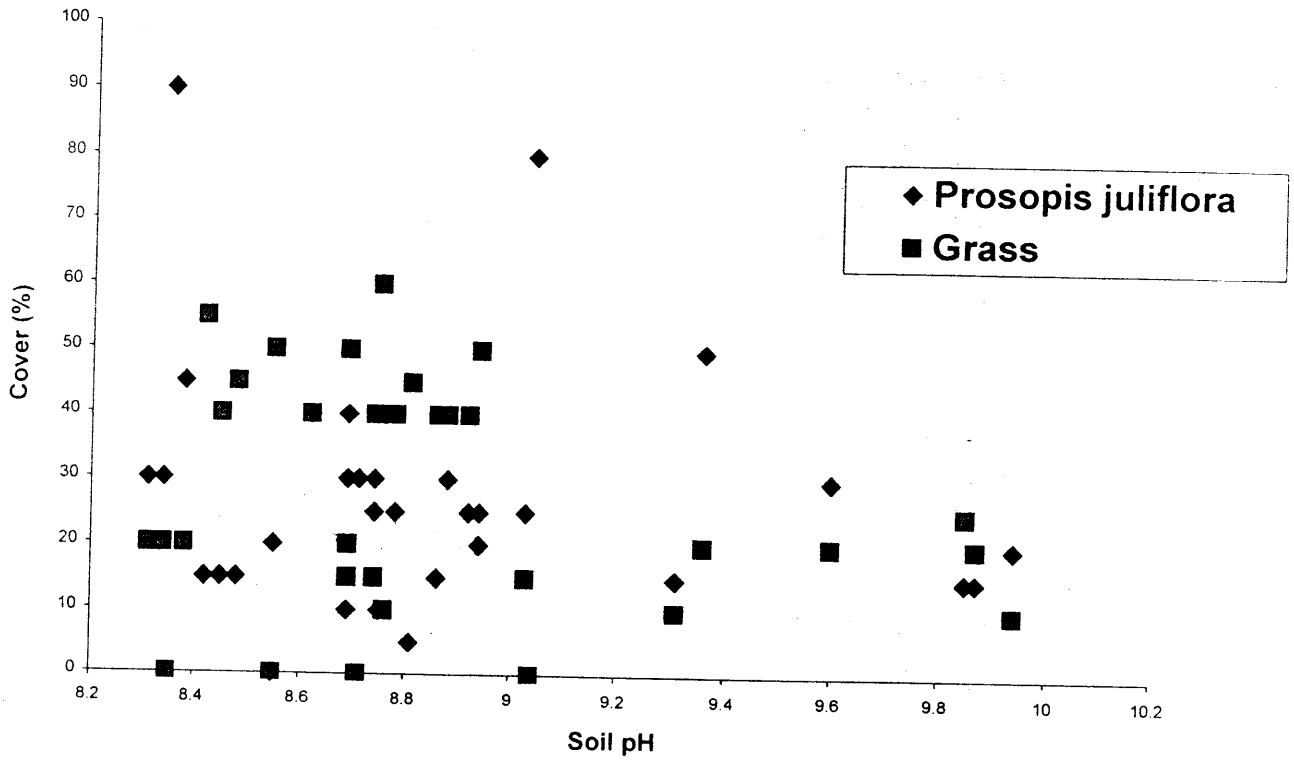

Fig. 3. Relationship of vegetation cover with soil pH.

immediate observation pixels than to the neighbourhood pixels. The darkness categories 2-3 mainly represented grass cover and moderate salt affected land where as category 4 represent thickets *P. juliflora* associated with highly salt affected lands. With increasing darkness categories, cover of P. *juliflora* and gravelly surface increased but bare surface decreased. Singh *et al.* (2000) have also reported cover of *P. juliflora* on highly salt affected land.

ANOVA

Means of surface properties belonging to distinct numerical darkness categories on February and October images indicated differences between categories at significance levels < 0.1 for several surface properties. February image showed fewer capabilities in distinguishing soil chemical properties, as is shown by not significant differences of soil EC and pH values. Numerical darkness categories of October images could distinguish soil EC and also surface cover.

The ANOVA performed on the value of numerical darkness categories of observation pixel on October FCC showed that there was significant difference in the cover of bare soils, stone cover, ECa and $EC_{2.5}$ values between the categories. In category 2 the average value of bare cover was 63%, it was 38% in category 3 and it was 36% in category 4.

Conclusion

The studies carried out during two transacts on a vast natural salt affected land of arid region have shown wide variations in soil salinity ($EC_{2.5}$ 3.7 to 28 dSm^{-1}) and alkalinity (pH 8.5-9.8), cover of *P. juliflora* (10-90%) and tolerant

grasses (10-55%) and gravelly surface (20-35%). Though *P. juliflora* and grasses were present at most of the observation points their cover started decline with soil $EC_{2.5}$ values more than 10 and 13 dSm^{-1} respectively.

The derived numerical darkness categories of the FCC images were slightly low for February images. The darkness values of observation pixel on February FCC correlated positively with *P. juliflora* cover and negatively with grass cover and soil pH indicating that surface features were related with the immediate observation pixels. The darkness categories 2 and 3 were characterised by grass cover and moderate salt affected soils (EC 3-10 dSm^{-1}) where as category 4 was dominated by thicket of *P. juliflora*. Category 1 represented fewer plant communities, high salinity (EC 28.7 dSm^{-1}) and gravelly surface.

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