Journal of Agricultural Science
www.ccsenet.org/journal.html
Vol. 1, No. 1
June 2009

Determination of Soya Plant Population Using NDVI in the Dasht-e-Naz Agri-Industry

Hojat Ahmadi
Department of Agricultural Machinery Engineering
Faculty of Biosystems Engineering, University of Tehran
P.O. Box 4111, Karaj 31587-77871, Iran

Kaveh Mollazade(Corresponding author)
Department of Agricultural Machinery Engineering
Faculty of Biosystems Engineering, University of Tehran
P.O. Box 4111, Karaj 31587-77871, Iran
Tel: 98-918-972-0639 E-mail: kaveh.mollazade@gmail.com, mollazade@ut.ac.ir

Abstract

Numerous efforts have been made to develop various indices using remote sensing data such as normalized difference vegetation index (NDVI), and vegetation condition index (VCI) for mapping and monitoring of yield estimating and assessment of vegetation health and productivity. NDVI and other indices that derive from satellite images are valuable sources of information for the estimation and prediction of crop conditions. In the present paper, NDVI data of Dasht-e-Naz in Iran in 2006 have been considered for crop yield assessment and estimating. The results showed that there is acceptable relationship between NDVI and Soya plant population. The correlation between NDVI and plant population in high plant population area of field was (R^2=0.923) and for low plant population area was (R^2=0.249). The crop population models were discussed about high and low plant population in the present paper and could improve in future with the use of long period dataset. Similar model can be developed for different crops of other locations.

Keywords: Soybean, Plant population, Precision farming, Satellite images, Normalized Difference Vegetation Index, NDVI

1. Introduction

Precision farming is a new agricultural system concept with the goals of optimizing returns in agricultural production and environment. This concept involves the development and adoption of remote sensing (Barnes et al., 1996), Geographic Information System (GIS) technology applications, and knowledge-based technical management systems (NRC, 1997). With a refined GIS and spatial knowledge-based management system, farmers should have the ability to appropriately manage field operations at each location in the field, as well as the ability to predict likely yield from early season indicators and distinguish crop type from far. Many studies have focused on variable rate applications (Gotway et al., 1996; Stafford and Miller, 1996) while some are focused on yield mapping (Sudduth et al., 1996). Yield mapping provides not only information about the yield itself, but it allows comparison to field conditions that may explain spatial yield variation.

Remote sensing techniques have a number of advantages over the conventional techniques such as field surveying in vegetation-dynamics studies. Satellite remote sensing has special advantages since it can produce multi temporal images at frequent intervals which facilitate temporal monitoring of vegetation over an area. During the last decade, coarse spatial resolution, high temporal frequency satellite data such as NOAA AVHRR were used extensively to monitor vegetation cover and climatic variability throughout the word (Kulawardhana et al., 2004). The normalized ratio of near-infrared reflectance to red reflectance, called the normalized difference vegetation index (NDVI) has been shown to be a sensitive indicator of biomass and leaf area in several crops, which can be used to distinguish crop. Once a relationship between yield and NDVI is developed, then farmers can predict their yield earlier in the growing season and therefore, better harvest management, planning the following season's inputs, and other more effective management can be achieved (Chewab and Murdock, 2002).

In the remote sensing, electromagnetic waves are recorded on different platforms. Reflective energy is the great importance and most of system. The rate of electromagnetic reflection in visible spectrum (green, red, and blue frequency) and close infrared depend on the surface of the subject (Jensen, 1996). The manner of reflection of visible spectrums and infrared is shown in figure 1.

Remote sensing has been used to evaluate nutrient deficiencies such as P concentrations of soybean (Milton et al. 1991), S, Mg, K, P and Ca of corn leaves (Al-Abbas et al. 1974), Fe, S, Mg, and Mn in corn, wheat, barley, and sunflower (Masoni et al. 1996) and P uptake of bermudagrass (Sembiring et al. 1998). Reflectance, the ratio of incoming to reflected radiance, can be used to estimate total N and chlorophyll content of fresh plant samples (Yoder and Pettigrew-Crosby 1995). Raun et al. (2001) showed that mid-season sensor reflectance measurements could be used to predict yield potential of winter wheat.

NDVI index is one of the best-known and also best-working indices ever which were first performed in 1974 by Rouse et al. One of the functions of this method is vegetation and plant refreshment and is capable to monitor those levels in different ages. In order to exploitation of vegetation from satellite images, existence or non - existence of satellite band are important. In other words, more correlation between satellite image bands can show more information about satellite image (Drost et al., 1997).

Several works have shown that NDVI is correlated with aboveground net primary production (ANPP) (Paruelo et al., 2000, 2004; Pineiro et al., 2006). Therefore, exploring NDVI interannual variation and its relationship with precipitation contributes to understanding ANPP variation. NDVI is more closely associated with ANPP when the situations being compared largely differ in leaf area and are similar in incident radiation and in radiation use efficiency (Pineiro et al., 2006).

Chewab and Murdock (2002) had applied the NDVI method for gathering amount of nitrogen fertilizer. In another research, using vegetation index from satellite images, cultivated area of soybean and corn were calculated (Drost et al., 1997).

The goal of this research was to predict and evaluate some characteristics of vegetation such as accumulation and plant population of soybean in the Dasht-e-Naz Agri-Industry using vegetation index.

2. Materials and methods

This study employed NDVI to examine the relationship between Soya plant population and the Normalized Difference Vegetation Index (NDVI) in the Dasht-e-Naz agri-industry. The relationship between Soya plant population and NDVI in the Dasht-e-Naz agri-industry was examined using spatial analysis methods. For NDVI interpretation and understanding the accumulation and vegetation populace, first the geographical information of subjected area was studied. Satellite images of Dasht-e-Naz Agri-industry were captured. Some samples were taken from that area and geographical region was determined. Dasht-e-Naze is about 3200 hectares and this area is located between 36˚37″ latitude and 53˚07″ longitude. This research was done between years 2005 and 2006. The time of information gathering from the field was obtained by using Orbitron software. Software showed that passing time of IRS satellite was in 2005/09/05 and data were gathered at this time.

Geographical positions of field were determined by using GPS and then population of Soya was investigated by the satellite images. The satellite images of Dasht-e- Naz area were captured by IRS-1C, 1D satellite. The LISS-III and PAN Images of subjected are shown in Figures 2 and 3, respectively.

The raw images were captured from satellite then were processed by PCI-GEOMATICA software. LISS-III images were containing visible bands and their resolutions were about 23.5 meter. For increasing the resolution of images, the PAN and LISS-III images were processed and merged by PCI-GEOMATICA software. Final processed image is shown in the Figure 4. Then the pixel values were exploited from the image in the final process by PCI-GEOMATICA software.

NDVI index was exploited through the below formula (Lillesand anf Kiefer, 1994):

$$NDVI = \frac{B3 - B2}{B3 + B2}$$

where B3 and B2 are spectral reflectance in the near-infrared band and reflectance in the red band, respectively. This is a less measure unit that their range usually is between -1 to 1. Water, snow, clouds or any other non-vegetated scene is represented by a negative number. Low positive numbers near zero indicate rock and bare soil, which reflect near infrared and red at the same level. Increasingly positive numbers indicate greener vegetation (Lillesand and Kiefer, 1994).

In order to determine the ground information, latitude and longitude of plots and measuring points were determined. Then by using a square frame, number of plants per frame was determined. Value of satellite image pixels was extracted proportionate with measuring points. Table 1 shows the plot number, latitude and longitude of plots, values of bands, NDVI, and plant population.

In order to determine the value of plant population, two regions of plot on the image were selected and pixel value was determined in an 8×9 matrix with 5.8 m^2 for area of each pixel. The stared pixel in the tables is the center of each matrix. The band values spectrum of two plots are shown in tables 2, and 3. Table 2 shows the values of two bands of high Soya population and another one showed these values about low Soya population. In order to show difference between populations and reduce the sample errors, two samples were selected for each plot.

3. Results and discussion

After gathering information from satellite images and field, the relationship between RGB bands were investigated. Figures 5 and 6 show the correlation between B2 and B3 in high and low plots. Strong relationship between two bands could give us more accurate information. The results showed that there was weak correlation between bands 2 and 3 for low population plots and against that there was strong correlation between those in accumulated fileds. The results showed that estimation of plant population in accumulated fileds were more accurate than fileds with low plant population because in high plant population fileds there was good relationship between the bands of satellite images.

The relationship between NDVI indices and Soya population were estimated and are shown in figure 7. A strong positive correlation between NDVI and Soya was found in high population fileds. The results showed that the relationship between NDVI and plant population was a liner relationship. The results showed that with increasing the NDVI, plant population is increased. Comparison between the filed's data and the results from satellite images showed that there was straight relationship between plant population and NDVI in different field with different plant population but in the field with high plant population, the correlation ratio was very better than that of low plant population.

In order to increase the accuracy of correlation between bands, number of samples from each geographical region was calculated. This leads to the proper show of the information between bands. Figure 8 shows the NDVI of high and low plant population via the number of samples. According to this figure, the NDVI of high plant population was more than low plant population.

The average of NDVI for high plant population and low plant population plots are shown in figure 9. The results showed that there was homogeneous plant population in both samples of high plant population and low plant population and only plant per square meter of plots was different. Based on the results, NDVI index less than 0.2 showed low accumulation and NDVI index with about 0.5 showed high accumulation. It was found that the reason of low plant population of some part of field was because no seed was planted.

4. Conclusions

It can be concluded that using the vegetation index could suitable to estimate the soybean accumulation. And with using this index we could distinguish the region with low and high plant accumulation. Based on the results, NDVI index less than 0.2 showed low accumulation and NDVI index with about 0.5 showed high accumulation. It was found that the reason of low plant population of some part of field was because of not planted seed by planter at planting time.

References

Al-Abbas, A. H., Barr, R., Hall, J. D., Crane, F. L., and Baumgardner, M. F. (1974). Spectra of normal and

nutrient-deficient maize leaves. *Agronomy Journal*, 66, 16–20.

Barnes, E.M., Moran M. S., Pinter P. J., & Clarke T. R. (1996). Multispectral remote sensing and site-specific agriculture: examples of current technology and future possibilities. *Proceedings of the 3rd International Conference*, 23-26 June, 845-854.

Chewab, G. J., & Murdock, T. W. (2002). *Nitrogen fertilization of corn grown in Kentucky*. Kentucky University Perss.

Drost, D., hang, M., & Ustin, S. (1997). *Corn and soybean yield indicators using remotely sensed vegetation index*. University of California Press.

Gotway, C.A., Ferguson R.B., & Hergert G.W. (1996). The effects of mapping and scale on variable rate fertilizer recommendations for corn. *Proceedings of the 3rd International Conference*. 23-26 June, 321-330.

Jensen, J. R. (1996). *Introductory digital image processing: A remote sensing perspective*, Prentice Hall Press.

Kulawardhana, R. W., Dayawansa, N. D. K., & De Silva, R. P. (2004). Determination of spatio-temporal variations of vegetation cover, land surface temperature and rainfall and their relationships over Sri Lanka using NOAA AVHRR data. *Tropical Agricultural Research,* 16, 282-291.

Lilles and, T. M., & Kiefer, R. W. (1994). *Remote sensing and image linter predation*, John Wiley and Sons Press.

Masoni, A., Ercoli, L., & Mariotti, M. (1996). Spectral properties of leaves deficient in iron, sulfur, magnesium, and manganese. *Agronomy Journal*, 88, 937–943.

Milton, N. M., Eisweth, B. A., & Ager, C. M. (1991). Effect of phosphorus deficiency on spectral reflectance and morphology of soybean plants. *Remote Sensing Environment*, 36, 121–127.

NRC. (1997). *Committee on assessing crop yield: site-specific farming, information systems, and research opportunities*, National Academy Press, 118 pp.

Paruelo, J. M., Oesterheld, M., Di Bella, C. M., Arzadum, M., Lafontaine, J., Cahuepe, M., & Rebella, C. M. (2000). Estimation of primary production of subhumid rangelands from remote sensing data. *Applied Vegetation Science*, 3, 189–195.

Paruelo, J. M., Golluscio, R. A., Guerschman, J. P., Cesa, A., Jouve, V. V., & Garbulsky, M. F. (2004). Regional scale relationships between ecosystem structure and functioning. The case of the Patagonian steppes. *Global Ecology and Biogeography*, 13, 385–395.

Pineiro, G., Oesterheld, M., & Paruelo, J.M. (2006). Seasonal variation in aboveground production and radiation-use efficiency of temperate rangelands estimated through remote sensing. *Ecosystems*, 9, 357–373.

Raun, W. R., Solie, J. B., Johnson, G.. V., Stone, M. L., Lukina, E. V., Thomason, W. E., & Schepers, J. S. (2001). Inseason prediction of potential grain yield in winter wheat using canopy reflectance. *Agronomy Journal*, 93, 131–138.

Sembiring, H., Raun, W. R., Johnson, G. V., Stone, M. L., Solie, J. B., & Phillips, S. B. (1998). Detection of nitrogen and phosphorus nutrient status in bermudagrass using spectral radiance. *Journal of Plant Nutrition*, 21, 1189-1206.

Stafford, J. V., & and Miller, P. C. H. (1996). Spatially variable treatment of weed patches. *Proceedings of the 3rd International Conference*. 23-26 June, 465-474.

Sudduth, K. A., Drummond S. T., Birrell S. J., & Kitchen, N.R. (1996). Analysis of spatial factors influencing crop yield. *Proceedings of the 3rd International Conference*. 23-26 June, 129-149.

Yoder, B.J., & Pettigrew-Crosby, R. E. (1995). Predicting nitrogen and chlorophyll content and concentrations from reflectance spectra (400–2500 nm) at leaf and canopy scales. *Remote Sensing Environment*, 53,199–211.

Table 1. Observed samples in the Dasht-e-Naz Agri-industrial Company and in the satellite image

Plot number	latitude	longitude	Band (B1,B2,B3)	NDVI	Plant Population (Plant/m^2)
40 (Middle)	53º07´18.7"	36º37´10.5"	37-96-67	0.44	17
40 (Middle)	53º07´18.7"	36º37´10.5"	43-101-72	0.4	17
40 (Middle)	53º07´18.9"	36º37´10.5"	41-98-70	0.41	17
40 (Middle)	53º07´19.1"	36º37´10.5"	45-99-102	0.37	16
40 (Middle)	53º07´19.3"	36º37´10.5"	43-96-71	0.38	16
40 west	53º07´1.4"	36º37´3.3"	38-89-65	0.4	17
40 west	53º07´1.4"	36º37´3.5"	39-90-66	0.39	16
40 west	53º07´1.4"	36º37´3.7"	38-89-65	0.4	17
40 west	53º07´1.4"	36º37´3.8"	39-90-66	0.39	16
40 west	53º07´1.4"	36º37´4"	42-93-69	0.37	16
40 East	53º07´36.1"	36º37´19"	41-95-69	0.39	16
40 East	53º07´36.3"	36º37´19"	43-87-62	0.34	16
40 East	53º07´36.4"	36º37´19"	37-90-65	0.41	17
40 East	53º07´36.7"	36º37´19"	34-88-61	0.44	17
40 East	53º07´36.8"	36º37´19"	34-91-63	0.45	18
39 west	53º07´53.4"	36º37´26.9"	25-92-57	0.57	19
39 west	53º07´53.6"	36º37´26.9"	39-95-60	0.53	19
39 west	53º07´53.8"	36º37´26.9"	31-98-63	0.51	19
39 west	53º07´54"	36º37´26.9"	33-98-64	0.49	18
39 west	53º07´54.2"	36º37´26.9"	32-97-63	0.5	19
39 East	53º08´11.7"	36º37´35"	98-99-66	0.44	17
39 East	53º08´11.9"	36º37´35"	35-94-64	0.45	18
39 East	53º08´12.1"	36º37´35"	38-93-66	0.41	17
39 East	53º08´12.3"	36º37´35"	40-94-68	0.4	17
39 East	53º08´12.5"	36º37´35"	45-97-72	0.36	16

Table 2. Band values spectrums of a high Soya population plot.

B2								
31	34	32	32	31	29	33	32	33
32	34	32	31	33	30	29	32	33
33	34	32	30	32	35	32	32	34
33	33	31	33	35	35	34	33	33
33	33	31	34	×35	35	30	33	32
34	32	32	35	35	35	29	32	32
34	31	32	36	34	32	32	33	31
33	33	33	36	33	27	30	33	30
B3								
92	95	93	93	92	90	94	93	92
93	95	93	92	94	91	91	94	94
94	95	94	92	94	97	94	94	96
94	94	92	95	97	97	96	95	95
94	94	92	95	×96	97	92	95	93
95	93	93	96	96	96	90	93	93
95	92	93	97	95	93	93	94	92
94	94	94	97	94	88	91	94	91

Table 3. Band values spectrums of a low Soya population plot.

B2								
68	69	70	69	70	69	68	69	71
71	69	70	69	70	68	68	69	72
70	69	70	68	69	68	68	69	72
69	68	70	69	69	68	69	70	73
68	68	67	66	×69	68	69	70	72
66	67	63	62	67	69	69	71	72
65	64	61	62	66	68	70	70	71
61	63	61	63	66	68	69	68	67
B3								
86	87	89	88	89	90	89	90	92
89	87	89	88	89	89	89	90	91
89	88	89	89	90	89	90	90	91
90	89	91	91	91	90	91	92	93
90	90	89	88	×69	90	91	92	94
91	91	87	86	90	92	92	94	95
91	88	87	88	91	93	93	93	94
88	89	87	91	92	93	94	93	93

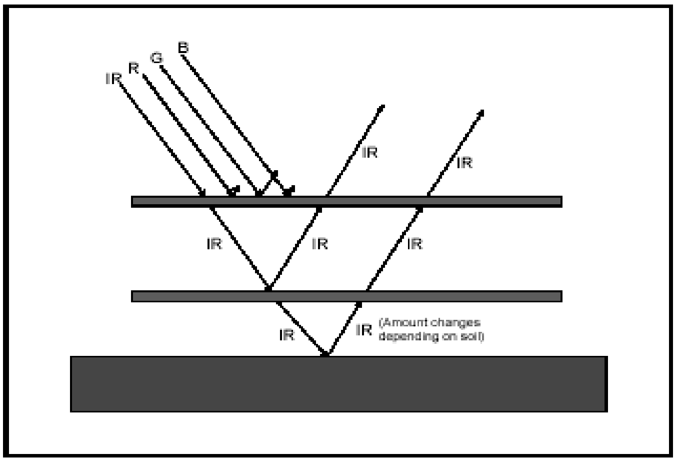

Figure 1. The manner of reflection of visible spectrums and infrared spectrum

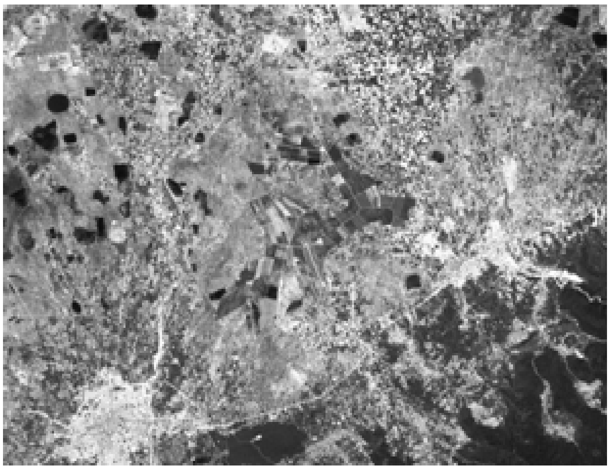

Figure 2. LISS-III image of Dasht-e-Naz

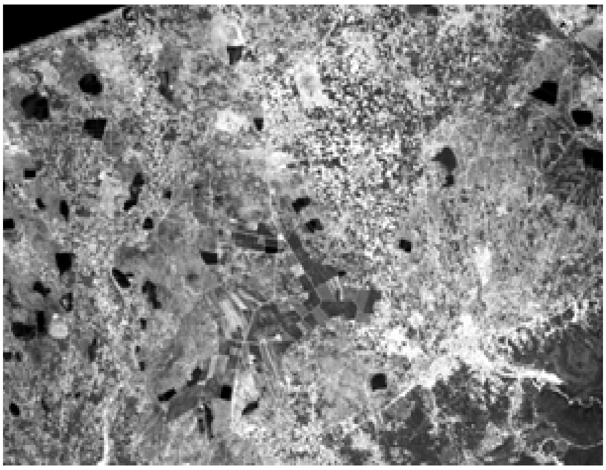

Figure 3. PAN image of Dasht-e-naz

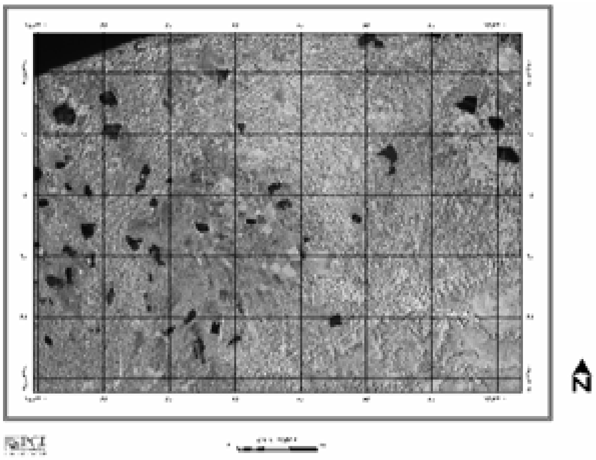

Figure 4. Merged image of Dasht-e-Naz

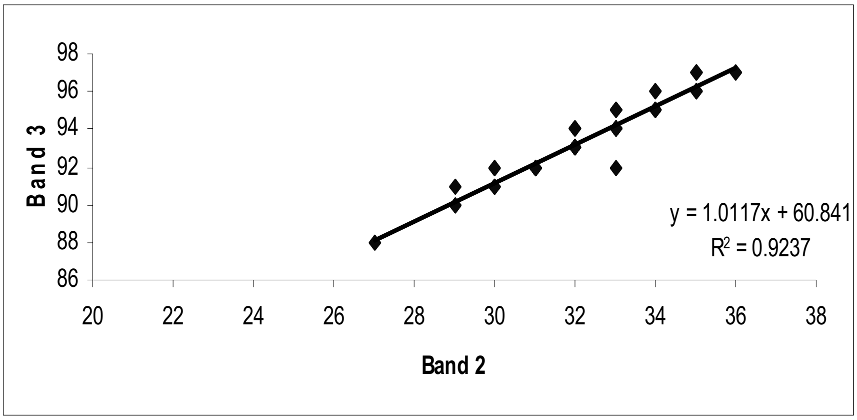

Figure 5. Relationship between bands 2 and 3 for high Soya population

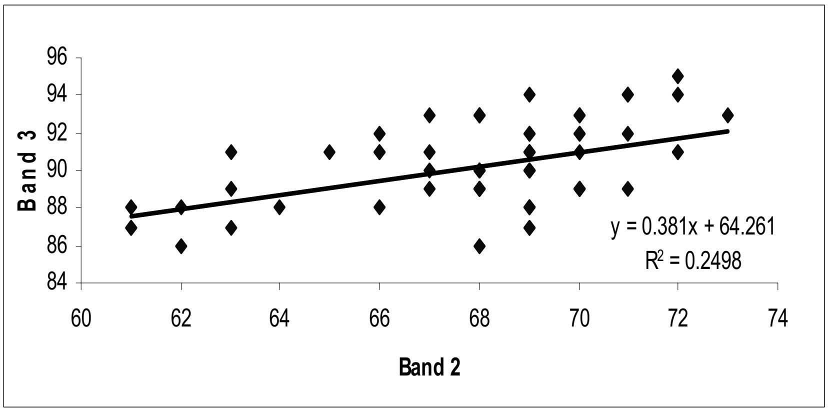

Figure 6. Relationship between bands 2 and 3 for low Soya population

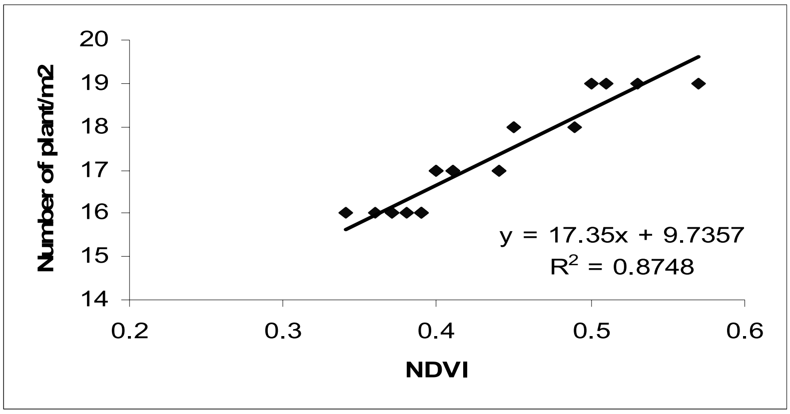

Figure 7. Relationship between NDVI and Soya population for high Soya population

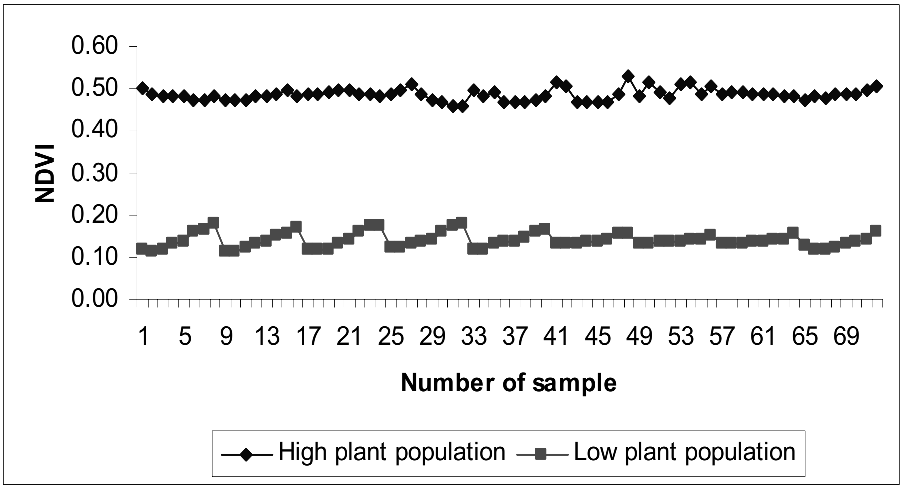

Figure 8. NDVI index for the samples with low and high plant population

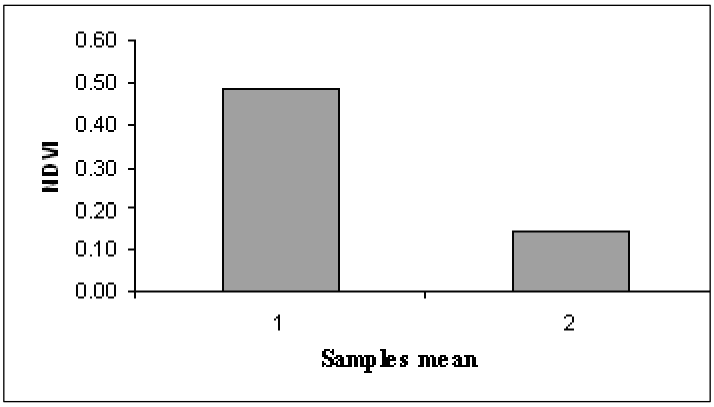

Figure 9. Average of NDVI index for the samples with (1) high and (2) low plant population