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Multispectral vegetation indices profiles of chickpea

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Abstract
The temporal spectral pattern of any crop encapsulates its phenology as well as its growth characteristics. Hence, temporal spectral profile of each crop is unique and can be used to differentiate crops. The temporal spectral profile has wide applications including crop identification, acreage estimation, plant health monitoring, yield modelling and water demand calculation. Temporal spectral profiles of chickpea crop grown in Akola district of Maharashtra state were studied The research analyses the potential of Sentinel 2A satellite data in extracting different vegetation indices when supported with adequate ground truth data. The four most common vegetation indices namely, Ratio Vegetation Index (RVI), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Soil Adjusted Vegetation Index (SAVI) were extracted from the Sentinel 2 A satellite data using ArcGIS and ERDAS Imagine Softwares. The temporal spectral profiles of chickpea crop was successfully derived from the study conducted at Akola district of Maharashtra State during 2021-22 based on data obtained from 39 ground truth stations. The profiles were obtained by plotting the weeks after sowing versus the VI values. Profiles of all the vegetation indices were found to follow a similar behaviour throughout the crop growth cycle showing lower values in the initial and crop development stage reaching to maximum values at the maturity and then decline up to senescence. The curves satisfy fourth order polynomial showing high R^2 values.

Keywords: Multispectral vegetation indices, chickpea, NDVI

Introduction
The increasing significance of precision agriculture, necessitates the use of remotely sensed data for quick and accurate data collection. Remotely sensed data can be further used for precision agricultural practices based on crop identification, acreage estimation, vegetative health determination etc. Multispectral vegetation indices derived from remotely sensed data characterize vegetation based on canopy reflectance. Vegetation indices can be used to model agronomic parameters and the crop monitoring inferences ultimately leads to better precision agricultural practices (Akkara *et al.*, 2022) [2]. The spectral profile parameters of a crop give information about significant physiological stages. Phenological information of a crop on spatial basis can be derived from a spectral-temporal profile. The spectral profile of each crop has got its own characteristic features *viz.* profile duration, amplitude and rise and fall time. Therefore, each crop has got an own characteristic temporal spectral profile and the differences and similarities in the profile features *viz.* trajectory, profile period, amplitude and shape of profile etc. can be used for crop identification at various levels (Odenweller and Johnson, 1984) [7]. Since spectral features are indicators of the growth and development characteristics of the crop, spectral growth profile are directly useful in crop-yield modelling. The crop spectral profile generated from remotely sensed vegetation indices has got pragmatic applications *viz.* crop identification, extraction, classification, crop growth stage determination, crop emergence date determination and crop yield modelling (Deosthali and Akmanchi, 2006) [5]. Even the variety of crop i.e. cultivars can be identified using the transverse shift in the spectral profile. Besides, spectral variables are found to be useful in differentiating high and low yielding cultivars under varying growing seasons (Mohandas *et al.*, 1991) [10]. Considering above facts temporal spectral profiles of chickpea, one of the dominant rabi crop in Akola district were studied to understand its behaviour.

Materials and Methods
The research was carried out in Akola district lying in middle east Maharashtra, which has a total size of 5428 square kilometers and is situated between latitudes 20.17º N and 21.16º N and longitudes 76.7º E and 77.4º E. The major rabi crop of the area, chickpea has been chosen

as the study crop. Multi-date, multispectral Sentinel-2A satellite images were downloaded from the USGS Earth Explorer website for a period of six months from November 2021 to April 2022 which coincides with crop chickpea crop growth period. The data of six months (12 dates) was collected to accommodate early or late sowing of chickpea at various places. The study area is spread across four tiles (T43QFC, T43QFD, T43QGC and T43QGD) of Sentinnel-2 satellite data and hence, images of 4 tiles were obtained corresponding to each date. Resampling of bands and layer stacking was carried out to obtain composite images for each tile. After mosaicking, subsets of comprising of study area for each date were prepared using the district boundary as an area of interest (AOI) in the raster subset module of ERDAS Imagine software (Fig. 1). The remote sensing and GIS part of the investigation is analyzed using ERDAS Imagine 2014 and ArcGIS version 10.2 software.

Ground Truth Data

Ground truth data collection was synchronized with satellite data acquisition. During the field visit, specific data was gathered, such as the GPS coordinates of the crop area using an android smartphone with the geotagging facility, the sowing date, the crop growth stage, height of the crop, other intercrops, the crop infestation, the soil type, the moisture condition and the crop calendar. In the study region, the ground truth work for the chickpea crop was completed between 25-27 December 2021, 9-11 January and 4-6 March 2022. Data from 39 sites were gathered. The GT point shape/vector file was created with the relevant annotations and attribute information corresponding to each location was added (Fig. 1).

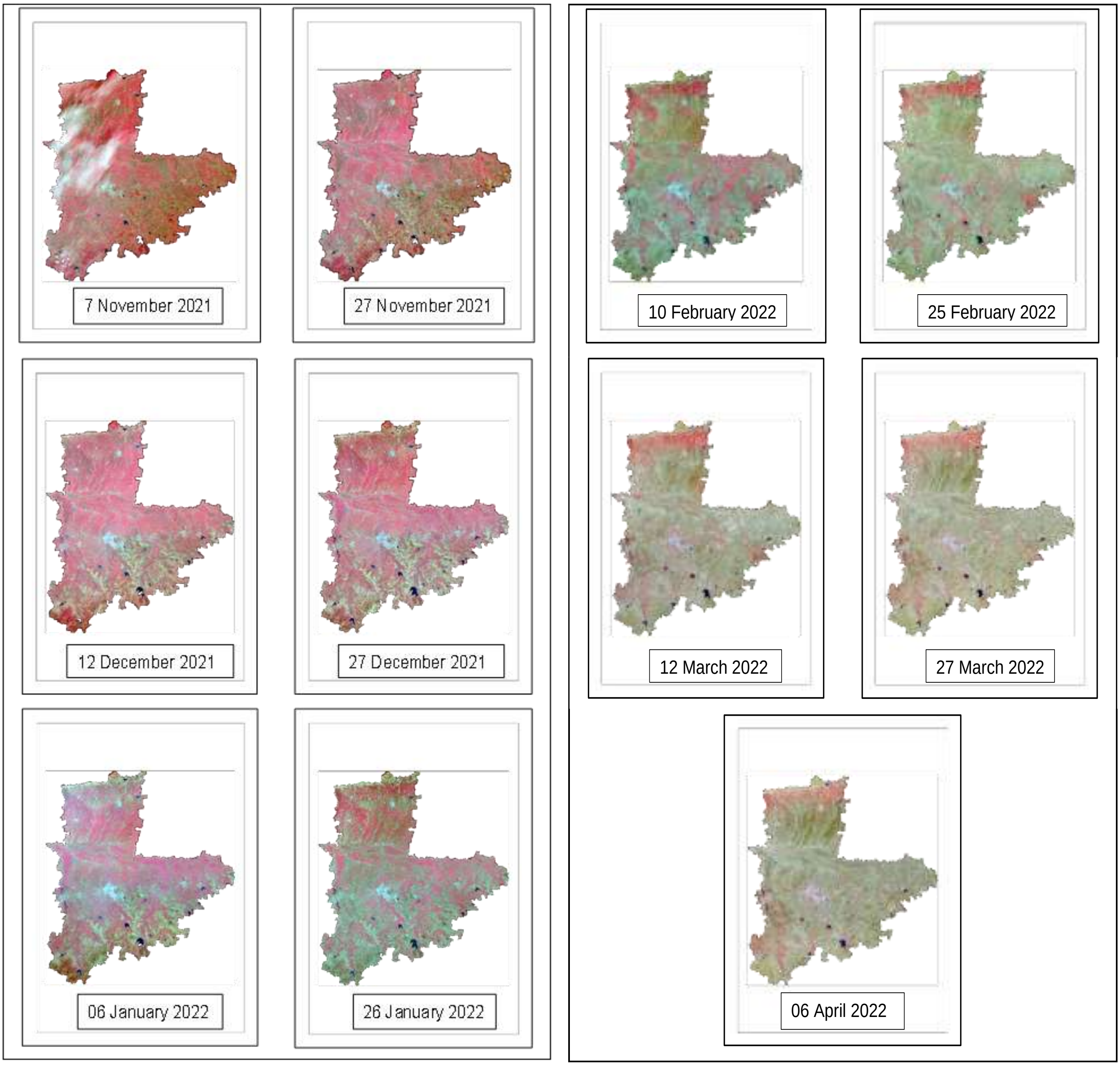

Fig 1: Sentinel 2 A subset images used for the study

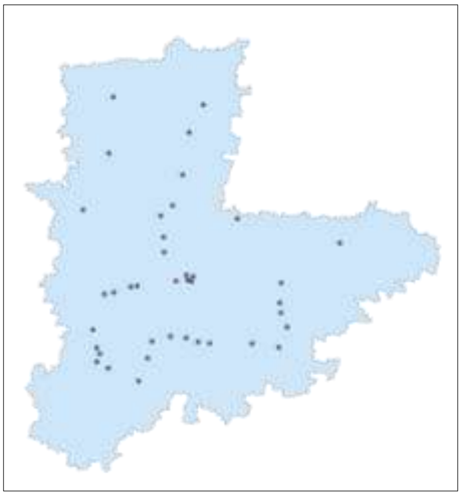

Fig 1: Point vector map of the study area

Visual observations were used to determine the age of the crop in the absence of a farmer in the field or the absence of information on the age of the crop. In this instance, crop age has been indirectly determined based on the criterion given by GRDC, Australia. This criterion was somewhat modified to fit local situations with the help of experts (Table 1).

Table 1: Modification of detection criterion of chickpea crop stage as per local conditions

Sr. No	Stage	Stage length (days)	Description
1	VG	7 to 15	Germination
2	VE	40 to 80	Emergence - The seedling emerges
3	V1		First node - First multifoliate leaf at first node fully unfolded
4	V2		Second node - First multifoliate leaf at second node fully unfolded
5	V3		Third node - First multifoliate leaf at third node fully unfolded
6	V(n)		Nth-node - First multifoliate leaf at nth node fully unfolded
7	R1	20 to 30	Initiation of flowering – One flower bud at any node on the main stem
8	R2		Calyx opening – Bud grows but is still sterile, sepals begin to form
9	R3		Anthesis – Pollination occurs before the bud opens
10	R4		Wings extend – Flower petals extend to form a flower
11	R5		Flower collapses
12	R6	10 to 15	Pod initiation – One pod found in any nod on the main stem
13	R7		Full pod – One fully expanded pod present
14	R8	10 to 15	Beginning seed – One fully expanded pod in which seed cotyledon growth is visible
15	R9		Full seed – One pod on the main stem filled with seeds when fresh
16	R10	20 to 30	Beginning maturity – one pod on the main stem turns to a light golden-yellow color
17	R11		50% of pods are golden yellow
18	R12		90% of pods are golden yellow

The exact date of the field visit and the date of the satellite overpass were matched for the satellite images of 27 December 2021 and hence chosen as the standard image or reference image (RI). This makes it easier to correlate the exact crop stage with the crop spectral data that was derived from the image. Once the age of the crop on the reference image date (27 December 2021) has been established, the trial-and-error method was devised as the criteria to determine the age of the crop on other image dates and it is provided in Table 2. The value of the vegetation indices of the chickpea crop was distributed accordingly.

Table 2: Criteria for week-wise distribution of data

Sr. No	Date of image	The time interval between successive images		Cumulative interval from RI date	Interval (Approx. weeks)	Age determined (weeks)
		Days	Weeks			
1	07-11-2021	20	2.9	7.1	3	RI-7
2	27-11-2021	15	2.1	4.2	2	RI-4
3	12-12-2021	15	2.1	2.1	2	RI-2
4	27-12-2021	RI date. Age on this date was determined as per GT data				
5	06-01-2022	10	1.4	1.4	1	RI+1
6	26-01-2022	20	2.9	4.3	3	RI+4
7	10-02-2022	15	2.1	6.4	2	RI+6
8	25-02-2022	15	2.1	8.5	2	RI+8
9	12-03-2022	15	2.1	10.6	2	RI+10
10	27-03-2022	15	2.1	12.7	2	RI+12
11	06-04-2022	10	1.4	14.1	1	RI+13

Multispectral vegetation indices (VIs) namely Ratio Vegetation Index (RVI), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Soil Adjusted Vegetation Index (SAVI) were extracted from multidate subset images of all the 11 dates of satellite pass given in Plate 1. Using the Model Builder Tool in ERDAS Imagine software, separate images for every vegetation index were generated corresponding to each day of the satellite overpass. Using the Raster menu in the ERDAS Imagine software, stacking of these images of each vegetation indices was done.

The crop vector layer representing the fields visited during the ground truth survey was processed in the ERDAS Imagine environment along with the layer stack images for the various vegetation indices *viz*. RVI, NDVI, NDWI and SAVI. The temporal values of the vegetation indices for each GT site corresponding to the respective image dates were compiled. Each crop site was categorized based on the age of the crop in weeks on the reference image date and then, the corresponding temporal values of each VI were distributed accordingly. For each week, corresponding VI values were averaged out. The weeks past sowing along the abscissa and corresponding average VI values on the ordinate were plotted to derive the overall trend of multi-temporal VI for the chickpea crop. The spectral VI profiles of chickpea crops are shown by the trend of VIs with increasing crop age.

Results and Discussion

The Sentinel 2A satellite data of the research area for 11 dates during the crop growing season of the chickpea were obtained. Composite images with all the required bands were prepared for each tile after resampling the 11th band. Composites of the same date were merged to form the mosaic. The subset images derived from the mosaics were processed using the ERDAS Imagine software by running models for the four vegetation indices under study, namely Ratio Vegetation Index (RVI), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Soil Adjusted Vegetation Index (SAVI), for each of the eleven dates of the satellite overpass. A total of 44 images were generated for all four vegetation indices. A layer stack of each vegetation index was obtained by stacking all the corresponding images in chronological order. The four stack layer images of the vegetation indices namely, RVI stack, NDVI stack, NDWI stack, and SAVI stack were obtained and are displayed in Plate 2.

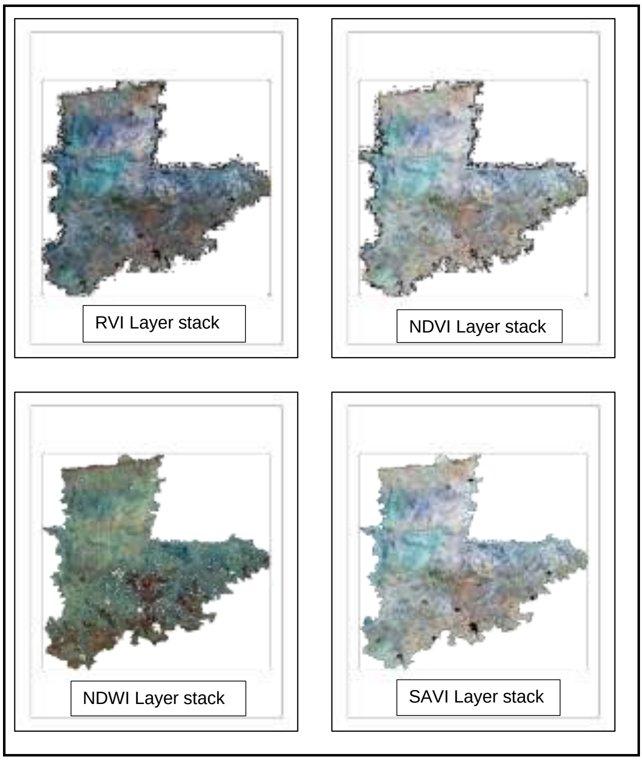

Plate 2: Layer stack images of vegetation indices

Digitization of fields visited during the ground truth survey was done. The value of the site-specific vegetation indices was obtained by superimposing the GT vector layer on the VI stack layers. The temporal values of all four vegetation indices for pure crop sites were obtained during the period of satellite data acquisition. These site-specific multi-date values of the vegetation indices were used for further study.

The age of the chickpea crop was determined using the information gathered from the farmers during the ground truth survey like sowing date, variety, and expected harvesting date. The exact age of the chickpea crop was ascertained using modified criteria as per discussion with the regional experts to fit the local conditions. The site-specific VI values on each day of the satellite overpass were distributed corresponding to the determined age of the crop in weeks by referring to age as on ground truth date and reference image date. The weekly values of each vegetation index *viz*. RVI, NDVI, NDWI, and SAVI of all the GT sites were averaged to obtain a mean VI value corresponding to each week. As the condition of the chickpea crop varied at each site, the weekly mean VI value served as the representation of the mean of all those crop conditions corresponding to the same week irrespective of changes in vegetation and soil.

The mean VI values for chickpea crop corresponding to various growth stages (weeks past sowing) were acquired through the aforementioned procedures. The VI trend along the life cycle of the chickpea crop is depicted by the plot of VI versus weeks past sowing. Smoothed data is represented by the dotted line that is drawn through the scattered points and is shown in Fig. 2.

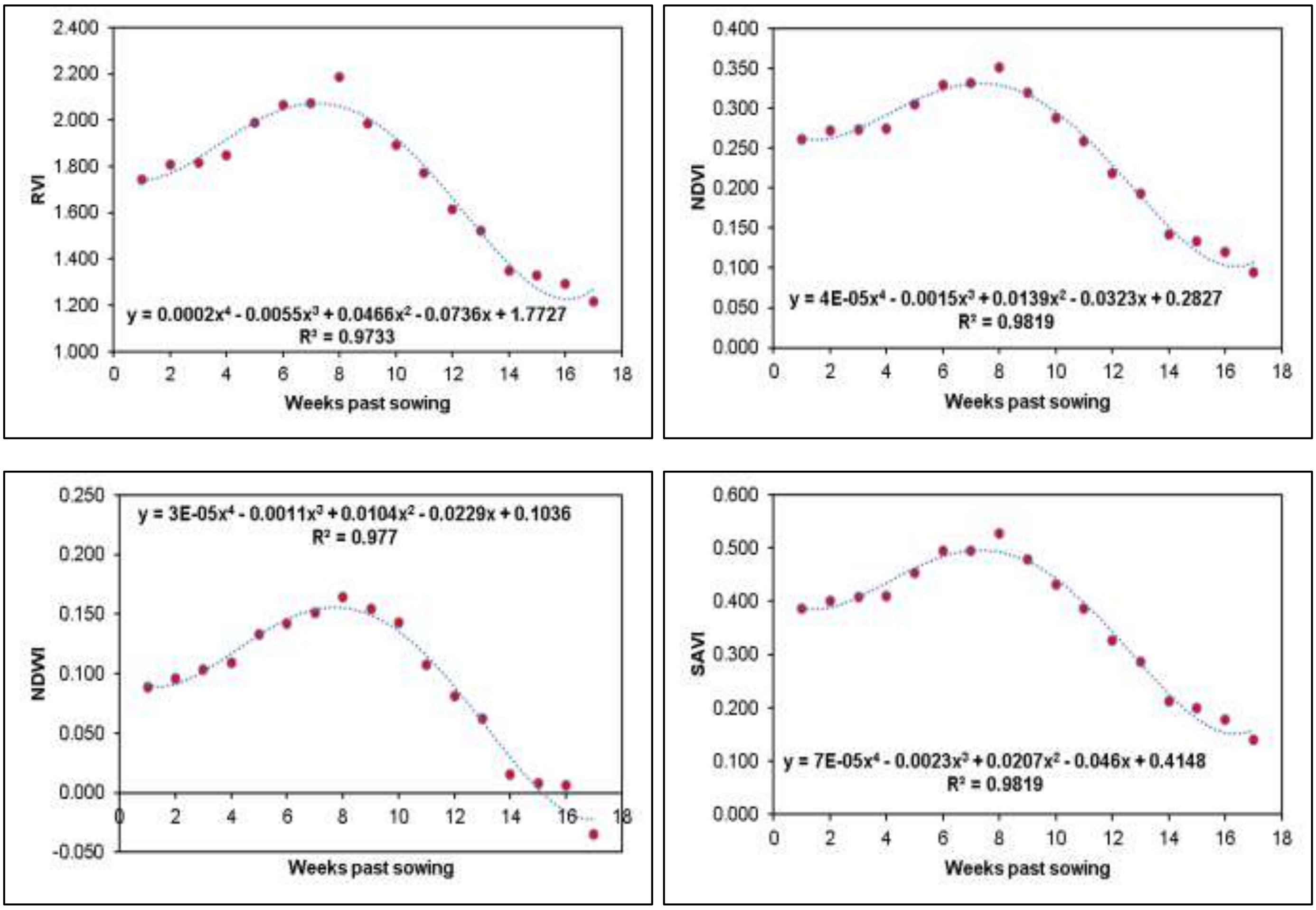

Fig 2: Spectral profile of chickpea

All the VI profiles depicts similar behavior of first starting from a lower value during the initial stages of germination and emergence and then going on increasing up to the 8 th week through the vegetative growth and initial reproductive stages indicating increasing photosynthetic activity. Peak values of each VI were obtained on the 8th week corresponding to pod initiation and thereafter, VI value undergoes a gradual decrease throughout the late season stage till the senescence indicating yellowing of leaves and stem owing to the reduction in photosynthetic activity. As the plants get dried more and more towards the later stages, the value even falls below the initial value and the VI values were observed to be nearly stable during maturity. Furthermore, all the VIs yielded higher values during the 5th to 10th week corresponding to late vegetative and early pod development stages respectively indicating the midseason stage of maximum growth, in general. During the midseason stage, all the VIs yielded nearly constant values during the 6th and 7th week corresponding to the initiation of flowering and 50% flowering respectively.

Conclusion

The study of the spectral behavior of chickpea indicated that all the VI profiles namely, RVI, NDVI, NDWI, and SAVI, have similar behavior of beginning with a lower value during the early stage of germination and emergence and gradually increasing up until the eighth week through the vegetative growth and early reproductive stages, signifying increasing photosynthetic activity. After attaining peak values in the 8th week corresponding to pod initiation, VIs showed a decline throughout the late season stage till the senescence. Towards the later stages, the value even falls below the initial value. All of the vegetation indices (VIs) followed a similar trend to crop coefficients. Conversely, temporal fluctuations in VIs can be used to track phenological information. The defined VI patterns can be used to determine the likely date of planting. Since the patterns of VIs and Kc are similar, Kc can be estimated using vegetative indices for chickpea crop. Furthermore, multispectral VI spectral profiles have got applications in crop identification, acreage estimation, water demand calculation, crop yield modelling etc.

References

1. Ajai, Gopalan A, Kamat DS. Discrimination of winter crops using temporal spectral profiles. International Journal of Remote Sensing. 1985;6(9):1575-1580.
2. Akkara MS, Pimpale AR, Wadatkar SB, Rajankar PB. Role of Multispectral Vegetation Indices in Precision Agriculture: A Review. Int. J Ag. Env. Biotech. 2022;15(Special Issue):277-285.
3. Anonymous. Agriculture Contingency Plan for District: AKOLA; c2017. accessed 2 September 2021
4. Cotton Info. Water Pak-a guide for irrigation management in cotton and grain farming systems; c2012. accessed 20 December 2021
5. Deosthali V, Akmanchi AN. Yield estimation of summer crops grown in a mixed cropping area, a spectral growth curve profile approach. Journal of the Indian Society of Remote Sensing. 2006;34(3):279-288.
6. Grains Research and Development Corporation. Grow Notes TM-GRDC; c2022. accessed 20 December 2021
7. Odenweller JB, Johnson KI. Crop identification using Landsat temporal-spectral profiles. Remote Sensing of Environment. 1984;14(1-3):39-54.
8. Pimpale AR, Wadatkar SB, Pimpale RA, Rajankar PB, Ramteke IK. Comparative performance of different multispectral vegetation indices for determination of crop coefficients of rabi sorghum. International Journal of Agricultural Sciences. 2019;2(6):8164-8167.
9. United States Geological Survey. Earth Explorer; c2022. accessed 15 April 2022 <http://www.earthexplorer.usgs.gov>
10. Wang JC, Passage MB, Yen PH, Shapiro LJ, Mohandas T. Uniparental heterodisomy for chromosome 14 in a phenotypically abnormal familial balanced 13/14 Robertsonian translocation carrier. American journal of human genetics. 1991 Jun;48(6):1069.