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Yield prediction model of summer groundnut based on spectral characteristics

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सार – पश्चिम महाराष्ट्र के मैदानी भागों, पुणे में मूँगफली की ग्रीष्मकालीन फसल में छोटे आकार की मूँगफली से विकसित होकर पूरी मूँगफली बनने की अवस्था (75 डी.ए.एस.) के दौरान स्पेक्ट्रल विशिष्टताओं के अध्ययन किए गए हैं। मूँगफली की ग्रीष्मकालीन फसल की पैदावार के बारे में पूर्वानुमान बताने के लिए एक सामान्य समाश्रयण निदर्श (फसल *vs* वनस्पति सूचकांक, R^2 = 0.94) और एक अन्य बहुसमाश्रयण निदर्श (फसल *vs* बी.:आर.,जी.:आर.,एन.आई.आर.:आर और VI, R^2 = 0.99) विकसित किए गए। पश्चिमी महाराष्ट्र के मैदानी भागों में मूँगफली की ग्रीष्मकालीन फसल की पैदावार के बारे में फसल तैयार होने से एक महीने पहले पूर्वानुमान बताने में छोटे आकार की मूँगफली से विकसित होकर पूरी मूँगफली बनने की अवस्था (75 डी.ए.एस.) के दौरान किए गए स्पेक्ट्रल अध्ययनों के अनुपातों पर आधारित फसल पूर्वानुमान प्रतिरूप सहायक सिद्ध होते हैं।

ABSTRACT. Spectral characteristics were studied at pod development stage (75 DAS) in summer groundnut, at Pune, in western Maharashtra plain zone. A simple regression model (yield *vs*. vegetation index, R^2= 0.94) and another multiple regression model (yield *vs*. B: R, G: R, NIR: R and VI, R^2= 0.99) were developed to predict the yields of summer groundnut. The yield prediction model based on spectral ratios at pod development stage (75 DAS) is helpful in forecasting the yield of summer groundnut, one month in advance, in western Maharashtra plain zone.

Key words – Spectral characteristics, Model, Vegetation index.

1. Introduction

Groundnut (*Arachis hypogea*, Linn.) is the foremost oil seed crop of India. In terms of area (6.93 M ha) and production (6.58 Mt), it occupies an important position amongst oil seed crops. In Maharashtra, in 1998-99, summer groundnut occupied 1,35,000 ha area and produced 1,93,000-ton pod with a productivity of 1430 kg per ha. Productivity of summer groundnut is higher than *kharif* groundnut (1164 kg per ha). Also, summer groundnut is free from pests and diseases. Though area under summer season is less its contribution to total production is high. Hence, it is very important to increase the productivity of summer groundnut. The yields can be predicted by remote sensing techniques, well in advance of harvest. Therefore, a study was conducted to develop the models for the same.

2. Materials and methods

The experiment was carried out during summer season of 1998 in Factorial Randomized Block Design with four replications and two crop geometeries with spacing of 30.0 × 15.0 cm (S_1) and 37.5 × 15.0 cm (S_2) at the farms of Center of Advanced Studies in Agricultural Meteorology, College of Agriculture, Pune. Groundnut cultivar SB-XI was dibbled on 15 January (D1), 30 January (D2) and on 17 February (D3) 1998

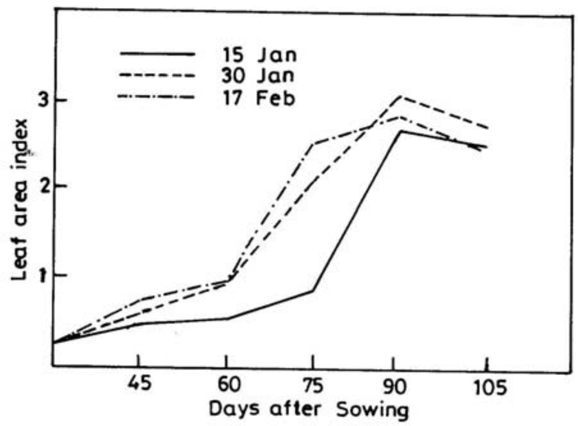

Fig. 1. Variation in leaf area index at different growth stages (DAS) under different sowing date

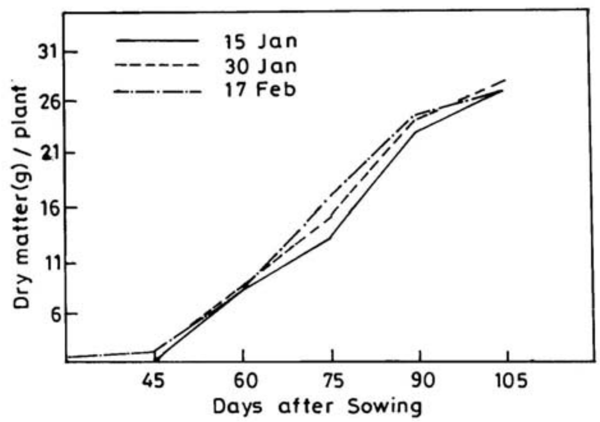

Fig. 3. Variation in dry matter (g) per plant at different growth stages (DAS) under different sowing date

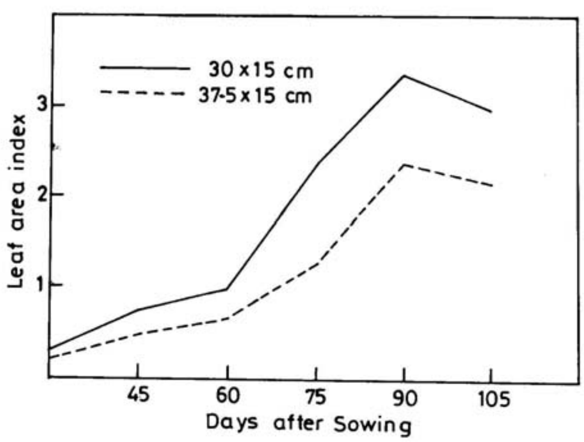

Fig. 2. Variation in leaf area index at different growth stages (DAS) under different row spacing

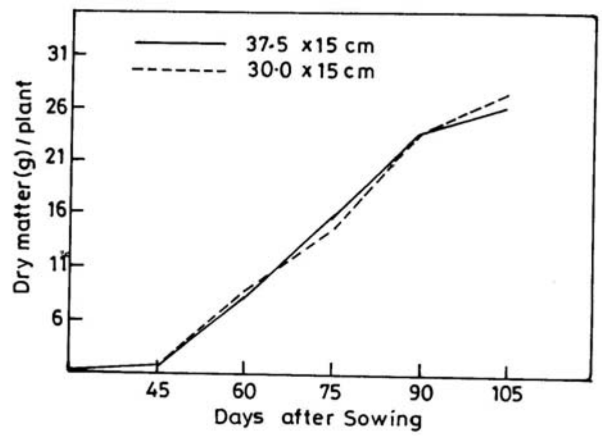

Fig. 4. Variation in dry matter (g) per plant at different growth stages (DAS) under different sowing date

by giving pre-sowing irrigation. The gross plot size was 6.0 × 4.5 m. The site was uniform, leveled and well drained with deep black soil of 100 cm depth.

The spectral reflectance of canopy was measured by remote cosine receptor (LI- 1800-10) inverted over the canopy, connected to the spectroradiometer (LI-1800) through a quartz fiber optic probe. The portable terminal (1800-01B) was used to operate the internal micro-computer of spectroradiometer. The reflectance ratios were computed by the internal microcomputer of spectroradiometer. The albedo of photosynthically active radiation (PAR; 400-700 nm), blue (B; 425-490 nm), green (G; 490-560 nm), red (R; 640-740 nm), and near infrared (NIR; 750-850 nm) were measured for each treatment in four replications. The vegetation index (VI), a normalized reflectance ratio was worked out as suggested by Ayyangar *et al*., (1980) and Wiegand and Richardson, (1984) as under ;

$$VI = (NIR - R) \div (NIR + R)$$

Where, VI is vegetation index and NIR is near infra red.

A stand of 3.6 m height was fabricated from 2.5 cm mild steel square pipe rested on a base frame of identical square pipes. Holes were drilled in the vertical pipe at 15 cm interval to hold 80 cm long beam of similar pipe

TABLE 1

Correlation coefficient between dry matter and yield with spectral reflectance ratios (B: R, G: R, NIR: R and VI)

Spectral Reflectance	Dry Matter					
DAS	30	45	60	75	90	105
B : R	-0.48*	0.52**	-0.46*	-0.41*	0.16	0.48*
G : R	0.10	0.40	-0.20	0.49*	0.46*	-0.01
NIR : R	-0.11	0.26	0.14	0.31	0.68**	-0.02
VI	0.18	0.01	0.37	0.36	0.33	-0.67**
	Yield					
DAS	30	45	60	75	90	105
B : R	-0.24	0.49*	-0.39	-0.82**	0.40	-0.09
G : R	-0.09	0.34	0.16	0.22	0.84**	-0.65**
NIR : R	0.22	0.27	0.77**	0.26	0.52**	-0.53**
VI	0.48*	0.3	0.87**	0.97**	0.04	0.64**

* Significant ** Highly significant

with the help of nuts and bolts. The cosine receptor was installed on a 30 × 30 cm wooden platform attached to the other end of the beam. The stand was strong and firm enough to hold the sensor inverted above the crop canopy. The sensor was leveled and held inverted above the crop canopy. The measurements were made at different heights above the crop canopy in each treatment and it was observed that a height, double the row spacing was appropriate because, cosine receptor viewed the crop as a homogeneous canopy at that height. Accordingly, all the measurements were made at 30,45,60,75,105 days after sowing (DAS) for the summer groundnut. Similarly, all measurements were made on clear days at solar noon when the angle of elevation of the Sun was maximum.

3. Results and discussion

3.1. *Correlation studies*

Correlation between dry matter and pod yield of summer groundnut with reflectance ratio of Blue: Red (B: R), Green: Red (G: R), Near infrared : Red (NIR: R) and Vegetation Index (VI) at different stages of crop growth were studied and presented in Table 1. Groundnut is an indeterminate crop and flowering continues for a longer time. Therefore, vegetative and reproductive growth goes on simultaneously. Leaf area index and dry matter per plant under different sowing dates and crop geometry were recorded at all the growth stages (Figs. 1- 4). It is evident that maximum variations because of sowing dates and crop geometry were clearly indicated at pod formation stage (75 DAS). Thus, pod formation stage (75 DAS) is one of the important growth stages, studies on spectral reflectance ratios, at this stage, can reveal valuable information of crop.

The correlation studies (Table 1) indicated that blue to red reflectance ratio B: R had significant correlation with dry matter at all the growth stages except at pod development stage (90 DAS). While, it had significant correlation with pod yields only at pegging (45 DAS) and at pod formation stage (75 DAS) of groundnut crop.

Green to red reflectance ratio G: R had significant correlation with dry matter at pod formation stage (75 DAS) and pod development stage (90 DAS). While, it had highly significant correlation at pod development stage (90 DAS) and at maturity stage (105 DAS) with pod yield.

Near infrared to red reflectance ratio NIR: R showed highly significant correlation at pod development stage (90 DAS) with dry matter and with pod yield at pod initiation (60 DAS), pod development stage (90 DAS) and at maturity stage (105 DAS).

Vegetation index (VI) expressed highly significant correlation at maturity (90 DAS) with dry matter. It had highly significant correlation with pod yield at pod initiation (60 DAS), pod formation stage (75 DAS) and at maturity (90 DAS).

Thus, it is evident that all the reflectance ratios except blue to red reflectance ratio had highly significant

TABLE 2

Observed yields and estimated yields by the simple regression model based on VI measured at 75 DAS

Treatments	Yield (kg ha^{-1})		Error (O-E) (%)
	Observed (O)	Estimated (E)	
T1	1955	1991.2	1.8
T2	1849	1841.2	0.4
T3	2536	2441.1	3.8
T4	2347	2391.1	1.8
T5	2418	2491.0	2.9
T6	2292	2241.2	2.7

TABLE 3

Observed yields and estimated yields by the multiple regression model based on B:R, G:R, NIR:R and VI ratios measured at 75 DAS

Treatments	Yield (kg ha^{-1})		Error (O-E) (%)
(kg ha^{-1})	Observed (O)	Estimated (E)	
T1	1955	1944.1	0.6
T2	1849	1851.7	0.1
T3	2536	2523.4	0.5
T4	2347	2448.9	4.8
T5	2418	2411.8	0.3
T6	2292	2300.6	0.4

correlation with pod yield at maturity (105 DAS). But, prediction need to be made in advance hence, correlation at maturity was of no use. Green to red reflectance ratio G: R and near infrared to red reflectance ratio NIR: R had highly significant correlation with pod yields at pod development stage (90 DAS). But this will leave very short time for processing the data. Correlation studies indicated that the blue to red reflectance ratio and vegetation index had highly significant correlation, with pod yield at pod formation stage (75 DAS), which had immense value for prediction. Thus, regression models were developed to predict the yield of summer groundnut based on spectral characteristics at pod formation stage (75 DAS).

3.2. *Yield prediction models*

In view of above correlation studies a simple regression model was developed with pod yield and vegetation index.

$$Y = -508.5 + 4999.4\ VI \qquad (R^2 = 0.94)$$

The observed and estimated yields with this model are given in Table 2. It is evident that error in yield prediction ranged from 0.4 – 3.8 % only, which is very small.

Similarly, a multiple regression model was developed with spectral reflectance ratio *viz.*, B: R, G: R, NIR: R and VI and pod yield. Ratio based yield prediction model was as under;

$$Y = 498 - 1841\ (B{:}R) + 1413\ (G{:}R) - 349\ (NIR : R) + 4607\ (VI) \qquad (R^2 = 0.99)$$

The result of multiple regression models was highly significant (Table 3). The predicted yields indicate that error ranged from 0.1 – 4.8 % only, which is again very small. These results are in conformity with the results of Rajhans *et al*., 1995 for sorghum and Shendage, 1996 for chick pea.

The yield predication model based on spectral ratios at the pod formation stage (75 DAS) is helpful in assessing the crop yield one month in advance. Such information would be useful as discriminating feature for remote sensing applications.

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