551.5 : 63

YIELD PREDICTION MODEL OF GRAM BASED ON SPECTRAL CHARACTERISTICS

1. Gram (*Cicer arientinum*) is an important pulse crop of India. In terms of area (6.76 M ha) and production (5.56 Mt), it occupies an important position amongst pulse crops. In Maharashtra, gram is grown during *rabi* season occupying an area of 0.76 M ha with a production of 0.56 Mt. The productivity is only 730 kg per ha. Hence, it is very important to increase the productivity of gram. 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. The experiment was carried out during summer season of 1995 in Factorial Randomized Block Design with four replications and two crop geometeries with spacing of 30.0 × 10.0 cm (S_1) and 22.5 × 10.0 cm (S_2) at the farms of Center of Advanced Studies in Agricultural Meteorology, College of Agriculture, Pune. Vijay variety of gram was dibbled on 11 November (D1), 26 November (D2) and on 11 December (D3), 1995.The gross plot size was 4.0 × 3.6 m and net plot size was 3.2 × 3.0 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 infra red (NIR; 750-850 nm) were measured for each treatment in four replications. The vegetation index (VI), a

TABLE 1

Correlation coefficient between LAI, Biomass and Seed yield with spectral reflectance ratios (B: R, G: R, NIR: R and VI) in gram

Spectral reflectance	LAI			Biomass			Seed yield		
	GS_1	GS_2	GS_3	GS_1	GS_2	GS_3	GS_1	GS_2	GS_3
B : R	-0.06	-0.75	-0.47	-0.12	-0.46	-0.73	0.22	0.76	0.62
G : R	0.57	-0.93*	-0.30	0.45	-0.55	-0.56	-0.51	0.42	0.48
NIR : R	0.69	-0.98*	-0.60	0.64	-0.62	-0.88	-0.47	0.54	0.71
VI	0.64	-0.98*	-0.60	0.57	-0.64	-0.88	-0.47	0.54	0.72

* Significant at 1% level of significance

TABLE 2

LAI, Biomass and Seed yield under different sowing dates and row spacings

Treatment	LAI			Biomass (g plant^{-1})			Seed Yield (kg ha^{-1})
	GS_1	GS_2	GS_3	GS_1	GS_2	GS_3	
Sowing Date							
11 Nov	0.22	1.79	0.44	0.45	3.78	9.33	4270
26 Nov	0.21	1.68	0.36	0.44	3.95	8.91	4219
11 Dec	0.25	1.75	0.37	0.45	4.05	9.38	4167
SE±	0.01	0.01	0.01	0.01	0.05	0.04	34.9
CD at 5 %	0.00	0.00	0.00	–	0.15	0.12	–
Spacing (cm)							
30×10	0.18	1.21	0.31	0.41	3.78	8.57	4203
22.5×10	0.27	2.20	0.46	0.48	4.06	9.84	4145
SE±	0.01	0.01	0.01	0.01	0.04	0.03	28.4
CD at 5 %	0.00	0.00	0.00	0.03	0.12	0.10	82.1
Interaction							
SE±	0.01	0.01	0.01	0.01	0.07	0.06	49.2
CD at 5 %	0.00	0.01	0.01	0.03	–	0.17	–
General mean	0.23	1.74	0.39	0.45	3.92	9.21	4219

TABLE 3

Observed yields and estimated yields by the multiple regression model based on B:R, G:R and NIR:R ratios measured at GS_2 in gram

Treatments	Yields (kg ha^{-1})		Error (O-E) (%)
	Observed (O)	Estimated (E)	
Sowing date			
11 November	4271	4265	0.13
26 November	4219	4215	0.09
11 December	4167	4164	0.07
Spacing			
30.0 ×10.0 cm	4293	4299	0.14
22.5 ×10.0 cm	4145	4152	0.15

normalized reflectance ratio was worked out as suggested by Ayyangar *et al.*, (1980) and Wiegand and Richardson, (1984) as under ;

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

A stand of 3.6m 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 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, the measurements were made at all the growth stages, *viz.*, flowering (GS_1), pod initiation (GS_2) and maturity (GS_3). Similarly, all measurements were made on clear days at solar noon when the angle of elevation of the sun was maximum.

3. *Correlation studies* - Correlation between leaf area index, biomass and seed yield of gram 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 are presented in Table 1. Leaf area index (LAI) and biomass per plant under different sowing dates and crop geometry were recorded at all the growth stages (Table 2). It is evident that maximum variations in leaf area index because of sowing dates and crop geometry were clearly indicated at pod initiation stage (GS_2). While, at maturity variations in biomass and seed yield were the highest. The seed yields were the highest in first sowing (11 November) and normal spacing (30.0 × 10.0 cm). However, predictions at maturity are of less practical importance since, it leaves very little time for crisis management, if any. Thus, pod initiation stage (GS_2) is one of the most important growth stage, 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 non-significant correlation with LAI, biomass and seed yield at all the growth stages.

Green to red reflectance ratio (G:R) had highly significant correlation with LAI, at pod initiation stage (GS_2) and non-significant correlation with biomass and seed yield at all the growth stages.

Near infrared to red reflectance ratio (NIR: R) also showed highly significant correlation at pod initiation stage (GS_2) with LAI and non-significant correlation with biomass and seed yield at all the growth stages.

Vegetation index (VI) also expressed highly significant correlation at pod initiation stage (GS_2) with LAI and non-significant correlation with biomass and seed yield at all the growth stages.

4. *Yield prediction model* - In view of above correlation studies a multiple linear regression model was developed with seed yield and spectral reflectance ratio *viz.*, B:R, G: R and NIR:R. Ratio based yield prediction model was as under;

$$Y = 4819 + 11351\ (B : R) + 13271\ (G : R) - 3672\ (NIR : R) + 4607\ (VI) \quad (R^2 = 0.99)$$

Which resembled with $Y = a_o + a_1 x_1 + a_2 x_2 + a_3 x_3$. The result of multiple linear regression model was highly significant (Table 3). The predicted yields indicate that error ranged from 0.07-0.15 % only. These results are in conformity with the results of Rajhans *et al.*, 1995 for sorghum and Jaybhaye, 1998 for summer groundnut.

The yield predication model based on spectral ratios at the pod initiation stage (GS_2) is helpful in assessing the crop yield one and half to two month in advance. Such information would be useful as discriminating feature for remote sensing applications.

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16 October 2000, Modified 21 June 2001