Spectral Reflectance of Sorghum Crop as Influenced by Nutrient, Irrigation and Plant Canopy

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Abstract : *Spectral response of sorghum was studied under different levels of nitrogen, irrigation and planting pattern using hand-held radiometer. The results revealed that the spectral ratio, (IR/R) was highest between 55 and 65 days of sorghum growth. There was significant difference between different levels of nitrogen. Highest spectral reflectance was obtained at 135 kg N/ha. There was no significant difference between solecrop of sorghum planted under normal row and paired row, but, the spectral reflectance was influenced by intercropping of sorghum with cowpea. Although nutrient stress can be monitored through remote sensing technique, discrimination of species in annual crops under intercropping/mixed cropping was found difficult.*

The crop production is a function of its growth conditions and is regulated by various parameters like water, nutrient supply, plant population, etc. Deviations in one or more of these factors from its normal condition induce stress in plants and affect the production. Use of remote sensing technique to monitor crop growth, detect stress and evaluate its productivity have received attention in recent times (Idso *et al.* 1977; Sahai *et al.* 1981; Singh & Das, 1983; Kamat *et al.* 1985).

MATERIALS AND METHODS

Two sets of field experiment were conducted in Vertisols at Tamil Nadu Agricultural University, Coimbatore during 1989-90 *kharif* season. Set one comprised of two varieties of sorghum (CO. 25 and CO. 26) each with four levels of nitrogen (0, 45, 90 and 135 kg N/ha) and with basal application of 45 kg P_2O_5/ha and 45 kg K_2O/ha. Set second included sorghum variety CO. 26 with two levels of irrigation (normal and at critical stages) and four methods of planting pattern (sorghum alone in normal, and in paired row planting; paired row planting intercropped with cowpea and sole cowpea).

Randomised Block Design with four replications in 5x5.5 m plot size was common. Critical stages of irrigation for sorghum were three phenophases, viz.

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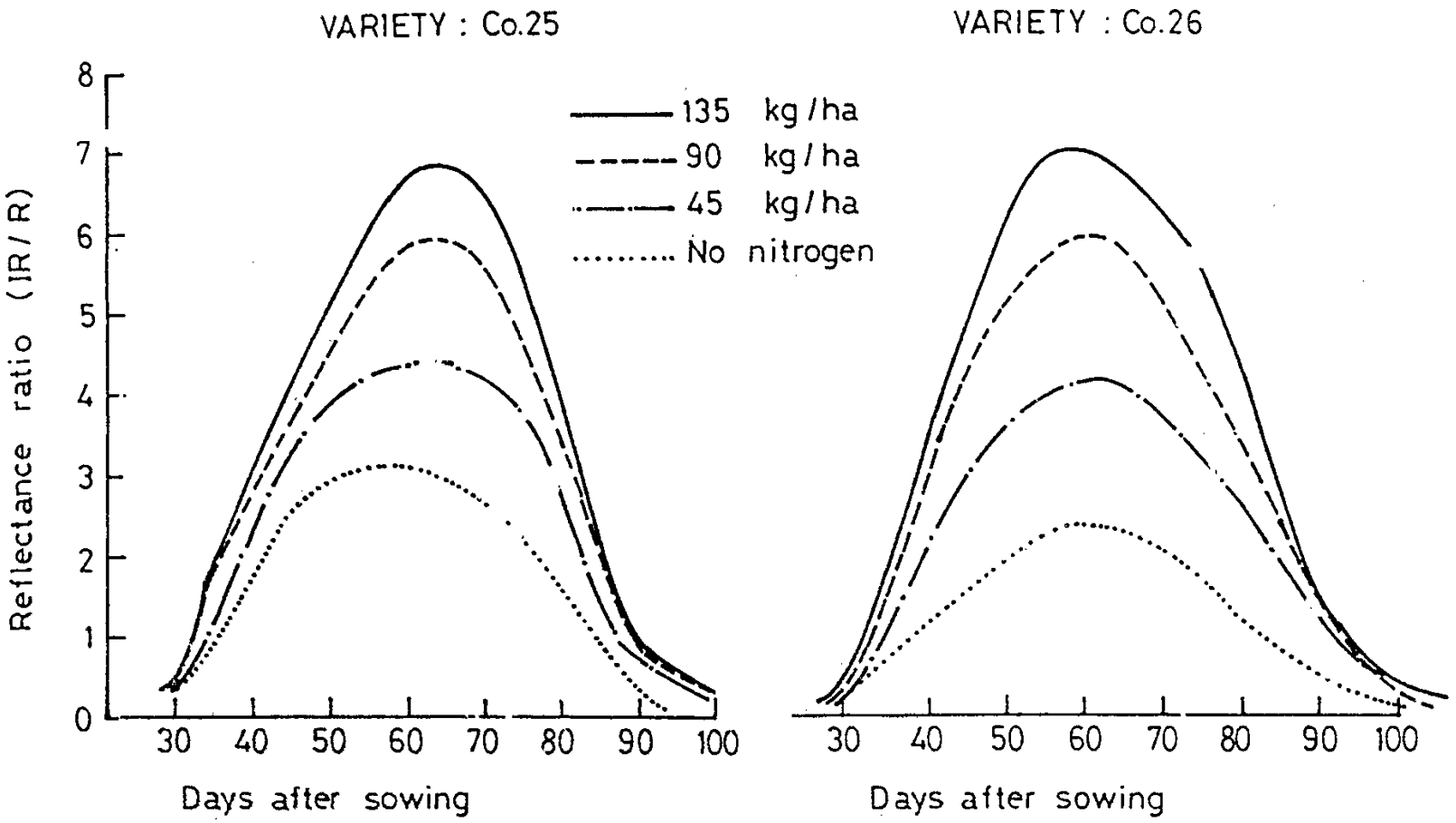

Figure 1. Temporal variation of reflectance ratio (IR/R)of sorghum under different levels of nitrogen

TABLE 3. Effect of nitrogen on LAI and production of sorghum

Treatment	Leaf Area Index (LAI)			Dry matter (kg/ha)			Grain yield kg/ha
	30th day	60th day	90th day	30th day	60th day	90th day	
V_1N_0	1.94	3.94	3.27	303	3865	4773	1333
V_1N_{45}	2.19	4.95	4.48	480	6094	7943	2570
V_1N_{90}	2.28	4.95	4.80	680	7185	8876	3006
V_1N_{135}	2.28	5.54	4.92	875	8159	10735	3309
V_2N_0	1.85	3.53	3.11	324	4362	5756	1418
V_2N_{45}	2.21	5.34	4.83	641	6725	8814	2570
V_2N_{90}	2.33	5.87	4.88	813	8218	9868	3115
V_2N_{135}	2.51	5.81	5.36	915	9000	11940	3636
SE	--	--	--	--	--	--	16.93
CD (0.05)	--	--	--	--	--	--	51.38

V_1 - Variety CO.25; V_2 - Variety CO.26

vegetative, flowering and maturity corresponding approximately 30th, 60th and 90th day after sowing. The vegetative and maturity stages for sole cowpea correspond to 30th and 60th day after sowing.

Leaf area index (LAI) and total biomass (above-ground) were measured at three phenophases of sorghum. Spectral data were collected using hand-held spectro radiometer with 10 days interval from 30 to 100 days in sorghum and from 30 to 70 days in cowpea, at wavelength between 400 and 850 nm with a difference of 50 nm.

RESULTS AND DISCUSSION

Effect of Nitrogen

The leaf area index and dry matter production were found to be influenced by different levels of nitrogen in both the varieties in all the three phenophases (Table 1). However, the dry matter production and LAI of CO. 26 was higher than CO. 25. The spectral reflectance of sorghum crop was influenced by different levels of nitrogen due to increase in leaf area and biomass production irrespective of varieties. However, there was no significant difference in spectral ratio IR/R between varieties (Fig. 1). The highest reflectance was observed in the treatment receiving more nitrogen (135 kg N/ha) followed by other levels. The spectral reflectance was lowest in plot receiving no nitrogen. The highest peak in reflectance was observed between 55 and 65 days. There was a positive relationship between the spectral reflectance and grain yield. The treatment which has given higher reflectance in all the three phenophases has also recorded significantly higher yield.

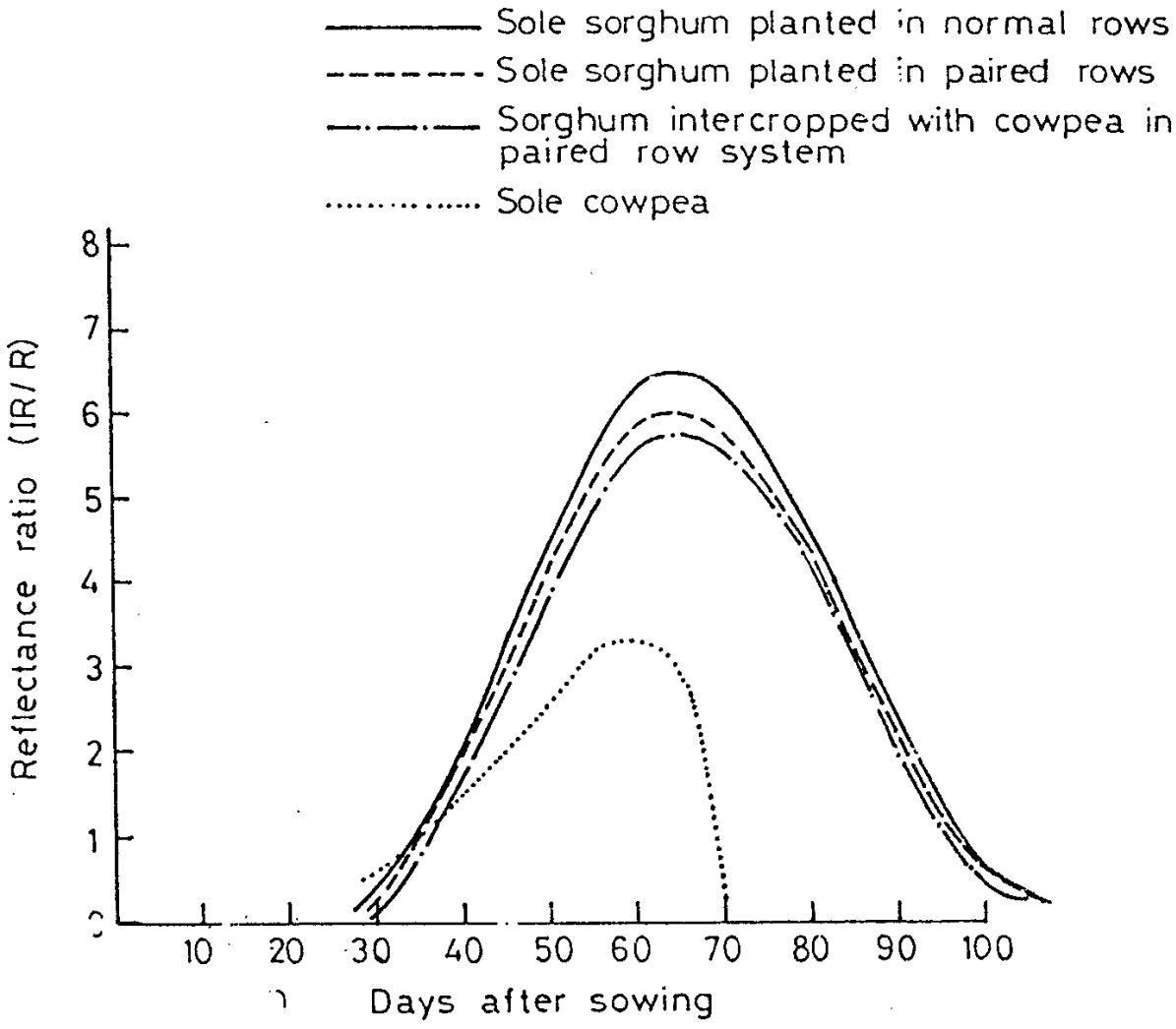

Figure 2. Temporal variation of reflectance ratio (IR/R) of sorghum under different planting pattern

TABLE 2. Effect of irrigation and planting pattern on LAI and crop production

Treatment	Leaf Area Index (LAI)			Dry matter (kg/ha)			Grain yield kg/ha
	30th day	60th day	90th day	30th day	60th day	90th day	
T_1	2.26	5.65	4.80	947	7950	11483	3272
T_2	2.25	5.61	4.70	933	7745	11377	2364
T_3	2.23	5.30	4.38	848	7215	11213	2182
	(1.60)	(3.65)		(440)	(1733)		
T_4	1.85	4.87	--	613	2552	--	388
T_5	2.24	5.64	4.78	930	7783	11452	3297
T_6	2.22	5.60	4.69	915	7358	11098	2339
T_7	2.25	5.25	4.33	840	7192	1159	2097
	(1.61)	(3.58)		(451)	(1712)		(161)
T_8	(1.82)	(4.88)	--	(577)	(2519)	--	(379)
SE	--	--	--	--	--	--	49.53
CD (0.05)	--	--	--	--	--	--	156.93

Figures in parenthesis denote cowpea

Treatments:

T_1 - Sorghum sole crop - normal planting - normal irrigation.
T_2 - Sorghum sole crop - paired row planting - normal irrigation.
T_3 - Sorghum + Cowpea - aired row planting - normal irrigation.
T_4 - Cowpea sole crop - normal planting - normal irrigation.
T_5 - Sorghum sole crop - normal planting - critical stage irrigation.
T_6 - Sorghum sole crop - paired row planting - critical stage irrigation.
T_7 - Sorghum + Cowpea - paired row planting - critical stage irrigation.
T_8 - Cowpea sole crop - normal planting - critical stage irrigation.

Effect of Irrigation

In all the three phenophases of sorghum, there was little difference in LAI, dry matter production and spectral reflectance between two methods of irrigation (Table 2). This is due to frequent rains during the phenophases studied. Because of sufficient soil moisture, there was no moisture stress and hence the treatmental effects were nullified. The dry matter production, leaf area index and spectral reflectance were slightly higher under normal planting compared to paired row planting in all the stages. Due to intercropping of cowpea, the dry matter production of sorghum was reduced which in turn reduces the spectral reflectance. (fig. 2). The discrimination of sorghum and cowpea based on spectral reflectance

alone may not be possible due to the combined reflection within a unit area under intercropping/mixed cropping. The sole crop of sorghum under normal planting has recorded higher biomass and higher spectral reflectance and ultimately the higher yield, showing a positive relationship in between them.

It is thus concluded that nutrient stress can be monitored through remote sensing technique. Discrimination of species in annual crops under intercropping/mixed cropping situation is difficult by measuring spectral reflectance alone. Since there is a positive, relationship between spectral reflectance and biomass and grain yield it is possible to estimate the biomass and grain yield of annual field crop like sorghum through remote sensing technique. Intensive basic and field studies on large scale are needed to confirm the results.

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