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Estimating extinction coefficient of Pigeon Pea (*Cajanus cajan* L.) grown under different spacings

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ABSTRACT

Extinction coefficient is a measure of attenuation of radiation within a crop canopy which solely depends on foliage volume of a crop. Field experiment on pigeon pea was carried out during winter season of 2004-05 at Kalyani, BCKV (22°30' N and 89° E) to find out the effect of plant height and LAI on the extinction coefficient of crop. The crop was sown on 25th October, 2004, with two spacings viz. 15cm x 30cm and 30cm x 45cm. The total solar radiation and photosynthetic active radiation were measured on 31st December 2004, 14th February and 15th March 2005 with LICOR Photoradiometer. The extinction coefficients, calculated using Beer's Law, increased with the increase in plant height and LAI with higher attenuation of radiation within the canopy. Crops grown with wider spacing was associated with higher attenuation of radiation and extinction coefficient and lesser yield and sunlit leaf than those obtained from crops grown with narrow spacing.

Key Words : Pigeon pea, total solar radiation, photosynthetic active radiation , leaf area index, extinction coefficient.

The crop production is a system of harvesting solar energy through biotic component of an ecosystem. Loomis *et al.* (1971) have suggested that its efficiency should be assessed in terms of conversion of solar energy into useful end-products. Understanding the radiation environment within the crop is of paramount importance for identifying the different processes of a crop growth and development. Even simple practices viz. varied dates of sowing and different spacings may lead to the marked variation in the radiation environment within the crop canopy. Pigeon pea (*Cajanus cajan* L.), has received less attention from researchers regarding radiation environment. Extinction coefficient for a particular medium or crop stand is a measure of attenuation of radiation within the medium or crop canopy. It depends on the canopy structure, leaf arrangement and leaf morphology and the branching pattern of a crop (Taylor, 1975). The present study aims to determine extinction coefficient and its relationship with plant height and leaf area index of pigeon pea.

MATERIALS AND METHODS

The experiment was carried out during winter season of 2004-05 at the 'C' Block Farm, Kalyani, Bidhan Chandra Krishi Viswavidylaya (22°30'N and 89° E) having a sandy clay loam soil texture and moderate fertility status. The pigeon pea seed was sown on 25th October, 2004 with two spacings, 15cm x 30cm (C1) and 30cm x 45cm (C2) and three replications. The total solar radiation (TSR) and photosynthetic active radiation (PAR) were measured at 75DAS, 90 DAS and 120 DAS with the help of LICOR Photoradiometer (Model 185 B). The direct incident radiation was measured by placing the sensor horizontally 25cm above the crop and transmitted radiation was measured below the canopy at ground level. A pyranometer sensor was used for TSR while a quantum sensor was used for PAR.

Nine green, expanded, uninjured leaves from each plot were selected and laminae were placed on a sheet of graph paper to draw their outline and to measure the areas. The collected leaf lamina were dried in hot air oven and weighed by high precision electrical balance to calculate the area-weight ratio for each treatment. This factor was multiplied with respective leaf by dry weight (per m^2).

Leaf area index was estimated at 75, 90 and 120 DAS as follows:

$$LAI = \frac{\text{Leaf area}}{\text{Land area}}$$

Five plants from each plot were tagged for measuring plant height. The average values have been used for analysis.

The extinction coefficient for TSR and PAR were calculated using Beer's law as adopted by Uchijima (1976) as follows:

$$K_b = \frac{Sb(O)\exp(-K_bL)}{\ln[S_b(L)/S_b(O)]} \Big/ -L$$

where, $S_b(L)$ = incident radiation at the bottom level of the canopy having LAI of L

$S_b(O)$ = incident radiation at the top level of the canopy; K_b = Extinction coefficient; L = Leaf area index.

RESULTS AND DISCUSSION

Results showed that transmission of TSR and PAR within the pigeon pea canopy was less when wide spacing was given to the crop (Table 1). Under wide spacing (C2), the value of extinction coefficient (Kb) was more on all dates of observations in comparison to the close spacing (C1). This might be attributed to more branching and bigger leaf size under wide spacing which offered more barrier to the transmission of light. The extinction coefficient (K_b) of the pigeon pea increased with the increase in spacing which recorded higher plant height as well as low leaf area index (Table 2). As the plant height increased, it created more impasse to the transmission of light to the lower layer of the canopy which ultimately increased the Kb value. Although in the wider spacing, LAI was low because of lesser number of leaves but it offered more resistance to the penetration of light because of higher leaf size. The extinction coefficient of pigeon pea and the plant height had a correlation value of 0.8. The yield of pigeon pea was low under the wide spacing due to more reduction of TSR and PAR within the crop canopy because of higher K_b values which curtailed the penetration of light and produced less amount of sunlit leaf within the lower strata of the canopy. The K_b value of pigeon pea showed that leaf was erectophile in nature. The K_b values obtained in this experiment are in agreement with Monteith (1969), Uchizima (1976), Jones (1996) and Robertson *et al.* (2001) where these authors obtained the values ranging from 0.5 to 0.7.

Table 1. Incident and transmitted radiation with Extinction Coefficient of Pigeon Pea under different spacings.

		75 DAE			90 DAE			120 DAE		
Treatment		Incident	Transmitted	Kb	Incident	Transmitted	Kb	Incident	Transmitted	Kb
TSR	C1	460.0	180.0	0.265	550.0	136.7	0.282	800.0	90.0	0.434
	C2	460.0	176.7	0.314	550.0	121.7	0.349	820.0	83.3	0.517
PAR	C1	63.0	23.0	0.284	93.0	13.5	0.391	141.0	5.0	0.664
	C2	72.0	21.0	0.404	93.0	11.5	0.483	141.0	6.0	0.713

Table 2. Plant Height, LAI, Extinction Coefficient and yield of Pigeon Pea under different spacings.

		75 DAE			90 DAE			120 DAE			YEILD
		Pl.Ht (cm)	LAI	Kb	Pl.Ht (cm)	LAI	Kb	Pl.Ht (cm)	LAI	Kb	(q/ha)
TSR	C1	84.3	3.55	0.265	97.8	4.94	0.282	122.3	5.03	0.434	17.42
	C2	87.0	3.05	0.314	100	4.33	0.349	130.3	4.43	0.517	11.90
PAR	C1	84.3	3.55	0.284	97.8	4.94	0.391	122.3	5.03	0.664	17.42
	C2	87.0	3.05	0.404	100	4.33	0.483	130.3	4.43	0.713	11.90

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