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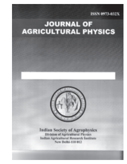

Short Communication

Leaf Area Index and Sunlit Leaf Area Index and their Impacts on Leaf Dry Matter Accumulation in Rice (*Oryza Sativa* L.) under Different Dates of Planting

P.K. CHAKRABORTY[1]*, S. BASU[2], S.K. DUTTA[2], D. FANGZAUVA[1], S. JENA[2] AND R. NATH[2]

[1]Department of Agril. Meteorology and Physics, [2] Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia-741 252, West Bengal

The distribution of radiant energy within a crop canopy is a function of leaf area index (LAI) (Monteith and Unsworth, 2001). The LAI significantly influences dry matter accumulation and yield of the crop. Transmission of radiation decreases as the LAI increases (Fangzauva, 2011). This leaves the possibility of shaded leaves within the crop canopy. Gates (1981) developed the idea of sunlit leaf area index (L*), which was modified by Monteith and Unsworth (2001). This was applied to compute the L* in field crop by Jena *et al.* (2010). The principle of radiation geometry is applied in the computation of sunlit LAI within a crop canopy. There have been few attempts to compute the sunlit LAI and its impact on dry matter accumulation of leaf in the rice crop. To address this, a two-year experiment (2007 and 2008) with rice was conducted at the B.C.K.V research farm, Kalyani ($22^0$56' N latitude and $88^0$32'E longitude, 9.75 m above mean sea level). The climate is tropical humid with an average annual rainfall 1600 mm, out of which 1300 mm occurs during monsoon. The soil is Entisol, sandy soil in texture, pH is 7.45, and N, P and K content are 0.07%, 22 kg P_2O_5 ha^{-1} and 126 kg K_2O ha^{-1} respectively.

The experiment was laid in a randomized block design with 4 replications. The seedlings (25 days old) of the variety *Satabdi* (IET 4786) was transplanted between 1^{st} and 29^{th} July with weekly interval (five dates of transplanting: D_1, D_2, D_3, D_4 and D_5). The row-to-row and plant-to-plant spacing were kept as 20 and 15 cm, respectively with the plot size as 30 m^2. The N: P_2O_5: K_2O fertilizers were applied as 80:60:60 kg ha^{-1} through urea, SSP and MOP. Half of N and entire amount of P_2O_5 and K_2O were applied as basal during puddling and the rest of the N was applied on 25 and 45 days after transplanting (DAT). The LAI was measured at tillering, panicle initiation, panicle emergence and 100% anthesis following area-weight relationship developed by Watson (1952). To measure the sunlit LAI, incident Photosynthetically Active Radiation (PAR) at the top of the canopy and the bottom of the canopy were taken with the help of line quantum sensor (APOGEE, Delta-T instrument, UK) at 7.30, 9.30, 11.30, 13.30 and 15.30 h. The sunlit LAI was computed following the procedure as given in Monteith & Unsworth (2001)

The LAI increased from tillering to 100% anthesis, but also decreased with delay in transplanting (Table 1). At tillering, the LAI reduced by 10, 18, 10 and 23% for D_2, D_3, D_4 and D_5 transplanting dates, compared to D_1. The trend was similar in other phenophases. The rate of increase in LAI was higher during transplanting

*Corresponding author, Email: prodip56@gmail.com

Table 1. Effect of dates of transplanting on LAI at the different phenophase of rice (pooled mean of 2007 and 2008)

Treatment	Tillering	PI	Emergence	Anthesis 100%
D_1	4.0	6.4	8.2	8.4
D_2	3.6	6.0	7.7	8.0
D_3	3.3	5.9	7.5	8.1
D_4	3.6	5.2	7.3	7.8
D_5	3.1	4.9	6.8	7.7
S.Em(+)	0.09	0.24	0.17	0.09
C.D. 5%	0.26	0.73	0.52	0.26

Table 2. Rate of LAI development (LAI day^{-1}) in rice as affected by dates of transplanting

Treatment	Transplanting-Tillering	Tillering-PI	PI-Emergence	Emergence-Anthesis
D_1	0.17	0.19	0.10	0.02
D_2	0.12	0.23	0.11	0.02
D_3	0.11	0.37	0.08	0.07
D_4	0.12	0.35	0.11	0.06
D_5	0.11	0.45	0.09	0.08

Table 3. Diurnal variation in sunlit LAI in rice under different dates of transplanting (Mean of two-years)

Treatment	7:30	9:30	11:30	13:30	15:30	Mean
			Tillering			
D_1	0.805	1.335	1.505	1.465	1.175	1.257
D_2	0.79	1.305	1.47	1.435	1.155	1.231
D_3	0.765	1.275	1.43	1.39	1.12	1.196
D_4	0.75	1.28	1.445	1.41	1.125	1.202
D_5	0.725	1.235	1.385	1.355	1.085	1.157
			PI			
D_1	0.77	1.385	1.61	1.555	1.19	1.302
D_2	0.75	1.365	1.59	1.535	1.17	1.282
D_3	0.73	1.35	1.575	1.525	1.16	1.268
D_4	0.71	1.33	1.55	1.5	1.14	1.246
D_5	0.69	1.31	1.53	1.475	1.115	1.224
			Emergence			
D_1	0.72	1.36	1.605	1.55	1.15	1.277
D_2	0.69	1.34	1.59	1.53	1.13	1.256
D_3	0.67	1.325	1.575	1.515	1.11	1.239
D_4	0.66	1.31	1.565	1.505	1.1	1.228
D_5	0.65	1.3	1.55	1.485	1.09	1.215
			100% Anthesis			
D_1	0.67	1.325	1.58	1.52	1.11	1.241
D_2	0.65	1.31	1.57	1.51	1.09	1.226
D_3	0.62	1.29	1.55	1.49	1.07	1.204
D_4	0.6	1.27	1.54	1.475	1.05	1.187
D_5	0.59	1.26	1.525	1.46	1.04	1.175

to tillering when the crop was transplanted on 1st July (D1) (Table 2). The rate of increase was less from panicle initiation to emergence because of increase in maximum temperature and reduction in afternoon humidity (Data not shown). An increment in LAI up to 100% anthesis was reported in rice (Takai *et al.,* 2006). In late transplanted rice, the rate of increase in LAI was higher during tillering to panicle initiation stage, although the total light harnessed by the crop was affected, leading to lower productivity than that in early transplanted crop.

The sunlit LAI (L*) recorded a continuous increase from 7.30 to 11.30 h, followed by a gradual decrease till 15.30 h irrespective of dates of transplanting and phenophases (Table 3). This was due to the change in solar elevation angle. The highest value of L* was recorded when the sun remained at the zenith, as also reported by Jena *et al.,* 2010. The L* increased from tillering to panicle initiation and then decreased. This reduction in L* was due to increased shedding of leaves because of increase in LAI. The L* reduced due to delay in transplanting and this might be

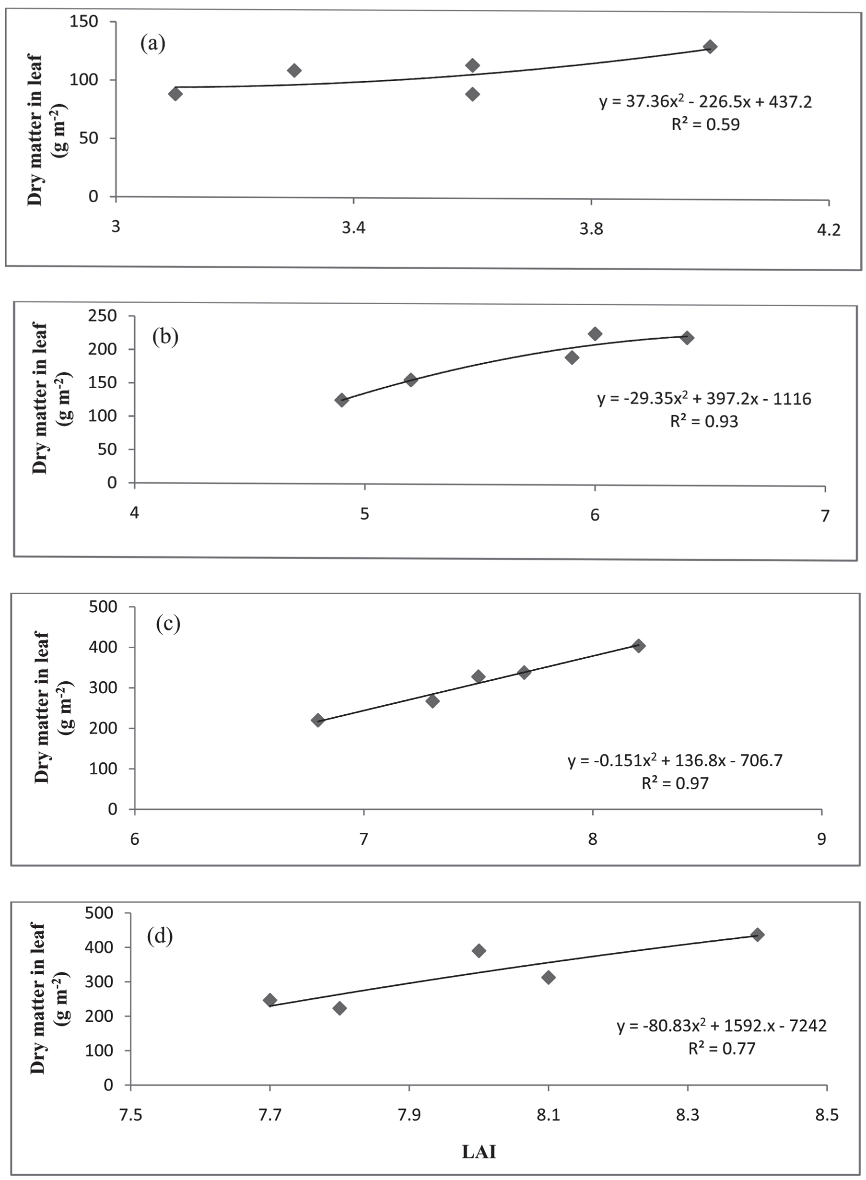

Fig. 1. Relationship between LAI and leaf dry matter accumulation in rice during (a) tillering, (b) panicle initiation, (c) panicle emergence and (d) 100% anthesis

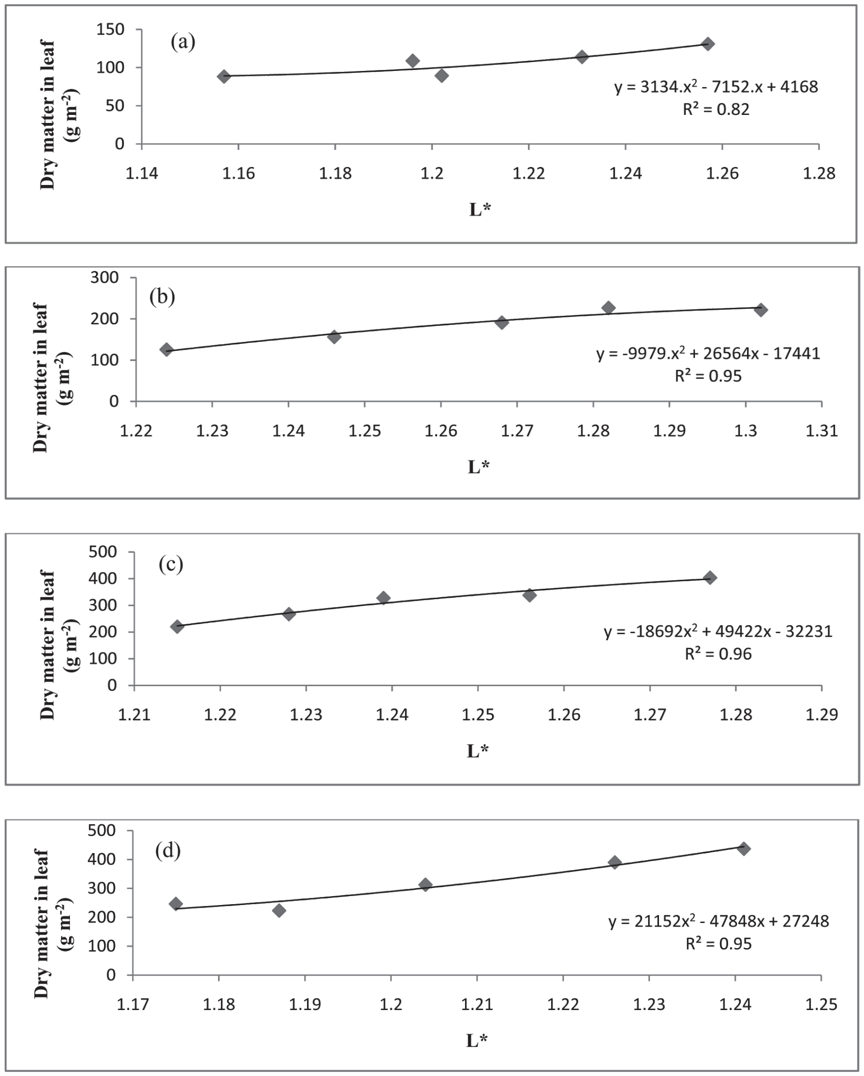

Fig. 2. Relationship between sunlit LAI (L*) and leaf dry matter accumulation in rice during (a) tillering, (b) panicle initiation, (c) panicle emergence and (d) 100% anthesis

attributed to lower LAI and simultaneous lower PAR interception by the rice canopy. The ratio of L*: LAI was the largest at tillering indicating that the mutual shading was less at this stage (Table 4). The L* or LAI decreased with the development of the crop when the mutual shading gradually increased. The L* and LAI ratio also increased with delay in transplanting, which indicated that the percent illuminated leaf under late transplanting decreased.

The L* computation involves the extinction co-efficient and total LAI at a particular height of the crop canopy (Monteith and Unsworth, 2001), but it also depends on the leaf inclination factor. The reduction in L* at later phenophases might be due to an alteration in leaf geometry with the change in leaf inclination angle along a more horizontal axis after flowering (Maruyama *et al.,* 2007). The variation in L* due to dates of planting could commonly be expressed as function of the development stage.

With the increase in LAI, dry matter accumulation in leaf significantly increased (Fig. 1) at panicle initiation, emergence and 100% anthesis stages. The variation in LAI explained the variation in leaf dry matter to an extent of 59,

Table 4. L* - LAI ratio in rice under different dates of transplanting

Treatments	Tillering	P.I.	Emergence	100% Anthesis
D_1	0.31	0.20	0.15	0.15
D_2	0.34	0.21	0.16	0.15
D_3	0.36	0.21	0.16	0.15
D_4	0.33	0.24	0.17	0.15
D_5	0.37	0.25	0.18	0.15

94, 97 and 77% for tillering, PI, emergence and 100% anthesis stages, respectively. However, the relationship between LAI and leaf dry matter production was non-significant at the tillering stage. The L* significantly explained the variation in leaf dry weight at all phenophases. The relationship between the L* and leaf dry weight was found to be more consistent than the relationship between LAI and leaf weight (Fig. 2). It may be concluded that L* is better to explain the variability in growth was better when compared to LAI, possibly due to incorporation of the radiation component.

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