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Diurnal variation in spectral properties of wheat crop sown under different dates

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ABSTRACT

Spectral properties of crop are important indicators regarding the pattern of absorption, interception and reflection by the crop; diurnal variation is also important to understand the veracity of the process. The results suggested that, delayed sowing decreased the absorption of PAR by the wheat crop; reduction was more during flowering than the vegetative phase. Depression of absorption was noted during early hours of the day. Interception was found to be maximum at 11:30 h. It was observed that delayed sown wheat intercepted more PAR during flowering and milking stages which led to the increase of leaf temperature of wheat. Diurnal variation in reflection of photosynthetically active radiation (PAR) showed a gradual decline from 7:30 h to 11:30 h and then an increase at 13:30 h. Reflectivity of crop increased from CRI to milk stage; delayed sown crop reflected more amount of PAR.

Key words: Absorption, interception, PAR, reflection, wheat

Radiation significantly affected the physiological process and productivity of crops (Sastry and Chakravarty, 1982; Chakraborty *et al*, 1991; Nath *et al.*, 2000; Khan *et al.*, 2010). Absorption of PAR during early or late hours of a day during the diurnal course seems to be important in the photosynthetic process, operated in the leaf mesophyll tissues (Heath and Orchard, 1957; Nayyar *et al.*, 1990; Chakraborty, 1994). Spectral properties of wheat crop and its diurnal variation are important in that sense that it will help to understand the productivity potential of this crop. With the changing climate, temperature variations have a profound impact on the duration of phenophases of wheat (Parya, *et al.*, 2010). However no systematic studies on spectral properties have been carried out to understand the impact of date of sowing on this crop. To address these lacunae, a three year study, on wheat crop, which was sown on three different dates, has been carried out under Gangetic alluvial zone of West Bengal, for understanding the variation in spectral properties under different dates of sowing.

MATERIALS AND METHODS

The experiment was carried out during *rabi* seasons of 2005- 06, 2006- 07 and 2007-08 at the Instructional Farm of BCKV, Nadia, West Bengal, having $22^0 56'$ N latitude, $88^0 32'$ E longitude and 9.75 m altitude. The experimental site falls under tropical humid climate having short and mild winter, average annual rainfall is 1457 mm and mean monthly temperature ranges 10- 37^0C. The experimental soil was sandy- loam in texture and neutral in reaction. The experiment was laid out in split plot design with three replications having three dates of sowing (18^{th} November, 3^{rd} December and 18^{th} December) to main plots and varieties (PBW 343, HD 2733, HW 2045, PBW 533 and K 9107) to sub plots. The land was prepared by ploughing and cross ploughing with tractor followed by laddering. Irrigation and drainage channels were laid out. Total experimental site was divided into 3 blocks. Each block was comprised of 3 main plots and was subdivided into 5 sub-plots. Treatments were randomly allocated to the main plots and sub- plots. The seed rate of wheat was 120 kg ha^{-1}, the rate of fertilizer was 150 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} of which $1/3^{rd}$ N, full P_2O_5 and K_2O were broadcasted as basal at the time of final land preparation, $1/3^{rd}$ N was applied as top dressing at 20- 25 days after sowing and rest $1/3^{rd}$ N was applied as top dressing at 45 days after sowing and these were applied in the form of urea, single super phosphate and muriate of potash. The row to row distance of wheat seed was 22.5 cm and plant to plant was continuous. One pre-sowing irrigation was given for uniform germination, and then six irrigations (at CRI, tillering, late jointing, flowering, milking and dough stage) at 5 cm each were given. Weeding was done at 2 times, one at 20- 25 days after sowing and another at 45 days after sowing.

The direct incident PAR above and below the wheat canopy was measured by placing the line quantum sensor (APOGEE Logan UT, UK) 25 cm above the crop and soil surface across the rows within the wheat canopy keeping the sensor horizontal to the surface. The reflected PAR was measured from the same positions by simply inverting the instrument. From the measured PAR values, absorbed PAR (APAR) was calculated by using the following formula

$$APAR = [PAR_{(o)} + R\ PAR_{(S)}] - [T\ PAR + R\ PAR_{(c)}]$$

(Gallo and Daughtry, 1986)

Where,

$PAR_{(0)}$ = Incident PAR above the canopy

$RPAR_{(S)}$ = Reflected PAR from soil

TPAR = Transmitted PAR through the canopy to the soil surface

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$RPAR_{(c)}$ = Reflected PAR from the crop

Intercepted PAR (IPAR) is calculated with the help of following expression-

IPAR = [PAR $_{(o)}$ – T PAR – R $PAR_{(c)}$] (Dhaliwal *et al.*, 2007)

As the radiation data is a kind of absolute data and replication invites error, the absorption, interception and reflection data were not subjected to statistical analysis as per norm.

RESULTS AND DISCUSSION

When radiation falls over a crop canopy, it is absorbed, intercepted and reflected by the crop canopy. Diurnal variation in the pattern of absorption, interception and reflection indicates the potentiality of the crop to utilize PAR.

Diurnal variation in the absorption of PAR

Diurnal variation in the absorption pattern of PAR is reported in Table-1. When crop was sown on 18th November, percent absorption of PAR ranged from 66.9 to 72.56, 66.64 to 82.66 and 69.36 to 81.18 during 2005-06, 2006-07 and 2007-08 at the tillering stage, the maximum absorption was observed at 11.30 h. Absorption of PAR increased from 7.30 h to 11:30 h and thereafter declined at 13.30 h. The pattern remained unaltered in all the years of the study irrespective of phenophases of the crop. However, the tillering phase recorded the lowest absorption.

When the crop was sown on 3rd December, similar pattern was observed, however amount of PAR absorbed was less as compared to earlier date of sowing. Similar observation was recorded when the crop was sown on 18th December.

In general, productivity of wheat decreases with the delay in sowing. Delayed sowing actually reduced the absorption of PAR by the crop. When the crop was sown on 3rd or 18th December, both the flowering and milking stages recorded a lower absorption of PAR when compared with the CRI and tillering stages. Due to delay in sowing, percent reductions in absorption at 7.30 h were 8.63 and 10.50 at the CRI stage in case of 3rd and 18th December sown crop in 2005-06. During flowering, reductions in absorption at 9.30 h in 2006-07 were 11.76 and 20.75 percent respectively in case of 3rd and 18th December sown crop when compared with 18th November sowing. Both the radiation and PAR use efficiency are reduced when sowing is delayed in case of wheat (Sastry and Chakravarty, 1982; Khan, *et al.*, 2010). Depression of absorption during early or late hours of the day due to delayed sowing may be an important limiting factor in case of the productivity of wheat as net photosynthetic gain remains high during early or late hours of the day (Heath and Orchard, 1957; Nayyar *et al.*, 1990; Chakraborty, 1994; Niwas *et al.*, 2006).

Diurnal variation in interception of PAR

Interception of PAR within wheat canopies was maximum at 11:30 h, it increased from 7:30 h to 11:30 h and then declined at 13:30 h during the diurnal course. When the crop was sown on 18th November, interceptions of PAR by wheat canopy increased from tillering to milking stage during different hours of a day with a few exception. The trend was similar in all the years of observations. This trend was also valid when the crop was sown on 3rd or 18th December (Table 2). Interception of PAR in case of a particular date of sowing increased from tillering to milking because of the increased LAI (Pandey *et al.*, 2004, Wajid *et al.*, 2004) whereas higher interception by late-sown crop might be due to lower foliage volume. In 2005-06, 3rd December sown crop intercepted higher amount of PAR during flowering and milking stages when compared with the 18th November and 18th December sown crop; however in 2006-07 and 2007-08, interception at flowering and milking stages were found to be higher in 3rd and 18th December sown crops. Higher interception of PAR during flowering or milking stages in case of late sown wheat crop may have detrimental effect which may lead to lower photosynthesis and higher respiration because of increased leaf temperature (Chakraborty *et al.*, 1991).

Diurnal variation in reflection of PAR

Diurnal variation in reflection of PAR by wheat canopies showed that the reflection decreased gradually from 7:30 h to 11:30 h and then increased (Table 3); the trend was similar under all dates of sowing as well as in all the years of observations. Higher reflection of the crop during early hours is due to lower solar elevation angle (β). Sunlight from a morning or afternoon sun is relatively richer in red wave length (680-710 nm) and poorer from blue wave lengths than sunlight from a high sun. This accounts for the shift in the mean reflectance for low and high sun (Gates, 1981; Monteith and Unsworth, 2001).

Table 1: Diurnal variation in absorption of PAR (%) of wheat at various phenophases under different dates of sowing

Treatments		2005-06				2006-07				2007-08			
DOS	Stages	07:30	09:30	11:30	13:30	07:30	09:30	11:30	13:30	07:30	09:30	11:30	13:30
D_1 (18th Nov.)	CRI	72.56	75.42	78.80	66.90	66.64	80.84	82.66	78.00	69.36	80.42	81.18	77.32
	Tillering	48.56	70.70	73.98	64.26	48.38	63.82	71.12	59.88	72.70	75.86	78.74	74.14
	Flowering	57.34	65.56	75.54	67.16	66.38	74.30	79.72	73.24	70.90	74.40	80.54	72.90
	Milking	59.68	63.50	74.10	65.68	74.90	81.08	83.06	80.46	73.16	75.04	76.80	73.52
D_2 (3rd Dec.)	CRI	66.30	69.18	72.60	66.20	64.56	69.10	73.30	66.64	63.78	73.40	82.32	71.34
	Tillering	48.08	64.16	69.50	61.88	44.50	60.26	68.00	60.94	71.42	75.18	78.64	70.84
	Flowering	52.04	60.42	71.84	59.96	56.82	65.56	73.16	64.44	52.78	58.70	68.40	63.3
	Milking	50.46	59.70	68.20	57.16	62.14	67.52	75.26	68.02	66.64	68.70	71.30	68.42
D_3 (18th Dec.)	CRI	64.94	66.54	68.64	62.34	69.70	82.28	84.06	80.90	62.46	71.84	80.32	77.14
	Tillering	50.62	56.76	64.80	54.96	58.98	74.38	76.72	71.06	62.62	69.48	71.56	67.62
	Flowering	36.02	55.40	64.46	56.12	41.60	58.88	65.64	56.96	51.00	57.10	61.70	52.66
	Milking	47.94	58.50	64.70	55.90	62.00	70.38	73.74	70.54	54.70	65.38	69.10	62.78

Table 2: Diurnal variation in interception of PAR (%) of wheat at various phenophases under different dates of sowing

Treatments		2005-06				2006-07				2007-08			
DOS	Stages	07:30	09:30	11:30	13:30	07:30	09:30	11:30	13:30	07:30	09:30	11:30	13:30
D_1 (18th Nov.)	Tillering	26.32	66.14	72.44	66.64	29.30	52.98	56.36	50.16	69.90	73.48	76.18	71.96
	Flowering	32.04	63.26	77.44	65.64	54.54	66.64	71.88	61.92	80.12	82.60	87.82	59.00
	Milking	33.24	65.70	82.84	63.90	65.22	74.76	79.68	76.28	81.50	83.58	89.14	80.68
D_2 (3rd Dec.)	Tillering	34.32	62.30	74.14	65.56	24.36	47.22	51.98	50.24	40.28	61.08	69.46	62.52
	Flowering	26.16	64.16	78.50	70.66	38.82	60.04	64.76	58.32	74.38	78.60	86.62	81.80
	Milking	36.92	70.30	85.34	73.70	48.36	64.06	67.92	64.58	84.14	90.18	91.12	82.42
D_3 (18th Dec.)	Tillering	32.98	42.40	63.88	49.56	36.62	55.52	69.40	53.52	40.52	63.34	68.92	64.80
	Flowering	39.40	60.70	72.16	65.50	45.60	66.58	71.12	62.94	78.42	0.64	83.32	80.96
	Milking	38.90	62.20	75.22	73.04	59.54	65.16	73.14	64.70	90.70	92.38	93.62	88.96

Table 3: Diurnal variation in reflection of PAR (%) of wheat at various phenophases under different dates of sowing

Treatments		2005-06				2006-07				2007-08			
DOS	**Stages**	**07:30**	**09:30**	**11:30**	**13:30**	**07:30**	**09:30**	**11:30**	**13:30**	**07:30**	**09:30**	**11:30**	**13:30**
D_1(18th Nov.)	CRI	10.64	10.24	9.33	11.06	10.69	9.55	8.80	9.46	6.3	6.61	6.06	7.43
	Tillering	18.76	14.03	3.56	14.88	19.70	16.58	11.29	16.08	10.59	9.53	8.78	10.62
	Flowering	16.63	14.21	9.90	14.08	16.41	15.34	8.50	14.25	13.44	10.94	3.99	13.13
	Milking	26.60	16.04	3.65	18.16	23.36	15.22	12.25	18.88	14.27	14.06	10.52	14.29
D_2(3rd Dec.)	CRI	15.44	12.63	2.88	11.74	14.22	11.91	8.21	12.59	4.08	4.21	3.47	6.37
	Tillering	24.94	18.36	8.94	15.83	19.76	14.01	10.90	14.14	8.56	8.21	7.65	8.63
	Flowering	21.81	15.06	13.93	16.43	24.50	18.63	15.60	15.74	14.66	10.23	7.10	11.99
	Milking	22.98	16.45	13.21	18.48	23.40	21.42	15.55	19.82	14.98	14.09	13.68	13.92
D_3(18th Dec.)	CRI	11.08	9.96	4.99	12.09	17.61	12.33	9.89	11.60	4.06	3.67	3.07	3.37
	Tillering	15.16	10.36	6.16	11.65	16.67	13.46	10.48	15.37	12.72	11.40	10.38	12.74
	Flowering	21.28	14.55	5.70	15.24	29.32	13.66	13.51	15.19	14.56	9.60	8.35	12.40
	Milking	29.74	19.48	14.99	20.29	30.25	17.21	16.16	19.04	15.33	14.09	13.56	13.85

On all dates of sowing, irrespective of time and year of observations, reflectivity increased from CRI to milking stage (with a few exceptions); the trend was more intact during 2006-07 and 2007-08. When the crop was sown on 18^{th} November, 2007 at 7.30 h, reflection increased to an extent of 68.09, 113.33 and 126.5 percent respectively at tillering, flowering and milking stages over the CRI stage, indicating less absorption of PAR during these stages. Delayed sown crop reflected more amount of PAR because of the protective mechanism of the crop to reduce the respiratory loss. Chen *et al.* (2003) also observed that light use efficiency and grain yield of wheat decreased as the interception was increased. However contradictory observations were also available (Lunagaria and Shekh, 2007).

Spectral properties of wheat leaf may be an important indicator for estimating the yield of wheat in well advance which may be helpful for the planners. Remote-sensing technique also uses spectral properties but for a larger area which may be erroneous in many occasions. Spectral properties of crop if measured may remove this error.

REFERENCES

Chakraborty, P. K. 1994. Effect of date of sowing and irrigation on the diurnal variation in physiological processes in the leaf of Indian mustard (*Brassica juncea*). *J. Oilseeds Res.,* **11**: 210- 16.

Chakraborty, P. K., Majumder, A. and Chatterjee, B. N. 1991. Physiological processes in Indian mustard (*Brassica juncea*) and Yellow sarson (*Brassica napus* var *glauca*) and their agronomic appraisal in mild and short winter prevailing in Gangetic plains of Eastern India. *Indian J. Agric. Sc*, **61**: 815-21.

Chen, Y. H., Yu, S. L. and Yu, Z. W. 2003. Relationship between amount or distribution of PAR interception and grain output of wheat communities. *Acta Agronomica Sinica*; **29**: 730- 34.

Dhaliwal, L. K., Hundal, S. S., Kular, J. S., Chahal, S. K. and Aneja, A. 2007. Radiation interception, growth dynamics and agroclimatic indices in Raya (*Brassica juncea*). *J Agromet.*, **9**: 242- 46.

Gallo, K. P. and Daughtry, C. S. T. 1986. Techniques for measuring intercepted and absorbed photosynthetically active radiation in corn canopies. *Agron. J.*, **78**: 752- 56.

Gates, D. M. 1981. *Biophysical Ecology*, Narosa Publishing, New Delhi, pp. 331- 32.

Heath, O. V. S. and Orchard, B. 1957. Temperature effects on the minimum intercellular space carbon dioxide concentration. *Nature*, London **180**: 181- 82.

Khan, S. A., Marak, H. C., Gupta, A. and Sarmah, K. 2010. Effects of dates of sowing on phenology, thermal and radiation regimes and yield of wheat. *J. Agromet.,* **12**:53-57.

Lunagaria, M. M. and Shekh, A. M. 2007. Radiation use efficiency of wheat (*Triticum aestivum* L.) crop as influenced by date of sowing, row spacing and row orientation. *J. Agromet.*, **9**: 282- 85.

Monteith, J. L. and Unsworth, M. 2001. *Principles of Environmental Physics*, 2nd Edition, Bufferworth, Oxford, pp. 79- 92.

Nath, R., Chakraborty, P. K. and Chakraborty, A. 2000. Effect of microclimate parameters at different sowing dates on capsule production of sesame (*Sesamum indicum* L.) in a tropical humid region. *J. Agron. Crop Sci.*, **184**, 247- 52.

Nayyar, H., Malik, C. P., Singh, P., Parmar, U., Grewal, M. And Kaur, S. 1990. Diurnal variation in photosynthetic parameters in peanut. *Photosynthetica*, **24**: 276- 79.

Niwas, R., Singh, M. and Kichar, M. L. 2006. Effect of sowing environment and nitrogen levels on light interception and its efficiency in dry matter production in wheat cultivars. *Annals Agric. Res.*, **27** : 271- 76.

Pandey, V., Chaudhari, G.B., Patel, H. R., Vadodaria, R. P., Bhatt, B. K. And Shekh, A. M. 2004. Radiation interception and light use efficiency in wheat crop at Anand. *J. Agromet.*, **6** :43- 46.

Parya, M., Nath, R., Majumder, D. and Chakraborty, P. K. 2010. Climate change-stress on wheat productivity in east Indian plain zones. *J. Agromet.*, **12**: 217- 20.

Sastry, P. S. N. and Chakravarty, N. V. K. 1982. Energy summation indices for wheat crop in India. *Agric. Meteorol.* **27**: 45- 48.

Wajid, A., Hussain, A., Ahmad, A., Rafiq, M., Goheer, A. R. and Ibrahim, M. 2004. Effect of sowing date and plant density on growth, light interception and yield of wheat under semi-arid conditions. *Int. J. Agric. and Biol.*, **6** :1119- 23.