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Leaf orientation and direct beam radiation interception in wheat (*Triticum aestivum* L.) crop as influenced by row direction

M.M.LUNAGARIA and A.M. SHEKH

Department of Agricultural Meteorology, Anand Agricultural University, Anand-388 110

ABSTRACT

A field experiment was conducted at the B A College of Agriculture, Anand Agricultural University, Anand (22°35'N, 72°55'E; 45.1 m above mean sea level) during *rabi* season of 2003-2004 on sandy loam soil. The objective was to study the effect of row orientation and row spacing on leaf orientation and direct beam radiation interception. The direct beam interception was calculated by the equation that is used to measure radiation intensity on slope. It was observed that leaves usually preferred N, S and W directions. The leaves were randomly oriented during the different times of the vegetative phase. No marked difference was observed in case of direct beam radiation interception for a particular treatment.

Key words: Leaf angle, Leaf orientation, Solar angle, Solar azimuth, Direct beam radiation interception

The growth and development of the crop plants are largely influenced directly or indirectly by solar radiation. The intercepted radiation on a leaf consists of diffused radiation and direct beam radiation. The canopy architecture of the crop is an important factor, which can influence the interception and absorption of solar radiation for the function of photosynthesis. Canopy architecture of the plant mainly depends on the leaf geometrical parameters like leaf angle and leaf orientation.

The present investigation was carried out with an objective to study the influence of row orientation on leaf orientation and direct beam interception of radiation in wheat crop at Anand. The approach to study this aspect was made with use of the equation used to measure radiation intensity on the slope. It is possible to measure direct beam interception fraction by a leaf with the knowledge of the specific parameters relating to the sun and leaf geometry (Kirkham, 1986). Very few research studies have been carried out in the past on the use of these parameters.

MATERIALS AND METHODS

A field experiment was conducted on the Agronomy farm of the B A College of Agriculture, Anand Agricultural University, Anand (22°35'N, 72°55'E; 45.1 m above Mean Sea Level) during *rabi* season of 2003-2004. The soil was sandy loam

(Alluvial soil, Orchrespt), locally known as "Goradu Soil". The cultivar of the wheat crop was GW-496 which was sown in two orientation (R_1: NS and R_2: EW), two row spacing (S_1:15 cm and S_2:22.5 cm) and two date of sowing (D_1:12 November and D_2:27 November of 2003). The experiment was laid out in split plot design with four replications. All the recommended cultural operations and protection measures were adopted.

The leaf geometrical parameters like leaf orientation, leaf angle and leaf length were studied in the present investigation. These parameters were measured during the noon hours (1130-1430 h) at 10-day intervals (on the days given in observation calendar). Five plants or shoots were chosen from the central rows of the plots in a single replication, for measurement of the leaf geometrical parameters. The first leaf from the top was not considered because usually it was not unfurled. Dead leaves were also ignored for the purpose of being used for measurement of leaf geometrical parameters. Only the second to top, third and fourth leaves (3 leaves per plant) were employed for measuring the required parameters (15 leaves per plot). The second to the top leaf was considered as first leaf for the calculation. The study was carried out during the vegetative growth period only because it was not possible to approach central rows after heading

The methodology employed to measure leaf orientation and leaf angle given below with appropriate description.

Leaf orientation

Leaf orientation is described by the aspect angle of the leaf surface measured clockwise between north and the projection of the normal to the leaf surface on the horizontal plane (Kirkham, 1986). The leaf orientation was determined by employing a thick and transparent plastic sheet. The sheet had the markings of directions (N, NW, W, SW, S, SE, E, NE) made on it. This sheet was then kept over the shoot and the direction towards which the leaf remained pointed was noted for each leaf. Here 'pointed' means direction of the projection of the leaf in the horizontal plane of the sheet.

Leaf angle

Leaf angle is defined as the angle the leaf in normal position makes with the vertical. The leaf angle was measured by means of a transparent protractor and was expressed in terms of the degrees at which the leaf was inclined with respect to vertical. A leaf that was upright measured 0° while one that was horizontal measured 90°.

The transparent protractor was held with its centre coinciding with the node and its 0-0 line pointing the vertical, to measure angle, which the normal position of leaf made with the vertical (Ladent and Moss, 1977; Kirkham, 1982).

The equation used to calculate direct beam interception fraction was as follows (Fons *et al.*, 1960):

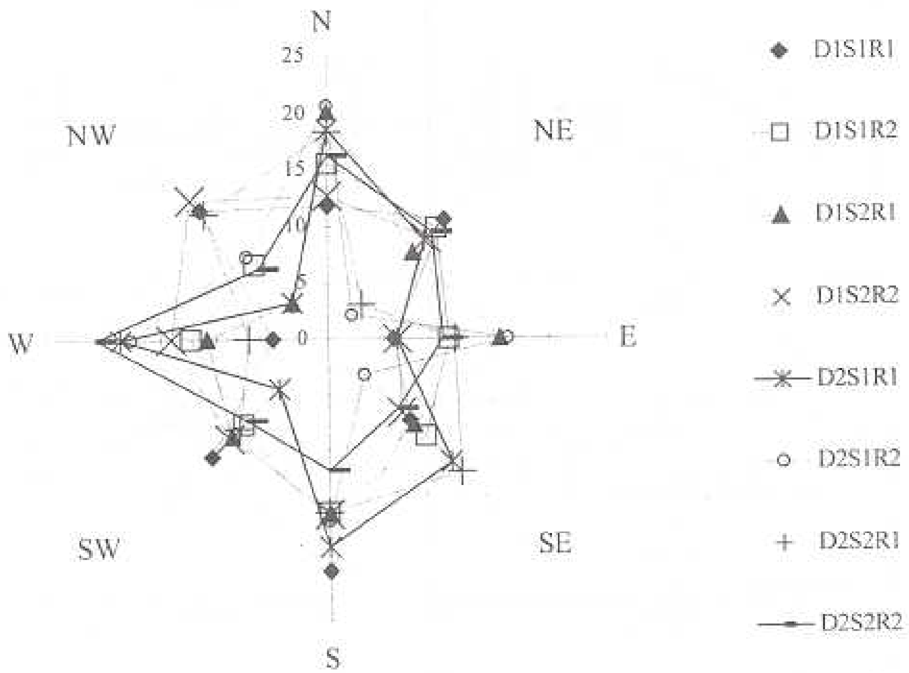

Fig.1 : Direction of leaves pointed under different treatments (Percentage values of azimuthal leaf orientation)

$$\frac{I}{I_0} = \mathrm{SinA} \cdot \mathrm{Cos}\alpha - \mathrm{CosA} \cdot \mathrm{Sin}\alpha \cdot \mathrm{Sin}(Z - \beta)$$

Where, I/I_0 is direct beam interception over the leaf (light intensity received by leaf)

A is solar altitude (Angular height above horizon) Z is ω-90° (ω = solar azimuth) α is angle between vertical and a normal to the leaf i.e.α= 90°- slope measured from horizontal β is aspect angle of leaf surface (direction that leaf pointed i.e. N, S, NW, E etc.).

The aspect angle of leaf surface measured clockwise between north and to the leaf surface on horizontal plane. The solar altitude A and solar azimuth ω for Anand (22°25N; 72°55'E) were obtained from Bennett (1978, p.39) also confirmed with List (1966.p.499-500).

RESULTS AND DISCUSSION

The leaf orientation in different directions is graphically depicted in Fig.1. It was clear from the percentage values that fell under different directions in case of each of the treatments that there was not much variation in the combinations that of between treatments comprising row

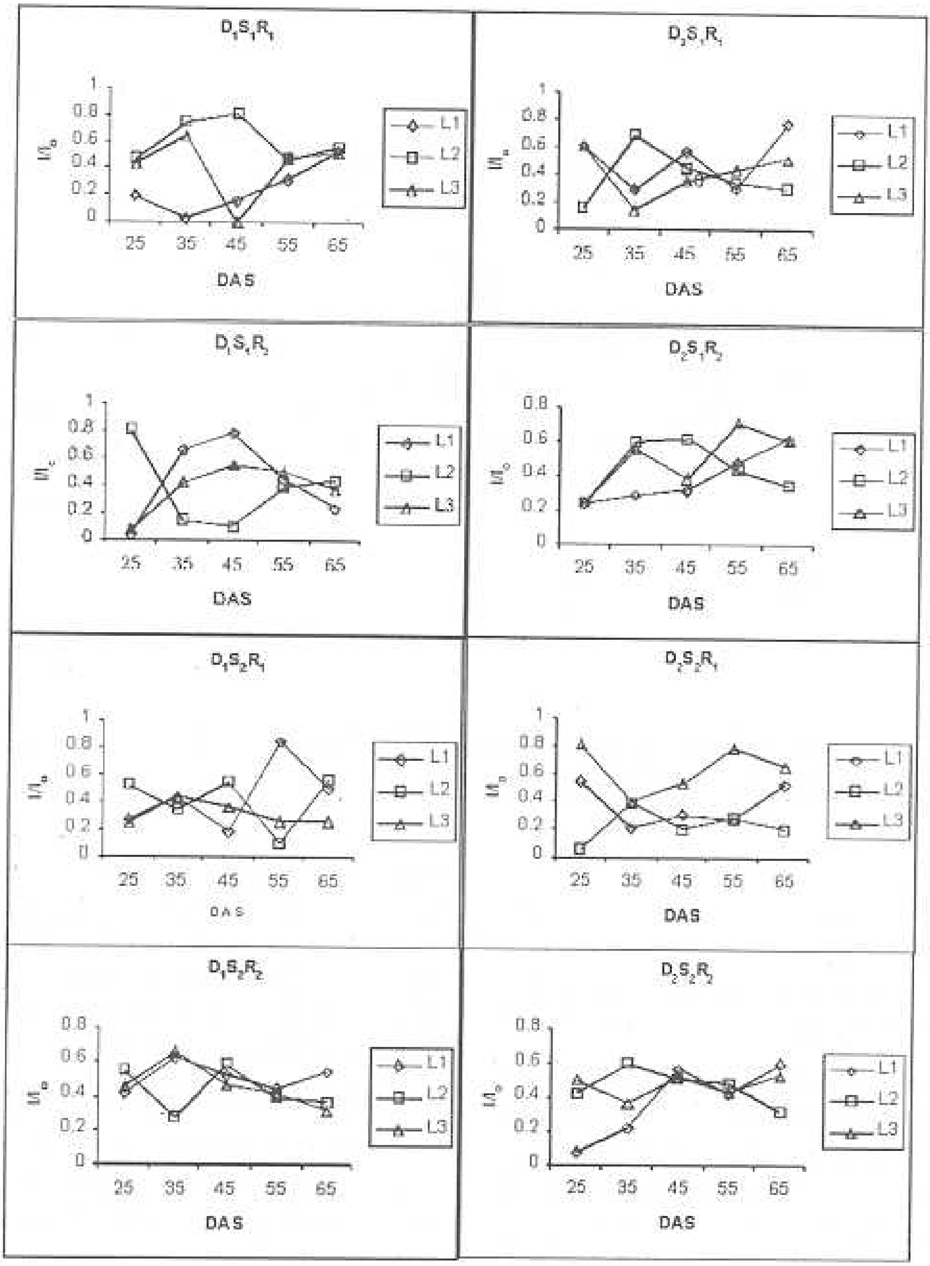

Fig.2 : Direct beam radiation interception for the treatments at Anand, during vegetative phase. (L1-1st leaf, L2-2nd leaf, L3-3rd leaf)

orientation and spacing. The average value over the entire study indicated that the high percentage of leaves (16.7 %) were oriented (pointed) towards N direction. The leaves pointing N (facing south) would be in the best position to intercept solar radiation in the northern hemisphere (Kirkham, 1984). The sequence of directions of leaf orientation in accordance with the values of percentage of leaves occupying that particular direction was S (15.7%), W (13.3%), SW (11.2%), SE (11.0%), NW (10.9%) and NE (10.5%) in order of magnitude. This result showed that leaves usually preferred N, S and W directions. General result showed that the leaves were randomly oriented at different time of the season. These observations were similar to those reported by Kirkham, 1982 and Lugg *et al.*, 1981.

The leaf angle observations indicated that the leaves were erect early in the seasons and turned gradually horizontal in the later observations.

The average values calculated from the observed data are graphically presented (Fig.2). The values of I/I_0 depend on the leaf orientation (angle α and β i.e. "slope" angle between leaf surface with respect to vertical and aspect angle [N=0°; NE=45°; E=90°, etc.] of the leaf surface). South pointing leaf faced north and had the lowest I/I_0 value i.e. 0. North pointing leaves faced south and had the highest I/I_0 value i.e. 1. And east pointing leaves (facing west) and west pointing leaves (facing east) had the intermediate values. The value 0 indicated that the direct beam interception was negligible and leaf intercepted mostly diffuse radiation for photosynthesis.

The direct beam interception fraction (I/I_0) values were found to differ with the observation time for different leaves and also with the different sowing time in all the treatments. The highest value recorded was 0.84 on 6 January over the first leaf of the wide NS row of the first date of sowing. The lowest value observed was 0 for narrow NS row on 27 December in the first date of sowing, i.e. leaf intercepted only diffuse solar radiation for the photosynthetic function.

The statistical analysis of the yield attributes revealed that, in general, there was no significant influence of the various radiation regimes under different row orientation and spacing on the crop performance.

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