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Prediction of grain yield of wheat using canopy temperature based indices*

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ABSTRACT

Canopy temperature based regression models were developed for the prediction of grain yield of wheat. During the reproductive phase, all the canopy temperature based indices viz., canopy temperature (T_c), average canopy minus air temperature (T_c-T_a) and summation stress degree days (SDD) showed a negative and significant relationship explaining 71-87% variation in grain yield. These findings signify an ample scope of mid day canopy temperature as a possible tool for monitoring plant water status and grain yield prediction.

Key words : Air temperature, canopy temperature, grain yield, stress degree days, wheat

Canopy temperature is strongly influenced by plant water status (Singh and Kanemasu, 1983). Plant water status has a direct bearing on vital physiological processes and morphological characteristics of a plant, which are the primary determinants of seed yield. Several canopy temperature based indices such as stress degree days (SDD) have been used in grain yield prediction. Summation of these temperature differences is used to evaluate statistically both crop water use and growth, and thus, provides a useful tool in managing irrigation water (Idso *et al* 1977). An attempt was made to develop regression models for explaining the yield relation for wheat with canopy temperature based indices for estimating grain yield.

MATERIALS AND METHODS

Field experiment was conducted during *rabi* 2006-07 and 2007-08 to study the effect of irrigation levels and planting methods on growth, microclimate and yield of wheat crop at the research farm of Punjab Agricultural University, Ludhiana situated at 30°54′ N, 75°48′ E and at an altitude of 247 m above mean sea level. The soil in the field was sandy loam in texture. The experiment was laid out in randomized block design. Wheat variety PBW-502 was sown in the first fortnight of November during both the years after a pre-sowing irrigation. The treatments included two planting methods (F : Conventional method of sowing on flat surface with row to row spacing of 22 cm and B : Sowing on raised beds 37.5 cm wide with two crop rows 20 cm apart and 30 cm wide furrow between two beds) and five irrigation levels (I_0: rainfed with no post-sowing irrigation; I_1, I_2, I_3 and I_4 with one, two, three and four post-sowing irrigations, respectively). I_1 treatment received irrigation at CRI stage, I_2 at CRI and flowering stages, I_3 at CRI, flowering and soft dough stages and I_4 treatment received recommended irrigation schedule i. e. Ist 4 WAS, 2nd 5-6 weeks after first, 3rd 5-6 weeks after second and 4th and last irrigation four weeks after third irrigation.

Measurement of canopy temperature was started after the crop attained full canopy cover from 83 to 135 DAS during both the crop seasons. Daily canopy temperature and canopy minus air temperature differential were recorded in all the treatments at 1430 h under clear sky conditions with the help of infra-red thermometer (FLUKE 574), keeping it inclined at an angle of 45° holding one metre above the crop canopy. It can sense temperature in the range of -30° to 900°C, but the ambient operating range is 0-50°C.

Average canopy temperature (T_c) and canopy-air temperature (T_c-T_a) for the reproductive growth period were calculated by summing up the daily mid-afternoon T_c and T_c-T_a values recorded in each treatment separately and dividing it by the number of days of observations recorded during this period. The summation of stress degree days (SDD) for each treatment was calculated by summing up the T_c-T_a value obtained for each day under each treatment separately for the reproductive phase, as during reproductive phase the crop had fully developed canopy.

The simple regression models were developed by using Tc, Tc - Ta and SDD for the prediction of final grain yield.

RESULTS AND DISCUSSION

The average of daily values of canopy temperature, canopy-air temperature and stress degree days during the reproductive phase and grain yield of wheat crop under different soil moisture regimes and planting methods during

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rabi 2006-07 and 2007-08 has been presented in Table 1.

The maximum average grain yield was observed to be 49.2 and 47.4 q ha^{-1} during *rabi* 2006-07 and 2007-08, respectively, for four post-sowing irrigations under flat sowing, whereas the minimum average grain yield for the corresponding years was 25.4 and 23.1 q ha^{-1} for bed planted crop with no post-sowing irrigation.

A negative and significant correlation was observed between grain yield (Y) and average canopy temperature (X_1) during the reproductive phase of the crop under different irrigation levels and planting methods. It indicated that with decrease in canopy temperature, the grain yield increased and vice-versa.

$Y = -10.80 X_1 + 313.7$ $R^2 = 0.71$

$Y = -5.604 X_1 + 166.6$ $R^2 = 0.87$

Thus, it showed that 71 and 87% variation in grain yield was explained by average mid-day canopy temperature during *rabi* 2006-07 and 2007-08, respectively.

A negative and significant correlation was observed between grain yield (Y) and average canopy minus air temperature (X_2). It indicated inverse relationship between these two parameters. The line of regression is as follows :

$Y = -8.061 X_2 + 36.19$ $R^2 = 0.71$

$Y = -5.645 X_2 + 32.27$ $R^2 = 0.86$

The coefficient of determination showed that average mid-day canopy minus air temperature difference explained 71 and 86% variation in the grain yield.

A correlation between grain yield and summation stress degree days showed significant negative relationship. The line of regression between grain yield (Y) and summation stress degree days (X_3) is as follows :

$Y = -0.309 X_3 + 36.20$ $R^2 = 0.71$

$Y = -0.125 X_3 + 32.28$ $R^2 = 0.86$

This showed that 71 and 86% variation in grain yield was explained by summation of stress degree days during *rabi* 2006-07 and 2007-08, respectively.

Thus, during the reproductive phase, all the canopy

Table 1: Relationship of grain yield with average mid-day canopy temperature (Tc), average canopy-air temperature (Tc - Ta) and stress degree days (SDD) in wheat under different planting methods and irrigation levels during *rabi* 2006-07 and 2007-08

Treatment	Average T_c (°C)	Average (T_c-T_a) (°C)	SDD	Grain yield (q ha^{-1})
		2006-07		
BI_0	26.2	0.67	17.4	25.4
BI_1	25.4	-0.37	-9.5	32.6
BI_2	25.4	-0.37	-9.5	44.7
BI_3	25.0	-0.91	-23.7	43.3
BI_4	24.4	-1.69	-43.9	46.3
FI_0	26.3	0.89	23.2	31.0
FI_1	25.2	-0.68	-17.7	40.4
FI_2	25.2	-0.61	-15.8	46.9
FI_3	25.2	-0.67	-17.5	45.8
FI_4	24.4	-1.67	-43.4	49.2
		2007-08		
BI_0	25.1	1.12	50.50	23.1
BI_1	24.2	0.22	10.10	26.7
BI_2	23.5	-0.42	-18.90	36.7
BI_3	22.9	-1.06	-47.90	39.7
BI_4	21.4	-2.53	-113.80	44.2
FI_0	24.6	0.62	27.90	28.0
FI_1	24.0	0.03	1.40	33.4
FI_2	23.4	-0.58	-25.90	39.6
FI_3	22.7	-1.24	-56.00	43.5
FI_4	20.8	-3.16	-142.10	47.4

temperature based indices viz., canopy temperature (T_c), average canopy-air temperature difference (T_c-T_a) and stress degree days (SDD) showed a negative and significant relationship explaining about 70 and 86% variation in grain yield of wheat. These findings signify an ample scope of mid-day canopy temperature as a possible tool for monitoring plant water status and grain yield prediction. Similar negative and significant relationship of grain yield with different canopy temperature based indices was also reported by several workers (Diaz *et al*., 1983; Smith *et al*., 1985, Singh *et al*., 1991; Kaur *et al*., 2002; Gill and Bains, 2007).

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