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Yielding ability of wheat (*Triticum aestivum*) at different dates of sowing — a temperature-dependent performance

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ABSTRACT

A study conducted during the winter (*rabi*) seasons of 1987–88 and 1988–89 showed that late sowings decreased the grain yield of wheat (*Triticum aestivum* L. emend. Fiori & Paol.). The rate of reduction in grain yield was 12.34 ± 7.28 kg/ha/day for delay in sowing beyond 15 November and 2 December respectively during 1987–88 and 1988–89. Regression equations were developed using 2 linear models for delay in sowing (D) and mean maximum temperature during period of ear growth (T). The predicted pattern of changes in grain weight/spike (GW), 1,000-grain weight (TGW) and grain yield (Y) fitted well with the observed pattern, showing linear reduction with delay in sowing. The maximum reduction in grain yield using either of the equations was found in 'UP 1182' and the minimum in 'UP 1179'.

The growth and development of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) crop, apart form being governed by genetic characters, depend largely on a number of environmental factors which vary under different sowing dates (Saini *et al.*, 1988). The sowing of wheat is delayed either to fit it in multiple or relay crop sequences where wheat is to be sown after a very short-duration winter (*rabi*) crop, or after long-duration rice crop or sugarcane ratoon. The yield of wheat decreases with delayed sowing, though the magnitude of reduction varies with the varieties. Numerous environmental variables also (viz. temperature) interact over the long period of crop growth in determining the magnitude of reduction. The present investigation was, therefore, undertaken to understand the effect of late sowing as reflected by variations in weather parameters on growth and yield of wheat genotypes in foot-hills conditions of Pantnagar.

MATERIALS AND METHODS

The field experiment was conducted at Pantnagar during the winter (*rabi*) seasons of 1987–88 and 1988–89. Treatments comprising 4 sowing dates (15 November, 5 December, 25 December and 15 January in 1987–88 and 2 December, 17 December, 18 January and 28 January in 1988–89) and 10 genotypes ('UP 1117', 'UP 1179,' 'UP 2275', 'UP 2276', 'UP 1182', 'UP 1183', 'UP 2234', 'UP 2283', 'UP 2285' and 'Sonalika'), were replicated thrice in split-plot design with sowing dates in main plots and genotypes in subplots. The soil was silty loam, containing 1.06% organic carbon, and 27.75 and 24.09 kg available P and 135.29

and 133.63 kg available k/ha during 1987–88 and 1988–89 respectively, with pH 7.1. The rainfall received during crop season of 1987–88 and 1988–89 was 83.0 and 85.1 mm respectively.

To examine the relationship between grain weight/spike (GW) obtained at harvest and delay in sowing (D) and mean maximum temperature during the grain-growth period (T), regression analysis in a linear model WG = a + bx was adopted (Figs 1,2).

RESULTS AND DISCUSSION

Grain weight/spike

Grain weight/spike showed continuous reduction with delay in sowing. The predicted pattern of changes in GW fitted well with the observed pattern. The coefficient of determination was well over 90% in both the models and years. The rate of decline in GW for every 1 day delay in sowing was 9.69 ± 0.54 mg during 1987–88 (beyond 15 November) and 2.9 ± 0.54 mg during 1988–89 (beyond 2 December). Similarly, with every 1°C rise in mean maximum temperature during grain-filling stage, the rate of decline was 107.6 ± 14.0 mg during 1987–88 (beyond 27°C) and 33.0 ± 5.5 mg during 1988–89 (beyond 30°C). The low grain weight of the ear, an important component of the yield, was primarily due to the deleterious effects of ascending temperature during the grain-filling period on grain size and grain-growth

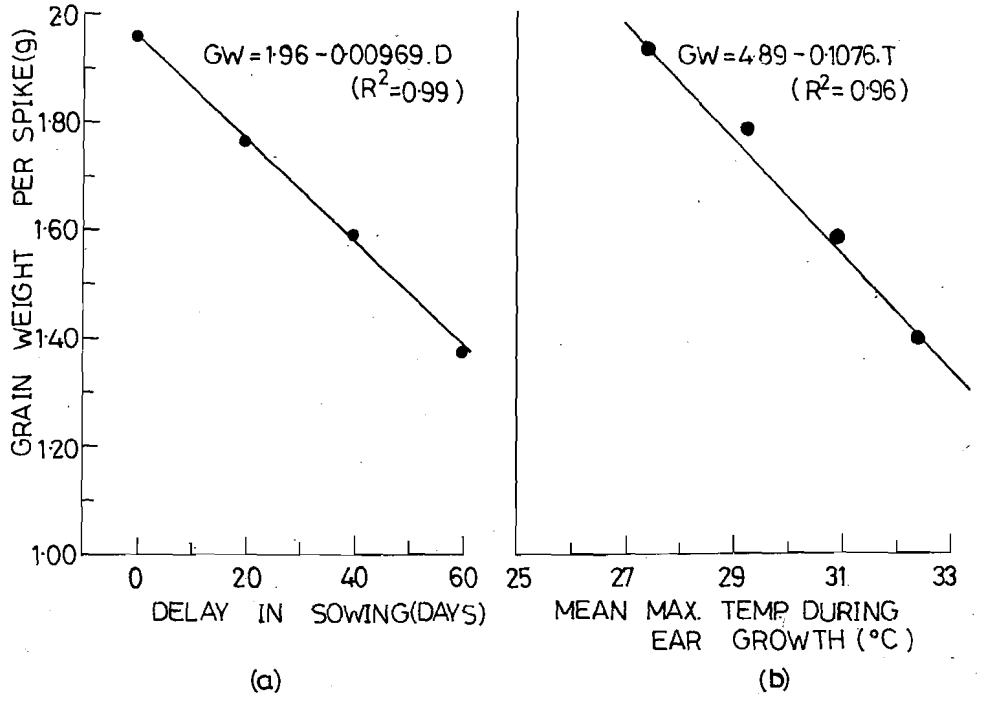

Fig. 1. Relationship between delay in sowing (*a*) and mean maximum temperature during ear growth (*b*) with grain weight/spike of wheat during 1987–88. Lines indicate predicted pattern of changes using regression analysis

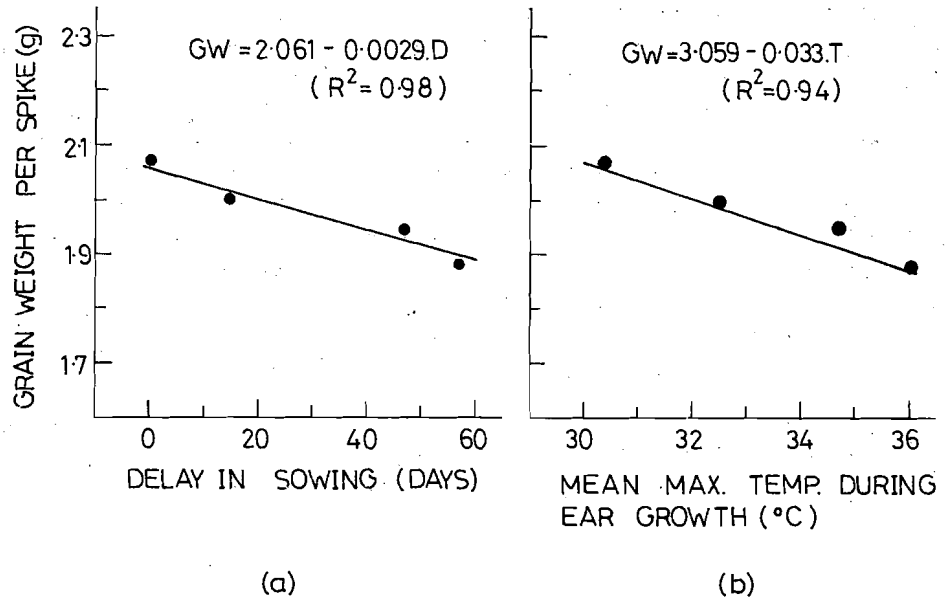

Fig. 2. Relationship between delay in sowing (*a*) and mean maximum temperature during ear growth (*b*) with grain weight/spike of wheat during 1988–89. Lines indicate predicted pattern of changes using regress. analysis

duration (Saini and Dadhwal, 1986). Wiegand and Cuellar (1981) estimated 3.2 mg decrease in kernel weight for each 1°C increase in temperature between 23.7 and 27.8°C during grain-growth duration. During both the years, 'UP 1182' gave the highest grain weight/spike, whereas 'UP 2243' gave the lowest grain weight (Table 1).

Grain weight

Based on the regression analysis of data for 1988–89, the rate of decline in 1,000-grain weight can be predicted as 165.78 ± 4.5 mg/day delay in sowing beyond 2 December and 1.87 ± 0.103 g/1°C rise in mean maximum temperature during ear growth (Fig. 3). The sharp rise in temperature, particularly in April, accompanied by hot winds adversely affected the grain development and resulted in immature and shrivelled grains in the late-sown crop which was in the mild stage during that period. The timely sown crop however was at advantage because after having completed its vegetative growth satisfactorily, it enters reproductive phase when grain development and maturity keep a favourable balance with the steady rise in temperature. Genotypic differences were also noticed (Table 1).

Grain yield

The reduction in grain yield was 12.34 ± 3.50 kg/ha with 1-day delay in sowing beyond 15 November (1987–88) and 51.68 ± 7.28 kg/ha beyond 2 December (1988–89). Similarly, with 1°C increase in mean maximum temperature during ear growth, the rate of decline in grain yield was 134.12 ± 47.26 kg/ha beyond 27°C (1988–89)

Table 1. Yield attributes and grain yield of wheat genotypes as affected by different dates of sowing

Treatment	Grain weight/ spike (g)		1,000-grain weight (g)		Grain yield (q/ha)	
	1987–88	1988–89	1987–88	1988–89	1987–88	1988–89
Sowing date						
D_1	1.96	2.07	48.69	44.52	38.66	39.87
D_2	1.87	2.00	46.45	42.14	38.53	38.66
D_3	1.59	1.95	41.46	37.01	35.87	17.57
D_4	1.37	1.88	37.94	34.95	31.32	12.69
CD (P = 0.05)	0.30	0.11	NS	2.12	3.61	2.11
Variety						
'UP 1177'	1.57	1.80	42.66	35.37	36.15	28.43
'UP 1179'	1.76	1.92	45.60	42.40	32.24	23.51
'UP 2275'	1.85	2.08	44.72	41.06	37.13	28.00
'UP 2276'	1.47	1.91	42.81	43.54	36.59	26.04
'UP 1182'	2.08	2.26	44.66	41.41	37.42	29.56
'UP 1183'	1.52	1.79	39.42	34.94	35.82	27.06
'UP 2243'	1.42	1.97	42.37	39.31	34.16	25.71
'UP 2283'	1.75	2.06	44.31	38.70	36.25	28.43
'UP 2285'	1.64	1.98	42.06	38.00	38.25	28.43
'Sonalika'	1.63	1.97	47.74	41.91	36.48	28.58
CD (P = 0.05)	0.11	0.11	2.13	2.14	3.14	2.40

D_1, 15 November; D_2, 5 December; D_3, 25 December; D_4, 15 January in 1987–87; D_1, 2 December; D_2, 17 December; D_3, 18 January; D_4, 28 January in 1988–89

Table 2. Regression parameters of grain-yield analysis using delay in sowing (D, days) and mean maximum temperature during grain-filling stage (T, °C) as independent variables

Regression parameter	1987–88	1988–89
Equation A	Y = 3979.7— 12.34 D	Y = 4257.38— 51.68 D
R^2	0.86	0.96
SE	3.50	7.28
Equation B	Y = 7626.6— 134.12 T	Y = 21988.17— 587.27 T
R^2	0.80	0.96
SE	47.26	73.83

Table 3. Effect of delayed sowing on wheat yield

Genotype	Reduction in grain yield (kg/ha)	
	Per day delay in sowing	Per °C increase in temperature*
'UP 1177'	47.08 ± 5.44	533.74 ± 57.89
'UP 1179'	33.19 ± 17.70	394.85 ± 181.08
'UP 2275'	60.89 ± 6.37	687.82 ± 78.49
'UP 2276'	54.51 ± 1.85	614.34 ± 45.97
'UP 1182'	63.95 ± 10.03	753.70 ± 156.89
'UP 1183'	48.19 ± 9.15	550.41 ± 89.67
'UP 2243'	45.93 ± 7.09	521.42 ± 75.03
'UP 2283'	48.92 ± 6.85	560.13 ± 49.53
'UP 2285'	52.69 ± 7.03	600.23 ± 63.50
'Sonalika'	61.56 ± 10.11	693.66 ± 123.58

* Mean maximum temperature of grain-filling

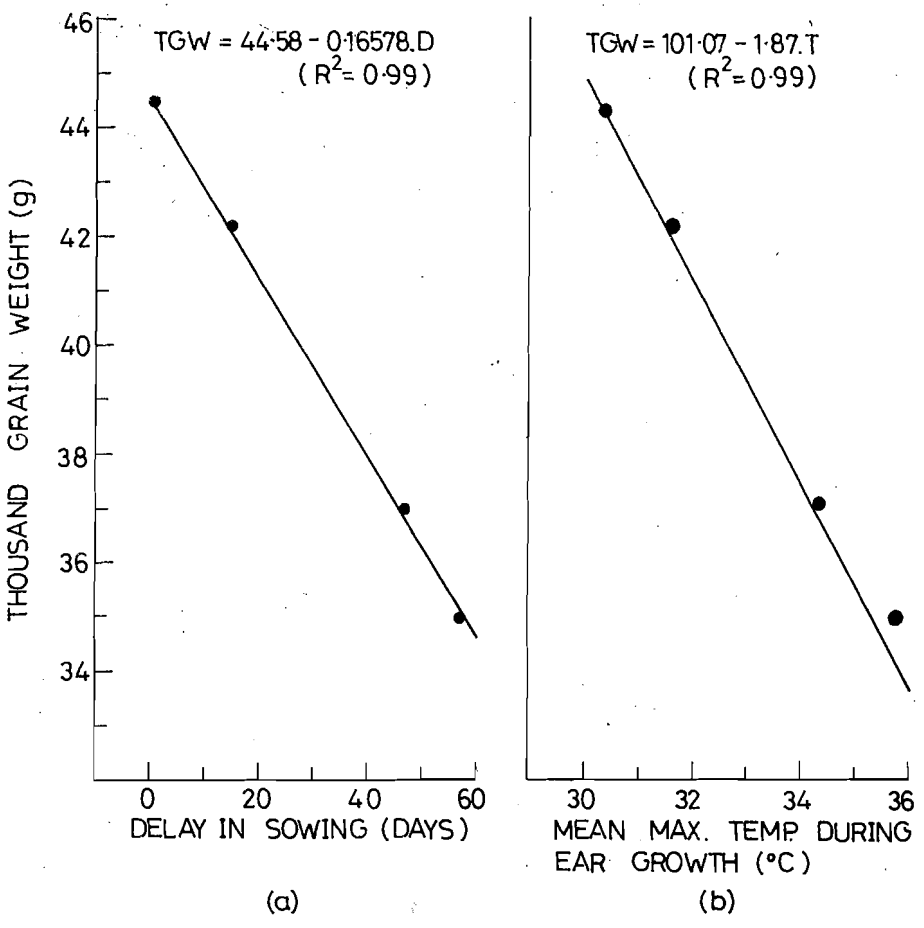

Fig. 3. Relationship between delay in sowing (*a*) and mean maximum temperature during ear growth (*b*) with 1,000-grain weight of wheat during 1988–89. Lines indicate predicted pattern of changes using regression analysis

(Table 2). Late-sown crop is exposed to higher temperature during reproductive growth, which has more complex relationship with spikelet formation, ripening and grain yield than any other weather parameter (Saini *et al.*, 1988). Though high temperature increases growth rate, it decreases the growth duration. Overall growth is the product of growth rate and growth duration and since growth duration is more affected by temperature, high temperature usually results in depressed growth and hence reduced grain yield (Evans and Wardlaw, 1976). From the regression analysis of yield data for different genotypes, the maximum reduction in grain yield with either delay in sowing or increase in mean maximum temperature during grain-filling was found in 'UP 1182' and the minimum in 'UP 1179' (Table 3).

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