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EFFECT OF CONTEMPORARY ROTATION SIMULATION ON THE GRAIN WEIGHT, PROTEIN AND LYSINE CONTENT OF BREAD WHEAT (*TRITICUM AESTIVUM* L.)

MAQBOOL AHMAD, M.A. ARAIN AND K.A. SIDDIQUI

Atomic Energy Agricultural Research Centre,
Tandojam, Sindh, Pakistan.

Abstract

Effect of contemporary rotation simulation on grain weight, protein and lysine content of four commercial cultivars (Pavon, Sarsabz, Mehran 89 and T.J. 83) and 21 new promising strains of bread wheat was studied. Late sowing decreased ($P < 0.05$) grain weight, but protein and lysine contents were significantly ($P < 0.05$) enhanced. Correlation between grain weight and development period of grain was positive ($r=0.581$), whereas, development period and protein ($r = -0.463$) and protein and grain weight ($r = -0.263$) was negative. Higher temperature in the post-anthesis period of late sown wheats probably shortened the grain filling period, which resulted in the reduced endosperm. The reduction in endosperm due to late sowing may be responsible for lower grain weight and enhanced protein content.

Introduction

Prevalent crop rotation patterns in the Sindh Province of Pakistan are: i) wheat - fallow - wheat, ii) wheat - cotton - wheat and iii) wheat - rice wheat. The normal sowing time for 1st and 2nd wheat rotation systems are 1-20th November and 21st November to 10th December, respectively. However, in wheat-rice-wheat zone, planting is delayed upto middle or end of December. Almost all the available cultivars of wheat are suitable for early and mid season planting. Due to peculiar agroclimatic requirements, late sowing of these cultivars affects their yield and quality (Hundel & Sandhu, 1990; Gubbles *et al.*, 1990; Ahmad *et al.*, 1992; Winter & Musick, 1993). The situation therefore, demands the evolution and testing of wheat genotypes which are reasonably good for yield and quality under late sowing conditions. Due to genotype x environment interaction every genotype has a different response in a specific ecological zone. Yet, earlier screening of genotypes under simulated conditions can be meaningful in promoting certain lines in the zonal trials.

Grain quality is an important consideration in wheat production programmes. Desirable quality depends on the end-use of wheat; but the major factors namely protein content and protein quality, are useful to characterize wheat quality (Orth *et al.*, 1976). The objective of the present study was to investigate the grain weight, protein and lysine response of 21 new promising wheat strains to different sowing dates in comparison to 4 commercial cultivars of this region.

Table 1. Hundred grain weight (g) of different wheat strains as influenced by sowing dates.

Strains	Sowing dates			Strain mean
	12 November	26 November	14 December	
MYT-14	4.77	4.48	3.91	4.39
WRS-01	5.62	4.93	4.27	4.94
HCWSN-11	6.02	4.57	4.60	5.06
NIFA-8804	5.82	5.62	4.77	5.41
SI8801	5.27	4.24	4.00	4.50
SI8837	5.03	4.79	4.02	4.61
SI8878	3.91	3.89	3.55	3.78
SI8887	5.65	5.77	4.52	5.31
SI8896	4.94	4.17	3.65	4.25
SI88123	5.15	4.69	4.54	4.79
SI88125	4.79	4.16	4.15	4.37
SI88126	4.54	4.65	4.05	4.42
SI88155	5.02	4.26	3.92	4.40
SI88165	4.50	4.27	3.03	4.13
SI88171	5.33	5.21	4.36	4.97
SI88229	4.94	4.23	4.14	4.44
SI88231	5.19	4.96	4.59	4.92
SI8603	5.72	4.61	4.28	4.87
SI8616	5.88	4.99	4.52	5.13
SI8692	5.03	3.93	4.11	4.35
SI86101	5.09	4.79	4.45	4.78
Sarsabz	4.84	4.95	4.10	4.63
Pavon	4.68	4.05	3.76	4.17
Mehran89	5.56	5.32	4.34	5.07
T.J.83	5.20	4.27	4.52	4.67
Sowing date mean	5.14	4.63	4.19	

LSD (5%) for sowing date means = 0.045, LSD (5%) for strain means = 0.046.

Materials and Methods

Twenty-one new promising strains (MYT-14, WRS-01, HCWSN-11, NIFA-8804, SI8801,SI8837, SI8878, SI8887, SI8896, SI88123, SI88125, SI88126, SI88155, SI88165, SI88171, SI88229, SI88231, SI8603, SI8616, SI8692, SI86101) and 4 commercial varieties of this region viz., Sarsabz, Pavon, Mehran 89 and T.J.83 were evaluated in 3 sets of trials at the Experimental Farm of AEARC, Tandojam. These trials were replicated six times in a 5x5 balanced lattice design with plot size measuring 5m x 1.2m. The trials were planted on three sowing dates viz., 12 November, 26 November and 14 December of 1990 to see the response of these strains to atmospheric conditions particularly temperature during grain filling period. Meteorological data on weekly fluctuations in temperature and humidity and grain development days (period from anthesis to maturity) were recorded, Grain weight was recorded in g after counting 100 grains. Protein contents were determined by the Udy dye binding capacity

Table 2. Grain development period (days) of different wheat strains as influenced by sowing dates.

Strains	Sowing dates			Strain mean
	12 November	26 November	14 December	
MYT-14	57	44	37	46.0
WRS-01	47	43	41	43.7
HCWSN-11	58	55	35	49.3
NIFA-8804	52	51	45	49.3
SI8801	55	50	41	48.7
SI8837	50	50	39	46.3
SI8878	49	45	41	45.0
SI8887	55	45	43	47.7
SI8896	45	45	38	42.7
SI88123	49	44	40	44.3
SI88125	55	49	39	47.6
SI88126	52	45	45	47.3
SI88155	50	47	44	47.0
SI88165	49	48	34	43.7
SI88171	54	46	41	47.0
SI88229	56	48	42	48.7
SI88231	49	48	30	42.3
SI8603	57	56	45	52.7
SI8616	57	52	42	50.3
SI8692	56	46	34	45.3
SI86101	55	50	41	48.7
Sarsabz	60	51	39	50.0
Pavon	51	44	44	46.3
Mehran89	52	40	38	43.3
T.J.83	54	55	40	49.7
Sowing date mean	52.9	47.8	39.9	

LSD (5%) for sowing date means = 1.91, LSD (5%) for strain means = 2.51.

Table 3. Correlation coefficient (r) between different characteristics of wheat strains (W = 75).

	Grain weight	Protein	Lysine
Grain filling period	0.581**	-0.463**	-0.008
Grain weight	-0.263*	-0.110	
Protein	-	-	0.132

method (Udy, 1971). Lysine contents were determined by a modified DBC method (100 mg flour, 0.45 mg/ml dye concentration) (Khan, 1978). Means were compared using LSD method.

Results and Discussion

Grain weight: Grain weight of wheat is usually a function of kernel size and density. Results regarding the effect of different sowing dates on the 100-grain weight of 25 strains of bread wheat are given in Table 1. Genotypes and sowing dates significantly affected the grain weight of wheat. Maximum 100-grain weight was recorded in case of NIFA 8804 strain (4.77 to 5.82 g). Other strains which possessed more than 5 g mean 100-grain weight were SI8887, SI8616, Mehran 89 and HCWSN-11. Lowest 100-grain weight was recorded in SI8878 (3.55 to 3.91g). Late sowing had an adverse effect on this yield component and caused drastic reduction. Mean 100-grain weight of 25 strains was 5.15 (4.50 to 5.82g) in case of 12 November sowing, but decreased to 4.63 (3.89 to 5.77g) in 26 November sowing and 4.19 (3.03 to 4.77g) in 14 December sowing.

Yield and composition of cereal grains are affected by environmental conditions operating prior to anthesis. It is during this grain development stage that the biological processes of starch and protein deposition are operative. Grain development period was significantly ($P < 0.05$) reduced in present study in case of late sown wheats (Table 2). This period varied from 45 to 60 days in wheat sown on normal date (12 November) but ranged from 40 to 56 days (26 November) and 30 to 45 (14 December) in case of late sown crop. The correlation between grain development period and 100-grain weight was positive and highly significant ($r=0.581$, Table 3). The regression equation for regression of grain weight (Y) over grain development period (X) was $Y = 2.135 + 0.054X$. The reduction in grain development period therefore, correlated to decrease in grain weight. Meteorological data (Table 4) indicate that ambient temperature was higher in the later maturity period of late sown wheats (26 November and 14 December) as compared to those sown on normal time (12 November). This higher termperature might have accelerated ripening process of grains (forced maturity) and reduced the grain development period (especially grain filling period) resulting in decreased grain weight. Post-anthesis elevated temperature ($>30^{\circ}C$) may cause premature cessation of starch deposition in the endosperm. While the rate of deposition may be faster under higher temperature, it does not compensate adequately for shortened

Table 4. Meteorological data during the wheat season (1990-91) at AEARC Tandojam.

Weeks	Temperature (°C)		Relative humidity (%)	
	Minimum	Maximum	Minimum	Maximum
Oct. 14 - Oct. 20	19	37	63	77
Oct. 21 - Oct. 27	15	33	30	50
Oct. 28 - Nov. 03	14	36	22	84
Nov. 04 - Nov. 10	16	34	29	91
Nov. 11 - Nov. 17	15	33	31	84
Nov. 18 - Nov. 24	12	33	35	100
Nov. 25 - Dec. 01	11	33	26	70
Dec. 02 - Dec. 08	11	30	33	78
Dec. 09 - Dec. 15	10	29	41	79
Dec. 16 - Dec. 22	08	28	38	79
Dec. 23 - Dec. 29	08	28	64	81
Dec. 30 - Jan. 05	06	28	28	100
Jan. 06 - Jan. 12	07	21	32	93
Jan. 13 - Jan. 19	05	23	29	93
Jan. 20 - Jan. 26	12	27	36	84
Jan. 27 - Feb. 02	10	28	36	100
Feb. 03 - Feb. 09	06	30	30	100
Feb. 10 - Feb. 16	08	28	28	95
Feb. 17 - Feb. 23	10	26	20	93
Feb. 24 - Mar. 02	11	30	33	100
Mar. 03 - Mar. 09	12	31	35	95
Mar. 10 - Mar. 16	13	32	32	90
Mar. 17 - Mar. 23	14	34	22	90
Mar. 24 - Mar. 30	18	37	25	71
Mar. 31 - Apr. 06	18	40	67	82
Apr. 07 - Apr. 13	16	37	68	83
Apr. 14 - Apr. 20	17	33	40	61
Apr. 21 - Apr. 27	18	41	61	86
Apr. 28 - May. 04	19	43	56	75

duration, so total amount of starch deposited is less (Bhullar & Jenner, 1985; Macleod & Duffus, 1988). Moreover, high temperature suppresses conversion of sucrose to starch (Bhullar & Jenner, 1986). It is plausible that high temperature might diminish endosperm sink capacity in cereals (Setter & Flanningan, 1989; Svihra, 1992). Late sowing (Anderson & Smith, 1990; Ahmad *et al.*, 1992) and high temperature (Stapper & Fischer, 1990; Tashiro & Wardlaw, 1990) during production season have been reported to reduce the size and weight of wheat grain.

Table 5. Protein (%) of different wheat strains as influenced by sowing dates.

Strains	Sowing dates			Strain mean
	12 November	26 November	14 December	
MYT-14	10.94	11.87	12.65	11.82
WRS-01	12.45	12.49	12.86	12.60
HCWSN-11	12.19	11.97	12.24	12.13
NIFA-8804	13.14	14.09	14.59	13.94
SI8801	11.53	12.33	12.90	12.25
SI8837	11.88	12.90	12.96	12.58
SI8878	10.49	13.19	13.71	12.46
SI8887	11.49	13.63	14.66	13.26
SI8896	11.45	12.69	14.23	12.79
SI88123	11.69	12.15	13.64	12.49
SI88125	11.62	11.62	13.87	12.37
SI88126	11.08	12.37	13.74	12.40
SI88155	12.85	13.15	14.74	13.57
SI88165	10.24	11.18	11.75	11.05
SI88171	11.61	11.71	12.37	11.89
SI88229	12.19	12.88	13.79	12.95
SI88231	11.14	12.68	13.11	12.31
SI8603	11.97	12.49	13.48	12.64
SI8616	12.49	13.48	14.59	13.52
SI8692	11.58	11.97	14.24	12.60
SI86101	11.62	13.15	13.55	12.77
Sarsabz	12.19	12.73	13.71	12.87
Pavon	14.13	14.32	14.74	14.39
Mehran89	11.97	13.94	13.68	13.19
T.J.83	11.08	13.44	13.28	12.60
Sowing date mean	11.80	12.74	13.87	

LSD (5%) for sowing date means = 0.074, LSD (5%) for strain means = 0.075.

Protein and lysine: Effect of genotypes as well as sowing dates on the protein and lysine content of wheat was significant ($P < 0.05$) (Tables 5 and 6). Highest amount of protein (%) and lysine (% protein) was recorded in Pavon (14.13 to 14.74) and SI88155 (3.23 to 3.50) strains respectively. These constituents were lowest in SI88165 (10.24 and 11.75) and Mehran-89 (2.67 to 3.05) wheats respectively. Delayed planting resulted in an increase in both protein and lysine contents. Mean protein (%) and lysine (% protein) contents in 12 November sowing were 11.8 and 3.26, in 26 November sowing were 12.74 and 3.27 and 14 December sowing were 13.87 and 3.29, respectively.

Table 6. Lysine (% Protein) of different wheat strains as influenced by sowing dates.

Strains	Sowing dates			Strain mean
	12 November	26 November	14 December	
MYT-14	3.20	3.27	3.29	3.25
WRS-01	3.33	3.34	3.16	3.32
HCWSN-11	3.30	3.33	3.31	3.31
NIFA-8804	3.18	3.35	3.38	3.30
SI8801	3.02	2.89	3.16	3.02
SI8837	3.29	3.31	3.13	3.30
SI8878	3.26	3.33	3.34	3.31
SI8887	3.28	3.33	3.35	3.32
SI8896	3.29	3.31	3.32	3.31
SI88123	3.29	3.28	3.32	3.29
SI88125	3.25	3.29	3.34	3.29
SI88126	3.22	3.28	3.33	3.27
SI88155	3.23	3.32	3.50	3.33
SI88165	3.26	3.27	3.32	3.28
SI88171	3.27	3.33	3.33	3.31
SI88229	3.28	3.31	3.33	3.31
SI88231	3.23	3.31	3.31	3.28
SI8603	3.34	3.31	3.33	3.32
SI8616	3.31	3.31	3.30	3.31
SI8692	3.30	3.29	3.34	3.31
SI86101	3.29	3.29	3.31	3.30
Sarsabz	3.24	3.33	3.34	3.30
Pavon	3.32	3.31	3.31	3.31
Mehran89	3.05	2.78	2.67	2.83
T.J.83	3.28	3.35	3.33	3.32
Sowing date mean	3.26	3.27	3.29	

LSD (5%) for sowing date means = 0.006, LSD (5%) for strain means = 0.051.

Variation in grain protein percentage of wheat could be due to changes in starch content, changes in protein content or a combination of the two (Kraybill, 1932). The correlation of protein with grain development period (r = -0.463) and grain weight (r = -0.263) was negative and significant (Table 3). The regression of protein (Y) on grain development period (X) can be represented by the equation Y = 16.26 - 0.076 X. The regression equation for regression of protein (Y) over grain weight (X) was: Y = 14.75 - 0.468 X.

Total carbohydrates constitute about three fourth of kernel by weight and there is negative correlation (r = -0.867) between carbohydrate and protein in wheat grains (Ahmad *et al.*, 1993). Increased grain protein percentage under shortened duration of grain development period in case of late sown crop, in the present study may be mainly due to reduced accumulation of starch. Therefore, grain protein percentage might have increased without an increase in protein deposition *per se*. While investigating the seasonal variation, Anjum *et al.*, (1987) found that higher temperature during wheat growing season was correlated with reduced grain weight and enhanced protein content. Puchkov *et al.*, (1983) reported that common winter wheat mutants with reduced endosperm (shrivelled grain) had significantly higher protein and lysine concentration in grain and lysine concentration in protein than that of its parent. Higher temperature in case of late sown wheats accelerated grain ripening and shortened grain filling period in present study (Table 2). There was therefore, probably less decrease in albumin content and less increase in gladin content in late sown wheats which resulted in high lysine content of their protein.

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