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Evaluating the Performance of Wheat Cultivars under Late Sown Conditions

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ABSTRACT

Delay in wheat sowing in rice-wheat cropping system is perhaps the one of the major factors responsible for low crop yield. This reduction in yield is due to the sub-optimal temperature during the germination, stand establishment and supra-optimal during the reproductive growth. In this study, performance of wheat cultivars (viz. Lasani-2008, Faisalabad-2008, Shafaq-2006, Sahar-2006 & Inqlab-91) sown on November 10 and December 10 was evaluated. Crop emergence was impaired when sowing was delayed owing to low temperature prevailing during stand establishment, which resulted in poor stand establishment and reduced the number of productive tillers and ultimately the final yield. With delay in planting, high temperature (32-39ºC) at reproductive stage during March and April reduced the patterns of dry matter accumulation as was evident from decrease yield related traits and the final yield. Nonetheless an increase in grain protein contents was observed in late sown crop. To conclude cultivar Inqlab-91 ontogenically being more plastic performed well in late sown conditions; nonetheless cultivar Faisalabad-2008 was at the top when planted timely. © 2010 Friends Science Publishers

Key words: Wheat cultivars; Thermal changes; Late sowing; Growth; Development

INTRODUCTION

Importance of wheat (*Triticum aestivum* L.) crop may be understood from the fact that it covers about 42% of total cropped area and 32% of total rice (*Oryza sativa* L.) area in rice-wheat system in South Asia (Iqbal *et al.,* 2002).

Uniform stand establishment and early vigor are the principal determinant of crop performance (Chivasa *et al.,* 1998). Amongst the factors limiting the uniform stand establishment poor quality seed (Radford, 1983), poor seedbed preparation (Joshi, 1987), low moisture (Harris, 1996), conventional sowing (Radford, 1983), late sowing and sub-optimum temperature at sowing (Farooq *et al.,* 2008) are more important in our region. Late planting affects the growth, yield and quality of wheat, because early sowing produces higher yields than late sowing due to longer duration. Each day delay in sowing of wheat after 20th November onward in decreases grain yield at the rate of 36 kg ha^{-1} day^{-1} (Hussain *et al*., 1998).

Temperatures below or above normal alter plant functions and productivity. In late planted wheat, low temperature prevailing during germination substantially affects the germination and seedling emergence. Germination is a critical process, as temperature below 12°C result in poor and uneven emergence (Timmermans *et al.,* 2007). Therefore, the rate of emergence and final emergence percentage are important factors in determine the crop potential in various temperature of wheat production cropping systems. In late planting season, temperature of soil can be expected to be below 10°C, which affects the seed germination and stand establishment. Poor crop establishment results in few tillers and finally decreased grain yield (Farooq *et al.*, 2008). Short period of high temperature stress i.e., ≥ 35°C at reproductive stage can decrease the grain weight (Wardlaw & Wrigley, 1994), reduced the grain quality in wheat (Randall & Moss, 1990; Savin *et al*., 1996).

Late planting results in poor tillering, reduces the tillering period and more chances of winter injury (Byerlee *et al.*, 1984; Joshi *et al.*, 1992). Generally wheat like other cool season crop is seeded early to take maximum period for growth and development toward maturity before the (possible) heat stress. However, mid-season seeding of winter wheat for any locality is usually most favorable, whereas late sown wheat suffers more winter injury, which produces fewer tillers and may ripen in lower grain weight and number of grains per plant (Razzaq *et al.,* 1986).

The genotypic response of wheat to planting dates varies for yield contributing characters due to different genetic potential. The decline becomes prominent in the cultivars requiring more days for heading under normal planting. Increase in temperature cause shortens of heading

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period (Tashiro & Wardlaw, 1999). Similarly, cultivars matured earlier when planted late, indicating the forced maturity due to high temperature. When optimum condition was provided by the wheat cultivar, grain filling period was higher as compared to late sown condition under high temperature stress at maturity.

Many high yielding wheat cultivars had been suggested for general cultivation in the past. These cultivars are losing their yield potential owing to segregation and climate change. Here the performance of newly evolved cultivars was evaluated under late sowing condition to identify the best-suited cultivar for late sowing.

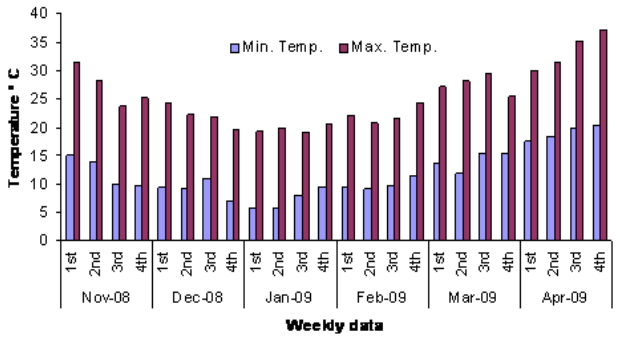
MATERIALS AND METHODS

This experimental work was done at the Agronomic Research Area, University of Agriculture Faisalabad (24°N to 37°N 61°E to 76°E) asl = 3000 m during 2008-09 in Randomized Complete Block Design (RCBD) in factorial arrangements with four replicates. Soil was clay loam in texture. Experiment was conducted to find out the performance of five wheat cultivars (Namely, Lasani-2008, Faisalabad-2008, Shafaq-2006, Sahar-2006 & Inqlab-91) under two sowing dates (November 10 (normal) and December 10 (late)) at the agro-ecological condition of Faisalabad, Pakistan. Experiment was laid out in the net plot size was 7.5 m × 5.0 m. The crop was sown in 25 cm spaced rows using single row hand drill with seed rate of 110 kg ha^{-1} on each sowing date. Fertilizer was applied @ 120-100 kg NP ha^{-1}. All phosphorus and one third of the nitrogen was applied as basal dose; Rest of the nitrogen was applied in two equal splits each with first and second irrigation. The crop was harvested on 13 April, 2009. Daily minimum and maximum temperature was recorded during the growing season of the crop (Fig. 1). Experiment was visited daily to record the daily emergence count. Time to get 50% emergence and mean emergence were calculated following Farooq *et al*. (2005) and Ellis and Roberts (1981), respectively.

From start of physiological maturity, growth traits were examined five times during growth season at 15-days interval; leaf area index (LAI) was calculated using the plant samples taken from a randomly selected unit area of each plot. Leaves were removed and measured the leaf area. Leaf area index (LAI) was calculated by taking the ratio of leaf area to ground surface area. Crop growth rate (CGR) was determined following Hunt (1978). Crop was harvested when fully ripened to record data regarding agronomic and yield related traits following standard procedure. Harvest index (HI) was taken as a ratio between grain yield and biological yield.

Data were statistically analyzed by using Fisher's analysis of variance (ANOVA) and least significantly difference (LSD) test at 5% probability level was applied to compare the treatments' means (Steel *et al.*, 1997).

Fig. 1: Summary of meteorological data (2008-2009)



RESULTS

Various wheat cultivars showed difference among the seedling emergence and stand establishment of wheat on different sowing time (Table I). In the cultivars of wheat, time to start emergence, time to 50% emergence (E_{50}) and mean emergence time (MET) was reduced when planted on Nov. 10. Minimum time to emergence and E_{50} were recorded in Faisalabad-2008 that was statistically similar to Inqlab-91. Minimum MET was recorded in Inqlab-91. Lasani-2008 and Sahar-2006 took maximum days for emergence when planted on Dec. 10. Maximum E_{50} and MET were recorded in Shafaq-2006 followed by the Sahar-2006 when planted on Dec. 10 (Table I).

Wheat cultivars showed difference in plant height, fertile tillers, spike length, spikelets per spike, grains per spike, 1000-grain weight and grain yield on different planting time (Table II). Maximum plant height, fertile tillers and grain yield was recorded in Faisalabad-2008 when planted on Nov 10, while Inqlab-91 gave maximum spike length, spikelets per spike, grains per spike and 1000-grain weight that was at par with Faisalabad-2008 in case of number of grains per spike and 1000 grain weight when planted on Nov 10 (Table III). Minimum plant height, fertile tillers, number of grains per spike and 1000 grain weight were observed in Shafaq-2006 when sown on Dec 10.

Protein content was also influenced by planting time. Maximum protein content was recorded in Inqlab-91 that was similar to Faisalabad-2008 sown on Dec 10, whereas Shafaq-2006 planted on Nov 10 gave minimum protein content (Table III).

Similarly LAI was also affected by genotypes and planting dates. Cultivar Inqlab-91 attained maximum LAI at 75 days after sowing (DAS) followed by Faisalabab-2008 when planted on Nov 10. Under late sown condition Inqlab-91 produced maximum LAI at 75 DAS which was lower than Nov planting (Fig. 2).

CGR was different among wheat cultivars on different sowing time. Higher value of CGR were observed in November planting (Fig. 3) in all cultivars. Maximum CGR was recorded in Inqlab-91 followed by the Faisalabad-2008 under early planting whereas; minimum CGR was produced by the Sahar-2006 under late planting.

Table I: Effect of different sowing dates on seedling emergence and stand establishment of wheat cultivars

Cultivars	Time to start emergence (days)		50 % emergence time (days)		Mean emergence time (days)	
	10 Nov.	10 Dec.	10 Nov.	10 Dec.	10 Nov.	10 Dec.
Lasani-2008	6.00 d	8.00 a	8.35 f	9.35 c	9.74 e	10.75 b
Faisalabad-2008	5.25 e	6.75 c	7.82 g	9.16 de	9.86 e	10.30 9c
Shafaq-2006	7.00 bc	7.25 b	9.05 e	10.10 a	10.12 d	10.95 a
Sahar-2006	6.00 d	8.00 a	8.26 f	9.67 b	9.55 f	10.70 b
Inqlab-91	5.50 e	7.00 bc	7.96 g	9.22 cd	9.20 g	10.14 d
Mean	5.95	7.40	8.29	9.49	9.69	10.58

Table II: Effect of different sowing dates on agronomic traits and yield components of wheat cultivars

Cultivars	Plant height (cm)		Fertile tillers (m^{-2})		Spike length (cm)		No. of spikelets/spike		No. of grains/spike	
	10 Nov.	10 Dec.	10 Nov.	10 Dec.	10 Nov.	10 Dec.	10 Nov.	10 Dec.	10 Nov.	10 Dec.
Lasani-2008	90.10 b	82.28 c	389 bc	354 de	10.75 b	9.36 e	18.75 a	17.63 cde	49.00 bc	41.00 d
Faisalabad-2008	94.87 a	79.55 d	442 a	414 ab	10.37 c	9.22 e	17.75 bcd	16.98 ef	53.75 ab	41.00 d
Shafaq-2006	73.81 e	70.93 f	390 bc	319 f	10.11 cd	9.79 d	16.70 f	17.08 def	42.25 d	39.00 d
Sahar-2006	88.64 b	82.33 c	396 bc	368 cd	10.20 c	9.01 e	18.62 ab	17.98 bc	52.50 ab	41.00 d
Inqlab-91	79.14 d	79.03 d	375cd	332 ef	11.58 a	10.10 cd	19.02 a	17.88 bc	57.50 a	44.00 cd
Mean	86.30	78.82	398	357	10.60	9.49	18.13	17.20	51.00	41.10

Table III: Effect of different sowing dates on agronomic traits and yield components of wheat cultivars

Cultivars	1000-grain weight (g)		Biological yield (t/ha)		Grain yield (t/ha)		Harvest index (%)		Protein contents (%)	
	10 Nov.	10 Dec.	10 Nov.	10 Dec.	10 Nov.	10 Dec.	10 Nov.	10 Dec.	10 Nov.	10 Dec.
Lasani-2008	43.68 de	38.41 f	12.38 a	11.75 a	4.38 bc	3.80 cd	35.35 a	32.34 a	8.46 f	10.56 b
Faisalabad-2008	50.33 b	43.51 e	19.10 a	14.03 a	5.95 a	3.68 cde	31.15 a	26.20 a	8.94 e	10.71 ab
Shafaq-2006	45.95 cd	34.73 g	13.50 a	10.88 a	3.68 cde	3.55 cde	27.22 a	32.64 a	8.26 f	10.21 c
Sahar-2006	42.45 e	41.94 e	17.25 a	13.35 a	5.23 ab	3.23 de	30.29 a	24.16 a	9.05 e	10.51 b
Inqlab-91	53.16 b	47.34 c	15.80 a	12.70 a	5.33 a	4.10 bc	30.70 a	22.05 a	9.40 d	10.97 a
MEAN	47.11	41.18	15.60	12.54	4.91	3.41	32.38	27.38	8.82	10.59

Mean values sharing the same letter for a letter do not differ significantly (P = 0.05)

DISCUSSION

The early sowing resulted in better development of the grains due to longer growing period. As timey planted wheat had more time for the dry matter accumulation to produce the higher grain yield (Spink *et al*., 2000; Shahzad *et al*., 2002). The short growing season cultivars like Inqlab-91 gave better grain yield in late sowing. These results suggest that cultivars should be chosen to suit the seasonal break, which may vary from November to December. Under late sowing, early germination and seedling growth are very important for better stand establishment of wheat crop. Cultivar Inqlab-91and Faisalabad-2008 germinate earlier, which reduced the time to start emergence and mean emergence time and attained the good stand establishment as compared with other cultivars. This might be due to the ability to tolerate low temperature during the germination. Benjamin (1990); Stewart *et al*. (1990) reported that low temperature during the germination and early seedling has detrimental effect on the crop establishment and productivity.

Tillering starts after the completion of the germination and reaches to the maximum at the end of the vegetative growth stage. Maximum number of productive tillers contributes to the highest yield. For late sown condition, cultivar Faisalabad-2008 and Inqlab-91 produced more number of productive tillers due to better germination and stand establishment as compared to other cultivars those had poor stand establishment. Poor emergence and stand establishment result in fewer fertile tillers (Farooq *et al*., 2008). The pattern of the tillering is affected by the sowing dates due to change in temperature and contribution of tillers to grain yield is maximum during the early planted crop and decreased with delayed planting (Table II).

Under late sown condition, minimum LAI and CGR was recorded in Sahar-2006, Lasani-2008 and Shafaq-2006, which might be due to sub-optimum temperature during the vegetative growth phase, as leaf development and dry matter accumulation greatly depends on the prevailing temperature (Warrington & Kanemasu, 1983). Thus in response to an increase in temperature, the leaf area remains too small to support the required growth of the seedling. In addition the low temperature slows down the rate of leaf initiation (Warrington & Kanemasu, 1983), which may decrease the LAI.

Under late planting, the cultivars showed the significant difference for all yield and yield contributing parameters. Cultivars Inqlab-91 and Faisalabad-2008 produced the maximum number of grain per spike, spike length and 1000 grain weight, which might be due to more production of dry matter and ability to tolerant heat stress during the reproductive phase. Due to sensitivity to high

Fig. 2: Effect of sowing dates and cultivars on leaf area index of wheat

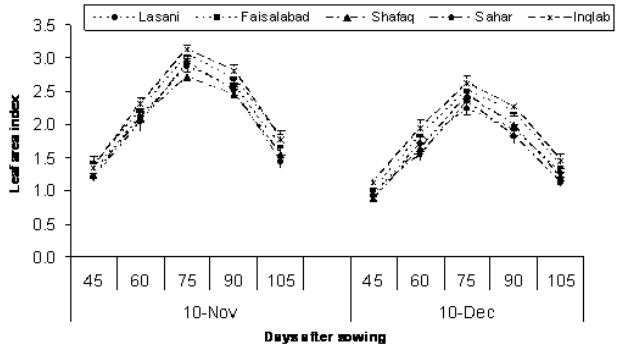
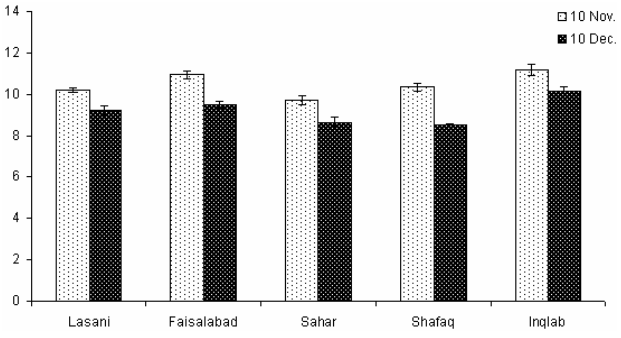


Fig. 3: Effect of sowing dates and cultivars on crop growth rate of wheat on two sowing dates Mean ± SE



temperature Sahar-2006, Shafaq-2006 and Lasani-2008 cultivars produced the low grain number and weight. High temperature induces modifications in plants may be direct as on existing physiological processes or indirect in changing the pattern of development (Downton & Slatyer, 1972). Low grain yield in late planting crop is resulted from thermal stress, which causes by higher temperature (≥ 32°C), which prevailing during grain filling. High temperature stretches the period of grain filling resulting in reduced development of grain ultimately decreasing the grain number and grain weight in wheat crop (Guilioni *et al*., 2003). Both grain numbers and weight are susceptible to the thermal stress, with increase in temperature the number of grain per spike were reduced at maturity (Ferris *et al*., 1998). Overall, it seems that reproductive phase (of wheat crop) is hampered by heat stress, which then affects the fertilization process leading to reduced crop yield.

Furthermore higher protein contents were recorded in cultivars Inqlab-91 and Faisalabad-2008 as compared to the other cultivars might be due the more tolerance to high temperature. Quality and physio-chemical characteristics of the wheat flour and bread are also changed due to high temperature stress during the grain filling peroid (Perrotta, 1998) with changes in protein content of the flour (Wardlaw *et al.*, 2002). The synthesis of heat shock protein i.e., late embryogenesis abundant (LEA) protein in the wheat grain increases the protein contents as a result of high temperature and is believed to have a protective role under environmental stress in late planting wheat (Reynolds *et al*., 2001).

To summarize in timely sowing, cultivar Faisalabad-2008 out-yielded other cultivars; whereas under late planting cultivar Inqlab-91 performed better followed by the Lasani-2008 and Faisalabad-2008.

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