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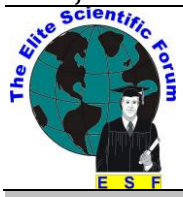

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RESEARCH ARTICLE

Effect of Different Sowing Times and Cultivars on Wheat Grain Quality under Cotton-Wheat Cropping System in Southern Punjab, Pakistan

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ABSTRACT

The quality of wheat grain can impact the farmer's income and also affect human health. The interaction between the planting time and genetic information indicated a significant effect. Determining correct planting time that can exploit the result of interaction between genotypes and atmosphere that enhance the production and grain quality. The main objective of this study was to choose the more suitable planting dates that maximize the wheat production and quality of wheat grain in cotton-wheat cropping system at different locations. Four wheat cultivars were planted at November 10th ,20th, December 1st, and December 10th at three different cotton-wheat system growing districts, i.e., Bahawalpur, Khanewal, and Multan during both years. Late sown crop December 10th recorded maximum protein content (16.32%), starch contents (55.24%), and gluten content (34.19%) while early sown crop showed maximum moisture content (23.33%). Cultivar ASS-2011 demonstrated maximum protein content (13.47%), moisture content (10.73%), and starch content (55.09% and gluten content (33.66%). Year-II recorded the maximum protein content 11.95% moisture content 13.91%, starch content (53.89%), and gluten content 4.90% as compared 1st year in case of wheat crop. Wheat cultivar AAS-2011 showed best results regarding quality attributes in case of the late sown condition.

INTRODUCTION

Wheat (*Triticum aestivum* L) is an important food crop cultivated for feed grain on the earth (Abbas and Ahmad, 2018; Ahmad et al., 2019). Approximately, 60-80% carbohydrates, 8-15 % protein, 1.5-2.0% fat, 1.5-2.0% inorganic ions along with vitamin (B-complex & E) are present in grain (Shahzad et al., 2007; Ahmed et al., 2019; Jabran et al., 2020; Khan et al., 2019). Wheat offers more than 50 percent of the total calories and 60 percent of the total protein used by people of the world. With the increase in temperature, physiology of the wheat plant, grain yield and quality of grain are changed. High temperature (>35°C) after the anthesis period reduced the grain quality (Sial et al., 2005). Wheat is an abundant source of food for people of the world as compared to any other food entity. Wheat grain storage and conversion of grain into flour are very simple and easy. Digestion of protein is very simple and easy and is similar to starch. Wheat grain quality is a role of grain composition, mainly in proteins, which is determined by cultivars and climate. The effect of inheritance is largely reflected by quality differences such as protein polymorphism followed by quantity dissimilarity of total protein units and subunits. Climatic effects were reflected by quantity differences in total protein, protein units, and subunits. Grain quality composition is controlled by genetics and cultural practices. It was concluded that conditions that condense grain filling i.e. maximum temperature or water deficit condition influenced the balance protein fractions. The protein content is considered a key

feature that describes the fitness of wheat as an ideal food. Qualitative and quantitative protein is significant in determining the suitability of flour for its end-produce superiority (Ferdous and Rehman, 2013). Grain yield, growth, and quality can be influenced by sowing wheat crop before or after the best time (Seleiman et al., 2011).

Getting more production and baking quality is critical for wheat crop competition. Planting time influenced the baking quality and it is very different task to increase grain yield and baking quality because a negative correlation is observed between these two factors. Suitable planting time influenced the water, temperature and solar radiations accessible for a crop. Unfavorable ecological conditions at the reproductive stage and grain development stage are significant factors in the baking superiority categorization of wheat (Silva et al., 2014). Wheat quality attributes especially flour protein, moisture content, starch content and gluten content, milling-yield, rheological properties along with bread making properties are affected by cultivars plus sowing time and their interaction (Spiertz et al., 2006). Higher protein, starch and gluten contents and smaller grain size were observed in the case of the late sown wheat crop due to higher temperature at/after anthesis stage and ultimately wheat reduced grain development with less endosperm and grain weight (Eslami et al., 2014). The productivity of wheat and grain quality is mainly affected by cultivar inheritance and different agronomic practices especially at the time of sowing (Sohrabi et al., 2010). Due to its high protein, starch and gluten values, wheat is used in various food industries. The quality of the wheat grain is influenced by unfavorable climatic conditions. Grain protein content and other quality characteristics might be significantly influenced by the host of ecological factors, with cultivating zone along with environmental variables indicating major effects (Saeed et al., 2014). Temperature stress decreased grain weight and impaired grain quality during the reproductive stage. Grain quality is a significant determinant in genetics and influences the commercial values of cultivars. The presence of specific alleles at loci enhanced the quality of grain. If a cultivar has some special allele combination at critical loci then it represents the quality of the end product. Production of cultivars with the best quality demanded climate which enhanced the genetic potential (Bagulho et al., 2015). Maximum temperature after the anthesis stage especially in late sowing indicated smaller endosperm, less grain weights, rose protein, starch and gluten contents (Abdullah et al., 2007).

This study was focused to investigate the impacts of appropriate sowing dates and different cultivars and their parallel interactions on wheat grain quality under the cotton-wheat cropping systems at different locations in southern Punjab, Pakistan.

MATERIALS AND METHODS

Four wheat cultivars viz. AAS-2011, AARI-2011, PUNJAB-2011 and MILLAT-2011 were sown at four different times i.e. November 10th, November 20th, December 1st and December 10th during the years 2015-16 and 2016-17.

Wheat grain quality

Grain quality parameters including grain protein, moisture, starch and gluten contents were determined by the following methods:

Protein contents

Nitrogen contents were quantified by Micro-Kjeldahl distillation method (Tecator, 1991). For titration purpose, sulphuric acid was taken which showed pink color as end point indicator . The nitrogen and protein contents were estimated as follows:

$$\text{Nitrogen } (\%) = \frac{V_2 - V_1}{W} \text{ x N x } 0.141 \text{ x } 100$$

Where, V_1 = Sulphuric acid amount used for titration; V_2 = Amount of normal sulphuric acid utilized for titration of vacant solution; N = Normality of sulphuric acid; and W = sample weight.

$$\text{Crude protein } (\%) = \% \text{ Nitrogen x } 625$$

Moisture contents

Wheat grains were changed into powder form by grinding to determine the moisture contents. We took weighed homogenous sample in weighed flat bottom dish and re-weighed again. This weighed sample dish was placed on heat at 100 °C for 240 minutes and placed the sample in desiccators for cooling purpose. The sample was reweighed after cooling and placed this sample in oven again for 120 minutes. The weight of samples was calculated after regular intervals until it achieved a constant weight. The moisture contents of wheat were calculated as followed.

$$\text{Moisture } (\%) = 100 \text{ x } \frac{\text{Weight of fresh sample} - \text{Weight of sample after drying}}{\text{Weight of sample}}$$

Starch contents

A total of 100 mg precisely weighed sample was placed in a test tube followed by addition of aqueous ethanol (0.2 mL) to soak dispersed particles. Whirlpool food mixer was used to mix the tube. Thermostable α-amylase (3 mL) was mixed and tube was placed in boiling water for 6 minutes approximately with continuous stirring. Amyloglucosidase (330 U) was added with 0.1 mL starch and incubated in water bath at 50 °C for half hour, stirring tube kept on vortex blender moved material of tube in flask. The volume was regulated with distilled water. This material was centrifuged for 10 minutes at 3000 rpm. Then, shifted the 0.1 ml extra aliquot of adulterate liquid to beaker test tube. Thereafter, 3.0 ml of GOPODN reagent was mixed to every tube holding D-glucose controls and GOPODN as a reagent vacant, placed to heat tube at 50°C for twenty minutes. Absorption for every sample

was pointed out and D-glucose was managed at 510 nm beside vacant reagent. The starch contents were calculated by using the formula as follows:

$$\text{Starch} \quad (\%) = \Delta A \times \frac{F}{W} \times FV \times 0.9$$

$$F = \frac{100}{\text{Absorbance of D-Glucose}}$$

Where ΔA = Absorption (reaction) study beside the digested sample; FV = Volume final for example equivalent 100 mL or 10 mL; and W = Weight of sample (in milligram)

Gluten content

Flour sample (25 gm) was obtained in porcelain cup and water was added to form strong dough bowl. The dough waas kept in H_2O at 25 °C for 30 minutes. The dough was pushed efficiently in brook of water tapped to exclude starch and all soluble materials. Though extra starch excluded gluten ball changed into black and obtained on a web like structure in 30 minutes. Then we noted weight of gluten bowl and it was regarded as wet gluten (W_1). After this soaked gluten was shifted into glutork for almost four minutes for drying and recorded weight known as dry gluten (W_2).

$$\text{Wet gluten} \quad (\%) = \frac{W_1}{\text{Weight of sample}} \times 100$$

$$\text{Dry gluten} \quad (\%) = \frac{W_2}{\text{Weight of sample}} \times 100$$

RESULTS

Protein content (%)

Protein is very significant part of our body. Effect of years remained significant on protein content at all experimental sites (Table 1). Maximum protein content was found 12.13% during 2nd year trial which was 11.95% more than 1st year (13.58%). Wheat protein was significant affected by cultivars at all sites. Maximum protein content was achieved by cultivar AAS-2011 (13.47%) which was 2.75% more than ARRI-2011(13.10%), 6.01% more than Punjab-2011 (12.66%) and Millat-2011 which achieved the minimum protein content (12.18%) which was 9.58 less than AAS-2011. Sowing time showed significant results regarding protein contents at all sites. Maximum protein content was achieved by late sown crop December 10th (16.32%). December 1st represented protein content 13.48% and November 20th showed 12.17% and minimum protein content was observed in early sowing November 10th (10.48%). Non-significant interaction between season and time of sowing, along with years, cultivars along with sowing dates was observed on all sites. Highly significant response regarding protein content was shown by years and cultivars at Bahawalpur, Khanewal along with Multan. Interaction between cultivars along with sowing dates was represented significant at Khanewal along with Multan but non-significant results at Bahawalpur. The highest protein contents 16.14, 14.33 and 13.20% in second year were displayed by cultivar AAS-2011. The cultivar AAS-2011 showed minimum protein content 11.40 during 1st year at Bahawalpur and Millat-2011 represented 10.87 and 10.30% during 2nd year at Khanewal along with Multan, respectively (Table 2). Cultivar AAS-2011 recorded the highest protein content 16.97 and 14.79% at December 10th sowing and Millat-2011 displayed the lowest protein content 8.88 and 9.22% in the wheat crop which sown in 1st week of November at Khanewal and Multan, respectively (Table 3). Average values for protein contents were noted 14.38 at Bahawalpur 12.55% at Khanewal and minimum protein content was seen 11.63% at Multan (Table 1).

Moisture content (%)

Table 1 showed that moisture content in wheat grain was significantly affected by the years at all sites. Maximum moisture content was recorded during 2nd year of trial than 1st year which exceeded 13.91% more (11.43 vs. 9.84%). Cultivars indicated significant results regarding moisture content at Bahawalpur, Khanewal, and Multan. Cultivar ASS-2011 produced the highest moisture content (10.73%) which was almost equal to ARRI-2011 (10.72%). Cultivar Punjab-2011 and Millat-2011 displayed moisture content with little difference 10.08 % and 9.77%, However, Millat-2011 showed minimum values. Sowing time displayed significant results regarding moisture content at all sites. Maximum moisture content was shown in early sown crop which was 23.33% more (11.79 vs. 9.04%) than late sowing. Years, cultivars along with sowing dates represented non-significant behavior regarding moisture content at Bahawalpur and Multan but highly significant results were noted at Khanewal. Significant results were observed among years and cultivars, years along with sowing dates on all sites. Interaction between cultivars and sowing dates remained non-significant on all sites. Cultivar AAS-2011 recorded the highest moisture content 12.92, 11.70, and 9.33% during the second year and Millat-2011 represented minimum moisture content 11.47, 8.51, and 8.28% for 1st year on Bahawalpur, Khanewal along with Multan (Table 6(b)). All-out moisture contents 14.19% was observed by early sowing at Bahawalpur, 11.98% at Khanewal, and 11.17% at Multan during 2nd year, and minimum moisture content was noted 10.44%, 7.63%, and 7.58% during 1st year by late sowing on Bahawalpur, Khanewal along with Multan, respectively (Table 2. Cultivar AAS-2011 displayed maximum moisture content 12.95% in November 10th sowing in 2nd year and Punjab-2011 displayed minimum moisture content 7.29% in December 10th sowing in 1st year at

Table 1: Wheat quality parameters (protein, moisture, starch and gluten contents) as effected by cultivars and sowing dates

Treatments	Protein Contents (%)				Moisture Contents (%)				Starch Contents (%)				Gluten Contents (%)			
	BWP	KWL	MLN	Mean	BWP	KWL	MLN	Mean	BWP	KWL	MLN	Mean	BWP	KWL	MLN	Mean
A. Years																
Year-I	12.92b	12.22b	11.24b	12.13	11.64b	9.20b	8.69b	9.84	53.63b	53.57b	51.96b	53.05	34.75b	30.33b	27.48b	30.58
Year-II	15.84a	12.88a	12.01a	13.58	12.34a	10.51a	9.55a	11.43	54.58a	54.55a	52.54a	53.89	35.81a	31.99a	28.43a	32.08
LSD %	0.44	0.20	0.25		0.22	0.37	0.25		0.17	0.22	0.28		0.58	0.35	0.71	
Significance	**	**	**		**	**	**		**	**	**		**	**	**	
B. Cultivars																
AAS-2011	13.77b	13.77a	12.87a	13.47	12.34a	10.66a	9.19ab	10.73	55.09a	54.23a	53.24a	54.19	35.36a	33.66a	29.48a	32.83
AARI-2011	14.39ab	13.15b	11.75b	13.10	12.29a	10.37a	9.50a	10.72	54.92a	54.09a	52.82a	53.94	35.30a	33.43a	28.67a	32.47
PUNJAB-2011	14.46a	12.13c	11.40b	12.66	11.83b	9.59b	8.81c	10.08	53.79b	54.01a	51.97b	53.26	35.31a	30.71a	27.65b	31.22
MILLAT-2011	14.89a	11.14d	10.50c	12.18	11.50b	8.82c	8.99bc	9.77	52.63c	53.90a	50.98c	52.50	35.14a	26.83a	26.02c	29.33
LSD %	0.62	0.29	0.36		0.32	0.42	0.36		0.24	0.32	0.39		0.82	0.50	1.01	
Significance	**	**	**		**	**	**		**	NS	**		NS	**	**	
C. Sowing Dates																
Nov. 10th	11.58d	9.83d	10.04d	10.48	13.55a	11.49a	10.34a	11.79	52.05d	52.15d	50.45d	51.55	32.68d	27.89d	25.49d	28.69
Nov. 20th	13.28c	12.11c	11.13c	12.17	12.33b	10.07b	9.45b	10.62	53.50c	53.54c	51.68c	52.91	34.33c	30.31c	26.91c	30.52
Dec. 1st	15.25b	13.03b	12.15b	13.48	11.41c	9.25c	8.86c	9.84	54.85b	54.87b	52.87b	54.20	36.60b	32.09b	28.70b	32.46
Dec. 10th	17.41a	15.22a	13.90a	16.32	10.66d	8.62d	7.83d	9.04	56.02a	55.67a	54.03a	55.24	37.50a	34.35a	30.72a	34.19
LSD %	0.62	0.29	0.36		0.32	0.42	0.36		0.24	0.35	0.39		0.82	0.50	1.01	
Significance	**	**	**		**	**	**		**	**	**		**	**	**	
Interactions																
A x B	**	*	**		**	**	*		**	NS	NS		NS	NS	NS	
A x C	NS	NS	NS		*	*	**		**	NS	NS		NS	NS	NS	
B x C	NS	**	**		NS	NS	NS		NS	**	NS		NS	.*	*	
A x B x C	NS	NS	NS		NS	**	NS		NS	NS	*		NS	NS	NS	
Mean	14.38	12.55	11.63		11.99	9.86	9.12		54.11	54.06	52.25		35.28	31.16	27.96	

Means sharing different letters in a column differ significantly at P = 0.05; BWP = Bahawalpur; KWL = Khanewal; MLN = Multan.

Table 2: Interactive effects of years and cultivars on wheat protein and moisture contents (%)

Year x Cultivar	Bahawalpur			Khanewal			Multan		
(a)-Protein contents									
	Year-I	Year-II	Mean	Year-I	Year-II	Mean	Year-I	Year-II	Mean
V_1	11.40d	16.14a	13.77	13.21b	14.33a	13.77	12.54b	13.20a	12.87
V_2	12.68c	16.10a	14.39	13.01b	13.29b	13.15	10.67de	12.82ab	11.75
V_3	13.33c	15.59a	14.46	11.78d	12.48b	12.13	11.07d	11.72c	11.40
V_4	14.24b	15.54a	14.89	10.87e	11.42d	11.15	10.69de	10.30e	10.50
Mean	12.91	15.84		12.22	12.88		11.24	12.01	
LSD %	0.88			0.40			0.50		
(b)-Moisture contents									
Year x Cultivar	Bahawalpur			Khanewal			Multan		
	Year-I	Year-II	Mean	Year-I	Year-II	Mean	Year-I	Year-II	Mean
V_1	11.76bc	12.92a	12.34	9.61bc	11.70a		9.04c	9.33bc	9.19
V_2	11.69bc	12.88a	12.29	9.45bc	11.29a		9.10c	9.89a	9.50
V_3	11.63bc	12.02b	11.83	9.24c	9.94b		8.35d	9.27bc	8.81
V_4	11.47c	11.54c	11.51	8.51d	9.13c		8.28d	9.68ab	8.98
Mean	11.64	12.34		9.20	10.52		8.69	9.54	
LSD %		0.45			0.60			0.51	
(c)-Moisture contents									
Year x Sowing dates									
	Year-I	Year-II	Mean	Year-I	Year-II	Mean	Year-I	Year-II	Mean
D_1	12.91b	14.19a	13.55	10.99b	11.98a	11.49	9.52bc	11.17a	10.35
D_2	12.06c	12.60b	12.33	9.64d	10.50bc	10.07	8.98d	9.91b	9.45
D_3	11.13d	11.70c	11.42	8.54e	9.95cd	9.25	8.70d	9.02cd	8.86
D_4	10.44e	10.87de	10.66	7.63f	9.62d	8.63	7.58e	8.08e	7.83
Mean	11.64	12.34		9.20	10.51		8.82	9.42	
LSD %		0.45			0.60			0.51	

Means sharing different letters in a column differ significantly at P = 0.05.

Table 3: Interactive effect of cultivars and sowing dates on wheat protein, starch and gluten contents (%)

Cultivar x Sowing dates		V_1	V_2	V_3	V_4	Mean
(a)-Protein contents						
Khanewal	D_1	10.56i	10.19ij	9.67j	8.88k	9.83
	D_2	13.33e	12.71fg	11.76h	10.67i	12.12
	D_3	14.22cd	13.67de	12.46g	11.77h	13.03
	D_4	16.97a	16.03b	14.62c	13.26ef	15.22
Mean		13.77	13.15	12.13	11.15	
LSD 5%				0.57		
Multan	D_1	10.22hi	10.30hi	10.40g-i	9.22j	10.04
	D_2	12.69cd	11.05fg	10.87gh	9.88ij	11.12
	D_3	13.77b	12.34de	11.75ef	10.75gh	12.15
	D_4	14.79a	13.28bc	12.56d	12.12de	13.19
Mean		12.87	11.74	11.40	10.49	
LSD 5%				0.71		
(b)-Starch contents						
Khanewal	D_1	51.60h	52.21gh	52.83fg	52.97h	52.40
	D_2	53.67e	53.47e	53.43ef	53.60e	53.54
	D_3	55.27bc	54.93cd	54.57d	54.73cd	54.88
	D_4	56.40a	55.77ab	55.20bc	55.31bc	55.67
Mean		54.24	54.10	54.01	54.15	
LSD 5%	0.63					
(c)-Gluten contents						
Khanewal	D_1	29.55gh	30.22gh	27.97i	23.83k	27.89
	D_2	32.95e	33.08e	29.38h	25.82j	30.31
	D_3	35.02c	34.39cd	31.78f	27.13i	33.73
	D_4	37.12a	36.05b	33.72de	30.50g	35.63
Mean		33.66	33.44	30.71	24.83	
LSD 5%				1.00		
Multan	D_1	27.56de	24.64f	24.82f	24.94f	25.49
	D_2	28.50cd	27.45de	26.28ef	25.39f	26.91
	D_3	30.11bc	29.97bc	28.51cd	26.21ef	28.70
	D_4	31.75ab	32.62a	30.97ab	27.55de	30.72
Mean		29.48	28.67	27.65	26.02	
LSD 5%				2.01		

Means sharing different letters in a column differ significantly at P = 0.05.

Khanewal (Table 4(a)). Average values for moisture content highest values were obtained 11.99 at Bahawalpur followed by 9.86 at Khanewal and minimum moisture content was noted 9.12% at Multan (Table 1).

Starch content (%)

Data in Table 1 showed that influence of years regarding starch content was significant on all sites. Average starch content values were observed highest in 2nd year of experiment (53.89%) than 1st year (53.05%). Significant response was demonstrated by cultivars regarding starch content at Bahawalpur along with Multan and remained non-significant in Khanewal. Highest starch content (55.09% and 53.24) was observed by AAS-2011 tracked by AARI-2011 (54.92% and 52.82) but difference is minute. Cultivar Punjab-2011 represented (53.79 and 51.97 %) and Millat-2011 showed minimum starch content (52.63% and 50.98) at Bahawalpur and Multan, respectively. Starch content was significantly affected by time of sowing at all sites. Maximum starch content was demonstrated by delayed sowing (55.24%) while timely sown crop displayed minimum values for starch content (51.55%). Non-significant interaction was noted between seasons, varieties and time of sowing at Bahawalpur and Khanewal while significant results at Multan site. Seasons and varieties along with seasons and time of sowing represented significant results regarding starch content at Bahawalpur. Significant results were observed between varieties and time of sowing concerning starch content at Khanewal. Highest starch content 56.22 % were demonstrated by delayed sowing during 2nd year of experiment and timely sowing showed lowest starch content 51.18% during 1st year at Bahawalpur (Table 5). Maximum starch content 55.59% was introduced by cultivar AAS-2011 during second year of trial and Millat-2011 produced minimum starch 52.45% in 1st year in Bahawalpur (Table 9). At Khanewal AAS-2011 represented highest starch 56.40 % in delayed sowing and lowest starch content 51.60% in early planted crop (Table 3). Cultivar AAS-2011 recorded highest starch 55.63% in delayed sowing during 2nd year along with Millat-2011 gave the lowest starch 48.27% in timely sowing during 1st year at Multan (Table 4(b)). Average values for starch content remained highest 54.11 at Bahawalpur followed by 54.06 at Khanewal and lowest starch content was observed 52.25% at Multan, respectively (Table 1).

Table 4: Interactive effect of years, cultivars and sowing dates on wheat moisture and starch contents (%)

Year x Cultivar x Sowing date		Year-I					Year-II				
		V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
(a)-Moisture contents											
Khanewal	D_1	12.42a-c	11.20de	10.97d-f	9.40g-j	11.00	12.95a	12.47ab	11.53b-d	10.98d-f	11.98
	D_2	10.14e-h	10.51d-g	9.81f-i	8.12k-n	9.65	11.57b-d	11.06de	10.13e-h	9.24h-k	10.50
	D_3	8.57j-l	8.74i-l	8.88i-l	7.97l-n	8.54	11.23c-e	10.86d-f	9.21h-k	8.52j-m	9.96
	D_4	7.32n	7.36mn	7.29n	8.56j-l	7.63	11.05de	10.75d-f	8.90i-l	7.76l-n	9.62
Mean		9.61	9.45	9.24	8.51		11.70	11.29	9.94	9.13	
LSD 5%						1.19					
(b)-Starch contents											
Multan	D_1	51.07l-n	51.87h-l	48.50o	48.27o	49.93	51.47j-m	51.27k-m	51.02l-n	50.10n	50.97
	D_2	52.33g-k	52.45f-j	50.70mn	50.13n	51.40	52.63f-i	52.50f-j	51.93h-l	50.73mn	51.95
	D_3	53.53c-f	53.07e-g	52.43f-j	51.60i-m	52.66	54.43b-d	54.40b-g	52.87f-h	51.60i-m	53.33
	D_4	54.83ab	53.47c-f	54.27b-d	52.90f-g	53.87	55.63a	54.54a-c	54.02b-e	52.53f-j	54.18
Mean		52.94	52.72	51.48	50.73		53.54	53.18	52.46	51.24	
LSD 5%						1.11					

Means sharing different letters in a column differ significantly at P = 0.05; *, ** = Significant at 5% and 1%, respectively; NS = Non-significant.

Table 5: Interactive effect of years and cultivars, years and sowing dates on wheat starch contents (%)

Year x Cultivar	Bahawalpur		
	Year-I	Year-II	Mean
V_1	54.58b	55.59a	55.09
V_2	54.42d	55.40a	54.91
V_3	53.05c	54.53b	53.79
V_4	52.45d	52.81	52.63
Mean	53.63	54.58	
LSD 5%	0.34		
Year x Sowing date			
D_1	51.18g	52.92f	52.05
D_2	52.91f	54.09e	53.50
D_3	54.60d	55.10c	54.85
D_4	55.81b	56.22a	56.02
Mean	53.63	54.58	
LSD 5%	0.34		

Means sharing different letters in a column differ significantly at P = 0.05; *, ** = Significant at 5% and 1%, respectively; NS = Non-significant.

Gluten content (%)

The effect of season on gluten content remained significant at all sites (Table 1). Gluten content in the second year of experiment exceeds 4.90% (32.08 vs. 30.58) than 1st year. Wheat gluten content was significantly affected by cultivars at Khanewal along with Multan but showed non-significant results in Bahawalpur. Maximum gluten was witnessed by AAS-2011 (33.66% and 29.48%) and minimum gluten content was noted (26.83% and 26.02%) in Millat-2011 at Khanewal and Multan, respectively. Sowing time significantly affected gluten content at all sites. Delayed sowing December 10th represented the highest gluten content (34.19%) which exceeds 5.05, 10.73 and 16.10% as compared to December 1st (32.46%), November 20th (30.52%) and November 10th sowing (28.69%). Interaction between cultivars along with the time of sowing displayed significant results in Khanewal and Multan, while other all kinds of interactions remained non-significant at all sites. Maximum gluten content was obtained by ASS-2011 (37.12) at Khanewal and by AARI-2011 (32.62%) at Multan in delayed sowing and Millat-2011 displayed minimum gluten content (23.83 at Khanewal and ARRI-2011 showed lowest gluten content 24.64% at Multan in early sown condition (Table 3). Average values for gluten content were recorded maximum 35.28 at Bahawalpur followed by 31.16 at Khanewal and minimum were noted 27.96% at Multan (Table 1).

DISCUSSION

Late sown crop resulted more water uptake and dough stability time but reduced the dough development time and dough weakness. Wheat dough properties were increased in case of late sowing of wheat crop. Late sown crop resulted in the maximum percentage of protein and wet and dry gluten in the grains which increased the water uptake and dough stability time (Abbas et al., 2020; Ahmad and Hasanuzzaman, 2020; Ahmad et al., 2015a, b; Ahmad et al., 2012; Ahmad et al., 2014; Ahmad et al., 2018; Ahmad et al., 2017; Ali et al., 2020; Atique-ur-Rehman et al., 2020). An increase in temperature during March displayed higher evapotranspiration along with evaporation which decreased the available water for crop. Rainfall in last week of March may recompense water scarcity (Seleiman et al., 2011). The quality of grain is determined by environmental factors with different planting time. During the grain filling process rising temperature initially showed positive impact on seed protein content (Bagulho et al., 2015). Increase in soil temperature showed more uptake of nitrogen which enhanced the vegetative stage to reproductive stage and the required temperature for protein formation is more than starch. Cultivar ASS-2011 is an early maturing cultivar and displayed more protein content because of

the inherent capacity of cultivar (Akhtar et al., 2012). Grain development stage is enhanced with increasing temperature leading to less concentration of carbohydrates and starch content in grain. The rising content of protein resulted less deposition of starch in grain (Silva et al., 2014). Higher temperature influenced the growth and development of wheat crop and also affected grain quality. Heat stress keeps negative effects on grain weight and grain quality. Elevated temperature 35-40 °C at grain filling stage deteriorates grain quality and some study resulted that heat shock has positive effect. Heat stress improved seed protein percentage in spite of reality that protein content per grain is decreased. More temperature at grain development stage increased protein concentration however the decreasing the function of protein. Gluten particle size was influenced by cultivar and environment interaction (Abdulah et al., 2007). The cultivar which keeps higher molecular weight gluten subunits allele was most susceptible to heat shock. Cultivar varies in quality characteristics to heat-shock based on ambient temperature at anthesis stage. Quality characteristics of heat susceptible cultivar were influenced strongly by temperature. The interaction between the cultivars and temperature in response to heat represented that potential for choice of cultivars with enhanced constancy of production in addition to grain quality at high temperature at the grain development stage. High temperature increased protein content and other related quality traits. Heat influenced rate of carbon and N accumulation in grain as an addition to synthesis of high molecular of starch along with protein particles. Differences with in the cultivars were greater than between the cultivars. Negative relationship exists between seed dry mass and flour protein concentration (Sial et al., 2005). The extent of negativity is primarily based on the sensitivity and acceptance of cultivars (Farooq et al., 2020; Ghaffar et al., 2020; Khan et al., 2020; Matloob et al., 2020; Munir et al., 2020; Tariq et al., 2017; Tariq et al., 2020a, b; Usman et al., 2010; Wajid et al., 2010). The flour protein concentration of heat-sensitive cultivar Millat-2011 decreased considerably with an enlargement of individual seed dry mass, while for heat tolerant cultivar AAS-2011 remained approximately stable (Spiertz et al., 2006). Rising temperature showed better results on grain protein content at grain development stage which indicated that 0.286% more grain protein content when increase in temperature 1 °C and when average annual monthly increase in temperature 1 °C then 0.425% raised protein content and 0.435 more when daily average increase in temperature 1 °C. When daily mean temperature rises from 20 °C to 28 °C at the grain development stage showed more grain protein content, dough stability time, and strong wheat gluten is observed (Sial et al., 2005). Rising temperature showed good results on protein content representing grain protein content is directly associated with low humidity. The mechanisms in which temperature regimes affect grain protein content, gluten content and starch content investigated the reasonably elevated soil temperature increases N uptake from soil and N movement from tissue parts to wheat seed along with the best temperature for protein . High temperatures during the grain development stage may motivate grain protein formation along with protein retransfer from vegetable tissue to wheat seeds along with decreasing rate of photosynthesis and stop both the change of sucrose into starch along with the movement of carbohydrate reserves from tissue organs into the wheat grain. Though, daily maximum temperatures increasing 32°C would decreased the period of seed ongenesis, indicate variation in protein composition, create shrunken wheat seeds comprising high quantity of bran and consequently decrease wheat grain quality (Kong et al., 2013). Precipitation effects on grain quality differ from site to site and showed bad effects on grain protein content and grain processing quality. If the quantity of collective post-anthesis rainfall is less than 50 mm indicated good results on seed protein content, grain gluten plus grain moisture content. If collective post-anthesis rainfall is greater than 50 mm negative effects on protein content was observed (Kong et al., 2013; Sohrabi et al., 2010). Rainfall before the start of the grain development stage decreased the grain protein content because of more nitrogen losses by leaching and diluting the nitrogen content in the vegetative tissue of plant. More rainfall at maturity resulted in the grain sprouting and attack of fungal disease leading to reduce the processing quality. If more than 30 mm d^{-1} rainfall at seed development stage followed by increase in temperature resulted dying of root of wheat, excessive loss of water from grain and shriveled wheat grain and finally deteriorated grain quality. Wheat grain quality is affected by period of sunshine and is linearly associated to grain protein content, starch content, moisture content, and wheat gluten content. Sunlight concentration may influence grain protein content because less sunlight intensity improved protein content (Kong et al., 2013). Grain protein content and gluten content were observed higher in fluvoaquic soil as compared to brown soil, black soil or cinnamon soil. Weak- and medium-gluten wheat cultivars cultivated in loamy soil showed more gluten content as compared to cultivated in clay and sandy soil and high gluten wheat cultivar cultivated in clay-soil resulted high protein content as compared to loam and sandy soil. High and low gluten content sown in clay soil and showed higher flour extraction as compared to in sandy soil and loam soil. Type of soil changes response of wheat quality attributes because of various factors i.e. soil nutrients soil moisture and precipitation (Silva et al., 2014).

New cultivars resulted in better desired quality as compared to conventional cultivars because of adaptableness with changing climate and good inherited characters. Genetic modification displayed better results for quality grain produce. Best application of genes variation i.e. maximum sprouting resistance and early maturity escaping of high temperature at grain development stage. Greater than forty percent progenies resulted more grain protein content, gluten content, moisture content and starch content than their parents (Ferdous and Rehman, 2013). High gluten and starch varieties which showed better gluten and starch in subunit genes well-matched with sprouting resistance have enhanced the processing quality (Kong et al., 2013). In conclusion, late sown wheat crop enhanced all quality characteristics of grain i.e. protein, starch gluten contents and less moisture content during 2nd year at Bahawalpur, Khanewal and Multan locations. Climatic condition i.e. temperature and effective rainfall during 2nd year was more appealing for the production of good quality wheat grain. Wheat cultivar AAS-2011 recorded best quality grains as compared to other cultivars at all locations during 2nd year. Late sowing is best for the wheat crop to enhance the quality characteristics of wheat which is very much essential for the human body.

Authors' Contribution

QA did field experimentation. GA, MNK, ZF, SN, HY, HU, PI reviewed literature. AR, NS, SH, MA, MI, MK analyzed data, and SA supervised the whole study. All the authors read and approved the manuscript before publication.

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