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Full Length Article

'MARKAZ-2019': A Spring Wheat Variety for Rainfed Areas of Pakistan

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Abstract

'Markaz-2019' is a spring wheat (*Triticum aestivum* L.) cultivar developed and released by the wheat breeding program at the Crop Sciences Institute, National Agricultural Research Center, Islamabad, Pakistan, in 2019. The cultivar was approved by the Punjab Seed Council of Pakistan in its 51st meeting (19th September 2019) held at the Punjab Seed Corporation, Lahore, Pakistan. Markaz-2019 is of known pedigree "SOKOLL//FRTL/2*PIFED", derived and selected from the 19th Semi-Arid Wheat Yield Trial (SAWYT) entry number (332) from CIMMYT during 2011–2012. Following evaluation of this candidate, 'NR-449' was used as candidate line for five growing seasons at NARC-Islamabad and in multi-location trials and then was officially named as Markaz-2019. Trials were conducted under rainfed conditions and grain yield and quality parameters such as grain color, size and 1000-grain weight were tested. This cultivar is a medium height wheat (107 cm) with semi-erect growth habit, stiff and hollow stem, medium to high grain volume weight in kilogram/ hectoliter (78.7 kg/hL), medium maturity (160 days), medium to high grain protein (151 g kg^{-1}) and flour protein concentration (151 and 105 g kg^{-1}). Markaz-2019 was released for its high yield, (ranging from 4500 kg ha^{-1} to 6050 kg ha^{-1}), its improved resistance to stripe rust (*Puccinia striiformis* var. *tritici*) and leaf rust (*P. triticina*) and tolerance to drought. Its grain yield was significantly higher than check cultivars, and therefore recommended for cultivation in rainfed areas of Pakistan.

Keywords: Wheat variety; Yellow rust; Yield; Rainfed areas; 1000-grain weight

Introduction

Wheat (*Triticum aestivum* L.) is one of the major food security crops worldwide along with rice (*Oryza sativa* L.) and maize (*Zea mays* L.) (Reeves *et al*. 2016). Wheat is most frequently grown throughout the world, contributing 20% of proteins and calories in the human diet (Johansson *et al*. 2020). Global wheat is highly vulnerable to climate change and global warming effects (Steenwerth *et al*. 2014). Biotic and abiotic stresses have a large impact on wheat yield and cause huge economic losses to the farming community (Husenov *et al*. 2020). Wheat production in Pakistan has been continuously decreasing in the last few years due to the impact of evolving pests and pathogens, more frequent drought episodes and heat waves due to rapidly changing climates. Fluctuations in temperature have led to an unprecedented spread of stripe rust from cooler regions to warmer plains. High temperatures cause floret and spikelet sterility at the pollination stage, resulting in shriveled grains and increased screenings at the grain filling stage. In 2021 Pakistan encountered a shortage of almost two million tons of wheat to mitigate the country's needs for this strategic crop. To cope with these challenges, new higher-yielding wheat varieties with improved performance under the currently fluctuating environments are required (Shiferaw *et al*. 2013).

This research was conducted to describe the process of evaluation/testing and development of a new wheat cultivar "Markaz-2019" as a package that combines resistance to economically important diseases and tolerance to abiotic stresses and therefore improved performance. This wheat cultivar was developed and released as part of the wheat program effort to develop new productive varieties for Pakistani farmers. The new cultivar was approved by the Punjab Seed Council of Pakistan in its 51st meeting (19th September 2019) held at Punjab Seed Corporation, Lahore, Pakistan, for its cultivation across rainfed areas of Punjab Provence. The cultivar name, Markaz-2019 was named after the capital of Pakistan, as the word 'Markaz' in Urdu means center or capital.

Major focus of wheat researcher in Pakistan is for variety development for irrigated areas that comprises about 75% of the country but rest of the 25% rainfed area contributes almost 10% of total wheat production in Pakistan. Particularly, 20% wheat area in Punjab is rainfed where no irrigation is available. Under such circumstances it is prerequisite to develop the wheat varieties for rainfed areas of Pakistan. Major focus of this study was to develop a wheat variety, resilient to moisture stress in rainfed areas of Punjab. 'Markaz-2019' was released due to its resistance

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against stripe rust and leaf rust caused by *Puccinia striiformis* var. *tritici* (*Pst*) and *P. triticina* (*Pt*) respectively, drought tolerance, lodging resistance and high grain yield potential in rainfed areas of Pakistan.

Materials and Methods

Plant material pedigree and breeding history

The pedigree of 'Markaz-2019' is SOKOLL//FRTL/2*PIFED. The cultivar was derived and selected from the 19th SAWYT genotype number (332) of CIMMYT during 2011–2012 and breeding history (CMSA04M00552S-040ZTP0Y-040ZTM-040SY-19ZTM-03Y-0B-01D). The breeding history provides information regarding the cross number "Cross 00552" which was made at Toluca, CIMMYT, Mexico in 2004. The F_1 was grown at Obregon and 40 spikes were harvested as bulk and multiplied as F_2 in Toluca using the modified pedigree method. Furthermore, 40 plants were selected and multiplied as F_3 in Obregon with reduced irrigation. The plants were selected and grown as F_4. From F_4 the three best plants were selected bulked and grown as F_5 in Obregon. All F_5 plants were harvested and bulked and grown as F_6 pure line at El Batan, Mexico. The crop was harvested and sent to Pakistan as Semi-Arid Wheat Yield Trial (Global Wheat *et al*. 2020). Following evaluation of this trial under field experiments for five years, candidate genotype (332) was given the institutional name 'NR-449' as candidate line and later officially given the name Markaz-2019.

Line selection and evaluation

A preliminary yield trial was conducted at the National Agricultural Research Center (NARC), Islamabad, under rainfed conditions during 2011–2012 containing 50 entries with two replications arranged in 5 by 5 blocks in alpha lattice design as described by Patterson and Williams (1976). Genotype number 332 was selected as a high grain yielder as compared to the check cultivar. An advanced yield trial (AYT) was conducted at NARC research station in Islamabad. Entry number AYT3#21 was selected for further testing in regional and national trials. The Regional Wheat Yield Trials (RWYT) were conducted in three locations (NARC-Islamabad, Barani Agricultural Research Institute-Chakwal, and Cereal Research Institute-Pirsabak). A total of 25 genotypes, including local check "Pakistan-2013", were evaluated in RWYT using randomized complete block design (RCBD) with three replicates per genotype, experimental plot dimensions were 1.5 m width and 5 m length. Several traits were measured including plant height (cm), grain yield (kg ha^{-1}), days to heading, days to maturity, stripe rust and leaf rust resistance. The Provincial Wheat Yield Trials (PUWYT) were conducted across 23 locations throughout the Punjab region under both rainfed and irrigated conditions. A total of 44 genotypes were tested in PWYT using RCBD design and three replications and the same plot dimensions as mentioned above. Over a period of two years, these genotypes were also tested for yield performance, stability and adaptability in the National Uniform Wheat Yield Trials (NUWYT) under both irrigated and rainfed conditions in all provinces of the country including Punjab, Sind, Baluchistan and Khyber Pakhtunkhwa. During 2014–2015 NUWYT was conducted in 31 locations with 40 genotypes and 2015–16 NUWYT was conducted in 30 locations with 50 entries (Table 1). Standard plot size 1.5 m width and 5 m length seed rate 40 kg ha^{-1} were used in two replications RCBD design. Data captured included: plant height, days to heading, days to maturity, grain yield kg ha^{-1} with the conversion of grams/plot to kg ha^{-1}, disease scoring of stripe rust, leaf rust and stem rust caused by *Puccinia striiformis* var. *tritici* (*Pst*), *P. triticina* (*Pt*) and *P. graminis f.* spp. *tritici* (*Pgt*), respectively, stem stiffness, lodging percentage, 1000-grain weight in grams, grain volume weight (kg h L^{-1}), grain protein concentration, starch and wet gluten percentage. The yield was compared with local check (LC) varieties. The technique of stratified ranking (Fox *et al*. 1990) provides a rapid assessment of broad adaptation of lines tested in different agro-ecological zones of the country and was used to rank genotypes tested. The number of locations for which a line occurs in the top, middle and bottom third of entries was determined. A line that occurs consistently in the top third of entries across locations is considered well-adapted to the environmental conditions sampled.

Statistical analysis

Statistical package STATISTIX 8.1 was used analysis of variance (ANOVA) and LSD (α = .05) test according to Steel *et al.* (1997). DOS based CIMMYT statistical package Alpha Lattice was used for data analysis of the yield and trials were planted in alpha lattice design.

Quality parameters and disease data

Dry and wet gluten, protein percentage, starch, moisture percentage and test weight were performed by following methods No.38-12 and 56-81 as reported by Bruckner *et al*. (2020). Disease scoring of *Pst*, *Pt* and *Pgt* was performed according to the procedure as described by McNeal *et al*. (1971) and Leogering (1959). Disease severity was measured followed by the modified Cobb's scale as described by Peterson *et al*. (1948). Calculation of average coefficient of infection (ACI), was performed according to the procedure of Saari and Wilcoxson (1974) and Pathan and Park (2006).

Results

Agronomic and botanical characteristics

Markaz-2019 is an awned variety requiring 160 days to reach maturity from seed to seed. This cultivar has the following characteristics: plant height 107 cm, semi-erect growth habit in the seedling stage, stem diameter 5–6 mm, stiff stem,

Table 1: Details of locations across Pakistan where NUWYT 2014–2015 & 2015–2016 were conducted

Sr. No.	Name of Location	Province	Latitude	Longitude	Elevation
1	Kallur Kot Bhakkar	Punjab	63.62°N	71.06°E	168 m
2	Krore	Punjab	31.16°N	70.97°E	155 m
3	IATI Sargodha	Punjab	32.07°N	72.67°E	190 m
4	Psc Khanewal	Punjab	30. 29°N	71. 93°E	140 m
5	RRS Bahawalnagar	Punjab	29.48°N	72.52°E	157.4 m
6	Dhakar Pakpatan	Punjab	30. 29°N	71. 93°E	149 m
7	Sahiwal	Punjab	30.04°N	72.34°E	139 m
8	Renala Khurd Okara	Punjab	30.04°N	72.34°E	139 m
9	Kala Shah Kaku	Punjab	31.16°N	70.97°E	155 m
10	Gujranwala	Punjab	32.15°N	74.18°E	226 m
11	Kotnanai	Punjab	32.15°N	74.18°E	226 m
12	Wri Faisalabad	Punjab	30.41°N	70.07°E	188 m
13	Moza Sarwar Walidg Khan	Punjab	30.04°N	72.34°E	139 m
14	Foartabbas MARROAT BWN	Punjab	30.04°N	72.34°E	139 m
15	Kikri Rahim Yar Khan	Punjab	30.29°N	73.07°E	154 m
16	Jalla Aarian Lodhran	Punjab	29.53°N	71.63°E	116 m
17	Jahanian	Punjab	32.27°N	72.26°E	184 m
18	Alipur Muzaffar Garah	Punjab	30.07°N	71.18°E	193 m
19	Rari Bahawalpur	Punjab	29.39°N	71.68 °E	212 m
20	UAF FSD	Punjab	30.41°N	70.07°E	186 m
21	NARC, Islamabad	Islamabad	33.71°N	73.06°E	683 m
22	Nifa Tarnab Peshawar	KPK	34.08°N	71.54°E	359 m
23	CCRI Pirsabak, Nowshera	KPK	34.02°N	72.14°E	288 m
24	Sawabi, KPK	KPK	34.19°N	72.04°E	309 m
25	MARC Juglot	Gilgit Baltistan	34.08°N	71.54°E	352 m
26	Ari Di Khan	KPK	31.82°N	70.90°E	173 m
27	Nia Tandojam	Sind	25.40°N	68.52°E	25 m
28	Wri Sakrand	Sind	26.00°N	67.92°E	31 m
29	Wri Tandojam	Sind	25.40°N	68.52 °E	25 m
30	Qari Larkana	Sind	27.55°N	68.20°E	174 ft.
31	Mardan	KPK	34.11°N	72.46°E	330 m

peduncle length 38 cm, lodging resistance, nodes per stem, absent stem anthocyanin, waxy stem, green colour at booting, tillers/m^2 275 in number, re-curved flag attitude, medium flag twist, 24 cm flag leaf length and flag leaf width 1.8cm, medium sheath wax, absent auricle hairiness. Markaz-2019 has 50% ear emergence in 120 days from sowing date 15 November in the winter season, the ear is tapering shape, ear density is dense, no shattering, long awn length, spikelets per spike is 23, the number of grains per spike seven, seed colour is amber with shiny surface, seed shape is oval, seed size medium, TKW is 36 gm and seed coat is hard.

Field performance and yield trials

The station yield trial for candidate variety Markaz-2019 was conducted at NARC under rainfed conditions (Table 2). During the first year of evaluation, Markaz-2019 had 7.3% higher yield than the check variety (NARC-2009). During years 2012–2013 the advanced yield trial (AYT) was also conducted at NARC, Islamabad under rainfed condition (Table 3) and Markaz-2019 had significant and 28% higher grain yield (5069 kg ha^{-1}) than the local check variety, NARC- 2009 (3947 kg ha^{-1}).

Regional wheat yield trials (RWYT)

The Regional Wheat Yield Trials were conducted during 2013–14 (Table 4) over three locations (NARC-Islamabad, BARI-Chakwal and CCRI-Pirsabak). About 25 entries including local check Pakistan-2013 were evaluated in RWYT. The average yield of 5537 kg ha^{-1} of Markaz-2019 was recorded over three locations in comparison with the local check (4635 kg ha^{-1}) when the data were pooled over three locations and Markaz-2019 attained 2nd position in yield (Table 4) and it had significant and 19% higher yield than the local check cultivar.

Provincial wheat yield trials (PWYT)

The Provincial Wheat Yield Trial was conducted over 23 locations throughout Punjab province under both rainfed and irrigated conditions (Table 5). Approximately 44 entries were tested in PWYT. The average yield for Markaz-2019 was 4084 kg ha^{-1} as compared to local check (3786 kg ha^{-1}) when the data was pooled for both irrigated and rained trials of 23 locations. Markaz-2019 had shown at par grain yield with 8% increase than the local check in PWYT with no disease symptoms for *Pst* and *Pt*.

National uniform wheat yield trials (NUWYT)

Markaz-2019 was evaluated at different locations in the NUWYT both under irrigated and rainfed conditions for two years. During the first year of testing (2014–2015), Markaz-2019 had 3793 kg ha^{-1} grain yield (Table 6) that was statistically at par with high yielding cultivars under irrigated conditions at the country level. Under rainfed conditions, it produced 4.3% higher grain yield (3888 kg ha^{-1}) than the composite check variety (3728 kg ha^{-1}) that was statistically at par when compared with the high yielding cultivars. In Punjab province, Markaz-2019 achieved 5% higher yield than the composite check variety.

During the second year of testing (2015–16) under both irrigated and rainfed conditions, Markaz-2019 was ranked fourth in grain yield (4100 kg ha^{-1}) country level (Table 7) and yield was recorded 5.6% higher than the composite check variety (3881 kg ha^{-1}). Under rainfed conditions, Markaz-2019 significant grain yield (4132 kg ha^{-1}) at the country level with 11.3% higher yield as compared to the check variety. However, it was ranked fourth in Punjab and had 9.3% higher yield than the composite check. When both irrigated and rainfed trial data were combined, Markaz-2019 showed significant results in terms of productivity with 4108 kg ha^{-1} and 8% higher yield than the composite check (3812 kg ha^{-1}).

In NUWYT-rainfed 2014–2015, Markaz-2019 had a higher yield than check varieties at 7 out of 9 locations in Punjab and Islamabad Capital Territory (Fig. 1). In NUWYT-rainfed 2015-2016, Markaz-2019 had a higher yield than check varieties at 5 out of 7 locations in Punjab

Table 2: Preliminary Yield trial of 19th SAWYT CIMMYT nursery during 2011–2012 at NARC-Islamabad, Pakistan

Cultivars	Pedigree	Days to heading	Plant height (cm)	Grain yield (kg ha^{-1})	*Pst* score [a]	[b]% ↑ ↓ Check cultivar
Markaz-2019	SOKOLL//FRTL/2*PIFED	140	102	6050	0	7.3
SAWYT # 330	SOKOLL/ROLF07	132	104	5652	0	0
NARC-2009	Check cultivar	139	114	5638	0	0
SAWYT # 323	SOKOLL*2/TROST	138	106	5408	0	-4
SAWYT # 339	ESDA/KKTS	141	101	5224		-7
SAWYT # 325	SOKOLL*2/ROLF07	144	109	4892	0	-13
SAWYT # 302	DHARWAR DRY	134	122	3974	5 MS	-30
	Mean	138	105	5787		
	CV	1.3	2.2	5.6		

[a] = *P. striiformis* (Yellow rust) scoring; MS, moderately susceptible
[b] = Percent increase or decrease of tested cultivars than local check cultivar

Table 3: Advanced yield trial (AYT rainfed) during 2012–2013 at NARC-Islamabad

Cultivars	Cross name	Days to heading	Days to maturity	Plant height (cm)	Grain yield (kg ha^{-1})	*Pst* score [a]	[b]% ↑ ↓ Check cultivar
Markaz-2019	SOKOLL//FRTL/2*PIFED	116	161	102	5069	0	28
AYT3 #47	SANOBAR-6	117	160	100	4352	0	10
NARC 09	Check cultivar	116	163	105	3947	TR	0
AYT3 #16	ONIX/ROLF07	116	166	102	3657	0	-7
AYT3 #48	REYNA-7	116	161	102	3509	0	-11
AYT3 #49	REYNA-13	116	163	106	3411	0	-14
AYT3 #46	SANOBAR-3	118	161	102	3113	TR	-21
AYT3 #45	DAMARA-6	113	159	108	2833	0	-28
	Mean	114	161	102	4121		
	CV	0.8	0.66	5.5	10.94		
	LSD (α = 0.05)	1.86	2.15	0	910		

[a] = *P. striiformis* (Yellow rust) scoring; TR, traces of *Ps*
[b] = Percent increase or decrease of tested cultivars than local check cultivar

Table 4: Performance of Markaz-2019 at regional wheat yield trials (RWYT) during the year 2013–2014 at three locations[a]

Rank	Cultivars	Days to heading	Days to maturity	Grain yield (kg ha^{-1})	Pst score [b]	[c]% ↑ ↓ Check cultivar
1	NR-429	120	162	5709	TRMR	23
2	Markaz-2019	126	166	5537	0	19
3	NR-448	127	167	5421	5R	17
4	NR-423	126	167	5410	5MR	17
22	Pakistan-2013	127	167	4635	TRMR	0
	CV	1.6	1.4	4.15		-
	LSD (α = 0.05)	4.3	3.0	155		-

Whereas, [a] = Regional trial were conducted at NARC-Islamabad, Barani Agricultural Research Station (BARI) Faithay Jhang and BARI-Chakwal. [b] = *P. striiformis* (Yellow rust) scoring; TRMR, traces with moderate resistance; R, resistant; MR, moderately resistant. [c] = Percent increase or decrease of tested cultivars than local check cultivar

and ICT (data not shown). The data showed that Markaz-2019 is a stable line across multi-locations for its grain yield.

The technique of stratified ranking as described by Fox *et al*. (1990) was used to provide a rapid assessment of broad adaptation of lines tested in different agro-ecological zones. The number of locations for which a line occurs in the top, middle and bottom third of entries was determined. A line that consistently ranks in the top third of best performance across locations could be considered as well-adapted to the vast range of diverse environmental conditions. Fig. 1 showed that Markaz-2019 displayed an optimal performance in the stratified ranking. Further, it showed superior stability compared to long term checks (Faisalabad-2008 and Pakistan-2013) and composite local check during two years of NUWYT testing under rainfed conditions. It was ranked in the top third of lines at nine locations, in the middle at five locations and in the bottom at only two locations for the first year. During the second year of testing in NUWYT, it was six times in the top position and five times in the middle third of lines. The composite local check occurred six times in the top, two times in the middle and eight times in the bottom third of lines during

Table 5: Performance of Markaz-2019 in provincial wheat yield trial (PUWYT) [a] during 2014–2015

Cultivars	Yield (kg ha^{-1})	Ranking	*Pst* score [b]	[c]% ↑↓ check cultivar
Markaz-2019	4535	3	5R	8.0
Faislabad-2008	4217	8	5MR	6.1
Local check cultivar	3981	19	TRMR	0.0
Mean	4018			
CV	3.17			
LSD (α = 0.05)	133			
Locations	11			

[a] = Provincial yield trials were conducted at 10 locations in Punjab province
[b] = *P. striiformis* (Yellow rust) scoring; TRMR, traces with moderate resistance; R, resistant; MR, moderately resistant; [c] = Percent increase or decrease of tested cultivars than local check cultivar

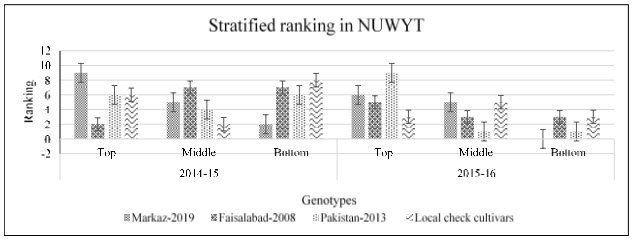

Fig. 1: Stratified ranking for Markaz-2019 in NUWYT-rainfed during the year 2014 to 2016

Table 6: National uniform wheat yield trials (NUWYT) pooled analysis during 2014-2015 yield (kg ha^{-1}) data under rainfed conditions

Entry name	Parent institute	KPK (5) [a]	Punjab (9) [b]	Pakistan (14) [c]
NR-423	NARC-Islamabad	3031	4448	3942
NR-429	NARC-Islamabad	2911	4547	3963
NR-436	NARC-Islamabad	2843	4212	3723
Markaz-2019	NARC-Islamabad	2926	4423	3888
Local check cultivar		2858	4212	3728
Faislabad-2008	WRI-Faisalabad	2710	3971	3521
Pakistan-2013	NARC-Islamabad	3150	4340	3915
Grand mean		2913	4254	3775
CV		9.8	10.0	10.1
LSD (α = 0.05)		99	912.2	667.2

[a] = NUWYT trials conducted at five locations in Khyber-Pakhtunkhwa province
[b] = NUWYT trials conducted at nine locations in Punjab province
[c] = NUWYT trials conducted at 14 locations in Pakistan and data was pooled for all locations

Table 7: National uniform wheat yield trials (NUWYT) grown under rainfed conditions, pooled analysis during 2015-2016 yield (kg ha^{-1})

Entries	Institute	Punjab (7) [a]	KPK (4) [b]	Pakistan (11) [c]
NR-443	NARC-Islamabad	4631	3242	4126
NR-429	NARC-Islamabad	4414	3415	4051
Markaz-2019	NARC-Islamabad	4509	3472	4132
NR-487	NARC-Islamabad	4140	2942	3704
NR-423	NARC-Islamabad	4523	3114	4011
Faisalabad-2008	NARC-Islamabad	4128	3354	3847
Pakistan-2013	NARC-Islamabad	4323	3470	4013
Local Check		4126	2994	3714
Grand means		4031	2871	3609
CV		8.9	9.8	10.3
LSD (α = 0.05)		912	890	680

[a] = NUWYT trials conducted at seven locations in Punjab province
[b] = NUWYT trials conducted at four locations in Khyber-Pakhtunkhwa province
[c] = NUWYT trials conducted at 11 locations in Pakistan and data was pooled for all locations

Table 8: Response of Markaz-2019 to *P. striiformis* (*Pst*) during 2015–2016 at the Crop Disease Research Institute (CDRI) NARC with artificial inoculation of urediniospores of *Pst*

Cultivar	*Pst* score [a]	ACIs	CARPA	RRI [b]
Markaz-2019	30MR	6.7	8	8.28
Morocco	100S	96.7		

[a] = *P. striiformis* (Yellow rust) scoring; ACI, average coefficient of infection; CAPRA, country average relative percentage attack; RRI, relative rust index
[b] = Desirable RRI Acceptable RRI
Pt 7 6 or 5
Pst 7 5

Table 9: Response of Markaz-2019 to three rusts (*Pts*, *Pt* & *Pgt*) along with their terminal reaction, average coefficient infection relative resistance index for NUWYT rainfed (2014–2015 & 2015–2016)

2014-2015	Cultivars	*Pst* [a]			*Pt* [b]			*Pgt* [c]		
		ACIs	CARPA	RRI	ACIs	CARPA	RRI	ACIs	CARPA	RRI
	NR-429	0.50	1.28	8.88	2.39	8.17	8.26	16	25.44	6.71
	Markaz-2019	1.33	3.40	8.69	0.73	2.84	8.74	42	66.78	2.98
	NR-423	0.50	1.28	8.88	1.23	4.21	8.62	16	25.44	6.71
	Pakistan-2013	2.67	0	0	0.3	0	0	16	25.44	0
	Faisalabad-2008	1.00	0	0	11.03	0	0	24	38.16	0
2015-2016	NR-429	0	0	9	41.9	72.0	2.52	32	44.16	5.02
	Markaz-2019	6.7	8	8.28	0.1	0.2	8.98	36	49.68	4.52
	NR-423	16	19.2	7.27	0.6	1.0	8.91	48	66.24	3.03
	Pakistan-2013	13.3	0	0	1.5	2.5	8.77	4	5.52	8.5
	Faisalabad-2008	7.3	0	0	49.3	84.7	1.37	56	77.28	2.04

[a] = Pst, *P. striiformis*; [b] = Pt, *Puccinia triticina*; [c] = Pgt, *P. graminis tritici*, rust scoring and calculation of ACI, average coefficient of infection; CAPRA, country average relative percentage attack; RRI, relative rust index
Desirable RRI Acceptable RRI
Pt 7 5 to 6
Pst 7 5
Pgt 7 5

Table 10: Grain quality characteristics of Markaz-2019

Cultivar	1000 grain weight (g)	Test vol. weight (kg/hL)	Grain protein concentration (g kg^{-1})	Flour protein concentration (g kg^{-1})	Flour yield (g kg^{-1})	Milling score	Starch (g kg^{-1})	Gluten wet (g kg^{-1})	Flour ash (g kg^{-1})	Grain moisture content (%)
Markaz-2019	35.9	78.7	151	105	690	92.13	543	285	5.50	13.70
Pakistan-2013 Check cultivar	43.9	76.6	144	104	559	89.81	549	270	4.30	14.50
CV	1.63	1.21	1.67	1.76	3.89	2.53	2.32	1.92	16.45	4.95
SE	2.3	0.67	1.81	1.29	17.17	1.60	1.50	1.6	0.57	0.50
LSD (α = 0.05)	*P > 0.05*	*P > 0.05*	*P > 0.05*	*P > 0.05*	*P > 0.05*	*P >.05*	*P > 0.05*	*P > 0.05*	*P > 0.05*	*P > 0.05*

the first year of testing, while Markaz-2019 stood in the top third of lines at three locations, five times in the middle and three times in the bottom in NUWYT-rainfed 2015–2016.

Disease resistance

Markaz-2019 carries desirable resistance against *Pst* and *Pt* but is susceptible for *Pgt*. During 2015–2016 Markaz-2019 was tested against *Pst* in a National Wheat Disease Screening nursery (NWDSN) at the Crop Disease Research Institute (CDRI, NARC, Islamabad) under confined conditions and rust inoculum was applied. Markaz-2019 revealed average coefficient infection (ACI) 6.7 and relative rust index (RRI) 8.29 for Pst and the check (Morocco) showed 90% susceptibility (Table 8).

Markaz-2019 was also evaluated in NUWYT for two years during 2014–2015 and 2015–2016 against *Pst*, *Pt* and *Pgt*, under field conditions (Table 9). Score of RRI for *Pst*, *Pt* and *Pgt* during 2014–2015 was recorded for Markaz-2019 as 8.69, 8.74 and 2.98 respectively. Markaz-2019 is susceptible to stem rust as RRI indicated that the 2.98 value falls under a susceptible range of RRI. During the second year of NUWYT testing (2015–16) Markaz-2019 obtained a score of RRI for *Pst*, *Pt* and *Pgt*; 8.28, 8.98 and 4.52, respectively.

Grain quality

In addition, Markaz-2019 displays almost similar quality traits with check cultivars with some exceptions in flour yield that is statistically at par. All parameters tested for grain qualities are presented in Table 10 are statistically non-significant which means that gain quality is similar to the check cultivars. Markaz-2019 has 35.9 g 1000 grain weight. The test weight was recorded as 78.7 kg hL^{-1} while in the check cultivar it was recorded as 76.6 kg/hL with protein content 150 g kg^{-1}. It has high bulk density. The grain protein content was estimated at about 151 g kg^{-1}, 1 g kg^{-1} higher than the check. Markaz-2019 has 105 g kg^{-1} flour protein concentration but is significantly different. It has a high flour yield as compared to the check cultivar 690 g kg^{-1} with a milling score of 92.13. It also revealed 543 g kg^{-1} starch content, however this reading was less than the local check Pakistan-2013. Markaz-2019 showed a high concentration of wet gluten content and flour ash of approximately 285 g kg^{-1} and 5.5 g kg^{-1}. Markaz-2019 has 13.7% moisture content at the time of harvest on maturity stage after sun dry.

Discussion

Markar-2019 is wheat variety that has awns on its spikes and its maturity time is about 160 days from seed to seed. It is an early to medium maturity variety that escapes terminal heat stress. Its semi-dwarf stature, semi-erect growth habit and stem stiffness gives strength to lodging resistance. Sheath wax provides protection against evapotranspiration and moisture exhaust during drought. Maturity in 170 to 190 days from seed to seed was reported by Khan (2016) in some commercial wheat varieties in Pakistan. The best date of sowing is between first week of November 15th November. Marlarz-2019 has Amber and shiny seed colour that is good for consumer's acceptance for Chapatti making.

Field performance of Marker-2019 was quite good both in terms of grain yield and disease resistance. Markaz-2019 gave 7% higher yield 6050 kg ha^{-1} that check cultivar in PYT trial and 28% higher yield in AYT trial during 2012–2013 with disease reaction almost nil for yellow rust at NARC-Islamabad. In the regional yield trials during 2013-2014 grain yield was recorded in the range of 4600 kg ha^{-1} to 5537 kg ha^{-1} that was more than 19% higher than check cultivar Pakistan-2013 at three locations in Islamabad, Chakwal and Pirsabak. According to these results Markaz-2019 is more suitable for cultivation in *Potohar* region of Rawalpindi/Islamabad.

Markaz-2019 was evaluated at different locations in the NUWYT both under irrigated and rainfed conditions for two years 2014–2015 and 2015–2016 at 31 locations. Markaz-2019 showed higher yield ranged from 4.5% to 12% higher grain yield than check cultivars. Yield performance of Markez-2019 in pool analysis NUWYT for Punjab data for both the cropping seasons (2014-2015 and 2015–2016) was observed above 4 tones ha−1. Markaz-2019 can be recommended for cultivation in wheat growing areas of Punjab especially in rainfed areas. These results are very much in accordance with the findings of Yang *et al*. (2021) under rainfed trials of wheat. However, Mukhtarullah and Akmal (2016) reported results of currently predominantly cultivated rainfed varieties of Pakistan and their results depicted less grain yield than Markaz-2019.

Markaz-2019 carries desirable resistance against yellow rust and leaf rust. It has acceptable range of average coefficient infection (ACI) that is 8.69 and 8.74 for yellow rust and leaf rust respectively under artificial inoculation of rust spores. It also performed batter in NUWYT during two years 2014–2015 and 2015–2016 against yellow rust and leaf rust and obtained a score of RRI was 8.28 and 8.98 respectively. Similar findings have been reported by Kokhmetova (2021).

Markaz-2019 showed almost similar quality parameters as compared to check cultivars with some exceptions in flour yield that is statistically at par. All parameters tested for grain quality are statistically non-significant which means that gain quality is similar to the check cultivars. Markaz-2019 has good *Chapatti* making quality.

Purification and increase of Markaz-2019 seed were commenced before its release in 2016 using 300 single head rows and by using separately harvested single spike seed in 5 m long rows. Each row was evaluated for disease resistance (*Pst*, *Pt*), lodging resistance, visual similarity, and uniformity between and among the head rows. Selected

head rows were separately harvested and progeny blocks were planted from each harvested head row and similar blocks were bulk harvested to produce Breeder Nucleus Seed (BNS) in 2017 and this process is continuing. Markaz-2019 breeder seed was increased in separate 0.5-hectare blocks to produce pre-basic seed. Inspection of field and stored grain samples was carried out by seed inspection and a seed analysis team from the Federal Seed Certification and Registration Department (FSC & RD), Ministry of National Food Security and Research under strict criteria of the standard procedure of ISTA codes of Wheat.

As regards seed availability, Pre-basic, Basic, and Certified seed of Markaz-2019 is available at the Punjab Seed Corporation (PSC) and the Wheat Research Program, CSI, NARC Islamabad. The wheat program produced 50 kg BNS seed, 1.5 tons pre-basic, 5 tons basic and 10 tons certified seed during 2019–2020 and 100 kg BNS, 2 tons pre-basic, 10 tons basic and 20 tons certified seed during 2020–2021 wheat season that was tested and certified by the Federal Seed Certification & Registration Department under the Ministry of NFS & R, Federal Government.

Conclusion

It is concluded from results that Markaz-2019 is a medium height wheat with semi-erect growth habit, stiff and hollow stem, medium to high grain volume weight in kilogram/ hectoliter, medium maturity, medium to high grain protein and flour protein concentration. Markaz-2019 has yield potential of 6 tones ha^{-1}, improved resistance to stripe rust and leaf rust and tolerance to drought. Its grain yield was significantly higher than check cultivars and therefore, recommended for cultivation in rainfed areas.

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Author Contributions

MQ; Design study, conducted experiments, data analysis, review manuscript MSA; Data collection, trails conduction, data anlysis, manuscript writeup and correspondance, SW; data collection data compilation, SKT; monitring, case preparation and presentation of variety, MS; Data collection, compilation, article review, IH; variety case presentation, arrange resoures, monitring and article review

Conflict of Interest

The authors have no conflict of interest.

Data Availabilty

Data can be provided on requst to the corresponding author

Ethics Approval

Authorss were careful while writing manuscrip for data policy and scientific writing ethics and did not breach privacy and authorship literature cited and data used in the manuscript.

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