

Research Article

“Naurang-2023”: The wheat variety with great yield potential, Stress tolerant and disease resistant

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Abstract

“Naurang-2023” is the spring wheat (*Triticum aestivum* L.) variety which was developed and released by the wheat breeding team of Agricultural Research Station Serai Naurang in 2023. Provincial Seed Council Khyber Pakhtunkhwa approved this variety in its 42nd meeting (20th March 2023) held at the office of the Directorate General Agricultural Research KPK under the chair of the Provincial Minister for Agriculture KPK. Naurang-2023 is with known parentage “NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/.” This cultivar was derived and selected from the 31st SAWSN (Semi-Arid Wheat Screening Nursery) having entry No.50 from International Maize and Wheat Improvement Center (CIMMYT) during 2013-14. After selection, this entry “SN-005” was used as a candidate line for six years at Agricultural Research Station Serai Naurang and in the Regional Yield Trial under Khyber Pakhtunkhwa Wheat Yield Trial (One year) and National Uniform Wheat Yield Trial (Two years) and then was named as “Naurang-2023” officially. On the average “Naurang -2023” gave 21.88% (8000 kg/ha), 22.48% (7043 kg/ha), 14.82% (4943 kg/ha), 9.40% (4456 kg/ha), 5.00% (5122 kg/ha) , 8.00 % (4344 kg/ha) and 3.70 % (4244 kg/ha) higher yield than local checks and concerned trial checks i.e. Pirsabak-13 (31stSAWSN), Pirsabak-13 Preliminary Yield Trial, Pirsabak-13 Advanced Yield Trial, Pirsabak-13 Micro Plot Trial (MPT), Passeena-17 and Khaista-17 (KPWYT), Ghazi-19, Pakistan -2013, Khaista-17 (NUWYT 2020-21) and Pakistan-2013, Akbar-19, Khaista-17 (NUWYT- 2021-22) respectively. Results revealed its excellent performance in grain yield, disease resistance and tolerance to drought, heat and salinity. Seed production as Breeder Nucleic Seed and Pre- Basic Seed was started in 2022-23. The diversity, availability and yield improvement of all the existing germplasms and cultivars will be increased by the adding this variety, “Naurang-2023”.

Keyword: Naurang-2023; Spring wheat; Variety

Introduction

Bread wheat (*Triticum aestivum* L.) is a crop that plays an important role in food security along with other crops, like rice (*Oryza sativa*

L.) and maize (*Zea mays* L.) grown worldwide [1]. The wheat crop is grown throughout the world, adding proteins and calories as 20% to the human diet [2].

Climate changes and Global warming are affecting the wheat crop strongly throughout the world [3]. Stresses (biotic and abiotic) have a terrible effect on the grain yield of wheat as a result of which the farming community faces heavy economic losses [4]. In Pakistan, wheat being the staple food, is cultivated on the largest acreages in almost every part of the country. During the 2020-21 cropping season, wheat was grown on 9.168 million hectares producing 27.464 million tonnes with an average yield of 2974 kg/ ha [5]. During 2018-19 wheat was cultivated on a 0.74 million hectares area in Khyber Pakhtunkhwa getting 1.3328 million tonnes of produce having an average yield of 1795 kg/ha [6]. As the population of Pakistan is increasing very rapidly and to meet this increasing demand of food grains, it is necessary to evolve cultivars that have a greater yield potential per hectare and disease resistance capability, especially to rusts [7]. The main objective of research in connection with the evaluation of varieties is to develop such varieties that are high - yielding, disease - resistant and suitable for general cultivation. To meet such tasks, several improved lines of wheat having high grain yield potential, resistance to diseases and tolerance to abiotic stresses were selected/developed either through selection or cross breeding. CIMMYT plays an important role in this regard and provides material for researchers to select such lines from these materials which are well adapted to the climatic conditions of different belts/locations of many countries and regions. Several cultivars of wheat such as Pirsabak -13, P.S-15, Pakhtunkhwa-2015, Khaista-17, Wadan (2017), Paseena-2017, KT-17, Gulzar-19, Pir Sabak-19, Abaseen-2021, Zarghoon-21, P.S-21 and Taskeen-2022 have greater yield potential. All these lines were selected from the materials of CIMMYT and proved their superiority in the belt of Khyber Pakhtunkhwa [8].

An entry with line name SN-005 gave better performance in line with grain yield and resistance to yellow rust (YR) and leaf rust (LR). It was also examined in Regional as well as in National Yield Trials in the whole of Pakistan consecutively for two years. Crop Disease Research Institute (CDRI) Islamabad tested it for various disease resistance while the Seed Certification Officer of the Federal Seed Certification & Registration Department (FSC&RD) Regional Office Dera Ismail Khan took DUS (distinct, uniform and stable) data. The important and key characters of this line are medium spike with amber color during maturity, beak large curved, resistant to lodging, glume shoulder elevated in shape, anthocyanin presence on the spike during maturity, seed bold with amber color grains and good quality of chapatti making.

Materials and Methods

The line with known parentage “NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2 *PASTOR/5/” derived/selected from 31st SAWSN (Semi-Arid Wheat Screening Nursery) with entry number (50) received from CIMMYT was first tested at Agricultural Research Station Serai Naurang during 2013-14. This line was selected on the basis of good performance regarding to yield and resistance against disease and so forwarded to the Preliminary Yield Trial (A-test-N) for comparison with other high-yielding lines and local check (Pirsabak-13) in 2014-15 [9]. This line was then forwarded to the Advanced Yield Trial (B-Test -N) for comparison with other high-yielding lines and local check (P.S-2013) in 2015-16. It was tested in Micro Plot Trial (MPT) under Normal planting for comparison with other high-yielding lines and local check (P.S-13) in 2016-17. As it showed good performance all over the checks in all trials so it was selected for further processes and named in abbreviation of the institutional name “SN-005” as the candidate line. Based on the

comparative high yield potential, this line was checked in the Regional Yield Trial as Khyber Pakhtunkhwa Wheat Yield Trial (KPWYT) under normal and late planting throughout the province during 2018-19. Its performance was also examined in the National Yield Trial (NUWYT) for two consecutive years during 2020-21 and 2021-22 across 31 and 40 locations respectively all over Pakistan. This line was also tested for response against yellow rust and leaf rust diseases [10]. The FSRI (Food Security and Research Institute), NARC lab Islamabad tested this line for quality attributes in 2020-

21 and 2021-22 [11]. Based on the results of the Preliminary Yield Trial, Advanced Yield Trial, MPT, Regional Yield Trial (KPWYT) and NUWYT, line named as SN-005 proved its superiority in producing higher grain yield than the local checks, showed resistance to yellow and leaf rusts as well as tolerance to drought, heat and salinity also. It was also tested for Distinct, Uniform and Stable (DUS) data by the Seed Certification Officer of Federal Seed Certification and Registration Department (FSC&RD) Dera Ismail Khan Sub office of Islamabad for two years during 2020-21 and 2021-22 (Table 1).

Table 1. Summary of breeding history

S. No.	Year	Generation/ Trial	Entry Number
1	2013-14	Semi-Arid Wheat Screening Nursery (31 st SAWSN)	50
2	2014-15	Preliminary Yield Trial (A-Test)	V-2
3	2015-16	Advanced Yield Trial (B-Test)	V-2
4	2016-17	Micro Plots Yield Trial (MPT)	V-5
6	2018-19	Khyber Pakhtunkhwa Yield Trial (KPWYT)	V-12
7	2020-21	NUWYT (National Uniform Wheat Yield Trial) 1 st year and DUS Data by (FSC&RD) DI Khan	V-55
8	2021-22	NUWYT (National Uniform Wheat Yield Trial) 2 nd year and DUS Data by (FSC&RD) DI Khan	V-15

Results and Discussion

Semi-Arid Wheat Screening Nursery (31st SAWSN) Trial (2013-14)

Wheat Line SN-005 (Naurang-2023), was selected as a candidate line at ARS Serai Naurang during the 2013-14 cropping season from 31st SAWSN (Semi-Arid Wheat Screening Nursery) received from CIMMYT, Mexico. This entry was selected on the basis of higher yield (8000 kg/ha) as well as disease resistance than check (P.S-13) with yield (6250 kg/ha) (Table 2).The serial number of this line was 50 in the 31st SAWSN, forwarding to the next trials on the basis of better performance and disease resistance.

Preliminary yield trials (A-Test, 2014-15)

Entry No.50 (SN-005) was chosen in the cropping season 2013-14 from the above-stated screening nursery received from CIMMYT. Out of 15 entries, SN-005 (Naurang-2023) got a grain yield of 7043 kg/hectare which was 22.48 % greater than the yield of check locally planted as Pir Sabak -2013 (5460 kilograms/hectare) shown in (Table 3). Our results are coincide with [12, 13] who conducted such trials and got the same results as we obtained in the initial and preliminary yield trials.

Advanced yield trials (B-Test, 2015-16)

Eleven wheat lines, including the above-stated variety line SN-005 (Naurang-2023), were evaluated during cropping season 2015-16 in the next year trial as advanced yield trial

(B-test) to test it for yield performance and disease resistance. This line SN-005 (Naurang-2023) produced the highest grain yield of 4943 Kg/Ha as compared to check (4210 Kg/Ha). So Naurang-2023 yielded 14.82 % more than the mentioned check (Table 4). For better performance than check in AYT the number of entries were decreased and its yield potential along with disease resistance characters were compared with the local check to get for better result than local check [11, 13].

Micro plots yield trial (MPT, 2016-17)

Twelve wheat lines along with the mentioned candidate line SN-005 (Naurang-2023) were tested during cropping season 2016-17 under MPT-2016-17 at ARS Serai Naurang Khyber Pakhtunkhwa, Pakistan with normal planting conditions for better yield potential and high disease resistance. SN-005 (Naurang-23) produced the highest grain yield (4456 kg/ha) while check P.S -2013 showed the grain yield as 4037 Kg/Ha. Thus Naurang-2023 yielded 9.40 % more yield than the stated local check as shown in (Table 5). Our results are according to Ahmad *et al.* [8] who Conducted similar trials for the evaluation of new variety of wheat as Bahawalpur 97 and got the similar results from MPT.

Khyber Pakhtunkhwa wheat yield trials (2018-19)

During the cropping season 2018-19 Regional Yield Trial as Khyber Pakhtunkhwa Wheat Yield Trial (KPWYT) was conducted to monitor / test the yield potential as well as disease resistance of SN-005 (Naurang-2023) along with candidate lines of various research stations and institutes of Khyber Pakhtunkhwa under normal conditions all over the Khyber Pakhtunkhwa. In this trial total 20 wheat lines were tested for their yield potential, among which SN-005 (Naurang-2023) got 8th position (Rank) with grain yield (5122 kg/ha) across overall the locations of KPK as shown in (Table 6). The Task of KPWYT trials was performed by the

department of Outreach, Agricultural Research Khyber Pakhtunkhwa who distributed elite lines of various research stations and institutes for different locations to conduct trials. In response, it collected data on these trials analyzed it and distributed it among breeders of concerned stations and institutes for further research and study [11-13].

National uniform wheat yield trials (2020-21 & 2021-22)

After the Regional Yield Trial, the National yield trial was conducted under NUWYT (National Uniform Wheat Yield Trial) for two years i.e.2020-21 and 2021-22 to test it under normal conditions throughout Pakistan. In the first year (2020-21) SN - 005 (Naurang-23) out yielded checks (Ghazi-19 & Pakistan-2013) by getting yield of 4344 kg/ha over checks (3990 kg/ha). In this way SN-005 (Naurang 2023) got 8 % greater yield than checks (Table 7). For the second year (2021-22) out of 70 wheat lines, SN-005 (Naurang-2023) ranked 2nd among all wheat lines in Pakistan and 1st in Punjab by producing grain yield of 4244 kg/ha outyielding checks (Pakistan-13 & Akbar - 2019) (Table 8). Our results are according to Ahmad *et al.* [8] who conducted trials as described by getting the findings as we got in the concerned trial.

Data related to resistance against diseases (2020-21 & 2021-22)

Line listed as SN-005 (Naurang-2023) was also checked out for major rust diseases such as yellow and leaf rust for two consecutive years i.e.2020-21 and 2021-22. This trial was conducted by the Crop Disease Research Program (CDRP) Islamabad. Observations were recorded at the maximum development of yellow rust and leaf rust on the artificially inoculated test material in the nurseries planted at National Agricultural Research Center (NARC) Islamabad, Cereal Crops Research Institute (CCRI) Pirsabak Nowshera and Nuclear Institute for Food and

Agricultur (NIFA) Peshawar, where the susceptible check “Morocco” developed upto 80–90 per cent severity. Yellow rust and leaf rust data of 3 locations along with Average Coefficient Infections (ACIs), Country Average Per cent Relative Attack (CARPA), Relative Resistance Index (RRI)

Disease	Desirable Index	Acceptable Index
Yellow rust	7 and above	5
Leaf rust	7 and above	6 or 5

Naurang-2023 indicated acceptable RRI (Relative Resistance Index) of 6.84 for YR with RRI of 8.98 against LR resistance during 2020-21 while in 2021-22, 8.12 desirable RRI for YR and 8.36 desirable RRI for LR resistance was shown by it. Same results were obtained by [10] while working on various wheat lines and other approved cultivars of wheat (Table 9). They worked on 188 varieties and found that 150 varieties were with RRI range $>7 < 9$ which was lying in the desirable range and other 28 varieties that were tested for diseases in the acceptable range with RRI value $>5 < 7$ while out of all these only ten numbers of varieties indicated RRI value as in undesirable range i.e. < 5 .

Evaluation for climatic stresses

Evaluation for climatic stresses was also determined and it was found out that the line SN-005 (Naurang-2023) showed tolerance to heat, drought and salinity (Table 10)

Tolerance Index (STI) = $[Y_p \times Y_s / Y_2 p]$
(Fernandez, 1992).

STI = 0.7 - 1.0 = Tolerant

0.5-0.69 = Moderately Tolerant

< 0.5 = Sensitive.

Quality standard determination

The NARC laboratory Islamabad tested this line SN- 005 (Naurang-2023) for quality standard. It was tested for 1000 grain weight, test weight, moisture %, starch content%,

and Terminal Reaction of the varieties is taken. The data collected by the Crop Disease Research Institute comprising of terminal leaf, stripe and rust reaction of the varieties. The desirable index and acceptable index number for rust are as under:

protein content and gluten content as in (Table 11). These findings are in agreement with the research work of scientists of breeding section of Cereal Crop Research Institute Pirsabak [11, 13].

Characteristics of SN-005 (Naurang-2023) wheat variety

Naurang-2023 shows an erect growth habit at the seedling stage. Blue green, and erect leaves are shown by it at the boot stage. Seedling anthocyanin is absent and color of coleoptile is white. Stem of Naurang-2023 is intermediately thick, stiff, weak bloomy wax, with hollow internodes and peduncle in erect mode having 100-110 cm average plant height with yellow white straw color. Naurang-2023 is a variety with awn, white red spike at maturity, medium spike strength and an elliptical seed having opaque surface, amber color, bold size, medium seed groove and short brush (Table 12). SN-005 (Naurang-2023) performed excellently through all research trials and was put before the 42nd Provincial Seed Council meeting and approved as Naurang-2023.

Availability

In the coming years it will be available on large scale at Agricultural Research Station Serai Naurang, however at present only Breeder Nucleic Seed as well as Pre-basic seed is present on small scale.

Table 2. Trial performed at Station with Summary Results of the Yield data of Semi-Arid Wheat Screening Nursery (31st SAWSN) at ARS, Serai Naurang 2013-14

S. No.	Location	Yield Kg/ ha	
		SN-005	Check (Pirsabak-2013)
1.	ARS Serai Naurang	8000	6250
2.	% Increase over check.		21.88 %

Table 3. Trial done in Station with Mean Grain Yield (GY) of Preliminary Yield Trial (A-Test) Normal Planted at ARS Serai Naurang during 2014-15

V. No.	Pedigree	Origin 2013-14	DTH (Days)	DTM (Days)	P. Ht (cm)	GY (Kg/ha)
2	SN-005 (Naurang -2023)	50	114	165	111	7043
15	Check	P.S-13	117	163	89	5460
% Increase over check.						22.48%

Table 4. Trial conducted at the Station with the Grain Yield (GY) Mean Value of Advanced Yield Trial (B- Test) Normal Planted at ARS Serai Naurang during 2015-16

V. No.	Pedigree	Origin 2014-15	DTH (Days)	DTM (Days)	P. Ht (cm)	GY (Kg/ha)
2	SN-005 (Naurang -2023)	A test-N-E2	107	151	103	4943
11	Check	P.S-2013	109	155	90	4210
% Increase over check						14.82%

Table 5. Trial at Station with Mean value for Grain Yield (GY) and other Characteristics of Micro Plot Yield Trial (MPT) Normal Planted at Agricultural Research Station Serai Naurang in 2016-17

V. No.	Pedigree	Origin 2014-15	DTH (Days)	DTM (Days)	P. Ht (cm)	GY (Kg/ha)
5	SN-005 (Naurang -2023)	B -Test- N (E-2)	115	152	107	4456
12	Check	Pirsabak-13	119	152	95	4037
% Increase over check						9.40%

Table 6. KPWYT (Khyber Pakhtunkhwa Wheat Yield Trials) under Normal Conditions 2018-19

S.#	Candidate Line	Days to Heading	Days to Maturity	Plant Height (cm)	Yield Kg/ ha ⁻¹
1	PS-60	122	167	95	4819
2	PS-61	124	166	93	4897
3	PS-62	125	164	95	5053
4	PS-63	123	165	105	5338
5	PS-64	125	165	100	5662
6	CT-161072	123	166	102	4950
7	CT-161030	123	166	99	5522
8	CT-HN16276	124	167	101	6260

9	NON-161053	124	164	105	4971
10	SN-002	125	166	102	4511
11	SN-004	125	166	101	3921
12	SN-005 (Naurang 2023)	122	165	105	5122
13	SN-010	124	165	104	5507
14	SWB-12/64	122	166	104	5184
15	SWB-116/64	123	166	103	5001
16	SWB-125/64	123	167	101	5192
17	DN-113	125	165	99	3858
18	DN-120	126	167	102	4639
19	Passina-17 check	125	167	102	4951
20	Local check	124	167	99	4866
Grand Mean		124	166	101	5011
Average % Increase over both checks.					4.18%

Table 7. NUWYT (National Uniform Wheat Yield Trials Normal) (Summery of Data 2020-21)

S. No.	Name of lines	Punjab (21) Kg/Ha	Sindh (5) Kg/Ha	KP (4) Kg/Ha	Baluchistan (1) Kg/Ha	Pak (31) Kg/Ha
55	SN-005(Naurang-2023)	4345	3540	5792	2549	4344
20	Ghazi-19 (Check)	4155	4011	5339	3995	4279
30	Pakistan-2013 (Check)	4038	3199	5013	2892	3992
70	Local Check	4312	3394	5407	2945	4261
% Average increase over check						3.84

Table 8. NUWYT (National Uniform Wheat Yield Trials) Irrigated (Summery of Data 2021-22)

S. No.	Name of lines	Punjab(23) Kg/Ha	Sindh(6) Kg/Ha	KP (6) Kg/Ha	Baluchistan (2) Kg/Ha	Gilgit(3) Kg/Ha	Pak(40) Kg/Ha
15	SN-005(Naurang-2023)	4517	5029	4133	2199	2167	4244
23	Pakistan-2013 (Check)	4074	4620	4387	1720	2631	3977
46	Akbar-19 (Check)	4257	5154	4114	1750	3676	4201
70	Local Check	4289	4168	3859	1946	4160	4080
% Average increase over check							3.70

Table 9. According to CDRI report 2021-22, Candidate Lines with desirable Relative Resistance Index (RRI) for Yellow and Leaf Rust for two consecutive years 2020-21 and 2021-22

S. No.	Lines	Yellow Rust		Leaf Rust	
		2020-21	2021-22	2020-21	2021-22
1	TWS-15110	9	7.75	8.98	8.08
2	V-SR-6026	2.67	8.17	8.71	8.71
3	18C117	9	8.75	9	9
4	AUP-1411815	7.5	8.92	8.47	7.85

5	PR-137	8.58	8.61	9	8.93
6	SN-005 (Naurang-2023)	6.84	8.12	8.98	8.36
7	TRB-2-103	8.78	7.12	8.3	8.22
8	PR-138	8.78	9	9	8.97
9	EV-18102	8	6.25	8.98	6.06
10	SWB-9	8.78	8.92	9	8.82
11	PR-139	8.83	9	9	8.85
12	WAL-10	8.11	7.08	8.15	8.42
13	SWB-11	8.78	8.06	9	8.28
14	NR-549	8.89	9	9	9
15	TRB-4-138	9	8.75	9	7.95

Table 10. The identified abiotic stress-tolerant NUWYT lines (2021-22)

Drought	Heat	Salinity	Drought only	Heat only	Salinity only
<ul style="list-style-type: none"> • 18C117 • HYT-70-16 • SN-005(Naurang-2023) • PR-138 			<ul style="list-style-type: none"> • TRB-2-103 • V-18352 • TRB-4-138 • TWS-15110 • TRB-14-116 	<ul style="list-style-type: none"> • V-SR-6026 • HYT-100-47 • V-19308 • HYT-100-74 	<ul style="list-style-type: none"> • HYT-100-74 • KT-2 • SWB-13

Table 11. Quality evaluation of SN-005 (Naurang-2023) in National Uniform Wheat Yield Trials candidate lines 2020-21 and 2021-22

Line/variety	Year	1K kernel wt. (g)	Test weight. (kg/hl)	Moisture content (%)	Starch content %	Grain Protein (% d.b)	Gluten content (%)	Zeleny
SN-005 (Naurang-2023)	2020-21	37.60	70.90	9.30	55.60	13.20	23.50	46.00
SN-005 (Naurang-2023)	2021-22	36.7	75.5	9.40	56.30	13.00	25.00	46.50

Table 12. Morphological Characteristics of SN-005 (Naurang-2023)

Characteristic	Description
Parentage	NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/...
Pedigree	CMSA06B00734T-099TOPY-099ZTM-099Y-099M-13WGY-0B
Maturity habit	Medium
Color of Coleoptiles	White
Growth habit.	Erect
Booting stage color	Blue green
Height of plant.	100 -110 centimeter
Stem wax at bloom	Weak
Thickness of wall	Intermediate
Stiffness of stem	Stiff
Straw color.	Yellow white
Flag orientation	Recurved

Sheath wax	Weak
Ear emergence	110-115 days
Ear size	Medium
Ear length (cm)	10-12 cm
Spike color at maturity	White Red
Spike shape	Tapering
Spike density	Medium dense
Color of anther.	Yellow
Awn distribution	Whole
Awn color	Green and white red at maturity
Awning habit.	Erect
Rachis hairs.	Present (Sparse)
Rachis length.	11.5 -13 cm
Rachis width (mm)	3.5- 4.50 mm.
Glume length (mm)	12-14 mm
Glume surface.	Rough
Shoulder Shape	Slopping
Length of beak (mm)	5-6 mm
Color of seed	Amber
Shape of seed	Elliptical
Length of seed (mm)	7-8 mm
Seed Width (mm)	3.5-4 mm
Seed Thickness (mm)	3-3.5 mm
Seed size	Bold
Nature of seed brush.	Short
Germ size of seed	Medium
Nature of Seed groove	Medium
Seed hardness.	Medium
Seeds/ear	65-70
Chapatti quality.	Excellent
Diseases	Resistant

Conclusion

The diversity, availability and yield improvement of all the existing germplasms and cultivars will be increased by the addition of this variety “Naurang-2023”.

Authors' contributions

Conceived and framed the trials A Quddoos & K Mahmood, Conducted the trials: A Quddoos, Performed the data analysis: K Mahmood & M Farooq, Searched materials / analysis/ tools: A Quddoos & M Farooq, Wrote the paper: A Quddoos & K Mahmood. Overall analysis and proof reading: A Khan.

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References

1. Reeves TG, Thomas G & Ramsay G (2016). Save and grow in practice: maize, rice, wheat a guide to sustainable cereal production. UN Food and Agriculture Organization, Rome. <http://www.fao.org/3/a-i4009e.pdf> (Accessed: September 25, 2020).
2. Johanson E, Henriksson T, Prieto-Linde ML, Andersson S, Ashraf R & Rahmatov M (2020). Diverse wheat-alien introgression lines as a basis for durable resistance and quality characteristics in bread wheat. *Front Plant Sci* 11: 1-15.
3. Steenwerth KL, Hodson AK, Bloom AJ, Carter MR, Cattaneo A, Chartres CJ & Jenkin BM (2014). Climate-smart Agriculture global research agenda: scientific basis for action. *Aric Food Sec* 3: 1-39.
4. Husenove BM, Otambekova, Muminjanov H, Morgounov A, Assad S, Garkava-Gustavsson L & Johanson E (2020). Constrain and perspectives for sustainable wheat production in Tajikistan. *Front Sustain Food Syst* 4: 27.
5. Pakistan Economic Survey 2020-21.
6. Crop statistics Khyber Pakhtunkhwa 2018-19.
7. Tila M, Sajjad HK, Fazle MI, Shah S, Muhammad SJAA & Khan AJ (2010). NIFA Bathoor-08: a high yielding and disease resistant wheat variety developed for irrigation areas of Khyber Pakhtunkhwa (KPK) province of Pakistan. *Pak J Bot* 42(4):2671-2680.
8. Ahmad M, Akhtar LH, Siddique SZ, Hussain M, Rasheed A, Hussain G & Tariq AH (2005). Development of a High Yielding Wheat Variety “Bahawalpoor-97” for Southern Punjab, Pakistan. *Biol Sci-PJSIR* 48(1): 42-46.
9. Dogan R & Aycicek M (2009). Adaptability performances of some wheat (*Triticum aestivum* L) cultivars in the Marmara region of Turkey.
10. Loegering WQ (1959). Methods for recording cereal rust data in International Spring Wheat Rust Nursery (IRN). USDA, Washington, DC.
11. Ahmad G, Ishaq M, Jan M, Afridi K, Khalil IA, Shah IA & Ahmad N (2018). Registration of “Pakhtunkhwa-2015” (PR-103), a Spring Soft White Cultivar. *J of Plant Reg* 12(3):347-356.
12. Tila M, Sajjad HK, Fazle MI, Shah S, Muhammad SJAA & Khan AJ (2010). NIFA Bathoor-08: a high yielding and disease resistant wheat variety developed for irrigation areas of Khyber Pakhtunkhwa (KPK) province of Pakistan. *Pak J Bot* 42(4): 2671-2680.
13. Ali A, Ahmad G, Ismail M, Zaib Q, AHMF, Ali K, Andaleeb Y, Ali I & Fatima (2023). “Swabi 1”: A high yielding and disease resistant wheat variety. *Pure Appl Biol* 12(1): 189-196.