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Research Article

New high yielding and disease tolerant wheat (*Triticum aestivum* L) variety NIFA AMAN-2017 for irrigated areas of Khyber Pakhtunkhwa

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Abstract
Varietal development, release and quality seed production of new high yielding and disease resistant wheat varieties is a continuous effort and a pre-requisite for sustainable wheat production. NIFA-AMAN 2017 as a new improved variety was developed at Nuclear Institute for Food and Agriculture, Peshawar, Pakistan. From 4th Stem Rust Screening Nursery (4th SRSN) the genotype was selected and material received from CIMMYT in 2009-10. Based on disease tolerance and higher grain yield, the genotype (SRN-09111) was selected from the nursery sown during 2009-10. Similarly, in preliminary and advanced yield trials conducted at NIFA during 2010-11 and 2011-12, the genotype was evaluated. The SRN-09111 was also evaluated in microplot trial at 07 different sites of the province during 2012-13, genotype showed outstanding yield performance among the other genotypes. The genotype out yielded (5647 & 4351 kg ha^{-1}) in 1st year mandatory evaluation of National Uniform Wheat Yield Trials (NUWYT) during 2013-14 and Ranked 1st at 5 sites in Khyber Pakhtunkhwa (KP) and 4th across Pakistan. On 2nd year mandatory evaluation in NUWYT, conducted during 2014-15, the genotype yield ranked 2nd (4047 kg ha^{-1}) at 31 sites on Pakistan basis. It is early maturing, disease tolerant and high yielding variety, more suitable for different agro-climatic zones of KP. Moreover, for yellow rust, leaf rust and stem rust, Relative Resistance Index (RRI) falls under acceptable range. The Provincial Seed Council (PSC), Khyber Pakhtunkhwa approved SRN-09111as a variety in 37th meeting held on 19th September, 2017 at Peshawar.

Keywords: Disease; High yield; Irrigated; KP; NIFA-AMAN 2017; *Triticum aestivum*; Variety

Introduction

Bread Wheat (*Triticum aestivum* L., 2n=6x=42, BBAADD genome) is a worldwide cultivated food crop **[1]**. It is mostly adapted crop from irrigated to dry and from warm humid to dry cold environments. The wheat genome is complex and diverse due to that the crop widely adapted **[2]**. Currently, a number of wheat cultivars are being grown by the farmers of Khyber Pakhtunkhwa. Although these varieties are playing a pivotal role in boosting the per acre

yield but the frequent changes in disease virulence, in particular, yellow rust forced the breeders to develop new resistant varieties for productivity enhancement. Continuous development of agronomically superior wheat varieties with high grain yield, good nutrition value, processing quality and tolerance to biotic and abiotic stresses is crucial for ensuring food security [3-5]. Improving wheat may be more difficult than for many other crops, since the breeder needs to "match" quantity and quality, allying yield with grain and flour quality [6].

Wheat program at NIFA reflects to develop potential varieties for enhancing the productivity in general and particularly in Khyber Pakhtunkhwa (KP) province as wheat is the main staple food of Pakistan and important strategic agricultural commodity. The earlier wheat varieties, i.e., Bakhtawar-92, Fakhre Sarhad and Bathoor-08 released for irrigated areas by this institute has played a pivotal role for increasing wheat production in the province. Overall, the country is self-sufficient at the moment but the scientists are in a continuous struggle to break the yield barriers being aware of the fact that in 2050 the 334.68 million populations will need about 37.14 million tons of wheat grain and the country must meet these requirements for its food security. Currently, wheat is being grown by 80% farmers (> 01 million) on about 40% of the total cultivated area and 65% of the food crops area in the country [7]. It contributes approximately 12.5% to the value added agriculture and 3.1% to GDP. The per capita wheat consumption in the country (125 kg a year) is among the highest in the world.

In Khyber Pakhtunkhwa wheat is grown on 0.738 million hectares and the production is 1.233 million tons as against the requirement of 3.0 million tons [7]. The current average yield of 1.56 tons per hectare in the province is very low. Due to high diseases and biophysical / socio-economic constraints the yield per acre is low. Therefore, continuous development and release of new high yielding / disease resistant varieties are direly needed to increase and stabilize wheat production in the province. The current manuscript discusses the development of new high yielding variety "NIFA AMAN-2017". The botanical description and other characteristics of NIFA AMAN-2017 are below in (Table 1).

Materials and Methods

The genotype was received from CIMMYT in the 4th Stem Rust Screening Nursery (SRSN) during 2009-10. The genotype at S. No. 6111 in the said nursery performed well regarding grain yield / rust resistance (*Yr* and *Lr*) and was selected for further studies for agronomic, disease resistance and yield performance. Initially, it was subjected to evaluation in regular yield trials in 2010-11 followed by multi-locational field evaluation for four consecutive crop seasons. The said genotype was designated with code name "SRN-09111". Randomized Complete Block Design (RCBD) was used for yield trials with the plot size of 04 rows (5 m long), keeping plant to plant and row to row spacing of 10 and 30 cm, respectively. Data analyses were performed in Statistix 8.1. All the cultural practices were carried out according to the standard procedures as recommended for the crop under irrigated condition. The developmental history of NIFA AMAN-2017 is shown in (Table 2).

Table 1. Botanical description and some characteristics of NIFA AMAN-2017

Parentage	PRL/2*PASTOR//PBW343*2/KUKUNA/3/ROLF 07
Pedigree	CMSS04B00025T-0T0PY-0992TM-099Y-8WGY-0B
Species	*Triticum aestivum* (L)
Origin	Exotic
Breeding method	Introduction
Areas of Adaptation	Irrigated areas of KP
Days of maturity	Range [165 - 168]
Sowing Time	1st November to 25th November
Maturity Duration	Medium
Suitable for Sowing	Early
Seedlings growth habit	Semi erect
Plant height (cm)	Range [104 - 110]
Lodging	Absent
Flag leaf attitude	Semi erect
Ear emergence	[Days from Sowing] 119
Glume length size	Medium
Beak size	Medium
Seed color	Amber
Seed size	Medium
Protein (%)	14.6
Chapati quality	Good
Yield / acre (md)	55
Stem rust (Black)	Resistance
Leaf rust (Brown)	Resistance
Stripe Rust (Yellow)	Resistance

Table 2 Summary of Developmental History of NIFA AMAN-2017 (SRN-09111)

S. No.	Crop Year	Selection Source	Remarks/Activity
1	**2009-10**	4th Stem Rust Screening Nursery (SRSN)	Based on high grain yield and rust resistance to *Yr* and *Lr* the said entry at S. No. 6111 was initially selected and designated as SRN-09111 (Table 3).
2	**2010-11**	Preliminary Yield Trial-6 (Normal)	SRN-09111 produced 5000 kg ha^{-1} grain yield as against the check cultivar Pirsabak-04 (4167 kg ha^{-1}) (Table 3).
3	**2011-12**	Advance Selection Yield Trial-2 (Normal)	Ranked 2nd and out yielded both the check varieties Bathoor-08 and Pirsabak-04 (Table 4).
4	**2012-13**	Multi-location Trial	Excelled the check variety Bathoor-08 after producing 4210 kg ha^{-1}grain yield (Table 5).
5	**2013-14**	NUWYT 1st Year	Ranked 1st at 5 sites in KPK and 4th across Pakistan (Table 6 & 7).
6	**2014-15**	NUWYT 2nd Year	Ranked 2nd at 31 sites on Pakistan basis (Table 8).
7	**2013-14**	Disease Screening	Showed highly desirable RRI of 8.79 for *Yr* and 8.68 for *Lr* (Table 9).
8	**2014-15**	Disease Screening	Showed highly desirable RRI of 8.85 for *Yr*; 8.94 for *Lr* & 8.43 for *Sr* (Table 10, 11 & 12).
9	**2013-14**	Quality Evaluation	Meets the recommended quality standard with 14.6 percent protein for 1st year (Table 13).
10	**2014-15**	Quality Evaluation	Meets the recommended quality standard with 15.55 percent protein 2nd year (Table 14).

Results and Discussion

The grain yield results of SRN-09111(NIFA AMAN-2017) are shown in (Table 3 to 8). The results regarding mean grain yield in 4th Stem Rust Screening Nursery (SRSN) sown during 2009-10 and Preliminary Yield Trial (PYT) conducted during 2010-11 at NIFA experimental farm depicted that SRN-09111 produced higher grain yields of 9867 and 5000 kg ha^{-1} compared to check variety Bathoor-08 (9333 and 4167 kg ha^{-1}, respectively (Table 3). In Advanced Yield Trials (AYTs), conducted during 2011-12**,** the candidate genotype (SRN-09111) produced high grain yields of 5023 kg ha^{-1} against that of check varieties Bathoor-08 (4747 kg ha^{-1}) and Pirsabak-04 (4511 kg ha^{-1}) (Table 4). Similarly, in Micro-Plot Trials (MPT) conducted at five locations in irrigated areas of Khyber Pakhtunkhwa (Peshawar, Nowshera, Charsada, Swat and Gilgit) during Rabi 2012-13, the genotype showed significantly higher mean grain yield of 4368 kg ha^{-1} in comparison to mean grain yield of 3899 kg ha^{-1} of check variety Bathoor-08 (Table 5). SRN-09111(NIFA AMAN-2017) also showed better results against the check varieties used for comparison in National Uniform Yield Trials (NUYTs) conducted by the National Wheat Coordinator, National Agricultural Research Centre (NARC), Islamabad, during 2013-14 and 2014-15. SRN-09111 ranked 1st in NUWYT 2013-14, at 5 sites in KP and 4th across Pakistan (Table 6 & 7). As per the results of second mandatory evaluation in NUWYT (2014-15), the genotype ranked second at 31 sites across Pakistan (Table 8). The SRN-09111 produced mean grain yield of 5037 kg ha^{-1} at 5 sites of Khyber Pakhtunkhwa in NUWYT 2013-14 which is higher compared to those of local check and

Pirsabak-13 i.e. 4473 and 4751 kg ha^{-1}, respectively. However, the genotype (SRN-09111) stood on 4th position with mean grain yield of 3945 kg ha^{-1} at 34 sites across the country compared to local check (3877 kg ha^{-1}) and Pirsabak-2013 (3930 kg ha^{-1}) in 2013-14 (Table 7). Similarly, with mean grain yield of 4047 kg ha^{-1}, SRN-09111 got 2nd position across the country compared to the local check (3973 kg ha^{-1}), Pirsabak-2013 (3927 kg ha^{-1}) and FSD-08 (3641 kg ha^{-1}) during 2014-15 (Table 8). Global research endures in wheat breeding will continue to increase the yield potential in order to meet the food requirements of an ever increasing population **[8]**.

Yellow rust of wheat is considered to be one of the most devastating diseases. It is not only limited to wheat but also infects barley, rye and more than 50 grass species **[9]**. It has the potential to cause 100% loss in wheat grain yield, if the susceptible cultivars become infected at an early stage and progress during the crop season. The damage by yellow rust is inflicted in the form of decreased yield, grain quality and forage value **[10]**. Furthermore, disease resistance in newly developed crop varieties controls yield losses **[1]**, and a new crop variety should surpass the susceptible ones in terms of agronomic performance. Therefore, the genetically tolerant varieties cultivation is more useful and economical to prevent diseases in under-develop countries **[11, 12]**. Beside Higher yielding capacity, the genotype under consideration was primarily selected on disease resistance basis. As reported by Crop Disease Research Institute (CDRI), Islamabad during 2013-14 and 2014-15, SRN-09111 (NIFA AMAN-2017) revealed desirable Relative Resistance Index (RRI) of 8.79 & 8.85 (acceptable: > 6) for yellow rust (*Yr*), 8.68 & 8.94 (acceptable: > 5) for leaf rust (*Lr*) and 8.43 for stem rust (*Sr*) (Tables 9, 10, 11 & 12).

Wheat is a key cereal crop for global economy and food security due to its protein and caloric values **[13]**. The chemical and physical quality characteristics of NIFA AMAN-2017 (SRN-09111) (high protein and gluten content in the grain) make it acceptable genotype for quality bread (Tables 13 & 14). In order to ensure smooth and abundant supply of quality seed to the farmers **[14]**, needed to evolve genetically improved wheat varieties with maximum seed production and for grain yield per unit area **[14]**. The current stagnancy in wheat yield can be overcome by introducing elite wheat germplasm. After testing the material under the local environment, either the promising genotypes can be used as improved varieties or they may be utilized in future breeding program for gene pyramiding in order to improve the agronomic traits of the existing varieties **[15-17]**. Moreover, with the passage of time, the recent varieties succumbed either due to adaptability problem **[5]** or new races of pathogen introduced **[11]**. Under such circumstances development of new improved verities with diseases tolerant, high yielding for commercial cultivation is imperative to fill up the gap created by exhausted varieties, avoid monoculture and stabilize wheat production. In light of the above mentioned realities, development and release of NIFA AMAN-2017 with inherent potential to higher yield, disease resistance, wider adaptability and good chapatti quality is a link to the chain of the word wide ongoing wheat breeding research efforts. It will not only meet the ultimate desire of the farmers for higher grain yield but will significantly add to bridging the yield gap in wheat production in the province as well as in the country.

Table 3. Yield performance of SRN-09111 in 4th SRSN (2009-10) and Preliminary Yield Trial (PYT) 2010-11at NIFA

Year	Trial / Nursery	Grain Yield (kg ha^{-1})		% ± over Check
		SRN-09111	**Check** (Bathoor-08)	
2009 - 10	4th SRSN (Entry # 6111)	9867	9333	+ 5.72
2010 - 11	PYT-6 -Normal (Entry # 117)	5000	4167	+ 20.0

Table 4. Yield performance of SRN-09111 in Advanced Selections Yield Trials (ASYT) at NIFA, 2011-12

Trial	Grain Yield (kg ha^{-1})		% ± over Check
	SRN-09111	**Check** (Bathoor-08)	
ASYT-2, Normal (Entry # 30)	5556	5111 (Bathoor-08) 5422 (Pirsabak-04)	2.47 – 8.70
ASYT-2, Late (Entry # 30)	4489	4383 (Bathoor-08) 3600 (Pirsabak-04)	2.41 – 24.70
Mean values	5023	4747 (Bathoor-08) 4511 (Pirsabak-04)	5.81 –11.35

Table 5. Mean yield performance of SRN-09111 in Micro-Plot Trials at 5 locations in irrigated areas of Khyber Pakhtunkhwa, 2012-13

Locations	Grain Yield (kg ha^{-1})		% ± over Check
	SRN-09111 (Entry # 12)	**Check** (Bathoor-08)	
NIFA, Peshawar	4333	3134	38.0
Pirsabak, Nowshera	3268	3145	4.0
Farmer's Field Charsadda	4889	3663	33.0
Swat	4073	4332	-6.0
Gilgit	5278	5222	1.0
Mean values	4368	3899	12.0

Table 6. Mean yield performance of SRN-09111 in NUWYT (Normal & Late) planted in different irrigated zones of Khyber Pakhtunkhwa (KPK), 2013-14

Entry	Grain Yield (kg ha^{-1}) 5 sites			Ranking on KPK basis
	Normal	**Late**	**Average**	
SRN-09111	5647	4426	5037	1st
Local Check	5040	3907	44473	
Pirsabak-2013	5419	4082	4751	
% ± over Checks	4.2 - 12.0	8.4 - 13.2	6.0 - 12.6	

Table 7. Mean yield performance of SRN-09111 in NUWYT (Normal & Late) at 34 locations across Pakistan, 2013-14

Entry	Grain Yield (kg ha^{-1}) 34 sites			Ranking on Pakistan basis
	Normal	Late	Average	
SRN-09111	4351	3538	3945	4th
Local Check	4285	3470	3877	
Pirsabak-2013	4370	3491	3930	

Table 8. Mean yield performance of SRN-09111 in NUWYT planted at different irrigated zones across Pakistan, 2014-15

S. #	Entry	KPK (6)	Sind (4)	Punjab (21)	Pakistan (31)
6	SRN-09111	3960	3894	**4101 1st**	**4047 2nd**
38	Local Check	4150	4037	3910	3973
39	FSD-08	3702	3947	3566	3641
40	PAK-2013	3863	4308	3872	3927

Table 9. Terminal disease reaction, resistant indices and cooperative data of NUWYT irrigated, 2013-14

S. #	Entry	*Yr*			*Lr*		*Sr*
		TR	ACI	RRI	ACI	RRI	TR
07	SRN-09111	5 MRMS	1.6	8.79	1.2	8.68	40 MR

Table 10. Response of SRN-09111 to yellow rust along with their Average Coefficient Infection, Country Average Relative Percent Attack and Relative Resistance Index, 2014-15

S. #	Entry	Islamabad	Peshawar	Nowshera	ACIs	CARPA	RRI
06	SRN-09111	5MR	0	0	0.67	1.72	8.85

Table 11. Response of Candidate lines to leaf rust along with their Average Coefficient Infection, Country Average Relative Percent Attack and Relative Resistance Index, 2014-15

S. #	Entry	Karachi	T. jam	Thatta	Kunri	Thatta	Faisalabad	BWP	ACIs	CARPA	RRI
1	99172	TMS	TMSS	TMS	TMSS	TMSS	5MSS	10MSS	2.79	11.70	7.95
2	99346	TMS	TMSS	TMSS	10MSS	TMSS	10MSS	10MSS	4.38	14.98	7.65
3	112802	50MSS	30MSS	5MSS	5MSS	5MSS	30MSS	20MSS	17.44	60.69	0.39
4	DN-102	5MSS	10MSS	TMSS	5MSS	5MSS	0	0	3.04	10.40	8.06
5	CT-09137	TMSS	10MSS	TMSS	TMSS	TMSS	0	5MSS	2.7	9.23	8.17
6	**SRN09111**	**TMS**	**0**	**0**	**0**	**0**	**0**	**0**	**0.21**	**0.72**	**8.94**

Table 12. Response of Candidate lines to stem rust along with their Coefficient Infection, Country Average Relative Percent Attack and Relative Resistance Index, 2014-15

S. #	Entry	Stem Rust	CI	CARPA	RRI
1	99172	40MR	16	25.44	6.71
2	99346	70M	42	66.78	2.98
3	112802	50MS	40	63.6	3.276
4	DN-102	60M	36	57.24	3.84
5	CT-09137	60M	36	57.24	3.84
6	**SRN-09111**	**10MR**	**4**	**6.36**	**8.43**

Table 13. Quality evaluation of National Uniform Wheat Yield Trials (irrigated) for SRN-09111, 2013-14

S. #	Entry	1000 K. wt (g)	Test wt. (kg ha^{-1})	Starch %	Moist. %	Grain protein (% d.b)	Gluten dry (%)	Gluten wet (%)
7	SRN-09111	36.1	71.9	52.3	11.7	14.6	8.9	27.1

Table 14. Quality evaluation of National Uniform Wheat Yield Trials (irrigated) for SRN-09111, 2014-15

S. #	Entry	1000 K. wt (g)	Test.wt (kg ha^{-1})	Protein (%)	Starch (%)	Gluten (%)
6	SRN-09111	36.7	76.65	15.55	52.65	35.5

Conclusion

NIFA AMAN-2017 is a disease tolerant and high yielding wheat variety and mainly recommended for cultivation in KP irrigated areas. It has an edge in grain yield over the check varieties at NIFA and other location of KP and Pakistan. The plant type is semi dwarf, in irrigated areas responsive to high input and also recommended for cultivation in diverse environment of the province.

Authors' contributions

Conceived and designed the experiments: F Subhan, Performed the experiments: F Subhan & MI Khan, Analyzed the data: F Subhan, M I Khan & ST Shah, Contributed materials/ analysis/ tools: F Subhan, MI Khan & ST Shah, Wrote the paper: ST Shah & F Subhan.

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