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EVOLUTION OF NEW WHEAT VARIETY NIA-AMBER FOR THE GENERAL CULTIVATION IN SINDH PROVINCE -A CASE STUDY

MAHBOOB ALI SIAL*, MUHAMMAD AFZAL ARAIN, KHALIL AHMED LAGHARI AND SHAMADAD KHANZADA

Nuclear Institute of Agriculture (NIA), Tando Jam, Pakistan
**Corresponding author: mahboobali.sial@gmail.com*

Abstract

A new wheat variety NIA-Amber developed by NIA Tando Jam has been released by the Government of Sindh in the year 2010. NIA-Amber possesses semi-dwarf stature with high tillering capacity endowed with high grain yield, early maturity, better grain quality and resistance to lodging. It possesses the highest protein content (16.02%), highest wet gluten (37.1%), high dry gluten (12.0%), and high SDS value (28.5). It confirmed its superiority in grain yield in series of trials such as preliminary yield trials (PYT), advanced strains yield trials (AST), comparative yield trials, micro yield trials, zonal trials and national trials. It showed stability and wide adaptation over different environments in province of Sindh. It performed well under normal and late conditions. It showed increase in yield with addition of zinc in combination with other fertilizers NPK. The variety showed resistance against leaf rust and tolerance to yellow rust diseases. In NUWYT, it produced higher grain yield and ranked first in Sindh under late sowing conditions; whereas, it acquired 6th position in NUWYT under normal sowings. The variety has the potential yield of 6406 kg/ha. Its release will make a significant contribution to genetic diversity and enhance the stability of yield, which will ultimately improve the socio-economic conditions of the farmers of the province of Sindh.

Introduction

Wheat is a major staple food crop of Pakistan grown over 9.046 million hectares with annual production of 24.032 million tones (Anon., 2008). The area and production of wheat crop (2008-09) has increased by 5.8 and 14.7% respectively as compared to 2007-08. The possible reason for substantial increase in wheat yield may be the better management practices by the growers and the introduction of new high yielding wheat varieties possessing tolerance to biotic and abiotic stresses. Wheat provides food for 36% of world population, about 40% (278.6 million tones) of the total world wheat production (681.4 million tones) has been produced from the Asia (Anon., 2010). It contributes 14% to the value added in agriculture. Wheat is being grown around one million hectares with annual production of 3.5 million tons in the province of Sindh. The average wheat yield in Sindh is comparatively higher (3543 kg/ha) than other provinces in the country. Wheat yields of the country often response to water stress, high temperature stress and the salinity (Savin & Nicolas, 1999; Royo *et al.,* 2000; Richards *et al*., 2001; Reynolds *et al*., 2001; Kimurto *et al*., 2003; Najafian *et al*., 2004; Sial *et al*., 2010). The higher yields can only be obtained when varieties cultivated are genetically stable and widely adapted to different locations having different climatic conditions (Finlay & Wilkinson, 1963; Eberhart & Russell, 1966; Sial *et al*., 2000; Yan & Rajcan, 2002). Preferred genotypes generally show low GxE interaction variances, above average response to environmental yield potential and lower deviations from the expected response within a target environment (Arain *et al.,* 2011).

With the evolution of new high yielding varieties and adoption of better production technology the grain yield per hectare in the province has gradually increased from 1889 kg/ha in 1980-81 to 3543 kg/ha in 2007-08. However, with the continuous increase in human population there would be need to produce more wheat to feed ever-increasing population. The new high yielding varieties are therefore regularly needed either to replace the old ones or to supplement the existing stock of varietal complex. High yielding varieties with better quality and tolerance to biotic and abiotic stresses is a desperate need for wheat growers. Nuclear Institute of Agriculture (NIA) has a very strong wheat breeding programme that has already developed 9 wheat varieties genetically diversified and with high yield and desired adaptability. In continuation of meeting further requirements, the new wheat variety NIA-Amber has been added to the genetic pool and varietal complex of Sindh province. The paper describes in detail the methodology of evolution and performance of new wheat variety 'NIA-Amber' in Sindh province and describes its salient features.

Materials and Methods

The conventionally bred wheat variety NIA-Amber previously named as RWM-9313 was originally selected from the exotic (CIMMYT/ICARDA) material "1ST Regional Bread Wheat Yield Trial-F.A-93-94", received from NARC Islamabad during year 1993-94. The line No. 13 was crossed with commercial wheat variety 'Soghat-90' (the variety possessing better grain quality). Selection was continued from F_2-F_6 (1995-96 to 1998-99). The selected line from F5 was coded as RWM-9313. A preliminary yield trial of this variety comprising of 52 newly evolved genotypes was conducted during 1998-99. Advanced yield trials comprising of 12 wheat genotypes including four local check varieties Sarsabz, Abadgar-93, T.J-83 and Kiran-95 were conducted during 1999-2000. The comparative advance yield trials consisting of 8 advance lines and 4 local checks were conducted during 2000-01. Sowing dates and high temperature stress trials comprising of ninety entries including NIA-Amber and 4 local checks Sarsabz, Kiran-95, Khirman and Abadgar-93 were evaluated in augmented design during 2002-03. NIA-Amber (RWM-9313) was evaluated in zonal trials conducted at different locations of Sindh for two years (2000-01 to 2001-02). Stability analysis (genotype x environment interaction) studies for grain yield were also conducted according to joint regression analysis method as suggested by Finlay & Wilkinson (1963) and Eberhart

& Russell (1966). The line was also evaluated in national wheat disease screening nursery (NWDSN) by CDRP, Islamabad for resistance to leaf and yellow rust diseases. On the basis of high grain yield potential, it was promoted to national uniform wheat yield trials (NUWYT) where it was tested along with 20 genotypes for two consecutive years (2003-04 to 2004-05). During first year the trials were conducted over 20 locations whereas in second year the trials were conducted over 36 locations in Pakistan. Micro yield trials were conducted during 2004-05 and extensive yield trials of the variety were conducted at grower's fields during 2005-06 to 2006-08. The proposal for its technical evaluation was discussed on 01st April 2008 by the Technical-sub Committee for Approval of Varieties and Techniques and by the Provincial Seed Council, Government of Sindh for release in the province on 02nd March 2010.

Results and Discussion

The performance of NIA-Amber in various trials is discussed below:

Advanced strain yield trial (AST): In advanced strain yield trial (AST), 12 wheat genotypes including 4 local check varieties were evaluated. NIA-Amber produced significantly higher yield (5314 kg/ha) than 3 check varieties (Abadgar-93, Sarsabz and Kiran-95) except T.J-83 (Table 1).

Table 1. Performance of NIA-Amber in advanced strain yield trial.

Genotypes	Days to heading	Days to maturity	Grain filling period	Plant height (cm)	1000-grain weight (g)	Grain Yield (kg/ha)
NIA-Amber	74	114	40	73	42	5314
Sarsabz	74	114	37	77	44	4748
Kiran-95	72	112	40	75	41	5274
Abadgar-93	65	109	44	54	39	4714
T.J-83	74	114	37	72	39	5635

Comparative advanced yield trial: Comparative yield trial of advanced wheat genotypes comprising of 8 advance lines and 4 local checks were evaluated. The studies were conducted for phenological traits and yield and yield components. NIA-Amber showed superiority in biological yield and grain yield (5042 kg/ha) than most entries and the check varieties (Table 2).

Table 2. Performance of NIA-Amber in comparative yield trial.

Genotypes	Yield components						
	Days to heading	Days to maturity	Grain filling period	Plant height (cm)	Biological yield kg/ha	Grain yield kg/ha	1000-grain weight (g)
NIA-Amber	80.0 b	131.0 e	51.5 ef	93.0b	14792ab	5042abc	40.7ef
Sarsabz	57.7e	128.0g	70.2ab	95.2b	14167bcd	5250ab	45.3
Abadgar-93	79.5bc	131.e	51.7ef	94.0b	13542bcd	4354def	41.9d
T.J-83	68.2d	131.5e	63.2bc	84.5c	12917cde	4729bcd	39.6gh
Kiran-95	68.5d	129.0f	60.5cd	93.7b	12917cde	4875bcd	45.9c1

Zonal trials: Twelve genotypes including NIA-Amber and two check varieties Kiran-95 and Sarsabz were evaluated in zonal trials for two years. NIA-Amber produced significantly higher overall mean grain yield (4093 kg/ha) than check varieties Kiran-95 (3738 kg/ha) and Sarsabz (3758 kg/ha). The highest yield 5958 kg/ha was recorded from this variety at Sanghar followed by N. Feroze (5625 kg/ha) and Nawabshah (5307 kg/ha) (Table 3). The variety produced 9% higher yield than check varieties Sarasabz and Kiran-95.

Table 3. Grain yield performance (kg/ha) of NIA-Amber in zonal trial.

Locations	Varieties			% Increase	
	NIA-Amber	Sarsabz	Kiran-95	Sarsabz	Kiran-95
T. Jam (Trial-1)	2738	2593	3010	5.5	-9.04
T. Jam (Trial-2)	2738	2217	2312	23.5	18.4
T. Jam (Trial-3)	3398	3815	3705	-10.9	-8.2
Tando Allahyar	4042	3875	3958	4.3	2.1
Petaro	3000	3042	2875	-1.4	4.3
Sanghar	5958	5000	4750	19.1	25.4
Nawabshah	5307	3362	2180	57.8	143.4
N. Feroze	5625	4312	4375	30.4	28.6
Khairpur	3875	3875	4145	0	-6.5
Shahdadkot	3875	4375	4653	-11.4	-16.7
Larkana	4478	4875	5062	-8.1	-11.5
Mean	4093	3758	3738	8.9	9.5

Stability analysis (G x E interaction) for grain yield of NIA-Amber: Stability parameters calculated were regression coefficient (b) and deviation from regression (S^2d). Mean grain yield of individual genotype was regressed on the mean of all genotypes at each location according to method proposed by Eberhart & Russell (1966). Regression (b) around 1.00 means less responsive to environmental changes; hence more adaptive (Finlay & Wilkinson 1963). Genotype NIA-Amber produced significantly higher grain yield (4093 Kg/ha) than check varieties and showed wide adaptation with regression value close to unity (b=1.10) and the lowest S^2d (0.09). It showed wide adaptation and stability over different locations in Sindh province. Stability analyses (b and S^2d) calculated for each wheat genotype is presented in Table 4.

Table 4. Stability analysis for grain yield of NIA-Amber in zonal trials.

Genotypes	Mean yield kg/ha	Regression coefficient b± s.e (b)	Variance due to deviation from regression (S^2d)
NIA-Amber	4093	1.10 ± 0.181	0.099
Kiran-95	3738	0.79 ± 0.249	0.207
Sarsabz	3758	0.90 ± 0.121	0.045

Evaluation of NIA-Amber under varying sowing dates: Ninety two entries including NIA-Amber and check varieties were evaluated under 3 sowing dates viz., early planting (23rd October), normal planting (19th November) and late planting (16th January) in an augmented design. NIA-Amber produced the highest grain yield under early and normal plantings, whereas it had higher yield than 3 check varieties except Kiran-95 under late sowings (Table 5).

Table 5. Performance of NIA-Amber at different sowing dates (early, normal and late).

Genotypes	S.D.1 (23rd October)		S.D.II (19th November)		S.D.III (16th January)	
	Grain yield $kgha^{-1}$	% Increase over checks	Grain yield $kgha^{-1}$	% Increase over checks	Grain yield $kgha^{-1}$	% Increase over checks
Sarasabz	4300	12	4833	20	1666	20
Khirman	4267	13	4900	19	1725	16
Kiran-95	4666	4	5333	9	2333	-14
Abadgar-93	4150	16	5375	8	1733	15
NIA-Amber	4833	--	5844	---	2000	----

National uniform wheat yield trials (NUWYT): NIA-Amber was evaluated in national trials (NUWYT) for two consecutive years (2003-04 and 2004-05).

NUWYT first year (2003-04): In first year, it produced higher mean grain yield (3637 kg/ha) over 6 sites and ranked first in Sindh province under late sowing conditions (Table 6), whereas, it produced higher mean grain yield (3939 kg/ha) under normal sowing conditions and ranked 6th position in NUWYT. In combined (normal & late sowing), NIA-Amber ranked 2nd position in NUWYT conducted in Sindh. The variety showed excellent performance under late sowings. On Pakistan basis NIA-Amber ranked on 6th position, produced 3182 kg/ha yield over 20 locations under late sowings; whereas local check variety produced 2981 kg/ha yield. It ranked 5th (3510 kg/ha yield) in combined (normal and late sowings) analysis of 20 locations in Pakistan (Table 6). The results revealed that NIA-Amber gave 21.2% higher average yield than local check and 10.8% more yield than Inqilab-91 in late planting conditions (NUWYT Late) in Sindh during 2003-04. Taking combined overall mean yield in to consideration, it showed 7.5%increase (3788 kg/ha) over local check (3523 kg/ha) and 3.4% than Inqilab-91 (3664 kg/ha) in Sindh province. Similarly, it showed 6.7% more yield (3182 kg/ha) than local check (2981 kg/ha) overall 20 sites under late plantings in Pakistan (Table 6).

Table 6. Summary of grain yield (kg/ha) performance of NIA-Amber in first year evaluation in national trials (NUWYT) during 2003-04.

Provincial/ National level	Seeding date trials	% Increase in yield over check varieties				
		NIA-Amber	Inqilab-91	% Increase over Inqilab-91	Local check	% Increase over local check
Sindh (6 sites) Pooled ANOVA	Normal	3939	4045	---	4045	---
	Late	3637	3282	10.8	3000	21.2
	Combined	3788	3664	3.4	3523	7.5
Pakistan (20 sites) Pooled ANOVA	Normal	3839	4048	---	3932	---
	Late	3182	3293	--	2981	6.7
	Combined	3510	3671	---	3456	1.6

NUWYT second year (2004-05): In second year it performed well under normal and late sowing conditions over 5 sites in Sindh and 36 locations of the country. In late sown trials at 5 locations in Sindh its performance was better and ranked 4th, produced 2802 kg/ha yield. Its yield was non-significantly different than local check (2882 kg/ha); however, it produced better yield than overall mean yield (2782 kg/ha) under late sowings (Tables 7-8).

Table 7. Grain yield performance (kg/ha) of NIA-Amber in NUWYT (2004-05).

Year	Provincial/ national level	Seeding date trial	NIA-Amber
2004-05	Sindh (5 sites)	Normal	3780
		Late	2802
		Combined	3385
	Pakistan (36 sites)	Normal	3624
		Late	2866
		Combined	3238

Table 8. Best yield performance (kg/ha) of NIA-Amber at 9 site in national trials (NUWYT).

Sites	NIA-Amber	Wafaq 2001	Local check
WRI, Sakrand	3990	3833	3865
Chak 103-P, Rahim Yar Khan	4444	4396	4236
Chak 88 WB, Vehari	3073	3094	2979
Ghausabad, D.G.Khan	3767	3378	3507
Roodhanwala, Muzafar Garh	4080	3300	3715
PSC Farm, Piplan Mianwali	2646	2583	2438
Mumtaz farm, Jhang	4531	3719	4271
Chak 277JB, Gojra T.T. Singh	2658	2576	2467
SSRI, Hafizabad	2771	2646	2396

Performance of NIA-Amber under water stress conditions: In NUWYT, variety NIA-Amber showed better yield performance with three irrigations at 13 locations overall the country. It produced the highest yield with three irrigations at Mirpurkhas, AARI, Faisalabad and CCRI, Pirsabak (Table 9).

Table 9. Grain yield performance (kg/ha) of NIA-Amber with 03 irrigations in NUWYT.

Sites	Date of sowing	Local Check	03 Irrigations				
			NIA-Amber	Inqilab-91 Check	Wafaq 2001	Diamond	Local check
Phant Farm, M. Khas	25-12-03	Sarsabz	5250	4958	5417	4750	3875
NIA, Tando Jam	16-12-03	T.J-83	3153	2873	2675	2377	2707
MMRI, Dadu	15-11-03	Abadgar	2083	1417	1125	1250	1125
MMRI, Dadu	12-12-03	Anmol-91	979	813	583	750	833
QARI, Larkana	03-12-03	Abadgar	2988	3838	3817	3221	3700
A.R.F, R.Y.Khan	23-12-03	BWP-2000	2526	2160	2510	2382	2708
O. Res. St. R.Y. Khan	16-12-03	BWP-2000	3335	3454	2458	2663	1958
A.R.F. Layyah	16-11-03	V-00055	3292	3771	3500	3396	3833
A.R.F. Layyah	17-12-03	V-00055	1742	2063	1979	1896	2333
S.M.Farm Jhang	06-11-03	V-00055	3708	4042	3750	4125	4875
MMRI. Sahiwal	08-11-03	V-00055	4167	4417	3583	3667	4229
AARI. Faisalabad	05-11-03	V-00055	5023	5273	4674	4986	5352
WRI, Faisalabad	02-12-03	V-00055	3597	3903	3750	3505	4257
Nakai Farm, Kasur	09-11-03	V-00055	4229	4896	4188	4583	5458
M.K. Farm Sheikhupura	12-11-03	V-00055	3500	4063	4188	4208	4521
ISTI, Sargodha	22-11-03	V-00055	3083	2979	3000	3333	3000
ISTI, Sargodha	27-12-03	V-00055	2313	1979	2271	1917	2354
ARF, Gujranwala	14-11-03	V-00055	4000	4583	4104	4458	4458
Narowal, Thilla Kalan	15-11-03	V-00055	3625	3708	3354	2729	4292
ARI, D.I. Khan	20-12-03	Nasir-2000	2588	2673	2054	2123	2527
ARS, Lakki Marwat	12-12-03	Khyber-87	2360	2388	2067	1910	2273
NIFA, Peshawar	10-11-03	S-2000	4083	4958	3942	4242	4683
CCRI, Pirsabak	30-10-03	S-2000	5780	5055	5890	6120	6170
CCRI, Pirsabak	20-12-03	Khyber-87	2350	3410	3350	2985	4010
S.R. Station Mardan	08-11-03	S-2000	2900	2710	3000	2640	4000
S.R. Station Mardan	22-11-03	Khyber-87	2398	2820	2955	2040	3870
Agri Res. St. Mingora, Swat	30-11-03	S-2000	3333	3533	3733	3867	4200
Agri Res. Stat. Mingora, Swat	30-12-03	Khyber-87	3033	3367	3467	3033	3933

Disease reactions (Leaf and yellow rusts) of NIA-Amber: NIA-Amber showed resistance to leaf rust and tolerance to yellow rust disease during both years of testing in national trials (the results communicated by CDRP, Islamabad).

Quality analysis: The quality analysis of wheat genotypes included in national trials (NUWYT) was performed by National Agricultural Research Centre (NARC), Islamabad. NIA-Amber possesses the highest protein percent (16.02%) than all genotypes and ranked second, the highest wet gluten (37.1%), high dry gluten (12.0%), high SDS value (28.5) and high test weight (76.4 kh/Hl) among all 20 genotypes included in NUWYT (Table 10). NIA-Amber (RWM-9313) showed considerable increase in protein content of 3.88 and 34.52% respectively over Inqilab-91and Wafaq-91 (Table 11). Similarly, the variety showed pronounced increase in wet gluten (4.85, 52.91 and 37.84 %) and in dry gluten of 1.6 and 41.18% respectively over Inqilab-91 and Wafaq-91 respectively.

Table 10. Quality analysis of NIA-Amber in NUWYT by NARC Islamabad.

Line/Variety	1000 grain wt.(g)	Test weight (kg/HL)	PSI	Grain ash (%)	Grain protein (%d.b)	Gluten consistency	Wet. gluten (%)	Dry gluten (%)	SDS value (cc)
99B4012	36.75	78.3	34	1.83	13.29	S	26.52	9.56	27.2
V-00125	32.69	76.3	45	1.41	13.57	MS	24.87	9.55	30.0
SD-66	46.62	77.1	41	1.74	16.73	MS	35.51	12.16	30.5
V-00183	44.09	79.8	33	1.55	13.99	S	25.06	9.64	28.0
Wafaq-2001	37.12	78.4	36	1.36	10.49	S	17.47	7.00	20.0
91BT010-84	57.85	77.4	36	1.50	13.35	MS	29.14	9.80	27.7
99B2237	37.76	75.7	35	2.88	13.11	S	25.96	9.21	25.2
V-01180	26.58	75.5	40	1.56	14.14	MS-W	31.86	10.19	26.0
SARC-5	40.57	79.2	40	1.40	13.43	MS	29.70	10.00	22.0
Inqilab-91	41.56	80.1	37	1.48	15.40	MS	35.30	11.71	30.0
CT-00231	41.25	75.6	45	1.57	11.69	VS	20.58	7.85	25.5
NIA-Amber	**32.96**	**76.4**	**40**	**1.82**	**16.02**	**MS-W**	**37.10**	**11.99**	**28.5**
93T347	38.09	74.2	38	1.73	11.95	MS	22.30	8.67	20.5
DIAMOND	40.32	75.4	34	1.50	12.73	S	23.06	8.69	25.5
V-99022	33.69	78.4	44	1.52	14.12	S	29.54	11.69	27.75
SN-122	30.15	70.8	45	1.83	14.09	MS	27.06	9.63	25.0
NRDW-1	43.0	-	26	1.30	12.27	S	20.74	8.84	24.0
99B2278	30.07	70.1	34	2.84	12.76	S	18.75	7.45	27.0
7-03	29.77	78.1	33	1.59	14.92	MS	32.86	11.02	30.0

Table 11. Percent increase of NIA-Amber for protein, wet and dry gluten over check varieties Inqilab-91 and Wafaq-2001.

Quality traits	NIA-Amber (RWM-9313)	Inqilab-91	Wafaq-2001	% Increase over	
				Inqilab-91	Wafaq-2001
Protein (%)	16.02	15.4	10.49	3.88	34.52
Wet Gluten (%)	37.10	35.3	17.47	4.85	52.91
Dry Gluten (%)	11.9	11.71	7.0	1.6	41.18

Production technology for NIA-Amber: NIA-Amber can be grown over all types of soils except highly saline soils. The variety possesses the highest tillering capacity; therefore low seed rate of 100-125 kg/ha may be used to obtain longer spikes with bold grains. The recommended normal fertilizer for NIA-Amber is 100N: 50 P_2O_5 kg/ha, while 120N: 90P:K30:Zn5 kg/ha dose has been observed as best dose to get higher yield. During entire season, 4-5 irrigations at various growth stages are enough to get potential yield; however the variety possess better tolerance to water stress conditions therefore under water shortage conditions, 2-3 irrigations are also enough to achieve appropriate yield.

Seed multiplication: Breeder's nucleus seed (BNS) and pre-basic seed of NIA-Amber has been produced at Nuclear Institute of Agriculture Tando Jam during 2009-10. This seed will be made available to public and private sectors where it will be further increased. The success of NIA-Amber will however depend on its rapid seed multiplication and acceptance of the growers that of course requires couple of years to increase seed in sufficient quantities and ensure supply to the end-users.

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