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Screening and Evaluation of the SAMNYT Germplasm for Yield and Disease Resistance and its Implication in the Indigenous Wheat Breeding Program

Nazeer Hussain Shah, Inamullah and Fateh Ullah Khan
Cereal Crops Research Institute, Pirsabak, Nowshera, Pakistan

Abstract: A set of 19 wheat genotypes of the First South Asia Harvestplus Yield Trial (SAMNYT) and one local check variety (Saleem-2000) were evaluated for yield and disease resistance in order to incorporate the high yielding and disease resistant entries in our indigenous wheat breeding program. The experiment was conducted at Cereal Crops Research Institute, Pirsabak, Nowshera (NWFP), Pakistan, under irrigated conditions during the growing season 2004-05. SAMNYT entries No. 9, 10, 13, 17, 18 and 20 performed tremendously well as compared with the local check variety. They produced significantly higher yields of 3360, 3680, 3700, 3390, 3500 and 3100 kg ha^{-1}, respectively and higher resistance to stripe rust, while the local check produced grain yield of 2660 kg ha^{-1}. Entries No. 7 and 14 produced grain yields (2920 and 2680 kg ha^{-1}, respectively) almost equal to that of local check variety and showed higher resistance to stripe rust.

Key words: Breeding program, CIMMYT germplasm, disease resistance, wheat, yield

INTRODUCTION

Wheat is the most important crop in the North West Frontier Province (NWFP) of Pakistan and is the staple food of the people of the province like the people of the rest of the country. Unfortunately, due to lower production and yield, the province has to import wheat every year to fulfill its food requirements. The province also has to import good quality seed of high yielding varieties for its wheat growers. During 2003-04, the average wheat yield of NWFP was 1382 kg ha^{-1}, which is far below the national average of 2373 kg ha^{-1}[1]. The lower wheat yield in NWFP is mostly attributed to its rainfed agriculture and the unavailability of high yielding varieties.

Cereal Crops Research Institute (CCRI) Pirsabak, of the NWFP Agricultural Research System has got the mandate to produce new high yielding and disease resistant varieties that can be grown in the rainfed and irrigated conditions of various agro-ecological pockets of the province. CCRI produced outstanding wheat varieties like Pirsabak-85 and Khyber-87 in the past which got extraordinary popularity not only in Pakistan, but in the neighboring countries like Iran and Afghanistan also[2]. As wheat varieties run out mostly due to diseases, continuous efforts are needed to produce new varieties to replace old ones.

Success of breeding programs always depends upon the availability of wide range of genetic resources. Thousands of wheat breeders working all over the world for the improvement and development of wheat varieties use different breeding techniques. They are interlinked with each other for the exchange of germplasm, not only for testing in various agro-ecological zones of the world but these germplasms provide breeders with the opportunity to select the best suited alleles to be incorporated in their indigenous breeding programs. CIMMYT, the International Maize and Wheat Improvement Center, Mexico is the biggest umbrella organization, playing vital role in interlinking wheat breeders of all over the world and provide wheat germplasm to them also. Most of the high yielding and disease resistant wheat varieties not only in Pakistan but all over the world have been selected from the germplasm received from CIMMYT. The present study was also conducted in such perspectives. Main objectives of the present study were as follows:

- To screen and evaluate the SAMNYT germplasm received from CIMMYT in the central agro-ecological zone of NWFP, Pakistan for high yield and disease resistance.
- To identify the entries having favorable and desirable donor alleles for various genotypic and phenotypic traits.

Corresponding Author: Dr. Inamullah, Cereal Crops Research Institute, Pirsabak, Nowshera, NWFP, Pakistan

- Implications of the selected donor alleles in indigenous breeding program for development of new, high yielding and disease resistant wheat varieties.

MATERIALS AND METHODS

A set of 19 wheat genotypes of the First South Asia Harvetplus Yield Trial (SAMNYT) received from CIMMYT, Mexico (Table 1) were evaluated for yield and disease resistance at the experimental farm of the Cereal Crops Research Institute, Pirsabak, Nowshera (34°N Latitude, 72°E Longitude and 288m Altitude) NWFP, Pakistan along with one local check variety (Saleem-2000) under irrigated conditions during the growing season 2004-05. The experiment was conducted in Randomized Complete Block Design with two replications. Planting was done on 16 December with mechanical drill designed for the purpose. Each plot consisted of six rows, 25 cm apart and five meters long. Uniform seed rate of 100 kg ha^{-1} was used. Fertilizer was applied at the rate of 120:90:60 kg ha^{-1} of NPK in the form of Urea, Single Super Phosphate (SSP) and Sulphate of Potash (SOP). SSP and SOP were applied as basal doses at the time of sowing while urea was applied in split doses; half at the time of sowing and half with first irrigation.

Central four rows were used for data collection. Days to 50% heading were recorded from the sowing date when 50% of the heads emerged from the plants. Similarly, days to maturity were recorded when 90% of the plants reached physiological maturity. Plant height was measured from the base to the tip of the awns just before harvesting. Grain yield was recorded by manually harvesting the central four rows and then threshing them on the experimental thresher. Yield per plot was converted to yield per hectare. Data were analyzed using the statistical package MSTAT-C (Knowledge Dynamics Corporation, USA) and the significant differences between treatments were determined using Tukey's test.

Table 1: Parentage, Pedigree and Origin of the 19 SAMNYT germplasm

Entry No.	Parentage	Pedigree	Origin
1	Local Check Variety (Saleem-2000)		
2	PBW343	CM85836-4Y-0M-0Y-8M-0Y-01ND	BV-04 G-9 INCREASE
3	INQALAB 91	PB19545-9A-0A-0PAK	BV-04 G-9 INCREASE
4	HUW 234	-01ND	BV-04 G-9 INCREASE
5	REBECA F2000	CM85295-0101TOPY-2M-0Y-0M-1Y-0M-(1-50)C-032R-0C	BV-04 G-9 INCREASE
6	UP 262	UP262-01ND	BV-04 G-9 INCREASE
7	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-26M-010Y-2ZLB-0SY-0B	BV-04 MF6ME4MNB
8	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-35M-010Y-5ZLB-0SY-0B	BV-04 MF6ME4MNB
9	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-11M-010Y-4ZLB-0SY-0B	BV-04 MF6ME4MNB
10	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-11M-010Y-5ZLB-0SY-0B	BV-04 MF6ME4MNB
11	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-70M-010Y-2ZLB-0SY-0B	BV-04 MF6ME4MNB
12	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-70M-010Y-3ZLB-0SY-0B	BV-04 MF6ME4MNB
13	T.DICOCCON PI94625/AE.SQUARROSA(372)//TUI/…	CMSA01M00382T-040Y-42M-010Y-3ZLB-0SY-0B	BV-04 MF6ME4MNB
14	T.DICOCCON PI94625/AE.SQUARROSA(372)//TUI/…	CMSA01M00382T-040Y-42M-010Y-5ZLB-0SY-0B	BV-04 MF6ME4MNB
15	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-73M-010Y-5ZLM-0SY-0B	BV-04 J8INCREASE
16	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-73M-010Y-4ZLM-0SY-0B	BV-04 INCREASINLF2
17	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-73M-010Y-3ZLM-0SY-0B	BV-04 INCREASINLF2
18	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-59M-010Y-2ZLM-0SY-0B	BV-04 INCREASINLF2
19	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00371T-040Y-59M-010Y-6ZLM-0SY-0B	BV-04 INCREASINLF2
20	T.DICOCCON PI94625/AE.SQUARROSA(372)//…	CMSA01M00370T-040Y-15M-010Y-6ZLM-0SY-0B	BV-04 INCREASINLF2

RESULTS AND DISCUSSION

Days to heading and maturity: The number of days taken to 50% heading by the genotypes under study showed significant differences (Table 2). Local check variety took 100 days to produce 50% heads while the ISAMNYT genotype-15 took maximum number of 105 days to produce 50% heads followed by the genotype-7 which took 104 days to produce heads. Genotypes 2 took 97 and genotypes 3 and 4 took minimum number of 96 days to produce 50% heads.

Genotypes showed significant differences in days to maturity also (Table 2). The local check took 142 days to show signs of physiological maturity while the ISAMNYT genotype-17 took maximum number of 147.5 days to mature followed by the genotype-15, which took 147 days to mature. All other genotypes took significantly smaller number of days to reach physiological maturity. Genotypes-2, 3, 4 and 14 along with the local check took the smallest number of days to mature.

Differences among wheat genotypes in the duration of the period between sowing and heading are largely governed by their sensitivity to photoperiod and vernalization[3]. However, when verbalized seedlings are grown under long photoperiods, genotypes can still differ markedly in time to ear emergence, indicating that a 'third factor'[4] must be involved. From the various names it has received[5], probably 'intrinsic earliness' (or late-ness) may be the most applicable since it implies that this genetic factor acts independently of the environment[6]. In the present study, differences among genotypes in time to heading and maturity under the same environmental conditions should indicate differences in 'intrinsic earliness' in maturity. In support of the concept, the data showed differences among genotypes. Thus, genotypes 2, 3, 4 and 14 had an intrinsic earliness while genotypes 15 and 17 had an intrinsic lateness. However, what has been considered as a static genotypic characteristic (intrinsic earliness), is primarily a result of a dynamic interaction between genotype and temperature[3].

Plant height: All genotypes showed highly significant differences in plant height (Table 2). Genotype 13 showed maximum plant height (96.5 cm) followed by genotype 10 with 93.5 cm plant height. Genotypes 2 and 3 showed minimum (significantly smaller) plant height of 76.5 cm. Local check variety showed 81 cm plant height. Since 1960's, there was high increase in the release of semi-dwarf wheat varieties for high yield all over the world especially in South Asia including Pakistan and its adoption rate was on rise rapidly till the early 1980`s[7,8]. In Pakistan, tall varieties are mostly grown in rainfed areas[7]. The ISAMNYT entry No. 13 and 10 showed maximum plant height as well maximum grain yield. These entries can be included in the indigenous breeding program for rainfed areas of NWFP, where more than 60% wheat is grown under rainfed conditions[1]. These entries are equally suitable for the irrigated conditions because they did not record any lodging (lodging data not shown).

Grain yield: Grain yield is the biggest reason for incorporating CIMMYT germplasm in wheat breeding programs[9]. ISAMNYT genotypes showed significant differences in grain yield (Table 2). Maximum grain yield (3700 and 3680 kg ha^{-1}) was recorded by genotypes 13 and 10, respectively. Minimum and significantly smaller grain yield of 1420, 1520 and 1570 kg ha^{-1} were recorded by genotypes 2, 3 and 4, respectively, probably because these entries showed higher susceptibility to stripe rust (Table 3). Local check variety (Saleem-2000) recorded grain yield of 2660 kg ha^{-1}. Entries No. 7, 9, 14, 17, 18 and 20 performed tremendously well in terms of grain yield and disease resistance. They produced significantly higher yields of 2920, 3360, 2680, 3390, 3500 and 3100 kg ha^{-1}, respectively and higher resistance to stripe rust. Grain yield is decreased by 42 % when sowing is done on 15 Dec. as compared with the normal sowing date of November 5[10]. The above-mentioned entries gave high yield although the trial was planted about four to five weeks late, so these entries are recommended for late sowing also.

Disease reaction: In the growing season 2004-05, the rust epidemic on wheat was very severe especially in the central agro-ecological zone of NWFP. Stripe rust caused by *puccinia striiformis*, is prevalent in wheat in this area. In the past, most of our outstanding varieties like Pirsabak-85 were eliminated by the stripe rust. In 2004-05, another outstanding wheat variety of Pakistan i.e., Inqalab-91 was severely attacked and eliminated by the stripe rust in especially in the central agro-ecological zone of NWFP. One of the main objectives of CCRI, Pirsabak is to develop wheat varieties which are resistant to stripe rust. Genotypes included in this experiment showed different levels of susceptibility and resistance to stripe rust. Less than 10% (10MSS) stripe rust infection has been reported as the high resistance and less than 5% (5MSS) as the effective resistance of the wheat variety/line/germplasm[11]. SAMNYT entry No. 2, 3 and 4 showed higher susceptibility to stripe rust (Table 3). Entry No. 13, 14, 17 and 20 were found totally resistant to

Table 2: DH, DM, PH and GY of the 19 SAMNYT germplasms and the local check variety (Saleem-2000)

Entry No.	DH	DM	PH (cm)	GY (kg ha^{-1})
1	100 e	142.0 g	81.0 I	2660 g-k
2	97 f	141.5 g	76.5 j	1420 l
3	96 f	142.0 g	76.5 j	1520 l
4	96 f	142.0 g	89.0 de	1570 l
5	101 de	145.0 bc	92.5 bc	3220 b-e
6	102 cd	143.0 f	86.5 f-h	2880 f-h
7	104 ab	145.5 b	89.0 de	2920 fg
8	102 cd	143.0 f	89.5 de	3320 b-d
9	101 de	143.0 f	92.0 bc	3360 b-d
10	102 cd	145.5 b	93.5 b	3680 a
11	102 cd	143.5 ef	86.5 f-h	2710 g-i
12	103 bc	144.0 de	88.5 def	3200 c-e
13	101 de	143.5 ef	96.5 a	3700 a
14	100 e	142.0 g	90.0 d	2680 g-j
15	105 a	147.0 a	91.0 cd	3320 b-d
16	103 bc	144.5 cd	90.0 d	3390 bc
17	100 e	147.5 a	92.5 bc	3390 bc
18	101 de	144.0 de	87.5 e-g	3500 ab
19	103 bc	145.0 bc	85.5 gh	2620 h-k
20	101 de	143.0 f	87.5 e-g	3100 d-f
LSD value:	1.697	0.831 6	2.028	286.2

Means in the same category followed by different letter (s) are significantly different. DH: Days to 50% heading, DM: days to maturity, PH: plant height, GY: grain yield

Table 3: Disease reaction of 19 SAMNYT germplasm and one local check variety (Saleem-2000)

	Resistance to Stripe Rust	
Entry No.	Replication No.1	Replication No.2
1	20MSS	30MSS
2	20MSS	30MSS
3	30MSS	40MSS
4	30MSS	30MSS
5	0/10MSS	10MSS
6	10MSS	5MSS
7	0	5MSS
8	5MR	10MSS
9	0	5MSS
10	5MSS	10MRMSS
11	TMR	0/10MSS
12	10MSS	0
13	0	0
14	0	0
15	0/10MSS	10MSS
16	10MSS	10MSS
17	0	0
18	0/10MSS	0
19	5MSS	20MSS
20	0	0

MSS: Moderately Susceptible to Susceptible; MR: Moderately Resistant; TMR: Traces of Moderate Resistance

stripe rust and entry No. 7 and 9 showed effective resistance (0 and 5MSS) to stripe rust. Entry No. 10 also showed high resistance to stripe rust. A major goal of most wheat breeding programs is to develop resistance to diseases, particularly rusts. Disease resistance is the second most important reason after grain yield for incorporating CIMMYT germplasm[12] in wheat breeding programs. As stripe rust is the killing disease of wheat in the central agro-ecological zone of NWFP, the identification of the above-mentioned stripe rust resistant SAMNYT germplasm from CIMMYT may not only be evolved as promising varieties of the future but the donor alleles for disease resistant they have may be incorporated in our indigenous crosses also.

Entries No. 7, 9, 10, 13, 14, 17, 18 and 20 performed well in terms of disease resistance and grain yield, so these entries were selected and will be used in preliminary yield trials of our indigenous wheat breeding program.

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