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Phule Satwik (NIAW 3170): A soft bread wheat variety for North Western Plains and Peninsular Zone of India

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Abstract

Wheat is an important crop that plays major role in a food grain production in the country. It is a lone source for industries involved in the manufacturing of bread, biscuits, flakes, cakes etc. These industries rely on quality parameters *viz*., grain hardness index, biscuit spread factor, bread quality score, and bread loaf volume. Bread wheat variety Phule Satwik (NIAW 3170) is developed at Agricultural Research Station, Niphad has been released and notified by Central Sub Committee on Crop Standards, India for cultivation in North Western Plains Zone and Peninsular Zone under restricted irrigation conditions *vide* notification number S.O. 3482 (E) dated 7th October, 2020. The variety has high yield potential under restricted irrigation conditions along with disease resistance and superior grain quality parameters. It was the softest grain variety among all the genotypes having a biscuit spread factor of more than 10. With good nutritional and quality parameters, it will be a promising variety for bakery industries.

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High Yield;
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Varietal Development;
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Introduction

Wheat (*Triticum aestivum* L.) is the second major *rabi*-cereal crop in India. It plays a crucial role in food grain production in the country. India ranks second in the production of wheat in the world. In India during 2022-23, the wheat was cultivated on 32.44 million ha with the production of 112.74 million tonnes.[1] In India, wheat is mostly consumed in the form of *chapatis* and *roti*. It is one of the major sources of diet which provides nearly half of the dietary protein and more than half of the calories to the Indian population. It is an important source for industries involved in the manufacturing of bread, biscuits, flakes, cakes etc. These industries rely on quality parameters viz., grain hardness index, biscuit spread factor, bread loaf volume, and bread quality score. Gluten a protein present in wheat is an important ingredient in bakery products because of its high elasticity, viscosity, and swelling power. It is a rich source of phosphorous and also increases the shelf life of bakery products. Considering these points, continuous efforts resulted in the development of a bread wheat variety Phule

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Satwik (NIAW 3170) which will be preferred by the biscuit industry. It was developed at the Agricultural Research Station, Niphad (MS), and was identified and recommended by the Varietal Identification Committee Meeting in the 58th AGM of AICRP on Wheat & Barley. It has been released and notified by the Central Sub-Committee on Crop Standards, India for cultivation in NWPZ and PZ under restricted irrigation conditions.

Material and Methods

Elite Germplasm Screening Nursery received from International Maize and Wheat Improvement Center (CIMMYT), Mexico was sown during *Rabi* 2012-13 at Agricultural Research Station, MPKV, Niphad. Entry no 59 having the pedigree of SOKOLL X ROLF 07 was selected and evaluated in Station Trials viz., Rod Row Trial and Progeny Row Trial during *rabi* 2013-14 and 204-15 respectively. Based on performance the genotype was further advanced and evaluated in Multilocation Varietal Trial at three different locations viz., Niphad, Rahuri, and Saval Vihir during *rabi* 2015-16. On basis of performance, it was promoted and evaluated in the National Initial Varietal Trial (NIVT-5A-RI-TS) at 31 locations in NWPZ and PZ during *rabi* 2016-17. The genotype was promoted to Advanced Varietal Trial-1 (AVT-RI-TS-PZ) and was evaluated at 16 and 11 locations in NWPZ and PZ respectively during *rabi* 2017-18. It was promoted to Advanced Varietal Trial-2 (AVT-RI-TS-PZ) and was evaluated at 23 and 17 locations in NWPZ and PZ respectively during *rabi* 2018-19. The severity of rust and its response in the field was recorded with score of 0-100 scale.[2] For statistical analysis, the rust reactions were transferred into a coefficient of infection (COI).[2] Gene postulation for rust resistance genes was done at the seedling stage scoring 0-4 scale.[3] The Distinctiveness, Uniformity, and Stability (DUS) characterization of NIAW 3170 was done following the guidelines given by PPVFRA.

Varietal Descriptors

NIAW 3170 has having semi-erect growth habit, pale green foliage colour, waxiness is present on flag leaf, leaf sheath, ear head, and peduncle. It has an average plant height of 78 cm, flowers in 44 to 71 days, and matures in 98 to 120 days. The ear head is tapering, white, long with medium density and short awns. It has white-colored, oblong shapes with very soft textured seeds with an average test weight of 39 g

Results

Yield Evaluation

The performance of NIAW 3170 was tested in station trials viz., Rod Row Trial (2013-14) and Progeny Row Trial (2014-15) under restricted irrigation conditions. It ranked first with an average yield of 34.08 q ha^{-1}. Then it was tested in a University Multilocation Trial during 2015-16 at two locations *viz*., Niphad and Rahuri.

Evaluation in Peninsular Zone trials

NIAW 3170 was included and evaluated for three years i.e. 2016-17 (NIVT-5A-RI-TS-PZ), 2017-18 (AVT-I-RI-TS-PZ) and 2018-19 (AVT-II-RI-TS-PZ) under All India Coordinated Wheat Improvement Programme. It showed stable and high-yielding performance under restricted irrigation conditions at various locations of the Peninsular Zone as compared to the checks DBW 93 and HI 1605 (Table 1). In NIVT-5,NIAW 3170 (44.3 q ha^{-1}) significantly out-yielded the check DBW 93. In AVT-I during 2017-18 NIAW 3170 recorded a yield of 31.1 q ha^{-1} which was statistically superior over all the checks of the zone. In the last year of its evaluation, in AVT-II (2018-19) it recorded 35.0 q ha^{-1} of yield which was again significantly superior over all the checks. The variety NIAW 3170 was found superior over the checks DBW 93 and HI 1605 with 20.3 % and 19.5 % increase over the mean and 15.4 % and 9.4 % over the weighted mean respectively. The frequency of occurrence of NIAW 3170 in the top non-significant group was the highest among all test entries and checks. It was 14/17 in a top non-significant group on the overall basis of three years as compared to the checks DBW 93 (5/17) and HI 1605 (7/16)[4,5,6] The yield potential of NIAW 3170 (44.3 q ha^{-1} at location ARS, Niphad, 2016-17) was highest when compared with all the checks (Table 1).

Evaluation in North Western Plains Zone Trials

In NWPZ trials the entry NIAW 3170 was evaluated for three years i.e. 2016-17 (NIVT-5A-RI-TS-NWPZ), 2017-18 (AVT-I-RI-TS-NWPZ) and 2018-19 (AVT-II-RI-TS-NWPZ). It showed high-yielding performance under restricted irrigation conditions at various locations of NWPZ as compared to the checks WH 1142, WH 1080, PBW 644, HD 3043, HD 3237, and HI 1620 (Table 2). In NIVT-5 it yielded an average of 54.7 q ha^{-1} which was significantly superior over the check WH 1142. In AVT-I during 2017-18, NIAW 3170 has given an average yield of 48.5 q ha^{-1}

which was significantly better over all the checks of the zone. In the final year of its testing, in AVT-II (2018-19) it recorded 50.1 q ha^{-1} of yield which was significantly superior to the checks viz., WH 1142, WH 1080, PBW 644, HD 3043, and HD 3237. The variety NIAW 3170 was found superior over the checks HD 3043, WH 1080, PBW 644, WH 1142, HD 3237 and HI 1620 with 17.74, 12.80, 12.80, 5.79, 4.39, and 0.20 % increases over respectively when compared with means. The frequency of occurrence of NIAW 3170 in the first non-significant group was 15/35 on overall basis of three years as compared to the checks WH 1142 (7/35), WH 1080 (1/27), PBW 644 (4/27), HD 3043 (1/27), HD 3237 (8/27) and HI 1620 (15/27) (ICAR- IIWBR 2017, ICAR- IIWBR 2018a, ICAR- IIWBR 2019a). Potential yield of NIAW 3170 was the highest (71.7 q ha^{-1} at IIWBR, Karnal location, 2018-19) as compared to all the check varieties (Table 2).

Table 1: Performance NIAW 3170 for grain yield under AICRP trials in PZ (2016- 2019)

Item	Year of testing	No. of Trials	NIAW 3170	Check varieties		CD -10%
				DBW 93	HI 1605	
Mean	NIVT- 5A (2016-17)	1	44.3	34.0	-	5.8
Yield	AVT-I (2017-18)	08	31.1	27.3	28.5	1.3
(q/ha)	AVT-II (2018-19)	08	35.0	30.5	33.0	1.7
	Mean	--	36.8	30.6	30.8	--
	Weighted mean	**--**	**33.7**	**29.2**	**30.8**	**--**
% Increase /	NIVT- 5A (2016-17)	--	--	30.3	--	--
decrease	AVT-I (2017-18)	--	--	13.9	9.1	--
over Checks	AVT-II (2018-19)	--	--	14.8	6.1	--
	Over mean	**--**	**--**	**20.3**	**19.5**	**--**
	Over weighted mean	**--**	**--**	**15.4**	**9.4**	**--**
Frequency	NIVT- 5A (2016-17)	--	**1/1**	0/1	--	--
in 1st NS	AVT-I (2017-18)	--	**⅞**	2/8	3/8	--
group	AVT-II (2018-19)	--	**6/8**	3/8	4/8	--
	Total	**--**	**14/17**	**5/17**	**7/16**	**--**
	Yield Potential (q/ha)	**--**	**44.3**	**36.9**	**37.3**	**--**

AICRP: All India Coordinated Research Project

Table 2: Performance NIAW 3170 for grain yield under AICRP trials in NWPZ (2016-2019)

Items	Year of testing	No. of Trials	NIAW 3170	Check varieties						CD (10%)
				WH 1142	WH 1080	PBW 644	HD 3043	HD 3237	HI 1620	
Mean	NIVT-5A (2016-17)	8	54.7	51.6	-	-	-	-	-	2.7
Yield	AVT I (2017-18)	13	48.5	45.5	44.8	44.7	41.7	47.9	49.7	0.9
(q/ha)	AVT II 2018-19	14	50.1	47.9	45.7	45.9	45.0	50.0	52.3	0.9
	Mean	--	51.1	48.3	45.3	45.3	43.4	49.0	51.0	--
	Weighted mean	**--**	**50.8**	**47.9**	**45.3**	**45.3**	**43.4**	**49.0**	**51.04**	**--**
% Increase /	NIVT-5A (2016-17)	--	-	6.01	-	-	-	-	-	--
decrease	AVT I (2017-18)	--	-	6.59	8.26	8.50	16.31	1.25	-2.41	--
over checks	AVT II 2018-19	--	-	4.59	9.63	9.15	11.33	0.20	-4.20	--

	Over mean	--	-	**5.79**	**12.80**	**12.80**	**17.74**	**4.39**	**0.20**	--
	Over weighted mean	**--**	**-**	**6.05**	**12.14**	**12.14**	**17.05**	**3.78**	**-0.47**	**--**
Frequency	NIVT-5A (2016-17)	--	**4/8**	2/8	-	-	-	-	-	--
in 1st NS	AVT I (2017-18)	--	**5/13**	1/13	1/13	2/13	0/13	3/13	7/13	--
group	AVT II 2018-19	--	**6/14**	4/14	0/14	2/14	1/14	5/14	8/14	--
	Total	**--**	**15/35**	**7/35**	**1/27**	**4/27**	**1/27**	**8/27**	**15/27**	**--**
	Yield Potential (q/ha)	**--**	**71.7**	**70.3**	**64.3**	**67.0**	**56.8**	**69.7**	**71.2**	

AICRP: All India Coordinated Research Project

Disease and Pest Resistance

NIAW 3170 showed resistance against Brown rust and Black rust in PZ and NWPZ trials under natural and artificial epiphytotic conditions in Plant Pathological Screening Nurseries (PPSN). NIAW 3170 was found resistant to major pathotypes of brown and black rusts under PZ trials (Table 3) and NWPZ trials (Table 4). Multi-environmental evaluation of large sets of wheat germplasm has already led to the identification of resistant sources[7] which can further be used in wheat breeding programs. Resistance gene for brown rust Lr13+16+ (NWPZ) and Lr13+10+ (PZ) and resistance gene for black rust Sr2+ (NWPZ & PZ) have been postulated in this variety through multipathotype testing for seedling resistance. It was also found resistant to Karnal Bunt, Flag Smut, Powdery Mildew, and Foot Rot diseases. It has shown better resistance to shoot fly and root aphids under controlled conditions.[8,9]

Table 3: Response to major threerusts under artificial epiphytotic conditions in PZ trials

Disease	**Year**	**NIAW 3170**		**DBW 93**		**HI1605**	
		HS	**ACI**	**HS**	**ACI**	**HS**	**ACI**
Yellow Rust	2016-17	30S	11.7	80S	35.7	40S	10.4
	2017-18	40S	14.5	80S	45.1	40S	27.0
	2018-19	40S	14.9	100S	51.5	40S	22.4
	HS & Mean ACI	**40S**	**13.7**	**100S**	**44.1**	**40S**	**19.9**
Brown Rust	2016-17	10MR	1.1	30S	7.2	20S	5.8
	2017-18	10S	3.4	20S	10.8	20MS	12.2
	2018-19	10S	2.5	60S	14.6	40S	13.2
	HS & Mean ACI	**10S**	**2.3**	**60S***	**10.9**	**40S**	**10.4**
Stem Rust	2016-17	20MS	4.3	30MS	6.4	20S	7.0
	2017-18	10S	4.7	10MR	1.6	20MS	7.3
	2018-19	10MS	4.3	5MS	2.3	20S	7.6
	HS & Mean ACI	**10S**	**4.4**	**30MS**	**3.4**	**20S**	**7.3**
		Gene Postulation					
Yellow Rust		-		Yr9+		Yr2+	
Black Rust		Sr2+		Sr31+2+		Sr5+11+	
Brown Rust		Lr13+10+		Lr26+		Lr13+	

HS = Highest score, ACI = Average coefficient of infection

Table 4: Response to all three rusts under artificial epiphytotic conditions in NWPZ trials

Disease	Year	NIAW 3170		WH 1142		WH 1080		PBW 644		HD 3043		HD 3237		HI 1620	
		HS	ACI	HS	ACI	HS	ACI	HS	ACI	HS	ACI	HS	ACI	HS	ACI
Yellow Rust	2016-17	30S	11.7	20S	5	-	-	-	-	-	-	-	-	-	-
	2017-18	40S	17.9	10S	3.3	10MS	3.1	60S	31	60S	30	10MS	4.1	20S	7.8
	2018-19	60S	17.4	20S	4.9	30S	17.6	60MS	21.4	60MS	23	10S	4.5	40S	10.6
	HS & Mean ACI	**60S**	**15.7**	**20S**	**4.4**	**30S**	**10.4**	**60S**	**26.2**	**60S**	**26.5**	**10S**	**4.3**	**40S**	**9.2**
Brown Rust	2016-17	5S	1	TS	0.2	-	-	-	-	-	-	-	-	-	-
	2017-18	5MR	0.3	20S	5.6	20S	7.3	5S	1.6	20S	12.9	40S	15.7	10S	2.7
	2018-19	20S	4.8	50S	11.8	80S*	17.3	50S*	10.3	100S	28.1	90S	22.8	10S	3.3
	HS & Mean ACI	**20S**	**2**	**50S***	**5.9**	**80S**	**12.3**	**50S***	**6**	**100S**	**20.5**	**90S**	**19.3**	**10S**	**3**
Stem Rust	2016-17	20MS	4.3	40MS	8.7	-	-	-	-	-	-	-	-	-	-
	2017-18	5S	1.7	5S	2.5	30MS	12.3	30S	18	10MS	4	20S	14.7	40MR	7.7
	2018-19	10MS	3	30MS	7	40MS	11.7	20S	15.5	20MS	4.5	40S	24	20S	8.6
	HS & Mean ACI	**5S**	**3**	**5S**	**6.1**	**40MS**	**12**	**30S**	**16.8**	**20MS**	**4.3**	**40S**	**19.4**	**20S**	**8.2**
Gene Postulation															
Yellow Rust	-	Yr9+		-		Yr2+		Yr9+A+		Yr2+		YrA+			
Black Rust	Sr2+	Sr31+2+		Sr9e+2+		Sr11+2+		Sr31+2+		Sr5+		Sr11+7b+			
Brown Rust	Lr13+16+	Lr26+23+10		Lr13+		Lr13+1+		Lr26+23+		Lr13+3+		Lr13+10+3			

HS = Highest score, ACI = Average coefficient of infection

Table 5: Evaluation of NIAW 3170 for quality traits under AICRP trials

Quality Parameter (Average of three years)	NWPZ							PZ		
	NIAW 3170	Checks						NIAW 3170	Checks	
		WH 1142	WH 1080	PBW 644	HD 3043	HD 3237	HI 1620		DBW 93	HI 1605
Grain Characteristics										
Protein (%)	**11.4**	10.92	10.73	10.67	10.9	10.3	10.93	**11.96**	12.27	11.86
Grain appearance (max score 10)	**5.5**	5.5	5.5	5.8	5.3	5.4	5.4	**5.6**	6.1	6.6
Hectoliter weight (kg/hl)	**78.2**	79.8	75.8	77.2	77.4	77.3	76.9	**80.4**	82.4	82.5
Sedimentation value (ml)	**46.6**	45.7	60	47.7	46.8	50.3	61.7	**54.1**	44.7	64.6
Grain Hardness index	**28.4**	90.6	79.7	82	83.4	79.4	86.1	**43**	80.9	85.6
Chapati, bread and biscuit quality										
Chapati quality (max score 10)	**7.27**	7.27	7.5	7.94	7.35	7.6	7.41	**7.08**	7.43	7.68
Bread loaf volume (ml)	**608**	580	545	478	628	568	510	**608**	630	607
Bread quality (max core 10)	**6.92**	6.96	6.18	4.76	8.01	6.45	5.6	**7.27**	8.15	8.01
Biscuit spread factor	**10.18**	8.84	5.65	8.13	8.49	8.08	7.9	**9.34**	7.46	7.19
Dry gluten (%)	**7.7**	7.5	8	8	7.9	8.1	7.9	**9**	9.9	10.2
Wet gluten (%)	**24.6**	23.7	25.1	26	23.6	25.7	23.8	**27.5**	31.2	30.4
Gluten index	**73**	84.5	91	37.5	66.5	65.5	87.5	**86.3**	59.3	86.3
Phenol test (max 0)	**6.9**	7	6.8	6.9	6.9	9.8	8	**7.4**	5.5	2.9
Nutritional quality										
Fe (ppm)	**36**	36.3	33	35.9	34.6	36	34	**40**	41.4	40.9
Zn (ppm)	**34.7**	34.1	31.1	36.1	38.7	33.2	32.7	**33.1**	35.5	32.4

AICRP: All India Coordinated Research Project

Quality Traits Analysis

As per quality analysis (Table 5), NIAW 3170 is having softest grains among all the genotypes and checks tested in Peninsular and North Western Plains Zones trials during 2016-17, 2017-18, and 2018-19. The average grain hardness index of NIAW 3170 was 28.4 and 43.0 in NWPZ and PZ respectively whereas the lowest grain hardness index by any check in NWPZ or PZ was 79.4 (HD 3237 in NWPZ). NIAW 3170 was the only genotype

among all genotypes and checks tested in NWPZ and PZ having a biscuit spread factor of more than 10 (10.18). NIAW 3170 has having good chapati-making score (7.27 and 7.08 in NWPZ and PZ), high bread loaf volume (608), better protein content (11.40 and 11.96 in NWPZ and PZ). Wet gluten and dry gluten content were recorded as 24.6 % and 7.7 % respectively whereas,the gluten index was 73.0 in NWPZ. In PZ trials wet gluten and dry gluten were 27.5 % and 9.0 % respectively and gluten index was 86.3. Fe content and Zn content were 36.0 ppm and 34.7 ppm in NWPZ while it was 40.0 ppm and 33.1 ppm in PZ trials respectively).[10,11]

Discussion

The variety Phule Satwik (NIAW 3170) significantly outyielded the check varieties in the Peninsular Zone and North Western Plain Zone. It has having softest grains along with a biscuit spread factor of more than 10 which makes this variety more suitable for bakery industries. It is also resistant to leaf and stem rust. Result of this the variety was identified and recommended by the Varietal Identification Committee in the 58th AGM of All India Coordinated Research Project on Wheat & Barley for cultivation in both above-mentioned zones under restricted irrigation conditions.

Conclusion

The cultivar Phule Satwik (NIAW 3170) was notified for cultivation in the Peninsular Zone (States of Maharashtra and Karnataka) and North Western Plains Zone (States of Punjab, Haryana, Rajasthan, Uttarakhand, Uttar Pradesh Delhi, and Jammu & Kashmir) vide notification No. S.O. 3482 (E) dated 7th October, 2020. The variety is registered under the Protection of Varieties and Farmers' Right Association (PPV&FRA), Ministry of Agriculture and Farmers Welfare, Government of India with certificate number REG/202/385 dated 15th November, 2022. Agricultural Research Station, Niphad (MS) is the main centre responsible for the maintenance and production of nucleus and breeder seed.

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Conflict of Interest

The authors declared no conflicts of interest with respect to the research, authorship, and publication of this article.

Author's Contribution

Dr Nilesh Madhavrao Magar Manuscript preparation and statistical analysis, Dr Suresh Shravan Dodake Station trials conduct and data analysis, Dr Dnyandeo Ambarnath Gadekar, Coordinated trials conduct data analysis, Dr Bhanudas Chhaburao Game Analysis of pathological data, Shri Rajendra Dada Lokhande Organizing seed production data, Prof Bhalchandra Madhukar Mhaske Analysis of entomological data, Dr Yogesh Jayant Patil Recording data on agronomic characters

Data Availability Statement

The experiments were conducted during 2012-13 to 2018-19 at Agricultural Research Station, Niphad and centers under Peninsular Zone and North Western Planes Zone of India and the data is available in the Progress Reports of ICAR-Indian Institute of Wheat and Barley Research, AICRP on Wheat and Barley in respective years. Link for data https://www.aicrpwheatbarleyicar.in/reports

Ethics Approval Statement

The present study doesn't involve an experiment on humans and animals.

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