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Varietal Release

HD 3298: Biofortified, climate-resilient, high-yielding wheat variety for very late sown conditions of North-Western Plains of India

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Wheat is one of the most important crops for global food security; in the year 2020-21, wheat was grown on 221.8 million ha of land with a production of around 775.83 million tonnes. In India, wheat production reached ever highest figure of 109.5 million tonnes from a 31.36 million-hectare area (USDA 2021). The development of high-yielding, climate-resilient wheat varieties, and improved agronomic practices have led to significant wheat production in India. However, the pace of developing high-yielding, biofortified wheat varieties is a little bit slow.

Wheat contains low levels of the essential micronutrients iron and zinc. Therefore, a major target in wheat biofortification programs is the improvement of iron (Fe) and zinc (Zn) content in the grain. In India, recent estimates reflect an unacceptably low consumption of iron among women aged more than 18 years, and 51–83% of pregnant women are deprived of the recommended daily allowance of iron (Shankar et al 2017). Thus, it is not surprising that India has the highest number of women with anemia globally and has significant economic implications for the nation's development (Rai et al 2018). In India, the most productive zone of wheat cultivation is the North-Western Plains Zone (NWPZ) which is also referred to as the 'food bowl of India'. In this zone, two biofortified wheat varieties viz., WB 02 and HPBW 01 having 40.0 ppm iron content were released in 2017 (Gaikwad et al 2021). The new wheat variety HD 3298 having 43.1 ppm iron and 12.12 % protein content is suitable for the very

late sown conditions of the North-Western Plains Zone (NWPZ) that comprises the areas of Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua districts), and parts of Himachal Pradesh (Una district and Paonta valley) and Uttrakhand (Tarai region). In addition to its biofortification traits, this variety is high-yielding and has tolerance to terminal heat stress.

HD 3298 is developed from an indigenous two-way cross consisting of CL1449/PBW343 as the female parent and CL882/HD2009 as the male parent. The modified bulk-pedigree method was adopted from F_2-F_5 generations, followed by a single plant selection in the F_6 generation to develop the line. Shuttle breeding facilities at two regional stations for rust screening and generation advancement were utilized. At ICAR-Indian Agricultural Research Institute (ICAR-IARI), Regional Station, Wellington, the breeding material was screened for leaf and stem rust; and, for stripe rust screening, the regional station of ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR), located at Lahaul Spiti, Himachal Pradesh was utilized. During 2016-17, this entry was evaluated in common varietal trials of ICAR-Indian Agricultural Research Institutes (IARI) across three locations. Based on its superior performance, this entry was promoted to the Special Varietal Trials under the All India Coordinated Research Project (AICRP) on Wheat and Barley.

During 2017-18, this entry was evaluated in Special trials for very late sown conditions (SPL-VLS) under the All India Coordinated Research Project (AICRP) on Wheat and Barley as HD 3298. The entry was evaluated at seven locations in randomized block design in four replications with a plot size (14.4 m^2) under irrigated very late-sown (VLS) conditions against checks DBW 71, DBW 14, WR 544. The recommended sowing time for the VLS trial is 1-15th January. During 2018-19, HD 3298 was evaluated under the same very late sown conditions at 7 locations with the same checks; this trial was termed as SPL-Advanced Varietal Trial I (SPL-AVT-I). During 2019-20 in AVT-II, the genotype was evaluated at 18 locations under late sown conditions. Due to administrative reasons, the VLS trial was discontinued and the entry was evaluated under late sown (LS) conditions in SPL-AVT II. In SPL-AVT II, five varieties viz., HD 3059, WH 1021, WH 1124, DBW 173, and PBW 771 were used as checks. In advanced varietal trials (AVTs) the entry and checks were evaluated in randomized block design with four replications and plot sizes of 14.4 m^2. Data on yield and yield contributing traits, reactions to major diseases and insect pests, grain, and nutritional quality traits were recorded. The entry was also characterized in terms of Distinctness, Uniformity, and Stability traits as per the guidelines for varietal identification in wheat (UPOV 2017, www.upov.int).

HD 3298 and the check varieties were artificially screened for stripe rust, leaf rust, and other important diseases like leaf blight, Karnal bunt throughout the yield evaluation process, and Powdery Mildew, Flag smut, and loose smut in AVT I. The average coefficient of infection (ACI) for both the rusts was calculated by multiplying disease severity and constant values of infection type. The constant values for infection types were used based on the following: R = 0.2, MR = 0.4, M = 0.6, MS = 0.8 and S = 1.0. The seedling resistance test against 16 races of stripe rust and 21 races of leaf rust was carried out for gene postulation using pathotype matching techniques (ICAR-IIWBR 2019a, 2020a). HD 3298 was also evaluated for timely, late, and very late sown conditions at 10 locations of NWPZ against five check varieties viz., HD 3059, WH 1021, WH 1124, DBW 173, and PBW 771 (Anonymous 2020). Quality attributes such as grain appearance score, hectolitre weight, protein%, sedimentation value, grain hardness, Chapati quality, bread loaf volume, bread quality, biscuit spread factor, wet and dry gluten %, gluten index, Fe and Zn content, and high molecular weight subunits were determined as per standard procedures and protocols and the data was made available by ICAR-Indian Institute of Wheat and Barley Research, Karnal, India under AICRP (Anonymous 2018, ICAR-IIWBR 2019b, 2020b).

Performance Characteristics

Varietal descriptors

HD 3298, a spring wheat variety with semi-spreading growth habit, flowers in around 72 and 84 days, matures in 103 and 122 days under VLS and LS conditions respectively and is classified as an early maturity group.

This variety attains a height of 85 and 94 cm under VLS and LS conditions respectively (ICAR-IIWBR 2018, 2019c, 2020c). It has lustrous, amber-colored oblong-shaped grains with having semi-hard texture. Thousand-grain weight under VLA and LS conditions is 32.5 and 39 gm respectively. The variety has green foliage and waxy attributes at the time of ear emergence. The ears are tapering, medium-long in length with medium grain density. The ear and awns turn white at the time of maturity. The non-pubescent glumes have sloping shoulder shape with long beak lengths. The grains have medium crease width and depth. The brush hair is shorter in length with a weak profile.

Yield evaluation

In the two years (SPL-VLS and SPL-AVT I) of testing under VLS conditions, on the weighted mean basis, HD 3298 out yielded (39.0 q ha^{-1}) the checks WR 544 (30.9 q ha^{-1}), DBW 14 (35.5 q ha^{-1}), DBW 71 (36.6 q ha^{-1}). In terms of yield gain, it comes at 26.3, 10.1, and 6.6 percent, respectively (Table 1). HD 3298 also out-yielded contemporary test entry which has been recently released for cultivation like PBW 757, HD 3271, and HI 1621 by 7.3, 4.3, and 2.4 percent, respectively under VLS conditions (Table 1). Out of the total of 14 locations during two years of testing under VLS conditions in NWPZ, 8 times it appeared statistically superior group which established its genetic superiority and wide adaptability. Potential yield realized for HD 3298 (47.4 q ha^{-1}) is much higher in comparison to checks DBW 71 (42.8 q ha^{-1}), DBW 14 (40.5 q ha^{-1}), WR 544 (41.0 q ha^{-1}) and recently released varieties PBW 757 (42.5 q ha^{-1}), HD 3271 (45.5 q ha^{-1}) and HI 1621 (43.1 q ha^{-1}) under VLS conditions (Table 1). Since the very late sown trial was terminated, in the third year, it was tested under late sown condition and was able to outperform three checks namely, HD 3059, WH 1021, and WH 1124 (Table 2).

Table 1: Yield performance of HD 3298 in VLS yield trials of AICRP (2017-19)

Item	Year of testing	No. of trials	HD 3298	Checks			Recently Released Varieties			CD
				DBW 71	DBW 14	WR 544	PBW 757	HD 3271	HI 1621	
Mean yield (q ha^{-1})	2017-18 (VLS)	7	38.0	35.7	35.8	31.2	35.9	35.9	37.9	1.1
	2018-19 (VLS)	7	40.0	37.5	35.1	30.6	36.8	38.9	38.3	1.2
	Weighted mean		39.0	36.6	35.5	30.9	36.4	37.4	38.1	
% Increase over check	2017-18 (VLS)	7		6.4	6.1	21.8	5.8	5.8	0.3	
	2018-19 (VLS)	7		6.7	14.0	30.7	8.7	2.8	4.4	
	Weighted mean			6.6	10.1	26.3	7.3	4.3	2.4	
Yield potential q ha^{-1} (VLS)			47.4	42.8	40.5	41.0	42.5	45.5	43.1	
Statistically superior group		14	8/14	2/14	2/14	0/14	5/14	7/14	6/14	

Table 2: Yield performance of HD 3298 in LS yield trial of AICRP (2019-20)

Item	Year of testing	No. of trials	HD 3298	Checks					CD
				HD 3059	WH 1021	WH 1124	DBW 173	PBW 771	
Mean yield (q ha^{-1})	2019-20 (LS)	18	47.4	46.3	39.0	44.9	49.1	49.7	0.8
% increase or decrease over check	2019-20 (LS)	18		2.4	21.5	5.6	-3.5	-4.6	

Wider adaptation

HD 3298 is suitable for sowing from timely to very late sown conditions. The potential yield of 79.61 q ha^{-1} (VLS) and 67.58 q ha^{-1} (LS) realized at one of the testing sites 'Sriganganagar' in the state of Rajasthan under agronomy trials, is the highest among all the checks under normal and late sown conditions (Anonymous 2020). Agronomy trial indicates its strong plasticity value as it has appeared first or second rank at several locations under timely, late, and very late sown conditions. Among 30 data sets of location by date of seeding in the agronomy trial, it has appeared 14 times in the statistically significant group against less than 10 times of WH 1021 and WH 1124, 10 times of DBW 173, 13 times of HD 3059, and 15 times of PBW 771, which indicates its superiority across location and time of seeding (Anonymous 2020).

Resistance to multiple diseases

HD 3298 exhibited a high level of resistance against both stripe rust and leaf rust both under natural and artificial epiphytotic conditions. Mean ACI was recorded 0.6 (natural) and 8.1(artificial) for stripe rust and 3.6 (artificial) for leaf rust (Table 3). Against two new highly virulent races of stripe rust i.e. 238S119 and 110S119, it has shown 5 MS and TR responses, respectively at the adult plant stage. HD 3298 is resistant against the prevalent races of stripe rust namely 46S119, 110S84, and 78S84 at the seedling stage and therefore likely to be resistant at all stages (ICAR-IIWBR 2020a). It showed a high level of resistance against Karnal bunt (3.75%). It also exhibited a high level of resistance against powdery mildew (3), foliar head blight (3), and flag smut (1.2%) under artificially inoculated conditions in the VLS production environment.

Table 3: Evaluation of HD 3298 along with checks for multiple diseases

Diseases	HD 3298	DBW 71	DBW 14	WR 544	PBW 757	HD 3271	HI 1621
Rusts	ACI	ACI	ACI	ACI	ACI	ACI	ACI
Stripe rust (natural)	0.6	2.5	5.6	26.0	1.1	2.5	3.6
Stripe rust (artificial)	8.1	8.15	24.15	57.6	10.3	9.1	6.25
Leaf rust (artificial)	3.6	6.7	5.0	11.2	3.0	3.7	9.9
Gene postulation							
Stripe rust	Yr2+	NA	Yr2+	NA	R	NA	NA
Leaf rust	Lr23+	NA	Lr23+	Lr13+1+	R	Lr23+	Lr13
Stem rust	R	R	Sr28+11+2+	Sr28+8a+2+	Sr2+	Sr11+2+	Sr28+
Other diseases (Artificial screening)							
Karnal bunt %	3.7	6.5	4.9	6.4	2.8	5.5	5.6
Flag smut %	1.2	3.3	0.6	2.1	2.9	4.9	2.8
Foliar head blight %	3	4	4	4	3	4	3

Grain and nutritional quality attributes

HD 3298 is superior in Iron content (43.1 ppm-VLS condition) in comparison to all checks (Table 4). Under LS conditions, HD 3298 has 39.3 ppm Fe content which is also higher than the rest of the checks. This variety has also a good level of protein content (12.12%) estimated under VLS conditions over the two years. The quality of protein is also good as indicated by a perfect Glu score of 10. This iron and protein-rich, variety is therefore very important for the nutritional food security of India. We believe that this variety will become popular among the farmers because of its higher yield under normal to very late sown and terminal heat stress conditions. Once this variety reaches into Public Distribution System in the coming years, it will certainly help in eliminating the problem of iron deficiency to some extent. This variety also has a good chapatti score (7.78). The other quality parameters of the variety are acceptable as per the prescribed standards (ICAR-IIWBR 2020b).

Table 4: nutritional quality traits of HD 3298

Parameters	Year of testing	HD 3298	Checks			Recently released varieties		
			DBW 71	DBW 14	WR 544	PBW 757	HD 3271	HI 1621
Fe (ppm)	2017-18	42.7	40.5	43.1	42.8	39.1	36.1	36.2
	2018-19	43.4	39.5	36.6	43.3	39.3	36.6	36.8
Mean		**43.1**	40.0	39.9	43.1	39.2	36.4	36.5
Zn (ppm)	2017-18	40.0	39.5	40.3	43.7	38.2	34.7	35.4
	2018-19	39.2	38.5	40.0	46.2	42.2	37.6	38.2
Mean		39.6	39.0	40.2	45.0	40.2	36.2	36.8

Heat stress tolerance studies

In NWPZ, the timely and late sown crop often suffers terminal heat stress during the growth period leading to yield loss. To identify the terminal heat-tolerant genotypes a Multi-location Heat Tolerance trial (MLHT) trial is conducted. This trial was conducted over a total of 15 localtons comprised of 4 locations each in NWPZ, NEPZ, and CZ respectively and 3 in PZ to identify the temperature stress-tolerant lines among AVT genotypes (ICAR-IIWBR 2020c). Heat Sensitivity Index (HSI) is calculated using the formula HSI=(1-YD/Yi)/(1-XD/Xi) Where YD and Yi are the grain yield for each genotype under heat stress and control conditions respectively. XD and Xi are the means of all study genotypes grain yield under heat stress and control conditions respectively. HD 3298 showed a Heat Sensitivity Index of 1 in NWPZ indicating its tolerance to heat stress (ICAR-IIWBR 2020c).

Notification and seed production

Wheat variety HD 3298 was released and notified by the central sub-committee on crop standards, notification and release of varieties *vide* notification in the official gazette number S.O. 500 (E), dated 29th of January, 2021. The ICAR–Indian Agricultural Research Institute, New Delhi is the maintainer of this cultivar and the producer of the nucleus and breeder seeds.

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