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Director's Message

Despite the pandemic outbreak, Indian wheat production in 2020-21 has reached 109.52 million tonnes, a record output for the sixth time in a row and consecutively crossing 100 million tonnes in the recent three years. The area under wheat also touched an all-time record of 31.62 million hectares with an average productivity estimated at 3464 kg/ha. In the case of barley, the production was 16.73 lakh tonnes during 2020-21 from 5.6 lakh hectares with 2805 kg/ha productivity at the national level. The gargantuan output with sustaining productivity shows the resilience of the Indian wheat and barley programme amidst the adverse effects and challenges posed by climate change. Among alternatives, new technological innovations and interventions like development and deployment of resistant and tolerant varieties, wide adoption of resource conservation technologies and scientific package of practices coupled with intensive extension efforts at the grassroot level to reach the farmers' field across India shall be attributed to the success

The year, 2020-21, is another successful year to the wheat producers, not only in terms of crop output but also with immense support from the government attaining an all-time record procurement (43.34 million tonnes) at the guaranteed minimum support price. A chunk of procurement was done from Punjab (13.22 million tonnes), followed by Madhya Pradesh (12.82 million tonnes) and Haryana (8.49 million tonnes).

ICAR-IIWBR, as an organization that prides itself on technological innovations and interventions, looks forward to serve the farming community and commodity stakeholders in a much better way. At the institute level, taking into account of the recommendations of various expert committees, research thrust is given on the development of climate resilient varieties and climate smart technologies to cater the demand of the farmers and to sustain the high-level production in order to reach 140 million tonnes by 2050. I am sure, our research endeavours in wheat and barley will lead to enhanced productivity and profitability, safeguarding the stakeholders' interest, especially the farmers.

During the reporting period, ICAR-IIWBR has celebrated its foundation day on February 09, 2021. In the current issue of the Newsletter on Wheat and Barley, latest research happenings, followed by accomplishments of fellow researchers in research and development, celebrations and major events at the institute level have been highlighted. The spirit of preparedness and togetherness of farmers, research fraternity and other stakeholders along the commodity value chain in ensuring food and nutrition security is well appreciated and expected to continue in the future as well.

Jai Kisan! Jai Vigyan!

(GP Singh)

RESEARCH NOTES

Release of new wheat varieties for different zones

Arun Gupta, Charan Singh, Gyanendra Singh and Gyanendra Pratap Singh

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During the year 2021, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops in its 85[th] meetings recommended the release and notification of nine wheat varieties (DBW 303, WH 1270, HD 3298, HD 3293, CG 1029, HI 1633, HI 1634, NIDW 1149(d) and DDW 48 (d)) vide notification number 500(E) dated 29.01.2021, respectively (Table 1). The Sub-Committee also recommended the extension of area of cultivation of DBW 187 to early sown, high fertility, irrigated condition of NWPZ.

Table 1. Wheat varieties released by CVRC during 2021.

S.N.	Variety Name and Parentage	Developed by	Prod. condition	Grain yield (q/ha) Pot.	Av.	Special features
Zone: NWPZ						
1	DBW 303 (Karan Vaishnavi)	ICAR-IIWBR, Karnal	IR, ES, High fertility	97.4	81.2	High grain protein content (12.1%), good Chapatti quality
2	WH 1270	CCS HAU, Hisar	IR, ES, High	91.5	75.8	Resistance to yellow and brown rusts
3	DBW 187 (Area Extension)	ICAR-IIWBR, Karnal	IR, ES, High fertility	96.6	75.5	High yield under early sown and high fertility
4	HD3298	ICAR-IARI, N. Delhi	VLS, IR	47.4	39.0	Grain protein (12.12 %); Good amount of Iron content(Fe=43.1ppm)
Zone: NEPZ						
5	HD 3293	ICAR-IARI, N. Delhi	TS, RIR	60.9	39.3	Resistance to wheat blast; better adaptability against moisture and heat stress
Zone: CZ						
6	CG 1029 (Kanishka)	IGKV RS, Bilaspur	LS, IR	94.9	52.1	Good Chapatti quality; tolerance to heat stress
7	HI 1634 (Pusa Ahilya)	ICAR-IARI Regional Station, Indore	LS, IR	95.7	51.6	Good Chapatti quality, highly resistance to brown and black rusts Zone: PZ
8	HI 1633 (Pusa Vani)	ICAR-IARI Regional Station, Indore	LS, IR	65.8	41.7	Nutritionally rich variety Grain protein (12.4 %), Iron =41.66ppm and Zinc =41.1ppm
9	NIDW 1149 (D)	MPKV-ARS, Niphad	TS, RIR	36.8	29.7	Attractive grains and resistance to brown rust and yellow rust
10	DDW 48 (D)	ICAR-IIWBR, Karnal	TS, IR	72.0	47.4	High grain protein (12.1 %), high yellow pigment content (5.6 ppm), high pasta acceptability

Note: pot. = potential; Av. = Average; D = Durum

Pydiflumetofen 15.0% w/v + Propiconazole 12.5% w/v SE: A new foliar fungicide for the management of yellow rust and head scab of wheat

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Yellow rust (*Puccinia striiformis* f. sp. *tritici*) and head scab (*Fusarium graminareum*) are important disease in wheat causing significant yield reductions, if not effectively managed. Moreover, resistance cultivars are not sufficiently advanced to cope with these diseases. Under this scenario, foliar fungicidal applications have become an important component of wheat disease management, but information on the effects of fungicide applications on yellow rust and head scab control in wheat is scarce. Therefore, to identify effective fungicide a new molecule combination [i.e. (Pydiflumetofen 15.0%w/v + Propiconazole 12.5% w/v SE (275 SE)] was evaluated for two consecutive *rabi* cropping seasons (2019-20 and 2020-21) under field conditions for the management of both the diseases. The results of both the cropping seasons (Table 2) revealed that minimum disease severity and maximum per cent disease control over untreated check in case of both head scab and yellow rust of wheat were recorded on foliar application of Pydiflumetofen 15.0% w/v + Propiconazole 12.5% w/v SE (275SE) @ 1.4 % immediately after the initiation of disease in the field. However, this treatment was found equally good with other dosages of it and standard fungicides (Propiconazole @0.1%), but superior over untreated control check. There was no adverse or phytotoxic effect of foliar application of Pydiflumetofen 15.0% w/v + Propiconazole 12.5%w/v SE (275SE) on wheat plants.

Table 2. Wheat protection offered by Pydiflumetofen 15.0% w/v+ Propiconazole 12.5% w/v SE against yellow rust and head scab of wheat under field conditions during two consecutive rabi cropping seasons (2019-20 and 2020-21).

Treatment(s)	Dosage(%)	Mean disease severity (%)		Disease reduction over control (%)	
		Yellow rust	Head scab	Yellow rust	Head scab
Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE)	1	6.83	11.38	88.61	86.32
Pydiflumetofen 15.0% + Propiconazole 12.5% (275SE)	1.2	3.67	7.88	93.89	90.53
Pydiflumetofen 15.0%+ Propiconazole 12.5% (275SE)	1.4	2.50	2.63	95.83	96.84
Pydiflumetofen 20% SC	1.1	8.00	13.13	86.67	84.21
Propiconazole 25 % EC	1	4.00	6.13	93.33	92.63
Tebuconazole 50 + Trifloxystrobin 25WG	0.6	5.17	4.38	91.39	94.74
Pyraclostrobin 133G/L + Epoxiconazole 50G/L SE	1.5	6.17	9.63	89.72	88.42
Control (Untreated Check)	-	60.00	83.13	-	-

Role of defence-related enzymes and phenolics in resistance of wheat genotypes towards corn leaf aphid, *Rhopalosiphum maidis* (Fitch)

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In India, wheat crop is attacked by an aphid complex which comprises of mainly four species *viz., Rhopalosiphum maidis* (Fitch), *Rhopalosiphum padi* (L.), *Sitobion miscanthi* (Takahashi) and *Sitobion avenae* (Fabricius). Among these, Corn Leaf Aphid (*R. maidis*) is the single most serious biotic stress in North Western plains of India. It belongs to the order Hemiptera, sub-order Homoptera and family Aphididae. It is a polyphagous pest and both nymphs and adults cause damage by sucking sap from the leaves, stems and earheads which leads to yellowing, curling and subsequent drying of the leaves. Yield is also affected due to the reduction in number and size of the earheads. Continuous desapping leads to the induction of rapid signals and responses in plants such as oxidative burst, accumulation of secondary metabolites and defensive proteins. Stress factors provoke enhanced production of H_2O_2 in plants. Since, excess H_2O_2 accumulation may leads to oxidative stress and eventual cell death, plants are endowed with H_2O_2-metabolizing enzymes. Response of various defensive enzymes and secondary metabolites in flag leaf samples of 25 bread wheat varieties towards nymphal mortality was investigated (Fig. 1; Table 3.) Overall, DBW 187 showed maximum whereas A-9-30-1 showed minimum production of secondary metabolites and defensive enzymes as presented in the correlogram (Fig. 2)., the nymphal mortality was significantly and positively correlated with total phenolics (TP), total proline content (TPC), tannins, Phenylalanine ammonia lyase (PAL), Polyphenol oxidase (PPO), Glutathione reductase (GR), hydrogen peroxide (HP), catalase (CAT), peroxidase (POX) and ascorbate peroxidase (APX) whereas

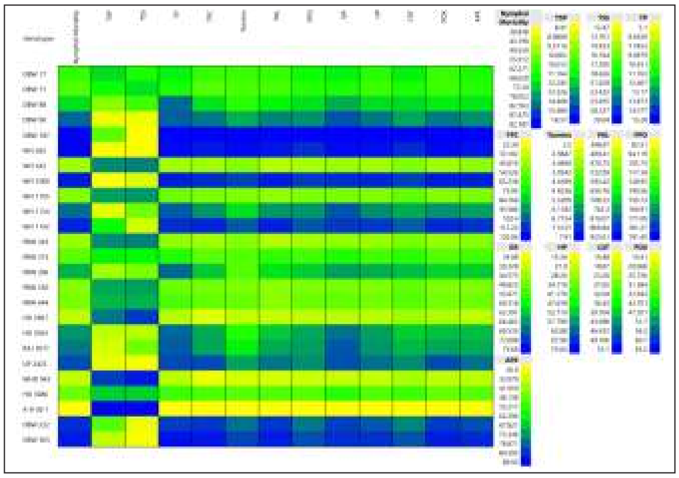

Fig. 1. The Cell Plot demonstrating nymphal mortality in various wheat genotypes in relation with the different biochemical constituents

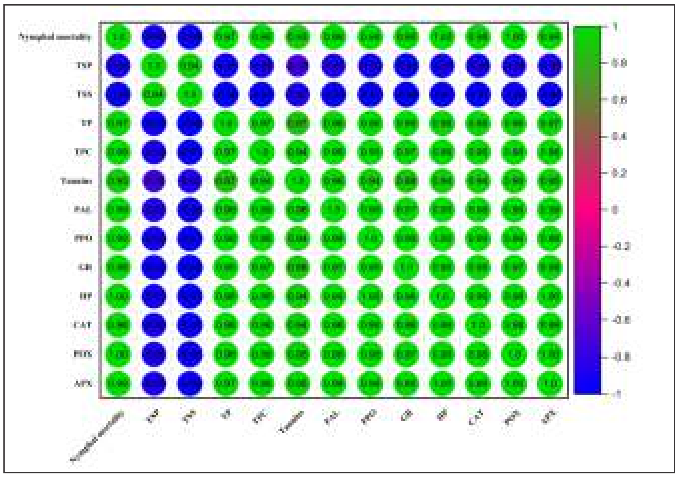

Fig. 2. Correlogram depicting relationship of nymphal mortality with different biochemical constituents

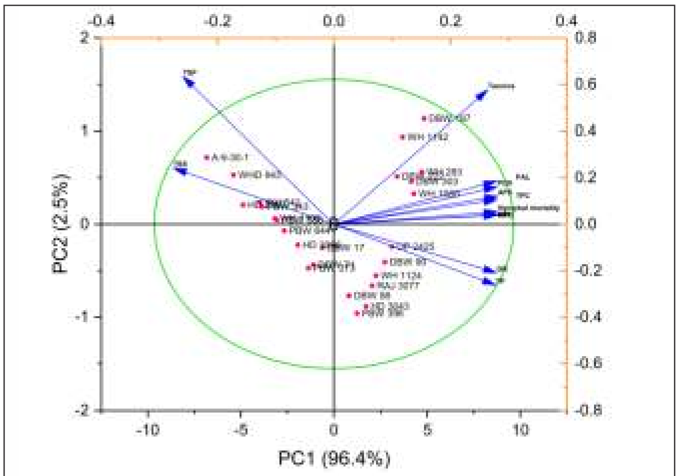

Fig. 3. Projection of per cent nymphal mortality in relation with the biochemical constituents on the first two principal components

Table 3: Principal component analysis for nymphal mortality and different biochemical constituents.

Parameters	Principal component	
	1	2
Eigen value	12.53	0.32
Variance (%)	96.38	2.50
Nymphal mortality	0.281	0.054
TSP	-0.260	0.634
TSS	-0.276	0.241
TP	0.278	-0.262
TPC	0.280	0.105
Tannins	0.264	0.576
PAL	0.279	0.185
PPO	0.281	0.039
GR	0.280	-0.209
HP	0.282	0.042
CAT	0.280	0.042
POX	0.280	0.161
APX	0.281	0.121

negatively correlated with total soluble proteins (TSP) and total soluble sugars (TSS). Two principal components (PCs) were extracted and the extraction communalities for all the variables tested were ≥ 0.5 indicating that the variables were well represented by the extracted PCs which together explained a cumulative variance of 98.88%. PC_1 explained 96.38% while PC_2 explained 2.50% of the total variance (Table 3). PC_1 had the loadings for nymphal mortality, TSS, TP, TPC, PAL, PPO, GR, HP, CAT, POX and APX. TSP and tannins were loaded in PC2 as explained in Table 3 and Fig. 3.

Development and optimization of methodology for screening wheat genotypes exposed to iron (Fe) and zinc (Zn) starvation in hydroponic experiment during seedling stage

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Hydroponic system has emerged as one of the potential system for nutrients starvation studies including iron (Fe) and zinc (Zn) in plants. In the present study, hydroponic system was optimized for growing wheat seeds with an aim to undertake Fe and Zn starvation studies to identify potential pathways and genes associated with efficient uptake and transport of Fe and Zn from root to shoot. Hydroponically grown wheat seedlings can be used for various studies including physiological, biochemical and molecular characterization of diverse set of genotypes under nutrient starvation. Even in off-season, this can serves as valuable system for seedling studies. For optimizing the growth in hydroponic conditions, we selected Narmada 195 (Fe and Zn efficient) and PBW 502 (Fe and Zn in-efficient) wheat genotypes with three treatments (control, T1, and T2). Seeds were treated with 1% NaOCl for 10 min, followed by rinsing with distilled water three times. The sterilized seeds were subjected to cold stratification at 4^0C overnight in the dark to break the dormancy, followed by germination for four days in Petri dishes containing three layers of

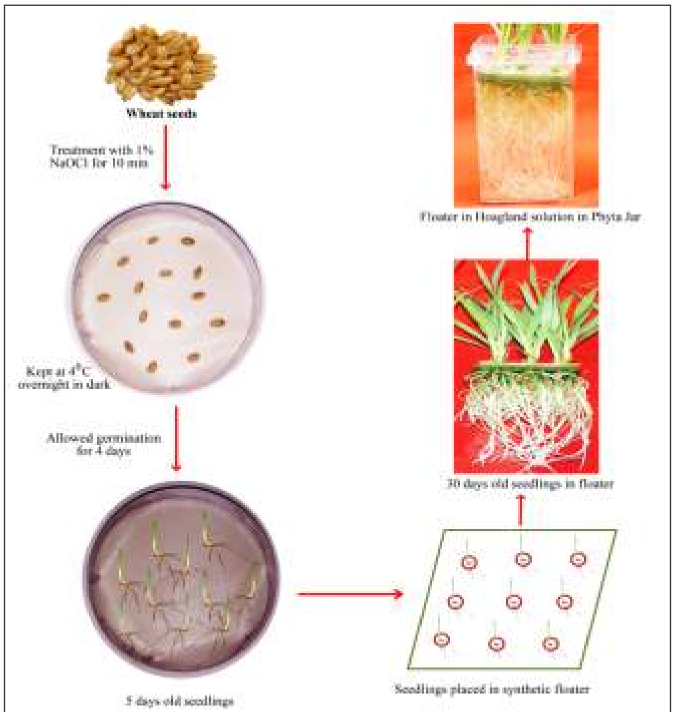

Fig. 4. Optimization of hydroponic experiment

moist and sterile Whatman filter paper. Subsequently, the seedlings were transferred to synthetic floater placed in polycarbonate Phyta Jar (75 x 74 x 138 mm) with 500 ml top size. Each synthetic floater was designed with utmost care to accommodate nine seedlings at an equidistant position (Fig. 4). Three treatments, i.e. control [C: Hoagland solution comprising full strength Fe (100 μM) and Zn (0.77 μM)], treatment 1 [T1: Hoagland solution comprising half-strength Fe (50 μM) and Zn (0.38 μM)] and treatment 2 [full strength for 18 days including four days germination on Petri plates followed by 0 μM Fe and Zn for the next 12 days], were used to see the differential response of Fe and Zn on contrasting wheat genotypes. Hoagland solution was prepared and frequently replaced on every alternate day. Seedlings were grown for 30 days in a growth chamber (E36H0; Percival Scientific Inc. Perry, IA) maintained with a 16 h day / 8 h night cycle at 20±1 °C, 50–70% relative humidity, and a photon rate of 300 μmol quanta $m^{-2}s^{-1}$. Each genotype was represented with three independent experimental replications for each treatment. These seedlings (root and shoot) were independently harvested and snap-frozen in liquid nitrogen and stored at –80 °C for transcriptome, physiological and biochemical analysis. The effect of T3 on Fe & Zn withdrawal was more significant & was clearly visible on plant phenotype.

Iron (Fe) and Zinc (Zn) withdrawal agonies physiological growth, phytosiderophore release, and triggers reactive oxygen species and antioxidant scavenging system in wheat

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Iron (Fe) and zinc (Zn) starved seedlings of Narmada 195 (efficient) and PBW 502 (in-efficient) developed distinct phenotypic responses observed at 30 DAS under T1 [Hoagland solution comprising half-strength Fe (50 μM) and Zn (0.38 μM)] and T2 [full strength for 18 days including four days germination on Petri plates followed by 0 μM Fe and Zn for the next 12 days]. A significant decrease in the total leaf area was observed in both the genotypes under T1 and T2 conditions, but the decline was more prominent in inefficient genotype PBW 502 (51% and 49% for T1 and T2, respectively) compared to efficient genotype Narmada 195 (33% and 35% for T1 and T2, respectively) (Table 4). Compared to control, we observed a significant decrease in the shoot length and enhanced chlorosis in both the genotypes under T1 and T2 conditions, with more prominent symptoms in PBW 502 (Fig. 4; Table 5). The reduction of shoot length was more significant in genotype PBW 502, where a decline of 44% and 51% was observed compared to 38% and 40% in Narmada 195 for T1 and T2, respectively (Table 4). The chlorophyll content decreased significantly in both the genotypes compared to controlled conditions, as is evident by the progressive chlorosis symptoms developed under T1 and T2. Compared to Narmada 195, we observed a steeper reduction of chlorophyll content in PBW 502, i.e. 38% and 81% under T1 and T2 conditions, respectively (Table 4). Compared to the control condition, there was a significant decrease in the number of lateral roots in both genotypes under T1 and T2 conditions (Fig . 5). There was no substantial change in root length as measured in both the genotypes under the T1 condition. Moreover, the root length increased slightly in Narmada 195 and decreased in PBW 502 under the T2 condition compared to the control condition (Table 4).

On the other hand, estimation of Fe and Zn content

Table 4. Morpho-physiological features, and Fe and Zn content (ppm on a dry weight basis) in contrasting wheat cultivars (Narmada 195 and PBW 502).

Treatments	Root Length (cm)	Shoot length (cm)	Chlorophyll conc. (SPAD value)	Leaf Area (cm^2)	Zn (ppm)		Fe (ppm)	
					Root	Shoot	Root	Shoot
Narmada 195								
Control (C)	13.2 ± 1.24^{ab}	25.9 ± 0.21^{e}	40.2 ± 2.41^{f}	9.3 ± 0.58^{c}	29.3 ± 5.24^{c}	19.4 ± 4.83^{c}	228.3 ± 13.26^{e}	192.4 ± 28.70^{e}
T1	14.5 ± 0.91^{abc} (9%)	16 ± 0.20^{c} (38%)	26.4 ± 0.89^{e} (34%)	6.2 ± 0.38^{b} (33%)	23.5 ± 6.86^{abc} (20%)	13.5 ± 2.54^{bc} (30%)	186.2 ± 14.10^{d} (18%)	123.5 ± 6.15^{d} (36%)
T2	14.7 ± 0.36^{bc} (11%)	15.7 ± 0.33^{c} (40%)	15.3 ± 0.53^{b} (62%)	6 ± 0.21^{b} (35%)	22 ± 5.23^{abc} (25%)	12.3 ± 2.63^{ab} (37%)	79.2 ± 10.03^{c} (65%)	58.8 ± 5.76^{b} (69%)
PBW 502								
Control (C)	15.8 ± 0.44^{c}	17.7 ± 1.12^{d}	28.8 ± 0.83^{d}	6 ± 0.07^{b}	25.6 ± 3.72^{bc}	15.4 ± 2.11^{bc}	199 ± 18.12^{d}	168.6 ± 10.57^{e}
T1	16 ± 0.93^{c} (1%)	10 ± 0.22^{b} (44%)	18 ± 1.49^{c} (38%)	3.1 ± 0.12^{a} (51%)	18.2 ± 4.50^{ab} (29%)	10 ± 3.86^{ab} (34%)	132.2 ± 17.57^{b} (34%)	92.6 ± 7.16^{c} (46%)
T2	12.8 ± 1.31^{a} (19%)	8.7 ± 0.45^{a} (51%)	5.5 ± 0.73^{a} (81%)	2.9 ± 0.23^{a} (49%)	14.5 ± 4.68^{a} (43%)	6.1 ± 3.21^{a} (60%)	50 ± 11.56^{a} (76%)	31.1 ± 5.12^{a} (82%)

Note: Different letters indicate significant differences between means ± SD of treatments (n = 3) at $P<0.05$. Figures in brackets depict percentage change from respective control in each genotype.

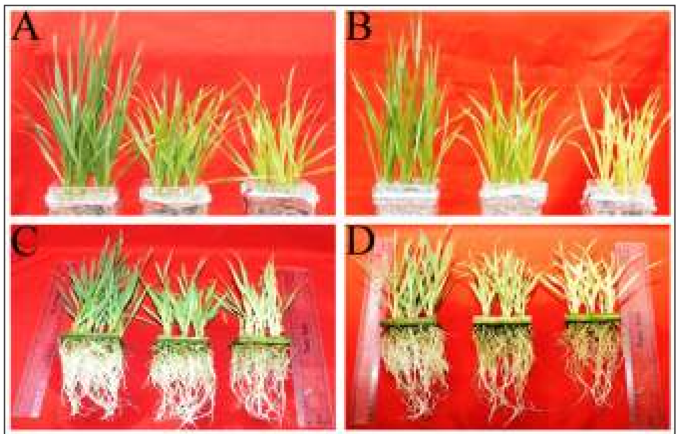

Fig. 5: Picture representing the progression of morphological symptoms depicting chlorosis of leaves in A: Narmada 195; and B: PBW 502; and reduction in the number of lateral roots in C: Narmada 195; and D: PBW 502.

in roots and shoots of both the genotypes suggested a significant decrease under both T1 and T2 conditions (Table 4); however, the decline was more evident in PBW 502 as compared to Narmada 195. The inefficient genotype PBW 502 suffered more reduction in Fe content in both roots and shoots under T1 (34%, 46% respectively) and T2 (76%, 82% respectively) (Table 4). Zn content decreased more in shoot than root, indicating a severe effect on Zn's translocation in shoot under stress. Zn deficiency caused a decline of 34% in T1 and 60% in T2 of PBW 502 compared to controlled conditions (Table 4). Moreover, phytosiderophore (PS) quantification showed that roots of Narmada 195 released more PS than roots of PBW 502 when plants were subjected to nutrient-deficient conditions, i.e. T1 and T2, with a maximum release under T2 condition (Table 5). This kind of favoured PS release in Narmada 195, even under T2 condition, signifies the genotypes dependent responses to efficient Fe and Zn transport and remobilization over other less efficient wheat genotypes.

Reactive oxygen species and enzymes (SOD, CAT and GR) related to the antioxidant system were measured in seedlings to evaluate the effect of Fe and Zn withdrawal on their activity in both the wheat genotypes grown under C, T1 and T2 conditions. The result showed that the activity of SOD decreased significantly in both Narmada 195 and PBW 502 under both T1 (1.19-fold in Narmada 195; 2.17-fold in PBW 502) and T2 (3-fold in Narmada 195; 7.6-fold in PBW

Table 5. Changes in SOD, CAT, GR, H_2O_2, MDA and PS content and antioxidant capacity in Narmada 195 and PBW 502.

Treatments	SOD (units/g FW)	CAT (µmoles/ min/g FW)	GR(mM TNB min/g FW)	H_2O_2 (µmol/ g FW)	MDA(µM/g FW)	DPPH Radical Scavenging activity (%)	PS (nmol of Fe equivalent/g root biomass)
Narmada 195							
Control	23.1±1.92[d]	8.6±0.91[a]	1.8±0.28[ab]	2.4±0.27[a]	4.7±0.77[a]	30.7±1.82[a]	2.7±0.19[a]
T1	19.4±0.97[c] (-1.19)	14.2±1.17[b] (1.65)	4.4±0.88[c] (2.4)	4.7±0.39[b] (1.95)	5.9±0.24[b] (1.25)	51.1±1.42[d] (1.66)	3.6±0.82[b] (1.32)
T2	7.7±2.32[b] (-3)	18.6±0.91[c] (2.61)	4.8±1.06[c] (2.6)	6.4±0.49[c] (2.66)	5.3±0.47[ab] (1.12)	53.6±1.53[d] (1.74)	6±0.22[c] (2.21)
PBW 502							
Control	21.3±0.94[cd]	10.1±1.68[a]	1.2±.036[a]	2.3±0.49[a]	5±0.25[ab]	37.4±1.41[b]	2.1±0.21[a]
T1	9.8±1.05[b] (-2.17)	10.5±2.14[a] (1.03)	2.4±0.35[ab] (2.0)	3.9±0.29[b] (1.69)	7.4±0.56[c] (1.48)	40.3±1.59[b] (1.08)	2.7±0.18[a] (1.32)
T2	2.8±0.36[a] (-7.6)	10.9±0.34[a] (1.07)	2.7±0.59[b] (2.25)	4.1±0.67[b] (1.78)	8.1±0.89[c] (1.62)	44.4±4.34[c] (1.19)	3.6±0.30[b] (1.72)

Note: Different letters indicate significant differences between means ± SD of treatments (n = 3) at $P<0.05$. The figure in brackets depicts fold change from respective control in each genotype. SOD = Superoxide dismutase; CAT=Catalase; GR= Glutathione reductase; H_2O_2 = Hydrogen peroxidase; MDA= Malondialdehyde; PS = Phytosiderophore

502) conditions (Table 5). At the same time, the activity of CAT increased significantly in Narmada 195 under T1 (1.65-fold), and T2 (2.16-fold) compared to PBW 502 genotype where the increase (1.03-fold in T1 and 1.07-fold in T2) was not significant (Table 5). In contrast, GR and total antioxidant activities (DPPH radical scavenging activity) increased in both Narmada 195 and PBW 502 under Fe and Zn deficiency in both treatments, but the increase was more noticeable in Narmada 195 (Table 5). Content of H_2O_2 and MDA increased significantly in both the genotypes, with a more pronounced effect in Narmada 195 (Table 5).

Post-transcriptional (miRNA-based) regulation plays a critical role in regulating core genes of Iron (Fe) and Zinc (Zn) homeostasis in wheat

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Post-transcriptional regulators such as miRNA play a central role in regulating the gene expression associated with various biotic, abiotic and nutrient homeostasis in plants. During the last decade, several reports have witnessed miRNAs' involvement in maintaining the cellular Fe and Zn homeostasis in various plants. However, reports on Fe and Zn deficiency's combined effect on miRNA cross-talk, especially in wheat, is limited. To decode miRNAs' involvement across the tissue and treatment conditions in efficient and inefficient wheat genotypes, a study was performed to identy the miRNAs targeting core genes of the Met cycle, PS biosynthesis, transporters, and antioxidant pathway. Results revealed 26 miRNAs targeting 14 core genes across all four pathways, while 11 genes did not show any corresponding miRNAs (Table 6). Interestingly, the highest number of miRNAs was represented by methylthioribose-1-phosphate isomerase gene, followed by s-adenosylMet decarboxylase, natural resistance-associated macrophage protein and catalase, each targeted by three miRNAs (Table 6). These miRNAs might play a critical role in regulating the transcript abundance of

Table 6. Identification of the corresponding miRNA of genes associated with methionine cycle, PS biosynthesis, transport system and antioxidant pathway.

S. No.	IWGSC gene Id	Gene name	miRNA	miRNA binding site
Methionine cycle				
1	TraesCS4B02G014700	Methionine synthase	tae-miR1847-5p	60-80
2	TraesCS2D02G493500	S-adenosylhomocysteine hydrolase	tae-miR530tae-miR96 77b2116-2136	702-722
3	TraesCS6D02G202500	S-adenosylmethionine	tae-miR9666a-3p tae-miR9666b-3p tae-miR531	3033-3054 3033-3054 1661-1681
4	TraesCS7D02G029100	5'-methylthioadenosine	tae-miR9652-5p	233-254
5	TraesCS4D02G104900	Methylthioribose	tae-miR5384-3p tae-miR9675-3p tae-miR9677b tae-miR9773	168-188 1165-1185 1671-1691 1338-1361
PS biosynthesis				
6	TraesCS1B02G300600	NAAT	tae-miR2275-3p	1318-1339
7	TraesCS7A02G159200	2'-deoxymugineic-acid 2'-dioxygenase	tae-miR9664-3p	1159-1179
Transporters				
8	TraesCS6D02G406400	Solute carrier family 30 (zinc transporter)	tae-miR164 tae-miR5384-3p	106-126 364-384
9	TraesCS4D02G299400	Natural resistance-associated macrophage protein 2	tae-miR9657b-5p tae-miR167b tae-miR5384-3p	645-665 1059-1079 634-656
10	TraesCS4B02G190300	Solute carrier family 25 (mitochondrial iron transporter)	tae-miR9773	109-132
11	TraesCS7D02G413000	Vacuolar iron transporter family protein	tae-miR9676-5p tae-miR1136	955-976 159-182
12	TraesCS1D02G295000	Iron transport multicopper oxidase	tae-miR9658-3p	98-118
Antioxidant pathway				
13	TraesCS6B02G056800	Catalase	tae-miR1137a tae-miR408 tae-miR9666a-3p	1620-1639 1403-1423 1150-1171
14	TraesCS6A02G383800	Glutathione reductase	tae-miR9658-3p	551-571

the cellular Fe and Zn homeostasis pathway, which could be decisive in controlling the level of grain Fe and Zn in wheat. Further work on Spatio-temporal expression profiling of miRNAs and their corresponding target genes and their functional validation in response to Fe and Zn withdrawal needs to be performed either in wheat or any model plants. This will help to develop the miRNA-based gene regulatory network to better understand the molecular mechanisms of Fe and Zn homeostasis at the level of post-transcription.

DBW308: A new wheat blast and rust resistant genotype

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Wheat blast (WB) disease reported first time from

Brazil in 1985 has recently emerged in Bangladesh in the year 2016, thereby putting a threat to wheat production in the entire South Asia. A very high propensity of WB becoming pandemic to a particular geographical localization takes the threat to the next level. Therefore, it is imperative to develop resistant varieties/genetic stocks in collaboration with national and international partners. Also, wheat rusts are widely distributed across all the major wheat-growing regions in the world. Regular shifts in virulences pose a major challenge to achieving durable rust resistance. Wheat breeder's strategy has been to utilize germplasm sources that are as diverse as possible for rust resistance.

DBW308 has been developed from cross between HD3108/HD2967 through pedigree method of breeding. Its multilocation testing for yield traits was done at 20 locations in the National Initial Varietal Trial 1A (NIVT-1A) under all India Coordinated Wheat Improvement trials (2019-20). The proposed genotype was found highly resistant (score 0, 0) against wheat blast during at International WB screening facility of CIMMYT when screened in two different dates of sowing, at three locations i.e., Jassore (Bangladesh), Okinawa and Quirusillas (Bolivia) during 2019-20 and at two locations i.e. Jassore and Quirassallis at two different dates of sowing during 2020-21 (Table 7).

Besides, screening for various wheat diseases Plant Pathological Screening Nursery (PPSN 2019-20) at 22 locations *viz.,* Bajaura, Malan, Dhaulakuan, Gurdaspur, Ludhiana, Jammu, Hisar, Karnal, Durgapura, Delhi, Pantnagar, Faizabad, Kanpur, Indore, Powarkheda, Vijapur, Junagadh, Pune, Niphad, Mahabalseshwar, Dharwad and Wellington. Based on multilocation testing DBW308 was found to be resistant to all the three rusts of wheat as indicated by low ACI score; leaf (brown) rust 2.1 south, 2.6 north, stem (black) rust 2.6, and stripe (yellow) rust 10.2, following disease score 0-100 scale. Plants of DBW308 are medium tall with average height of 101 cm and have maturity duration of 154 days in NWPZ. Grains are hard textured with amber colour and have 1000 gain weight of 43g. Overall, DBW308 has multiple disease resistance in good agronomic background.

DTW119: A potential donor for heat and drought stress tolerance in wheat

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High temperature is a constraint to the sustainable production of wheat, negatively affecting the crop growth and development, which ultimately leads to a reduction in yield and productivity. The wheat belt along the Indo-Gangetic Plains (IGP) in India is an emergent hotspot of climate change-driven crop loss. Therefore, identification and development of heat tolerant wheat germplasm lines is of prime importance in recent years. In this direction, the genotype DTW119 (RIL119) was developed from the cross Dharwar Dry/DPW621-50 at ICAR-Indian Institute of Wheat & Barley Research (ICAR-IIWBR), Karnal under Incentivizing project. The parental line DPW621-50 is high yielding genotype released for

Table 7. Data testing under PPSN (22 locations) and International WB screening facility of CIMMYT (three locations two years).

Genotype	Average coefficient of infection (ACI) of rust				Av. WB score	
	Stem	Leaf (South)	Leaf (North)	Stripe	2019-20	2020-21
DBW308	2.6	2.1	2.6	10.2	0	0
Susc. Check	77.5	77.5	70.0	72.5	100	100

timely sown irrigated conditions of the NWPZ whereas Dharwar Dry is a landrace with well-established abiotic stress tolerant Indian genotype The parental adaptability to endure in the stress condition has been combined in wheat genotype DTW119. The promising genotype DTW119 was screened under 33rd Drought and Heat Tolerance Screening nursery (DHTSN) of AICRP programme, under late sown and rainfed condition during 2020-21 crop season. The nursery was conducted across nine locations (Dharwad, Prabhani, Indore, Durgapura, CSSRI (Karnal), IIWBR (Karnal), Ludhiana, Pusa and Sabour). The nursery comprised of 49 genotypes including 8 checks (C306, DBW110, DBW150, DDW47 (d), MP3288, K3717, NI5439 and WH730). The nursery was sown in lattice design under drought (DR), irrigated (IR) and late sown (LS) conditions. Phenotypic data such as, days to heading, days to maturity, plant height, grain yield, grain number per spike and thousand grain weight (TGW) were also recorded. Based on the pooled data, it was found that DTW119 showed lesser percent yield reduction (15.2%) as compared to all the checks under late sown condition. DTW119 (0.79) was also found superior with lowest Heat Susceptibilty Index (HSI) in pooled analysis across centres as compared to check varieties viz., C 306 (1.62), DBW 150 (1.18), DDW49(d) (1.24), MP3288 (1.35), NI5439(1.34), WH730 (1.35) (Table 8). DTW119 is an early flowering genotype with a plant height of 82cm having 46 grains per spike. Since DTW119 was found heat stress tolerant across the zones of the country, this shows its wider adaptability as well.

The promising entry along with six checks was also evaluated in Extramural Project for heat stress during crop season 2019-20 at ICAR-IIWBR (Karnal) and at three locations viz., ICAR-IIWBR (Karnal), ICAR-NBPGR (New Delhi), ICAR-IARI (New Delhi) in year 2020-21 under three conditions (timely irrigated-TSIR; timely rainfed-TSRF; and late irrigated-LSIR) (Table 9). Data was recorded for phenological traits and grain yield components under all the three conditions of sowing. Based on the pooled data across locations and years, genotype DTW119 showed lowest HSI (0.42) and DSI (-0.25) as compared to all the checks used (Table 10). The identified donor can be used as potential donor for heat stress in wheat with adaptability to water stress condition also.

Table 8. Pooled analysis of HSI and agro-morphological traits of DHTSN genotypes during crop season 2020-21.

Trait/component	Test genotype	Checks					
	DTW119	WH730	DBW150	NI5439	MP3288	C306	DDW47(d)
Days to heading	68	68	69	71	74	75	76
Days to maturity	112	111	111	113	115	117	115
Thousand grain weight (g)	39	37	37	37	40	39	38
Plant height (cm)	82	85	92	100	88	111	85
Grain number per spike	46	45	49	45	39	44	49
HSI	0.79	1.35	1.18	1.34	1.38	1.62	1.11
% Yield reduction	15.2	25.9	22.7	25.7	25.9	31.1	21.4

Source: Progress Report 2020-21 Crop Improvement, AICRP on Wheat & Barley

Table 9. Pooled analysis of agro-morphological traits of genotypes at IIWBR, Karnal.

Condition		Test genotype	Checks					
	Trait	DTW119	AKAW3717	WH 730	DBW 150	DHTW 60	AKW2862-1	HTW11
TSIR	SPKL	17.5	9	13.8	10.1	10.5	9.2	10.5
	SPKLT	22	20	20	18	15	17	20
	GN/S	67	33	47	45	46	54	67
	GW/S	2.71	1.24	2.26	2.16	1.9	2.8	2.85
TSRF	SPKL	12.4	7.8	11.7	8.8	8	9.7	10.3
	SPKLT	21	18	20	20	16	18	18
	GN/S	59	40	82	42	47	31	49
	GW/S	2.23	1.59	3.52	1.73	1.9	1.53	2.36
LSIR	SPKL	12.2	9	11	10.2	10.2	11	10
	SPKLT	22	17	19	18	16	18	20
	GN/S	67	48	51	52	34	41	64
	GW/S	2.43	1.716	2.136	2.516	1.408	1.928	2.53

SPKL-spike length; SPKLT-spikelet number; GN/S-grain number per spike; GW/S-grain weight per spike; TSIR-timely sown irrigated; TSRF-timely sown rainfed; LSIR-late sown irrigated

Table 10. Pooled analysis of Heat and Drought Susceptibility Index of genotypes.

Genotype	2019-20	2020-21				2019-20	2020-21		
	KNL	KNL	NBPGR	IARI	Pooled	KNL	KNL	NBPGR	Pooled
	HSI					DSI			
DTW-119	1.72	-1.26	0.76	0.47	0.42	0.82	0.57	-2.14	-0.25
AKAW3717 (c)	5.25	1.91	-0.09	1.27	2.09	-1.47	0.69	0.41	-0.12
WH 730 (c)	2.22	1.31	0.57	1.29	1.35	-1.83	0.87	-0.23	-0.40
DBW 150 (c)	5.19	0.21	-2.27	1.31	1.11	3.43	0.51	-0.40	1.18
DHTW 60 (c)	0.84	0.36	1.53	1.42	1.04	1.08	1.01	-0.34	0.58
AKW2862-1(c)	3.80	1.22	1.96	1.32	2.08	0.60	1.15	-0.84	0.30
HTW11(c)	2.34	0.83	1.35	1.57	1.52	-0.22	1.16	2.21	1.05

DWRFB 40: A promising six row huskless barley genotype with combination of agro-morphological and quality traits

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In present time, people are facing health problems due to many diseases. Among them, diabetes and *cardiovascular diseases* are important one. Hulless barley (*Hordeum vulgare* L. var. *nudum*) is a potential crop for health benefits because it is a rich source of ß-glucan and a large number of antioxidants. ß-glucan plays a critical role to reduce the glucose and cholesterol levels in human body. It can be used as whole grain or blended with wheat flour in order to make more nutritious and healthy products for daily consumption. Hence, hulless barley is restoring a good status due to its grain has nutritional and medicinal properties. In this direction, a team of barley scientists has got success to identify a potential hulless barley genotype DWRFB-40 having good agro-morphological and quality traits.

DWRFB-40 is a six row hulless barley genotype. It was derived from a cross DL456/EIBON17. Subsequently, it was advanced through pedigree method of plant breeding approach. DWRFB40 was evaluated for agro-morphological traits at ICAR-IIWBR, Seed and Research Farm, Hisar during 2018-19 and 2019-20. DWRFB 40 flowers in 87 days and matures in 125 days. Its average plant

Table 11. Average values of agro-morphological traits of DWRFB40 and checks.

Genotype	Days to 50% heading	Days to maturity	Plant height (cm)	Number of tillers/meter	Spike length (cm)	Number of grains/spike
DWRFB40	87	125	100	92	8.8	65
NDB943	91	124	104	74	8.3	64
Karan16	94	129	102	91	8.4	64

*Average values of two years data (2018-19 and 2019-20).

Table 12. Average quality traits of DWRFB40 and checks during 2020-21 at six locations in NWPZ.

Genotype	ß-glucan (%)	Hectoliter Weight (Kg/hl)	1000-grain Weight (g)	Bold Grain (%)	Thin grain (%)	Protein Content (%)	Starch Content (%)
DWRFB40	6.0	72.9	43.2	76.7	5.9	13.3	63.3
NDB943 (C)	5.6	68.8	31.7	30.8	21.5	14.5	62.4
Karan 16(C)	5.6	68.6	30.3	22.0	35.2	13.4	62.4
PL 891 (C)	6.0	69.5	43.9	39.7	12.9	15.0	61.3

height is 100 cm and has 92 tillers /meter. The average spike length is 8.8 cm with 65 grains per spike (Table 11).

DWRFB-40 was grown at six locations namely, Hisar, Karnal, Ludhiana, Durgapura, Kanpur and Pantnagar during 2020-21 and analyzed for quality traits at Karnal (Table 12). Results revealed that DWRFB-40 had highest bold grain (76.7%) and the lowest thin grain (5.9%). This genotype also showed high values of test weight (72.9%) and starch content (63.3%) over all the check varieties under study. However, 1000-grain weight was found at par to the two row check variety PL891. The genotype has high ß-glucan (6%), which is found to be equal to check variety PL 891. It is concluded from present study that DWRFB-40 has a good combinations of desirable morphological and quality traits. This genotype can be used as potential donor in hybridization programme for hulless barley improvement.

QLD 118: Very high grain zinc along with high grain yield

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Worldwide over 2 billion people suffer from iron (Fe), zinc (Zn) and/or other (multiple) micronutrient deficiencies. In India, 48% of children under the age of 5-10 years have zinc/iron or some other micronutrient deficiency. Zinc is one of the important micronutrient for normal growth and development. QLD 118 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing 43rd IBWSN1137 (MINO/898.97) / 43rd IBWSN1049 (WHEAR/SOKOLL). The genotype was evaluated at 15 different locations across the country

Table 13. Grain iron and zinc concentration of QLD 118 and check varieties at 10 locations during 2020-21.

Zone	Location	Genotype		Check Varieties											
		QLD118		HS490		WB02		DBW187		HD3226		GW322		DDW47	
		Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe
NWPZ	Karnal	33.5	37.3	32.3	35.4	35.1	36.9	31.0	35.7	32.5	35.0	33.6	34.6	35.0	38.3
	Hisar	45.3	46.0	43.13	37.3	44.4	42.8	35.8	40.9	42.1	40.5	40.1	35.1	48.2	38.7
	Delhi	70.3	46.2	57.6	37.5	59.1	39.9	48.7	39.3	53.3	40.0	52.4	37.1	59.9	37.4
	Ludhiana	49.3	35.5	35.8	38.1	37.4	41.6	33.7	44.0	34.4	37.5	35.5	37.0	38.0	41.9
NEPZ	Kanpur	40.5	35.1	37.8	32.4	38.0	34.0	32.3	32.0	40.6	35.2	38.4	31.3	42.0	32.8
	Varanasi	39.3	35.5	33.3	34.0	34.6	38.0	29.2	37.0	33.2	37.9	34.2	34.9	36.9	35.9
CZ	Indore	55.1	43.8	46.1	37.0	51.1	40.2	42.8	41.3	50.7	42.7	47.4	38.0	46.6	39.3
	Vijapur	52.2	42.0	48.0	41.0	56.1	46.5	44.1	43.3	49.6	45.5	49.5	42.4	50.4	39.7
PZ	Pune	57.6	44.6	45.1	40.2	50.0	44.2	42.4	40.6	46.7	40.6	47.8	38.0	47.4	39.3
	Dharwad	39.5	44.1	31.3	37.1	37.6	43.1	29.9	41.7	31.2	39.8	34.9	37.7	33.9	38.3
Mean	**(National)**	**48.3**	**41.0**	**41.0**	**37.0**	**44.3**	**40.7**	**37.0**	**39.6**	**41.3**	**39.5**	**41.4**	**36.6**	**43.8**	**38.1**

Table 14. Agro-morphological, disease, and quality traits of QLD 118 and check varieties during 2020-21.

Trait	Test Genotype	Check Varieties					
	QLD 118	HS490	WB02	DBW187	HD3226	GW322	DDW47
Agro-Morphological Traits							
Grain yield (q/ha)	56.4	45.9	45.8	54.6	56.7	51.4	45.8
Plant Height (cm)	97	101	86	93	98	92	91
Heading (days)	78	79	72	75	80	76	80
Thousand Kernel weight (gm)	41	41	39	44	40	40	39
Disease Reaction (IPPSN)							
Stripe Rust (ACI)	10.8	6.4	-	3.2	-	36	3.8
Leaf Rust-North (ACI)	6.0	3.6	-	5.9	-	8.6	3.4
Leaf Rust-South(ACI)	12.2	4.1	-	9.5	-	7.3	7.7
Quality Traits							
Grain Protein Content (%)	12.5	11.5	13.9	12.1	12.9	10.9	12.1
Sedimentation Value (ml)	59.0	39.7	60.7	57.3	59.6	38.6	32.5
Hectolitre Weight (Kg/hl)	78.4	74.7	77.3	78.6	78.3	76.8	78.1

for different agro-morphological traits in Quality Component and Wheat Bio-fortification Nursery (QCWBN) and the results are presented in Table 13. However, the hand threshed grains of 10 centres in QCWBN comprising all the major wheat growing zones of the country has been analysed for grain iron and zinc concentration. QLD 118 was found to be superior for grain zinc concentration (48.3 ppm) over the locations to all the check varieties (Table 13). High grain zinc has been incorporated in to the high yielding genetic background through conventional breeding. The QCWBN nursery was also tested for rust reaction in Initial Plant Pathological Nursery (IPPSN) 2020-21 and the results are presented in Table 14. QLD 118 was also resistant to both stripe and leaf rust. Thus, QLD 118 would be a potential source to be utilized in future breeding programs to develop high yielding, disease resistant bread wheat varieties with enhanced grain zinc concentration.

QLD 120 – Promising soft grain wheat genotype with high nutritional value

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Grain hardness is an important trait in wheat quality with a profound effect on milling, baking and end-use qualities of wheat. It is common to differentiate soft and hard wheat in the world trade for product specific utility. Soft wheat is more friable, requires less energy to mill, and produces flours and meals with finer particles and lower starch damage, which are suitable for cake and biscuit production. Soft grain textured wheat produces tender and larger biscuits. QLD 120 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing PBW343 / VL738 // PBW611 /3/ 39th IBWSN1108 (SUNSU/CHIBIA) / DBW17. The genotype was evaluated at 15 different locations across the country for different agro-morphological traits in Quality Component and Wheat Bio-fortification Nursery (QCWBN) and the results are presented in Table 15. However, due to high heritability of grain hardness index, only 06 centres comprising all the major wheat growing zones of the country has been analyzed for grain hardness index. QLD 120 was found to be superior with 29 grain hardness index over the locations to all the check varieties including soft grain check variety HS 490 (Table 15). QLD 120 recorded the soft textured grain hardness index in all the tested centres. QLD 120 recorded lowest grain hardness index of 44, 19, 24, 30, 29, and 28 at Karnal, Delhi, Kanpur, Indore, Vijapur, and Pune centres respectively, whereas, the soft grain check variety HS 490 reported 37, 29, 23, 39, 40, and 37 at above listed centres respectively. The QCWBN was also tested for rust reaction in Initial Plant Pathological Screening Nursery (IPPSN) and the results are presented in Table 16. The genotype was highly resistant to all the three rusts (stripe, leaf and stem). QLD 120 is also having lowest sedimentation value compared to all the checks. Low grain hardness index and sedimentation value are very important factors to obtain high spread factor of biscuit and better biscuit quality. Thus, QLD 120 would be a potential source to be utilized in future breeding programs to develop bread wheat varieties suitable for better biscuit making.

Table 15. Grain hardness index of QLD 120 and check varieties at 6 locations during 2020-21.

Zone	Location	Genotype	Check Varieties					
		QLD 120	HS490 (Soft grain)	WB02	DBW187	HD3226	GW322	DDW47
NWPZ	Karnal	44	37	79	79	85	83	91
	Delhi	19	29	70	79	83	80	85
NEPZ	Kanpur	24	23	80	75	78	70	81
CZ	Indore	30	39	69	75	80	88	88
	Vijapur	29	40	76	78	84	86	90
PZ	Pune	28	37	75	73	76	87	89
Mean	**(National)**	**29**	**35**	**75**	**77**	**81**	**82**	**87**

Table 16. Agro-morphological, disease and quality traits of QLD 120 and check varieties during 2020-21.

Trait	Genotype	Check Varieties					
	QLD 120	HS490 (Soft grain check)	WB02	DBW187	HD3226	GW322	DDW47
Agro-Morphological Traits							
Grain yield (q/ha)	52.1	45.9	45.8	54.6	56.7	51.4	45.8
Plant Height (cm)	90	101	86	93	98	92	91
Heading (days)	78	79	72	75	80	76	80
Thousand Kernel weight (gm)	42	41	39	44	40	40	39
Disease Reaction (IPPSN)							
Stripe Rust (ACI)	6.4	6.4	-	3.2	-	36	3.8
Leaf Rust-North (ACI)	2.6	3.6	-	5.9	-	8.6	3.4
Leaf Rust-South(ACI)	6.0	4.1	-	9.5	-	7.3	7.7
Stem Rust (ACI)	3.6	11.8	-	12	-	8.3	3.5
Quality Traits							
Grain Iron (ppm)	41.2	37.0	40.7	39.6	39.5	36.6	38.1
Grain Zinc (ppm)	47.2	41.0	44.3	37.0	41.3	41.4	43.8
Grain Protein Content (%)	13.1	11.5	13.9	12.1	12.9	10.9	12.1
Sedimentation Value (ml)	42.1	39.7	60.7	57.3	59.6	38.6	32.5
Hectolitre Weight (Kg/hl)	77.6	74.7	77.3	78.6	78.3	76.8	78.1

QLD 121 - Soft grain with low sedimentation value for better biscuit making

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Grain hardness is an important trait in wheat quality with a profound effect on milling, baking and end-use qualities of wheat. It is common to differentiate soft and hard wheat in the world trade for product specific utility. Soft wheat is more friable, requires less energy to mill, and produces flours and meals with finer particles and lower starch damage, which are suitable for cake and biscuit production. Soft grain textured wheat

Table 17. Agro-morphological, disease and quality traits of QLD 121 at 15 locations during 2020-21.

Trait	Genotype	Check Varieties					
	QLD 121	HS490 (Soft Check)	WB02	DBW187	HD3226	GW322	DDW47
Agro-Morphological Traits							
Grain yield (q/ha)	53.3	45.9	45.8	54.6	56.7	51.4	45.8
Plant Height (cm)	93	101	86	93	98	92	91
Heading (days)	81	79	72	75	80	76	80
Thousand Kernel weight (gm)	41	41	39	44	40	40	39
Disease Reaction (IPPSN)							
Stripe Rust (ACI)	11.7	6.4	-	3.2	-	36	3.8
Leaf Rust-North (ACI)	3.5	3.6	-	5.9	-	8.6	3.4
Leaf Rust-South(ACI)	5.2	4.1	-	9.5	-	7.3	7.7
Stem Rust (ACI)	1.8	11.8	-	12	-	8.3	3.5
Quality Traits							
Grain Iron (ppm)	36.8	37.0	40.7	39.6	39.5	36.6	38.1
Grain Zinc (ppm)	42.7	41.0	44.3	37.0	41.3	41.4	43.8
Grain Protein Content (%)	12.4	11.5	13.9	12.1	12.9	10.9	12.1
Sedimentation Value (ml)	38.8	39.7	60.7	57.3	59.6	38.6	32.5
Hectolitre Weight (Kg/hl)	75.7	74.7	77.3	78.6	78.3	76.8	78.1

Table 18. Grain hardness index of QLD121 at 6 locations during 2020-21.

Zone	Location	Genotype	Check Varieties					
		QLD 121	HS490 (Soft Check)	WB02	DBW187	HD3226	GW322	DDW47
NWPZ	Karnal	24	37	79	79	85	83	91
	Delhi	14	29	70	79	83	80	85
NEPZ	Kanpur	17	23	80	75	78	70	81
CZ	Indore	18	39	69	75	80	88	88
	Vijapur	22	40	76	78	84	86	90
PZ	Pune	27	37	75	73	76	87	89
Mean	**(National)**	**21**	**35**	**75**	**77**	**81**	**82**	**87**

produces tender and larger biscuits. QLD 121 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing DPW621-50 / PBW550. The genotype was evaluated at 15 different locations across the country for different agro-morphological traits in Quality Component and Wheat Bio-fortification Nursery (QCWBN) and the results are presented in Table 17. However, due to high heritability of grain hardness index, only 06 centres comprising all the major wheat growing zones of the country has been analysed for grain hardness index. QLD 121 was found to be superior with 21 grain hardness index over the locations to all the tested genotypes and checks including soft grain check variety HS 490 (Table 17). Although, grain hardness of parentage of QLD 121 was hard, transgressive segregants were appeared for soft grain. QLD 121 recorded the lowest grain hardness index in all the tested centres compared to the best check variety (HS 490) for low grain index. QLD 121 recorded lowest grain hardness index of 24, 14, 17, 18, 22, and 27 respectively at Karnal, Delhi, Kanpur, Indore, Vijapur, and Pune centres, whereas, the soft grain check variety HS 490 reported 37, 29, 23, 39, 40, and 37. The QCWBN nursery was also tested for rust reaction in Initial Plant Pathological Nursery (IPPSN) and the results are presented in Table 18. The genotype is resistant to all the three rusts (stripe, leaf and stem). QLD 121 also has the lowest sedimentation value compared to all the checks. Low grain hardness index and sedimentation value are very important factors to obtain high spread factor of biscuit and better biscuit quality. Thus, QLD 121 would be a potential source to be utilized in future breeding programs to develop high yielding, disease resistant bread wheat varieties suitable for better biscuit making.

QLD 122: Very high grain iron and zinc content genotype

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ICAR- Indian Institute of Wheat and Barley Research, Karnal

Worldwide over 2 billion people suffer from iron (Fe), zinc (Zn) and/or other (multiple) micronutrient deficiencies. In India, 48% of children under the age of 5-10 years have zinc/iron or some other micronutrient deficiency. Zinc is one of

Table 19. Grain iron and zinc concentration of QLD 122 at 10 locations during 2020-21.

Zone	Location	Genotype		Check Varieties											
		QLD 122		HS490		WB02		DBW187		HD3226		GW322		DDW47	
		Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn
NWPZ	Karnal	55.5	36.2	35.4	32.3	36.9	35.1	35.7	31.0	35.0	32.5	34.6	33.6	38.3	35.0
	Hisar	41.1	43.6	37.3	43.13	42.8	44.4	40.9	35.8	40.5	42.1	35.1	40.1	38.7	48.2
	Delhi	40.0	63.5	37.5	57.6	39.9	59.1	39.3	48.7	40.0	53.3	37.1	52.4	37.4	59.9
	Ludhiana	39.4	32.9	38.1	35.8	41.6	37.4	44.0	33.7	37.5	34.4	37.0	35.5	41.9	38.0
NEPZ	Kanpur	34.6	40.1	32.4	37.8	34.0	38.0	32.0	32.3	35.2	40.6	31.3	38.4	32.8	42.0
	Varanasi	37.8	34.8	34.0	33.3	38.0	34.6	37.0	29.2	37.9	33.2	34.9	34.2	35.9	36.9
CZ	Indore	47.3	61.1	37.0	46.1	40.2	51.1	41.3	42.8	42.7	50.7	38.0	47.4	39.3	46.6
	Vijapur	47.3	50.1	41.0	48.0	46.5	56.1	43.3	44.1	45.5	49.6	42.4	49.5	39.7	50.4
PZ	Pune	46.6	57.1	40.2	45.1	44.2	50.0	40.6	42.4	40.6	46.7	38.0	47.8	39.3	47.4
	Dharwad	50.4	37.6	37.1	31.3	43.1	37.6	41.7	29.9	39.8	31.2	37.7	34.9	38.3	33.9
Mean	**(National)**	**44.0**	**45.7**	**37.0**	**41.0**	**40.7**	**44.3**	**39.6**	**37.0**	**39.5**	**41.3**	**36.6**	**41.4**	**38.1**	**43.8**

the important micronutrients for normal growth and development. QLD 122 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing 15th HRWSN286 (MILAN/3 /PAT24/ALD//DOVE/BUC) /CIMMYT 165. The genotype was evaluated at 11 centres in Quality Component Screening Nursery (QCSN) comprising all the major wheat growing zones of the country. QLD 122 was found to be superior for grain iron (44 ppm) and zinc (45.7 ppm) over the locations to all the check varieties (Table 19). High grain iron and zinc has been incorporated in to the improved genetic background through conventional breeding. QCWBN nursery has been evaluated at 15 different locations across the country for agro-morphological traits.

QLD 122 is also resistant to all the three rusts (stripe, leaf and stem rust). Thus, QLD 122 could be a potential source to be utilized in future breeding programs to develop high yielding, disease resistant bread wheat varieties with enhanced grain iron and zinc concentration.

Effect of sowing time on wheat yield in different zones of India

S.C. Tripathi, Subhash Chander, R S Chhokar, Anil Khippal, RP Meena, Neeraj Kumar and Gyanendra Pratap Singh

ICAR- Indian Institute of Wheat and Barley Research, Karnal

In recent years, sowing time of wheat is debatable question due to change in climate particularly in North Eastern Plains Zone (NWPZ) North Western Plains Zone (NEPZ) of India. Sowing time is the most important factor which affects the maximum grain yield loss, if not followed properly. Earlier finding is that delaying wheat sowing (normal to late) resulted in decrease in yield by 15.5, 32.0, 27.6, 32.9 and 26.8 Kg^{-1} $ha^{-1}day^{-1}$ under North Hill zone (NHZ), NWPZ, NEPZ, Central Zone (CZ) and Peninsular Zone (PZ), respectively for timely sown varieties. The corresponding yield loss was 7.6, 18.5, 17.7, 17.0 and 15.5 per cent. For late sown varieties, delay in wheat sowing (late to very late) decreased the grain yield by 42.7, 44.8, 51.6 and 44.2 $Kg^{-1}ha^{-1}day^{-1}$ or 22.8, 27.1, 30.9 and 25.6 % under NWPZ, NEPZ, CZ and PZ, respectively. To address this issue, a multilocation trial across the zones were

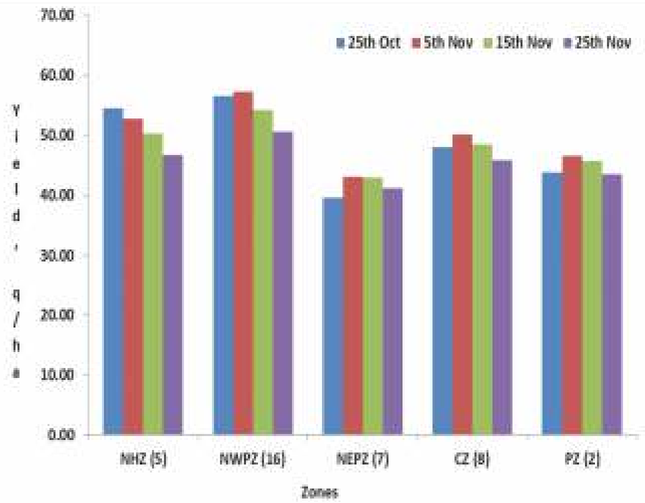

Fig. 6. Effect of sowing time on wheat yield in different zones of India

conducted with sowing time (25th October, 05th November, 15th November and 25th November) in main plots and nutrient management [Recommended Fertilizer Dose (RFD), 150% RFD + FYM15 t ha^{-1} and 150% RFD + FYM15 t ha^{-1} + Growth Regulators] in sub plots with three replications. Two sprays of growth regulators as tank mix-Chlormequat chloride (Lihocin) @ 0.2% + Tebuconazole (Folicur 430 SC) @ 0.1% of commercial product dose at first node and flag leaf stage (tank mix application) were done. The sowing was done using the normalized (adjusted considering 1000 grains weight of 38 g) seed rate of 100 Kg ha^{-1} at a row-to-row spacing of 20 cm. One third nitrogen, full phosphorus and potash as basal dose as per treatments and the remaining 2/3rd nitrogen as 1/3rd at first irrigation and 1/3rd at second irrigation. Recommended rate for NHZ, NWPZ and NEPZ was 150 Kg ha^{-1} and for CZ and PZ was 120 Kg ha^{-1}. Irrigation and weed control measures were followed as per recommended package of practices for the concerned zone. This trial was conducted in 2019-20 and 2020-21 at five locations in NHZ, sixteen in NWPZ, seven in NEPZ, eight in CZ and two in PZ.

Mean of two years data revealed that wheat can be grown with maximum grain yield from 25th October to 5th November in NHZ and NWPZ, 5th to 15th November in NEPZ, CZ and PZ (Fig. 6). Data in parenthesis denotes conduction of trials number in each zone. Therefore, it can be concluded that NHZ and NWPZ is the real area that needs to be popularized for early wheat sowing to get higher grain yield. Early wheat sowing i.e. last week of October in NEPZ, CZ and PZ should be discouraged as there was significantly decline in wheat grain yields. The optimum sowing time for NHZ and NWPZ is, thus, last week of October to first week of November and second week of November for NEPZ, CZ and PZ.

High wheat yield potential technology for North West Plains Zone of India

S.C. Tripathi[1], Subhash Chander[1], R S Chhokar[1], Anil Khippal[1], R P Meena[1], Neeraj Kumar[1], Hari Ram [2], Maninder Kaur[2], Charanjit Kaur[3], Uttam Kumar[4], V P Singh[5], Rajeew Kumar[5], Bhagat Singh[6], Uma Devi[6] and G. P. Singh[1]

[1]ICAR-IIWBR, Karnal, [2]PAU, Ludhiana, [3]PAU RRS, Gurdaspur, [4]BISA Ladowal [5]GBPAU&T, Pantnagar and [6]CCSHAU, Hisar

Generally, there was no yield increase, if we apply more than the recommended dose of inorganic fertilizer. Farmers of Punjab, Haryana and western Uttar Pradesh are applying a higher quantity of nitrogenous fertilizer in quest of getting a higher grain yield. In this practice, wheat crop gets luxurious growth which increases the chances of lodging particularly when there is rain leading to other problems of disease and pest problem, hurdles in combine harvesting and reduction in grain yield. All these lead to an increase in the cost of cultivation. To avoid such problems, farmers sometimes skip last irrigation, which is crucial for better grain filling. Lodging also leads to shrivelling of grains, which reduces thousand-grain weight and ultimately lowers the grain yield. In both types of situations, farmers are left with losses. There is a need to develop an ideal plant type that possesses lodging resistance at a high yield potential of 8.0 t/ha. To include anatomical characters like thicker diameter of basal wheat culm and thicker stem wall, robust root density is an ideal plant type for wheat variety. Generally, agronomist has to develop the production technologies for managing the lodging at higher yield level. To overcome this problem, a multiplication experiment was conducted to maximize the wheat yield with a target yield of 8 t/ha by using the higher level of inorganic and organic fertilizers combined with the spraying of growth retardant to control the lodging. The experiment consisted of two nutrient management treatments viz. recommended doses of fertilizers (RDF, i.e 150:60:40 N:P:K kg/ha) and 150% RDF + 15 t FYM/ha + two sprays as tank mix-Czhlormequat chloride (Lihocin) @ 0.2% + Tebuconazole (Folicur 430 SC) @ 0.1% of commercial product dose at first node and flag leaf stage, in main plots and 16 high yielding wheat genotypes in subplots having three replications. The experiment was conducted at six centres namely Gurdaspur, Hisar, Karnal, Ludhiana, BISA Ladowal and Pantnagar during 2019-20 and four centres namely Gurdaspur, Karnal, Ludhiana, BISA Ladowal in 2020-21. Each year different high yielding wheat varieties and advanced lines were tested to find out the response of fertilizers. The sowing was done using normal seed rate of 100 kg/ha (adjusted considering 1000-grains weight as 38 g) during the last week of October. The sowing was done in early condition so that varieties have enough time for grain filling and to escape the effect of hot wind blowing during the grain-filling period. Irrigation and weed control measures were applied as per recommended package of practices.

Application of 150% RDF along with 15 t/ha FYM and two sprays as tank mix-chlormequat chloride (Lihocin) @ 0.2% + Tebuconazole (Folicur 430 SC) @ 0.1% of commercial product dose at first node and flag leaf stage displayed a tremendous increase in biomass (7.02%), grain yield (10.85%), earhead/m^2 (10.9 %), grain per earhead (5.59 %) but with a slight decrease in thousand-grain weight (5.23%) and plant height (10.01%) with almost nil lodging. This showed that the application of growth retardant provided dual effects of reducing the plant height and enhancing the tillering with additional grains on each earhead. It is noteworthy that the reduction in plant height with more tillering provided additional biomass and grain yield. In this process, a slight reduction in thousand- grains weight was might be due to spraying of growth retardant, which leads to the development of late tillers. Replacing RDF with 150% RDF + 15 t/ha FYM + GR increased biomass (152.22 to 162.87 q/ha), grain yield (60.62 to 67.19 q/ha), earhead/m^2 (380.0 to 421.5), grains/earhead (37.35 to 39.44), while reduced 1000-grain weight (44.29 to 41.98 g) and plant height (98.75 to 88.85 cm) (Fig. 7). Hence, control of lodging in high yield potential varieties is possible with integrated management of fertilizers and the use of growth retardants.

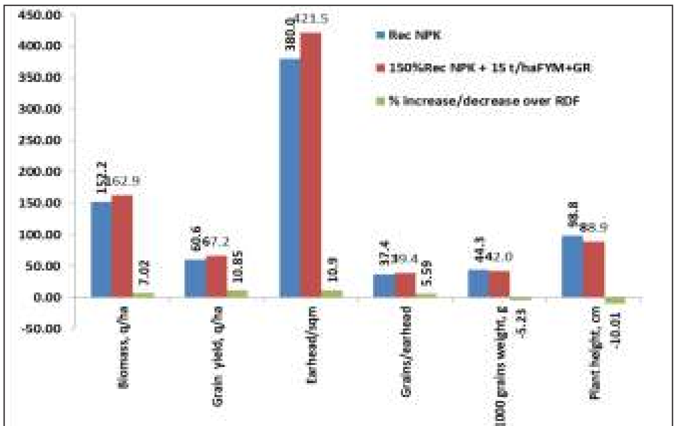

Fig. 7. Grain yield and yield attributes under RDF and 150% RDF+15 t/ha FYM+G

Research impact of DBW187 (*Karan Vandana*) – Economic surplus approach

Sendhil R, Satyavir Singh, Anuj Kumar and Gyanendra Pratap Singh

ICAR-Indian Institute of Wheat and Barley Research, Karnal

Impact of research on societal gain is of continuous interest for researchers, research managers and policy makers. Quantifying the agricultural research impact, especially after technology adoption, has gained a lot of prominence in the context of fund allocation and prioritization. In Indian agriculture, wheat production has attained significant strides attributed to the technological interventions in the form of high yielding varieties post-Green Revolution. In the realm of modern wheat varieties, DBW187 (*Karan Vandana*) notified in 2019 has resulted in significant gains owing to its superiority over other ruling varieties, and transformed the landscape of wheat production. The high yielding potential capacity of the variety (incremental yield ranging from 12.36 % to 25% at the farmers' field) with the ability to produce more tillers, longer grain-filling period, high input responsive nature, better chapati quality coupled with a wider adaptability to different wheat growing agro-ecologies garnered a quick attention and popularity among the farmers. Further, organized seed production at different levels, followed by distribution of seeds under the public-private partnership led to apparent quantum jump in the national wheat production. Several methods are being used to quantify the welfare effects of a technology and 'Economic Surplus Model' is the most widely used method for technology response under demand-supply framework. The data used in the model were sourced from multiple documents for elasticity coefficients; frontline demonstration reports, seed production reports and expert opinion for assessing the variety adoption rate; and agmarket portal for price related information. In terms of acreage, the variety occupied 1.91 million hectares (estimated through tracking the seed distribution along with expert opinion). Our estimates indicate that DBW187 has 9.8% share in national production (10.49 million tonnes) for the year 2020-21. Using the available statistics in the 'Economic Surplus Model' (Fig 8), it has been estimated that DBW187, since its release, has generated a total gain (producer surplus + consumer surplus) of ₹599.15 crores (at constant price using 2011-12 as the base year)

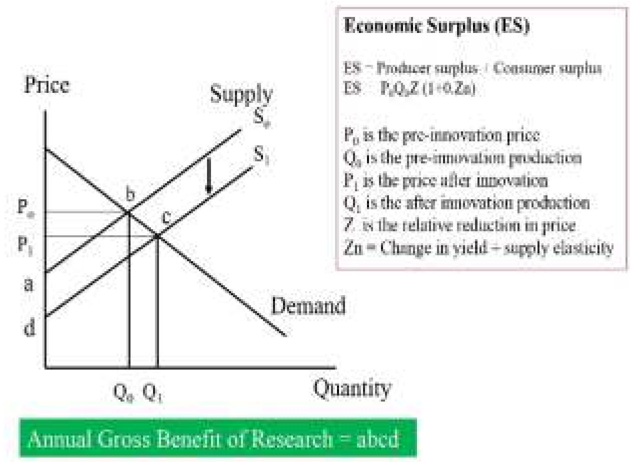

Fig. 8. Economic surplus approach

INSTITUTIONAL ACTIVITIES

VII[th] Foundation Day

Institute celebrated its 7[th] foundation day on February 9, 2021. Padma Shri awardee Shri Kanwal Singh Chauhan, Member, Governing Body(ICAR) and founder Gulab Fruits & Vegetable Growers & Marketing Cooperative Society, Sonipat was the chief

Dr GP Singh, Director, ICAR-IIWBR felicitating the Chief Guest Shri Kanwal Singh Chauhan guest on this occasion. In his address, he emphasized on crop diversification in the agriculture.

Visitor's Week

Due to COVID 19 pandemic, this year visitor's week (22-31 March, 2021) was organized instead of Wheat and Barley Field Day. This gave wider window to participants to visit international trial block planted at ICAR-IIWBR, Karnal and make *in-situ* selections. During this period, 15 scientists from 8 universities/institutes visited the institute and made around 1480 selections. Later on seed of the selected lines were supplied to them.

Scientists visiting in international wheat trial block during visitor's week

Institute Research Council Meeting (2021)

The Institute Research Council Meeting (IRC) was held on 16th June, 2021 & research being carried out under various projects was merged in seven concise programmes as a mid-term correction.

IRC meeting under the Chairmaship of Dr. GP Singh, Director, ICAR-IIWBR

Research Advisory Committee (2021)

Research Advisory Committee (RAC) meeting of the ICAR-IIWBR was held on February 23, 2021 at IIWBR Karnal in a virtual mode under the chairmanship of Dr. HS Dhaliwal, Vice-Chancellor, Eternal University, Baru Sahib, Sirmour. Significant achievements were presented by the respective PIs/station incharge. Based on deliberations and discussion, RAC committee submitted various recommendations to ICAR.

World Water Day

On the occasion of World Water Day, an awareness programme was organized by ICAR-IIWBR on March 22, 2021. Students from various schools participated in the awareness programme. The main objective of the program was to demonstrate water conservation technologies to the students. Dr. SC Tripathi, PI (NRM) highlighted the importance of water in human life. He also told the students how can they save water in their routine life, how can they save water in their neighbourhood, how they can make people more sensitive to water conservation.

International Yoga Day

International Yoga Day 2021 was celebrated under theme **"Yoga for wellness"** on 21.06.2021. Several of its staff members enthusiastically participated and performed yoga at their residence between 6.00am to 8.00am on 21.06.2021 and shared the photographs.

Awards

Institute of the Excellence Award 2020

ICAR-IIWBR received the All India Agricultural Students Association's (AIASA) Institute of the Excellence Award for the year 2020 for outstanding contribution in the research and youth empowerment. The award was presented to Dr. GP Singh, Director ICAR-IIWBR, Karnal during

6th National Youth Convention on "Innovation and Agricultural Reforms towards Farmers' Prosperity" at PJTSAU, Hyderabad on 20 - 21 February, 2021.

VII Rao Bahadur B Viswanath Award

Dr. GP Singh, Director, ICAR-IIWBR received the prestigious VII Rao Bahadur B Viswanath award for the Biennium 2018-19 for his outstanding research contribution in the field of "Wheat Improvement for Abiotic Stress Tolerance and Increasing Profitability of Wheat Farmers".

Prof. K.C. Mehta Memorial Award, 2021

Dr Sudheer Kumar, Principal Scientist, ICAR-IIWBR, Karnal received Prof. K.C. Mehta Memorial Award, 2021 for outstanding contribution in the field of Plant Pathology by Agro Environmental Development Society (AEDS) Majhra Ghat, Rampur Uttar Pradesh.

Young Scientist Award, 2020

Young Scientist Award 2020 by the All India Agricultural Students Association was awarded to Dr Gopalareddy K, Scientist, ICAR-IIWBR, Karnal for his outstanding contribution in the research and development.

Awards awarded by ICAR- IIWBR

- For the year 2020-21, ICAR – IIWBR awarded the best worker award to Dr. Gopalareddy K under scientific category, Shri Anil Kumar (Regional station, Shimla) under administrative category, Shri Ronak Ram under technical category and Shri. Rampal Saini under supporting category. The awards were given to them on the occasion of foundation day (09.02.2021).
- Appreciation certificate from Director, ICAR-IIWBR were given to Dr. Bhumesh Kumar (Principal Scientist), Dr. CN Mishra (Scientist), Shri Jagdish Chander (FAO) and Shri P Chandrababu (ACTO) for their outstanding contribution in the respective fields during 2020.

Chief Guest Shri Kanwal Singh Chauhan presenting the best worker award

Capacity Building

Training / Awareness / progarmme / Travelling seminar organized

- Farmers Awareness cum Training Programme on "Promotion of resistant varieties of wheat and disease monitoring for enhanced productivity" in North Eastern Plains Zone (NEPZ) was organized in virtual mode on 19th-20th January, 2021.
- Interaction meeting with AICRP/BSP Centres of NEPZ and state government was organized on "Promotion & popularization of New Wheat & Barley varieties in NEPZ" during January 20-21, 2021.
- A 3-days e-refresher course on "Creation of epiphytotics for disease and insects pests,

uniform data recording and reporting in wheat and barley crop protection trials" was organized by ICAR-IIWBR, Karnal in collaboration with its Regional Centre, Flowerdale, Shimla, H.P. from 28-30 January 2021. More than 100 participants including scientists, research scholars and technical staff from various AICRP centres attended this course.

Interaction and discussion during 3 days e- refresher course organised at IIWBR

- Virtual training on health and mental well being of ICAR staff for enhancing proficiency was organized at ICAR-IIWBR, Karnal during 25 - 27 February, 2021. Various topics such as yoga for health and well being, nutrition during pandemic, balancing professional efficiency and household responsibilities, mental well being and handling depression and anxiety at workplace were covered during the training program.
- Three days travelling seminar on "Technology Appraisal for Strengthening Public-Private Partnership in Wheat & Barley" was organized at three places in MaurMandi, (Punjab), Pilibanga (Rajasthan) and Sirsa, (Haryana) during 1-3rd March, 2021.
- Training programme on "Capacity building to improve efficiency of AICRP on Wheat and Barley" was organized at ICAR-IIWBR, Karnal in virtual mode from March 3-9 2021.
- Farmers Awareness cum Training Programme on "Promotion of Latest Varieties & Quality Seed Production of wheat" at RPCAU, and BISA, Pusa (Bihar) on 12th March, 2021.
- Farmers Awareness cum Training Programme on "Quality Seed Production & Adoption of latest resistant varieties of wheat" at KVK-2, Gorakhpur (UP) was organized on 21st March, 2021.
- One day Awareness cum training on "Promotion of High Yielding wheat varieties and Strengthening Public-Private Partnership in Wheat & Barley" was organized on 27th March, 2021.

Personnel

New Joining

- Dr. J Kumar, Pr. Scientist joined ICAR-IIWBR Karnal on 22.01.2021 on account of his transfer from ICAR-NIBSM, Raipur.

Transfer

- Dr. Ankita Jha, Scientist transferred from ICAR-IIWBR, Karnal to ICAR-IIWM, Bhubaneswar on 18.01.2021.
- Dr. Karnam Venkatesh, Scientist transferred from ICAR-IIWBR, Karnal to ICAR-IIMR, Hyderbad on 26.02.2021.

Promotions

- Shri Yogesh Sharma promoted from ACTO to CTO (Computer /IT) w.e.f. 24.12.2019.
- Shri Abhay Nagar promoted from ACTO to CTO (Library Documentation) w.e.f. 12.02.2020.
- Shri Ram Pal Saini promoted from SSS to T-1 (Lab. Technician) w.e.f. 23.03.2021.

Obituary

With deep sorrow, we regret to inform the sad demise of Dr. Bhumesh Kumar, Principal Scientist (Plant Physiology) at ICAR-IIWBR, Karnal on 16th April, 2021. He was a dedicated and sincere research worker in the field of Plant Physiology and did exemplary research work in the field of Weed Physiology. His untimely death is a great loss to scientific community. The ICAR-IIWBR offer sincere condolences to his bereaved family.