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Research Article

Enhancing bread wheat production in Central India through Varietal Improvement

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Abstract

Bread wheat (*Triticum aestivum* L.) is a major staple crop and plays a vital role in ensuring food and nutritional security in Central India. However, wheat productivity in the region is constrained by climatic variability, emerging biotic and abiotic stresses, and the limited adoption of improved cultivars. Varietal improvement has emerged as a key strategy for enhancing wheat productivity, stability, and resilience. This study evaluates the contribution of improved bread wheat varieties developed through conventional and modern breeding approaches to wheat production in Central India. Emphasis is placed on the development and dissemination of high-yielding, disease-resistant, and climate-resilient cultivars adapted to diverse agro-ecological conditions. The adoption of improved varieties has significantly increased grain yield, resource-use efficiency, and farmers' income while reducing production risks. The findings highlight the importance of continuous genetic enhancement and targeted varietal deployment in sustaining wheat production and strengthening regional food security under changing climatic conditions.

Key words: Bread wheat, Varietal improvement, Central India, Climate resilience, Grain

Introduction

Wheat production in India was just about 6.46 million tones in 1650-51. In early nineties India was the fourth largest wheat producer in the world with 55.4 million tones from 24.1 million hectares. The total production increased by more than six folds from nearly 12.3 million tones in 1964-1965 to 78.4 million tones in 2007-2008. Presently the productivity is almost is equal to that of global level. Ever-highest wheat production in India which is approximately had occurred with 6.4% increase in production during 2010-11 with a productivity of 2.94 t/ha. It must be reiterated that increase in the wheat production can be made either through expansion in the area under the crop or by bringing increased genetic productivity. There is a considerable scope for raising production through productivity path, our efforts should be further improvement. Accordingly, overall strategy would be to sustain production. It is also imperative to re-orient and infuse new innovations along with varietal improvement programmes of the context of climatic change.

Agro-climatic conditions of Central India

- Soils : Mostly black cotton vertisols
- Rainfall average : 750 to 1000 mm
- Crop rotation : Wheat – soybean
- Average wheat yields : 23 q/ha
- Potential yields: 50 – 60 q/ha
- Thermal humidity regime: Hot and dry
- Vegetative period: Shorter, compared to north
- Reproductive period: Longer, compared to north
- October temperatures:
- Ground: 12 - 44ºC
- 5 cm soildepth: 32 – 38ºC
- 10 cm soil depth: 26 30ºC
- Coolest month: January (mean temperature): 18ºC
- Temperature range : 15 - 22ºC
- VPD : 12 mb
- Solar radiation : 18 MJ/m^2/d

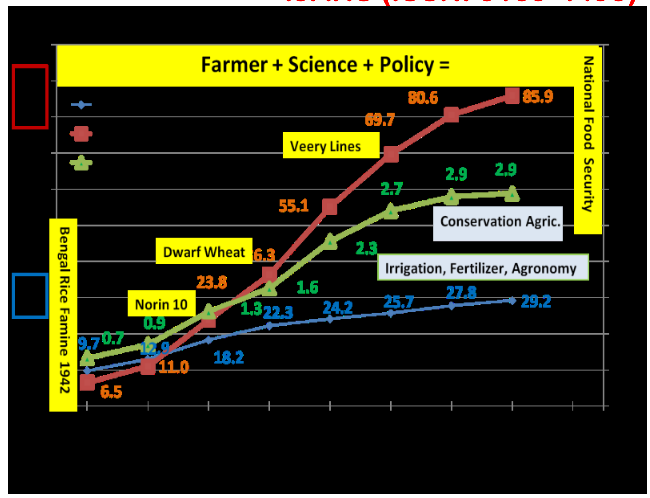
India is expected to produce 109 million tons of wheat production to meet the future demand owing to ever increasing population by the year 2020 with annual rate of increase in production of about 2.2 per cent while present rate of annual increase is about less than 1 per cent. The experimental results have indicated that each degree rise in ambient temperature reduces the yield by 3-4 per cent. In 2004-2005 crop season heat stress was alone one of the major reasons for the considerable quantity loss of good amount of wheat. Hence breeding for heat tolerance is a major concern in this stress environment. Among biotic stresses, the rust diseases pose major threat to wheat production in India. The criterion to choose cultivars for a particular zone is mainly based upon the potential of these genotypes to restrict epidemics occurring due to respective races / pathotypes of rust pathogens prevalent. At this juncture none of the genes or their compatible combinations in use is capable of providing complete protection from stripe and leaf rusts. Therefore, it becomes imperative to make use of other unexploited genes especially those derived from alien sources as well as those related to adult plant resistance to keep the rust epidemics under check.

Organizational Structure

The IARI RS Indore centre is involved in the development and testing of varieties across the zones. In addition, some other assignments are also being carried through the assistance of CIMMYT and DBT, Govt of India. The materials are tested first under Small Scale Trial (SSTs), Common Varietal Trials (CVTs), National Initial Varietal Trials (NIVTs) system in the zones. After one-year evaluation under NIVTs, deserving genotypes are/were tested under AVTs for two consecutive years before identification of superior genotypes and their subsequent release under different growing conditions.

Infrastructure

IARI RS Indore has excellent infrastructure facility for conducting research in the different areas of bread wheat research. Recently facilities have been created for conducting studies in the area of abiotic stresses such as drought and heat stress. State of the art facility has been created for wheat quality research. The multidisciplinary and multilocation coordinated approach has so far been successful in providing rich dividends through development of high yielding disease resistant varieties and matching production technology, which has completely revolutionized wheat production in the country. This achievement in India's wheat production had been perhaps the most important and unparallel in the history of entire developing world as stated by the late Nobel Laureate Dr. N.E. Borlaug. The overall increase in area, production and productivity of wheat in our country during 1965 to 2011 is given in the adjoining figure.



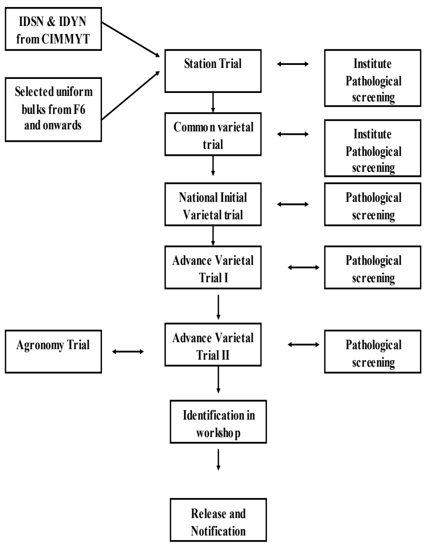
In addition to development and release of wheat varieties, characterization and development of trait specific genetic stocks of wheat has been another big achievement of the centre. These genetic stocks include donors for resistance/ tolerance to major biotic and abiotic stresses, primary yield component, grain quality attributes etc.

Objectives

- Incorporating diverse rust resistance genes in newly generated material for evolving improved cultivars.
- Evolving genotypes tolerant to high temperature, moisture stress conditions and hard threshing.
- Evolving wheat genotypes for good grain quality and for other quality parameters like high protein content and chapati, bread and biscuit making purposes.
- Maintenance Breeding: Production of BS and NS of IARI-bread wheat varieties to meet the seed requirements of central zone.

– Evolving early maturing genotypes combining high yield.

Stages of evaluation of improved strains before identification and release of varieties



Recently Developed High Yielding Varieties of Wheat

To realize the high yield potential of any crop use of recently released recommended varieties of that crop is most essential. Non availability of good quality seed of recently released wheat varieties for the area is one of the important factors for lower productivity of the crop.

Table 1: Varieties developed recently by the Station, Year Wise:

Durum Wheat			
SN	**Year**	**Variety**	**Parentage**
1	1961	NP 406	GAZA/EKD 6
		NP 412	GAZA/EKD 69
2	1965	NP 401	GAZA/EGYPT 8626
		NP 404	GAZA/EKD 6
3	1973	HI 7483 (Megdhoot)	GAZA/GD11//A098/ GAZA/3/NP 404
4	1994	HI 8381 (Malavshree)	JO 69-SIB/AA SIB/FGO SIB
5	1999	HI 8498 (Malavshakti)	CR’S’-GS’S’//A9-30-1/Raj911
6	2000	HD 4672 (Malvaratna)	Bijaga Red / PBW 34 //ALTAR 84
7	2005	HI 8627 (Malavkriti)	HD4672/PDW 233
8	2007	HI 8663 (Poshan)	HI 8177/HI 8185
		HD 2932 (Pusa-111)	-
9	2011	HD 2987 (Pusa bhahar)	HI 1011/HD 2348//MENDOS//1WP72/DL 153-2
10	2012	HI 8713 (Pusa Mangal)	HD 4672/PDW 233
11	2014	HI 8737 (Pusa Anmol)	HI 8177/HI 8158//HI 8498
12	2017	HI 8759 (Pusa Tejas)	-
13	2021	8823 (Pusa Prabhat)	HI8709/HD4676
14	2022	HI 8830	-
		HI 8826	-

Bread Wheat			
SN	**Year**	**Variety**	**Parentage**
1	1960	NP 832	E 145 / Pissi Local
2	1965	NP 839	GB-AUS / Niphad-4
3	1975	HI 385 (Mukta)	Hyb 633 // GAZA // PR/ PKD 25
4	1978	HI 617 (Sujata)	Selection from C-306
5	1982	HI 784 (Swati)	NAPO/TobSIB//8156/3KAL/Bb

6	1989	HI1077 (Mangla)	GLL/AUSTII 61.157//CNO/NO/3/KAL/BB
		HI 977	GLL/AUSTII61.157//CNO/NO /3/Y50E/3*KAL
7	2000	HI1418(Navin Chandausi)	HI 999 / HI 601
		HI1454 (Abha)	HI 1076 / CC 505 // HI 1136
9	2002	HI1479 (Swarna)	HD 2195 / HD 2160 // WH 283
10	2003	HI1500 (Amrita)	HW2002*2//Strempalli/PNC 5
11	2006	HI1531 (Harshita)	HI 1182/CPAN 1990
12	2007	HI1544 (Purna)	HD 2402/HW 3007
14	2010	HI 1563 (Pusa Prachi)	-
13	2017	HI 1605 (Pusa Ujala)	BOW/VEE/5/ND/V/G9144/KA L/BB/3/YACO/4//CHIL/6/CAS KOR/3/CROC_1/AE.SQUARR OSA(224)/OPATA/7/PASTOR //MILAN/KAUZ/3/BAV92
14	2021	HI 1636 (Pusa Vakula)	DL788/HW4032
		HI 1634 (Pusa Ahilya)	GW-322/PBW-498
		HI-1633 (Pusa Vani)	GW-322/PBW-498
15	2022	HI 1650	-
		HI 1653	-
		HI 1654	-
		HI 1655	-

Table 2: Congenial temperature for various wheat crop growth stages

Growth stages	**Temperature requirements**
Germination	20-22^{0}C mean daily temperature
Tillering	16-20^{0}C mean daily temperature
Accelerated growth	20-23^{0}C mean daily temperature
Proper grain filling	23-25^{0}C mean daily temperature

Important parameters

	Early germination and good plant vigour
Good plant stand	Good plant stand
Tolerant to root rot	Not so important
Tolerant to Barley yellow mosaic	Tolerant to Barley yellow mosaic
Lower leaves forming mulch	Not so important
Holding the soil intact (black cotton soils)	Not so important
Medium tall to D1 height (> 90 cm)	D2 height (< 90 cm)
Medium early to medium late maturity	Medium early to early maturity
Non-synchronous tillering and flowering	Synchronous tillering and flowering
Tillering - responsive to cold conditions	Not so important
Long coleoptile length	Not so important
High biomass with drooping leaves	High biomass with erect leaves
High tolerant to early heat conditions	High tolerant to late heat conditions
High CTD values	High CTD values
Resistance to leaf and stem rusts	Resistance to leaf and stem rusts
High 1000 grain weight with bold grains	High 1000 grain weight with bold grains
High grain yield	High grain yield

Biotechnology in wheat improvement - Marker assisted selection has been performed in early segregating generations to select the plants generated in the background of popular cultivars such as PBW 343, HD2733, WH147, HUW 234, Lok1 etc. with different effective leaf rust (*Lr24, Lr28, Lr34, Lr35, Lr37*) and stripe rust (*Yr10, Yr15*) resistance genes. Successful introgression of these resistance genes using molecular markers was accomplished. Plants having gene combination *Lr24+Lr37, Lr24+ Lr28, Lr24+Lr28+Yr15* etc were confirmed. This would lead to early identification of potential cultivars /

resistance sources for future breeding programmes.

Host Resistance: ICAR- IARI wellingtonEvery year more than 3000 wheat genotypes are evaluated at hot spots and under artificial inoculated conditions in different nurseries for identifying resistant sources. This has led to development of disease and pest resistant varieties. Moreover, off – season nursery for Rust Screening., i.e. Gerua (Rust) Research Station, Mahabaleshwar (Maharashtra) were utilized during the course of study and variety development were being utilized.

Rusts: Wheat crop is infested by three rusts, namely, yellow rust or stripe rust (*Puccinia striiformis*) (Pst), brown rust or leaf rust (*Puccinia triticina*Eriks.) (Ptr) and black rust or stem rust (*P. graminis tritici* Eriks & Henn.) (Pgt). Rusts are airborne and can cause severe losses under favourable weather conditions for the pathogen and if susceptible varieties are grown over large area. There is a strong system of development of rust resistant varieties in central India ever since inception of the centre in 1951. Rusts pathotypes / races collected through extensive surveys are identified at RRS Shimla and Mahabaleshwar and deployed for resistance screening of breeding material and advance lines as a result of which no severe epidemic had occurred in the country except stripe rust occurrence in high proportions at few locations during last few years.

Preparedness to tackle new stem rust race, Ug 99

A new race of stem rust known as Ug 99 or TTKS has evolved in Uganda (Africa) in 1999. The most important thing about Ug 99 which is different from other existing races of stem rust elsewhere in the world is that it has rendered *Sr*31 gene ineffective located on 1BL/1RS (*Sr31, Lr26, Yr9, Pm 8*) chromosome along with a group of other important stem rust resistance genes. Since over last four decades the serious epidemics of stem rust have been kept under control with the extensive use of *Sr31* and *Sr2* complex of resistance genes, hence, the defeat of the important stem rust resistance gene *Sr31* and some of the other known *Sr* genes has become a cause of great concern world over. This variant of Ug 99 has been popping up in fields throughout East Africa. Plant breeders, geneticists, plant pathologists and molecular biologists are collaborating internationally to identify and incorporate genetic traits that will protect wheat from the pathogen. Under the aegis of ICAR/DWR in collaboration with Borlaug Global Rust Initiative (BGRI) evaluated many wheat materials for Ug99 at Kenya (2009-2011) which has resulted into identification of resistant varieties in seed chain and genetic stocks.

Multi-pronged bread wheat production strategies include breaking yield ceilings by pre-breeding initiatives, enhanced heat and drought tolerance, durable disease and pest resistance and hybrid genotypes. Sustainable production techniques with qquality seed production and supply, conservation agriculture for soil health and increasing input use efficiency and ultimately capacity building for improved efficiency and impact. The strategies for enhanced production visualizes enhanced productivity levels through new genotypes with high genetic yield potential, disease resistance especially leaf rust, flexibility to tolerate water stress conditions, tolerance to heat stress and late sown genotypes for high cropping intensity.

Variety name	**Pedigree**	**Year release**	**Tested in 2006**		**Retest in 2007**
			1st score	**2nd score**	
Bread wheat					
HI 1500	HW 2002*2// STREMPAL LI / PNC 5	2003	TR	10 RMR	Highly resistant

Enhancing yield methodologies: The conventional methodology (pedigree /bulk/backcross and modifications for faster output in targeted conditions) must be supplemented with molecular tools having precision breeding, marker aided selection, gene pyramiding, and manipulating physiological traits. Mitigating heat stress by regular screening for high temperature tolerance under *natural as well as polyhouse* environments, superior genotypes possessing high temperature tolerance are being used in breeding programmes and adopting resource conservation technologies like zero tillage and bed planting. Germplasm sharing should be done through IIWBR, Karnal (Haryana) by way of raising international trials and nurseries [Semi arid wheat yield trial (SAWYT), Semi arid wheat screening nursery (SAWSN), Elite spring wheat yield trial (ESWYT), International bread wheat screening nursery (IBWSN) and Cereal System Initiative for South Asia (CSISA) trials]; national nurseries [National Genetic stock nursery (NGSN), Yield component screening nursery (YCSN), Short duration cum late heat tolerant nursery (SDHTN), Drought and heat tolerance screening nursery (DHTSN) and Segregating stock nursery (SSN)]. For central zone the immediate breeding strategy involves more physiological manipulations for changed plant type; high fertility genotypes (Need 4-5 irrigation at present); high fertility genotypes (need 3 irrigations for same yield); dwarf plants, more water efficiency, high CTD, input responsive; rainfed varieties (less yield) Varieties for restricted irrigation (01) (more than 50% yield increase).

Limitations / Challenges to wheat production in Central India:

Inadequate availability of irrigation water, stem and leaf rusts, may serve as secondary focus of rust infection, frosting is common, warmer temperatures during the crop growing season, non-availability of drought tolerant varieties, limited availability of quality seed. Environmental advantages in central India for production of quality wheat depicts the availability of low atmospheric humidity during grain filling – hence, low yellow berry incidence, produce has high hectolitre weight and high protein content – due to nutritionally rich vertisol, absence of seed and soil-borne diseases like loose smut and Karnal bunt, excessive vegetative growth is checked due to short growing period resulting in more productive tillers and longer grain filling period ensures bold and high density grain.

Rich varietal diversity created under wheat cultivation: For executing the concept of gene deployment and popularisation of new releases, I actively involved in breeder seed production of about more than 8600 quintals of latest IARI – Wheat varieties during rabi season, which helped in increasing the wheat productivity and production in Central India, particularly in the state of Madhya Pradesh. This assured availability of "quality seed" of improved wheat varieties created effective genetic diversity under cultivation in Central India, eliminating the chances of rust epidemics in the country.

Quality parameters in wheat for various end products:

Product	Characters
Bread	Strong gluten wheat with > 60 ml sedimentation value, > 12.0 % protein, 5 + 10 High Molecular Weight Glutenin Subunit with 9 to 10 Glu-1 score
Biscuit	Weak and soft wheat with < 10.0 % protein, < 30 ml sedimentation value and ~ 50 % Alkaline Water Retention Capacity (AWRC).
Chapati	Protein between 10 to 12 %, sedimentation value between 30 – 60 ml, with good dough making quality
Pasta	Hard durum wheat with > 12.0 % protein, > 40 ml sedimentation value, below 10 % yellow berry incidence, > 7 ppm β-carotene content and γ-gliadin 45 is required.

Quality of Indian bread wheat: Normally, the average protein content is relatively low in northern parts of the country (10 – 11.5 %) and it improves in the Central and Peninsular region where it remains between 12 – 13 %. The average extraction rate is maximum in Madhya Pradesh (70.7 %). The upper part of the country comprising of Himachal Pradesh, Uttaranchal and Punjab is comparatively better in biscuit quality and the middle part of the country particularly Madhya Pradesh, Rajasthan and Gujarat is good in chapati quality. Likewise, the lower part of the country comprising Gujarat, Maharashtra and Karnataka is comparatively better for bread loaf volume. HI 1544 is a promising varieties for various bread wheat products in central zone. The above identified varieties for various wheat products are the result of the breeding programme for high yield and disease resistance, but not from any systematically adopted quality breeding programme. Hence, the urgent need is to improve the quality traits right from the selection of parents and advancement of generation based on the product specific requirements along with yield and rust resistance, so as to develop varieties, which can make various wheat products of international standard. Focussed efforts in germplasm evaluation and working out relationship of end products with different yield and quality components are required. Basic studies on identification of bio-chemical or molecular markers associated with key nutritional components like protein, β-carotene, iron and zinc are further required to assist the bio-fortification in wheat.

Test weight or hectoliter weight or weight per unit volume: Test weight usually determines the plumpness of the grain. Flour yield increases and flour ash decreases with the increase in test weight. A flour yield upto 70 % and flour ash of 0.4 % would be normal for wheat with 75 kg hectoliter weight, whereas a flour yield of 62.5 % and flour ash of 0.6 % would be expected from wheat with 62 kg hectoliter weight. Kernel size and shape are the two most important features, which influence the overall test weight of the grain. Immature and shriveled wheat are usually low in test weight and give correspondingly poor yields of flour. A correlation co-efficient of + 0.75 between test weight and flour yield has been established by previous workers. At lower weights than 71 kg, the milling yield usually falls off rather rapidly with decreasing test weight. Immature wheats or wheat that is badly shriveled as a result of drought or disease is usually low in test weight and give correspondingly poor yield of flour.

Terminal heat: Late sown and very late sown wheat crop, usually sown after potato crop, suffers considerably from high temperatures during grain development. Only, high tillering, early maturing varieties with good biomass and grain weight yield better under these conditions. A number of early maturing rust resistant varieties like DL 788-2, HI 1454, HI 1418 and GW 173 have been released for late sown conditions. Heavy soils in larger parts of Central India, maintain a better flow and utilization of underground water by the crop. Medium late or late genotypes in both durum and *aestivum* wheat, suffered heavily under terminal heat as reflected by a heavy loss of test weight and grain quality. Thermodynamic energy flow in wheat, like any other living near equilibrium system exchanging energy and matter with the environment, works in a specific range of minimax temperature gradient. Any thing beyond these limits, affect the entire physiology of the plant. Averages give only a superficial idea, and air temperatures are always much lower than the surface soil temperatures of black cotton soils, which may reach as high as 46ºC in day time, affecting the growth and functioning of the nodal roots, water use efficiency and ultimately yield. It is ironical that high temperatures can largely be managed only by timely application of proper irrigation water, a resource already in limited supply. Irrigation plays a crucial role in mitigating the effects of high temperatures both in early and terminal heat conditions. IARI – Regional Station, Indore has averted a serious crisis of wheat production by developing suitable heat tolerant bread wheat varieties like HI 1531 for early October sown conditions and high yielding heat escaping early maturing wheat varieties like HI 1563 for late sown conditions along with the entire package of technology.

Two entirely different genotypes are required to be tailored for the management of early heat and terminal heat, although genes imparting resistance against heat shocks are required in both the types. We can achieve 50 – 60 q/ha of good quality grain even under high temperatures by sowing in early October utilizing the stored moisture to its best and supplemental irrigation depending on the variety.

Latest varietal bouquet:

HI 1605 (Pusa Ujala) - Recommended for Timely Sown, Restricted Irrigated Conditions of Peninsular Zone.

- Average Yield: 29.1 q/ha
- Potential Yield: 44.0 q/ha
- Plant Height: 95-100 cm
- Flowering: 65-70 days. Good Chapati and Biscuit making quality, Perfect Protein quality (Glu score: 8/10)
- Grain Iron = 43.0 ppm
- Grain Zinc = 35.0 ppm
- Protein = >13.0%
- Sedimentation value = 55 ml
- Resistant to Stem and leaf rusts

Resistant to Leaf blight, Karnal bunt, *Fusarium* head blight, Flag smut and Foot rot

Tolerant to drought and terminal heat.

HI 1633 (Pusa Vani) - Recommended for Late Sown, Irrigated Conditions of Peninsular Zone. (Maharashtra, Karnataka & Plains of Tamil Nadu)

- Average Yield: *41.7* q/ha
- Potential Yield: *65.8* q/ha
- Plant Height: *80-85* cm
- Flowering: *55-60* days
- *Good Chapati and Biscuit making quality*
- Good Protein quality (*Glu* score : 8/10)
- Grain Iron = *41.6* ppm
- Grain Zinc = *41.1* ppm
- Protein = >*12.5*%
- Sedimentation value = *45* ml

Resistant to Stem and leaf rusts and Resistant to Leaf blight, Karnal bunt, *Fusarium* head blight, Flag smut, Foot rot and Loose smut.

HI 1634 (Pusa Ahilya) - Recommended for Late Sown, Irrigated Conditions of Central Zone. Madhya Pradesh, Gujarat, Chhattisgarh, Rajasthan (Kota and Udaipur divisions) and U.P. (Jhansi division)

- Average Yield: *51.6* q/ha
- Potential Yield: *70.6* q/ha
- Plant Height: *80-85* cm
- Flowering: *60-65* days

High pasta acceptability with *7.0* hedonic score

- Grain Iron = *38.0* ppm
- Grain Zinc = *37.0* ppm
- Protein = *>12.0*%
- Sedimentation value = *50* ml
- Resistant to Stem and leaf rusts

Resistant to Leaf blight, Karnal bunt, *Fusarium* head blight, Flag smut, Foot rot and Loose smut.

HI 1636 (Pusa Vakula) –

Recommended for Timely sown, Irrigated conditions of Central Zone

- Average Yield: *56.6q/ha*
- Potential Yield: 78.8 q/ha
- Plant Height: *90– 95 cm*
- Flowering: *60 -65 days*
- Resistant to Stem and leaf

"Zinc bio-fortified high yielding bread wheat" suitable for *Chapati and Biscuit making quality*

- Grain Iron = *35.7 ppm*
- Grain Zinc = *44.4 ppm*
- Protein = *>12 %*
- Sedimentation value = *42.6 ml*

Resistant to Rusts, Leaf blight, Karnal bunt, *Fusarium head blight, Flag smut, Foot rot and Loose smut*

HI 8737 (Pusa Anmol) - Recommended for Timely Sown, Irrigated Conditions of Central India (Madhya Pradesh, Gujarat, Chhattisgarh, Rajasthan (Kota and Udaipur divisions) and U.P. (Jhansi division)

- Average Yield: *53.4* q/ha
- Potential Yield: *71.0* q/ha
- Plant Height: *85-90* cm
- Flowering: *70-75* days

High pasta acceptability with *7.3* hedonic score

- Grain Iron = *38.5* ppm
- Grain Zinc = *40.0* ppm

- Protein = *>12.0%*
- Yellow pigment = *>6.0* ppm
- Sedimentation value = *36* ml

Resistant to Stem and Leaf rusts

Resistant to Karnal bunt, *Fusarium* head blight, Flag smut and Loose smut

HI 8759 (Pusa Tejas) -Recommended for Timely Sown, Irrigated Conditions of Central India. Madhya Pradesh, Gujarat, Chhattisgarh, Rajasthan (Kota and Udaipur divisions) and U.P. (Jhansi division)

- Average Yield: *56.9* q/ha
- Potential Yield: *75.5* q/ha
- Plant Height: *85-90* cm
- Flowering: *70-75* days
- Protein = *>12.0%*

High pasta acceptability with *7.5* hedonic score

- Grain Iron = *42.1* ppm
- Grain Zinc = *42.8* ppm
- Yellow pigment = *>6.0* ppm
- Sedimentation value = *35* ml

Resistant to Stem and Leaf rusts

Resistant to Karnal bunt, Foot rot, Flag smut and Loose smut, Tolerant to terminal heat

HI 8777 (Pusa Wheat 8777) -Recommended for Rainfed, Timely Sown Conditions of Peninsular India

- Average Yield: *18.5* q/ha
- Potential Yield: *28.8* q/ha
- Plant Height: *70-75* cm
- Flowering: *55-60* days
- Sedimentation value = *35* ml

High pasta acceptability with *7.0* hedonic score

- Grain Iron = *48.7* ppm
- Grain Zinc = *43.6* ppm
- Protein = *>14.0%*
- Yellow pigment = >5.5 ppm

Resistant to Stem and Leaf rusts

Resistant to Karnal bunt, Foot rot, Flag smut and Loose smut

HI-8823 (Pusa Prabhat) - Recommended for Timely sown, Restricted irrigation conditions of Central Zone India

- Average Yield: *38.5 q/ha*

- Potential Yield: 65.6 *q/ha*
- Plant Height: 80-85 *cm*
- Flowering: 70-75 *days*

"Dual quality" durum wheat suitable both for pasta products as well as for chapati making quality

- Grain Iron = 37.9 *ppm*
- Grain Zinc = *40.1 ppm*
- Protein = *>12.0%*
- Yellow pigment = *>5.8 ppm*
- Sedimentation value = *36.6 ml*

High pasta acceptability with *5.9 hedonic score*

Resistant to Stem and Leaf rusts, Resistant to Karnal bunt, Foot rot, Flag smut and Loose smut

New genetic material generated: Each year around150 fresh crosses including simple and three way combinations are/were attempted among different wheat breeding lines. These materials will be/would be further evaluated during the next *rabi* season. The resistant sources (28) used in the crossing programme are/were CPAN-1235, CPAN-1676, CPAN-1796, CPAN-1842, DL-788-2, GW-322, GW-326, GW-366, HD-2135, HD-2380, HD-2402, HD-2501, HD-2733, HI-784, HI-1434, HI-1479, HP-1761, HS-295, HS-365, K-7827, K-9107, K-9465, NIAW-34, PBW-498, Raj-3765, Raj-3777, UP-2473 and VL-804.

Germplasm rejuvenation, characterization and evaluation: IARI RS Indore maintains more than 900 germplasms along with their rejuvenation and evaluation for various metrical and non-metrical traits.

Selection from station trials: From different SSTs a sizable number of selections are/were made based on field and table screening each year. From breeding materials (F_1, F_2 and crossing block a considerable number of entries were being maintained and evaluated. The collaborative programmes viz., Dhandhuka rainfed testing**;** Kenya testing for Ug-99: 40 lines; Wellington testing for rust reaction: 412 bulks; Mahabaleshwartesting for rust reaction: 412 bulks; Indore pathology section: 412 bulks.

As new initiativeBARC-IARI INDORE collaborative programme on selection for hard threshing and good chapati making were started.

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