Indian Journal of Agricultural Sciences **80** (3): 203–7, March 2010

Performance of micronutrients-rich, rust-resistant early-maturing, high-yielding wheat (*Triticum aestivum*)

LAKSHMI KANT[1], S K PANT[2], V MAHAJAN[3], K A GOPINATH[4] and H S GUPTA[5]

Vivekananda Parvatiya Krishi Anusandhan Sansthan Almora, *Uttarakhand 263 601*

Received: 9 July 2009; Accepted 7 January 2010

ABSTRACT

A study was conducted during 2004–07 to evaluate 'VL *Gehun* 892' wheat with respect to micronutrients, rust resistance and grain yield in 13 trials at 7 different locations in northern hills. 'VL *Gehun* 892' was developed from a cross between 'WH 542' selected for high grain yield, rust resistance, high iron, zinc and copper content and 'PBW 226' characterized for earliness and high grain weight. The results indicated that 'VL *Gehun* 892' possesses higher content of iron (37.2 ppm), zinc (35.7 ppm), copper (4.79 ppm) and manganese (49.8 ppm) coupled with good *chapati* quality (6.92). In addition, it also possesses high resistance to brown and yellow rust, exhibited higher yield than the prevailing varieties. It also has early maturity (143 days) and higher average productivity/day (102 kg/ha/day) making it a suitable for late sowing in northern hills of India.

Key words: Brown and yellow rust, *Chapati* quality, Micronutrients

One sustainable agricultural approach for reducing micronutrient malnutrition among people at higher risk (ie, resource-poor women, infants and children) globally is to enrich major staple food crops (eg rice, wheat, maize, beans and cassava) with micronutrients through plant breeding strategies. These target groups are dependent on these staples for their sustenance (Welch 2002). The household nutritional and food security is also essential in the areas of northern hills of India comprising Jammu and Kashmir, Himachal Pradesh and Uttarakhand hills. Wheat (*Triticum aestivum* L. emend. Fiori. & Paol.) is the most important winter crop in this area covering around 10 lakh ha area, which is around 3.8% of the total wheat area in the country (Chanda *et al.* 2007). Besides, northern hills are considered as foci of infection for rust diseases, therefore, cultivation of rust-resistant varieties in northern hills zone is the key national strategy to reduce the inoculum load for the wheat crop of north-western plains.

During the last 5 years there was almost negligible rains, particularly during October and November, the normal sowing time of wheat in the hills. Therefore, most of the hill farmers are now resorting to the late sowing of wheat in December after the onset of winter rains. This particular condition requires specific set of varieties, possessing early maturity and faster grain-filling rate. Though few options available to the farmers are 'Sonalika', 'HS 295' and 'HS 420' but with passage of time they have become highly susceptible to yellow and brown rust diseases. In addition, they have lower micronutrients content calling for immediate replacement. To meet the demand for a micronutrients rich, suitable variety with early-maturity and high grain-filling rate, high-yielding and rust resistance, a breeding programme was started in 1990s at Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora (29º 36'N and 79º40' E and 1250 m amsl).

MATERIALS AND METHODS

'WH 542', a well known high-yielding variety developed by CCS HAU, Hisar was selected for high grain yield, rust resistance, high iron, zinc and copper content and 'PBW 226', another high-yielding variety developed by PAU, Ludhiana, characterized for earliness and high grain weight were chosen as parents. The F_1 was developed by crossing 'WH 542' and 'PBW 226'. In subsequent generations the modified bulk pedigree breeding method was followed. Five plants were selected in F_2 on the basis of agronomic suitability and rust resistance. Subsequently, in F_3 5 plant progeny rows were planted. One progeny was rejected due to susceptibility to yellow rust. Desirable plants selected in the remaining

[1]Senior Scientist (e mail: lkant_vpkas@yahoo.com) (Plant Breeding), [2]Senior Scientist (e mail: sk_pant@yahoo.com) (Plant Pathology), [3]Head (e mail: vinmaha@yahoo.com), Crop Improvement Division, [4]Scientist (e mail: gopinathka @indiatimes.com) (Agronomy)

[5]Director (e mail: hsgupta @lycos.com), Indian Agricultural Research Institute, New Delhi 110 012

progenies and seed was bulked after selecting for grain acceptability. In F_4 the bulk seed was planted. Selection was practised for agronomic traits, rust resistance and seed of desirable plants bulked after selecting for grain acceptability. In F_5, bulk seed was planted. Eleven plants were selected initially for agronomic superiority, rust resistance, earliness and high grain-filling rate and finally 6 plants were retained after grain selection. In $F_{6,}$ 6 plant progeny rows were planted. Four plants were selected from 3 progenies on the basis of maturity, good yield, grain acceptability, agronomic suitability and rust resistance and in F_7 all the 4 promising progenies were harvested as individual bulks. Out of these 4 bulks, 2 strains each were evaluated in timely-sown and late-sown station trial. Only one strain 'VW 0340' yielded highest under late sowing and was further evaluated as 'VL 892' in 13 All India Co-ordinated Wheat Improvement yield evaluation trials at 7 different locations in Himachal Pradesh and Uttarakhand northern hills during 2004–07 under late-sown conditions. During 2004–05 total 14, during 2005–06 and 2006–07 total 11 entries each including checks were tested at all the location following randomized complete block design with 6 replicates. The recommended sowing time of first fortnight of December was followed. Uniform 6 row plot of 3 m with 18 cm row-to-row distance for each entry was followed at all the locations. The crop received 40 kg/ha N and 20 kg/ha P as a basal dose. The crop was not protected against leaf rust (*Puccinia recondita* Rob. Ex Desm f. sp. *tritici*), stripe rust (*Puccinia striiformis* Westend.), loose smut [*Ustilago nuda tritici* (Jens.) Rostr.] and powdery mildew (*Erysphe tritici* Em. Marchai) to test the level of resistance of the test entries. Yield, ancillary and disease susceptibility data were recorded at individual location and complied at Directorate of Wheat Research, Karnal, Haryana. The standard analysis of variance was done for individual location as well as for pooled data.

Grain samples of each entry from all the locations were

Fig 1 'VL *Gehun* 892' Field view, grains (*inset*)

analyzed for different quality parameters as well as micronutrients content following standard procedures at Quality Laboratory, DWR, Karnal, Haryana. The centre-wise data was then pooled.

For disease screening under artificial epiphytotic conditions the entries were planted in a multi-location Plant Pathological Screening Nursery. Infector rows, which are often mixture of highly susceptible genotypes, were planted in and around the nursery and inoculated with mixture of races of yellow and brown rust. The heavy inoculums load in the infector rows ensured the infection to susceptible materials in the nursery. The data on susceptibility to rust was recorded as per Nayar *et al.* (1997) at individual location.

RESULTS AND DISCUSSION

One of the most promising entry in these trials 'VL 892' has been named as 'VL Gehun 892' (Fig 1) and notified in December 2007 by the Central Sub-Committee on Crop Standards, Notifications and Release of Varieties for Food Crops, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi. It is recommended for cultivation under late-sown conditions in this region. 'VL *Gehun* 892' is a spring wheat with semi-erect growth habit during early phase. Its foliage color is light-green. Plants are semi-tall of about 79 cm in height. At the flowering stage the whole plant has a layer of wax with leaf sheath and peduncle having very high level of wax. At maturity the ears become dough white in color and tapering in shape with intermediate density.

Micronutrients

The pooled data indicated that 'VL *Gehun* 892' possesses 37.2 ppm of iron, 35.7 ppm of zinc, 4.79 ppm of copper and 49.8 ppm of manganese. The iron content is higher by 59.7% of 'HS 295' and 34.3% of 'HS 420'. The zinc content is 19.0% higher of 'HS 295', 7.9% of 'Sonalika' and 8.8% higher of 'HS 420'. The copper content is higher by 3.9% of 'HS 295', 9.6% of 'Sonalika' and 5.3% of 'HS 420'. Similarly the manganese content is higher by 6.6% of 'HS 295', 2.3% of 'Sonalika' and 21.5% of 'HS 420' (Gupta *et al.* 2005, Gupta *et al.* 2006, Gupta *et al.* 2007) (Table 1). Therefore 'VL *Gehun* 892' has much higher zinc, manganese, copper and iron (except 'Sonalika') content and is nutritionally richer than all the 3 prevailing varieties, 'HS 295', 'Sonalika' and 'HS 420' being cultivated under late-sown conditions in hills.

Quality

The quality analysis data suggest that 'VL *Gehun* 892' is a quality wheat. It possesses average protein content of 10.95% and sedimentation value of 38 ml suggesting that it is better suited for *chapati*, the most preferable mode of wheat consumption in India. The presence of 2+12 Glu D1 subunit of high molecular weight glutenin further confirmed its suitability for *chapati*. During product evaluation it has scores

Table 1 Daily dietary requirements of the micronutrients in human beings$ and their availability in 'VL *Gehun* 892' and other prevailing varieties

Gender	Iron (mg/kg)	Zinc (mg/kg)	Copper (mg/kg)	Manganese (mg/kg)
Dietary requirement/mg				
Male	10–18	15	2–3.0	2.5–5.0
Female	18	15	2–3.0	2.5–5.0
Availability through wheat varieties				
'VL *Gehun* 892'	37.2	35.7	4.79	49.8
'HS 295'*	23.3	30.0	4.61	46.7
'Sonalika'*	38.0	33.1	4.37	48.7
'HS 420'*	27.7	32.8	4.55	41.0

*Based on 3 years data.

$ *Source: Taber's Cyclopedic Medical Dictionary* 1990, pp 2401 Medical Publishers, New Delhi.

6.92 score out of 10, which is categorized as good *chapati* (6.1–7.0 is graded as good *chapati*). The high hectolitre weight of 79.9 kg/ha indicates a very good flour recovery during milling (Gupta *et al.* 2005, Gupta *et al.* 2006, Gupta *et al.* 2007).

Yield and grain-filling rate

During the 3 crop seasons (2004–05 to 2006–07) of testing in All India Coordinated multi-location trials in northern hills of India, 'VL *Gehun* 892' gave an average grain yield of 3 760 kg/ha which was 8.4, 7.7 and 3.6% higher than the checks 'Sonalika', 'HS 420' and 'HS 295', respectively (Fig 2). It has an early heading at 106 days as compared to 107, 102 and 109 days of 'HS 295', 'Sonalika' and 'HS 420', respectively (Chatrath *et al.* 2005, Shoran *et al.* 2006, Shoran *et al.* 2007). The average days to maturity are 143 days that is at par with 'Sonalika' (144 days) the earliest maturing variety (Kant 2006) (Table 2). It can be inferred that it has higher grain-filling rate than the prevailing varieties and its average productivity/ha/day of 102 kg/ha/day is higher than that of 96, 83 and 88 kg/ha/day of 'HS 295', 'Sonalika' and 'HS 420', respectively.

Adaptability to the sowing conditions

The experiment conducted during 2006–07 to assess the

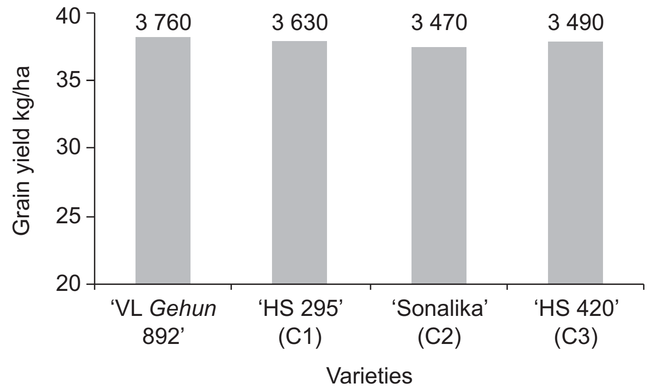

Fig 2 Average grain yield (kg/ha) of 'VL *Gehun* 892' along with checks

suitability of 'VL *Gehun* 892' to different dates of sowing at Bajaura, Malan and Shimla indicated that it performed better and gave 2.99% higher yield under late-sowing conditions, whereas there was reduction in the yield of 2 checks, 'HS 295' and 'HS 420' by 14.93 and 14.89%, respectively (Sharma *et al.* 2007). The gain in grain yield under late sowing was however; non-significant in 'VL *Gehun* 892' but the reduction in grain yield was significant in case of 'HS 295' and 'HS 420' under late sowing.

The increase in grain yield in 'VL *Gehun* 892' was also expressed in its yield components under late sowing. Number of ear heads/m^2 increased in 'VL *Gehun* 892' tremendously under late sowing, however it was at par in case of 'HS 295' and decreased in case of 'HS 420' (Fig 3). Thousand-grain weight is an important yield attribute and there was slight decrease in this component under late sowing (Sharma *et al.* 2007) however, the decrease was less in case of 'VL *Gehun* 892' as compared to 'HS 295' (Fig 3). Therefore, broadly these parameters indicate that among these 'VL *Gehun* 892' is much more suitable variety for late sowing conditions.

Resistance to brown and yellow rust

Brown and yellow rust are the two most important diseases of wheat in northern hills. During 2004–05 to 2006–07 the highest brown rust score of 10S with average co-efficient of infection (ACI) of 4.8 was recorded on 'VL *Gehun* 892' under

Table 2 Days to flowering and maturity of 'VL *Gehun* 892' in the northern hills

Character	Years	'VL *Gehun* 892'	'HS 295' (C1)	'Sonalika' (C2)	'HS 420' (C3)
Days to flowering	2004–05	111	111	106	114
	2005–06	101	101	96	103
	2006–07	106	110	104	111
	Mean	106	107	102	109
Days to maturity	2004–05	149	151	151	154
	2005–06	142	144	143	148
	2006–07	139	140	139	144
	Mean	143	145	144	149

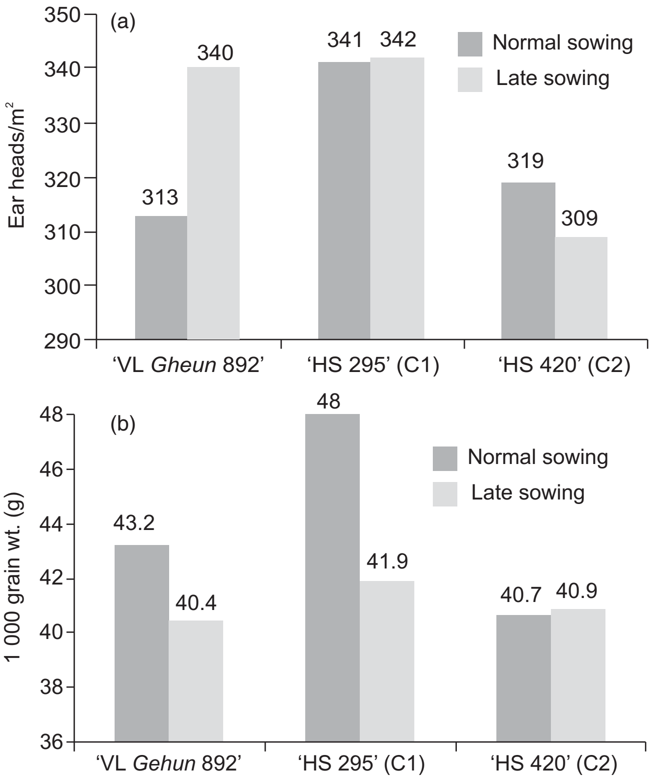

Fig 3 Number of ear heads/m^2 under normal and late-sown conditions (a), 1000 grain weight (g) under normal and late-sown conditions (b).

multi-locational All India Plant Pathological Screening Nursery under artificial conditions. However, during the same year, brown rust scores of 60S, 60S and 40S with ACI of 35.5, 42.5 and 21.5 were recorded on the prevailing checks, 'HS 295', 'Sonalika' and 'HS 420', respectively (Table 3). Even under natural conditions 'VL *Gehun* 892' scored a maximum brown rust score of 10S with ACI of 3.7, whereas

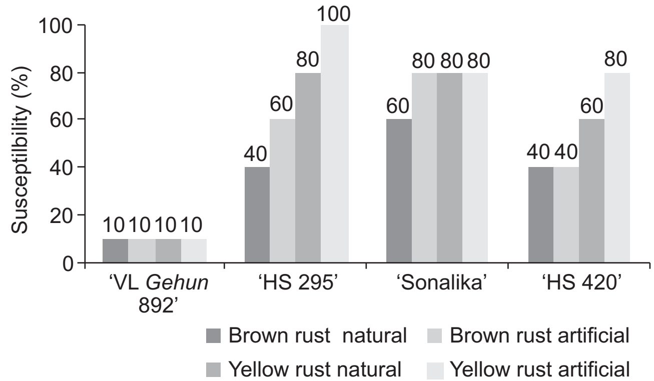

Fig 4 Highest level of susceptibility (level of resistance) among 3 years in 'VL *Gehun* 892' against checks

checks, 'HS 295', 'Sonalika' and 'HS 420' scored highest score of 40S*, 60S and 40S* with ACI of 13.3, 28.3 and 13.4, respectively (Sharma *et al.* 2005, Sharma *et al.* 2006, Sharma *et al.* 2007) (Table 3). These data indicate that all the prevailing varieties, 'HS 295', 'Sonalika' and 'HS 420' recommended for late sowing in northern hills have become highly susceptible to brown rust disease, whereas the newly developed variety 'VL *Gehun* 892' has shown high degree of resistance to brown rust under both natural as well as artificial conditions (Fig 4).

'VL *Gehun* 892' has been evaluated for yellow rust resistance along with 3 checks, 'HS 295', 'Sonalika' and 'HS 420' under natural as well as artificial conditions continuously during, 2004–05 to 2006–07. It has shown highest susceptibility of 10S with an ACI of 2.6 only, whereas, checks 'HS 295', 'Sonalika' and 'HS 420' have shown highest susceptibility of 100S, 80S and 80S with ACI of 42.0, 56.7 and 31.8, respectively (Table 3). Under natural conditions also, 'VL *Gehun* 892' has scored maximum score of 10S only as compared to the 40S, 20S and 60S for 'HS 295',

Table 3 Resistance to brown and yellow rusts under natural and artificial conditions

Condition	Years	'VL *Gehun* 892'	'HS 295' (C1)	'Sonalika' (C2)	'HS 420' (C3)
Brown rust					
	2004–05	10S (3.7)	40S* (13.3)	60S (28.3)	40S* (13.4)
Natural	2005–06	0	40S	20S	TS
	2006–07	0	0	tS	TS
	2004–05	5S (2.4)	NR	80S (53.3)	NR
Artificial	2005–06	10S (3.0)	50S (20.0)	80S (45.0)	40S (10.2)
	2006–07	10S (4.8)	60S (35.5)	60S (42.5)	40S (21.5)
Yellow rust					
	2004–05	tR (0.0)	0 (0.0)	80S (39.2)	0 (0.0)
Natural	2005–06	10S	40S	20S	60S
	2006–07	0 (0.0)	80S (26.3)	60S (42.5)	50S (20.0)
	2004–05	10S (2.5)	NR	80S (65.0)	NR
Artificial	2005–06	5S (2.0)	40S (11.0)	80S (29.6)	20S (8.0)
	2006–07	10S (2.6)	100S (42.0)	80S (56.7)	80S (31.8)

Disease score-high susceptibility; Figures in parentheses indicate average co-efficient of infection (ACI); * Highest reaction at one location only; NR, not reported

'Sonalika' and 'HS 420', respectively (Sharma *et al.* 2005, Sharma *et al.* 2006, Sharma *et al.* 2007) (Table 3). These data clearly suggested that all the prevailing varieties, 'HS 295', 'Sonalika' and 'HS 420' have become highly susceptible to yellow rust whereas, 'VL *Gehun* 892' has shown consistently high degree of resistance against this disease (Fig 4).

Gene postulation analysis at National Facility, Directorate of Wheat Research Regional Station, Flowerdale, Shimla, Himachal Pradesh revealed that 'VL *Gehun* 892' possesses *Lr*13+10+ genes for brown rust resistance, which is common to 'HS 295' and 'HS 420', whereas, 'Sonalika' has Lr13+ only (Sharma *et al.* 2005, Sharma *et al.* 2006, Sharma *et al.* 2007). In case of yellow rust it possesses Yr9+ which is different from 2(SKA)+ of 'Sonalika'. Therefore, cultivation of 'VL *Gehun* 892' will further add to genetic diversity in rust resistant genes in northern hills. The + sign indicates that there may be some additional resistant genes present which could not be identified at present.

Suitability to changed racial flora

Appearance of new races of brown and yellow rust have been reported in northern hills over last 4 years. Earlier, pathotype 77–2, 77–5, and 104–2 of brown rust and I, N, M, Yr9 were the prevalent races of yellow rust in northern hills. Now races, like 77–4, 77–6, 104–3, 162–1, 162–2 and 162 A of brown and P and 31 of yellow rust have been reported from northern hills. This indicates that there is shift in the racial pattern in the northern hills and probably that may be the reason that earlier varieties are showing high susceptibility. Further, 46S119 and 78S84 are the two most threatening pathotypes of yellow rust in northern hills in recent times. Therefore, varieties having resistance to these two pathotypes are to be cultivated in northern hills to reduce the losses and save the crop from these pathotypes, besides reducing the inoculum load of yellow rust which is important for north-western plains also. Incidentally, 'VL *Gehun* 892' has shown moderate resistance to both these pathotypes.

Enriching food crops with micronutrients through plant breeding approaches is probably one of the most suitable and cost-effective strategies. VPKAS, Almora, has developed a wheat variety, 'VL *Gehun* 892', having higher micronutrient content, possesses higher yield combining with higher resistance to brown and yellow rusts as compared to the prevailing varieties and is best suited for *chapati* making. The cultivation of 'VL *Gehun* 892' will provide nutritional security in the difficult and inaccessible areas of northern hills. In addition, it will reduce the inoculum load of brown and yellow rust diseases by virtue of having high degree of rust resistance.

ACKNOWLEDGEMENTS

The authors acknowledge Mr B D Pandey and D Shanker for their technical help during the course of field experimentation and data recording.

REFERENCES

Chanda T K, Sati K and Robertson C. 2006. *Fertilizer Statistics*, 51st edn, The Fertilizer Association of India, New Delhi.

Chatrath R, Shoran J, Singh R P, Bisht S S, Singh G, Kumar R, Tyagi B S, Rane J, Ganga Rao N V P R, Singh S K, Verma R P S, Tewari R, Malik R and Mishra B. 2005. *Directorate of Wheat Research*, *Results of the All India Coordinated Wheat and Triticale Varietal Trials and Wheat Physiology*, Vol. I, Directorate of Wheat Research, Karnal.

Gupta R K, Mohan D, Ram S and Shoran J. 2005. *Progress Report*, Wheat Quality, AICW and BIP, Vol IV, Directorate of Wheat Research, Karnal.

Gupta R K, Mohan D, Ram S and Mishra B. 2006. *Progress Report*, Wheat Quality, AICW and BIP, Vol IV, Directorate of Wheat Research, Karnal.

Gupta R K, Mohan D, Ram S and Mishra B. 2007. *Progress Report*, Wheat Quality, AICW and BIP, Vol IV, Directorate of Wheat Research, Karnal.

Kant L. 2006. Approaches to improvement in wheat and barley productivity. (*in*) *Sustainable Production from Agricultural Watershed in NWH*, *bulletin* pp 139–51, Gupta H S, Srivastva A K, Bhatt J C (Eds), Vivekananda Parvaitya Krishi Anusandhan Sansthan, Almora.

Nayar S K, Prashar M and Bhardwaj S C. 1997. Manual for Current Techniques in Wheat Rusts. *Research Bulletin* No. 2, pp 32. Regional Station, Directorate of Wheat Research, Flowerdale, Shimla.

Sharma A K, Singh D P, Saharan M S, Singh A K, Babu K S, Shoran J and Mishra B. 2005. *Report of the Coordinated Experiments Crop Protection* (*Pathology, Nematology and Entomology*), AICW and BIP, Vol. III, Directorate of Wheat Research, Karnal.

Sharma A K, Singh D P, Saharan M S, Singh A K, Babu K S and Mishra B. 2006. *Report of the Coordinated Experiments Crop Protection* (*Pathology, Nematology and Entomology*), AICW and BIP, Vol. III, Directorate of Wheat Research, Karnal.

Sharma A K, Singh D P, Saharan M S, Singh A K, Babu K S and Mishra B. 2007. *Report of the Coordinated Experiments Crop Protection* (*Pathology, Nematology and Entomology*), AICW and BIP, Vol. III, Directorate of Wheat Research, Karnal.

Sharma R K, Tripathi S C, Chandra S, Chhokar R S, Singh K and Mishra B. 2007. *Progress Report,* Resource Management Programme, AICW and BIP, Vol II, Directorate of Wheat Research, Karnal.

Shoran J, Chatrath R, Singh R P, Bisht S S, Singh G, Kumar R, Tyagi B S, Rane J, Singh S K, Tewari V, Verma R P S and Tewari R. 2006. *Results of the All India Coordinated Wheat and Triticale Varietal Trials and Wheat Physiology,* Vol. I, Directorate of Wheat Research, Karnal.

Shoran J, Chatrath R, Tewari V, Singh G, Kumar R, Tyagi B S, Rane J, Singh S K, Malik R and Mishra B. 2007. *Results of the All India Coordinated Wheat and Triticale Varietal Trials and Wheat Physiology,* Vol. I, Directorate of Wheat Research, Karnal.

Welch R M. 2002. Breeding Strategies for biofortification staple plant foods to reduce micronutrient malnutrition globally. *The Journal of Nutrition* **495**S–9S.