# Development of high yielding, micronutrient-rich, rust-resistant, winter x spring wheat (*Triticum aestivum* L.) derivative, suitable for climate change conditions of Northern Hills of India

LAKSHMI KANT, S.K. PANT, J.C. BHATT, D. MAHANTA and H.S. GUPTA[1]

[1]*ICAR-VPKAS, Almora,(Uttarakhand), BISA, New Delhi 110 012*

**ABSTRACT :** A study was conducted during 2007-09 to evaluate 'VL *Gehun* 907' wheat with respect to adaptation to rainfed and irrigated timely sown conditions, micronutrients, end product quality and rust resistance in 21 rainfed trials at 10 and 11 irrigated trials at 6 locations in northern hills zone. 'VL *Gehun* 907' was developed from a winter x spring wheat cross between 'DYBR1982-83/842ABVD50' selected for drought tolerance and high tillers, 'VW9365', an advance line selected for shorter duration and rust resistance and 'PBW343' selected for wider adaptation, high grain yield, high iron and zinc. The results indicated that 'VL *Gehun* 907' have better response to changed climatic conditions, higher content of iron (43.5 & 45.2 ppm), zinc (35.4 & 36.3 ppm), copper (5.29 & 5.12 ppm) and manganese (42.5 & 41.8ppm), respectively under rainfed and irrigated conditions, coupled with very good chapatti quality (7.52-7.64). In addition, it also possesses resistance to brown and yellow rust, exhibited higher grain yield than the prevailing varieties.

**Key words :** Brown and yellow rust, chapatti quality, micronutrients, 'VL Gehun 907'.

Wheat (*Triticum aestivum* L. em. Thell) contributes more than 25% of the global cereal output, and constitutes the main source of calories for more than 1.5 billion people (Reynolds *et al.,* 1999). Developing countries are expected to increase their demand of cereals by 80% between 1999 and 2020 (Pinstrup-Anderson and Pandya-Lorch, 1997). With the current levels of food crop productivity in developing countries are expected to import 138 million tonnes of wheat every year by 2020. Thus for ensuring food security, breaking of yield stagnation through exploitation of gene pools of winter and spring wheats is considered as one of the potential approaches.

Wheat is the most important winter cereal crop of Northern hills of India comprising the states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand hills and covering around 10 lakh ha area, which is around 3.7% of the total wheat area in the country (Chanda *et al.,* 2010). Though area-wise this is very small but it assumes national significance for the management of rust diseases, since the northern hills are considered as foci of infection for these diseases. Therefore, cultivation of rust resistant varieties in northern hill zone is the key national strategy in rust management to reduce the inoculum load for the wheat crop of north-western plains, the wheat bowl of India. Besides, household nutritional and food security is essential in the areas of Northern hills as the majority of area is landslide prone and has difficult accessibility. Although, around 83 % of the area in northern hills is rainfed, the seasonal precipitation of about 200 mm is sufficient to grow a good crop of wheat under rainfed conditions. Further, comparatively cooler season and longer crop duration in hills are suitable to achieve fairly good yields even under rainfed conditions, if appropriate high yielding varieties and matching agro-technology are adopted (Kant, 2006). Despite these apparent advantages wheat productivity is quite low (17.5 q/ha) in the zone as compared to the national average of 29 q/ha (Chanda *et al.*, 2010) mainly due to unavailability of inputs (seed, fertilizer *etc.*) at appropriate time and place, small and fragmented land holdings and poor extension of recent technologies. But during recent times there has been a change in the climatic conditions with reduction in winter rains as well as higher temperatures during the crop growth period. These affected the crop adversely, particularly the timely sown rainfed and irrigated crop and it has experienced frequent dry weather conditions, sometimes drought like situations. The prevailing varieties did not perform well under these changed climatic conditions and they require immediate replacement. Besides, 'HS 240' and 'VL

*Gehun* 738', still being cultivated under timely sown rainfed and irrigated conditions of northern hills zone, have become highly susceptible to rusts and other diseases. The other variety 'VL 804' released in 2002 has shown tolerance to the new races of the yellow & brown rust pathogens and changed climatic conditions and, is the only option left with the farmers. All the three recommended varieties have lower micronutrient content calling for suitable replacement. This situation requires specific set of varieties, which should be characterized with the ability to tolerate drought, has wider adaptability and capability to yield higher particularly under rainfed conditions coupled with rich micronutrients. To meet the demand for a suitable high yielding and rust resistant variety with better tolerance to rainfed situations under change climatic conditions and nutritionally rich, a typical pedigree breeding programme has been taken up at *Vivekananda Parvatiya Krishi Anusandhan Sansthan* (VPKAS), (ICAR), Experimental Farm, Hawalbagh, India (29º 36'N and 79º40' E and 1250 m amsl) in 1996-97.

## MATERIALS AND METHODS

The winter wheat 'DYBR1982-83/842ABVD50' was selected from 6th Facultative and Winter Wheat Observation Nursery (FAWWON) from CIMMYT, Turkey for drought tolerance and higher number of tillers. This was an outcome of CIMMYT-ICARDA-Turkey International Winter Wheat Improvement Programme and was originated at Izmir, Turkey. The other parent 'VW 9365' was an advance line developed at VPKAS, Almora by crossing 'NI 8188' and 'CPAN 1869'. This advance line was selected for shorter duration and rust resistance. The $F_1$ of 'DYBR1982-83/842ABVD50' and 'VW 9365' was crossed with 'PBW 343' the Mega variety selected for wider adaptation, high grain yield and high iron (45.8 mg/kg) and zinc (43.9 mg/kg). The $F_1$ was bulked harvested and in subsequent generations typical pedigree method was followed. Five plants were selected in $F_2$ on the basis of agronomic suitability as well as rust resistance. Subsequently, in $F_3$, $F_4$ and $F_5$ 9, 8, 12 progenies were selected, respectively. In $F_6$, 5 promising progenies were harvested as individual bulks. One of the progenies was advanced to $F_7$ and harvested as bulk. This strain 'VW 0546' was tested under timely sown rainfed and irrigated conditions at Experimental Farm, Hawalbagh. Almora, Uttarakhand and rainfed condition at KVK, Chinyalisaur, Uttarakashi, Uttarakhand and yielded better than the best check HS 240, therefore, further evaluated as 'VL 907' under 21 and 11 All India Co-ordinated Wheat Improvement yield evaluation trials at 10 and 6 different locations under timely sown rainfed and irrigated conditions, respectively, in Himachal Pradesh, Jammu & Kashmir, West Bengal, Manipur and Uttarakhand states of northern hills during 2006-09. During 2006-07, 2007-08 and 2008-09 total 25, 8 and 14 entries (including checks), respectively, were tested at all the location following randomized complete block design with 6 replicates. The recommended sowing time of second fortnight of October for rainfed and 1st fortnight of November for irrigated conditions was followed. Uniform 6 row plot of 3 m with 23 cm row to row distance for each entry was followed at all the locations. The crop received 60 kg/ha N, 60 Kg/ha P and 40 Kg/ha K as a basal dose and 30 kg/ha N as a top dressing each after first irrigation and at the jointing stage. 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 compiled 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 analyzed for different quality parameters as well as micronutrients content following standard procedures at Quality Laboratory, Directorate of Wheat research, Karnal, Haryana. The centre wise data was then pooled.

Disease screening was done 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 predominant 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

'VL 907' the most promising entry in these trials was identified by Varietal identification Committee of ICAR and subsequently named as 'VL *Gehun* 907' (Fig 1) and notified in December 2010 by the Central Sub-

Committee on Crop Standards, Notifications and Release of Varieties for Food crops, Department of Agriculture & cooperation, Ministry of Agriculture, Govt. of India, New Delhi. It has been recommended for cultivation under timely sown rainfed and irrigated conditions of H.P., J& K., Uttarakhand, West Bengal and Manipur hills. 'VL *Gehun* 907' is a spring wheat with semi-erect growth habit during early phase. Its foliage color is dark green. Plants are semi tall of about 82-97 cm in height. At the flowering stage the flag leaf and leaf sheath has a layer of wax. At maturity the ears become creamy white in color and tapering in shape with medium density.

***Utilization of winter wheat for breaking yield barrier through incorporating drought tolerance***

Winter wheats possess tolerance to drought as well as heat in addition to huge variability for tillering, leaf size, spike length, grain size, grain number and better N and P efficiency even under low input conditions (Nanda and Sohu , 1998). But, they have a specific vernalization and photoperiod requirement depending upon their genetic constitution making their commercial cultivation impossible in subtropical climate (Kant *et al.,* 2001; Kant and Gupta, 2002; Shoran *et al.,* 2003). However, under sub-temperate conditions like Almora, they usually flower without any artificial vernalization treatment. This gene pool assumes great importance for enhancing wheat production by insulating future varieties with the abiotic stresses tolerance along with other desirable attributes. Some of the compelling pieces of evidence of drought tolerance of winter x spring wheat derivatives comes in the form of 'Veery S' and 'Nesser', which combines high yield performance in favorable environments and adaptation to drought in more marginal areas. When 'Veery S' was tested in 73 environments in the early 1980s, it yielded better than other cultivars not only in high yielding environments but also under reduced irrigation. By 1990, 63% of the dryland wheat area in developing countries was sown to semi-dwarf wheats (Byerlee and Moya, 1993). The performance of Nesser in the dryland environments of WANA has been widely publicized, and the line is considered to represent a uniquely drought-tolerant genotype. Considerable progress can thus be made by exploiting winter wheat gene pool for improving spring wheats by developing the optimal combinations of these genes for a particular environment (Reeves *et al.,* 1999). 'VL *Gehun* 907' proves to be another evidence of drought tolerance and yield responsiveness.

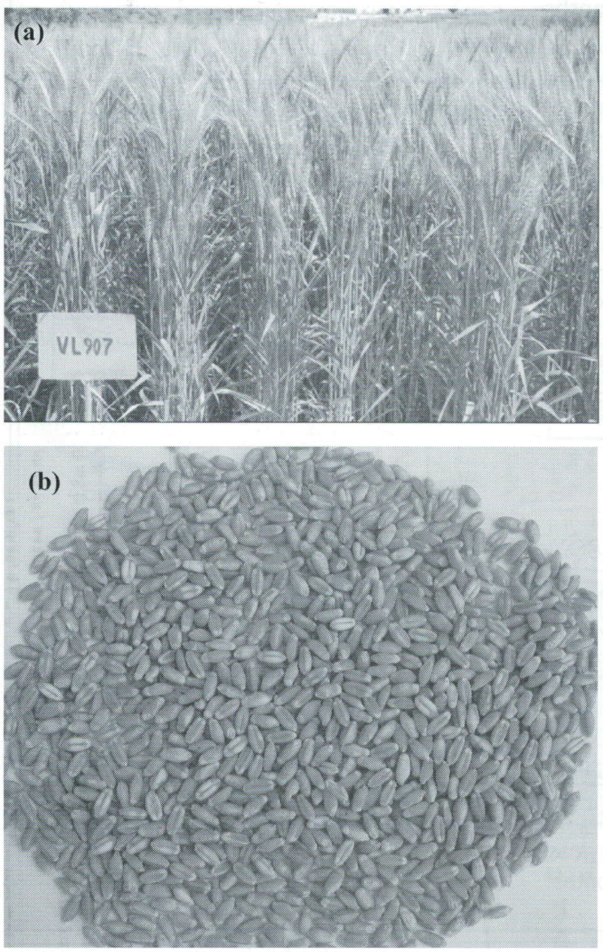


**Fig 1.** Field view of 'VL *Gehun* 907' (a) and Grains of 'VL *Gehun* 907' (b)

During the last 5 years, there has been reduction in winter rains in Northern hills. This fact is very well illustrated by the Hawalbagh climate data as the same from other stations is not available. The reduction in winter rains is prevailing during all the months of wheat crop growth in the hills, except February (Fig 2). Interestingly, the average temperature did not show any drastic change but the maximum temperature has increased up to the tune of 2.26°C and the minimum temperature has decreased up to 1.38 °C (Fig 3). Therefore, most of the wheat crop has suffered as the prevailing varieties could not respond well to the changed climatic conditions.

During the 3 crop seasons (2006-07 to 2008-09) of testing in All India Coordinated multi-location trials in northern hills of India, 'VL *Gehun* 907' gave an average grain yield of 2795 and 4428 q/ha, respectively under rainfed and irrigated conditions, which was 18.0, 24.2 & 16.4% and 15.9, 11.0 & 5.9 % higher than the checks 'HS 240', 'VL *Gehun* 738' and 'VL 804', respectively under the

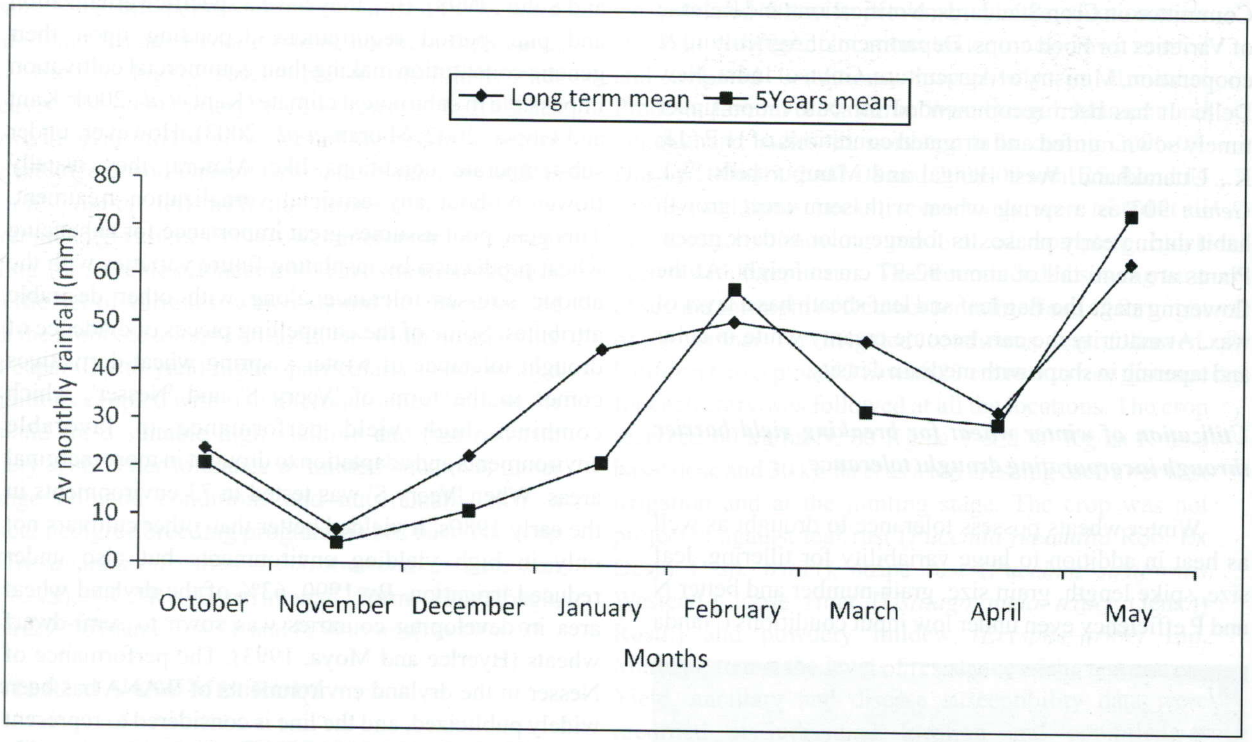


**Fig. 2:** Long term and last 5 year's average monthly rainfall (mm) at Hawalbagh, Almora

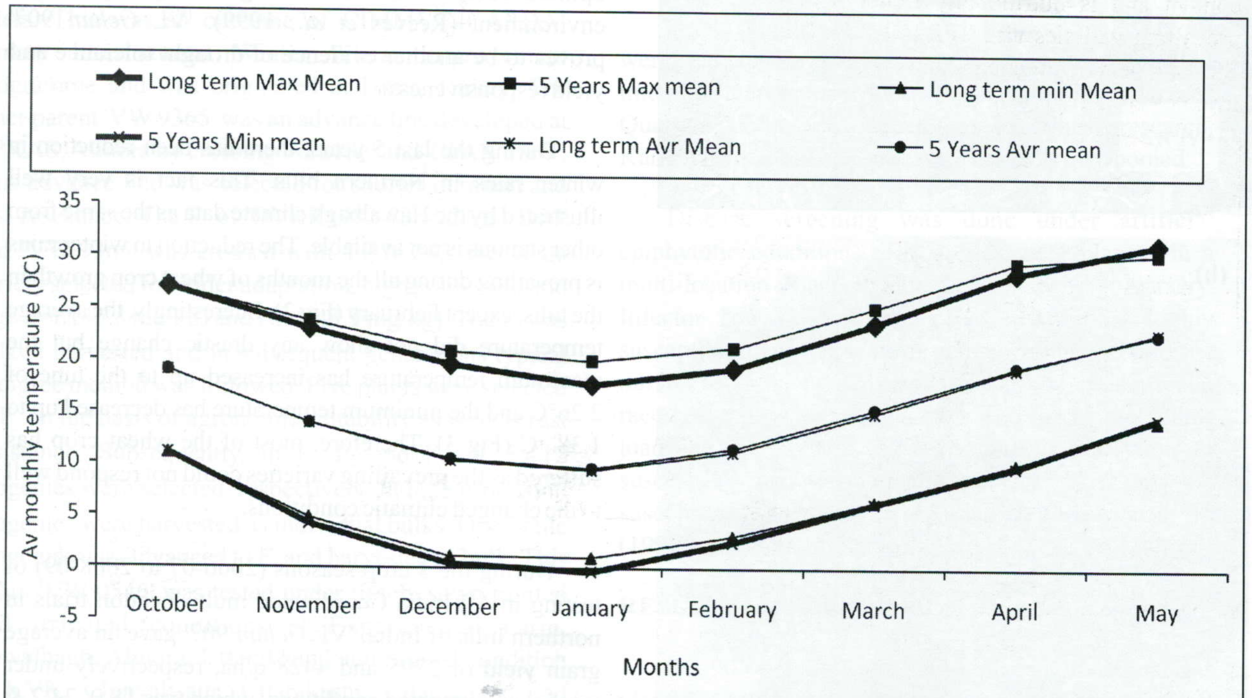


**Fig. 3:** Long term and last 5 year's mean maximum, minimum and average monthly temperature ($^0$C) during the crop growth period at Hawalbagh, Almora

respective conditions (Fig. 4.) (Shoran *et al*., 2007; Shoran *et al*., 2008; Shoran *et al.,* 2009). It can be inferred that 'VL *Gehun* 907' has performed significantly higher than all the prevailing checks under the changed climatic conditions and this gain is more pronounced in rainfed conditions.

***Micronutrients***

VL *Gehun* 907' possesses 43.5 & 45.2 ppm of iron, 35.4 & 36.3 ppm of zinc, 5.29 & 5.12 ppm of copper and 42.5 & 41.8 ppm of manganese under rainfed and irrigated conditions, respectively. The iron content is higher by 3.08 & 12.4% of 'HS 240', 13.6 & 28.1 % of 'VL *Gehun* 738' and 19.5 & 39.5% of 'VL 804', respectively under rainfed and irrigated conditions. The zinc content is 8.3 &17.5% higher of 'HS 240', 5.4 & 9.0% of 'VL *Gehun* 738' and 19.2 & 21.0% higher of 'VL 804', respectively under rainfed and irrigated conditions. The copper content is higher by 83.1 & 84.8% of 'HS 240', 76.3 & 68.4% of 'VL *Gehun* 738' and 37.4 & 35.8% of' VL 804', respectively under rainfed and irrigated conditions. Similarly the manganese content is higher by 24.3 & 27.8% of 'HS 240', 32.4 & 38.0% of 'VL *Gehun* 738' and 13.6 & 9.1 % of 'VL 804', respectively under rainfed and irrigated conditions (Gupta *et al*, 2007, Gupta *et al*, 2008, Gupta *et al*, 2009) (Table 1). Therefore, 'VL *Gehun* 907' has much higher zinc, manganese, copper and iron content and is nutritionally richer than all the three prevailing varieties *viz.,* 'HS 240', 'VL *Gehun* 738' and 'VL 804' being cultivated under timely sown rainfed and irrigated conditions in hills.

***Quality***

The results of quality analysis suggest that 'VL *Gehun* 907' is quality wheat. The average protein content of 10.29 and 11.62% under rainfed and irrigated conditions, respectively and sedimentation value of 37 ml is suggestive of its better suitability for chapatti, the most preferable mode of wheat consumption in India. During product evaluation it scored 7.64 and 7.58 score out of 10 for chapatti quality, under rainfed and irrigated conditions, respectively, which is categorized as very good chapatti (7.1-8.0 is graded as very good chapatti) with maximum score of 10. The high hectolitre weight of 79.4 and 78.4 kg/ha under rainfed and irrigated conditions, respectively indicates a very good flour recovery during milling (Gupta *et al*, 2007, Gupta *et al*, 2008, Gupta *et al*, 2009).

***Adaptability to agronomic treatments***

The experiment conducted during 2008-09 to assess the suitability of 'VL *Gehun* 907' to different dates of sowing at Almora, Bajaura, Malan, Shalimar and Shimla under irrigated conditions indicated that it performed better and gave less reduction in yield (18.10%) under late sowing conditions, whereas reduction in the yield of two checks, 'HS 240' and 'VL *Gehun* 738' was by 26.62 and 23.87 percent, respectively was higher (Sharma *et al*., 2009) (Fig 5a). Only check 'VL 804' showed lesser reduction than 'VL *Gehun* 907'. However, 'VL *Gehun* 907' was significantly superior to all the 3 checks at both

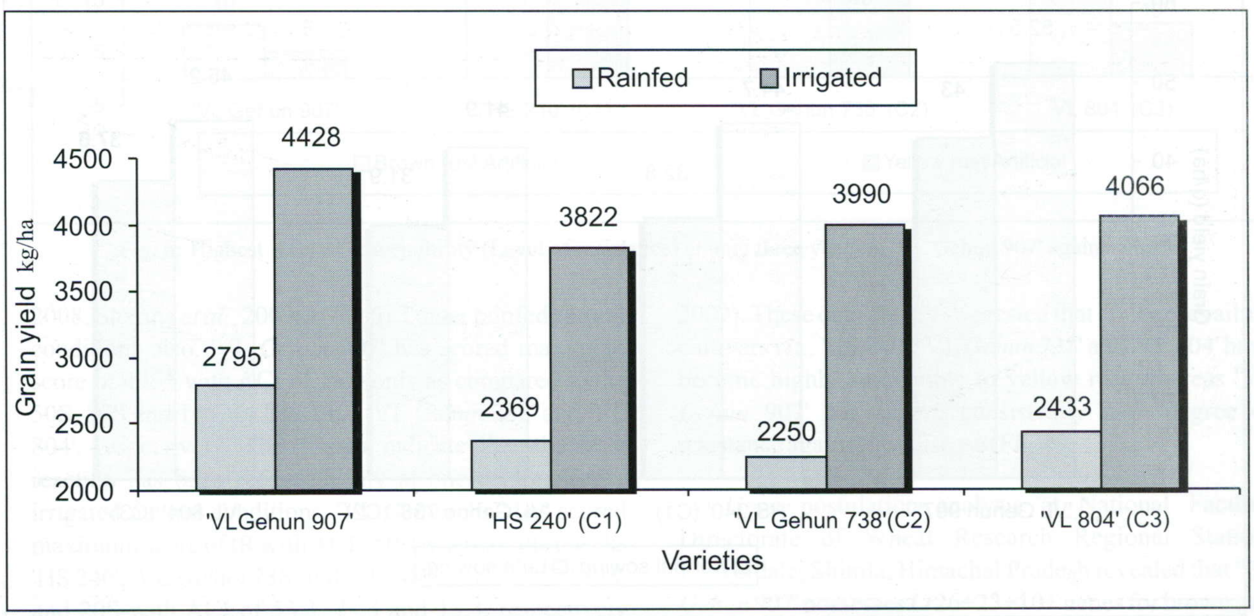


**Fig. 4:** Average grain yield (kg/ha) of 'VL Gehun 907' along with checks

the sowings. Another experiment on fertilizer response at Almora, Bajaura, Malan, Shalimar and Shimla under rainfed conditions indicated that 'VL *Gehun* 907' responded up to 60 Kg/ha N, but yielded significantly superior to all the 3 checks at all the 3 levels of N (Fig 5b).

The increase in grain yield in 'VL *Gehun* 907' was also expressed in its yield components under late sowing as well as higher dose of N. The 1000 grain weight increased from 48.8 to 49.7 g in 'VL *Gehun* 907' under late sowing, however, it decreased in case of 'HS 240' (from 43.2 to 40.7 g) , 'VL *Gehun* 738' (from 43.2 to 41.9 g) and 'VL 804' (from 46.7 to 45.4 g). Under rainfed conditions the ear head/sq. m (from 289 to 311) and 1000 grain weight (from 45.3 to 46.1 g) increased up to 60Kg/ha N in 'VL *Gehun* 907'. However, 1000 grain weight decreased in 'HS 240' (from 39.2 to 38.5 g) and 'VL *Gehun* 738' (from 42.5 to 41.6 g) at the same level. Therefore, broadly these parameters indicate that among these 'VL *Gehun* 907' responded better to the changed climatic conditions, hence, is much more suitable variety.

***Resistance to brown and yellow rust***

Brown and yellow rust are the two most important diseases of wheat in northern hills. During 2006-07 to 2008-09 the highest brown rust score of 10MS with average coefficient of Infection (ACI) of 2.3 was recorded on 'VL *Gehun* 907' under multi-locational All India Plant Pathological disease screening nursery under artificial conditions. However, during the same year, brown rust scores of 30S, 60S and 30S with ACI of 9.7, 15.5 and 13.0 were recorded on the prevailing checks *viz.,* 'HS 240', 'VL *Gehun* 738' and 'VL 804', respectively (Sharma *et al.* 2007, Sharma *et al.* 2008, Sharma *et al.* 2009) (Fig 6). Under natural conditions, 'VL *Gehun* 907' was free from rust whereas checks, 'HS 240', 'VL *Gehun* 738' and 'VL 804' scored highest score of tR, 20S and 80S, respectively under irrigated conditions (Fig 6). These data indicate that all the prevailing cultivars *viz.,* 'HS 240', 'VL *Gehun* 738' and 'VL 804' recommended for timely sowing in Northern hills have become highly susceptible to brown rust disease whereas the newly developed cultivar 'VL *Gehun* 907' has shown high degree of resistance to brown rust under both natural as well as artificial conditions (Shoran *et al.*, 2007; Shoran *et al.*, 2008; Shoran *et al.* 2009).

'VL *Gehun* 907' has been evaluated for yellow rust resistance along with three checks, *viz.,* 'HS 240', 'VL *Gehun* 738' and 'VL 804' under multi-locational All India Plant Pathological disease screening nursery under artificial conditions continuously for three years *i.e.,* 2006-07 to 2008-09. It has shown highest susceptibility of 5S with an ACI of 1.4 only, whereas checks 'HS 240', 'VL *Gehun* 738' and 'VL 804' have shown highest susceptibility of 60S, 60S and 10S with ACI of 45.0, 36.6 and 3.6, respectively (Sharma *et al.*, 2007; Sharma *et al.*,

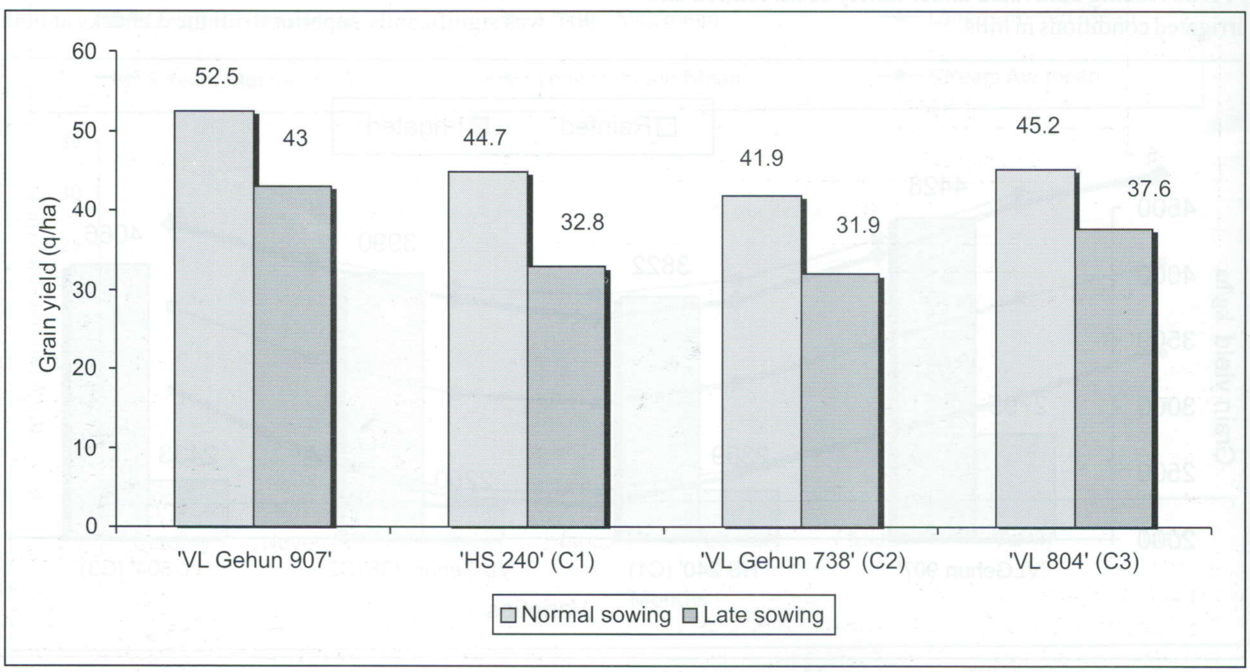


**Fig. 5a:** Response of 'VL Gehun 907' to normal (NS) and late sowing (LS)

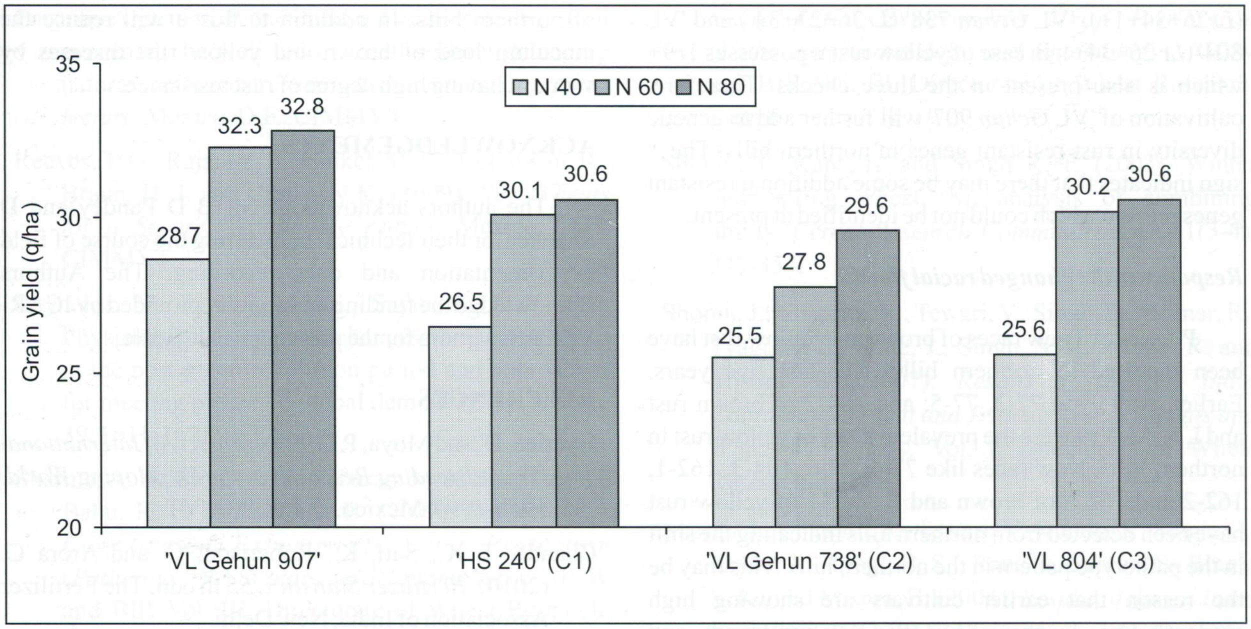


**Fig. 5b:** Response of 'VL Gehun 907' to different level of Nitrogen

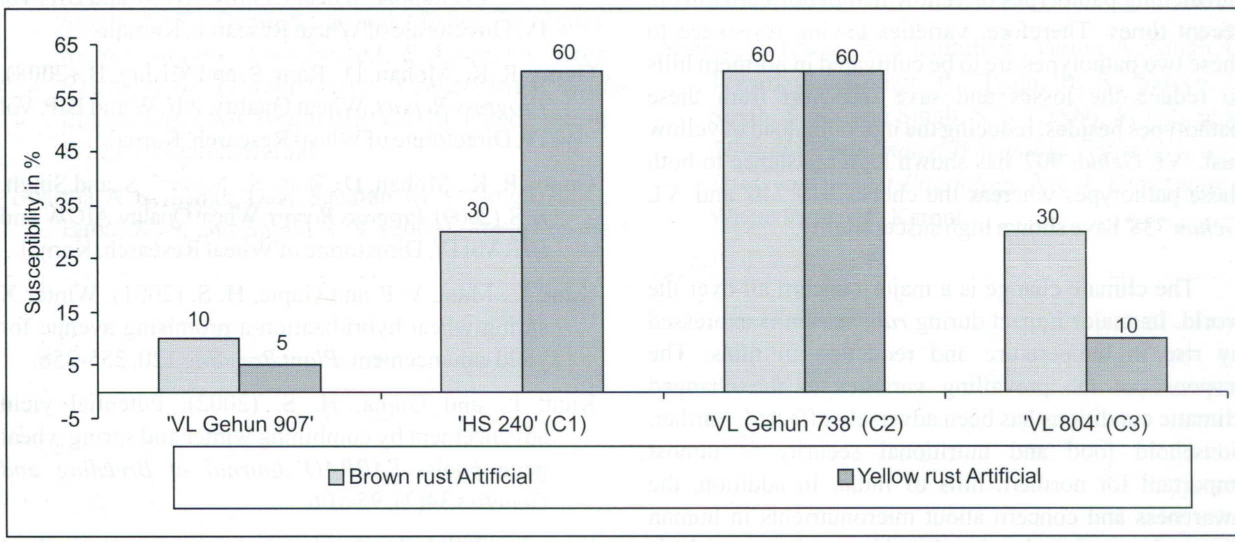


**Fig. 6:** Highest level of susceptibility (Level of resistance) among three years in 'VL Gehun 907' against checks

2008; Sharma *et al*., 2009a) (Fig 6). Under rainfed natural conditions also, 'VL *Gehun* 907' has scored maximum score of 40S* with ACI of 16.0 only as compared to the 50S, 50S and 10S for 'HS 240', 'VL *Gehun* 738' and 'VL 804', respectively. The * sign indicate that the high reaction has been recorded only at one centre. Under irrigated natural conditions, 'VL *Gehun* 907' has scored maximum score of tR with ACI of 0.1whereas, the checks 'HS 240', 'VL *Gehun* 738' and 'VL 804' scored 60S, 100S, and 20S with ACI of 53.3. 73.3 and 13.3, respectively (Shoran *et al*. 2007, Shoran *et al*. 2008, Shoran *et al*. 2009). These data clearly suggested that all the prevailing cultivars *viz*., 'HS 240', 'VL *Gehun* 738' and 'VL 804' have become highly susceptible to yellow rust whereas 'VL *Gehun* 907' has shown consistently high degree of resistance against this disease (Fig. 6).

Gene postulation analysis at National Facility, Directorate of Wheat Research Regional Station, Flowerdale, Shimla, Himachal Pradesh revealed that 'VL *Gehun* 907' possesses *Lr*26+23+10+ genes for brown rust resistance. This combination is different to 'HS 240'

(*Lr*26+34+1+), 'VL *Gehun* 738' (*Lr*26+23+34.) and 'VL 804' (*Lr* 26+34+). In case of yellow rust it possesses *Yr*9+ which is also present in the three checks. Therefore, cultivation of 'VL *Gehun* 907' 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.

***Response to the changed racial flora***

Presence of new races of brown and yellow rust have been reported in northern hills over last five 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 detected from northern hills indicating the shift in the pathotype pattern in the northern hills. This may be the reason that earlier cultivars are showing high susceptibility. Further, 46S119 (*Yr*9 virulence) and 78S84 ('PBW 343' virulence) 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. 'VL *Gehun* 907' has shown high resistance to both these pathotypes whereas the checks 'HS 240' and 'VL *Gehun* 738' have shown high susceptibility.

The climate change is a major concern all over the world. Its major impact during *rabi* season is expressed by rise in temperature and reduction in rains. The response of the prevailing varieties to the changed climatic conditions has been adversely affected. Further, household food and nutritional security is utmost important for northern hills of India. In addition, the awareness and concern about micronutrients in human diet is increasing day by day. Now-a-days enriching major staple food crops (e.g., rice, wheat, maize etc.) with micronutrients through plant breeding approaches is being considered as one of the most suitable and cost effective strategies. VPKAS, Almora, Uttarakhand has developed a wheat variety, 'VL *Gehun* 907', having better response to climate change conditions, higher micro-nutrient content, higher yield combining with higher resistance to brown and yellow rusts as compared to the prevailing varieties and is best suited for chapatti making. Therefore, the cultivation of 'VL *Gehun* 907' will provide higher yields under climate change conditions and nutritional security in the difficult and inaccessible areas of northern hills. In addition to this it will reduce the inoculum load of brown and yellow rust diseases by virtue of having high degree of rust resistance.

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