

## Is the national wheat breeding programme demand-driven? – An analysis

D. Mohan, S. Nagarajan, R. V. P. Singh and Jag Shoran

*The varietal improvement programme in wheat research deals with different species, production conditions and mega-environments. The system developed by the All India Co-ordinated Wheat Improvement Project (AICWIP) has notified 51 new wheat varieties during the period 1995–2000 and produced 66.5 thousand quintals of breeder seed of 106 varieties to enhance varietal diversity. The quantity of breeder seed produced, varietal diversity in the seed chain and the new notifications have been taken as criteria to assess whether the AICWIP is demand-driven. The study revealed that topmost priority should be given to develop normal sown varieties for the north-western plains and late sown varieties for the north-eastern plains. Durum in the north-western plains has been over emphasized. The rainfed bread wheat and irrigated durum varieties carry demand mostly in the central India and varietal improvement programme for such situations is well organized in that region. The analysis can help the AICWIP to restructure the varietal improvement programme for better resource investment.*

The wheat (*Triticum* spp) breeding programme under the AICWIP (All India Coordinated Wheat Improvement Project) of ICAR is the nodal agency for developing wheat varieties for cultivation by farmers. The positive growth in wheat production and productivity over the last three decades suggests that the challenge of meeting the varietal needs under

diverse environments has been accomplished very successfully by the AICWIP. Between 1995 and 2000, fifty-one wheat varieties have been notified through the efforts of AICWIP covering six mega wheat-growing environments, i.e. North-Western Plains Zone (NWPZ), North-Eastern Plains Zone (NEPZ), Central Zone (CZ), Peninsular Zone (PZ),

Northern Hills Zone (NHZ) and Southern Hills Zone (SHZ). They cover various production conditions like normal-sown, late-sown, rainfed, etc. (Table 1). The normal-sown as well as late-sown wheat is generally planted under assured irrigation. The late-sown crop is planted between 10 and 25 December, while normal-sown is seeded between 10 and

**Table 1.** Detail of the 51 wheat varieties notified during 1995–2000

Production condition	NWPZ	NEPZ	CZ	PZ	SHZ	NHZ
Bread wheat Timely-sown, irrigated	UP 2338 PBW 343 HD 2687	HP 1731 K 9107 HP 1761 K 9006* NW 1012 HUW 468 PBW 443	GW 273	AKW 1071* Parbhani 51*	HW 1085	VL 719* VL 738
Bread wheat Late-sown, irrigated	UP 2338 PBW 373* Raj 3765 Sonak* UP 2425	HD 2643 HP 1744 NW 1014 UP 2382*	GW 173 DL 803-3 DL 788-2 HI 1418* HI 1454*	DWR 195 NIAW 34* Parbhani 51*	–	–
Bread wheat Timely-sown, rainfed	PBW 396	NIL	JWS 17 HW 2004	K 9644	–	Saptdhara* Surbhi* HS 365
Bread wheat Late-sown, rainfed	–	K 8962 K 9465	–	–	–	–
Bread wheat Salt-affected soils, timely-sown, irrigated	KRL 19	KRL 19	KRL 19	–	–	–
Durum Timely-sown, irrigated	WH 896 PDW 233*	–	HI 8381 HI 8498	DWR 185* MACS 2694* MACS 2846	–	–
Durum Timely-sown, rainfed	–	–	HD 4672	NIL	–	–
Dicoccum Timely-sown, irrigated	–	–	–	DDK 1001 DDK 1009	–	–

\*Varieties recommended for states only.

25 November. Naturally, the growth duration of normal-sown wheat is longer and it yields better. Yield of the late-sown wheat is highly influenced by the preceding crop and the available growth period. Short duration wheat has been successfully utilized by the farmers for increasing the cropping intensity. The rainfed wheat gets no irrigation and sowing is normally completed between 15 and 30 October, to take advantage of the receding moisture left behind by the monsoon. To cater seed demand for various production systems in the six mega zones, 66.5 thousand quintal breeder seed of 106 wheat varieties were produced by the ICAR/SAU system during this period<sup>1</sup>. And this facilitated the spread of high-yielding genotype to the farmers.

The relative importance of a production condition or a particular zone can largely be judged by the amount of breeder seed produced for the variety meant for that situation. The number of varieties in the breeder seed programme is a reflection of the varietal diversity existing in a zone or production condition. The AICWIP arranges breeder production on the basis of seed indents received from the Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, Government of India. This seed demand and the varieties that were notified during the period 1995–2000 were examined to assess if the AICWIP is demand-driven and client-friendly. This study may thus help to fine-tune the programme and redefine the priorities for future.

### New wheat varieties

Wheat varieties have been notified for all cultivated *Triticum* species (*aestivum*, *durum* and *dicoccum*) and production conditions in the plains (Table 2). It appears that the success rate was higher in late-sown bread wheat as more varieties were notified even though area under late-sown condition is much less than normal-sown situation. For irrigated situation, seven *durum* and two *dicoccum* varieties have been notified, even though area under irrigated tetraploid in the country is around 0.7–0.8 mha. The salt-affected soils along the Ganges system in the NWPZ and NEPZ have wheat in around 1.0 mha area and for this specific situation one wheat variety, i.e. KRL 19 was notified. The number of varieties

released annually per million hectare area was minimum for the most prevalent production condition i.e. timely-sown, irrigated. The diversity index suggested by Byerlee and Traxler<sup>2</sup>, i.e. the number of releases per million hectares per year, underlines the point that varietal diversity for this important environment could not be properly supplemented, whereas release of new varieties for small production conditions like rainfed-late-sown or *durum* was much higher.

An attempt was made to understand how effectively the varietal improvement programme responded in providing better alternate varieties for these specific growing conditions. The breeder seed demand and quantity produced for recommended varieties can serve as an easy yardstick to quantify the client, i.e. farmer's need. Data related to the period

1995–2000 was culled from the annual reports of the AICWIP and examined (Table 3).

### Irrigated vs rainfed wheat

The six-year mean for breeder seed production of varieties for irrigated, timely-sown condition accounted for 93.6% of the total breeder seed demand. This roughly matches the ground reality, as about 90% of the area sown to wheat in India has access to irrigation. Information on the breeder seed production indicates that seed demand is fairly in accordance with the area under these situations. Since the seed demand was within limit, the number of genotypes released for various situations by the crop improvement programme was examined.

**Table 2.** Wheat varieties released for different production conditions in plains during 1995–2000

Production condition	Varieties notified	Approx. area (mha)	Releases/ mha/yr
<b>Bread wheat</b>			
Timely-sown, irrigated	13	14.0	0.15
Late-sown, irrigated	17	6.0	0.47
Timely-sown, rainfed	4	1.5	0.44
Late-sown, rainfed	2	0.5	0.66
Salt-affected soils, irrigated	1	1.0	0.17
<b>Durum</b>			
Timely-sown, irrigated	7	0.8	1.46
Timely-sown, rainfed	1	0.7	0.24
<b>Dicoccum</b>			
Timely-sown, irrigated	2	0.01	33.3

**Table 3.** Total breeder seed production, varieties in seed chain and release of new wheat varieties for different production conditions of plains (total: 1995–2000)

Production condition	Seed produced (q)	Varieties multiplied	Varieties released
<b>Irrigated vs rainfed (all <i>Triticum</i> species)</b>			
Irrigated	61520	76	38
Rainfed	4240	18	7
<b><i>Triticum</i> spp (all conditions)</b>			
<i>T. aestivum</i>	63812	84	35
<i>T. durum</i>	1928	10	8
<i>T. dicoccum</i>	0	0	2
<b>Timely-sown vs late-sown (bread wheat)</b>			
Timely-sown <sup>†</sup>	44527	46	14
Late-sown <sup>‡</sup>	15104	22	15

<sup>†</sup>Includes timely-sown varieties also suitable for late sowing and salt-affected soils.

<sup>‡</sup>Varieties recommended exclusively for late sowing.

### Normal-sown vs late-sown wheat

It is evident that greater success has been achieved by the irrigated late-sown programme in comparison to the irrigated timely-sown programme with regard to the release of bread wheat varieties. The demand for breeder seed of the irrigated, timely-sown varieties is almost three times higher than that of the varieties meant for late-sown conditions. Yet with nearly 14.0 mha area under irrigated timely-sown situation, the number of wheat varieties that were released in six years was only 13 and it included PBW 343, a variety that has occupied at least 4.0 mha during 1999–2000 in the NWPZ. On the contrary, 17 new varieties were released for the nearly 6.0 mha under irrigated late-sown situations. Because of this, there seems to be a greater diversity under late-sown situation and area dominance by a single variety is not happening.

### Importance of different *Triticum* species

India is the only country having a well-organized varietal improvement effort for the three *Triticum* species, i.e. *aestivum*, *durum* and *dicoccum*. The estimated area under tetraploid (*durum* and *dicoccum*) in central, peninsular and the north-western India is nearly 1.51 mha. For irrigated situation, seven *durum* and two *dicoccum* varieties have been notified during this five-year period. Also, one *durum* was released for the rainfed situation. The nine *durum* varieties under seed multiplication and eight new releases for a target environment of only 1.2–1.5 mha indicates that *durum* improvement research is either not demand-driven or is getting over-emphasized. The number of varietal releases and the varieties for which seed is produced show that there is adequate varietal diversity in *durum*.

### Comparison of various wheat production conditions in the plains

Nationwide, there is a great demand for the timely-sown bread wheat varieties. The seed production programme also involved maximum varieties for this situation. However, the number of new varieties released during 1995–2000 for different situations indicates that ongoing research efforts are more beneficial in

certain situations (Table 4). Except for the timely-sown situation, for all other conditions, more wheat varieties were made available in comparison with their actual demand. The gap between seed demand and newly released varieties was disproportionately large for *durum* and rainfed wheat, suggesting that there is an overemphasis of these situations in the wheat breeding programme of the AICWIP.

### Comparison of different mega environments

The NWPZ, also called the wheat bowl of the country, has the maximum demand of wheat seed and accounts for over 52.3% of the total breeder seed production in the country (Table 5). In the other extreme, there was no demand for seed in the SHZ. Breeder seed production of 46 wheat varieties in the NWPZ indicates that there has always been a great demand to cultivate different types of varieties in this region. However, a critical look at the varietal notification for different zones during the past six years reveals that in comparison to the NWPZ, newer varieties are being made

available to the NEPZ and CZ. Though the NWPZ has many varieties in the seed chain, the number however is not sufficient in comparison to the large seed programme in this zone. Jain and Byerlee<sup>3</sup> had earlier pointed out similar disparities in this zone in a report prepared in 1992. This zone has relatively poor varietal diversity as just four varieties (PBW 343, WH 542, UP 2338 and HD 2329) account for half of the seed demand. All other zones are not over-dependent on so few varieties. Spatial diversity measured using number of cultivars by percentage of area<sup>4</sup> is also lowest in the NWPZ, whereas the zones, like the NHZ and PZ, with an area around one million hectares register high spatial diversity. The NWPZ, therefore, requires more genetic diversity, but it appears that success in getting a variety released is restricted, as the candidate varieties are seldom able to excel the check PBW 343 in grain yield. The reverse may be true for the NEPZ where a large number of genotypes have been notified and the variety released in 1984, i.e. HUW 234 is still in great demand. The average life of a wheat variety in the NEPZ is about 12 years and it is mainly due to poor seed replacement. The north-eastern region is

**Table 4.** Varietal diversity in breeder seed production under different production conditions of plains (total: 1995–2000)

Production condition	Breeder seed produced (q)	Varieties multiplied	Varieties notified
<i>T. aestivum</i> – timely-sown <sup>†</sup>	44527	46	14
<i>T. aestivum</i> – late-sown <sup>§</sup>	15104	22	15
<i>T. durum</i> – timely-sown	1890	8	7
<i>T. aestivum</i> – rainfed	4182	16	6
<i>T. durum</i> – rainfed	38	2	1
<i>T. dicoccum</i> – timely-sown	0	0	2

<sup>†</sup>Includes timely-sown varieties also suitable for late sowing and salt-affected soils.

<sup>§</sup>Varieties recommended exclusively for late sowing.

**Table 5.** Breeder seed production, varieties in seed chain and notification of wheat varieties in different zones during 1995–2000

Zone	Approx. area (mha)	Seed produced (1000 q)	Varieties multiplied	Varieties released
NWPZ	9.0	34.38	36	11
NEPZ	9.5	13.67	28	14
CZ	5.5	12.68	18	12
PZ	1.5	5.01	12	10
NHZ	1.0	0.78	12	5
SHZ	0.01	0.00	0	1
All India	26.51	66.53	106	51

**Table 6.** Zone-wise breeder seed production, varieties in seed chain and notification of wheat varieties for different production conditions of plains (total: 1995–2000)

Production condition	Seed production (q)	Varieties multiplied	Varieties released	Seed production (q)	Varieties multiplied	Varieties released
	NWPZ			NEPZ		
Timely-sown <sup>†</sup>	25762	18	4	5731	14	8
Late-sown <sup>‡</sup>	6232	8	4	7326	8	4
<i>Durum</i>	793	4	2	NA	NA	NA
Rainfed <i>aestivum</i>	1595	6	1	610	6	2
Rainfed <i>durum</i>	NA	NA	NA	NA	NA	NA
<i>Dicoccum</i>	NA	NA	NA	NA	NA	NA
	CZ			PZ		
Timely-sown <sup>†</sup>	8640	9	2	4394	5	2
Late-sown <sup>‡</sup>	958	2	5	588	4	2
<i>Durum</i>	1070	3	2	27	1	3
Rainfed <i>aestivum</i>	1975	3	2	1.2	1	1
Rainfed <i>durum</i>	35	1	1	3	1	0
<i>Dicoccum</i>	NA	NA	NA	0	0	2

<sup>†</sup>Includes timely-sown varieties also suitable for late sowing and salt-affected soils.

<sup>‡</sup>Varieties recommended exclusively for late sowing.

NA, Not applicable.

catching the attention in release of new wheat varieties, but the seed demand of new varieties is quite low. The developmental agencies will have to play a significant role in popularizing the new high-yielding wheat varieties with the farmers. The big seed demand thus generated will also reduce the sizeable yield gap existing in the NEPZ. Although the CZ got 12 new varieties, one-third of the total breeder seed demand is still met through a 1981 release variety called LOK 1. This genotype continues to dominate in the CZ and has the acceptance of the farmers due to its good grain quality. In both the zones, ignorance of the farmers and lack of interest by the state functionaries are the two main reasons for poor varietal spread.

### Comparison of wheat production conditions in each zone

The breeder seed production and release of new wheat varieties was examined within the zone, to find the difference in trend between the zones for various situations (Table 6). Zone-wise priority for different situations has been noted to work out the strength and weakness of the programme in each region.

#### NWPZ

This zone has maximum demand for the normal-sown wheat varieties (74.9%),

but only four varieties could be notified for this production condition in comparison to the same number of varieties released for the late-sown situation, with just 18.1% demand of total breeder seed production. The *durum* demand in this region is minimal as against 2.3% share in the total seed production; there were four varieties in the seed chain, including two new genotypes released during 1995–2000. The rainfed programme in the NWPZ is well-supported.

#### NEPZ

In contrast to the NWPZ, the late-sown wheat varieties are in greater demand (53.6%), but there are not enough varieties to meet this requirement. In comparison to four wheat varieties for late-sown, eight were notified for the timely-sown situation, with 41.9% demand of the total breeder seed. Demand for rainfed wheat is very little (4.5%) and there are enough varieties to meet this demand.

#### CZ

Like the NWPZ, this zone has maximum demand for the timely-sown wheat varieties and this programme seems to be well-supported. The late-sown varieties, were however, preferred, with release of new genotypes as against four wheat varieties for normal-sown condition; five were notified for the late-sown situation.

Among all the zones, the CZ has highest seed demand for the irrigated *durum* and rainfed *aestivum* and both these programmes are well-addressed in this region.

#### PZ

This zone has seed demand mostly for the timely-sown wheat varieties (87.7%) and it needs more varieties for this situation. Demand for the late-sown situation is 11.7% and the programme has received good attention by way of varietal release and seed production. However, the *durum* and *dicoccum* varieties have not registered much impact on the farmers, therefore, judicious effort is needed in these programmes keeping in view the small area they occupy. There was also no demand of rainfed wheat varieties and efforts put in this direction can be better channelled in other activities, till a mechanism is developed by the DAC, Ministry of Agriculture for seed replacement under rainfed situation.

### Conclusion

The AICWIP has been giving equal emphasis to normal-sown, late-sown, rainfed bread wheat and normal-sown *durum* programme in each zone<sup>5</sup>. This analysis made it evident that there is a great need to re-define priorities for each zone. These are also locations where a big yield gap exists between farms and

farmers. It is now better understood that there is a need to have more varieties under timely-sown situation. The NWPZ needs varietal diversity under timely-sown situation, as only a few varieties occupy a very large area. In the NWPZ, it is becoming difficult to surpass the ruling variety PBW 343 which has a good blend of useful traits that help it to perform well under diverse situations. This widely-adapted variety is input-responsive and has a high level of resistance to the diseases that are of economic importance in this zone. In the yield trials, though 328 genotypes were evaluated during 1996–2000, none exceeded the latest checks either PBW 343 or HD 2687. To design a plant type superior to PBW 343, the crop improvement programme has to focus on its time and energy in searching for new sources or gene pools.

The late-sown programme has served a great deal in raising cropping intensity by making a slot for wheat in different crop sequences. The breeding for short-duration wheat has been well attended by the AICWIP, except in the NEPZ where it has to be better structured to suit the cropping diversity in this region. In view of very little maturity and yield differences between normal-sown and late-sown wheat in the peninsular region, there is a need to re-examine the relevance of late-sown materials in this warmer area.

The *durum* programme in the NWPZ is running on an unjustified need, as more attention is being paid by researchers, while the response of the farmers to grow *durum* has not been overwhelming. In the NWPZ, *durum* suffers due to unattractive grain quality, i.e. low test weight and mottled kernels. The trader, therefore, shows reluctance in procuring *durum* from here as it falls short of the industrial needs. Rightsizing the *durum* and *triticale* programme of the NWPZ to optimise cost and diverting human and financial resources to normal-sown bread wheat programme, is felt desirable. The crop improvement programme of this zone should better address the compelling issues of varietal diversity, to get rid of over-dependence on a few varieties. The grain quality of *durum* produced in the CZ is very good, being hard, lustrous and yellow berry-free; the farm produce meets the pasta industry needs. There is a need to promote *durum* research in this region, but the demand for *durum* seed has not been forthcoming. *Durum* yields better in the PZ and the grain size is large and attractive, but the zone suffers from inadequate seed production, rapid varietal replacement and lack of trade promotion.

The area under rainfed wheat is about 2.0 mha and much of it lies in the CZ, PZ and NHZ. Current data analysis shows that rainfed programme is well-addressed

in the CZ, which has the highest acreage under un-irrigated wheat. In view of no breeder seed demand of rainfed bread wheat or *durum* varieties in the PZ, popularization of recent varieties should be taken up seriously by the state agencies.

1. Progress Report, Directorate of Wheat Research, Karnal, 1994–1995 to 1999–2000, vol. 1.
2. Byerlee, D. and Traxler, G., CIMMYT Research Report No. 5, 1999, pp. 46–57.
3. Jain, K. B. L. and Byerlee, D., CIMMYT Research Report No. 5, 1999, pp. 85–102.
4. Smale, M. and McBride, T., World Wheat Facts and Trends, Part I, CIMMYT, 1996, pp. 1–31.
5. Jag Shoran, Mohan, D., Tyagi, B. S. and Kumar, J., in *Wheat Research Needs Beyond 2000 AD* (eds Nagarajan, S. et al.), Narosa Publishing House, New Delhi, 1998, pp. 89–99.

ACKNOWLEDGEMENTS. We are grateful to all the wheat breeders and the various seed production units engaged in the development and seed production of wheat varieties suited to different environments. This is an outcome of a core project DWR/RP/98-1, funded for the Directorate of Wheat Research by ICAR.

*D. Mohan\**, *S. Nagarajan*, *R. V. P. Singh* and *Jag Shoran* are in the Directorate of Wheat Research, Karnal 132 001, India.  
\*For correspondence. (e-mail: [snagarajan@flashmail.com](mailto:snagarajan@flashmail.com)).